East Goshen Township

1580 Paoli Pike, West Chester, Pennsylvania

Milltown Dam (DEP ID No. D15-146)
Dam Assessment and Alternatives Analysis

March 2016

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EAST GOSHEN TOWNSHIP

MILLTOWN DAM
DAM ASSESSMENT AND ALTERNATIVES ANALYSIS

FINAL REPORT

MARCH 2016

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EAST GOSHEN TOWNSHIP

MILLTOWN DAM
DAM ASSESSMENT AND ALTERNATIVES ANALYSIS

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ABREVIATIONS

APPROX	Approximate
ACB	Articulated Concrete Blocks
AC-FT	Acre-Feet
ALT	Alternative
BLDG	Building
CAD	Computer Aided Design
CFS	Cubic Feet per Second
CIP	Cast Iron Pipe
CONC	Concrete
CY	Cubic Yard
GALV	Galvanized
GF	Gannett Fleming
PADEP	Pennsylvania Department of Environmental Protection, Division of Dam Safety
PFBC	Pennsylvania Fish and Boat Commission
PHMC	Pennsylvania Historic and Museum Commission
EAP	Emergency Action Plan
EL, ELEV	Elevation
EX	Existing
FEMA	Federal Emergency Management Agency
FT	Feet
HDPE	High Density Polyethylene
HMR	Hydrometeorological Report
H:V	Horizontal to Vertical
LB	Pounds
LF	Linear Foot
NAVD	North American Vertical Datum
NRCS	Natural Resources Conservation Service
No	Number
O&M	Operation and Maintenance
PA	Pennsylvania
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipation
PVC	Polyvinyl chloride
RCC	Roller Compacted Concrete
SDF	Spillway Design Flood
SF	Square Foot
STA	Station
TYP	Typical
USGS	United States Geological Survey
USACE	United States Army Corps of Engineers
WCAMA	West Chester Area Municipal Authority

EXECUTIVE SUMMARY

The Pennsylvania Department of Environmental Protection, Division of Dam Safety (PADEP), has informed East Goshen Township (Township) under cover letter dated June 17, 2014, that Milltown Dam has inadequate spillway capacity. In response to this letter from PADEP, the Township has secured the services of Gannett Fleming, Inc. to provide a high level assessment of Milltown Dam (DEP ID No. D15-146) using historic file reviews and visual observations and to evaluate alternatives for addressing known deficiencies, including inadequate spillway capacity. The purpose of this report is to provide East Goshen Township with the information needed to make an educated decision as to whether-or-not to upgrade Milltown Dam to bring it into compliance with current dam safety regulations or to decommission the dam.

Seven alternatives are explored for increasing conveyance capacity of Milltown Dam. Five of these alternatives involve increasing spillway capacity to prevent the design storm from overtopping the dam and two alternatives involve armoring the downstream face of the dam which allows the dam to be overtopped. Of the seven evaluated alternatives, the overtopping protection options are found to be the most economical. These alternatives include 1) armoring the downstream embankment with articulated concrete blocks (ACB's), and 2) armoring the downstream embankment with roller compacted concrete (RCC). Of the two overtopping protection options, the RCC option was found to provide the greatest level of protection and is also the most economical with a total program cost of approximately $2.4 million. Consequently, the RCC alternative is the preferred alternative for increasing conveyance capacity at Milltown Dam.

A bathymetric survey performed by Gannett Fleming confirms the presence of sediment deposits within the Milltown Dam reservoir. In comparison to the original construction drawings from 1923, it is believed that over 60 percent of the reservoir storage volume has been lost to sedimentation. This sedimentation results in decreased water depths which can adversely affect water quality, the aquatic habitat of the reservoir and public use of the facility. Should the Township decide to upgrade the dam, it is recommended that the Township plan for a future dredging project to remove some or all of the sediment deposits.

One decommissioning and two partial breach options are evaluated. The full breach option is the only alternative which decommissions the dam by removing the concrete spillway and portions of the left and right embankments. At $3.1 million, sediment management plays a significant role in the cost of the full breach which will require a pilot channel to be excavated through the sediment deposits to reestablish the stream channel through the reservoir. Excavated material is spoiled within the remaining footprint of the reservoir. The partial breach options, which attempt to minimize sediment removal, are the most economical. Assuming that the dam can be reclassified as a low-hazard structure, the lowest cost alternative is approximately $0.8 million.

INTRODUCTION

1.0 OVERVIEW AND SCOPE OF STUDY

On June 16, 2015, East Goshen Township selected Gannett Fleming to provide dam related engineering services to prepare an assessment and to evaluate alternatives for both increasing conveyance capacity and decommissioning Milltown Dam (DEP ID No. D15-146). These services are performed under a Master Services Agreement, Service Authorization No. 1 between Gannett Fleming and the Township dated July 9, 2015. The scope of services to be provided are detailed in Gannett Fleming's proposal dated May 29, 2015 and are briefly summarized herein:

Phase 1A, Task 1: Data Collection and Review. Review historic files held by both the Township and the Pennsylvania Department of Environmental Protection (DEP) to gain an understanding of the dam. This task also includes a visual inspection of the dam.

Phase 1A, Task 2: Topographic and Bathymetric Survey of Dam and Reservoir. Perform a topographic survey of the dam site and develop a base map which would be used to prepare alternatives for increasing the conveyance capacity at the dam to meet Pennsylvania Department of Environmental Protection (PADEP) requirements. A bathymetric survey of the reservoir would be performed and compared against the original construction drawings to estimate the amount of sediment which has accumulated within the reservoir.

Phase 1A, Task 3: Hydrologic and Hydraulic Analysis. In 2014 PADEP completed a hydrologic and hydraulic analysis of Milltown Dam that included an incremental dam breach assessment. As such, Gannett Fleming intends to review and use the most recent analysis prepared by PADEP.

Phase 1A, Task 4: Perform Dam Assessment and Summarize Known and Potential Dam Deficiencies. Based on the review of available data and the surveys performed by Gannett Fleming, a comprehensive list of known and potential deficiencies of Milltown Dam would be developed.

Phase 1B, Task 1: Prepare Conceptual Rehabilitation Design(s) for Increasing Conveyance Capacity. Prepare conceptual designs and associated construction cost estimates for increasing conveyance capacity at Milltown Dam.

Phase 1B, Task 2: Prepare Conceptual Breach Design. Prepare a conceptual design and associated construction cost estimate to decommission Milltown Dam.

Phase 1B, Task 3: Design Report. The findings of Phase 1A, Tasks 1 through 4 and Phase 1B, Tasks 1 and 2, would be summarized within a single design report.

Phase 1B, Task 4: Meeting with DEP. Meet with PADEP to discuss the findings and obtain general concurrence with the alternatives for increasing conveyance capacity and decommissioning the dam.

Phase 1B, Task 5: Public Meetings. Attend two meetings at the Township to present the findings of Phase 1A and Phase 1B.

The following report represents the culmination of Phase 1A, Tasks 1 through 4 and Phase 1B, Tasks 1 through 4.

1.1 PURPOSE OF THE STUDY

East Goshen Township (Township) currently owns and operates Milltown Dam as a recreational facility. The dam was identified by PADEP as having inadequate capacity to pass the Spillway Design Flood (SDF) which has been established as 50 percent of the Probable Maximum Flood (PMF) through an incremental breach analysis completed by PADEP in 2014. With the current spillway passing approximately 26 percent of the SDF (per PADEP Letter dated June 17, 2014), the dam is considered to be “unsafe” under PA Code, Title 25, Chapter 25, Section 105.136. As such, PADEP, Bureau of Waterways Engineering and Wetlands, is requesting that the Township increase the conveyance capacity at the dam to current standards. Decommissioning or breaching the dam is an alternative to increasing the spillway capacity.

The purpose of the Milltown Dam Study is to evaluate options which are available to the Township to allow the Township to make an educated and informed decision as to whether-or-not to: (1) upgrade the dam so that it complies with current standards, or (2) decommission or breach the dam. The results of the study are documented in the *Milltown Dam, Dam Assessment and Alternatives Analysis* report as presented herein. This report summarizes the various options that are available for repairing, modifying and removing the dam, provides conceptual drawings and planning-level construction cost estimates for the options which were investigated, and recommends the preferred dam rehabilitation alternative.

1.2 PROJECT LOCATION

Milltown Dam (DEP ID No. D15-146) is located in East Goshen Township, Chester County, Pennsylvania approximately 3.2 miles east of West Chester. The dam is situated along the east side of Reservoir Road approximately 550 feet north of the intersection of Reservoir Road with Route 3 at latitude 39º 58’ 03”N and longitude 75º 32’ 40”W. Refer to Figures 1-1 and 1-2 for the general location of Milltown Dam. The dam is located on and discharges to East Branch Chester Creek which is a tributary to the Delaware River. The drainage area to the dam is approximately 6.3 square miles. Approximately 2.6 square miles of the contributing watershed passes through Township Line Dam (DEP ID No. D15-266) owned by AQUA Pennsylvania which is located approximately 2 miles upstream of Milltown Dam along the west side of Airport Road. Figure 1-3 shows the drainage area to Milltown Dam.

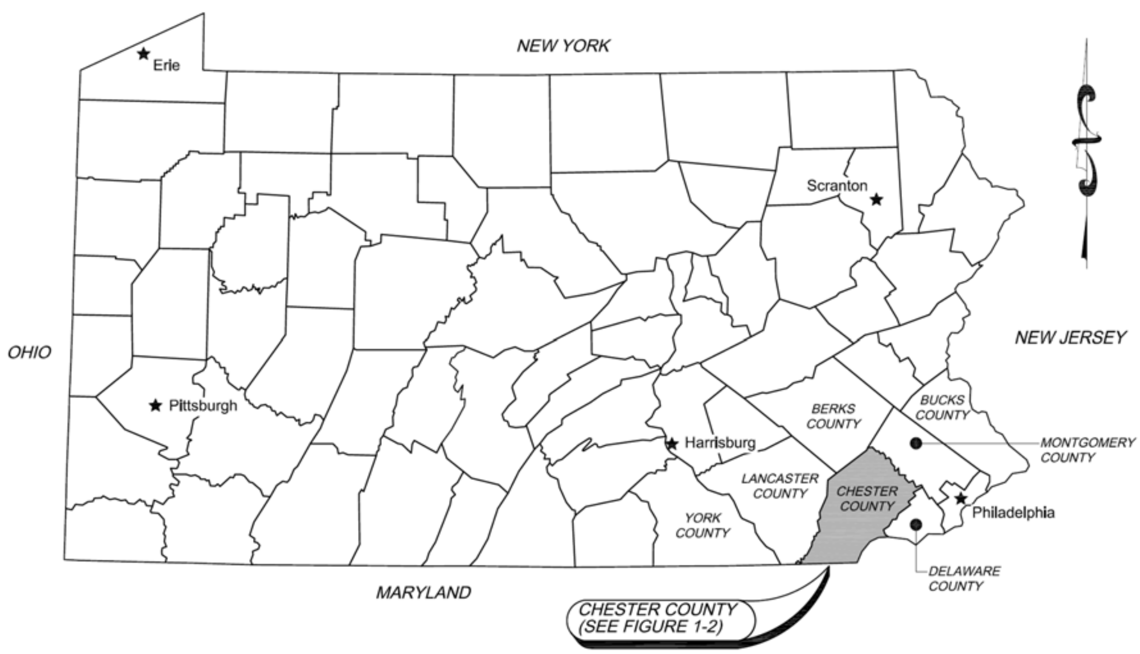


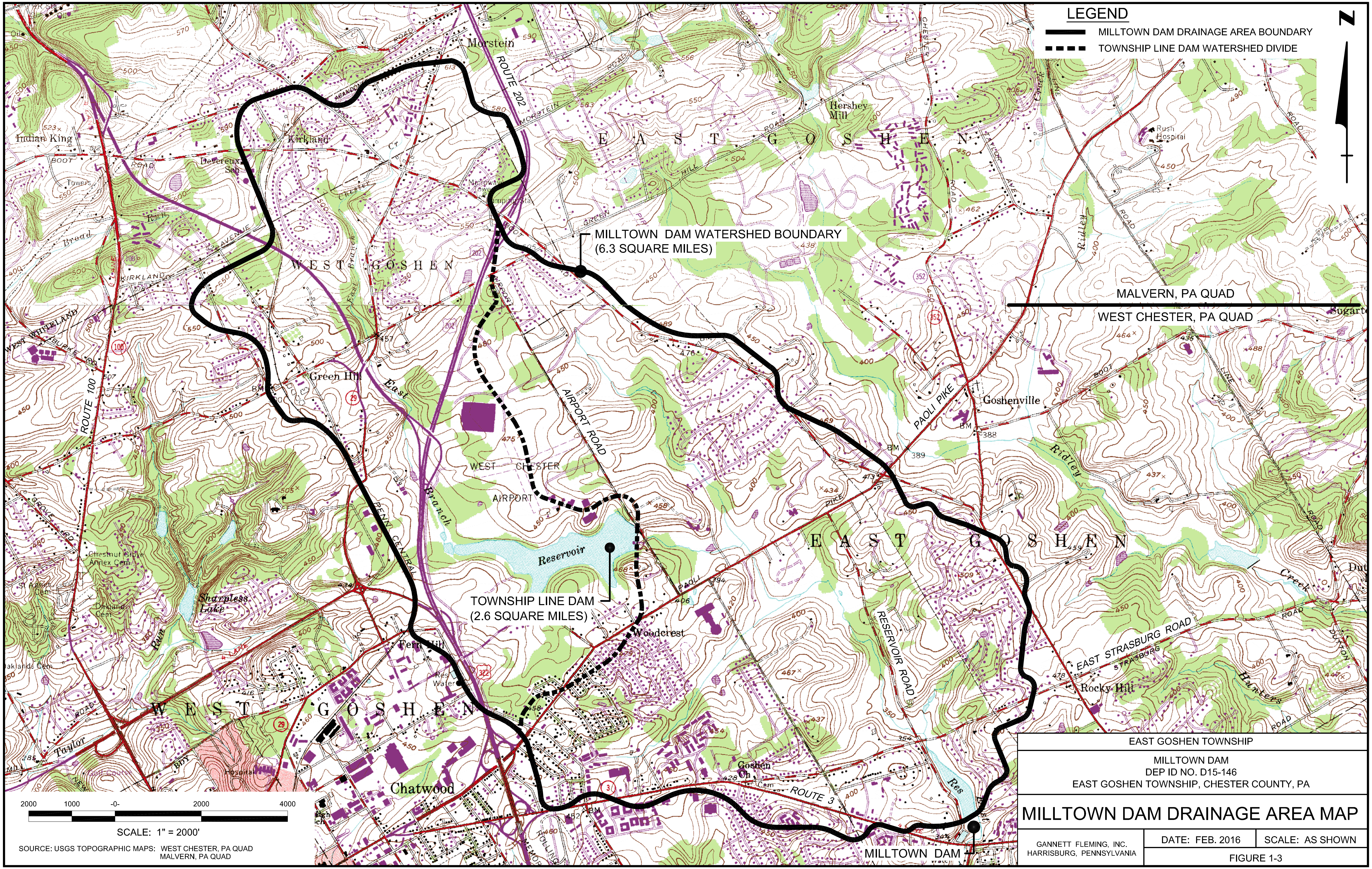
Figure 1-1
Vicinity Map of Chester County, Pennsylvania

Figure 1-2
Location Map of Chester County and Milltown Dam

1.3 DESCRIPTION OF THE DAM

Milltown Dam (listed in the National Dam Inventory as PA-00218) was designed by Franklin & Company, Consulting Engineers in 1920 as a water supply reservoir for the Borough of West Chester. The design was modified by Remington & Vosbury who prepared final construction drawings dated February 20, 1923. Construction of the dam was performed by H.W. Fitzgerald of Binghamton, New York (Contractor). Construction began in May 1923 and continued through August 1924. The structure was used for water supply and replaced a low diversion weir located approximately 500 feet upstream from the current dam. At some point ownership of the dam was transferred to the West Chester Area Municipal Authority (WCAMA).

The use of the structure for water supply diminished over time due to excessive sediment build-up within the reservoir. A letter from WCAMA to the Township dated April 28, 1981 indicates that the reservoir was so badly silted that in 1961 a bypass water supply line was installed around the reservoir to feed the old Milltown water supply plant. By the early 1980's the reservoir was no longer a necessary component of the WCAMA's water supply system. On January 10, 1984 ownership of the reservoir was transferred to Mr. Robert C. Wiggins. On January 16, 1985, Mr. Wiggins granted a 19.5± acre parcel containing the Milltown Dam and the associated reservoir to the Township for the sum of one dollar. The dam and reservoir are currently not used for water supply or stormwater management purposes and are currently operated as a recreational facility. Refer to Appendix B for topographic mapping showing the dam, reservoir and the parcel boundary. Mapping in Appendix B was prepared from a combination of topographic and bathymetric surveys completed by Gannett Fleming in July 2015 and LiDAR data.


LEGEND
MILLTOWN DAM DRAINAGE AREA BOUNDARY
TOWNSHIP LINE DAM WATERSHED DIVIDE
MILLTOWN DAM WATERSHED BOUNDARY
(6.3 SQUARE MILES)
TOWNSHIP LINE DAM
(2.6 SQUARE MILES)
MILLTOWN DAM
MALVERN, PA QUAD
WEST CHESTER, PA QUAD
E A S T G O S H E N
W E S T G O S H E N
ROUTE 202
ROUTE 100
ROUTE 3
AIRPORT ROAD
RESERVOIR ROAD
PAOLI PIKE
EAST STRASBURG ROAD
WEST CHESTER AIRPORT
Reservoir
Goshenville
Rocky Hill
Woodcrest
Chatwood
Fern Hill
Green Hill
Kirkland
Morstein
Hershey Mill
Indian King
Sharpless Lake
2000 1000 -0- 2000 4000
SCALE: 1" = 2000'
SOURCE: USGS TOPOGRAPHIC MAPS: WEST CHESTER, PA QUAD
MALVERN, PA QUAD
EAST GOSHEN TOWNSHIP
MILLTOWN DAM
DEP ID NO. D15-146
EAST GOSHEN TOWNSHIP, CHESTER COUNTY, PA
MILLTOWN DAM DRAINAGE AREA MAP
GANNETT FLEMING, INC.
HARRISBURG, PENNSYLVANIA
DATE: FEB. 2016
SCALE: AS SHOWN
FIGURE 1-3

The dam is comprised of a left embankment (looking downstream) which is approximately 30-feet long, a right embankment which is approximately 250-feet long, a concrete gravity ogee spillway structure which is approximately 69-feet long and a low level dewatering system consisting of a valve house and piping systems (refer to Figure 1-4). The left and right embankments are homogeneous earth fill structures containing a concrete core wall keyed into bedrock along the centerline of the dam. Figure 1-5 depicts a typical cross section taken through the left embankment as shown on the 1923 construction drawings.

Figure 1-4
Plan View of Milltown Dam

At the maximum section, the dam is approximately 20 feet high. Based on the 1923 construction drawings, the right core wall is 250 feet long extending from the valve house to Reservoir Road and the left core wall is approximately 30 feet long extending from the left spillway training wall into the left hillside. The top of each core wall is set approximately 1.8 feet below the top of dam elevation. The bottom of each core wall extends to bedrock. Those portions of the core wall located below existing ground (i.e., pre-dam existing ground) are three feet wide. Those portions of the core wall located above existing ground (i.e., pre-dam existing ground) taper in width from three feet at the existing ground line to 18-inches at the top of the wall. Figure 1-6 shows the construction of the right concrete core wall and shows the use of large stones to create a shear key between vertical concrete pours.

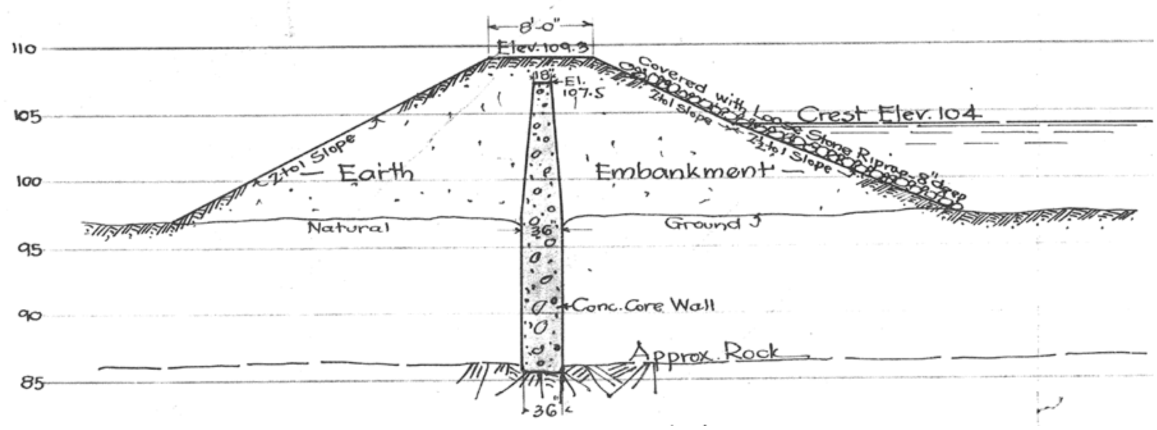


Figure 1-5
Typical cross section through left embankment.
(Source: 1923 Construction Drawings)

Figure 1-6
Photograph of right core wall construction taken on September 26, 1923.

The original embankment cross section contained an eight-foot top width, a 2H:1V downstream embankment slope and a 2H:1V upstream embankment slope above normal pool and a 2.5H:1V slope below normal pool. The original design called for rock protection on the upstream embankment slope and vegetative ground cover on the embankment crest and downstream embankment slope. A retrofit project constructed in 1985 placed rock slope protection chinked with aggregate on the downstream slope and on the upstream slope above normal pool. The 1985 retrofit also surfaced the crest of the dam with aggregate, increasing its width from 8 feet to approximately ten feet. Refer to Section Two of this report for a description of the various improvements which have been made to the dam since its original construction in 1924.

The spillway consists of a concrete gravity ogee structure with a crest length of approximately 69-feet. A low flow notch, six-inches in depth and approximately 40-feet long, is located in the center of the spillway. The spillway has concrete training walls on the left and right. The top of the training walls are set at the top of dam elevation located approximately 5.3 feet above the low flow notch in the spillway. A four-foot wide concrete core wall located under the crest of the spillway extends into bedrock. A concrete toe wall is present at the downstream end of the spillway. The toe wall does not extend to bedrock.

The spillway drops approximately 15.5 feet and discharges onto a rock-lined stilling basin. The 1923 drawings indicated that this stilling basin was to be stabilized with hand-laid stone grouted in place. A concrete sill located approximately 25 feet downstream of the spillway contains the rock-lining. Figure 1-7 provides a typical cross section through the center of the spillway as shown on the 1923 construction drawings. The hand-laid stone stilling basin can be seen in Figure 1-8.

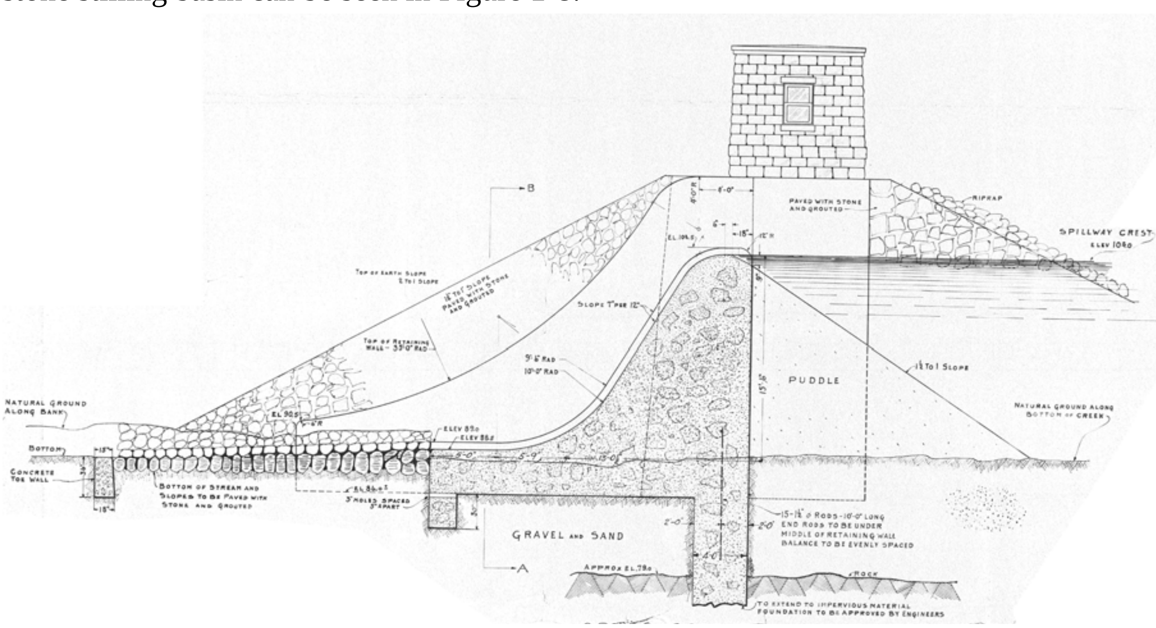


Figure 1-7
Typical cross section through principal spillway.
(Source: 1923 Construction Drawings)

Figure 1-8
Construction photograph taken on December 26, 1923.

The downstream embankment slopes immediately to the left and right of the spillway training walls slope steeply towards the spillway at 1.25H:1V. The 1923 construction drawings indicate that these slopes were to be stabilized with hand-laid stone grouted in place. The area immediately upstream of the spillway was backfilled with puddle material consisting of an earth slurry sluiced into place with a 1.5H:1V upstream slope.

The low level outlet works is comprised of a concrete valve chamber located at the right spillway abutment (refer to Figures 1-9 and 1-10). The interior of the valve chamber is 6.5-feet long by 8-feet wide and approximately 22-feet deep. A valve house constructed of stone masonry is present on top of the valve chamber and houses the manual floor stands for four sluice gates. Two pipes, each controlled by an individual sluice gate mounted on the interior upstream wall of the valve chamber, extend from the valve chamber upstream into the reservoir.

The lower pipe is a 24-inch-diameter cast iron pipe (CIP) which is located approximately 20-feet below the floor of the valve house. This pipe, reported to be 48-feet long extending upstream to the original streambed of East Branch Chester Creek, is used to dewater the reservoir storage area. A 16-inch-diameter CIP, reported to be 38-feet in length, is located approximately 15’-7” below the floor of the valve house and extends upstream to the toe of the dam. This pipe was historically used to convey water from the reservoir for water supply. Both pipe entrances were equipped with trash racks in 1997.

A 16-inch-diameter CIP and a 24-inch-diameter CIP, both located approximately 20-feet below the floor of the valve house, have historically been used to dewater the valve chamber. The 16-inch-diameter CIP was used as part of the original water supply system and conveyed water from the reservoir to the downstream water treatment plant. This pipe has since been abandoned and the sluice gate which covers the entrance of this pipe is reported to be frozen in the closed position. The 24-inch-diameter CIP is used as part of the low level dewatering system and discharges into East Branch Chester Creek approximately 80-feet downstream of the valve house. The sluice gate at the upstream entrance of this pipe is reported to be inoperable and frozen in the open position. A valve manhole is present near the outlet of the 24-inch-diameter CIP. This structure is not referenced on the original 1923 construction drawings and it is unknown when this manhole was added or if it is operational. The valve within this manhole is currently in the open position.

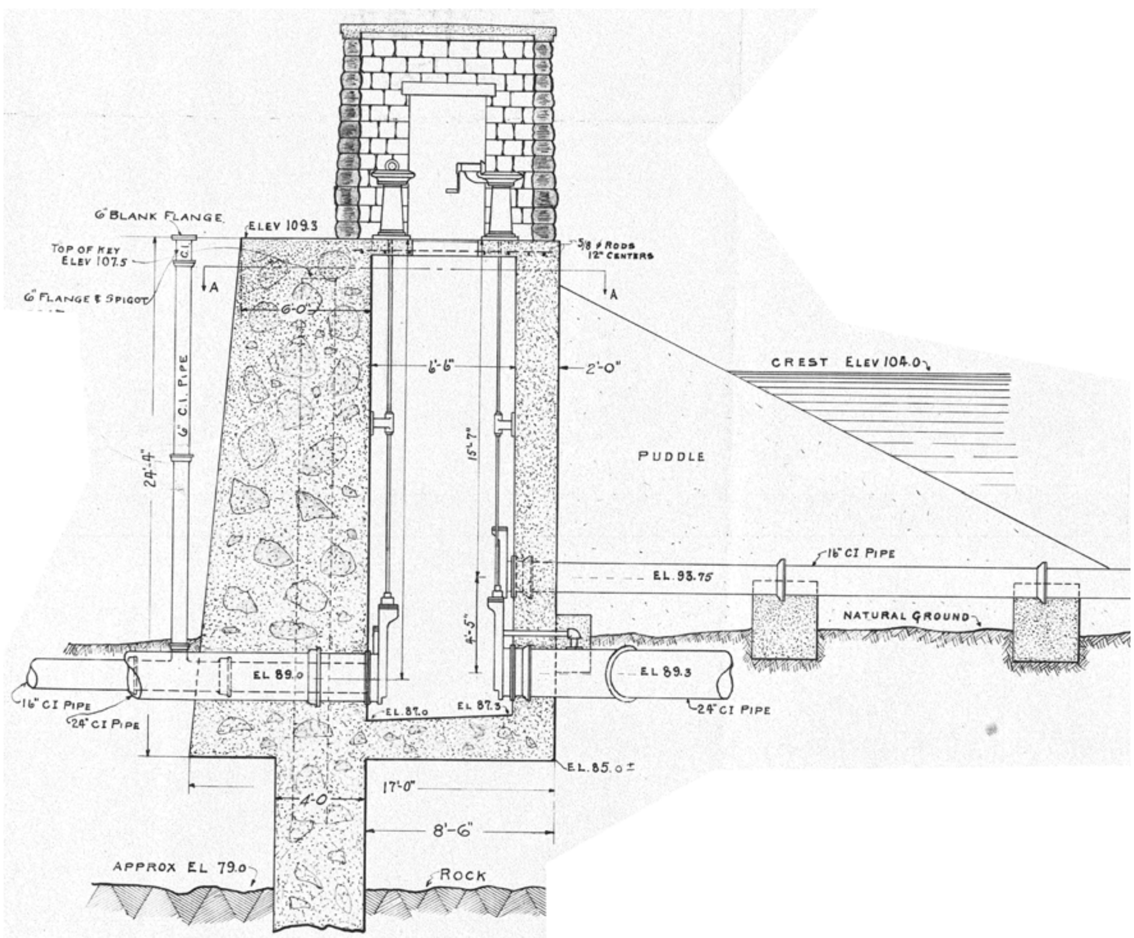


Figure 1-9
Cross section through valve chamber (from 1923 construction drawings).

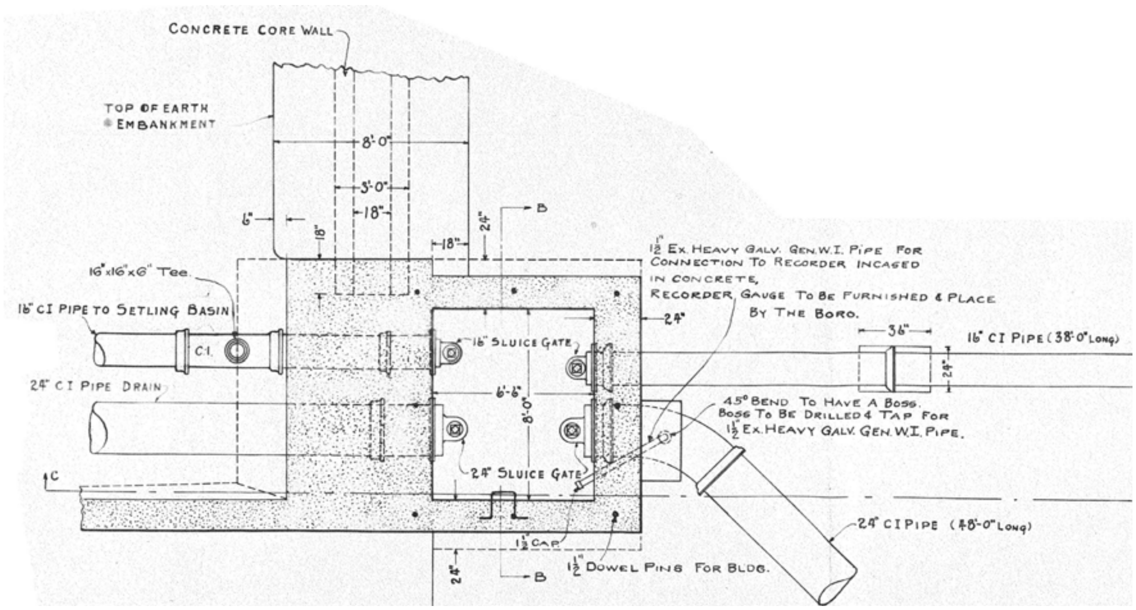


Figure 1-10
Plan view of valve chamber (from 1923 construction drawings).

1.4 AVAILABLE INFORMATION

The scope of work for the Milltown Dam study does not include detailed subsurface geotechnical investigations or environmental surveys. Historic information associated with Milltown Dam, including site geometry, key elevations, hydrology, hydraulics, etc., was derived from the following sources:

- Original construction drawings, prepared by Remington & Vosbury, dated February 20, 1923.
- Phase I Inspection Report, prepared by Berger Associated, dated July 1981.
- Topographic and bathymetric surveys performed by Gannett Fleming in July 2015.
- Review of historic files held by the Township and PADEP.
- Visual inspection of the dam performed by Gannett Fleming on August 4, 2015.

CONSTRUCTION HISTORY

2.0 OVERVIEW

Understanding the history of a dam can provide valuable insight into the overall condition of the structure. Recurring maintenance activities can be an indication of a larger underlying concern. Based on a review of the files held by both the Township and PADEP, Section 2.1 provides a general chronology of the repairs and modifications which have been made to Milltown Dam since its original construction in 1923-1924.

2.1 CONSTRUCTION HISTORY AND MILESTONES

- 1923 – 1924 Original dam construction.

- 1933 Settlement of the dam crest immediately adjacent to the left and right spillway training walls was reported as early as 1927. Additional embankment fill was reported to be placed in 1933; however, subsequent inspections continued to report low areas on the embankment crest to the left and right of the spillway.

- 1941 Inspection of the dam reported downstream embankment slopes steeper than the design grades of 2H:1V and embankment top widths less than the design width of 8-feet. No documentation was found indicating that this condition was addressed until 1985.

- 1952 Inspection of the dam reported uncontrolled vegetation growth on the embankments and low areas along the crest of the dam. No documentation was found indicating that this condition was repaired until 1985.

- 1962 Inspection of the dam reported woody vegetation growth on the embankments. No documentation was found indicating that this condition was repaired until 1985.

- 1981 Phase I Inspection performed by Berger Associates. Based upon the hydrologic analysis, the spillway was estimated to be capable of discharging 18 percent of the Probable Maximum Flood (PMF) without overtopping the embankment. The spillway was therefore considered to be “seriously inadequate” and the dam was categorized as “unsafe, non-emergency”. In accordance with the

Corps of Engineers guidelines, the size classification of the dam was “small” and the hazard classification was “high”. The Phase I Report also noted woody vegetation growing on the crest of the dam and on the upstream and downstream embankments. Photographs presented in the Phase I report show the extent of the trees and brush growing on the dam embankment. The left embankment was observed to be lower than the design top of dam elevation. Dislodged hand-placed rock armoring was observed throughout the stilling basin below the spillway. The dam was judged to be in poor condition.

- 1985 Township secures ownership of Milltown Dam.

- 1985-1986 Spillway and embankment rehabilitation project. Designed by Yerkes Associates, Inc., the work consisted of concrete repairs to the spillway and spillway training walls, rock stabilization of the left and right embankments, and replacement of rock scour protection in the stilling basin immediately downstream of the spillway. Embankment stabilization was intended to provide overtopping protection. Figure 2-1 shows the installation of the dumped rock slope protection on the downstream right embankment. Figure 2-2 shows the reconstruction of the elevated portions of the spillway outside of the low flow notch.

Figure 2-1
Installation of riprap slope protection on the downstream right embankment. (Photograph taken on October 26, 1986)

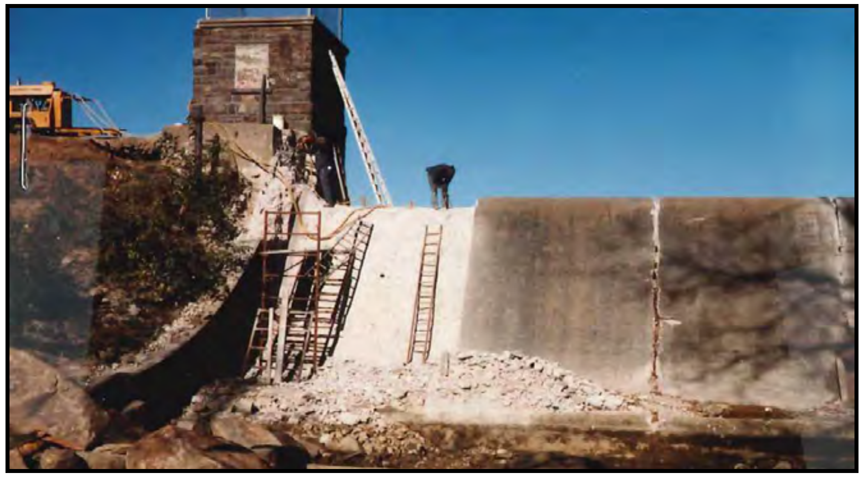


Figure 2-2
Extent of spillway demolition/reconstruction at right spillway abutment (Photograph taken on October 29, 1985)

- 1997 Trash racks were added at the upstream entrances of the 16-inch-diameter and 24-inch-diameter CIPs which draw water from the reservoir into the valve chamber (refer to Figure 2-3). A letter from Yerkes Associates to DEP dated March 15, 2000, indicates that both CIPs were inspected and cleaned free of debris and one valve was rebuilt at the same time the trash racks were installed.

Figure 2-3
Installation of trash rack(s).
Note sediment deposition in bottom of reservoir.

- 2006 Aggregate added to the crest of the right embankment with the intent that this material would withstand sheet flow during an overtopping event.

- 2007 Swing gate added at right abutment interface with Reservoir Road to prevent unauthorized vehicular access (refer to Figure 2-4).

Figure 2-4
Swing gate prevents unauthorized vehicular access to dam crest.

- 2008 Bare areas located on the downstream right embankment immediately adjacent to the right spillway training wall were surfaced with dumped riprap. The crest of the left embankment was raised by approximately 18-inches by adding riprap to bring the crest of the embankment up to the design top of dam elevation (refer to Figure 2-5). No documentation was found indicating whether-or-not compacted fill or bedding material was placed beneath the riprap on the left embankment.

Figure 2-5
Left embankment raised 18-inches by adding riprap.

- 2012 Riprap located on the downstream right embankment immediately below the valve house was slush grouted with concrete to stabilize the riprap (refer to Figure 2-6).

Figure 2-6
Area of slush grouted riprap (photograph taken on June 19, 2015).

- 2013 Replaced roof on valve house.

- 2013-Present Surface concrete repairs on spillway. Areas of the spillway outside of the low flow notch were coated with a liquid applied urethane (CIM 1000). Areas of the initial coating failed (refer to Figure 2-7) and the coating was reapplied/repaired in the fall of 2015.

Figure 2-7
Failing areas of black urethane coating on downstream face of spillway. Ongoing repair work observed on June 19, 2015.

- 2014 Bids received for the replacement of the sluice gates within the valve chamber. All bids were rejected by the Township.

- 2014 PADEP identifies Milltown Dam as having inadequate spillway capacity under cover letter dated June 17, 2014.

- 2014 PADEP performs an incremental breach analysis and determines that the 1/2 Probable Maximum Flood is the minimum design storm for Milltown Dam. As part of this analysis, PADEP updates hydrology to current standards and estimates the 1/2 PMF inflow to be 12,700± cubic feet per second (cfs). Corresponding spillway adequacy determined to be 14 percent of the PMF.

- 2014 Pennoni Associates, Inc. performs a high level alternatives analysis which evaluated options and associated costs to: (1) increase the conveyance capacity of the dam, and (2) breach the dam.

- 2015 East Goshen Township requests proposals from qualified engineers to evaluate options for increasing conveyance capacity. Gannett Fleming's proposal accepted by the Township on June 16, 2015.

- 2015 Valve stem and guides on the upstream 24-inch sluice gate were replaced. Connection between valve stem and gate failed during operation of the gate during the Annual Inspection performed on August 4, 2015. Township reports that the connection was repaired and that the 24-inch sluice gate is operable.

Figure 2-8
Replacement of 24-inch gate stem and guides visible in center of photograph. (Photograph taken on August 4, 2015).

PERTINENT DATA

3.0 OVERVIEW

The information provided in Section Three provides a summary of pertinent data associated with Milltown Dam. Information was obtained from historic documents and surveys performed by Gannett Fleming (refer to Section 1.4).

It is noted that various vertical elevation datums have been used since the original construction of the dam. The original construction drawings from 1923 were based on an assumed local datum which placed the normal pool at elevation 104.0 feet. The Phase I Inspection Report estimated the normal pool elevation to be 345.0 feet based on the U.S.G.S. Quadrangle, West Chester, PA. The Gannett Fleming topographic survey performed in July 2015 used the North American Vertical Datum of 1988 (NAVD 88) and found normal pool to be at elevation 342.2 feet.

3.1 PERTINENT DATA ASSOCIATED WITH MILLTOWN DAM

Dam

NID I.D. No.	PA-00218
PADEP I.D. No.	D15-146
Type:	Compacted earth with concrete core wall.
Height:	20± feet
Length:	350± feet
Crest:	8 feet wide (original design) Increased to 10± feet wide in 1985 *(10' top width confirmed by GF Survey, July 2015)*
DEP Classification:	C-1, high hazard
Upstream Slope:	2H:1V above normal pool 2.5H:1V below normal pool
Downstream Slope:	2H:1V *Note: 2015 survey by Gannett Fleming reports areas of the downstream slope as steep as 1.75H:1V.*

Reservoir / Drainage Basin

Drainage Area:	6.3 square miles	
Contributing Stream:	East Branch Chester Creek	
Reservoir Length:	2,000± feet	
Surface Area*:	Normal Pool:	10± acres
	Top of Dam:	27 acres
Storage Capacity*:	Normal Pool:	17 acre-feet
	Top of Dam:	104 acre-feet
½ PMF Peak Inflow:	6,531 cfs (Phase I Inspection Report)	
	12,700± cfs (PADEP 2014 analysis)	
½ PMF Max Overtopping:	2.5 feet (Phase I Inspection Report)	
	4.1 feet (PADEP 2014 analysis)	

Key Elevations	1923 Drawings	1981 Phase I	GF Survey
Top of Dam:	109.3 feet	349.1 feet (Low Point)	347.5 feet
Principal Spillway Crest: (Low Flow Notch)	104.0 feet	345.0 feet	342.2 feet
Normal Pool:	104.0 feet	345.0 feet	342.2 feet

Principal Spillway

Crest Type:	Concrete ogee crest with a 6-inch deep low flow notch. Spillway drops 15'-6" to downstream apron.
Crest Length:	69 feet total length. Low flow notch is 40 feet long centered in spillway.
Spillway Channel:	Concrete channel with concrete training walls. Spillway discharges onto a 25 foot long rock apron which is contained by a concrete end sill.
Capacity:	2,063 cfs (Phase I Report - observed top of dam) 3,084 cfs (Phase I Report - design top of dam)
Maximum Recorded Flow:	Unknown.

*Note: Surface area and storage capacity information based on Results of topographic and bathymetric survey performed by Gannett Fleming in July 2015 and current LiDAR data.

Low Level Dewatering Structure

Inlet Conduit (2):	16-inch-diameter CIP (38 feet long) with trash rack. 24-inch-diameter CIP (48 feet long) with trash rack.
Outlet Conduit (2):	16-inch-diameter CIP (abandoned). 24-inch-diameter CIP (80 feet long) discharges to East Branch Chester Creek downstream of rock apron.
Primary Closure:	Concrete valve chamber and stone masonry valve house at right spillway training wall. Sluice gate on 16-inch CIP inlet conduit (operable). Sluice gate on 24-inch CIP inlet conduit (operable). Sluice gate on 16-inch CIP outlet conduit (inoperable frozen in the closed position). Sluice gate on 24-inch CIP outlet conduit (inoperable frozen in the open position).
Secondary Closure:	24-inch valve on 24-inch CIP outlet conduit housed within a manhole near the discharge location (condition unknown – currently in the open position).

Instrumentation

Staff Gauge:	Horizontal paint markings on left spillway training wall which correspond to Emergency Action Plan event trigger levels.

DAM ASSESSMENT

4.0 OVERVIEW

Through review of existing data and a visual observation of the dam on August 4, 2015, an assessment of the compliance of Milltown Dam with current dam safety standards was made. With the construction of Milltown Dam occurring more than 90 years ago, this assessment is based on historical documents found within Township files and within the records of PADEP including, but not limited to, the original construction drawings, past inspection reports and historic photographs, and as such, the assessment involves considerable engineering judgement. No subsurface geotechnical investigations, analysis or environmental investigations were performed as part of this study.

In some cases where a feature of the dam is not in full compliance with current dam safety standards, the deficiency is obvious and the correction of the deficiency is required to satisfy PADEP requirements. These deficiencies are often noted in previous assessment reports such as the Phase I Inspections completed by the U.S. Army Corps of Engineers (USACE), previous annual inspection reports, or in correspondence from PADEP. In other cases, where a feature of the dam does not meet the design standards for a new dam, but the performance of the dam is judged to be adequate based on an effective monitoring program and/or a well-documented evaluation or analysis, the modification(s) needed to bring the dam into compliance with current design standards are presented as optional risk reduction items. These optional risk reduction items have not been requested by PADEP. In most cases, the optional risk reduction items are provided to address a potential failure mode or public safety issue. The decision whether-or-not to implement an optional risk reduction item depends on the Township's deliberation of the value provided by the modification.

4.1 EMBANKMENT STABILITY, SEEPAGE AND INTERNAL DRAINAGE

The original engineering data for Milltown Dam are limited to the 1923 construction drawings (three drawings), the original construction specifications, and a report prepared by PADEP dated February 16, 1921 which summarizes PADEP's review of the original dam permit application. The original design calculations for the dam are not available. The original construction drawings dated February 20, 1923 are provided in Appendix A.

Based on the 1923 construction drawings, the embankment is composed of compacted earth with a central concrete core wall. The original construction specifications indicate that the earthen embankment material placed upstream of the concrete core wall is material "*…free from all sod, top soil, muck, brush, wood, or other vegetable matter. It* *shall contain not less than 5% nor more than 15% of clay, about the same proportion of fine sand; about 20% of fine gravel, 1/4" size; and the balance coarse gravel not exceeding one inch (1") in size. No stone larger than two inches (2") in diameter will be allowed in this portion of the embankment.*" The earth material placed downstream of the concrete core wall is reported to be material "*…entirely free from all top soil, sod, or any vegetable matter, and shall be free from stones having a diameter greater than six inches*."

The original construction specifications indicate that all earthen embankment material be placed in irregular layers varying from six inches to twelve inches in depth, wetted and compacted with a heavy grooved roller. The dam permit application issued for Milltown Dam modified the specifications and required that the material used to construct the earth embankments be spread in uniform layers not exceeding six inches in depth. Based on the configuration of the dam which contains a narrow top width bisected with the concrete core wall, placement of compaction equipment on the upper lift surfaces would be difficult. No documentation was found indicating if the upper earth embankment lifts were compacted by hand.

Figure 4-1
Excavation for Concrete Core Wall
(Photograph taken on July 17, 1923)

The concrete core wall extends to foundation bedrock and is located along the centerline of the embankment. Those portions of the core wall located below the original ground line are three feet wide with the exception of the core wall located under the spillway which is four feet wide. Above the original ground line the core wall varies in width from three feet to eighteen inches at the top of the wall. The original construction specifications indicate that the concrete is a 1:2:4 mix

"*…composed of one (1) part Portland Cement, and six (6) parts of fine and coarse aggregate; each measured separately and accurately by volume.*" An inspection performed during the construction of the dam on July 17, 1923 indicates that the overburden consists of large boulders and loose seamy stone with excavations for the core wall reaching 15-feet in depth. Observed bedrock was classified as very hard gneissic rock with tight seams. Figure 4-1 shows a section of the core wall excavation as observed during the July 17, 1923 inspection. Perspective is given to the depth of the core wall excavation by the two workers standing within the trench in the top center of the photograph.

In 1985, the upstream embankment located above normal pool and the downstream embankment were covered with riprap consisting of 24-inch to 30-inch diameter quarry rock chinked with #3 stone. A six-inch layer of 2B stone was placed under the riprap as a bedding layer. A construction inspection performed by PADEP on October 26, 1986 reported that the installed rock appeared to be smaller than the specified size and that the aggregate bedding had been changed from 2B material to 2RC material. Based on photographs taken during the inspection, it is questioned if the aggregate bedding material was placed beneath the riprap on the downstream embankment slope (refer to Figure 2-1). Figure 4-2 provides a typical view of the upstream right embankment. Note that the surface of the riprap has been chinked with aggregate to create a relatively smooth surface.

Figure 4-2
View of upstream right embankment (photograph taken on June 19, 2015).

The dam permit application review report prepared by PADEP, dated February 16, 1921, indicates that the spillway section was stable. Visual inspection of the dam on August 4, 2015 found hairline cracks and several areas of spalled concrete on the left and right spillway training walls. Surface concrete deterioration was observed on the downstream face of the spillway. No evidence of embankment instability was observed. The 1923 construction drawings indicate that the majority of the concrete spillway and portions of the valve vault are founded on erodible material (i.e, up to 7 feet of gravel and sand – Refer to Figures 1-7 and 1-9). Loss of this material from beneath the spillway, either through scour, erosion or internal piping, could result in failure of the spillway. **Any future modifications to the embankment and/or spillway should consider remediation measures to either remove or encapsulate the erodible material beneath the spillway as an additional risk reduction measure.**

Based on historic photographs and comparison of the original design drawings to the survey performed by Gannett Fleming in July 2015, it appears that excavation activities occurred along the left reservoir bank upstream of the dam. It is likely that the excavated material was used as fill to construct the dam embankment. According to the NRCS Web Soil Survey, the soils around the rim of the Milltown Dam reservoir belong to the Gladstone complex and the Hatboro complex and most of these soils have been impacted by urbanization of the surrounding area. Both of these soil series have engineering properties which can be classified as CL-ML, ML, and SC-SM. The Urban Land component is classified as SM and GP.

Recommended embankment slopes for small dams in “Design of Small Dams”, Bureau of Reclamation, Third edition, indicates that the downstream slope for embankments constructed of SM and CL/ML material should be no steeper than 2H:1V and 2.5H:1V, respectively. Based on historic documents and the topographic survey performed by Gannett Fleming, the downstream embankment slope is approximately 2H:1V with localized areas being slightly steeper. The downstream embankment immediately adjacent to the left and right spillway training walls steepens to slopes reaching 1.5H:1V. The Township has reported areas of unstable riprap on these slopes and slush grouting has been used to stabilize the riprap below the valve house (refer to Figure 2-6).

Although not a requirement, as a risk reduction measure, the Township should consider **raising the left and right spillway training walls to match the profile of the existing/proposed embankments as part of any embankment rehabilitation project.** This would allow the embankment slopes immediately adjacent to the spillway to be flattened, improving embankment slope stability.

As mentioned in Section Two of this report, in 2008 the left embankment crest was raised 18-inches by adding riprap. If impervious material was not used to construct the crest, the top 18-inches of the left embankment is relatively pervious and would allow flow to pass through the riprap and over the downstream face of the left embankment prior to the reservoir reaching the top of dam elevation. This condition could lead to saturation and erosion and possible failure of the left embankment. **If the impervious core of the left embankment is not present in the top 18-inches of the riprap, it is recommended that Township extend the core wall to the crest of the dam as part of any embankment rehabilitation project.**

Current industry practice for earth embankment dams includes installation of a filtered seepage collection and conveyance system as a defensive measure to protect the structure from internal erosion conditions that may exist or develop over the life of the structure. Filters and drains typically include trench, blanket, and chimney drains consisting of an engineered media (typically a washed sand material) that allows seepage to enter the filter without conveying soil particles from or between various zones and foundations of embankment dams. Such soil movement, if not controlled, can result in the development of concentrated leaks that can lead to internal erosion and piping and eventual failure of the embankment. The blanket and/or chimney drain typically discharges into a toe drain which conveys the collected seepage to a monitoring facility (typically a weir or outlet pipe) before discharging to the downstream watercourse.

The current practice for constructing toe drains includes installation of a specially designed perforated HDPE or PVC pipe surrounded by a gravel drain which, itself, is surrounded by a filter. This arrangement is known as a two-stage toe drain. The gradation of a toe drain system must be checked to make sure the filter material(s) is compatible with adjacent embankment and foundation soils to prevent piping of soil material through the drain system, or to make sure that the filter material(s) does not act as a barrier reducing the desired seepage control. Current best practices include providing facilities to monitor drain flow, detection of turbid seepage, and sediment accumulation. Drain conduit access ports at the ends and at intermediate points along the drain system are also required to accommodate future cleaning and video examination of the drain pipe. These features are considered the minimum necessary for an effective toe drain system [FEMA 2011].

Based on the 1923 construction drawings, the earthen embankment does not contain an internal filtered seepage collection system. The concrete core wall is intended to act as the seepage barrier. Seepage calculations from the original design are not available. Past inspection reports have documented damp or wet areas within the riprap downstream of the right embankment; however, it is believe that this is a result of poor surface drainage. Historically, seepage below the dam has not been reported. It is noted that a sanitary sewer trunk line is located immediately downstream of the dam and runs parallel to the right embankment. This conduit and the aggregate bedding and backfill placed around the sewer line, have the potential to act as a toe drain. In this case, the potential exists for subsurface seepage to be occurring without visual detection from the surface.

Although the existing embankment does not have an internal drainage system, the compacted embankment fill and concrete core wall appear to be effectively controlling seepage through the dam. Increased sediment buildup immediately upstream of the dam may also be helping to reduce seepage. Given the above, the need to install a toe drain with a modern toe drain design is judged to be optional. Mitigating factors include the presence of a concrete core wall within the embankment and the apparently long history of satisfactory performance of the dam. **Any future modifications to the embankment, such as raising the top of dam, should consider including an internal drainage system as an additional risk reduction measure.** The internal drainage system should be equipped with a seepage collection and monitoring system so that the amount of seepage, and changes in the seepage, can be monitored.

4.2 SPILLWAY CAPACITY

The original 1921 design calculations for Milltown Dam are unavailable. Information contained within the 1981 Phase I Inspection Report indicates that the storage capacity of the reservoir (at top of dam) is 114 acre-feet and that the spillway capacity with the pool at the top of dam elevation is approximately 2,060± cfs. Due to observed low areas along the crest of the dam, the Phase I Inspection found the top of dam to be 4.1-feet above the low flow notch in the spillway. Based on the design top of dam elevation (5.3 feet above the low flow notch in the spillway), the Phase I Inspection Report calculated the spillway capacity to be 3,080± cfs. According to current USGS stream statistics published for this site, the 100-year flood discharge is estimated to be approximately 3,500 cfs. The current spillway capacity is therefore less than the 100-year flood. Figure 4-3 shows the condition of the spillway crest as observed on August 4, 2015.

The spillway flow capacity calculated within the Phase I Inspection Report is based on a weir coefficient of 3.88 for the ogee-shaped crest. This weir coefficient appears reasonable for the original design; however, sediment buildup at the entrance of the spillway can reduce the approach depth of the flow and decrease the efficiency of the spillway. The as-built approach depth to the spillway was approximately 15.5 feet. The current approach depth is approximately 5 feet. The impact of the reduced approach depth was analyzed using procedures in *Design of Small Dams* and found to be negligible. The currently estimated discharge capacity of the spillway is therefore reasonable.

Figure 4-3
View of spillway crest. (Note 6-inch deep low flow notch)

The 1981 Phase I Inspection determined the minimum Spillway Design Flood (SDF) to be the one-half Probable Maximum Flood (PMF) and estimated the peak inflow rate for the SDF to be approximately 6,500 cfs using HMR-33 to estimate the Probable Maximum Precipitation (PMP). Based on the hydrologic analysis, the spillway was estimated to be capable of discharging 18 percent of the PMF without overtopping the embankment. The hydrologic analysis provided in the Phase I Inspection Report indicates that the embankment would be overtopped by approximately 2.5 feet for approximately 8 hours during a flood event equal to 50 percent of the PMF. Based on the limited spillway capacity, the Phase I Inspection Report classified the spillway as “seriously inadequate” and the overall Milltown Dam was classified as “unsafe, non-emergency”.

In 1985, an embankment rehabilitation project was completed which restored the crest of the dam to its original design height and provided riprap overtopping protection. Restoring the design top of dam elevation increased the spillway capacity to approximately 3,080± cfs. Using the 1981 hydrology within the Phase I Inspection Report, a depth of overtopping for the design flood was estimated at 1.7 feet.

Since 1985, there have been significant changes in dam safety regulations, policy and engineering methodology. In 2011, changes in the Pennsylvania dam safety regulations allow the spillway design flood for a high hazard dam to be less than the PMF provided an incremental dam breach analysis demonstrates that a lower flood event is acceptable. Precipitation data and methodology for determining the PMF have been revised since 1981 and presently use HMR-51 to estimate the Probable Maximum Precipitation. It is noted that PADEP is currently pursuing a state-wide PMP re-study conducted for Pennsylvania. This study, if completed, may result in precipitation depths that vary from those calculated through the use of HMR-51.

At the request of the Township, PADEP performed an incremental breach analysis to determine the appropriate spillway design flood for Milltown Dam. This analysis determined that the one-half PMF is the minimum design storm acceptable for Milltown Dam. The PADEP analysis also calculated the PMP using HMR-51 and calculated the peak flow rate for the ½ PMF to be approximately 12,700 cfs which is significantly higher than the peak flow of 6,531 cfs calculated within the 1981 Phase I Inspection Report.

Based on the revised hydrology, it is estimated that the dam would be overtopped for a period of approximately 6 hours with a maximum flow depth of approximately 4.1 feet during the one-half PMF event. With the spillway capable of passing approximately 3,080 cfs (prior to overtopping), the existing spillway can pass only approximately 14 percent of the PMF before the embankment is overtopped.

Based on this analysis, the conveyance capacity of Milltown Dam is inadequate. The minimum design discharge that would be accepted by PADEP based on their incremental assessment for Milltown Dam is 12,700 cfs (inflow hydrograph). Since this discharge is based on an incremental assessment, a re-study of the PMP would not impact the minimum design discharge accepted by PADEP for this structure.

There are few examples of riprap protection used for overtopping protection at high hazard dams. PADEP does not accept the use of riprap as an overtopping protection measure due to its poor performance for this armoring method. Dumped riprap used as overtopping protection for embankments with steep slopes has been found to become unstable when overtopped. Gabion baskets filled with rocks have also been used as overtopping protection. However, gabions have also been found to be problematic and are not recommended for overtopping protection.

If Milltown Dam continues to be operated and maintained by the Township, the conveyance capacity at the dam would need to be increased to pass, at a minimum, a design discharge of 12,700 cfs. This can be accomplished by increasing the conveyance capacity of the existing spillway, adding a new spillway, or by armoring the embankment so that it can be overtopped. Alternatives for increasing the conveyance capacity of Milltown Dam are presented in Section Seven of this study.

4.3 OUTLET WORKS

The outlet works consist of a stone masonry valve house situated over a concrete valve chamber placed on native material (refer to Figures 1-9, 1-10 and 4-4). Section 1.3 of this report provides a detailed description of the low level outlet works. The majority of this structure is founded on erodible material (refer to Figure 1-9). **Any future modifications to the embankment should consider remediation measures to either remove or encapsulate the erodible material beneath the valve vault as an additional risk reduction measure.** The concrete valve chamber has two intakes; a 24-inch CIP which enters the bottom of the valve chamber and a 16-inch CIP which enters the valve chamber approximately 4.75 feet above the 24-inch CIP. Both pipes extend into the reservoir and each pipe entrance is equipped with a trash rack. Both pipe intakes are controlled by sluice gates mounted on the interior upstream wall of the valve chamber. Both sluice gates are operated by manual floor stands mounted on the floor of the valve house and are reported to be in working condition.

Two discharge pipes leave the bottom of the valve chamber; a 24-inch CIP which discharges into East Branch Chester Creek approximately 80 feet downstream of the valve house and a 16-inch CIP which was used to convey flows to the water treatment plant. The 16-inch CIP is reported to be abandoned and believed to be plugged downstream of the dam. Both discharge pipes are controlled by sluice gates mounted on the interior downstream wall of the valve chamber. The 16-inch and 24-inch sluice gates are reported to be inoperable with the 16-inch gate frozen in the closed position and the 24-inch gate frozen in the open position. The inoperable gates on the downstream wall of the chamber vault do not impact the performance of the low level dewatering system. Since the dam no longer serves as a water supply structure, there is no need to operate the downstream 16-inch sluice gate. With the downstream 24-inch sluice gate frozen in the open position, the valve chamber would drain to East Branch Chester Creek when the upstream sluice gates are operated.

As part of DEP's review of the 2008 and 2013 annual inspection reports, the Department requested a video inspection of the low level dewatering system be performed and submitted for their review. No records were found indicating that such an inspection has been performed. **PADEP is currently requesting that detailed video inspection of the low level dewatering system be performed at least every 10 years**. If deficiencies are found that require monitoring, the frequently of these inspections may be increased depending on the nature and severity of the deficiency.

The valve house is a stone masonry structure situated over a concrete valve chamber (refer to Figure 4-4). A lockable door provides access to the interior of the valve house. The door locks are protected with steel shrouds to prevent vandalism which is reported by the Township to be a recurring problem. The original windows have been bricked shut to prevent/deter vandalism. The roof on the valve house was replaced in 2013 and contains an access hatch to facilitate future gate repairs/replacements. A chain-link fence prevents unauthorized access to the roof. The stone masonry valve house appears to be in fair condition.

Figure 4-4
View of Valve House situated at the right spillway training wall.

The exterior portions of the concrete valve chamber which are exposed contain hairline cracks with efflorescence deposits. The valve chamber walls vary in thickness with the left and right walls being the thinnest at 16-inches. The interior of the valve chamber was inspected from the floor of the valve house through an access port on the floor. A damp area was observed near the normal pool elevation in the downstream left corner of the valve chamber.

4.4 CONCRETE STRUCTURES

Concrete structures at Milltown Dam include the spillway, the concrete core wall and the concrete valve chamber. Based on the 1923 construction drawings, no steel reinforcement was used within these structures with the exception of the connection between the spillway and the underlying concrete core wall. The concrete valve chamber is discussed in detail within Section 4.3. The concrete core wall is not visible; consequently, its condition cannot be assessed without intrusive measures that are beyond the scope of this study. Seepage has <u>not</u> been reported emanating from the dam embankment, indicating that the concrete core wall is performing as intended. The spillway is a mass concrete structure with an ogee crest configuration. The spillway crest is approximately 69-feet long and contains a low flow notch which is approximately 6-inches deep and 40-feet long centered within the spillway. The spillway has concrete training walls which extend to the top of dam elevation. The upper portions of the training walls and those portions of the spillway crest located outside of the low flow notch were reconstructed as part of the 1985 spillway and embankment rehabilitation project (refer to Figure 2-2).

Prior to acquiring the dam in 1985, the Township requested Valley Forge Laboratories to perform an investigation into the condition of the concrete within the spillway. Four concrete core samples were taken from the spillway, one at the top of each training wall and two in the downstream face of the spillway at locations outside of the low flow notch. The resulting report dated June 1984 found boulders within two of the four samples and rated the compressive strength of the concrete as 4,000 psi. The presence of boulders within the mass concrete structure indicate that cyclopean concrete construction methods were used to construct the spillway gravity structure which was common practice at that time. Surface cracking was observed in the samples that contained boulders. The spillway condition study concluded that the observed cracking was a result of high stresses generated at the interface between the boulders and the surface concrete.

In 2013, surface repairs were made to those portions of the spillway located outside of the low flow notch. These repairs involved painting the surface of the spillway with a liquid applied urethane coating (CIM 1000) as manufactured by C.I.M. Industries Inc. These repairs were only marginally effective as the coating failed to adhere to the structure and peeled away from the surface of the spillway at numerous areas (refer to Figure 2-7). The work performed in 2013 was under warranty and the Township reports that the coating was reapplied in the fall of 2015.

The spillway and the left and right training walls were observed during a visual inspection on August 4, 2015. Hairline cracking with light efflorescence deposits were observed on the vertical faces of the left and right training walls and concrete spalls were observed on the downstream right training wall (refer to Figure 4-5). Exposed aggregate was observed throughout the low flow notch (refer to Figure 4-6). **It is recommended that the concrete spalls be repaired.**

Figure 4-5
Spalls and hairline cracking on right spillway training wall.
(Photograph taken on August 4, 2015)

Figure 4-6
Exposed aggregate on downstream face of spillway.
(Photograph taken on June 19, 2015)

4.5 INSTRUMENTATION

Horizontal paint markings are present on the left spillway training wall. These markings correspond to the Emergency Action Plan (EAP) event trigger levels (refer to Figure 4-7). No additional instrumentation is present at Milltown Dam.

While the lack of instrumentation at Milltown Dam is not uncommon for dams of this age and size, the Township may wish consider additional instrumentation. Pertinent instrumentation may include the following:

- ***Staff Gage.*** Although the painted markings on the spillway are innovative and provide an excellent visual indication of the water level, the flow approaching the spillway and discharging over the crest of the spillway would have considerable velocity which results in the flow depth contracting vertically. Therefore the horizontal paint marking on the left spillway wall may not provide an accurate reservoir level reading. If a new staff gage is installed, it should be easily readable from the Reservoir Road pull-off area at the right abutment of the dam.

- ***Piezometers.*** Although piezometers and surface monuments are common instruments installed at high hazard dams, our assessment of Milltown Dam did not identify a compelling condition that would warrant monitoring with this types of instrument. Instead, the Township may want to consider installing a seepage collection and monitoring system at the toe of the dam. An effective seepage monitoring system at a dam provides important information on the overall performance of the dam and provides early warning of any changing conditions.

Figure 4-7
EAP event trigger levels marked on left spillway training wall.

4.6 MECHANICAL EQUIPMENT

With the exception of the sluice gates located within the valve chamber and the valve manhole located on the 24-inch low level discharge pipe as discussed elsewhere in this report, there are no other mechanical components to Milltown Dam. Depending on the alternative selected by the Township (i.e., maintain or breach the dam) the Township should consider rebidding the sluice gate replacement project which was put on hold in 2014.

4.7 ELECTRICAL EQUIPMENT

There is no electrical equipment associated with Milltown Dam. Overhead electrical power lines are present along Reservoir Road; however, these are not related to the dam.

4.8 RESERVOIR STORAGE AREA

The Milltown Dam forms a reservoir storage area that extends approximately 2,000 feet upstream to East Strasburg Road (i.e., normal pool). The upstream end of the reservoir was originally planned to be excavated to a depth of four feet below normal pool to provide the intended storage capacity of 21,835,000 gallons (67 acre-feet) as indicated on the 1923 construction drawings. No historic documentation was found to confirm or deny if this planned excavation was performed within the upstream reaches of the reservoir. The 1981 Phase I Inspection Report lists the surface area of the reservoir at normal pool as 9.2 acres, the storage capacity of the reservoir below normal pool as 18.5 acre-feet, and the storage capacity at top of dam as 114 acre-feet.

The Milltown Dam reservoir has a history of chronic sediment deposition. Reports from the water company indicate that in 1961, the reservoir was so heavily silted that a bypass water line was needed to pass flows around the reservoir, indicating that the raw water intakes at the dam site were no longer usable for water supply purposes. Photographs taken in 1997, during the installation of the trash racks on the low level intake pipes, clearly show sediment buildup in the lower end of the reservoir (refer to Figure 2-3). Consequently, it appears that the majority of the sedimentation within the reservoir occurred between 1923 and 1961 when the watershed was being converted from farmland to residential type development. As such, it is difficult to estimate the current rate of sedimentation. With the majority of the watershed in a stabilized residential condition, the most likely source of sedimentation is expected to be from stream bank erosion. The trap efficiency of the reservoir is also decreasing with time causing more suspended sediments to pass through the reservoir and be transported over the spillway and downstream of the dam.

Gannett Fleming performed a bathymetric survey of the reservoir in July 2015. Topography above normal pool was supplemented with County Lidar data. The 2015 bathymetric survey confirms the presence of significant sediment deposits throughout the reservoir. Figure 4-9 compares the top of sediment surveyed in 2015 against the original contours shown on the 1923 construction drawings and depicts the depth of sediment within the reservoir. Approximately 46,800 cubic yards (29 acre-feet) of sediment is estimated to be deposited in the Milltown Dam reservoir. Figure 4-8 compares the storage volume of Milltown Dam at normal pool as depicted on the 1923 construction drawings to the bathymetric survey performed by Gannett Fleming in 2015. According to this information, approximately 63 percent of the reservoir storage has been displaced with sediment.

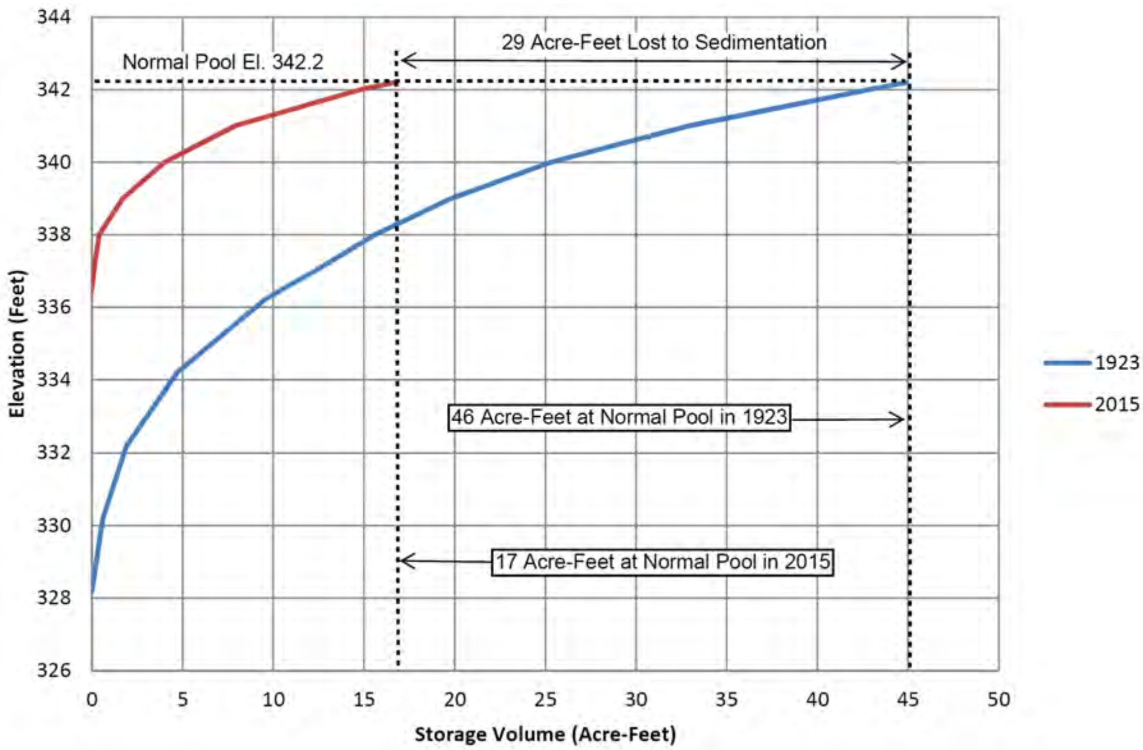
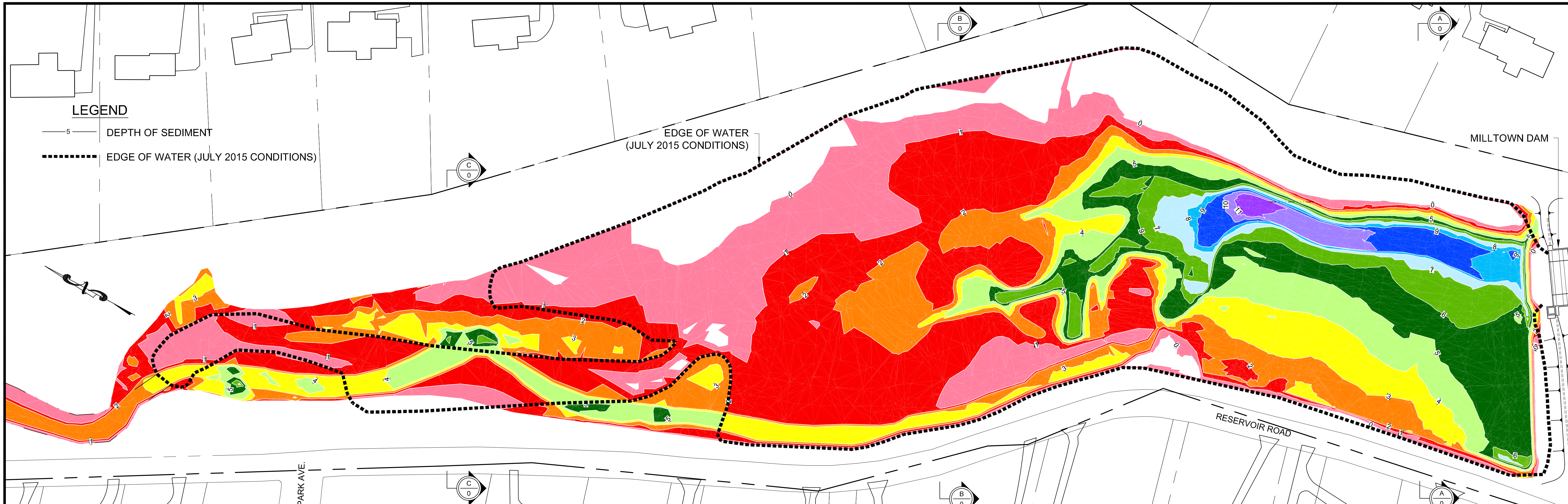
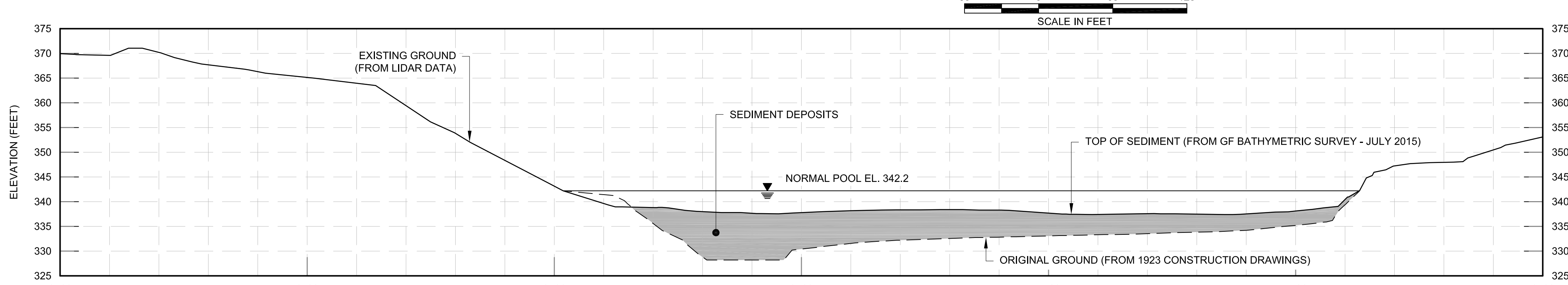


Figure 4-8
Stage-Storage Capacity of Reservoir

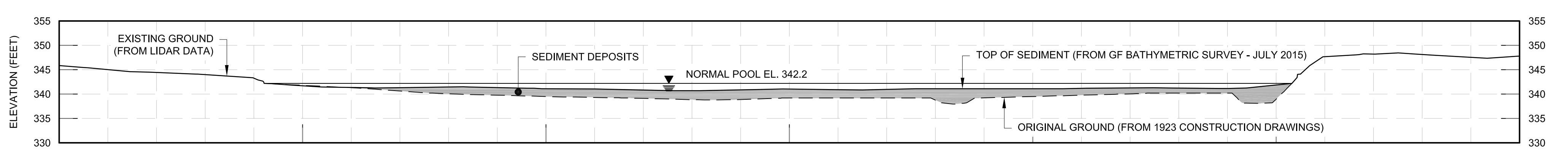
Using County LiDAR data, the current surface area of reservoir is estimated to be 10± acres at normal pool and 27+ acres at top of dam which extends upstream of East Strasburg Road. The reservoir storage volume is calculated to be approximately 17 acre-feet at normal pool and 104 acre-feet at the top of dam elevation.



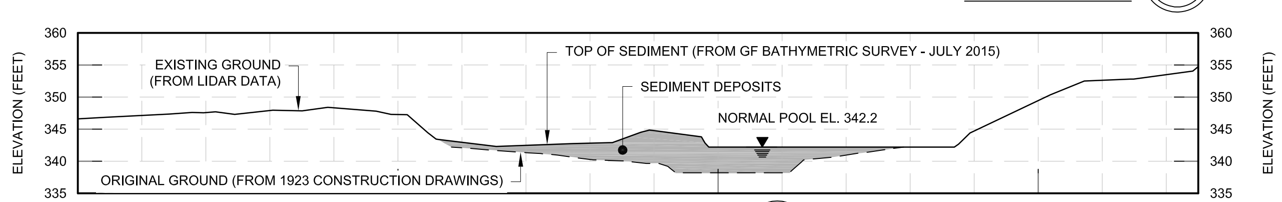
RESERVOIR SEDIMENT DEPTH



SECTION A/0



SECTION B/0



SECTION C/0

SCALE IN FEET: 30 -0- 30 60

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	

NOTES:

1. SEDIMENTATION DEPTH COMPARES THE CONTOURS SHOWN ON THE 1923 CONSTRUCTION DRAWINGS TO THE TOP OF SEDIMENT ELEVATION SURVEYED BY GANNETT FLEMING IN JULY 2015.
2. APPROXIMATELY 46,800 CY (29 ACRE-FEET) OF SEDIMENT IS ESTIMATED TO BE PRESENT WITHIN THE MILLTOWN DAM RESERVOIR.

EAST GOSHEN TOWNSHIP

MILLTOWN DAM
DEP ID NO. D15-146
EAST GOSHEN TOWNSHIP, CHESTER COUNTY, PA

RESERVOIR SEDIMENTATION MAP

GANNETT FLEMING, INC.
HARRISBURG, PENNSYLVANIA

DATE: FEB. 2016 | SCALE: AS SHOWN

FIGURE 4-9

It also appears that the eastern shoreline of the current reservoir is located farther to the east than what is shown on the 1923 construction drawings. It is possible that this shoreline was excavated during construction as a source of fill material for construction of the Milltown Dam embankment. Review of construction photos confirms disturbance of the eastern shoreline in the area immediately upstream of the dam.

Figure 4-9 indicates that sediment deposition immediately upstream of the dam ranges in depth from 6 to 12 feet with the deepest sediment deposits being located within the original footprint of East Branch Chester Creek. Sediment depths within the upper end of the reservoir average between one and three-feet. Actual sedimentation depths in the upper end of the reservoir may be greater than those shown on Figure 4-9 if the over-excavation of this area was performed as indicated on the 1923 construction drawings. Current water depths within the reservoir range from 1 to 2 feet in the upper end of the reservoir to approximately 4 to 5 feet in the area immediately upstream of the dam.

Most freshwater lakes provide habitat for native flora and fauna, replenish groundwater supplies, store and filter stormwater and provide recreational opportunities. The Milltown Dam reservoir's ability to provide these functions is currently being limited by the significant amount of sediment deposition which has occurred over the past 90+ years. The shallow water depths within the reservoir result in increased water temperatures through solar heating. Increased water temperatures coupled with shallow and stagnant water can increase algae population which in turn reduces the amount of dissolved oxygen within the water and water clarity. All of these symptoms adversely affect the plant and animal life not only within the reservoir but also downstream of the reservoir due to the reduced quality of water being released from the dam.

Reservoir sedimentation at Milltown Dam is expected to continue. Over time, the upstream end of the lake would continue to infill with sediment and become overgrown with wetland vegetation. Eventually, if no action is taken to dredge the reservoir, an equilibrium would be reached where the reservoir area would consist of a stream channel through the reservoir with shallow wetlands within the channel overbank areas. **Should the Township choose to maintain the dam, it is recommended that the Township plan for a future dredging project.**

Complete or partial dredging of the reservoir to maintain the benefits of the lake can be a costly undertaking. The requirements and costs associated with lake maintenance dredging are discussed in more detail in Section Eight of this report.

4.9 SITE ACCESS

Access to the crest of the dam is provided by a gravel parking area at the right abutment immediately adjacent to Reservoir Road. This parking area is very small and can only accommodate several cars. A lockable swing gate prevents unauthorized vehicular access to the crest of the dam. Access to the downstream toe of the right embankment is provided by a vegetated access drive that was established during the 1985 embankment renovation project. This easement is documented on the As-Built Site Plan prepared by Yerkes Associates, Inc. dated December 16, 1986.

Access to the left embankment is problematic. Residential lots and a thick tree line along the bank of the reservoir prevent access to the left embankment from Lochwood Lane located to the east of the dam. The reservoir and East Branch Chester Creek prevent access from the right embankment and Reservoir Road.

It is recommended that the Township establish access to the left embankment for maintenance and emergency purposes. Potential access routes are shown on Figure 4-10. Access could be provided by establishing an easement with one or more homeowners along Lochwood Road (Option 1 on Figure 4-10) or by using the parking lot and grassed field associated with the public pool located just downstream of the dam (Option 2 on Figure 4-10). Both of these options would require removal of trees in order to gain access to the dam. Installation of a ford crossing within East Branch Chester Creek is also an option for providing access to the downstream left embankment (Option 3 on Figure 4-10). Most of the conveyance capacity alternatives identified in Section Seven can incorporate a ford crossing of East Branch Chester Creek.

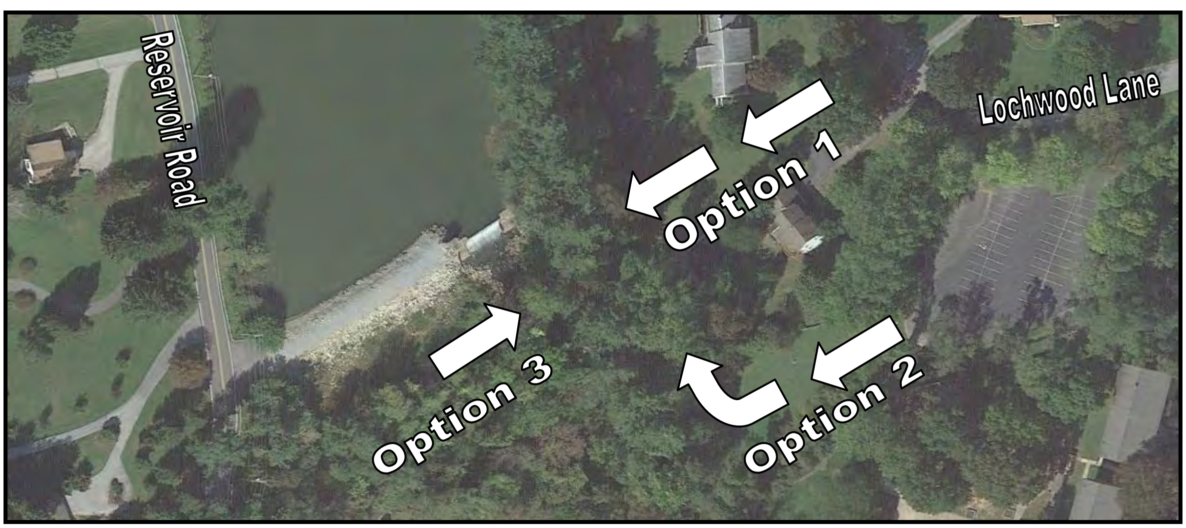


Figure 4-10
Potential site access routes to left embankment.

4.10 SITE SECURITY AND PUBLIC SAFETY

The Township currently operates Milltown Dam as a recreational facility. The dam is located in a highly urbanized setting and pedestrian access to the dam and reservoir is allowed. The Township reports that vandalism is a recurring concern. Vehicular access to the crest of the dam is prohibited by a swing gate along Reservoir Road at the right abutment. This gate has a warning sign indicating that no boating, swimming and/or wading is allowed (refer to Figure 2-4). Graffiti was observed on the warning sign at the time of the August 4, 2015 visual inspection (refer to Figure 4-11). Chain-link fence is installed at the top of the left and right spillway training walls to prevent public access to the crest of the dam. Chain-link fence is also installed on top of the valve house to prevent access to the roof and access hatch.

Figure 4-11
Warning sign on swing gate.

Boating and swimming are not permitted on/in the reservoir, therefore there are no boating safety barriers at the approach to the spillway. Based on the file review, there have been no reported public safety incidents at the dam.

Public safety around dams is very important and often overlooked by dam owners. **Based on the visual inspection of the dam on August 4, 2015, there appear to be opportunities to enhance and improve upon the public safety measures that are currently in place.** The Township should consider the following:

- Replacing the existing warning sign located at the right abutment of the dam so that it is legible. The warning sign should be displayed at a location which is clearly visible to the public before they enter the property.
- Adding a second warning sign at the left abutment to warn pedestrians who approach the dam from the east.
- Adding fencing or handrail along the top of the spillway walls to reduce the risk of falling into the spillway.
- The existing parking area off of Reservoir Road has limited site distance to the south which presents a safety hazard to the traveling public as vehicles enter and leave this parking area. Consider adding additional parking to the north.

4.11 SUMMARY OF DEFICIENCIES AND POTENTIAL RISK REDUCTION OPPORTUNITIES

Table 4-1 provides a summary of the risk reduction opportunities at Milltown Dam as discussed within Section Four. All identified measures result in reduced risk to the Township; however, not all are required. Should the Township choose to maintain Milltown Dam as a regulated structure, additional evaluation and consideration should be given to incorporating the identified risk reduction measures into the dam rehabilitation project.

Table 4-1
Summary of Deficiencies and Potential Risk Reduction Opportunities
*(Items in **bold** are required by PADEP, all other items are optional)*

Category	Risk Reduction Item	Comment
Embankment Stability	Raise/extend left and right spillway training walls to match downstream slope and flatten embankment slopes adjacent to the raised spillway walls.	Recommend incorporating into embankment rehabilitation project.
	Eliminate or encapsulate the erodible material located beneath the existing spillway	
	Investigate, and if needed, raise the left concrete core wall to eliminate seepage through the riprap.	
Seepage and Internal Drainage	Add seepage collection, conveyance and monitoring system to dam embankments.	Recommend incorporating into embankment raising project.
Spillway Capacity	**Increase spillway capacity and/or provide overtopping protection.**	**Required by PADEP Dam Safety.**
Outlet Works	**Video inspect low level dewatering system.**	**Required by PADEP Dam Safety.**
Concrete Spillway	Repair spalls.	Recommended.
Instrumentation	Add staff gage.	Recommended.
Reservoir Area	Remove reservoir sediment deposits.	Recommended as a future project.
Site Access	Establish access to left embankment.	Recommend incorporating into embankment rehabilitation project.
Site Security and Public Safety	Repair/replace and add warning signs.	Recommended
	Add fence/railing on top of spillway training walls.	

FUTURE COSTS TO COMPLY WITH REGULATORY REQUIREMENTS

5.0 OVERVIEW

PADEP has primary regulatory jurisdiction over Milltown Dam and has both published and unpublished requirements for the ongoing operation and maintenance of high hazard dams. Published requirements can be found in the Dam Safety Encroachments Act (Act 325 of 1978), the Amendment for "High-Hazard Dam" Act 325, and Pennsylvania Code, Title 25, Chapter 105, Dam Safety and Waterway Management. Unpublished requirements are generally conveyed by PADEP through letters to dam owners based on technical reviews and are based on their understanding of current industry standards. Additional regulatory agencies such as the Pennsylvania Fish and Boat Commission (PFBC), the Pennsylvania Historic and Museum Commission (PHMC), and the U.S. Army Corps of Engineers (USACE) are agencies that may impose additional requirements on the operation and maintenance of a dam. The following provides a review of current common regulatory compliance requirements as they pertain to Milltown Dam.

5.1 DEP ANNUAL DAM REGISTRATION FEE AND PERMIT FEES

As of February 16, 2013, PADEP revised its Chapter 105 Dam Safety and Waterways Management Regulations to include annual registration fees for certain dam classifications. In addition, fees were revised or created for other dam activities including application fees, letters of amendment, and transfer of permits. The fee language can be found in Chapter 105.13 of the PADEP Regulations. However, as a municipal agency, East Goshen Township is exempt from these fees as stated in Chapter 102.13(a).

5.2 ANNUAL DAM INSPECTIONS

Annual dam inspections sealed by a registered professional engineer are required by Pennsylvania Code Chapter 105, Section B, 105.53 for Hazard Category 1 and 2 dams. In addition, Code Subsection 105.134 includes a requirement that the annual inspections include a certification that EAP notices are posted in the public locations listed in the EAP. The Township routinely hires a consulting firm to perform the annual dam inspections for Milltown Dam. For the purpose of this study, it is assumed that the Annual Dam Inspection has a cost of $3,000.

5.3 EMERGENCY ACTION PLAN

An Emergency Action Plan (EAP) revision is required every 5 years in accordance with PA Code Chapter 105, Section B, 105.134. The EAP for Milltown Dam was last updated on October 20, 2010 and is due to be revised in October 2015. Under Township cover letter dated July 7, 2015, the Township has requested a time extension from PADEP for submitting the EAP update until the results of this study are complete and the Township has decided whether-or-not to keep or remove the dam. For the purpose of this study, it is assumed that the EAP update has a cost of $5,000 every five years.

5.4 CONDUIT AND VIDEO INSPECTIONS

There currently are no written regulations within the Pennsylvania Code regarding video inspection of the interior of outlet conduits. However, PADEP has a “rule of thumb” (preference) for conduit inspections every 10 years. PADEP may require conduit inspections more or less often depending on the facility and history of any issues. It is PADEP’s current practice to provide written notification to dam owners requesting that video inspection of outlet conduits in embankment dams be performed. The Township has received several notifications from PADEP in the past requesting a full inspection of the low level dewatering system. Based on the file review, no evidence was found indicating that a comprehensive video inspection has been performed.

Regular video inspections (every 10 years) of the interior of the conduit and valve chamber are recommended to obtain a record of its condition and to confirm that there are no obstructions, deflections, issues at the joints, or other problems that could create a dam safety or operational concern. These inspections also provide a point of reference for future inspections to determine if conditions have changed.

Based on the current configuration of the low level dewatering system, a dive crew and a swimmer ROV would be required to inspect those pipes and the associated trash racks located upstream of the valve house. An alternative approach would be to dewater the reservoir so that the trash racks and piping systems are accessible in the dry. Based on similar conduit inspections which involve a dive crew, it is anticipated that the cost to perform a conduit inspection would be in the range of $10,000 to $15,000.

5.5 OPERATION AND MAINTENANCE PLAN

In accordance with PA Code Chapter 105, Section A, 105.51 and Section B, 105.131, Milltown Dam must be operated in accordance with the Operation and Maintenance (O&M) Manual established for the dam. Based on the file review, no O&M Manual was found for Milltown Dam. Preparation and implementation of an O&M Manual is recommended. PADEP has recently been requiring dam owners to provide an O&M plan following significant modifications to their dam. O&M Manuals can vary in their complexity and level of detail depending on the type of dam and the various features of the dam. For the purpose of this study, the cost to prepare an O&M Manual for Milltown Dam is assumed to be $10,000.

5.6 MINIMUM RELEASE / COLD WATER RELEASE

The original dam permit issued to the Borough of West Chester on February 22, 1921 contains no requirements for a minimum release or a cold water release from Milltown Dam.

5.7 FISH PASAGE

The original dam permit issued to the Borough of West Chester on February 22, 1921 contains no requirements for providing fish passage at Milltown Dam. Based on current regulations, any requirement to provide fish passage in the future would come from the Pennsylvania Fish and Boat Commission (PFBC). While fish passage facilities are being installed on dams in Pennsylvania at the request of the PFBC, there do not appear to be any focused efforts on part of the PFBC to require fish passage at dams on the East Branch Chester Creek.

DAM OPERATION AND MAINTENANCE COSTS

6.0 OVERVIEW

All dams require some level of maintenance in order to ensure that the facility functions property and does not endanger life, health, safety or property located above or below the dam. The value and importance of a regular maintenance program cannot be overemphasized. PADEP's publication entitled "*Inspection, Maintenance and Operation of Dams in Pennsylvania*", dated 2009 and reprinted in 2013, defines routine maintenance as "…minor maintenance, the performance of which neither affects the normal operation of the facility or results in a modification of the original design and/or specifications". Maintenance activities which modify a dam from its original design and/or specifications require the issuance of a written permit from PADEP.

The following provides a high level overview of routine operation and maintenance activities and their associated costs which are applicable to Milltown Dam. Should the Township continue to operate the dam as a regulated structure, a formal Operation and Maintenance Manual should be prepared.

6.1 DEFERRED MAINTENANCE

Based on the file review and the visual observation of the dam performed on August 4, 2015, it appears that Milltown Dam is well maintained. Several deficiencies were observed, most of which are related to management of vegetation on and around the dam. The following list of outstanding maintenance items requiring attention was compiled from the 2015 Annual Inspection Report. The location of each deficiency is shown on Figure 6-1 which was taken from the 2015 Annual Inspection Report.

1. Woody vegetation growth should be cleared at the right abutment on both the upstream and downstream embankments.
2. Woody vegetation growth should be cleared from the left embankment.
3. Remove vegetation growth on the upstream and downstream embankment slopes.
4. Replace riprap which has been dislodged from the stilling basin below the spillway.
5. Replace top support rail in the chain link fence adjacent to the valve house.
6. Repair spalls on right spillway training wall and replace mortar around frame and cover of the valve manhole situated on the 24-inch CIP low level discharge pipe.

In August of 2014, the Township rejected bids associated with the replacement of the sluice gates within the valve house with the intent that this maintenance would be deferred until a determination is made regarding whether-or-not the Township would maintain, decommission or otherwise modify the dam. Three bids were received which ranged in price from $70,620 to $113,400. Should the Township choose to maintain the dam, the sluice gate replacement project should be considered as deferred maintenance.

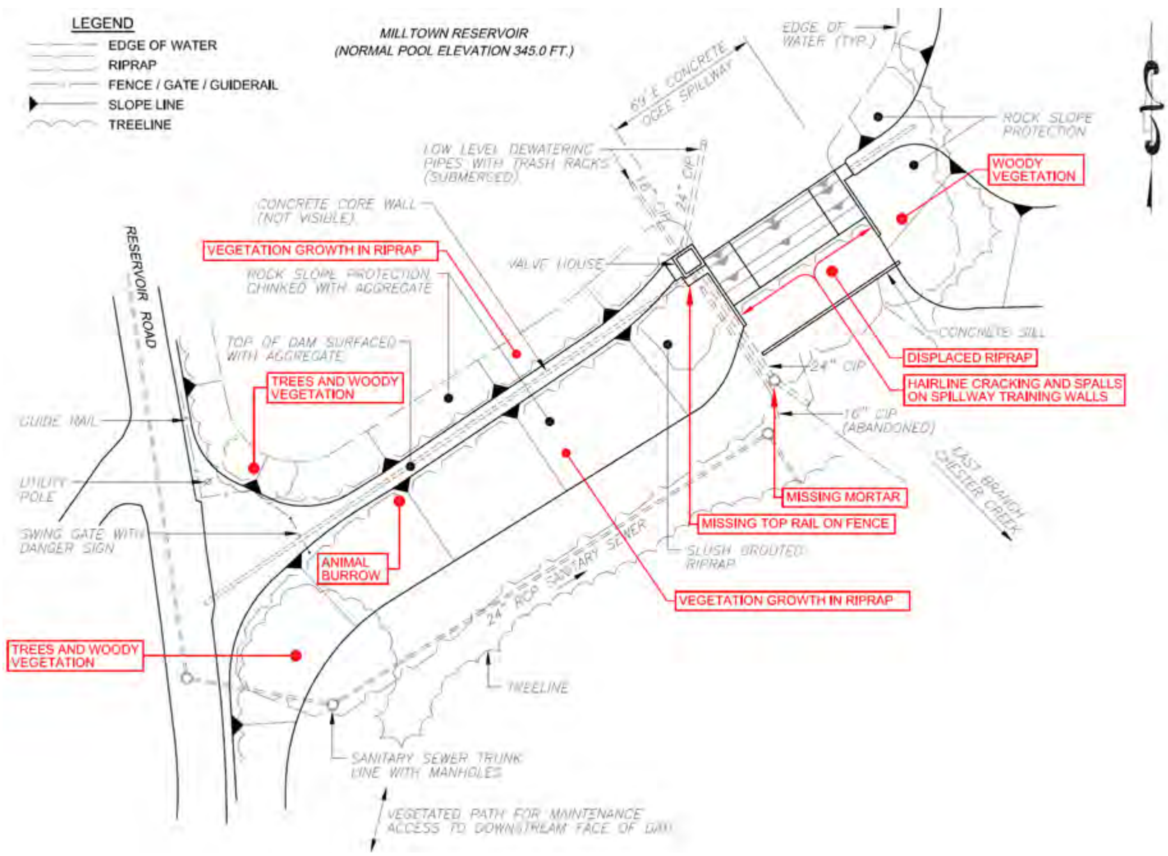


Figure 6-1
Noted deficiencies from 2015 Annual Inspection Report

It should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with available historic documents. It is also important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam would continue to represent the condition of the dam at some point in the future. Continued care and inspection are necessary to detect unsafe conditions.

6.2 ROUTINE OPERATION AND MAINTENANCE

The following is a list of routine operation and maintenance activities that are appropriate at Milltown Dam. Frequencies listed should be considered minimums, and should be more frequent if any unusual or changed conditions are observed.

- ***Weekly site visit to the dam.*** At a minimum, it is recommended that the dam be visited on a weekly basis and during/after significant rainfall events. Site visits should look for changes in the condition of the dam, obstructions in or around the spillway, any vandalism, debris accumulations and vegetation growth. Depending on the conditions observed, remedial maintenance activities should be scheduled to address the identified deficiencies. All features of the dam should be visually observed during the weekly site visits with specific attention given to the embankments, the spillway, and security/safety features.

    - **Embankments.** View embankments for changes in alignment, bulges, settlement, seepage and areas of erosion and/or displaced riprap. Vegetation should also be controlled to prevent root intrusion into the underlying soils, deter animal activity and allow for visual observation of the embankment. Identified deficiencies should be corrected and/or reported to PADEP, depending on the severity of the condition.

    - **Principal spillway.** View the spillway, the approach area and the downstream receiving channel for debris and/or sediment deposits which may reduce the capacity of the system or otherwise adversely impact the performance of the spillway. Monitor the condition of the riprap apron immediately downstream of the spillway and replace rocks which have been dislodged or moved.

    - **Site security and public safety features.** View security fence, gates, signs, locks, etc. Identified deficiencies should be corrected immediately.

- ***Monitoring during significant rainfall events.*** It is recommended that the dam be visited during significant rainfall events to monitor water levels as they relate to activation of the Emergency Action Plan. The frequency and duration of site visits would be dependent on the intensity and duration of the storm and may vary from storm to storm. Monitoring of the dam should continue until the rainfall has ceased and observed water levels are on a downward trend.

- ***Low Level Dewatering System***. The two operable sluice gates mounted on the upstream wall of the valve chamber should be maintained in accordance with the gate manufacturer's recommendations. At a minimum, the gates should be exercised once per year. The Township's current practice is to operate the gates more frequently than once per year.

- ***Mowing and control of vegetation.*** Vegetation should be controlled on the dam itself, at the left and right abutment interface with native ground, and downstream of the dam for a distance of at least 25 feet beyond the toe of the dam. All trees and woody vegetation should be removed from these areas. At a minimum, mowing should be performed twice during the growing season. Since Milltown Dam is open to the public, the Township may consider a more frequent mowing schedule to provide a more aesthetic appearance.

- ***Inspect and maintain concrete and masonry structures.*** Monitor the condition of the concrete structures. Document cracks and other deficiencies so that a comparison can be made during future inspections. Spalls and displaced mortar should be repaired to prevent further deterioration of the concrete structures. These activities may be performed as part of the annual dam inspection unless the weekly site visits report a condition that requires a more immediate action.

- ***Perform annual dam inspections.*** As discussed in Section 5.2, annual dam inspections are required.

- ***Review and update the posting of the EAP notification list.*** As part of the annual dam inspection, dam owners are required to verify that their EAP notices are posted per the approved Emergency Action Plan. This activity is to occur annually.

- ***Review and update the EAP.*** As discussed in Section 5.3, the Emergency Action Plan shall be reviewed and updated once every five years.

- ***Video inspection of the Low Level Dewatering System.*** As discussed in Section 5.4, video inspection of the low level dewatering system is recommended by PADEP once every 10 years.

6.3 SUMMARY OF OPERATION AND MAINTENANCE COSTS

A summary of the anticipated operation and maintenance costs for Milltown Dam is presented in Table 6-1. More detailed cost information is included in Appendix D.

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.

OPTIONS FOR INCREASING CONVEYANCE CAPACITY

7.0 OVERVIEW AND METHODOLOGY

Milltown Dam has inadequate spillway capacity resulting in overtopping of the dam during the Spillway Design Flood (SDF) by approximately 4.1 feet. This section provides a description of each alternative evaluated for increasing conveyance capacity at Milltown Dam. Figures presenting the plan and typical cross section(s) of each alternative are provided in Appendix E. Each alternative increases the conveyance capacity of the dam so that the SDF can safely pass the structure. Methods for achieving this include widening the spillway, increasing the depth of the spillway (either through lowering the spillway, raising the embankment, or a combination of both), improving the efficiency of the control section, or providing overtopping protection. Seven alternatives were evaluated and are discussed in Sections 7.1 through 7.7.

While each alternative maintains the existing normal pool elevation, certain alternatives may require a temporary draw-down of the reservoir and/or the use of temporary cofferdams in order to facilitate construction of the proposed improvements.

For ease of comparison, the physical characteristics of the current spillway are summarized in Table 7-1.

Table 7-1
Summary of Existing Spillway Characteristics

Normal Pool	
Spillway Crest Elev.:	342.2
Spillway Width:	69 feet
Reservoir Area:	10± acres
Reservoir Volume:	17± acre-feet
Top of Dam	
Top of Dam Elev.:	347.5
Reservoir Area:	27± acres
Reservoir Volume;	104± acre-feet
Spillway Depth:	5.3 feet
Spillway Capacity:	3,080 cfs
Required Capacity:	12,700 cfs

As previously discussed in Section 4.2, PADEP updated the hydrology and performed an incremental breach analysis for Milltown Dam in 2014. The results of this analysis established the 1/2 Probable Maximum Flood as the minimum SDF. This storm event has a peak inflow rate of approximately 12,700 cfs. For the purpose of evaluating options for increasing conveyance capacity, this peak inflow served as the basis for sizing the alternatives (refer to Figure 7.1 for the SDF inflow hydrograph). No additional hydrologic analysis was performed as part of this study.

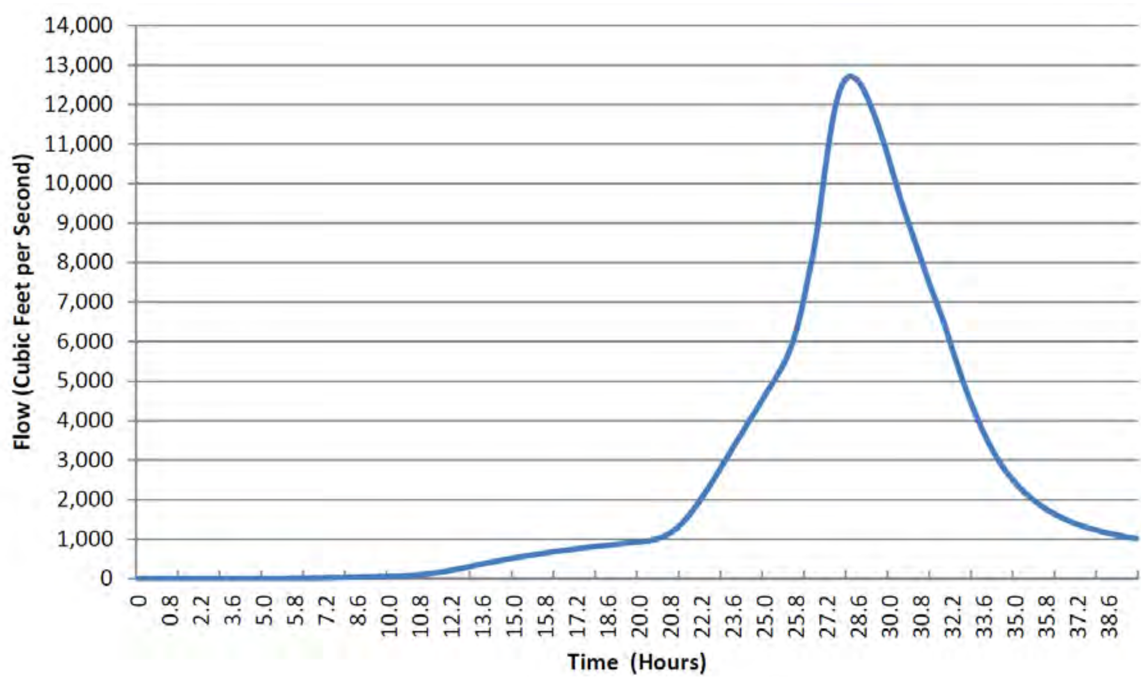


Figure 7-1
Spillway Design Flood Inflow Hydrograph

All of the alternatives described within Section Seven require material resources for the construction of the proposed improvements. These resources include, but are not limited to, earth fill, aggregates (i.e., sand and gravel), cement and steel reinforcing. The proximity of the supplying quarry and/or ready-mix concrete plant to the job site can have a significant impact on construction costs due to hauling distances. In the case of ready-mix concrete, the delivery radius is limited by the maximum time allowed between batching and placement of the concrete (typically less than 90 minutes). Roller Compacted Concrete (RCC) can have even shorter time limitations; approaching 45 minutes from the time it is mixed to the time it is paced and compacted. Projects located outside of the maximum hauling radius would require an on-site batch plant or pug mill to be erected for making ready-mix concrete and/or RCC. Based on a search of the area, multiple quarries and concrete suppliers are located within a ten mile radius of Milltown Dam; consequently, availability of material resources is not expected to be a concern.

Certain alternatives would require demolition and excavation activities in order to construct the proposed improvements. Where practicable, it is assumed that excess material would be used and/or spoiled onsite; otherwise, excess material would need to be hauled offsite to an approved disposal area.

Preliminary hydraulic analyses were completed to develop the conceptual sizing of the various alternatives. Each alternative is capable of passing the peak rate of the SDF (12,700 cfs). Albeit, it is noted that several options (i.e., those that involve raising the top of dam) would require additional analysis to determine if the increased loading on the embankment would require further modifications to the dam or spillway. For each alternative, it was assumed that no flow would be discharged through the low level outlet works during the SDF event. Flow through the low level outlet works will be controlled by the single 24-inch-diameter discharge pipe. This pipe can pass approximately 68 cfs with the reservoir at normal pool. This flow is considered to be insignificant in comparison to the SDF of 12,700cfs, and as such, would not have a measurable impact on the overall conveyance capacity of the dam.

The elevation-discharge relationships were calculated using the weir equation:

$$Q = CLH^{1.5}$$

Where: Q = Flow rate in cubic feet per second (cfs)
C = Discharge coefficient
L = Length of the weir crest in feet (ft)
H = Hydraulic head above the weir crest in feet (ft)

The Discharge Coefficient is a dimensionless number that is used to adjust the calculated flow rate based on the geometry of the weir and the approach conditions of the flow. Studies indicate that this value can range from 2.6 for long, flat broad-crested weirs to 4.0 or greater for ogee spillways. For the purpose of this analysis, a value of 3.8 was used for options that have an ogee spillway crest (which is consistent with the calculations performed by PADEP in 2014). These numbers are consistent with test results and published studies for ogee spillways.

The stage-discharge relationship for the labyrinth spillway alternative was based on relationships derived by physical model studies completed by the University of Utah and published results by others.

The proposed alternatives are based on preliminary calculations and engineering judgment. The selected alternative would require further optimization and design in the preliminary and final design phases. Additional considerations include, but are not limited to, the following:

- Subsurface geotechnical investigations.
- Detailed hydrologic and hydraulic analysis. For certain alternatives, a two-dimensional hydraulic analysis is recommended to check for flow mounding, standing waves or any other unusual flow patterns which may impact the design.
- Geotechnical and structural analysis/design of the proposed features.
- Constructability issues including sequencing of construction and diversion of water.
- Control of sediment-laden runoff.
- Permitting.
- Public coordination.

7.1 ALTERNATIVE 1: INCREASE SPILLWAY DEPTH

Alternative 1 consists of maintaining the existing 69-foot spillway width and raising the top of dam elevation to allow the SDF to pass through the spillway without overtopping the embankment. This option represents the maximum height to which the embankment would need to be raised without widening the spillway. Key components of this option include the following:

- Raise embankment crest from El. 347.5 to approximately El. 356.0 (~8.5-feet).
- Demolish and reconstruct the spillway and left and right spillway training walls to accommodate the increased embankment height.
- Reconstruct the right spillway retaining wall, valve vault and associated low level dewatering system. Raise the valve vault to match the new top of dam elevation.
- Raise Reservoir Road to match or exceed the new top of dam elevation.

Figure 7-2 compares the current site conditions to the proposed Alternative 1 conditions. Figure 7-3 provides an enlarged view of the proposed spillway modifications. Refer to Sheet Nos. E1-1 and E1-2 in Appendix E for plan and cross sections of the proposed Alternative 1 improvements.

It is assumed that the centerline of the embankment is maintained and fill is placed on both the upstream and downstream embankment slopes as needed to establish the new top of dam elevation. Sediment deposits within the reservoir would be removed from the footprint of the proposed embankment in order to establish a stable foundation for the new embankment material. Both the upstream and downstream embankments would be graded to a 3H:1V slope to promote embankment stability and facilitate maintenance activities such as mowing. Riprap salvaged from the existing dam embankment would be placed on the upstream slope of the embankment to provide erosion protection. The remainder of the upstream slope and downstream embankment slopes would be stabilized with vegetation.

It is assumed that the existing concrete core wall would be raised in conjunction with raising the dam. Raising the dam also provides the opportunity to incorporate a modern seepage collection and conveyance system into the dam embankment. Following stripping the riprap from the downstream embankment face, a blanket drain would be placed on the downstream slope and extended to a toe drain. The toe drain would include a perforated drain pipe to collect and direct discharges into a monitoring weir.

Figure 7-2
Alternative 1 – Increase Embankment Height

Both the left and right spillway training walls would be demolished and new walls would be constructed to accommodate the increased embankment height. It is recommended that the spillway training walls be founded on bedrock resulting in walls that reach a maximum height of 36-feet. The excavation required to construct the right spillway training wall necessitates removal and reconstruction of the valve vault and associated low level dewatering system. The valve vault would be raised to accommodate the increased embankment height.

The original construction drawings indicate that the spillway has a 4-foot wide cutoff wall or heel along the upstream side of the structure. This cutoff wall reaches into bedrock and is an extension of the concrete core walls located within the left and right embankments. However, the majority of the existing spillway is not founded on bedrock but on a layer of gravel and sand which is approximately 7-feet in thickness. This is a less than desirable foundation for this structure (refer to Section 4.1). Consequently, as part of Alternative 1, it is recommended that the spillway be reconstructed so that the entire spillway is founded on bedrock. As part of this reconstruction, the downstream concrete apron of the spillway would be extended into the area currently occupied by the riprap stilling basin. This configuration would resolve the rock movement which has been reported within the stilling basin.

The estimated construction cost for Alternative 1 is $5.4 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $6.7 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 1.

Figure 7-3
Alternative 1 - Spillway Improvements

Raising the dam has several benefits. It creates the opportunity to flatten the embankment slopes to provide increased stability. The work on the downslope embankment offers the opportunity to incorporate a modern internal filter and drainage system into the dam embankment. However, raising the embankment also has several drawbacks which include:

- An increased hydraulic loading on the embankment. Should this alternative be considered, additional stability analysis should be performed to verify the stability of the embankment under the increased water elevations.

- Increased downstream consequences should the dam fail during a flooding event. Should this alternative be considered, the dam breach analysis and Emergency Action Plan for the dam should be reviewed and revised as appropriate. It is also possible that the SDF may need to be increased for this alternative if the incremental damage assessment shows that it is warranted.

- Requires large amount of fill to be imported to the site resulting is significant truck traffic during construction.

- The high spillway training walls poses design and construction challenges. Founding these walls on bedrock requires significant excavation which in turn impacts the existing valve vault and spillway.

- Relocation of the downstream sanitary sewer trunk line is required to remove this utility from the footprint of the dam.

- The fill for the earth embankment and the raising of Reservoir Road would require permanent construction/maintenance easements on at least five properties in the vicinity of the dam encompassing approximately 0.5 acres. Furthermore, Alternative 1 would increase the upstream water elevation generated by the SDF by approximately 4 to 5 feet above the current conditions. This increase in water elevation would impact approximately 47 upstream properties. Approximately seven of these properties would experience dwelling unit flooding which do not currently experience flooding during the SDF. PADEP requires flowage easements be obtained from each impacted property.

- The raising of Reservoir Road to accommodate the new top of dam elevation results in increased slopes on Reservoir Road and exacerbates the poor sight distance conditions which currently exist at the pull-off area at the right abutment of the dam.

An alternative to raising the top of dam by approximately 8.5 feet in order to gain the required spillway depth is to maintain the existing top of dam elevation and lower the spillway crest. This condition eliminates the permanent pool and converts the dam into a dry reservoir/pond unless complemented with a significant dredging project in order to create open water within the reservoir. This option is considered to be a partial breach of the dam and is discussed in Section 9.2. Refer to Section Eight of this report for additional discussion on dredging options.

7.2 ALTERNATIVE 2: INCREASE SPILLWAY WIDTH

Alternate 2 consists of maintaining the existing top of dam and normal pool elevations and widening the spillway as needed to allow the SDF to pass through the spillway without overtopping the embankment. This option represents the maximum width to which the spillway would need to be increased without raising the top of dam assuming an ogee spillway control section is selected. Key components of this option include the following:

- Demolish the majority of the existing dam, including the spillway, left and right training walls, valve vault, low level dewatering system, left and right earthen embankments and associated concrete core walls.

- Spoil excavated embankment material within the reservoir along the shoreline or haul this material offsite to an approved disposal area.

- Widen the spillway control section from 69-feet to 320-feet (a 250-foot± increase). The new concrete ogee spillway shall be founded on bedrock.

- Reconstruct the left and right spillway training walls to accommodate the new spillway limits.

- Reconstruct the valve vault and low level dewatering system.

- Provide a concrete stilling basin immediately downstream of the ogee spillway for the dissipation of energy. Grade as needed to direct spillway flows back into East Branch Chester Creek.

Figure 7-4 compares the current site conditions to the proposed Alternative 2 conditions. Figure 7-5 provides an enlarged view of the proposed spillway modifications. Refer to Sheet Nos. E2-1 and E2-2 in Appendix E for plan and cross sections of the proposed Alternative 2 improvements. For the purpose of this analysis, it is assumed that the centerline of the dam is held at its current location and the spillway widening extends into both the left and right earthen embankments. Due to the length of required spillway, the majority of the existing dam would be demolished, including the existing spillway, training walls, valve vault and low level dewatering system. The proposed grading associated with the new spillway is expected to generate approximately 16,200 cubic yards of spoil material. This material may be spoiled within the reservoir at the expense of open water area or it can be hauled offsite to an approved disposal area at an increased cost.

Figure 7-4
Alternative 2 – Increase Spillway Width

The new spillway would use an ogee cross section founded on bedrock in order to maximize the efficiency of the spillway. The new spillway would mimic the existing conditions by using a 40-foot wide low flow notch set in line with East Branch Chester Creek. The low flow notch would be set at elevation 342.2 in order to maintain the existing normal pool elevation. The remainder of the spillway would be set at elevation 342.7. The ogee spillway would discharge into a concrete stilling basin for energy dissipation. The stilling basin would be configured to allow flow to be directed back into East Branch Chester Creek. Riprap salvaged from the existing embankment may be used to stabilize downstream areas and disturbed embankment areas created by the construction of the left and right spillway training walls.

The new spillway would be founded on bedrock, and as such, would require excavation of the existing earth and sediment deposits located immediately upstream of the dam. It is recommended that the area immediately upstream of the ogee spillway be only partially backfilled, creating a pool of deeper water immediately in front of the spillway.

The increased water depth helps to improve the overall efficiency of the spillway. If the budget allows, it is recommended that additional sediment deposits be removed from the reservoir to improve the long-term functionality of the reservoir. Refer to Section Eight for additional discussion on dredging options.

The proposed improvements associated with Alternative 2 also include construction of a new valve vault and low level dewatering system. It is recommended that these facilities be located at the right spillway training wall to allow direct access from Reservoir Road.

Figure 7-5
Alternative 2 – Spillway Improvements

The estimated construction cost for Alternative 2 is $7.8 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $9.6 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 2.

Widening the spillway has several benefits. These benefits include, but are not limited to: (1) the work can be performed on lands owned by the Township without the need for permanent construction/maintenance easements, (2) the spillway configuration would not increase upstream water elevations, eliminating the need for flowage easements, (3) the water depth during the SDF would be reduced by approximately 4 feet, resulting in a reduced flooding area upstream of the reservoir, (4) the new spillway is founded on bedrock which eliminates the erodible material which is located under the existing spillway, and (4) the spillway can be constructed in stages which improves constructability and reduces the risk of overtopping during construction. However, widening the spillway also has several drawbacks which include:

- Significant demolition which would generate a large amount of spoil material.
- Excavated material may be disposed of within the reservoir at the expense of the open water footprint. Hauling material offsite would result in increased costs.
- Widening the spillway results in less attenuation of the incoming flood flows and increased flows being released downstream as compared to existing conditions.
- Depending on construction methods, temporary construction easements encompassing up to 0.3 acres may be required in the vicinity of the left and right abutments to accommodate temporary excavation slopes.

7.3 ALTERNATIVE 3: RAISE EMBANKMENT AND WIDEN SPILLWAY

Alternate 3 consists of a combination of raising the top of dam and widening the spillway as needed to allow the SDF to pass through the spillway without overtopping the embankment. This option represents a combination Alternatives 1 and 2 in an attempt to balance cut and fill volumes and prevent increased water elevations upstream of the dam during the SDF. Key components of this option include the following:

- Demolish the existing spillway, left and right training walls, valve vault, low level dewatering system, and the left earthen embankment and associated concrete core wall.
- Widen the spillway control section from 69-feet to 130-feet (a 60-foot± increase) using an ogee section.
- Raise the embankment crest from El. 347.5 to approximately El. 351.5 (a ~4-foot increase).
- Reconstruct the left and right spillway training walls to accommodate the raised embankment geometry.
- Reconstruct the valve vault and low level dewatering system.

Figure 7-6 compares the current site conditions to the proposed Alternative 3 conditions. Figure 7-7 provides an enlarged view of the proposed spillway modifications. Refer to Sheet Nos. E3-1 and E3-2 in Appendix E for plan and cross sections of the proposed Alternative 3 improvements.

For this alternative, the embankment height was increased by approximately 4-feet to match the current flow elevation of the SDF. By designing the spillway width to keep the SDF below the top of dam, this option would not increase water elevations upstream of the dam during the SDF event as compared to the current overtopping condition.

For the purpose of this analysis, it is assumed that the centerline of the embankment is maintained and fill is placed on both the upstream and downstream embankment slopes as needed to establish the new top of dam elevation. Both the upstream and downstream embankment slopes are graded to 3H:1V to promote embankment stability and facilitate maintenance activities such as mowing. Riprap salvaged from the existing dam embankment would be placed on the upslope embankment to provide erosion protection. The downstream embankment would be stabilized with vegetation. It is assumed that the concrete core wall would be raised in conjunction with the raised embankment. Raising the dam also provides the opportunity to incorporate a modern seepage collection and conveyance system into the dam. Following stripping of the riprap from the downstream embankment face, a blanket drain would be placed on the downstream slope and extended to a toe drain. The toe drain would include a perforated drainpipe that discharges into a monitoring weir.

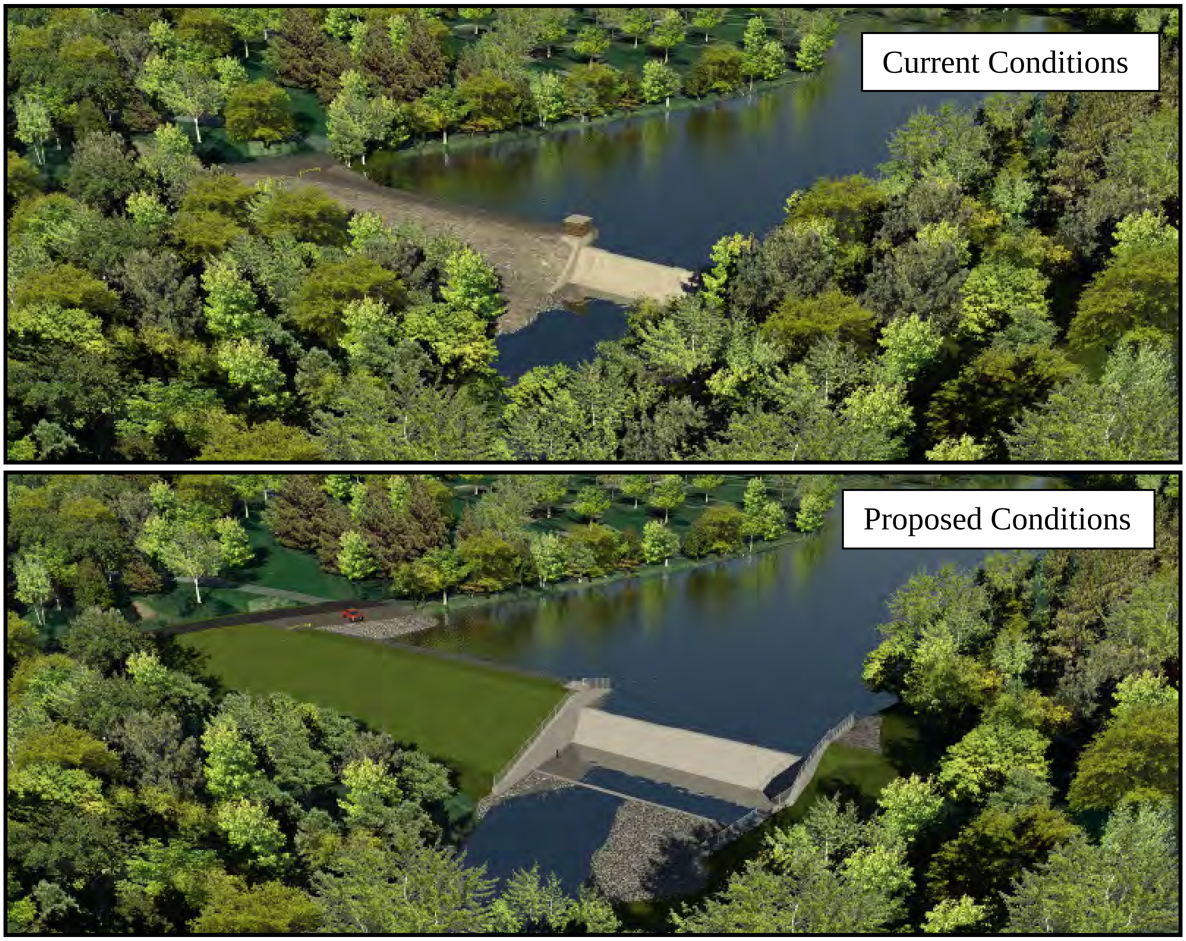


Figure 7-6
Alternative 3 - Raise Embankment and Widen Spillway

For the spillway widening, it is assumed that the location of the right spillway training wall is held at its current location and the spillway is extended into the left hillside. The existing spillway would be reconstructed in its entirety and extended to a total length of 130-feet using an ogee section to maximize the hydraulic efficiency and conveyance capacity of the spillway. The new ogee spillway section is centered along the centerline of the existing dam and provided with a low flow notch at El. 342.2 to match the existing conditions and maintain the normal pool elevation. For the purpose of this analysis, it is assumed that the material excavated from the left embankment to accommodate the widened spillway is suitable material to be used as fill to raise the right embankment. The ogee spillway would discharge onto a concrete stilling basin for energy dissipation. This concrete apron would extend into the area currently occupied by the riprap stilling basin. This configuration would resolve the erosion of the rock fill reported within the stilling basin.

The new left and right spillway training walls and ogee spillway would be founded on bedrock. It is anticipated that the excavation required to perform this activity would necessitate the reconstruction of the valve vault and low level dewatering system. The valve vault would be raised to match the new top of dam elevation and the low level dewatering system would be incorporated into the right spillway training wall.

Figure 7-7
Alternative 3 - Spillway Improvements

The estimated construction cost for Alternative 3 is \$5.5 million. Accounting for engineering, permitting and construction management costs, the total project cost is approximately \$6.8 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 3.

The combination of raising the dam and widening the spillway has several benefits over the other alternatives as it better balances the amount of cut and fill, minimizes the amount of spoil, eliminates the erodible material located under the current spillway, and does not result in increased water elevations upstream of the dam during the SDF, eliminating the need for flowage easements. However, this alternative also has several drawbacks which include:

- An increased hydraulic loading on the embankment. Should this alternative be considered, additional stability analysis should be performed to verify the stability of the embankment under the increased water elevations.

- Increased downstream consequences should the dam fail during a flooding event. Should this alternative be considered, the dam breach analysis and Emergency Action Plan should be reviewed and revised as appropriate. It is also possible that the SDF may need to be increased for this alternative if the incremental damage assessment shows that it is warranted.

- The high spillway training walls pose design and construction challenges. Founding these walls on bedrock would require significant excavation which would in turn impact the existing valve vault and spillway.

- Significant demolition activities associated with the existing spillway, left and right training walls and valve vault which would generate a large amount of spoil material. Consider using salvaged riprap material on the upstream slope of the dam for erosion protection.

- Widening the spillway results in less attenuation of the incoming flood flows and increased flows being released downstream as compared to existing conditions.

- Depending on construction methods, temporary construction easements encompassing up to 0.3 acres may be required in the vicinity of the left and right abutments to accommodate temporary excavation slopes and the raising of Reservoir Road.

7.4 ALTERNATIVE 4: FUSEGATES

Alternative 4 consists of deepening the spillway to accept a Hydroplus fusegate system. The crest of the fusegate system maintains the normal pool elevation. However, as the SDF passes through the spillway, the fusegates are designed to tip at predetermined elevations in order to increase the spillway capacity. With all of the fusegates tipped, the spillway is capable of passing the SDF without overtopping the embankment. Key components of this option include the following:

- Demolish the existing spillway and left and right training walls and reconstruct these features to accept the Hydroplus fusegate system.
- Lower the spillway control section to El. 332.0.
- Reconstruct the valve vault and low level dewatering system.
- Construct a concrete stilling basin with end sill downstream of the fusegate system to replace the existing riprap-lined stilling basin.

Figure 7-8 compares the current site conditions to the proposed Alternative 4 conditions. Figure 7-10 provides an enlarged view of the proposed spillway modifications. Refer to Sheet Nos. E4-1 and E4-2 in Appendix E for plan and cross sections of the proposed Alternative 4 improvements. The Hydroplus fusegate system is a unique proprietary system consisting of freestanding gates (of either steel or concrete construction) set side by side to form a watertight barrier across the spillway sill. An air chamber is present at the base of each gate. As the water level in the reservoir rises, flow enters inlet wells which are set at predetermined elevations. The inlet wells flood the air chamber at the base of the gate, causing an uplift pressure. This uplift pressure destabilizes the gate and the gate rotates and "tips" off of the spillway sill. As each gate tips, the capacity of the spillway is increased. After all gates have tipped, the spillway has the capacity to pass the SDF without overtopping the embankment.

Following a "tipping" event, the pool elevation within the reservoir will be reduced to the crest of the concrete sill which supports the fusegates. The lost fusegates must be refabricated, delivered to the site and set in place in order to reestablish the normal pool elevation of the reservoir.

Figure 7-8
Alternative 4 - Hydroplus Fusegate System

The Hydroplus fusegate system has been used throughout Europe and is gaining popularity in the United States as an acceptable concept for increasing spillway capacity. This system is accepted by PADEP and has been used at Muleshoe Dam which is a water supply dam owned by the Borough of Hollidaysburg in Blair County, Pennsylvania and is proposed at Pennsylvania American Water's Pikes Creek Dam, in Wilkes-Barre, Pennsylvania and at AQUA's Springton Dam, near Philadelphia. Figure 7-9 shows photographs of the installation of five fusegates at Muleshoe Dam during construction and prior to filling of the reservoir.

Figure 7-9
Hydroplus Fusegate System at Muleshoe Dam near Hollidaysburg, Pennsylvania.

The fusegate system can take the form of a straight crest such as those shown in Figure 7-9, or they can form a labyrinth crest such as those shown in Figure 7-10. The configuration of the fusegates and the number of fusegates would be established during preliminary and final design. For the purpose of this analysis, five fusegates have been assumed, each being approximately 10-feet high by 14-feet wide and each containing a labyrinth crest configuration.

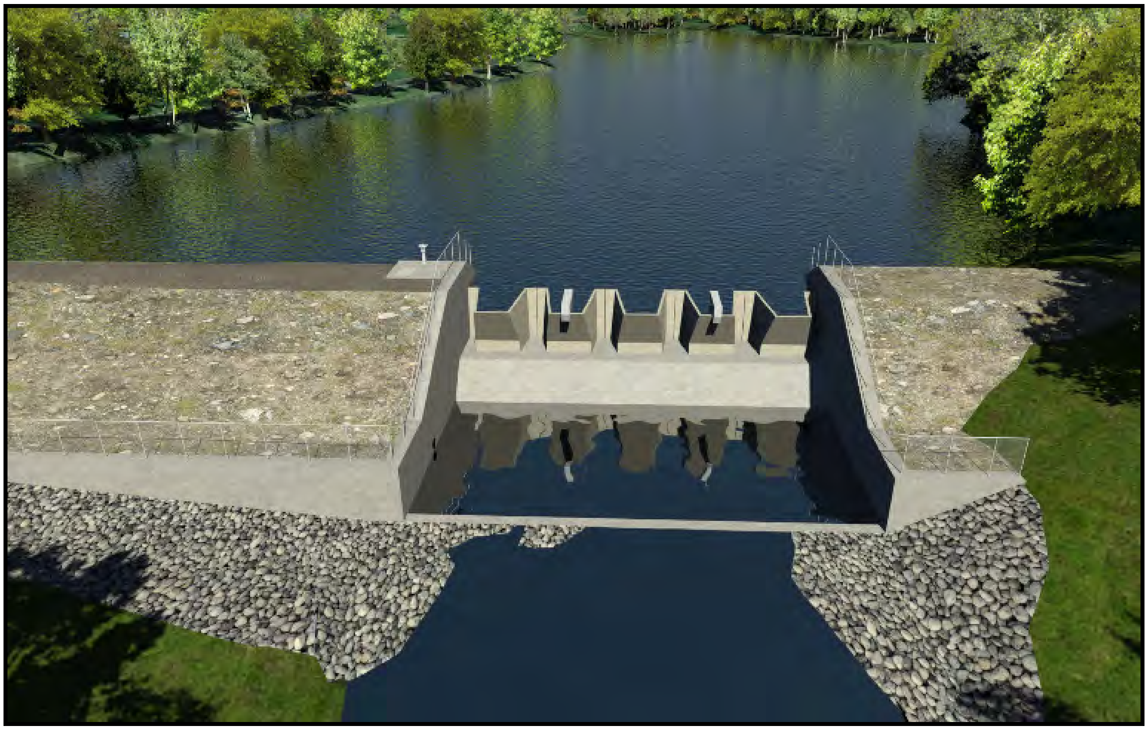


Figure 7-10
Alternative 4 – Spillway Improvements

The footprint of the fusegate system would generally fit within the footprint of the existing spillway and would require a new concrete base to support the fusegates and new spillway training walls, both founded on bedrock. The excavation required to construct these facilities would necessitate replacing the valve vault and low level dewatering system. The fusegates would discharge onto a concrete apron with an end sill for energy dissipation and would replace the existing rock-lined stilling basin.

It may be important to the successful operation of the fusegate system to prevent sediment deposition against the upstream face of the fusegates. Such a condition could impact the stability and tipping motion of the gates so that they do not perform as intended. For this alternative, the Township may need to implement a sediment monitoring and dredging program to keep the area immediately upstream of the spillway free of sediment.

The estimated construction cost for Alternative 4 is $4.7 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $5.8 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 4.

The use of a fusegate system has several benefits over the other alternatives as it minimizes the overall amount of disturbance to the existing dam and the surrounding areas, does not required permanent construction/maintenance easements from the adjacent property owners, minimizes the amount of spoil, eliminates the erodible material located under the current spillway, does not result in increased water elevations upstream of the dam eliminating the need for flowage easements, and reduces the upstream water elevations during the SDF.

However, this alternative also has several drawbacks which include:

- The loss of approximately 10-feet of storage in the event that one or more gates tip. The duration that the reservoir is drawn-down would be dependent upon the time it takes to fabricate, deliver and install the replacement fusegate(s).

- The cost to replace one or more fusegates following a tipping event.

- Fuse gates require replacement of rubber seals approximately once every 20 years which necessitates the temporary drawdown of the lake.

- Requires high training walls within the spillway.

- A sediment monitoring and removal program may be required to keep the area immediately upstream of the spillway free of sediment.

- The increased effective length of the labyrinth-shaped crest of the spillway results in less attenuation of the incoming flood flows and increased flows being released downstream as compared to existing conditions.

7.5 ALTERNATIVE 5: WIDEN SPILLWAY WITH LABYRINTH

Alternate 5 consists of widening the spillway coupled with the addition of a labyrinth spillway control section in order to pass the SDF through the spillway without overtopping the embankment. This option is a variation of Alternative 3 in which the addition of the labyrinth spillway eliminates the need to raise the embankment. Key components of this option include the following:

- Widen the spillway control section from 69-feet to 100-feet (a 30-foot± increase).
- Demolish the existing spillway and left and right training walls and replace the spillway control section with a three cycle labyrinth control section.
- Reconstruct the spillway training walls and floor to accommodate new spillway geometry and labyrinth control section.
- Install a downstream concrete apron with end sill to replace the existing rock-lined stilling basin.

Figure 7-11 compares the current site conditions to the proposed Alternative 5 conditions. Figure 7-12 provides an enlarged view of the proposed spillway modifications. Refer to Sheet Nos. E5-1 and E5-2 in Appendix E for plan and cross sections of the proposed Alternative 5 improvements. For the spillway widening, it is assumed that the location of the right spillway training wall is held at its current location and the spillway is extended to the east into the left embankment. The new labyrinth spillway is located upstream of the current spillway and the spillway crest elevation is held at El. 342.2 to maintain the existing normal pool. The proposed grading associated with the spillway is expected to generate approximately 7,000 cubic yards of excess excavation which can be either spoiled within the reservoir at the expense of the open water footprint or hauled offsite to an approved disposal area at an increased cost. It is anticipated that the existing riprap removed from the left embankment would be used as instream scour protection immediately downstream of the spillway.

Figure 7-11
Alternative 5 - Widen Spillway with Labyrinth

The spillway would be widened to from 69- to 100-feet in order to accommodate a three cycle labyrinth spillway. The reservoir area immediately upstream of the spillway would be excavated to accept the labyrinth spillway section and prevent the submergence of the control section during the SDF. It is critical that this area remain free of sediment in order to maintain the approach depth and performance of the spillway. As such, the Township would need to implement a monitoring and dredging program to keep this area free of sediment. New spillway retaining walls would be required which would approach 28-feet in height. It is anticipated that the floor of the spillway channel would be protected with a reinforced concrete slab which would extend downstream and serve as a stilling basin. Beyond this point, the spillway discharge channel would be transitioned to match the geometry of East Branch Chester Creek.

The proposed improvements associated with Alternative 5 also include reconstruction of the valve vault and the low level dewatering system. It is anticipated that these features would be incorporated into the right spillway training wall.

Figure 7-12
Alternative 5 – Spillway Improvements

The estimated construction cost for Alternative 5 is $5.5 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $6.7 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 5.

Widening the spillway to accept a labyrinth control section has several benefits over the other alternatives. This alternative provides a fixed crest weir which is capable of passing the SDF without requiring replacement (such as with the fusegate system), it eliminates the erodible material located under the current spillway, no permanent/maintenance easements are required, the spillway configuration does not result in increased water elevations upstream of the dam eliminating the need for flowage easements, and the upstream water elevations are reduced during the SDF.

However, the labyrinth spillway option has several drawbacks which include:

- Requires high training walls within the spillway.
- Requires intricate concrete work associated with the labyrinth spillway and replacement of the valve vault and low level dewatering system.
- A sediment monitoring and removal program would be required to keep the area immediately upstream of the spillway free of sediment.
- The increased effective length of the labyrinth-shaped crest of the spillway results in less attenuation of the incoming flood flows and increased flows being released downstream as compared to existing conditions.
- Depending on construction methods, a temporary construction easement encompassing up to 0.2 acres may be required on one property in the vicinity of the left abutment to accommodate temporary excavation slopes for the spillway foundation.

7.6 ALTERNATIVE 6: ACB EMBANKMENT OVERTOPPING PROTECTION

Alternate 6 maintains the existing spillway in its current condition and allows the embankment to be overtopped during the SDF. To protect the embankment from damage during an overtopping event, the crest, downstream slope and toe of the dam would be armored with Articulated Concrete Blocks (ACBs). This configuration essentially converts the entire top width of the dam into a secondary spillway. Key components of this option include the following:

- Strip riprap from the downstream face of the embankment and grade to a 3H:1V slope.
- Armor downstream embankment with ACBs.
- Raise the existing concrete core wall to anchor ACBs at the crest of dam. Downstream edges of the ACBs would be anchored in a rock-lined trench.
- Consider installing ACBs within East Branch Chester Creek to form a ford crossing to allow future maintenance access to the spillway.
- Raise and extend the downstream spillway training walls as needed to accommodate the flattened 3H;1V slope of the downstream embankment.
- Extend the concrete apron downstream of the spillway to replace the existing rock-lined stilling basin and encapsulate the erodible material located under the existing spillway.

Figure 7-13 compares the current site conditions to the proposed Alternative 6 conditions. Figure 7-15 provides an enlarged view of the proposed spillway modifications, which for this option, only involves the raising and extension of the downstream left and right training walls which are needed to accommodate the flattened downstream embankment slopes. Refer to Sheet Nos. E6-1 and E6-2 in Appendix E for plan and cross sections of the proposed Alternative 6 improvements.

Based on the anticipated overtopping depth (approximately 4 feet), the use of articulated concrete blocks are considered to approach their upper performance limits for this application. PADEP generally does not approve of the use of ACBs for embankment overtopping depths greater than 4-feet due to limited laboratory test results under these high-head conditions.

Figure 7-13
Alternative 6 - ACB Embankment Overtopping Protection

Alternative 6 converts the entire crest of the dam into an auxiliary spillway with a 280-foot± length. The overtopping protection includes grading the downstream embankment slope to 3H:1V and installing a geotextile, aggregate drainage layer and geogrid to prepare the ACB foundation. The ACB mats are laid on the prepared surface with each adjoining mat connected to each other by the use of laced steel cable connections. This results in a continuous mat of concrete blocks over the armored embankment. The sides and downstream edges of the ACB coverage are toed down into a trench that is either rock-lined or armored with A-jacks. The downstream limit of the ACB system is set at a location where the erosive velocity of the flow over the embankment no longer threatens the integrity of the embankment. For the purpose of this study, a run-out length of 30-feet was assumed beyond the downstream toe of the embankment. Figure 7-14 provides photographs of a typical ACB embankment armoring project.

Figure 7-14. Photographs showing example of an ACB embankment armoring

The interaction of Milltown Dam and Reservoir Road introduces additional hydraulic concerns. During an overtopping event, flow would also be bypassing the dam as it flows over and along Reservoir Road. As this flow attempts to re-enter East Branch Chester Creek, it would concentrate at the location where the downstream embankment abuts Reservoir Road, making this area susceptible to erosion. Should this option be pursued by the Township, it is recommended that a detailed two-dimensional hydrologic model be performed to determine the limits of the armoring system in this area. For the purpose of this study, it was assumed that the embankment armoring extends downstream along Reservoir Road for a distance of approximately 90-feet from the centerline of the dam. Should this limit be confirmed during preliminary and final design, a permanent construction/maintenance easement would be required from the downstream property owner.

Figure 7-15
Alternative 6 – Spillway Improvements

The estimated construction cost for Alternative 6 is $2.6 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $3.3 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 6.

The option of overtopping protection has many benefits over the other alternatives, several of which include:

- The existing spillway, valve vault and low level dewatering system can be maintained which reduces construction costs and simplifies diversion of water concerns during construction.

- Overtopping protection can be installed with a full reservoir.

- The close proximity of Reservoir Road to the dam provides easy delivery of the ACB mats which typically arrive on a flatbed tractor-trailer trucks.

- No change to the existing hydraulic performance of the dam, eliminating the need for flowage easements.

Drawbacks to the overtopping protection alternative include:

- May require a permanent construction/maintenance easement from two adjacent property owners encompassing approximately 0.4 acres.

- Truck traffic for ACB deliveries during construction may require partial or full closure of Reservoir Road.

- Contractor with experience in ACB placement is recommended.

- The ACB's cover the existing sanitary sewer line located downstream of the dam, hindering future maintenance access to this utility. Consider relocating the sanitary sewer outside of the ACB footprint to avoid compromising the ACB slope protection in the event that said sewer line would require excavation in the future.

- DEP only accepts the use of ACB's for overtopping depths up to four feet. In the event that regulations and/or hydrologic analysis should change in the future, resulting in an overtopping depth exceeding the DEP allowable limit, additional modifications to the dam may be required.

- The addition of the concrete apron downstream of the spillway encapsulates the erodible material located under the current spillway. However, the erodible material remains in place.

7.7 ALTERNATIVE 7: RCC EMBANKMENT OVERTOPPING PROTECTION

Alternate 7 is nearly identical to Alternative 6 in that it maintains the existing spillway in its current condition and allows the embankment to be overtopped during the SDF. To protect the embankment from damage during an overtopping event, the crest, downstream slope, and toe of the dam would be armored with a non-erodible material (i.e., conventional concrete or Roller-Compacted Concrete). Based on the anticipated volumes of concrete needed to armor Milltown Dam, Roller-Compacted Concrete (RCC) is anticipated to be the preferred material due to lower material costs. This configuration essentially converts the entire top width of the dam into a secondary spillway. Key components of this option include:

- Strip downstream face of the embankment, install drainage layers and armor with RCC.

- Extend RCC to bedrock at downstream toe of the embankment in order to provide a condition that would adequately protect the dam embankment during an overtopping event. Figure 7-17 shows the full height of the RCC placement extending from bedrock to the top of dam. Figure 7-18 shows the final RCC configuration after the excavation needed to found the RCC on bedrock has been backfilled.

- Raise the left and right abutments and armor with RCC to an elevation which would contain the SDF.

- Lower the top of dam elevation by approximately 1.8-feet to correspond with the top of the core wall elevation (El. 345.7) and raise Reservoir Road by approximately one foot in the area of the right abutment to keep the SDF on the RCC slope protection.

- Place RCC immediately downstream of the spillway to provide scour protection and encapsulate the erodible material located under the existing spillway.

Figure 7-16 compares the current site conditions to the proposed Alternative 7 conditions. Figures 7-17 and 7-18 provide enlarged views of the proposed spillway modifications, which for this option, only involves buttressing the existing walls with RCC. Refer to Sheet Nos. E7-1 and E7-2 in Appendix E for plan and cross sections of the proposed Alternative 7 improvements. Photographs showing examples of similar embankment armored with RCC are presented in Figure 7-19.

Figure 7-16
Alternative 7 - RCC Embankment Overtopping Protection

Alternative 7 converts the entire dam into an auxiliary spillway with a 270-foot length. The overtopping protection starts by excavating the downstream toe of the dam down to bedrock (refer to Figure 7-17). The RCC would be founded on bedrock and placed in horizontal lifts (typically one-foot in thickness) to form a stepped face over the entire downstream embankment. A drainage layer is proposed under the RCC to reduce any uplift pressure.

Similar to Alternative 6, the interaction of Milltown Dam and Reservoir Road introduces additional hydraulic concerns. Water flowing over/along Reservoir Road can potentially breach the dam at the right abutment. To address this concern, it is proposed that the top of dam be lowered to the top of the concrete cutoff wall (a 1.8-foot lowering of the top of dam to El. 345.7) in conjunction with raising Reservoir Road by approximately one foot in the vicinity of the right abutment to prevent extreme flood flows from discharging down Reservoir Road and bypassing the RCC overtopping system. This would force the SDF to pass over the RCC slope protection.

Figure 7-17
Alternative 7 - RCC Placement – Temporary Excavation to Bedrock

Figure 7-18
Alternative 7 - RCC Placement – Final Conditions

Figure 7-19
Photographs Showing Examples of RCC Embankment Armoring Projects

The proposed improvements associated with Alternative 7 do not impact the existing spillway. However, RCC would be placed within the downstream stilling basin to provide scour protection and buttress the end sill of the existing spillway in order to encapsulate the erodible material beneath the existing spillway.

The estimated construction cost for Alternative 7 is $1.9 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $2.4 million. Refer to Section Ten for additional information supporting the estimated cost of Alternative 7.

This option has many benefits over the other alternatives, several of which include:

- The existing spillway, valve vault and low level dewatering system can be maintained which reduces construction costs and simplifies diversion of water concerns during construction.

- Overtopping protection can be installed with a full reservoir.

- No significant change to the existing hydraulic performance of the dam, eliminating the need for flowage easements.

- **Overtopping protection can pass flows in excess of the SDF.**

Drawbacks to the overtopping protection alternative include:

- Requires temporary staging areas of adequate size to support a batch plant and stockpiling of materials. Due to limited space onsite, it is anticipated that the batch plant would be established at a nearby quarry.

- Requires contractor with experience in RCC placement.

- The addition of the RCC overtopping protection encapsulates the erodible material located under the current spillway. However, the erodible material remains in place.

- Permanent/temporary construction easements from up to four adjacent property owners encompassing up to 0.5 acres may be required in the vicinity of the left and right abutments to accommodate temporary excavation slopes, RCC slope protection and the raising of Reservoir Road.

LAKE MAINTENANCE DREDGING

8.0 OVERVIEW

As discussed in Section 4.8, the Milltown Dam reservoir has experienced significant sedimentation since the original construction of the dam in 1923. Comparing the original construction drawings to the bathymetric survey performed by Gannett Fleming in 2015, over 60 percent of the original storage volume of the reservoir has been lost to sedimentation. Water depths within the reservoir which exceeded 15-feet at the time the dam was constructed, have been reduced to four to five feet in the area immediately upstream of the spillway. The upper end of the reservoir also shows signs of significant sediment buildup with areas of aerated sediment (i.e., vegetated islands) and water depths which have been reduced to less than one foot in many areas.

While it appears that the majority of this deposition may have occurred prior to the 1960's, sediment deposition within the reservoir would continue to occur. Likely sources of sedimentation include stream bank erosion, erosion from construction projects and other areas of disturbance within the watershed, grit and gravel washed from roadway surfaces, etc. Consequently, it is reasonable to believe that over time, the remainder of the reservoir would experience additional sediment deposition, resulting in reduced water depths, reduced open water area and areas of aerated sediment. Such conditions would continue to have a negative impact on water quality and the aquatic habitat within the reservoir. Consequently, should the Township consider an option that involves maintaining the dam, consideration should be given to dredging the reservoir.

8.1 TYPICAL DREDGING METHODS

Dredging projects are typically accomplished by one of three methods. These methods can be classified as Hydraulic Dredging, Mechanical Dredging and Mechanical Excavation. The following provides a brief description of each method.

> **Hydraulic Dredging:** Hydraulic dredging uses centrifugal pumping equipment to pull or "vacuum" soil and/or sediment from the bottom of the reservoir. The pumping equipment is typically located on a dredge vessel which can be maneuvered over the areas to be dredged (refer to Figure 8-1). The pumping process mixes the sediment with water to create a slurry that can be pumped to either a container vessel moored alongside the dredge vessel or pumped directly to an upland dewatering facility. Dredge material can be pumped long distances using in-line booster pumps along the pipeline.
>
> Hydraulic dredging allows the reservoir to be maintained in a full or partially full condition and works well for removing fine sediment deposits and soils that are free of large debris or other material (such as root balls, branches, large rocks, etc.). This objectionable material may damage the pumps or become lodged in

the discharge pipe. In areas where the sediment/soil material is dense and/or difficult to move by the suction created from the pump, additional techniques can be implemented such as water jets and rotating cutter heads to losen the sediment and improve the efficiency of the dredging activity.

Figure 8-1
Hydraulic Dredging

Hydraulic dredging removes a large quantity of water with the sediment. Slurries of 80 to 90 percent water with 10 to 20 percent solids are typical. This slurry must be dewatered in order to produce a soil mass that is dry enough to either transport offsite or dispose of onsite. A typical method to dewater the slurry is to construct containment dikes to detain the slurry for an extended period of time to allow the sediment to settle and dry. These containment dikes can become large in order to accommodate the large water content of the slurry.

Mechanical Dredging: Mechanical dredging allows the reservoir to be maintained in a full or partially full condition and involves removal of material from the bottom of the reservoir using mechanical excavation methods. Typical methods include clamshell buckets and articulated-arm excavators which are situated on a barge (often referred to as a dredge plant) and lowered through the water column to excavate the sediment from the bottom of the reservoir. The excavated sediment is brought to the surface and placed within a second barge that is moored alongside the dredge plant. The dredged material is then moved to the shoreline where it is unloaded from the barge by mechanical or hydraulic equipment into a dewatering facility. Alternatively, a long-arm excavator, such as a backhoe, can also be used in place of a clamshell bucket with similar results if water depths are shallow enough to allow the sediments to be reached. Figure 8-2 shows a long reach excavator situated on a barge with a second barge for collecting the excavated sediment.

Figure 8-2
Mechanical Dredging

Mechanical dredging often involves handling a large amount of water. The dredged material which is brought to the surface can be as much as 50 percent water. Consequently, just as with Hydraulic Dredging, large upland dewatering areas would be required to allow the dredged material to settle and dry before the dredged material can be either transported offsite or disposed of onsite.

Mechanical Excavation: Mechanical excavation requires the dredging area to be dewatered or otherwise isolated from the rest of the waterbody through the use of cofferdams. With the sediments exposed, they can be removed with conventional excavation methods such as dozers, excavators and dump trucks. Figure 8-3 shows the use of mechanical excavation to remove sediment deposition at Huntsman Lake in Fairfax County, Virginia. This method can be very efficient in removing sediment due to the reduced water content of the material. Depending on the moisture content, the sediment may be hauled to a disposal area with no other dewatering activities required. Haul distance and cost of disposal at a landfill or on available property greatly impact the cost. If a nearby disposal site is unavailable, property may need to be acquired for disposal of the dredged material.

Figure 8-3
Mechanical Excavation

This method introduces other challenges which are not associated with Hydraulic and Mechanical Dredging. These include adequate site access to allow vehicular equipment to access the bottom of the reservoir, stabilizing haul roads through the bottom of the reservoir, diversion of offsite runoff around/through the work area and management of water that enters the work area.

The use of hydraulic dredging and mechanical dredging are unlikely candidates for removing sediment from the Milltown Dam reservoir. Shallow water depths within the reservoir may limit or prevent the use of a barge system and limited upland area makes dewatering sediments a challenge. Consequently, mechanical excavation in the dry is the most likely dredging option at Milltown Dam.

A typical Mechanical Dredging operation would include the following operations:

Design Phase

- Perform sampling of the sediment horizon to determine the chemical composition of material to be removed. Results of this analysis would determine if the material can or cannot be classified as clean fill, which in turn would determine the available options for disposal of the material.
- Develop a dredging plan which coordinates the volume of material to be removed with the available budget established by the Township.
- Consider incorporating various in-lake options for improving water quality and aquatic habitat. Such options may include a sediment forebay, aquatic benches, wetland plantings, fish habitat structures, shoreline stabilization measures, etc.

- Obtain required permits for the dredging activity. It is anticipated that such a project would require a Section 404 Joint Permit Application through the PADEP and the U.S. Army Corps of Engineers. Components of the permit application would need to address how the sediment would be removed (i.e., the method of excavation), how the sediment would be dewatered, and how the sediment would be disposed of. Erosion control plan approval would also be required from the County Conservation District.

Construction Phase

- Dewater the reservoir. If possible, dewater the reservoir well in advance of the dredging project to promote dewatering of the in-lake sediments.
- Develop site access and install erosion control measures.
- Install diversion channel(s) or other diversion measures to convey areas of concentrated inflow through the reservoir to the existing low level intake structures located immediately upstream of the spillway. These diversion channels are intended to keep live flows away from the active dredge area and would also help to dewater the in-place sediment deposits. Side channels can also be constructed into the dredge area to further expedite the dewatering of in-place sediment deposits.
- Establish in-lake haul roads and begin dredging activities. Employ measures such as rock construction entrances, wash racks, watertight trucks, etc. as needed to prevent sediment from being deposited onto public roadways during the hauling process.
- Dispose of dredge material in a lawful manner. Disposal alternatives available to the contractor would be investigated during the design phase.
- Employ topographic surveys during the dredging activities to confirm volume of material removed from the site for the purpose of verifying contractor pay requests and development of as-built drawings.
- If incorporated into the design, install water quality enhancements such as a sediment forebay, aquatic benches, wetland plantings, shoreline stabilization, etc.
- At the completion of the dredging activities, stabilize disturbed areas, remove all equipment and debris from the lake bed and initiate filling of the reservoir.

8.2 DREDGING COSTS

Every dredging project is unique and estimating construction costs can be difficult. Key factors which influence the cost of dredging include the following:

- Amount of material to be removed. The cost of a dredging project is obviously dependent on the amount of material to be removed. However, a dredging project requires a significant amount of pre-dredging coordination and setup, including the establishment of site access routes, locating and securing drying/disposal areas, installation of erosion controls, diversion of water, equipment mobilization, etc. These initial costs are generally the same regardless of how much material is being dredged. Consequently, a greater dredge volume typically results in a lower unit cost per cubic yard of dredged material.

- Physical and chemical nature of the sediment. Depending on the dredging method being used, the physical composition of the sediment (i.e., gravel, stones, branches, tree stumps and other debris) may slow production rates, resulting in increased construction costs. The chemical composition of the dredge material may prohibit the disposal of this material as clean fill, requiring disposal at a regulated landfill, resulting in increased disposal costs. Based on photographs taken of the dewatered Milltown Dam reservoir in 1997 (refer to Figure 2-3), there is no indication of large debris, rocks, etc. within the area immediately upstream of the dam embankment.

- The dredging method. As discussed herein, the dredging method to be used should be carefully considered in order to provide the most feasible and economical method possible. Physical restraints such as site access, water depths, available drying areas, sediment composition, etc, should be taken into consideration when determining the dredging method to be used.

  Dredging methods in the wet which use a barge system appear to be problematic at Milltown Dam due to the shallow water depths which would prevent the barge from freely moving throughout the reservoir. Furthermore, since the lake is used for recreation and is no longer needed for water supply, there are less operational drawbacks associated with dewatering the reservoir. As such, mechanical excavation in the dry appears to be a reasonable method for dredging the Milltown Dam reservoir.

- Need for dewatering. Hydraulic dredging and mechanical dredging methods remove a significant amount of water with the sediment. This water must be removed prior to final disposal of the sediment. This is typically accomplished by depositing the sediment slurry in an upland containment dike where the sediment is allowed to dry. Other dewatering methods such as prefabricated filter bags can also be used; however, these types of facilities have limited capacity which can significantly slow the speed at which sediment can be removed from the lake.

  To a lesser degree, dewatering may also be required if mechanical excavation methods are used. However, this can usually be accomplished by allowing the material to dry in place or by excavating and stockpiling onsite to allow the material to drain to the point where it can be transported by truck to the final disposal area.

- Land availability. As stated above, hydraulic dredging and mechanical dredging require upland areas for dewatering activities. For economic reasons, it is preferable if these areas are located adjacent to the dredging activities. Likewise, land is also required for the final disposal of the dredged material of which the most economical location would be either onsite or areas immediately adjacent to the lake. At Milltown Dam, the surrounding area is completely built-out with residential development. Consequently, adjacent areas for dewatering and/or disposal of dredged material do not appear to be available. Portions of the actual reservoir could be used to dispose of dredged material; however, this would result in a reduced footprint of the lake (i.e., less open water) which is less than desirable.

- Transportation method and distance. Sediment can be transported to the final drying and/or disposal site using a variety of methods. Hydraulic dredging may use pump and piping methods to transport the dredged material. Pipe/pump methods can transport material for long distances (i.e., miles) by adding booster pumps along the transmission line. Mechanical dredging and mechanical excavation typically use more traditional methods (i.e., dump trucks) for moving sediment to the final disposal area. Trucking operations can have a negative impact on the local community during construction due to the significant volume of truck traffic which is needed. Obviously, the longer the distance that the material must be transported, the greater the transportation cost. For that reason, onsite disposal areas are the most economical.

- Disposal method. Dredged material may be disposed of in a variety of ways. If the sediment is determined to be clean fill as a result of chemical testing, the dredged material may be stockpiled in upland areas, used as fill at quarries, used as daily cover on landfills, or used as fill for construction projects assuming the dredged material meets the requirements of the project. Should the chemical testing indicate the material is not suitable as clean fill, the disposal options would be limited to placement of the material within a landfill.

In an attempt to develop a range of costs for dredging the Milltown Dam reservoir, a review of recently implemented projects was completed. Over the last eight years, Fairfax County, Virginia has implemented a number of dredging projects at their regional stormwater management facilities. Table 8-1 provides a quick summary of each project and lists the dredging method and associated unit cost which was observed for each project. Older projects were trended to 2016 dollars at 3% per year.

Dredging of Milltown Dam would likely involve Mechanical Excavation in the dry with offsite disposal of the dredged material, similar to the Huntsman Lake and Woodglen Lake projects in Fairfax County, Virginia. These Fairfax County projects ranged in price from $70 per cubic yard to $170 per cubic yard. For the purpose of this study, $75 per cubic yard was assumed for dredging Milltown Dam Reservoir.

Table 8-1
Recent Dredging Projects and Associated Costs

Project:	**Goose Creek Dam in Ashburn, Virginia**
Description:	200,000 cubic yards of material hydraulically dredged and pumped into adjacent dewatering/disposal facility (15 acre site – no land purchase cost) in 1997.
Cost:	$2.4 Million resulting in a unit cost of $12 per cubic yard (1997 dollars). 2015 equivalent is approximately **$20 per cubic yard** for hydraulic dredging and onsite disposal.

Project:	**Lake Barton in Fairfax, Virginia**
Description:	20,000 to 30,000 cubic yards of mechanical dredging in the wet in 2010. Dredge material was hauled offsite for disposal at a local landfill.
Cost:	$51 to $59 per cubic yard. 2015 equivalent is **$68 per cubic yard**.

Project:	**Huntsman Lake in Fairfax, Virginia**
Description:	44,000 cubic yards of material removed by mechanical excavation in the dry in 2014. Included transportation and disposal at nearby landfill.
Cost:	$70 per cubic yard. 2015 equivalent is approximately **$72 per cubic yard**.

Project:	**Lake Accotink in Fairfax, Virginia**
Description:	Hydraulic dredging of 193,000 cubic yards of material with 3 miles of pumping to dewatering and disposal site. Although not confirmed, it is believed that there were no land acquisition costs. Work completed in 2008.
Cost:	$52 per cubic yard. 2015 equivalent is approximately **$62 per cubic yard**.

Project:	**Woodglen Lake in Fairfax County, Virginia**
Description:	30,000 cubic yards of material removed by mechanical excavation in the dry in 2015. Material was hauled offsite for disposal at a local landfill.
Cost:	**$170 per cubic yard**.

At this rate, it would cost approximately $3.5 million to remove 46,800 cubic yards of sediment and restore the reservoir to its original grades per the 1923 design drawings. A full dredging project may not be economically feasible for the Township. At a minimum, it is recommended that a dredging project involve the removal of sediment around the low level intake structures in order to keep these features fully operational.

Consideration may be given to excavating the sediment deposits within the upper end of the reservoir to create a sediment forebay. The intent of the sediment forebay is to trap the incoming sediment deposits to reduce the amount of sediment deposition in the downstream portion of the reservoir. It is recommended that vehicular access be provided to the forebay to facilitate routine cleanings in the future. A conceptual plan showing the locations for the partial dredging concept is provided in Figure 8-4.

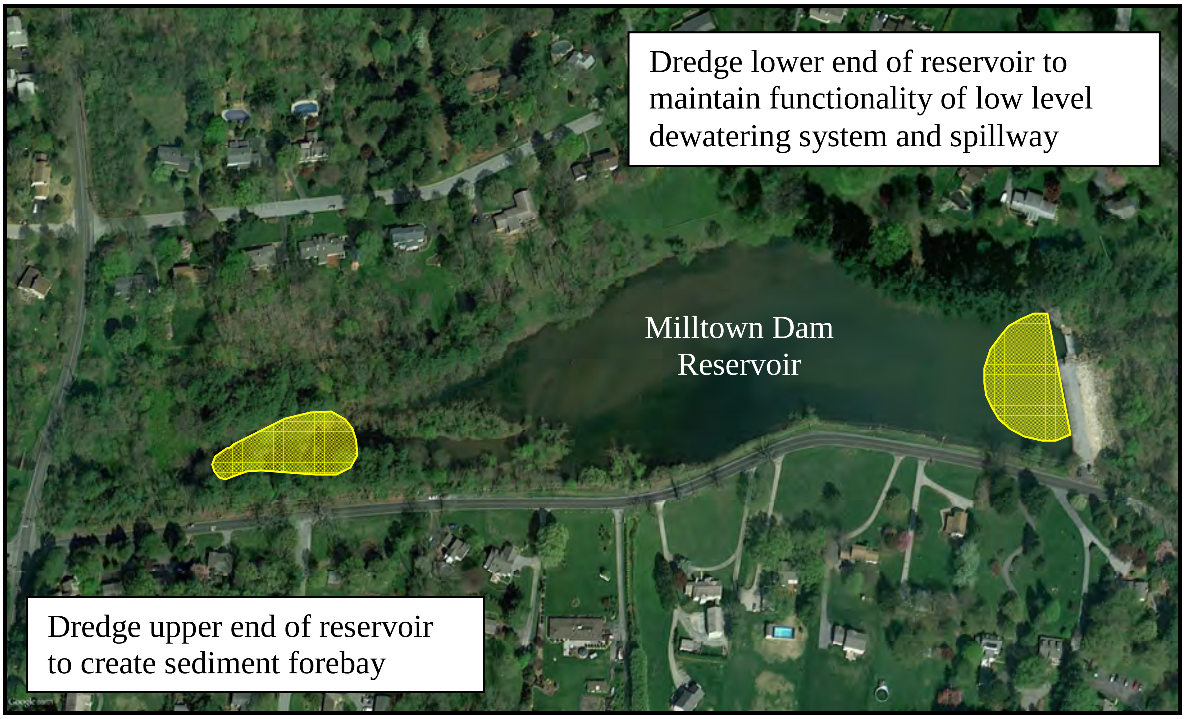


Figure 8-4
Partial Dredging Locations for Milltown Dam Reservoir

The extent of dredging can be tailored to accommodate the Township's budget. However, for the purpose of establishing a cost associated with the dredging shown in Figure 8-4, the following assumptions are made.

- A 100-foot radius is dredged upstream of the dam and returned to its original grade per the 1923 construction drawings. Based on this assumption, approximately 6,000 cubic yards of sediment would be removed.
- A sediment forebay approximately four feet in depth and up to one acre in area would be excavated in the upper reaches of the reservoir near Park Avenue. Access to the sediment forebay would be via a gravel road originating at the intersection of Reservoir Road and Park Avenue and secured with a swing gate. Based on the assumed dimensions, approximately 9,000 cubic yards of material would be removed.

Using $75/cubic yard, the resulting cost for the partial dredging of Milltown Dam would be approximately $1.1 million.

DAM DECOMMISSIONING OPTIONS

9.0 OVERVIEW

Dam decommissioning can consist of the full or partial removal of the dam and its associated facilities. With over 3,400 regulated dams in Pennsylvania (most of which exceed 50-years in age), the question of whether-or-not a dam should be decommissioned is a common question for dam Owners. American Rivers (www.americanrivers.org) reports 971 dam removals across the country over the past 20 years. Pennsylvania has led this effort for twelve years in a row with over 250 dams removed during this period and 17 dams removed in 2014 alone. The majority of these removals have been low-head mill dams constructed during the industrial revolution which no longer serve their intended purpose.

The pros and cons associated with decommissioning a dam would vary from dam to dam and from Owner to Owner. A dam Owner must carefully assess a variety of factors to determine if decommissioning is appropriate for the dam in question. Historically, the most popular reasons for dam decommissioning include environmental impacts, safety concerns and economic impacts. The following provides additional discussion related to reasons for decommissioning a dam:

- *The structure no longer performs its intended use*. Many dams no longer perform the service for which they were constructed. For example, many of the dams constructed during the late 1800's and early 1900's provided hydro-mechanical power to operate grist mills, formed reservoirs for ice harvesting and provided backwater for the operation of canal systems. These structures have since become obsolete due to current industrial practices and more efficient means of transporting goods. These dams are often left in disrepair and pose a safety hazard to the public. Such safety hazards may include localized conditions in the immediate area of the dam (i.e., fall hazards, drowning, or other unauthorized activities) as well as potential downstream flooding in the event of a dam failure. An Owner of such a dam may find repair costs to be significant and not economically viable. In these cases, decommissioning a dam can be a favorable option as it reduces/eliminates the owner's legal liability and eliminates future operation and maintenance costs.

  In the case of Milltown Dam, the structure no longer performs its original function as a water supply reservoir. However, since being acquired by the Township in 1985, the dam and reservoir have served as a recreational facility.

- *Upgrade, operation and maintenance costs.* Every dam requires routine maintenance in order to keep the facility in a safe and working condition. In addition to routine operation and maintenance costs, more significant alterations may be required in order to comply with existing and new dam safety regulations. These costs can be significant and a dam Owner may find that the one-time cost to breach the dam outweighs the costs to upgrade, operate and maintain the dam.

  East Goshen Township may be in such a situation with Milltown Dam. While the annual costs to operate and maintain Milltown Dam are relatively modest (refer to Section Six), the Township is faced with a significant cost to increase the conveyance capacity of the dam in order to bring the dam into compliance with current dam safety regulations.

- *Environmental impacts*. Dams placed across natural streams form a manmade barrier which may result adverse environmental impacts to the local riverine ecology. These impacts vary from dam to dam; however, it is not uncommon for the dam to prevent movement of both local aquatic species and migratory aquatic species, eliminate the natural stream channel through the dam footprint and within the reservoir, and result in increased water temperatures as a result of thermal heating of the reservoir pool. Decommissioning activities attempt to eliminate these adverse impacts by restoring the natural stream to a free flowing condition.

  In the case of Milltown Dam, a full breach would open approximately 2 miles of East Branch Chester Creek to aquatic movement. Upward movement of aquatic species would be blocked by Township Line Dam which is owned by AQUA PA. Elimination of the permanent pool would result in the establishment of stream bed and banks and improved water quality through the elimination of the shallow pool of water which is currently impounded by the dam (refer to Section 4.8).

- *Public opinion*. It is not uncommon to find strong public opinion for both preserving and decommissioning a dam. Local residents become accustomed to the open water activities (i.e., boating, fishing, bird watching, etc.) and aesthetics associated with a dam and reservoir. Alternatively, dam removal activists feel just as strongly about decommissioning a dam in order to restore the pre-dam conditions of the watershed.

  In the case of Milltown Dam, the Township intends to hold several public meetings to discuss the alternatives described within this report and solicit feedback from the public.

Sediment management is an important aspect of decommissioning a dam and can become costly to address depending on the volume, location and chemical composition of the sediment. For decommissioning projects where there is minimal sediment deposition within the reservoir, it is typical to allow the stream to naturally reestablish through the reservoir. However, when significant sediment deposits are present, alternative practices have historically been used to restore the channel through the breach and reservoir. These practices include either removing all sediment deposits from the reservoir or constructing a stabilized pilot channel to convey stream flows through the reservoir in an attempt to protect the remaining sediment which is left within the reservoir. A growing practice in dealing with impounded sediment is the use of “in-stream sediment management”. This approach allows the stream to naturally redistribute the impounded sediment downstream while forming its own channel through the reservoir following the breach of the dam. This method may be met with opposition from the public and reviewing agencies as it goes against the typical approach of preventing sediment from entering Waters of the Commonwealth.

In the case of Milltown Dam, a significant amount of sediment is present within the reservoir. In the area immediately upstream of the existing embankment, the sediment deposits are believed to be 6- to 9-feet in depth with several localized areas reaching 10- to 12-feet in depth (refer to Section 4.8). Given the volume of impounded sediment, the use of “in-stream sediment management” may not be possible.

Decommissioning projects are permitted through PADEP, Division of Dam Safety through a streamlined approval process. Supporting documentation needed by PADEP typically includes plans, drawings and specifications for the breach, a drawdown permit from the Pennsylvania Fish and Boat Commission, an approved erosion and sediment control plan from the County Conservation District, proof of municipal notification and other environmental and cultural resource coordination. If the project activities exceed the scope of the dam removal authorization, additional permits may be required. Federal authorization from the U.S. Army Corps of Engineers would require a Section 404 permit which could take the form of an Individual Permit, General Permit or Nationwide Permit depending upon the proposed activities and the extent of the impacts.

Two breach options are presented herein. A full breach option is described in Section 9.1 (Alternative 8) which includes removal of the dam embankment and construction of a pilot channel through the reservoir as a sediment management strategy. Section 9.2 describes two “partial breach” options (Alternatives 9 and 10) which attempt to manage the sediment in place. However, the partial breach option(s) still leaves the Township with a dam to operate and maintain.

9.1 DAM DECOMMISSIONING OPTION (ALTERNATIVE 8)

Decommissioning the dam restores the natural channel to a free flowing condition through the footprint of the dam and can involve the partial or complete removal of the dam embankment and associated structures. A pilot channel is typically used through the breach to contain and direct base flow and flow from smaller storm events (say events more frequent that the 10-year storm) through the breach and into the natural downstream channel. The pilot channel typically mimics the natural stream conditions in the immediate vicinity of the dam. For Milltown Dam the pilot channel geometry has been assumed to be approximately 4.5-feet in depth and contain a 40-foot bottom width which matches the natural stream downstream of the dam. Flows which exceed the capacity of the pilot channel are allowed to spread into an “overbank” area.

The combination of the pilot channel and the overbank area constitute the breach width. The minimum breach width is determined by a two-step process. First, the 100-year flood elevation of the natural stream is estimated assuming the dam is not present. Second, the 100-year flood elevation is estimated using a trial and error method using subsequently larger and larger breach widths. The minimum breach width is defined as the width which results in no more than a one foot rise in the water surface above the 100-year water elevation established assuming that no dam is present. Using a simplified normal flow calculation, a breach configuration containing a 40-foot wide pilot channel and a 120-foot overbank area is estimated for Milltown Dam (refer to Sheets F1-1 and F1-2 in Appendix F for a plan view and typical cross sections associated with the full breach alternative). It is noted that the opportunity exists to refine this breach cross section with more detailed hydraulic calculations which take into account the backwater created by the Route 3 bridge located approximately 600-feet downstream of the dam.

Establishment of the breach cross section through Milltown Dam requires the full demolition of the existing spillway and associated training walls, the valve vault and low level dewatering system, portions of the concrete core wall, and removal of approximately 7,100 cubic yards of earth material from the left and right embankments. Assuming that the demolished material is classified as clean fill, this material may be disposed of onsite. It is common practice to dispose of the breach material within the reservoir area along the shorelines upstream of the dam. If still in place, the original water supply weir (i.e., pre-1923) located upstream of the dam should be removed as part of the decommissioning option.

As stated in Section Nine, sediment management within the reservoir can complicate a breach project. Such is the case with Milltown Dam. After establishment of the breach cross section, the sediment contained within the reservoir (estimated to be 46,800 cubic yards) is free to migrate downstream. If left uncontrolled, base flows and storm events would suspend and convey this material downstream. To some extent, sediment movement through a watershed is a naturally occurring condition and helps to support the natural ecosystem of the waterway. However, a significant and sudden release of sediment could result in adverse downstream impacts such clogging of downstream culverts and bridges, water supply intakes, impacts to the natural stream ecology, and sedimentation of private properties. Consequently, sediment management should be considered as part of a decommissioning project.

The sediment deposits within Milltown Dam can be managed in several ways. The most expensive option is to physically remove all of the sediment, returning the reservoir to its 1923 grades, prior to breaching the dam. As discussed in Section Eight, a dredging project of this magnitude which involves hauling all sediment material (46,800cy) offsite could cost $3.5 million. With the addition of the dam breach, such a project could easily exceed $4 million.

A variation of this option is to construct a pilot channel through the reservoir that mimics the original stream bed alignment and grade, leaving the sediment in the left and right overbank areas in place. This option is portrayed on Sheets F1-1 and F1-2 in Appendix F and in Figure 9-1.

Figure 9-1
Dam Decommissioning Alternative

The vertical alignment of the pilot channel is established by connecting the existing elevation downstream of the dam with a uniform slope to the historic streambed elevation at the upstream end of the reservoir near the culvert under East Strasburg Road. The horizontal alignment of the pilot channel also attempts to mimic the original stream bed as shown on the 1923 construction drawings with the upper and middle reaches of the pilot channel aligned against the western shoreline and the lower reaches of the pilot channel aligned against the eastern shoreline. The material excavated from the breach and through the reservoir can be spoiled within the reservoir on both sides of the pilot channel. Based on the volume of excavation, it is anticipated that the majority of the remaining reservoir would be required for spoiling activities, assuming that the material is spoiled no higher than the top of dam elevation. Spoiling activities may impact adjacent properties depending on how the spoil pile is configured.

The estimated construction cost for the full breach option as shown on Sheets F1-1 and F1-2 within Appendix F is $2.5 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $3.1 million. Refer to Section Ten for additional supporting cost information. With the full breach option, the Township would no longer incur annual operation and maintenance costs associated with a dam (refer to Section Six).

A unique opportunity provided by the full dam breach option is the potential to obtain a grant or full funding of the project through an environmental mitigation fund. Funding dam removal projects can provide opportunities for others to mitigate the environmental impacts of their nearby projects. Removing the dam to restore the stream to its natural free flowing condition is viewed as a valuable environmental credit. Restoring or creating wetlands within the reservoir area can provide similar credits. Dam removal projects in Pennsylvania have been funded through this process and this source of funding should be considered if removal of Milton Dam is pursued.

9.2 PARTIAL BREACH OPTIONS (ALTERNATIVES 9 AND 10)

Upon review of the costs associated with the full breach option described in Section 9.1, it is apparent that over half of the costs are associated with management of sediment. Consequently, an alternative to the full breach is a partial breach which leaves the majority of the sediment deposits in place within the reservoir. This can be accomplished by leaving the dam in place and cutting down a portion of the existing spillway to an elevation which is at or near the sediment elevation. This configuration would contain the sediments in place; however, it would also eliminate the recreation pool.

It is noted that the partial breach alternative is not a true decommissioning option as the dam would remain as a regulated structure. Three criteria are used to determine if an impounding structure is classified as a dam, (1) is the embankment greater than 15-feet in height, (2) does the structure impound more than 50-acre-feet of water, and (3) is the contributing drainage area greater than 100 acres. If any one of these criteria is met, the structure is determined to be a regulated dam by PADEP. With the partial breach configuration in place as described above, the structure would continue to be viewed as a regulated dam by PADEP due to the 6.3 square mile drainage area.

One option (Alternative 9) would be to lower the existing spillway crest to elevation 331.5 (refer to Sheets F2-1 and F2-2 in Appendix F) and raise the top of dam by approximately one foot to elevation 348.5 to pass the SDF through the spillway without overtopping the dam (assuming that the dam retains its C-1 High Hazard classification). A shallow pilot channel (approximately five feet at its maximum depth) could be excavated through the sediment layer to channelize and direct flows through the lowered spillway. This option allows the majority of the sediment deposits to be left in place and essentially converts the reservoir into a dry pond, only filling during larger storm events. Additional structural investigations would be needed to determine if the integrity of the existing concrete spillway can be maintained with the center of the spillway lowered to elevation 331.5. For this option, the Township would continue to own and operate Milltown Dam as a regulated structure and the Township can expect to incur the annual operation and maintenance costs as identified in Section Six.

Figure 9-2
Partial Breach Alternative

Figure 9-3
Partial Breach Alternative – Spillway Modifications

The estimated construction cost for the partial breach option as shown on Sheets F2-1 and F2-2 within Appendix F is $1.0 million. Accounting for engineering, permitting and construction management costs, the total program cost is approximately $1.3 million. Refer to Section Ten for additional supporting cost information.

Variations of this option may show that in the partially breached condition, the dam is no longer a high-hazard structure and can be reclassified as a low-hazard dam. Rather than raising the dam to pass the SDF, the dam could be lowered to prevent the buildup of stored water and eliminate the consequences associated with the dam failure. Assuming that the dam can be reduced to a C-4 hazard classification, the SDF would be reduced to the 100-year storm event which would require a spillway which is 69-feet wide and approximately 6.5-feet high. The reduction in hazard classification would also eliminate the need to perform annual inspections and maintain an EAP for the dam.

Alternative 10 assumes the partially breached scenario results in reclassification of the dam to a low-hazard structure. For the purpose of estimating costs, the following assumptions are made:

- The existing spillway is cut down to an elevation at or slightly below the existing sediment elevation. It is assumed that the spillway will be overcut by 12-inches and built back up to the design elevation using conventional concrete.
- A pilot channel half the length of that shown in Alternative 9 is needed to direct flow into the lowered spillway.
- The left and right embankments are cut down to an elevation which is approximately 6.5-feet above the new spillway elevation. The lowered top of dam surface will be stabilized with riprap downstream of the existing core wall.
- Excavation from the pilot channel and from lowering the embankment will be spoiled within the reservoir.
- Fencing will be added to the left and right spillway training walls.
- No permanent/temporary construction easements are required (typical for Alternatives 9 and 10).

It is noted that the partial breach options do not address the erodible material which is present under the existing spillway. However, with the elimination of the permanent pool, there is less risk that this material will be lost due to piping and internal erosion.

Based on these assumptions, the estimated construction cost for Alternative 10 is approximately $670,000. Accounting for engineering, permitting and construction management costs, the total program cost would be approximately $820,000. Refer to Section Ten for additional supporting cost information. Assuming that some sediment release is acceptable, these costs may be able to be reduced by eliminating the pilot channel and cutting down the spillway in increments (say one foot each year) until the desired spillway crest elevation is reached. This would allow the stream to naturally form through the reservoir while preventing a sudden release of sediment at any one time.

The partial breach alternatives provide the opportunity for environmental and public enhancements within the reservoir. Localized grading within the reservoir can create a variety of habitat areas, including open water, wetlands and upland areas which would support a wide variety plant and animal species. Upon establishment of the stream bed through the reservoir, tree plantings can be incorporated into the reservoir to create a vegetated buffer along the stream which will further help to stabilize the soils, shade the stream and create a natural condition. Public enhancements may include parking areas, walking trails, overlook areas, informative kiosks, etc. Similar options can also be incorporated into the decommissioning option (Alternative 8); however, the extent of these enhancements may be limited due to the large areas of the reservoir which are needed to spoil the excavated material. Such enhancements could be performed at any time in the future and do not necessarily need to be incorporated into the breaching project.

COST COMPARISON

10.0 OVERVIEW

An Engineer's Opinion of Probable Cost (cost estimate) has been prepared for each of the alternatives described in Sections Seven and Nine. These estimates are intended to be used as a basis for comparing relative costs between the different alternatives. The cost estimate for the selected alternative should be reviewed and updated in the future as the project moves through preliminary and final design and as more site specific information is gathered (i.e., such as topographic surveys, subsurface information, detailed modeling/analysis, etc.). These cost estimates are conceptual in nature and caution should be taken when using these estimates for any other purpose than comparing alternatives. The conceptual designs from which the cost estimates are based are contained in Appendix E for the options which involve increasing conveyance capacity and in Appendix F for the options which involve decommissioning the dam.

It is noted that actual contractor bids are affected by a number of factors beyond the control of the Owner and Engineer, such as the supply and demand for materials and labor, weather conditions, global and local economic conditions, etc. Consequently, actual contractor bids may vary significantly from the conceptual cost estimates provided herein.

10.1 QUANTITY ESTIMATES

Quantity estimates were developed using the conceptual designs for the various Alternatives contained within Appendix E and Appendix F. Where available, quantities were estimated through the use of Computer Aided Design (CAD). However, given the conceptual nature of the designs, many of the quantities are based on assumptions and engineering judgment. Refer to Section 10.4 for the key assumptions used in the preparation of the cost estimates.

10.2 UNIT COSTS

Unit costs were derived from past construction projects, RS Means, and engineering judgment. The logic, methods and procedures for developing the unit costs are typical for the construction industry and are generally accepted as standard engineering practice. The Unit Price for each pay item is shown in Table 10-2.

10.3 CONTINGENCY

Based on the conceptual level of design, a thirty (30) percent contingency has been applied to all construction related items. This contingency is intended to account for unlisted items, items which are not yet designed, quantity uncertainties, changes in site conditions, and other unknowns.

10.4 ASSUMPTIONS

Based on the conceptual nature of the proposed alternatives, it is necessary to make assumptions in the development of the cost estimates. Key assumptions used in the development of the various cost estimates are as follows:

- Contractor mobilization and demobilization is assumed to be seven (7) percent of the estimated construction costs (refer to Item 1 in Table 10-2).
- Contractor required bonds and insurances are assumed to be one (1) percent of the estimated construction costs (refer to Item 2 in Table 10-2).
- A $150,000 allowance is allocated to Alternatives 1 through 5 for care and diversion of water as these alternatives would require management of the reservoir in order to perform the spillway and embankment improvements. A $50,000 allowance is allocated to Alternatives 6 and 7 for care and diversion of water as these alternatives would require less management of the reservoir from that required for Alternatives 1 through 5. A $350,000 allowance is allocated to Alternative 8 as this option would require management of water through the entire length of the reservoir (refer to Item 3 in Table 10-2).
- A $30,000 allowance for erosion control measures is allocated to those alternatives which involve the greatest amount of earth disturbance (Alternatives 1, 2, 3, 6 and 7). A $20,000 allowance for erosion control measures is allocated to those alternatives which involve the least amount of earth disturbance (Alternatives 4 and 5). A $150,000 allowance for erosion control measures is allocated to Alternative 8 as this option would involve earth disturbance throughout the entire reservoir.
- A $115,000 allowance is allocated to Alternatives 1 through 5 for the demolition of the existing spillway, training walls and valve vault (refer to Item 6 in Table 10-2).
- A $150,000 allowance is allocated to Alternatives 1 through 5 for the reconstruction of the low level outlet works, valve chamber and valve house. This allocation includes associated features such as access doors, valves, trash racks and piping. A $15,000 allowance is allocated to Alternatives 6 and 7 as these alternatives maintain the existing valve vault but will require the

reconstruction of the 24-inch CIP low level dewatering pipe located downstream of the valve vault.

- Bedrock is assumed to be in the vicinity of El. 318 based on the original 1923 construction drawings. For this analysis, bedrock is assumed to be horizontal throughout the footprint of the dam.
- Excavation quantities assume that one foot of weathered rock would be removed below the footprint of all new concrete structures in order to prepare a suitable foundation.
- An allocation for site restoration has been applied to each alternative. This may include site stabilization/landscaping and other surface restoration features such as replacing access gates, guide rail, etc. $20,000 has been allocated to those Alternatives with the largest area of disturbance. $10,000 has been allocated to those Alternatives with the smallest area of disturbance. $100,000 has been allocated to Alternative 8 as this option has the largest disturbed area.
- Unless stated otherwise, all excess material from excavations is assumed to be spoiled onsite or at an offsite location within a reasonable hauling distance of the dam.
- Costs to prepare and acquire temporary and/or permanent easements for construction and long term maintenance (if needed) are not included.
- Costs to secure flowage easements (if needed) are not included.

10.5 SUMMARY OF COST ESTIMATES

The total project cost of each alternative described within Section Seven and Section Nine is presented in Table 10-1. In addition to the construction costs, the total program costs include engineering design (assumed to be ten [10] percent of the construction cost), permitting (assumed to be one [1] percent of the construction cost), and construction management services (assumed to be twelve [12] percent of the construction cost).

Table 10-1
Summary of Total Estimated Project Costs
(2016 Prices)

Alternative Description	Construction Cost	Engineering, Permits & Construction Management	Total Project Cost
Increase Capacity Alternative 1 Increase Spillway Depth	$5.4 Million	$1.2 Million	$6.6 Million
Increase Capacity Alternative 2 Increase Spillway Width	$7.8 Million	$1.8 Million	$9.6 Million
Increase Capacity Alternative 3 Increase Spillway Width & Depth	$5.5 Million	$1.3 Million	$6.8 Million
Increase Capacity Alternative 4 Fusegates	$4.7 Million	$1.1 Million	$5.8 Million
Increase Capacity Alternative 5 Widen Spillway with Labyrinth	$5.5 Million	$1.2 Million	$6.7 Million
Increase Capacity Alternative 6 ACB Overtopping Protection	$2.6 Million	$0.6 Million	$3.2 Million
Increase Capacity Alternative 7 RCC Overtopping Protection	$1.9 Million	$0.4 Million	**$2.4 Million**
Decommissioning Alternative 8 Dam Breach with Restored Channel	$2.5 Million	$0.6 Million	$3.1 Million
Partial Dam Breach Alternative 9 Partial Dam Breach (High Hazard Dam)	$1.0 Million	$0.3 Million	**$1.3 Million**
Partial Dam Breach Alternative 10 Partial Dam Breach (Low Hazard Dam)	$0.7 Million	$0.1 Million	**$0.8 Million**

Table 10-1 indicates that Alternative 7 (RCC Overtopping Protection) is the most economical alternative for increasing conveyance capacity with total program costs of $2.4 million, while the Partial Dam Breach Alternative 10 is the least expensive option at $820,000. The full breach option, which is the only option that totally eliminates the annual operation and maintenance costs associated with owning a regulated dam, has a cost of $3.1 million and is the only option that has the potential to be fully or partially funded through grants, environmental mitigation funds, or other sources. The partial dam breach options are less likely to be eligible for this kind of funding. Refer to Table 10-2 for a detailed breakdown of the cost estimate summarized in Table 10-1.

Table 10-2
Itemized Breakdown of Estimated Project Costs (2016 Dollars)
Options for Increasing Conveyance Capacity and Decommissioning Milltown Dam

Item No.	Item Description	Quantities										Unit	Unit Price	Cost									
		Alt. 1 Raise Dam	Alt. 2 Widen Spillway	Alt. 3 Raise & Widen	Alt. 4 Fuse Gates	Alt. 5 Labyrinth	Alt. 6 ACB Protection	Alt. 7 RCC Protection	Alt. 8 Full Breach	Alt. 9 Partial Breach	Alt. 10 Partial Breach			Alt. 1 Raise Dam	Alt. 2 Widen Spillway	Alt. 3 Raise & Widen	Alt. 4 Fusegates	Alt. 5 Labyrinth	Alt. 6 ACB Overtopping	Alt. 7 RCC Overtopping	Alt. 8 Full Breach	Alt. 9 Partial Breach (High Hazard)	Alt. 10 Partial Breach (Low Hazard)
1	Mobilization, Demobilization and Preparatory Work (Assume 7%)	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	LS	XXX	$269,495	$389,593	$274,008	$233,314	$273,455	$129,759	$96,929	$124,362	$52,044	$33,194
2	Bonds and Insurance (Assume 1%)	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	LS	XXX	$38,499	$55,656	$39,144	$33,331	$39,065	$18,537	$13,847	$17,766	$7,435	$4,742
3	Care & Diversion of Water	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	LS	XXX	$150,000	$150,000	$150,000	$150,000	$150,000	$50,000	$50,000	$350,000	$200,000	$150,000
4	Erosion & Sediment Control	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	LS	XXX	$30,000	$30,000	$30,000	$20,000	$20,000	$30,000	$30,000	$150,000	$75,000	$50,000
5	Clearing and Grubbing	0.5	0.5	0.5	0.2	0.3	0.5	0.5	1.0	0.0	0.0	Ac	$7,000	$3,500	$3,500	$3,500	$1,400	$2,100	$3,500	$3,500	$7,000	$0	$0
6	Demolition of Structures (Existing Spillway and Training Walls)	1	1	1	1	1	0	0	1	0	0	LS	$115,000	$115,000	$115,000	$115,000	$115,000	$115,000	$5,000	$3,000	$115,000	$30,000	$30,000
7	Excavation - Unclassified	15,000	26,300	25,100	8,500	14,800	6,900	9,000	50,900	11,000	6,700	CY	$8.00	$120,000	$210,400	$200,800	$68,000	$118,400	$55,200	$72,000	$407,200	$88,000	$53,600
8	Excavation - Rock (Assume 1 foot removal below new structures)	490	590	460	300	630	70	200	-	-	-	CY	$35.00	$17,150	$20,650	$16,100	$10,500	$22,050	$2,450	$7,000	-	-	-
9	Excavation - Stripping of Existing Riprap from Dam Face	1,400	1,400	1,400	710	710	1,050	1,050	1,400	100	400	CY	$5.00	$7,000	$7,000	$7,000	$3,550	$3,550	$5,250	$5,250	$7,000	$500	$2,000
10	Spoil Excess from Excavation (Onsite or Haul Offsite)	6,000	16,220	8,100	3,000	6,900	500	5,200	50,900	11,000	6,700	CY	$6.00	$36,000	$97,320	$48,600	$18,000	$41,400	$3,000	$31,200	$305,400	$66,000	$40,200
11	Foundation Preparation (Under Concrete Structures)	13,140	16,000	12,400	8,100	16,900	1,800	4,800	-	-	-	SF	$2.00	$26,280	$32,000	$24,800	$16,200	$33,800	$3,600	$9,600	-	-	-
12	Approved Embankment Fill	23,800	10,080	14,500	5,500	7,900	900	4,000	-	-	-	CY	$10.00	$238,000	$100,800	$145,000	$55,000	$79,000	$9,000	$40,000	-	-	-
13	Coarse/Fine Drainfill for Blanket and Toe Drain System	1,300	-	840	-	-	-	2,200	-	-	-	CY	$60.00	$78,000	-	$50,400	-	-	-	$132,000	-	-	-
14	Reinforced Concrete to Raise Core Wall	150	-	70	-	-	100	15	-	45	-	CY	$900	$135,000	-	$63,000	-	-	$90,000	$13,500	-	$40,500	-
15	Reinforced Concrete Slabs	2,125	4,850	2,600	1,700	2,200	600	10	-	25	25	CY	$600	$1,275,000	$2,910,000	$1,560,000	$1,020,000	$1,320,000	$360,000	$6,000	-	$15,000	$15,000
16	Reinforced Concrete Walls	600	475	530	400	1,150	200	-	-	-	-	CY	$900	$540,000	$427,500	$477,000	$360,000	$1,035,000	$180,000	-	-	-	-
17	Furnish, Mix, Convey, Place and Cure RCC	-	-	-	-	-	-	4,100	-	-	-	CY	$190	-	-	-	-	-	-	$779,000	-	-	-
18	Steel Reinforcement (@ 160 LBS / CY of reinforced concrete)	460,000	852,000	512,000	336,000	536,000	144,000	4,000	-	11,200	4,000	LB	$1.40	$644,000	$1,192,800	$716,800	$470,400	$750,400	$201,600	$5,600	-	$15,680	$5,600
19	Hydroplus Fusegate System	-	-	-	Job	-	-	-	-	-	-	LS	XXX	-	-	-	$800,000	-	-	-	-	-	-
20	Articulated Concrete Block Slope Protection System	-	-	-	-	-	31,300	-	-	-	-	SF	$25.00	-	-	-	-	-	$782,500	-	-	-	-
21	HDPE Toe Drain Pipe	300	-	240	-	-	-	-	-	-	-	LF	$50.00	$15,000	-	$12,000	-	-	-	-	-	-	-
22	PVC Drain Pipe under RCC	-	-	-	-	-	-	900	-	-	-	LF	$20.00	-	-	-	-	-	-	$18,000	-	-	-
23	Toe Drain Cleanouts and Monitoring Weirs	4	-	2	-	-	-	4	-	-	-	Each	$4,500	$18,000	-	$9,000	-	-	-	$18,000	-	-	-
24	Fencing (At Top of Walls)	300	260	260	250	270	190	70	-	70	70	LF	$40.00	$12,000	$10,400	$10,400	$10,000	$10,800	$7,600	$2,800	-	$2,800	$2,800
25	Riprap	1,500	1,500	1,300	1,100	900	600	0	6,700	3,200	1,900	CY	$50	$75,000	$75,000	$65,000	$55,000	$45,000	$30,000	$0	$335,000	$160,000	$95,000
26	New Low Level Outlet Works, Valve Vault & Gates	Job	Job	Job	Job	Job	Job	Job	-	-	-	LS	$150,000	$150,000	$150,000	$150,000	$150,000	$150,000	$15,000	$15,000	-	-	-
27	Site Restoration	Job	Job	Job	Job	Job	Job	Job	Job	Job	Job	LS	XXX	$20,000	$20,000	$20,000	$10,000	$10,000	$20,000	$20,000	$100,000	$50,000	$30,000
28	Full Depth Asphalt Pavement (Reservoir Road)	1,400	530	600	-	-	-	530	-	-	-	SY	$25	$35,000	$13,250	$15,000	-	-	-	$13,250	-	-	-
29	Utility Relocations (Sanitary Sewer)	220	-	50	-	-	-	220	-	-	-	LF	$500	$110,000	-	$25,000	-	-	-	$110,000	-	-	-
	Opinion of Probable Construction Cost													$4,157,924	$6,010,870	$4,227,552	$3,599,694	$4,219,020	$2,001,996	$1,495,476	$1,918,728	$802,958	$512,136
	Contingency (30%)													$1,247,377	$1,803,261	$1,268,266	$1,079,908	$1,265,706	$600,599	$448,643	$575,618	$240,888	$153,641
	Total Construction Costs													**$5,405,302**	**$7,814,130**	**$5,495,818**	**$4,679,602**	**$5,484,726**	**$2,602,595**	**$1,944,119**	**$2,494,346**	**$1,043,846**	**$665,777**
	Engineering (10%)													$540,530	$781,413	$549,582	$467,960	$548,473	$260,259	$194,412	$249,435	$104,385	$66,578
	Permits (1%)													$54,053	$78,141	$54,958	$46,796	$54,847	$26,026	$19,441	$24,943	$10,438	$6,658
	Construction Management (12%)													$648,636	$937,696	$659,498	$561,552	$658,167	$312,311	$233,294	$299,322	$125,262	$79,893
	Total Other Project Costs													**$1,243,219**	**$1,797,250**	**$1,264,038**	**$1,076,309**	**$1,261,487**	**$598,597**	**$447,147**	**$573,700**	**$240,085**	**$153,129**
	Total Project Costs													**$6,648,521**	**$9,611,380**	**$6,759,856**	**$5,755,911**	**$6,746,213**	**$3,201,192**	**$2,391,266**	**$3,068,046**	**$1,283,930**	**$818,905**

Abbreviations:

Ac Acre

CY Cubic Yard

SF Square Foot

LB Pound

LF Linear Foot

LS Lump Sum

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**

Table 10-3 Notes:

1. Refer to Table 10-1 and 10-2 for the initial project costs (i.e., construction, engineering, permitting and construction phase services) associated with each alternative.
2. Refer to Pages 8b through 8e in Appendix D for the 30-year operation and maintenance costs plus deferred operation and maintenance costs for Alternatives 1 through 7, 9 and 10. Other than potential mowing, no operation and maintenance costs are assumed for Alternative 8.
3. Dredging costs assume a partial dredge as shown on Figure 8-4.

Table 10-3 summarizes the anticipated 30-year life cycle costs for Alternatives 1 through 10. Alternative 7 (RCC Overtopping) is the most economical option for increasing conveyance capacity. Assuming that the dam can be reclassified as a low hazard structure, Alternative 10 is the least expensive option overall.

CONCLUSIONS AND RECOMMENDATIONS

11.0 OVERVIEW

Seven conceptual designs were evaluated to increase the conveyance capacity of Milltown Dam (Alternatives 1 through 7), one option was evaluated to decommission the dam (Alternative 8) and two Alternatives were evaluated to partially breach the dam (Alternatives 9 and 10). These alternatives are described in detail in Section Seven and Section Nine, respectively. Of these ten alternatives, Alternative 7 (RCC Overtopping) and the partial breach options (Alternatives 9 and 10) were found to have significant lower program costs when compared against the remaining alternatives and are considered to be the preferred alternatives. Although Alternative 8 (Decommissioning the dam) is estimated to have a significant construction cost, it has the potential to receive outside funding as an environmental mitigation project and may also be an attractive option for the Township to consider. It is noted that additional analysis is required in order to determine the full extent of the modifications which must be made in order to reclassify the dam as a low hazard structure (Alternative 10).

In order to further rank the preferred alternatives, each alternative was compared against each other in a variety of categories. These categories included overall costs, construction concerns, permitting requirements and overall performance and risk. These categories are listed within Table 11-1 for the two lowest cost alternatives which increase conveyance capacity and Table 11-2 which compares decommissioning the dam to partially breaching the dam assuming that the dam can be converted to a low-hazard structure. Alternatives which provide a favorable advantage when compared to the other alternatives are shaded in blue. Alternatively, those alternatives which have a disadvantage when compared to the other alternatives are shaded in red. As such, Tables 11-1 and 11-2 provide a visual comparison of the ranking of each alternative. Those alternatives which contain more red shading are less desirable in comparison to those which contain more blue shading.

Table 11-1
Side-By-Side Comparison of Embankment Armoring Alternatives

Issue	Alternative 6 ACB Overtopping	Alternative 7 RCC Overtopping
Program Costs	$3.2 Million	$2.4 Million
O&M Costs	Similar to Existing	Similar to Existing
Need to Lower Lake	Although temporary lowering of the reservoir during construction is desirable, ACB construction can be completed without lowering the reservoir.	Although temporary lowering of the reservoir during construction is desirable, RCC construction can be completed without lowering the reservoir.
Diversion of Water	Requires management of upstream flows during work within the spillway.	Requires management of upstream flows during work within the spillway.
Dam Safety	Maintains existing spillway and top of dam. Permitted with Letter of Amendment	Alters top of dam elevation. May require Dam Permit Application
Earth Disturbance	Area of disturbance of approximately 1 acre.	Area of disturbance of approximately 1 acre.
Consequence to Dam During 100%PMF	100% PMF exceeds approved overtopping depth for ACB's.	RCC can pass 100% PMF.
Potential to Conceal Embankment Problem	ACB's can transmit subsidence to surface for detection of problem.	Potential to conceal embankment problem by sealing over embankment face.
Increase in Peak Outflow	No change in performance hydraulic performance of dam.	Negligible change in peak outflow due to lowering of embankment crest.
Impacts to Embankment Stability	Flatter downstream slopes improve embankment stability.	Addition of RCC improves slope stability of embankment.
Complexity of Construction	Contractor with ACB experience preferred.	Requires contractor with RCC experience. Requires larger staging area.

Alternative 7 RCC Overtopping has the lowest program cost for the dam rehabilitation options and is believed to be feasible and permitable. The RCC Overtopping option also has a significant advantage over all other rehabilitation options in that it can safely pass overtopping depths greater than 4-feet and can provide passage of the full PMF. Furthermore, should the regulations and/or the hydrology for the SDF change in the future, the RCC overtopping protection would accommodate those changes and prevent or reduce the need for future conveyance capacity modifications. **As such, the RCC Overtopping provides an increased level of protection over all other options evaluated and is the recommended alternative for increasing conveyance capacity at Milltown Dam.**

As discussed in Section 4.8 and Section Eight, the capacity of the Milltown Dam reservoir has been reduced by over 60 percent as a result of historic sedimentation. Water depths within the reservoir which once exceed 15-feet have been reduced to 4- to

5-feet in depth. Water depths in the upper end of the reservoir are currently less than one foot in many areas. The current sedimentation rate is unknown and sedimentation of the reservoir would continue to occur. Should the Township choose to rehabilitate the dam, consideration should be given to conducting a reservoir dredging project to maintain the desired benefits from the reservoir.

Table 11-2
Side-By-Side Comparison of the Preferred Alternatives for Decommissioning/Partial Breach

Issue	Alternative 8 Decommissioning	Alternative 10 Partial Breach
Program Costs	$3.1 Million	$0.82 Million
O&M Costs	None	Less than Existing
Need to Lower Lake	Full breach results in the permanent loss of the reservoir.	Partial breach results in the permanent loss of the reservoir.
Diversion of Water	Significant care and diversion of water required during breach excavation and to construct pilot channel through reservoir.	Diversion of water required during spillway notch demolition and to construct pilot channel through reservoir.
Dam Safety	Can be permitted with waiver	Alters top of dam elevation. May require Dam Permit Application
Earth Disturbance	Area of disturbance of approximately 15 acres.	Area of disturbance of approximately 6 acres.
Consequence to Dam During 50%PMF	Not applicable. Dam removed from service.	Not applicable. Assumes dam is reclassified as a low-hazard structure.
Increase in Peak Outflow	Increase in peak rates of runoff expected due to loss of flow attenuation through reservoir. Generally accepted as part of breach project.	Dam provides storm attenuation similar to what currently exists.
Impacts to Embankment Stability	Not Applicable. Dam removed from service.	Existing deficiencies identified in Section Four remain.
Complexity of Construction	Does not require specialty contractor. Earthwork and demolition contract.	Does not require specialty contractor. Earthwork and demolition contract.
Opportunities to Enhance Reservoir	Limited opportunities due to expansive nature of sediment disposal areas.	Opportunity to incorporate wetlands, open water, walking trails, etc.

Both the full breach option and the partial breach option are believed to be feasible and permitable. The full breach alternative is similar in cost to the RCC overtopping alternative at $3.1 Million and eliminates the annual operation and maintenance costs associated with owning a dam. The partial breach option is the least expensive at $0.82 million assuming the dam can be reclassified as a low-hazard structure; however, the Township would continue to incur some operation and maintenance costs associated with owning a dam, however, at a lesser amount (refer to Table 10-3).

REFERENCES

12.0 REFERENCES

2015 Annual Inspection Report for Milltown Dam prepared by Gannett Fleming, Inc. Date of Inspection: August 4, 2015.

Dam Safety and Waterway Management, Pennsylvania Code, Chapter 105. Onlice reference: http://www.pacode.com/secure/data/025/chapter105/chap105toc.html

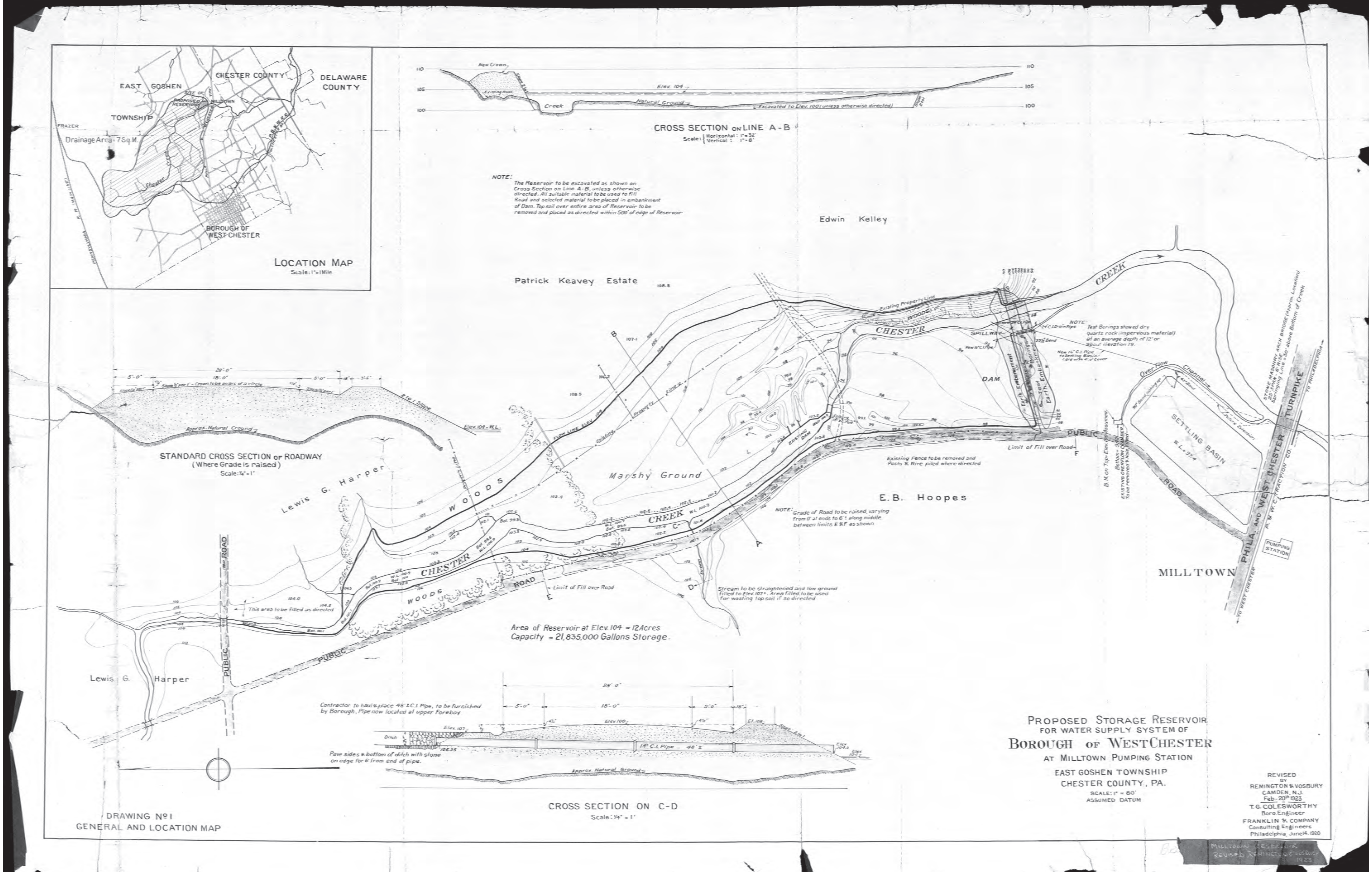
Filters for Embankment Dams, Best Practices for Design and Construction. Federal Emergency Management Agency (FEMA). October 2011.

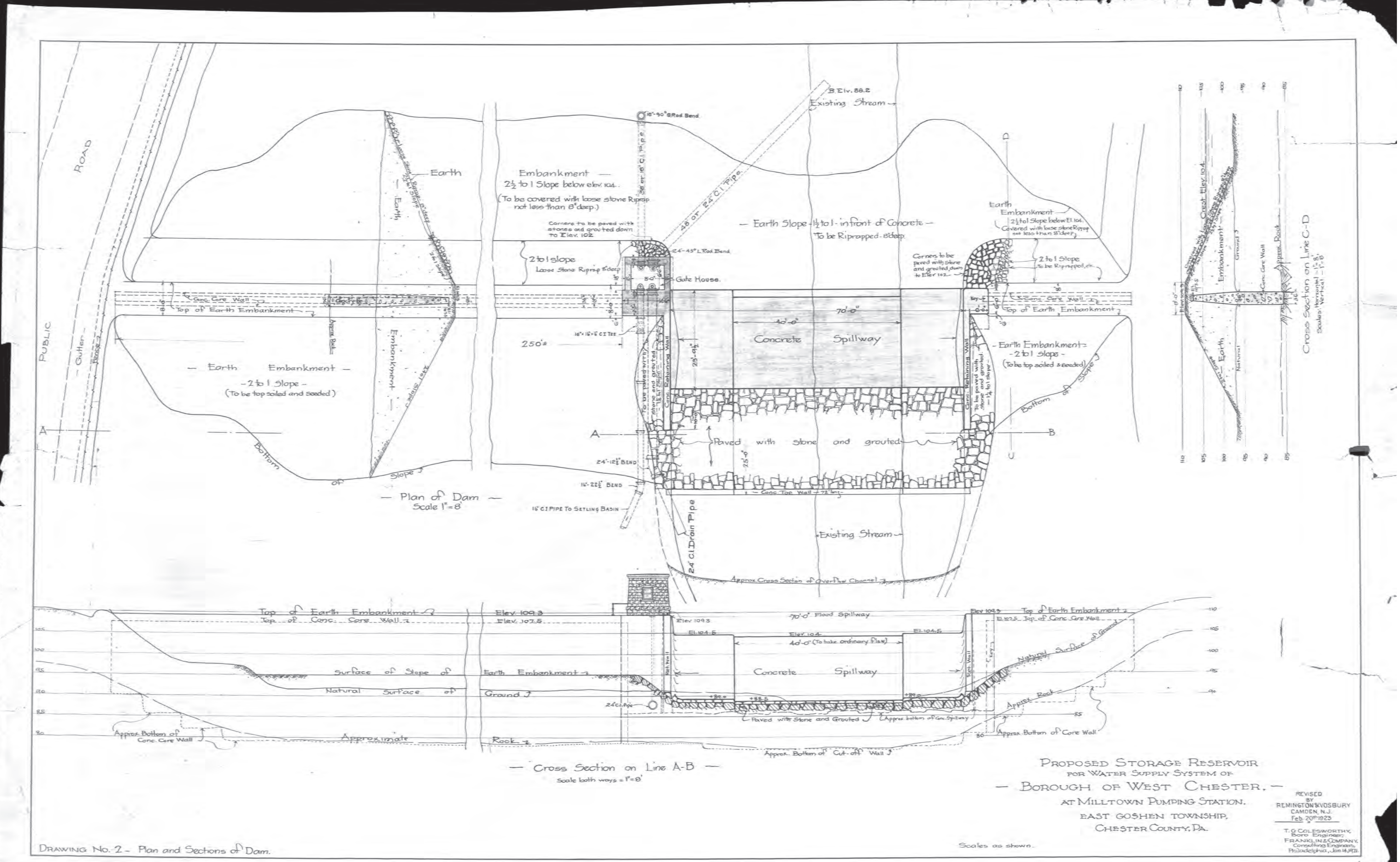
Inspection, Maintenance and Operation of Dams in Pennsylvania prepared by the Pennsylvania Department of Environmental Protection, 2009 edition, reprinted 2013.

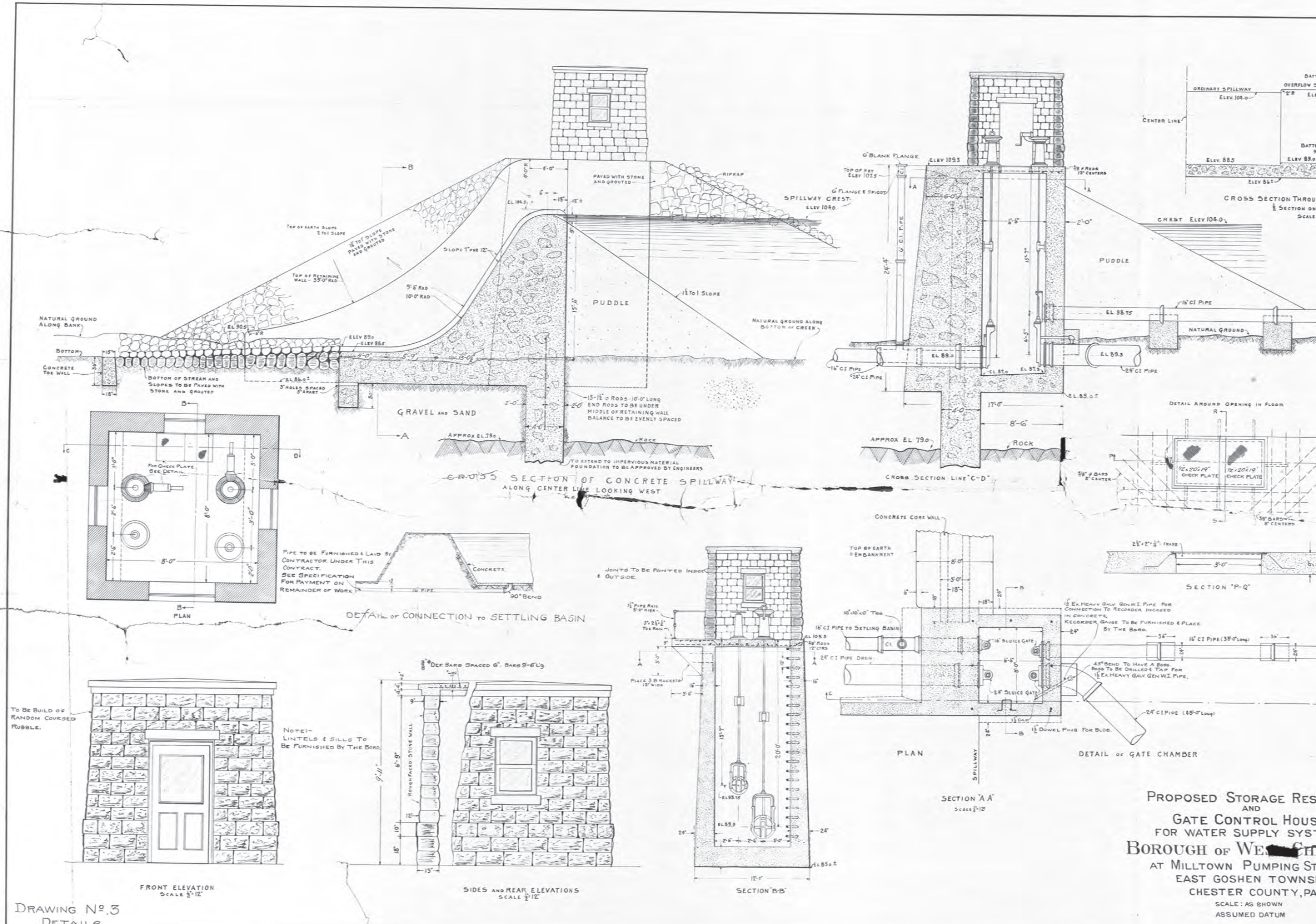
Phase I Inspection Report for Milltown Dam prepared by Berger Associates for the U.S. Army Corps of Engineers, July 1981.

Article entitled *In-Stream Sediment Management for Dam Breaching Projects: Increasing Acceptance, Decreasing Costs at Small Dams* as published in the USSD Newsletter, Issue No. 167, dated November 2015.

APPENDIX A
ORIGINAL CONSTRUCTION DRAWINGS FROM 1923


LOCATION MAP
Scale: 1" = 1 Mile
EAST GOSHEN
TOWNSHIP
CHESTER COUNTY
DELAWARE COUNTY
FRAZER
Drainage Area = 7 Sq. M.
BOROUGH OF WEST CHESTER
CROSS SECTION ON LINE A-B
Scale: Horizontal: 1" = 32' Vertical: 1" = 8'
New Crown
Elev. 104
Creek
Natural Ground
Excavated to Elev. 100 (unless otherwise directed)
NOTE: The Reservoir to be excavated as shown on Cross Section on Line A-B, unless otherwise directed. All suitable material to be used to fill Road and selected material to be placed in embankment of Dam. Top soil over entire area of Reservoir to be removed and placed as directed within 500' of edge of Reservoir
Edwin Kelley
Patrick Keavey Estate
STANDARD CROSS SECTION OF ROADWAY
(Where Grade is raised)
Scale: 1/4" = 1'
Approx. Natural Ground
Elev. 104 - W.L.
Lewis G. Harper
WOODS
FLOW LINE ELEV. 104
Marshy Ground
CHESTER CREEK
EXISTING DAM
Existing Property Line
SPILLWAY
DAM
Earth Embankment
NOTE: Test Borings showed dry quartz rock (impervious material) at an average depth of 12' or about elevation 79.
Over Flow Channel
SETTLING BASIN
PUBLIC ROAD
Limit of Fill over Road
Existing Fence to be removed and Posts & Wire piled where directed
E.B. Hoopes
NOTE: Grade of Road to be raised, varying from 0' at ends to 6' ± along middle between limits E & F as shown
PUMPING STATION
MILLTOWN
PHILA. AND WEST CHESTER TURNPIKE
P. & W. C. TRACTION CO.
TO WEST CHESTER
TO PHILADELPHIA
Stream to be straightened and low ground filled to Elev. 107 ±. Area filled to be used for wasting top soil if so directed
This area to be filled as directed
Area of Reservoir at Elev. 104 = 12 Acres
Capacity = 21,835,000 Gallons Storage.
Lewis G. Harper
PUBLIC ROAD
Contractor to haul & place 48" ± C.I. Pipe, to be furnished by Borough. Pipe now located at upper Forebay
Pave sides & bottom of ditch with stone on edge for 6' from end of pipe.
Elev. 107
Elev. 108
14" C.I. Pipe - 48' ±
Approx. Natural Ground
CROSS SECTION ON C-D
Scale: 1/4" = 1'
DRAWING No 1
GENERAL AND LOCATION MAP
PROPOSED STORAGE RESERVOIR
FOR WATER SUPPLY SYSTEM OF
BOROUGH OF WESTCHESTER
AT MILLTOWN PUMPING STATION
EAST GOSHEN TOWNSHIP
CHESTER COUNTY, PA.
SCALE: 1" = 80'
ASSUMED DATUM
REVISED BY REMINGTON & VOSBURY CAMDEN, N.J. Feb-20th 1923
T. G. COLESWORTHY Boro. Engineer
FRANKLIN & COMPANY Consulting Engineers Philadelphia, June 14, 1920


PUBLIC ROAD
Gutter
Fence
B. Elv. 88.2
Existing Stream
18"-90° B Rod Bend
Earth Embankment
2½ to 1 Slope below elev. 104.
(To be covered with loose stone Riprap not less than 8" deep.)
48" or 24" C.I. Pipe
Earth Slope 1½ to 1 in front of Concrete
To be Riprapped - 8" deep
Corners to be paved with stones and grouted down to Elev. 102
24"-45° L Rod Bend
2 to 1 slope
Loose Stone Riprap 8" deep
Gate House
Conc. Core Wall
Top of Earth Embankment
250'±
16"×16"×6" C.I. Tee
Earth Embankment
2 to 1 Slope
(To be top soiled and seeded)
70'-0"
40'-0"
Concrete Spillway
Conc. Retaining Wall
Paved with Stone and grouted
Bottom of Slope
24"-12½° Bend
16"-22½° Bend
16" C.I. Pipe To Setling Basin
Conc. Toe Wall - 72' lin.
24" C.I. Drain Pipe
Existing Stream
Approx. Cross Section of Overflow Channel
Plan of Dam
Scale 1" = 8'
Corners to be paved with Stone and grouted down to Elev. 102
Earth Embankment
2½ to 1 Slope below El. 104.
Covered with loose stone Riprap not less than 8" deep
2 to 1 Slope
To be Riprapped, etc.
Earth Embankment
2 to 1 Slope
(To be top soiled & seeded)
Crest Elev. 104
Embankment
Ground
Approx. Rock
Conc. Core Wall
Natural
Earth
Cross Section on Line C-D
Scales: Horizontal 1" = 8', Vertical 1" = 8'
Top of Earth Embankment
Top of Conc. Core Wall
Elev. 109.3
Elev. 107.5
70'-0" Flood Spillway
El. 104.5
Elev. 104
40'-0" (To take ordinary flow)
Concrete Spillway
Surface of Slope of Earth Embankment
Natural Surface of Ground
Natural Surface of Ground
24" C.I. Pipe
Paved with Stone and Grouted
Approx. bottom of Conc. Spillway
Approx. Rock
Approx. Bottom of Core Wall
Approx. Bottom of Conc. Core Wall
Approximate Rock
Approx. Bottom of Cut-off Wall
Cross Section on Line A-B
Scale both ways = 1" = 8'
PROPOSED STORAGE RESERVOIR
FOR WATER SUPPLY SYSTEM OF
BOROUGH OF WEST CHESTER.
AT MILLTOWN PUMPING STATION.
EAST GOSHEN TOWNSHIP,
CHESTER COUNTY, PA.
REVISED BY REMINGTON & VOSBURY CAMDEN, N.J. Feb. 20th 1923
T. G. COLESWORTHY, Boro Engineer;
FRANKLIN & COMPANY, Consulting Engineers, Philadelphia, Jan. 14, 1921.
Scales as shown.
DRAWING No. 2 - Plan and Sections of Dam.

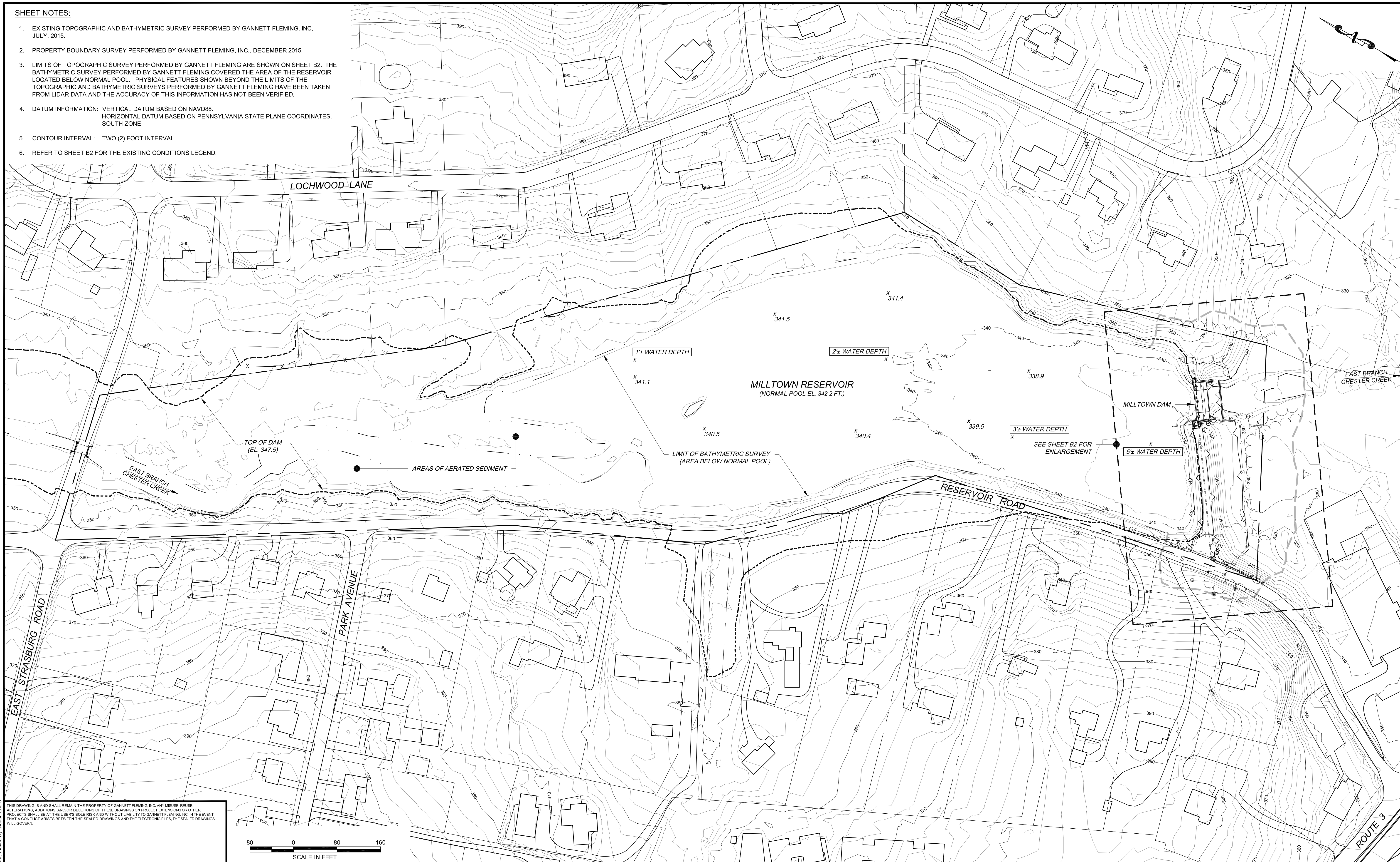


CROSS SECTION OF CONCRETE SPILLWAY
ALONG CENTER LINE LOOKING WEST
PUDDLE
GRAVEL AND SAND
RIPRAP
SPILLWAY CREST
NATURAL GROUND ALONG BANK
NATURAL GROUND ALONG BOTTOM OF CREEK
CONCRETE TOE WALL
BOTTOM OF STREAM AND SLOPES TO BE PAVED WITH STONE AND GROUTED
PAVED WITH STONE AND GROUTED
CROSS SECTION LINE "C-D"
CREST ELEV 104.0
ROCK
APPROX EL 79.0
DETAIL AROUND OPENING IN FLOOR
SECTION "P-Q"
PLAN
DETAIL OF CONNECTION TO SETTLING BASIN
PIPE TO BE FURNISHED & LAID BY CONTRACTOR UNDER THIS CONTRACT. SEE SPECIFICATION FOR PAYMENT ON REMAINDER OF WORK
CONCRETE CORE WALL
SECTION "A-A"
DETAIL OF GATE CHAMBER
SECTION "B-B"
TO BE BUILD OF RANDOM COURSED RUBBLE.
NOTE:- LINTELS & SILLS TO BE FURNISHED BY THE BORO.
FRONT ELEVATION
SIDES AND REAR ELEVATIONS
PROPOSED STORAGE RESER
AND
GATE CONTROL HOUSE
FOR WATER SUPPLY SYSTE
AT MILLTOWN PUMPING STAT
EAST GOSHEN TOWNSHI
CHESTER COUNTY, PA.
SCALE: AS SHOWN
ASSUMED DATUM
DRAWING No. 3
DETAILS

APPENDIX B
CURRENT SITE CONDITIONS

SHEET NOTES:

1. EXISTING TOPOGRAPHIC AND BATHYMETRIC SURVEY PERFORMED BY GANNETT FLEMING, INC, JULY, 2015.
2. PROPERTY BOUNDARY SURVEY PERFORMED BY GANNETT FLEMING, INC., DECEMBER 2015.
3. LIMITS OF TOPOGRAPHIC SURVEY PERFORMED BY GANNETT FLEMING ARE SHOWN ON SHEET B2. THE BATHYMETRIC SURVEY PERFORMED BY GANNETT FLEMING COVERED THE AREA OF THE RESERVOIR LOCATED BELOW NORMAL POOL. PHYSICAL FEATURES SHOWN BEYOND THE LIMITS OF THE TOPOGRAPHIC AND BATHYMETRIC SURVEYS PERFORMED BY GANNETT FLEMING HAVE BEEN TAKEN FROM LIDAR DATA AND THE ACCURACY OF THIS INFORMATION HAS NOT BEEN VERIFIED.
4. DATUM INFORMATION: VERTICAL DATUM BASED ON NAVD88. HORIZONTAL DATUM BASED ON PENNSYLVANIA STATE PLANE COORDINATES, SOUTH ZONE.
5. CONTOUR INTERVAL: TWO (2) FOOT INTERVAL.
6. REFER TO SHEET B2 FOR THE EXISTING CONDITIONS LEGEND.



80 -0- 80 160
SCALE IN FEET

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
XXX	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	ECN

Gannett Fleming

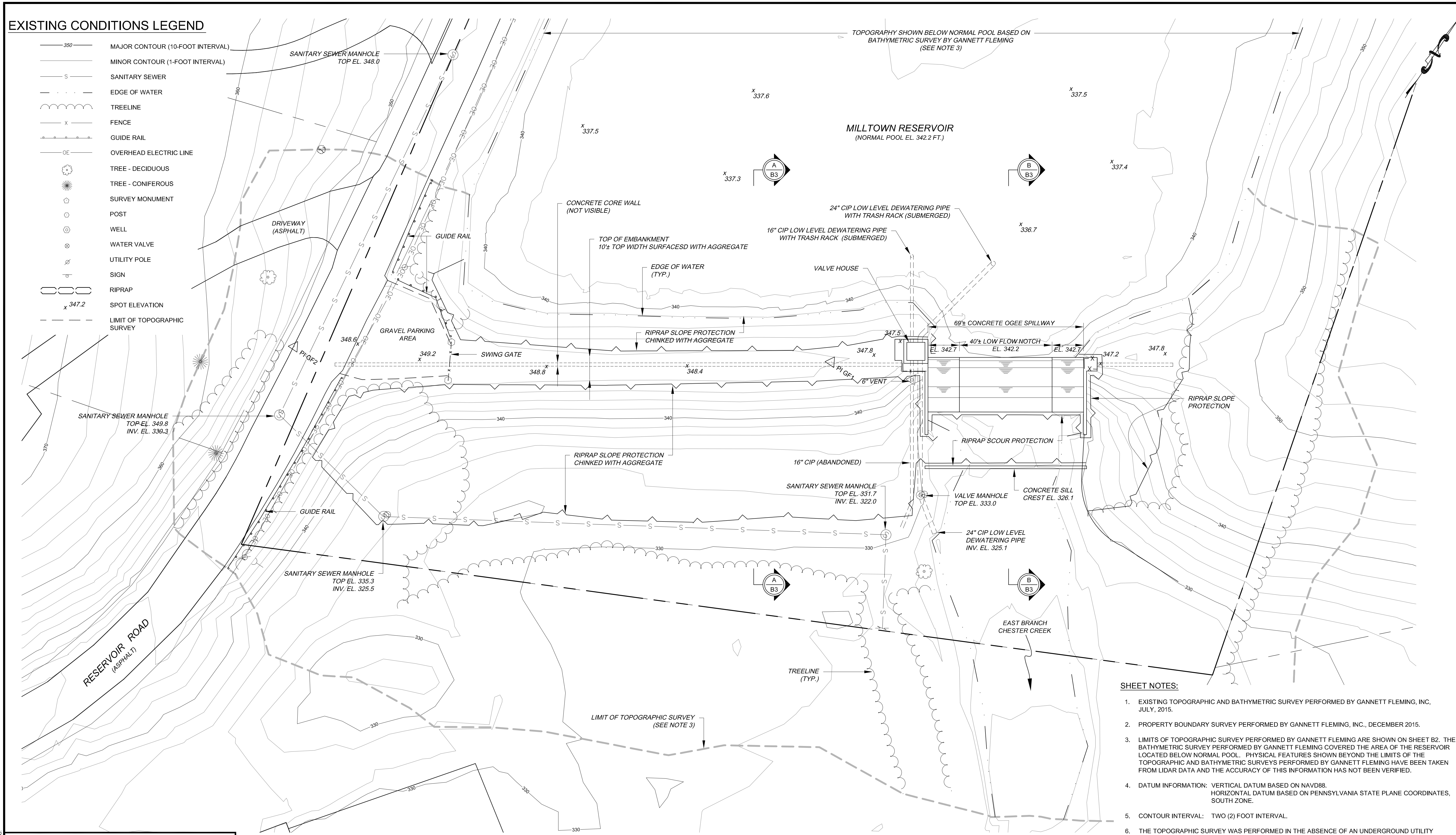
EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

OVERALL SITE PLAN
EXISTING CONDITIONS

JOB NO.	SHEET NO.
60466	B1
DATE	DRAWING NO.
FEB. 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\EXISTING SITE PLAN.dwg
Plot Date: 2/25/2016 10:00 AM, Plotted By: Neast, Eric C.



SHEET NOTES:

1. EXISTING TOPOGRAPHIC AND BATHYMETRIC SURVEY PERFORMED BY GANNETT FLEMING, INC, JULY, 2015.
2. PROPERTY BOUNDARY SURVEY PERFORMED BY GANNETT FLEMING, INC., DECEMBER 2015.
3. LIMITS OF TOPOGRAPHIC SURVEY PERFORMED BY GANNETT FLEMING ARE SHOWN ON SHEET B2. THE BATHYMETRIC SURVEY PERFORMED BY GANNETT FLEMING COVERED THE AREA OF THE RESERVOIR LOCATED BELOW NORMAL POOL. PHYSICAL FEATURES SHOWN BEYOND THE LIMITS OF THE TOPOGRAPHIC AND BATHYMETRIC SURVEYS PERFORMED BY GANNETT FLEMING HAVE BEEN TAKEN FROM LIDAR DATA AND THE ACCURACY OF THIS INFORMATION HAS NOT BEEN VERIFIED.
4. DATUM INFORMATION: VERTICAL DATUM BASED ON NAVD88. HORIZONTAL DATUM BASED ON PENNSYLVANIA STATE PLANE COORDINATES, SOUTH ZONE.
5. CONTOUR INTERVAL: TWO (2) FOOT INTERVAL.
6. THE TOPOGRAPHIC SURVEY WAS PERFORMED IN THE ABSENCE OF AN UNDERGROUND UTILITY STAKEOUT AND NO TEST PITTING OF UTILITIES WAS PERFORMED. ALL EXISTING UTILITIES SHOWN ON THE PLANS ARE BASED ON THE BEST AVAILABLE INFORMATION. THE ENGINEER DOES NOT CERTIFY THE CORRECTNESS OR COMPLETENESS OF THE EXISTING UTILITY PORTRAYAL.
7. LOCATION AND DIMENSIONS OF THE 16" AND 24" CIP LOW LEVEL DEWATERING PIPES AND THE CONCRETE CORE WALL HAVE BEEN TAKEN FROM THE ORIGINAL CONSTRUCTION DRAWINGS AS PREPARED BY FRANKLIN AND COMPANY DATED JUNE 14, 1920 AND AS REVISED BY REMINGTON AND VOSBURY DATED FEBRUARY 20, 1923. FACILITIES NOT SURVEYED BY GANNETT FLEMING.

CONTROL POINT TABLE

CONTROL POINT DESIGNATION	DESCRIPTION	COORDINATES (FT) NORTH	EAST	ELEVATION (FT)
GF-1	IRON PIN WITH CAP	238,725.06	2,586,652.17	348.16
GF-2	PK NAIL IN ASPHALT	238,598.34	2,586,452.13	349.55

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\EXISTING SITE PLAN.dwg
Plot Date: 2/25/2016 10:01 AM, Plotted By: Neast, Eric C.

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
XXX	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	ECN

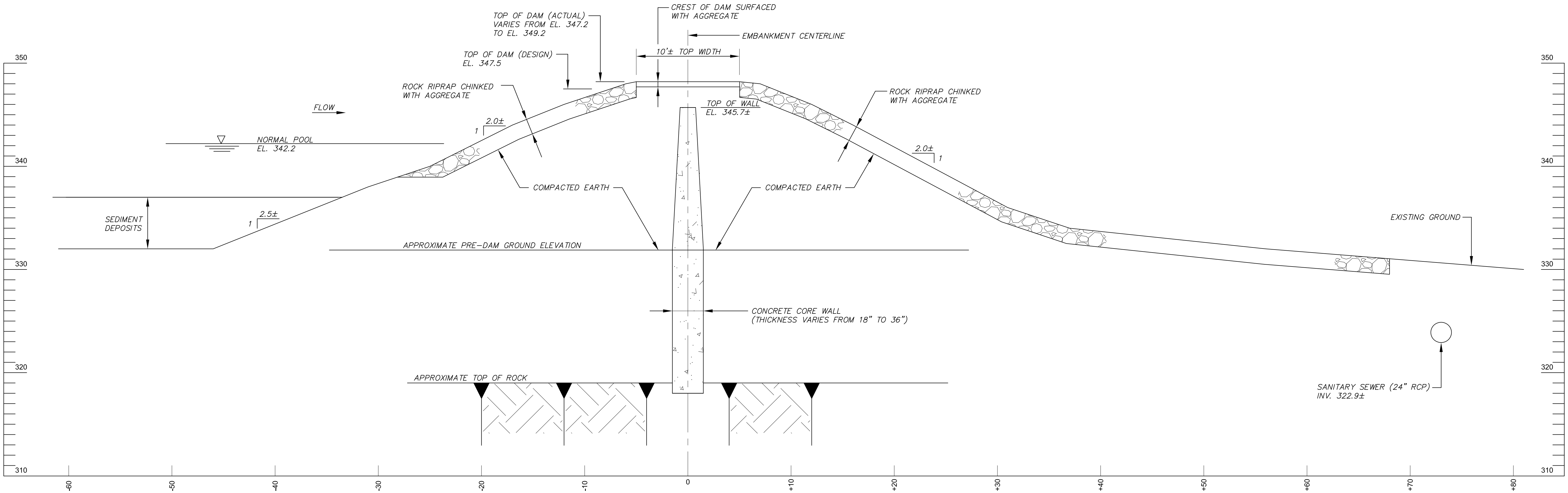
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

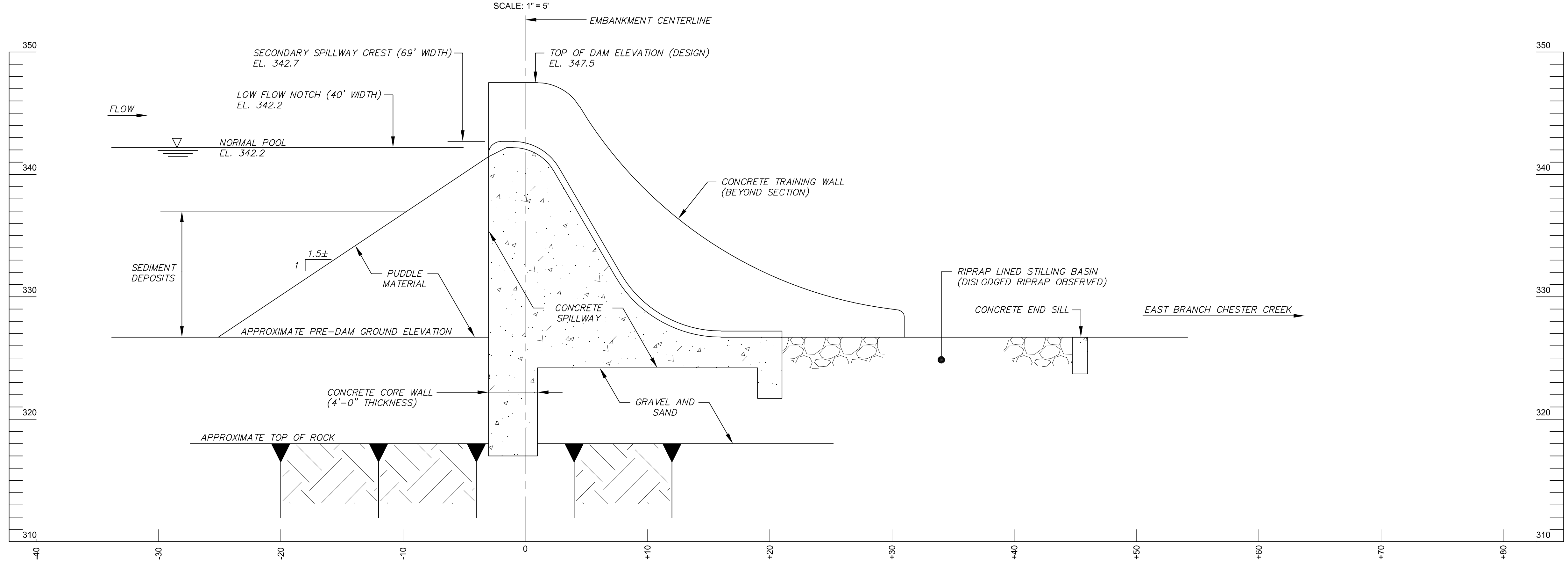
ENLARGED SITE PLAN
EXISTING CONDITIONS

JOB NO. 60466
SHEET NO. B2
DATE FEB. 2016
DRAWING NO.



TYPICAL EMBANKMENT CROSS SECTION - SECTION A-A

SCALE: 1" = 5'



TYPICAL SPILLWAY CROSS SECTION - SECTION B-B

SCALE: 1" = 5'

SHEET NOTES:

1. LOCATION AND DIMENSIONS OF SUBSURFACE FEATURES SUCH AS THE CONCRETE CORE WALL, SPILLWAY FOUNDATION, BEDROCK, ETC. HAVE BEEN TAKEN FROM THE ORIGINAL CONSTRUCTION DRAWINGS AS PREPARED BY FRANKLIN AND COMPANY DATED JUNE 14, 1920 AND AS REVISED BY REMINGTON AND VOSBURY DATED FEBRUARY 20, 1923. SUBSURFACE FACILITIES HAVE NOT BEEN SURVEYED OR OTHERWISE VERIFIED BY GANNETT FLEMING. GANNETT FLEMING MAKES NO GUARANTEE TO THE ACCURACY OR COMPLETENESS OF THE INFORMATION PORTRAYED.

5 -0- 5 10
SCALE IN FEET

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\EXISTING SITE PLAN.dwg
Plot Date: 2/25/2016 10:02 AM, Plotted By: Neast, Eric C.

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
XXX	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	ECN

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

TYPICAL CROSS SECTIONS

JOB NO.	SHEET NO.
60466	B3
DATE	DRAWING NO.
FEB. 2016	

APPENDIX C
SITE PHOTOGRAPHS

Photo C-1
Standing on Reservoir Road looking across top of dam towards left abutment.

Photo C-2
Looking across upstream face of dam towards left abutment.

Photographs provided in Appendix C were taken on August 4, 2015.

Photo C-3
Looking across downstream face of dam towards left abutment.

Photo C-4
Looking upstream at downstream face of principal spillway.

Photo C-5
Looking across the Principal Spillway crest towards left abutment.

Photo C-6
View of Valve House.

Photo C-7
View of interior of Valve House and upstream gate operators.

Photo C-8
Looking across downstream face of dam towards right abutment.

Photo C-9
Looking across upstream face of dam towards right abutment.

Photo C-10
Looking downstream at receiving channel (i.e., East Branch Chester Creek).

APPENDIX D
OPERATION AND MAINTENANCE COST BACKUP INFORMATION

1. Annual Dam Inspections

DEP requires high hazard dams to be inspected each year. Inspections include visual observation of the dam, vertification that public notices are posted, and submission of the annual dam inspection report to DEP by December 31st of each year.

East Goshen Township reports that the cost of the annual dam inspection, as performed by an outside consultant, was $2,000 in 2014 and $3,375 in 2015.
For the purpose of this exercise, assume a price of $3,000 for the annual dam inspection.

Estimated Annual Cost (2015 Base Year Cost Level): $3,000

2. Update Emergency Action Plan

The Emergency Action Plan for Hazard Potential Category 1, 2 or 3 Dams shall be reviewed and updated once every five years in accordance with Chapter 105, Section 105.134.(f). Based on recent experience with similar EAP updates, assume approximately $5,000 per update.

Estimated Project Costs for EAP Update (2015 Base Year Cost Level): $5,000
Once Every Five Years

3. PADEP Dam Owner Annual Fee

Per Chapter 105, Section 105.13.(a), "*An application for a permit, registration for a general permit, request for permit amendment, major or minor letter of amendment or authorization, major dam design revision, environmental assessments, permit transfer or annual dam registration under this chapter shall be accompanied by a check for the applicable fees* ***except for submissions by Federal , State, county or municipal agencies or a municipal authority.*** "

As such, East Goshen Township is exempt from the annual dam registrations fee.

Estimated Cost for Annual Dam Registration (2015 Base Year Cost Level): $0

4. Low Level Outlet Works Inspection

DEP typically requires video inspection of the low level outlet works once every ten years. Such an inspection for Milltown Dam will require a dive team (assume one day), confined space observation of the valve vault, swimmer and crawler ROV inspection of the upstream / downstream piping syetems, inspection oversight by a Professional Engineer, and submission of a report to DEP.
Based on recent experience with similar video conduit inspections assume $15,000 per inspection.

Estimated Cost for Low Level Outlet Works Inspection (2015 Base Year Cost Level): $15,000

5. Operation and Maintenance Plan

Should the Township continue to maintain Milltown Dam as a regulated structure, an Operation and Maintenance (O&M) Manual should be prepared in accordance with the Chapter 105 rules and regulations. O&M Manuals can vary in their complexity and level of detail depending on the type of dam and the various features of the dam. For the purpose of this study, a cost of $10,000 is allocated to prepare the O&M Manual.

Estimated Cost to Prepare O&M Manual (2015 Base Year Cost Level): $10,000

1. Weekly Site Visits

At a minimum, it is recommended that Milltown Dam be visited once a week to view the condition of the dam, confirm that there are no obstructions or debris which would reduce the conveyance capacity of the dam, verify public safety features are in place and look for unauthorized activity.

Assume this task can be accomplished by Township maintenance personnel. Assume one individual in a pickup truck which an allocation of one hour per site visit.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel (1)	52	$35.83	$1,863.16
Vehicle (Pickup Truck)	52	$47.83	$2,487.16

Estimated Annual Cost (2015 Base Year Cost Level): $4,350

2. Control of Vegetation (i.e., grass, weeds, brush and woody vegetation)

The Township reports that they typically have two deployments to the dam each year to manage vegetation, including tree and brush removal. The Township also sprays the dam two times each year to control weed growth. Historic maintenance costs associated with vegetation control, as reported by the Township, are as follows:

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	40	$35.83	$1,433.20
(5 People at 4 Hours Each Deployment)			
Vehicle (Pickup Truck)	8	$47.83	$382.64
Spray Dam for Weed Control (Assume a Lump Sum Price)			$1,050.00

Estimated Annual Costs for Control of Vegetation (2015 Base Year Cost Level): $2,866

Say $2,900

3. Exercise Valves

The Township reports that the two operable sluice gates within the Valve Chamber are exercised four times per year. It is reported that this task is accomplished by Township personnel and that it takes two individuals one hour to perform the task.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	8	$35.83	$286.64
(2 People at 1 Hour Each per Deployment x 4 Deployments per Year)			
Vehicle (Pickup Truck)	4	$47.83	$191.32

Estimated Annual Cost to Exercise Valves (2015 Base Year Cost Level): $478

Say $500

4. EAP Monitoring

The Township reports that they monitor the dam and associated reservoir level during significant rainfall events. The magnitude of this effort will vary depending on the intensity and duration of the storm event. For the purpose of this analysis, assume that the Township responds to two storm events each year. Two Township maintenance personnel will visit the dam four times throughout the duration of each storm, with one hour allocated for each deployment.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	16	$35.83	$573.28
(2 People at 1 Hour Each per Deployment x 4 Deployments per Storm x 2 Storms per Year)			
Vehicle (Pickup Truck)	8	$47.83	$382.64

Estimated Cost for Low Level Outlet Works Inspection (2015 Base Year Cost Level): $956

Say $950

**Hourly rates for Maintenance Personnel and Pickup Truck provided by East Goshen Township. Rates represent 2015 calendar year rates.*

1. Removal of Vegetation

The 2015 annual inspection identified areas of woody vegetation growth at the left and right abutments. It is recommended that trees, shrubs, weeds and other unwanted vegetation be removed. It is assumed that this activity can be performed by Township maintenance personnel. Assume work can be completed in two days by a six man crew with two pickup trucks, plus rental of a brush chipper and stump chipper.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	96	$35.83	$3,439.68
(Assume a 6 man crew for two days)			
Vehicle (Pickup Truck)	16	$47.83	$765.28
Brush Chipper and Operator (1)	1 Day	$1,040	$1,040.00
Stump Chipper and Operator (2)	1 Day	$820	$820.00
Estimated Cost to Remove Woody Vegetation (2015 Base Year Cost Level):			**$6,065**
			Say $6,100

1. *Refer to Means 2015, Crew B-7 for Brush Chipper costs.*
2. *Refer to Means 2015, Crew B-86 for Stump Chipper costs.*

2. Repair Chain Link Fence Support Rail

The 2015 annual inspection identified a damaged/missing top support rail on the chain link fence immediately adjacent to the Valve House. Assume that this can be repaired by Township maintenance personnel. Assume work can be completed within two hours using a two man crew.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	4	$35.83	$143.32
(Assume a 2 man crew for two hours)			
Vehicle (Pickup Truck)	2	$47.83	$95.66
Maiscellaneous Material	1 Lump Sum	$100	$100.00
Estimated Cost to Repair Fence (2015 Base Year Cost Level):			**$339**
			Say $400

3. Repair Concrete Spalls on Right Spillway Training Wall and on Valve Manhole

The 2015 annual inspection identified several concrete spalls on the downstream right spillway training wall and loss of mortar around the frame and cover of the valve manhole on the 24-inch low level discharge pipe. Assume these repairs can be completed by Township maintenance personnel. Work will involve removal of loose material, cleaning/preparation of surfaces and patching with a cementious mortar. Assume a two man crew can complete this work in one day.

Workforce Description	Hours	Rate*	Total Cost
Maintenance Personnel	16	$35.83	$573.28
(Assume a 2 man crew for eight hours)			
Vehicle (Pickup Truck)	8	$47.83	$382.64
Maiscellaneous Material	1 Lump Sum	$250	$250.00
Estimated Cost to Repair Concrete (2015 Base Year Cost Level):			**$1,206**
			Say $1,200

4. Replace Dislodged Riprap at Downstream Toe of Principal Spillway

The 2015 annual inspection identified dislodged and missing riprap within the stilling basin located immediately downstream of the principal spillway. The dislodged riprap has been moved downstream by high spillway flows. It is recommended that the scour protection be replaced or alternate methods implemented to prevent scour and undermining of the principal spillway. For the purpose of establishing a cost of this repair, it is assumed that the missing riprap will be refreshed by moving riprap found within the stream back into the stilling basin. For the purpose of this cost estimate, it is assumed that this work will be performed by a Contractor and not by Township forces. Assume work can be completed within one week which includes mobilization, developing site access, performing instream work activities, site cleanup/stabilization and demobilization activities.

Workforce Description	Hours	Rate*	Total Cost
Regulation of Normal Pool	8	$35.83	$286.64
(Assume 2 Township workers x 4 hours to regulate and lower reservoir)			
Vehicle (Pickup Truck)	4	$47.83	$191.32
Contractor Work Crew (say two days)**	2 Days	$3,500	$7,000.00
Miscelleanous Materials / Site Access	1 Lump Sum	$1,000	$1,000.00
Mob and Demob / Site Stabilization	1 Lump Sum	$500	$500.00
Estimated Cost to Replace Dislodged Riprap (2015 Base Year Cost Level):			**$8,977.96**
			Say $10,000

***Assume a Crew B-14 from Means 2015 (Backhoe, Operator, Foreman and 4 Laborers)*

5. Replace Sluice Gates (2) within Valve Chamber

The Township has identified a need to replace the two upstream sluice gates located within the Valve Chamber. The Township received bids for this work in 2014 which ranged between $70,620 and $113,400. For the purpose of this study, it is assumed that the replacement of the two sluice gates will be required should the Township choose to maintain the dam. Based on the historic bid prices from 2014, assume a cost of $90,000 for this work activity (average of high and low bids).

Estimated Cost to Replace Sluice Gates (2015 Base Year Cost Level): $90,000

6. Instrumentation

It is recommended that a staff gauge be added closer to the right abutment of the dam. It is anticipated that the staff gauge will be an aluminum u-channel with painted markings. The u-channel will be supported by a concrete foundation placed along the shoreline and extended below the frost line to prevent movement of the staff gauge.

Assume material costs (i.e., concrete base and staff gauge) are approximately $500
Assume Contractor time to pour foundation and set staff gauge (say 1.5 days with a 3-man crew)
Say $3,000
Assume a Survey Crew to set staff gauge at proper elevation (say 0.5 days with a 2-man crew)
Say $1,000

Total Cost for Staff Gauge is approximately $4,500

7. Site Security

It is recommended that additional signage be added around the dam to warn the public of the dangers associated with the dam.

Assume material costs (i.e., signs and support posts) are approximately $500
Assume Contractor time to install signs (say 0.5 days with a 3-man crew)
Say $1,050

Total Cost for Signage is approximately $1,500

EAST GOSHEN TOWNSHIP

MILLTOWN DAM - SUMMARY OF ANTICIPATED OPERATION AND MAINTENANCE COSTS - CURRENT CONDITIONS

Basic Parameters:

Annual Inflation Rate: 3.0% percent

Rate of Return: 1.0% percent

Year	Regulatory Complaince			Routine Operation and Maintenance				Total Cost	
	Annual Inspection	Update EAP	Outlet Works Inspection	Weekly Site Visits	Weed / Brush Control	Valve Operation	EAP Monitoring	Future Worth	Present Worth
2015	$3,000	$5,000	$15,000	$4,350	$2,900	$500	$950	$31,700	$31,700
2016	$3,090			$4,481	$2,987	$515	$979	$12,051	$11,932
2017	$3,183			$4,615	$3,077	$530	$1,008	$12,413	$12,168
2018	$3,278			$4,753	$3,169	$546	$1,038	$12,785	$12,409
2019	$3,377			$4,896	$3,264	$563	$1,069	$13,168	$12,655
2020	$3,478	$5,796		$5,043	$3,362	$580	$1,101	$19,360	$18,420
2021	$3,582			$5,194	$3,463	$597	$1,134	$13,970	$13,161
2022	$3,690			$5,350	$3,567	$615	$1,168	$14,390	$13,421
2023	$3,800			$5,510	$3,674	$633	$1,203	$14,821	$13,687
2024	$3,914			$5,676	$3,784	$652	$1,240	$15,266	$13,958
								Total Present Worth Operating Cost (10-Year Life):	**$153,511**
2025	$4,032	$6,720	$20,159	$5,846	$3,897	$672	$1,277	$42,602	$38,567
2026	$4,153			$6,021	$4,014	$692	$1,315	$16,196	$14,516
2027	$4,277			$6,202	$4,135	$713	$1,354	$16,681	$14,804
2028	$4,406			$6,388	$4,259	$734	$1,395	$17,182	$15,097
2029	$4,538			$6,580	$4,387	$756	$1,437	$17,697	$15,396
2030	$4,674	$7,790		$6,777	$4,518	$779	$1,480	$26,018	$22,411
2031	$4,814			$6,980	$4,654	$802	$1,524	$18,775	$16,012
2032	$4,959			$7,190	$4,793	$826	$1,570	$19,338	$16,329
2033	$5,107			$7,406	$4,937	$851	$1,617	$19,918	$16,652
2034	$5,261			$7,628	$5,085	$877	$1,666	$20,516	$16,982
								Total Present Worth Operating Cost (20-Year Life):	**$340,277**
2035	$5,418	$9,031	$27,092	$7,857	$5,238	$903	$1,716	$57,254	$46,922
2036	$5,581			$8,092	$5,395	$930	$1,767	$21,765	$17,661
2037	$5,748			$8,335	$5,557	$958	$1,820	$22,418	$18,011
2038	$5,921			$8,585	$5,723	$987	$1,875	$23,091	$18,368
2039	$6,098			$8,843	$5,895	$1,016	$1,931	$23,784	$18,731
2040	$6,281	$10,469		$9,108	$6,072	$1,047	$1,989	$34,966	$27,265
2041	$6,470			$9,381	$6,254	$1,078	$2,049	$25,232	$19,480
2042	$6,664			$9,663	$6,442	$1,111	$2,110	$25,989	$19,866
2043	$6,864			$9,952	$6,635	$1,144	$2,174	$26,769	$20,260
2044	$7,070			$10,251	$6,834	$1,178	$2,239	$27,572	$20,661
								Total Present Worth Operating Cost (30-Year Life):	**$567,502**

EAST GOSHEN TOWNSHIP

MILLTOWN DAM - SUMMARY OF ANTICIPATED OPERATION AND MAINTENANCE COSTS - ALTERNATES 1 THROUGH 5

Basic Parameters:

Annual Inflation Rate: 3.0% percent

Rate of Return: 1.0% percent

Year	Regulatory Complaince			Routine Operation and Maintenance				Total Cost	
	Annual Inspection	Update EAP	Outlet Works Inspection	Weekly Site Visits	Weed / Brush Control	Valve Operation	EAP Monitoring	Future Worth	Present Worth
2015	$3,000	$5,000	$15,000	$4,350	$2,900	$500	$950	$31,700	$31,700
2016	$3,090			$4,481	$2,987	$515	$979	$12,051	$11,932
2017	$3,183			$4,615	$3,077	$530	$1,008	$12,413	$12,168
2018	$3,278			$4,753	$3,169	$546	$1,038	$12,785	$12,409
2019	$3,377			$4,896	$3,264	$563	$1,069	$13,168	$12,655
2020	$3,478	$5,796		$5,043	$3,362	$580	$1,101	$19,360	$18,420
2021	$3,582			$5,194	$3,463	$597	$1,134	$13,970	$13,161
2022	$3,690			$5,350	$3,567	$615	$1,168	$14,390	$13,421
2023	$3,800			$5,510	$3,674	$633	$1,203	$14,821	$13,687
2024	$3,914			$5,676	$3,784	$652	$1,240	$15,266	$13,958
								Total Present Worth Operating Cost (10-Year Life):	**$153,511**
2025	$4,032	$6,720	$20,159	$5,846	$3,897	$672	$1,277	$42,602	$38,567
2026	$4,153			$6,021	$4,014	$692	$1,315	$16,196	$14,516
2027	$4,277			$6,202	$4,135	$713	$1,354	$16,681	$14,804
2028	$4,406			$6,388	$4,259	$734	$1,395	$17,182	$15,097
2029	$4,538			$6,580	$4,387	$756	$1,437	$17,697	$15,396
2030	$4,674	$7,790		$6,777	$4,518	$779	$1,480	$26,018	$22,411
2031	$4,814			$6,980	$4,654	$802	$1,524	$18,775	$16,012
2032	$4,959			$7,190	$4,793	$826	$1,570	$19,338	$16,329
2033	$5,107			$7,406	$4,937	$851	$1,617	$19,918	$16,652
2034	$5,261			$7,628	$5,085	$877	$1,666	$20,516	$16,982
								Total Present Worth Operating Cost (20-Year Life):	**$340,277**
2035	$5,418	$9,031	$27,092	$7,857	$5,238	$903	$1,716	$57,254	$46,922
2036	$5,581			$8,092	$5,395	$930	$1,767	$21,765	$17,661
2037	$5,748			$8,335	$5,557	$958	$1,820	$22,418	$18,011
2038	$5,921			$8,585	$5,723	$987	$1,875	$23,091	$18,368
2039	$6,098			$8,843	$5,895	$1,016	$1,931	$23,784	$18,731
2040	$6,281	$10,469		$9,108	$6,072	$1,047	$1,989	$34,966	$27,265
2041	$6,470			$9,381	$6,254	$1,078	$2,049	$25,232	$19,480
2042	$6,664			$9,663	$6,442	$1,111	$2,110	$25,989	$19,866
2043	$6,864			$9,952	$6,635	$1,144	$2,174	$26,769	$20,260
2044	$7,070			$10,251	$6,834	$1,178	$2,239	$27,572	$20,661
								Total Present Worth Operating Cost (30-Year Life):	**$567,502**

Deferred Operation and Maintenance Costs	
Removal of Vegetation (per 2015 Annual Inspection)	$0
Repair Chain Link Fence (per 2015 Annual Inspection)	$0
Repair Concrete Spalls (per 2015 Annual Inspection)	$0
Replace Dislodged Riprap below Spillway	$0
Replace Sluice Gates (2) within Valve Chamber	$0
Prepare Operation and Maintenance Manual	$10,000
Instrumentation and Site Security	$6,000
Total Deferred Operation and Maintenance Costs:	**$16,000**

Total Present Worth O&M Cost (10-Year Life)	**$169,500**
Total Present Worth O&M Cost (20-Year Life)	**$356,300**
Total Present Worth O&M Cost (30-Year Life)	**$583,500**

EAST GOSHEN TOWNSHIP
MILLTOWN DAM - SUMMARY OF ANTICIPATED OPERATION AND MAINTENANCE COSTS - ALTERNATES 6 and 7

Basic Parameters:

Annual Inflation Rate: 3.0% percent
Rate of Return: 1.0% percent

Year	Regulatory Complaince			Routine Operation and Maintenance				Total Cost	
	Annual Inspection	Update EAP	Outlet Works Inspection	Weekly Site Visits	Weed / Brush Control	Valve Operation	EAP Monitoring	Future Worth	Present Worth
2015	$3,000	$5,000	$15,000	$4,350	$2,900	$500	$950	$31,700	$31,700
2016	$3,090			$4,481	$2,987	$515	$979	$12,051	$11,932
2017	$3,183			$4,615	$3,077	$530	$1,008	$12,413	$12,168
2018	$3,278			$4,753	$3,169	$546	$1,038	$12,785	$12,409
2019	$3,377			$4,896	$3,264	$563	$1,069	$13,168	$12,655
2020	$3,478	$5,796		$5,043	$3,362	$580	$1,101	$19,360	$18,420
2021	$3,582			$5,194	$3,463	$597	$1,134	$13,970	$13,161
2022	$3,690			$5,350	$3,567	$615	$1,168	$14,390	$13,421
2023	$3,800			$5,510	$3,674	$633	$1,203	$14,821	$13,687
2024	$3,914			$5,676	$3,784	$652	$1,240	$15,266	$13,958
								Total Present Worth Operating Cost (10-Year Life):	**$153,511**
2025	$4,032	$6,720	$20,159	$5,846	$3,897	$672	$1,277	$42,602	$38,567
2026	$4,153			$6,021	$4,014	$692	$1,315	$16,196	$14,516
2027	$4,277			$6,202	$4,135	$713	$1,354	$16,681	$14,804
2028	$4,406			$6,388	$4,259	$734	$1,395	$17,182	$15,097
2029	$4,538			$6,580	$4,387	$756	$1,437	$17,697	$15,396
2030	$4,674	$7,790		$6,777	$4,518	$779	$1,480	$26,018	$22,411
2031	$4,814			$6,980	$4,654	$802	$1,524	$18,775	$16,012
2032	$4,959			$7,190	$4,793	$826	$1,570	$19,338	$16,329
2033	$5,107			$7,406	$4,937	$851	$1,617	$19,918	$16,652
2034	$5,261			$7,628	$5,085	$877	$1,666	$20,516	$16,982
								Total Present Worth Operating Cost (20-Year Life):	**$340,277**
2035	$5,418	$9,031	$27,092	$7,857	$5,238	$903	$1,716	$57,254	$46,922
2036	$5,581			$8,092	$5,395	$930	$1,767	$21,765	$17,661
2037	$5,748			$8,335	$5,557	$958	$1,820	$22,418	$18,011
2038	$5,921			$8,585	$5,723	$987	$1,875	$23,091	$18,368
2039	$6,098			$8,843	$5,895	$1,016	$1,931	$23,784	$18,731
2040	$6,281	$10,469		$9,108	$6,072	$1,047	$1,989	$34,966	$27,265
2041	$6,470			$9,381	$6,254	$1,078	$2,049	$25,232	$19,480
2042	$6,664			$9,663	$6,442	$1,111	$2,110	$25,989	$19,866
2043	$6,864			$9,952	$6,635	$1,144	$2,174	$26,769	$20,260
2044	$7,070			$10,251	$6,834	$1,178	$2,239	$27,572	$20,661
								Total Present Worth Operating Cost (30-Year Life):	**$567,502**

Deferred Operation and Maintenance Costs	
Removal of Vegetation (per 2015 Annual Inspection)	$0
Repair Chain Link Fence (per 2015 Annual Inspection)	$400
Repair Concrete Spalls (per 2015 Annual Inspection)	$0
Replace Dislodged Riprap below Spillway	$0
Replace Sluice Gates (2) within Valve Chamber	$90,000
Prepare Operation and Maintenance Manual	$10,000
Instrumentation and Site Security	$6,000
Total Deferred Operation and Maintenance Costs:	**$106,400**

Total Present Worth O&M Cost (10-Year Life)	**$259,900**
Total Present Worth O&M Cost (20-Year Life)	**$446,700**
Total Present Worth O&M Cost (30-Year Life)	**$673,900**

EAST GOSHEN TOWNSHIP

MILLTOWN DAM - SUMMARY OF ANTICIPATED OPERATION AND MAINTENANCE COSTS - ALTERNATE 9

Basic Parameters:

Annual Inflation Rate: 3.0% percent
Rate of Return: 1.0% percent

Year	Regulatory Complaince			Routine Operation and Maintenance				Total Cost	
	Annual Inspection	Update EAP	Outlet Works Inspection	Weekly Site Visits	Weed / Brush Control	Valve Operation	EAP Monitoring	Future Worth	Present Worth
2015	$3,000	$5,000	$0	$4,350	$2,900	$0	$950	$16,200	$16,200
2016	$3,090			$4,481	$2,987	$0	$979	$11,536	$11,422
2017	$3,183			$4,615	$3,077	$0	$1,008	$11,882	$11,648
2018	$3,278			$4,753	$3,169	$0	$1,038	$12,239	$11,879
2019	$3,377			$4,896	$3,264	$0	$1,069	$12,606	$12,114
2020	$3,478	$5,796		$5,043	$3,362	$0	$1,101	$18,780	$17,869
2021	$3,582			$5,194	$3,463	$0	$1,134	$13,373	$12,598
2022	$3,690			$5,350	$3,567	$0	$1,168	$13,775	$12,848
2023	$3,800			$5,510	$3,674	$0	$1,203	$14,188	$13,102
2024	$3,914			$5,676	$3,784	$0	$1,240	$14,613	$13,362
								Total Present Worth Operating Cost (10-Year Life):	**$133,041**
2025	$4,032	$6,720	$0	$5,846	$3,897	$0	$1,277	$21,771	$19,709
2026	$4,153			$6,021	$4,014	$0	$1,315	$15,503	$13,896
2027	$4,277			$6,202	$4,135	$0	$1,354	$15,969	$14,171
2028	$4,406			$6,388	$4,259	$0	$1,395	$16,448	$14,452
2029	$4,538			$6,580	$4,387	$0	$1,437	$16,941	$14,738
2030	$4,674	$7,790		$6,777	$4,518	$0	$1,480	$25,239	$21,740
2031	$4,814			$6,980	$4,654	$0	$1,524	$17,973	$15,328
2032	$4,959			$7,190	$4,793	$0	$1,570	$18,512	$15,631
2033	$5,107			$7,406	$4,937	$0	$1,617	$19,067	$15,941
2034	$5,261			$7,628	$5,085	$0	$1,666	$19,639	$16,256
								Total Present Worth Operating Cost (20-Year Life):	**$294,903**
2035	$5,418	$9,031	$0	$7,857	$5,238	$0	$1,716	$29,259	$23,979
2036	$5,581			$8,092	$5,395	$0	$1,767	$20,835	$16,906
2037	$5,748			$8,335	$5,557	$0	$1,820	$21,460	$17,241
2038	$5,921			$8,585	$5,723	$0	$1,875	$22,104	$17,583
2039	$6,098			$8,843	$5,895	$0	$1,931	$22,767	$17,931
2040	$6,281	$10,469		$9,108	$6,072	$0	$1,989	$33,919	$26,449
2041	$6,470			$9,381	$6,254	$0	$2,049	$24,154	$18,648
2042	$6,664			$9,663	$6,442	$0	$2,110	$24,878	$19,017
2043	$6,864			$9,952	$6,635	$0	$2,174	$25,625	$19,394
2044	$7,070			$10,251	$6,834	$0	$2,239	$26,394	$19,778
								Total Present Worth Operating Cost (30-Year Life):	**$491,828**

Deferred Operation and Maintenance Costs	
Removal of Vegetation (per 2015 Annual Inspection)	$6,100
Repair Chain Link Fence (per 2015 Annual Inspection)	$400
Repair Concrete Spalls (per 2015 Annual Inspection)	$1,200
Replace Dislodged Riprap below Spillway	$10,000
Replace Sluice Gates (2) within Valve Chamber	$0
Prepare Operation and Maintenance Manual	$10,000
Instrumentation and Site Security	$6,000
Total Deferred Operation and Maintenance Costs:	**$33,700**

Total Present Worth O&M Cost (10-Year Life)	**$166,700**
Total Present Worth O&M Cost (20-Year Life)	**$328,600**
Total Present Worth O&M Cost (30-Year Life)	**$525,500**

EAST GOSHEN TOWNSHIP

MILLTOWN DAM - SUMMARY OF ANTICIPATED OPERATION AND MAINTENANCE COSTS - ALTERNATE 10

Basic Parameters:

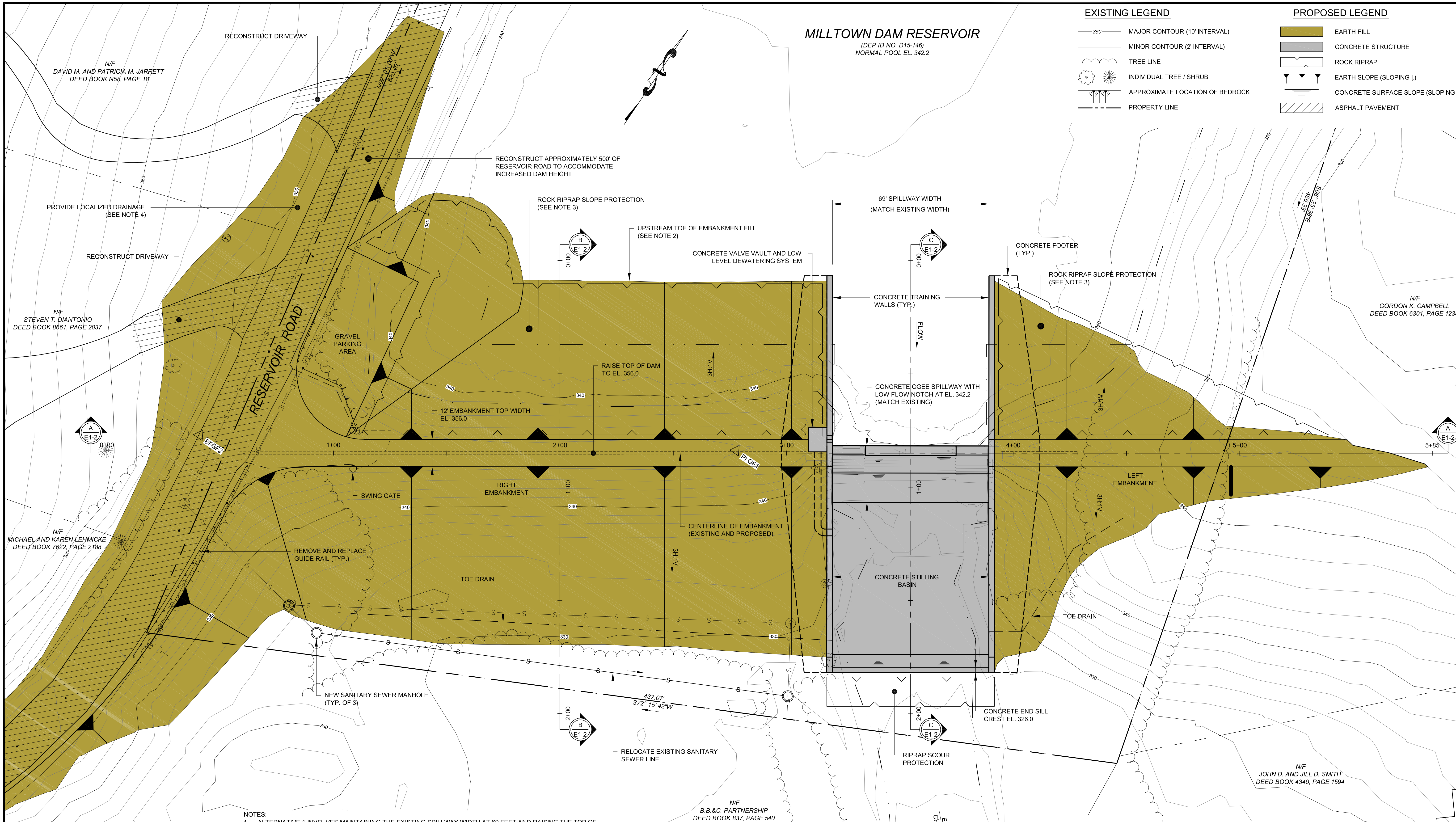
Annual Inflation Rate: 3.0% percent
Rate of Return: 1.0% percent

Year	Regulatory Complaince			Routine Operation and Maintenance				Total Cost	
	Annual Inspection	Update EAP	Outlet Works Inspection	Weekly Site Visits	Weed / Brush Control	Valve Operation	EAP Monitoring	Future Worth	Present Worth
2015	$0	$0	$0	$4,350	$2,900	$0	$950	$8,200	$8,200
2016	$0			$4,481	$2,987	$0	$979	$8,446	$8,362
2017	$0			$4,615	$3,077	$0	$1,008	$8,699	$8,528
2018	$0			$4,753	$3,169	$0	$1,038	$8,960	$8,697
2019	$0			$4,896	$3,264	$0	$1,069	$9,229	$8,869
2020	$0	$0		$5,043	$3,362	$0	$1,101	$9,506	$9,045
2021	$0			$5,194	$3,463	$0	$1,134	$9,791	$9,224
2022	$0			$5,350	$3,567	$0	$1,168	$10,085	$9,406
2023	$0			$5,510	$3,674	$0	$1,203	$10,388	$9,593
2024	$0			$5,676	$3,784	$0	$1,240	$10,699	$9,783
Total Present Worth Operating Cost (10-Year Life):									**$89,706**
2025	$0	$0	$0	$5,846	$3,897	$0	$1,277	$11,020	$9,976
2026	$0			$6,021	$4,014	$0	$1,315	$11,351	$10,174
2027	$0			$6,202	$4,135	$0	$1,354	$11,691	$10,375
2028	$0			$6,388	$4,259	$0	$1,395	$12,042	$10,581
2029	$0			$6,580	$4,387	$0	$1,437	$12,403	$10,790
2030	$0	$0		$6,777	$4,518	$0	$1,480	$12,775	$11,004
2031	$0			$6,980	$4,654	$0	$1,524	$13,159	$11,222
2032	$0			$7,190	$4,793	$0	$1,570	$13,553	$11,444
2033	$0			$7,406	$4,937	$0	$1,617	$13,960	$11,671
2034	$0			$7,628	$5,085	$0	$1,666	$14,379	$11,902
Total Present Worth Operating Cost (20-Year Life):									**$198,846**
2035	$0	$0	$0	$7,857	$5,238	$0	$1,716	$14,810	$12,138
2036	$0			$8,092	$5,395	$0	$1,767	$15,254	$12,378
2037	$0			$8,335	$5,557	$0	$1,820	$15,712	$12,623
2038	$0			$8,585	$5,723	$0	$1,875	$16,183	$12,873
2039	$0			$8,843	$5,895	$0	$1,931	$16,669	$13,128
2040	$0	$0		$9,108	$6,072	$0	$1,989	$17,169	$13,388
2041	$0			$9,381	$6,254	$0	$2,049	$17,684	$13,653
2042	$0			$9,663	$6,442	$0	$2,110	$18,215	$13,923
2043	$0			$9,952	$6,635	$0	$2,174	$18,761	$14,199
2044	$0			$10,251	$6,834	$0	$2,239	$19,324	$14,480
Total Present Worth Operating Cost (30-Year Life):									**$331,629**

Deferred Operation and Maintenance Costs	
Removal of Vegetation (per 2015 Annual Inspection)	$6,100
Repair Chain Link Fence (per 2015 Annual Inspection)	$400
Repair Concrete Spalls (per 2015 Annual Inspection)	$1,200
Replace Dislodged Riprap below Spillway	$10,000
Replace Sluice Gates (2) within Valve Chamber	$0
Prepare Operation and Maintenance Manual	$0
Instrumentation and Site Security	$6,000
Total Deferred Operation and Maintenance Costs:	**$23,700**

Total Present Worth O&M Cost (10-Year Life)	**$113,400**
Total Present Worth O&M Cost (20-Year Life)	**$222,500**
Total Present Worth O&M Cost (30-Year Life)	**$355,300**

APPENDIX E
CONCEPTUAL DESIGN DRAWINGS FOR INCREASING CONVEYANCE CAPACITY



NOTES:

1. ALTERNATIVE 1 INVOLVES MAINTAINING THE EXISTING SPILLWAY WIDTH AT 69 FEET AND RAISING THE TOP OF DAM TO ELEVATION 356.0 IN ORDER TO PASS THE SPILLWAY DESIGN FLOOD THROUGH THE SPILLWAY WITHOUT OVERTOPPING THE DAM.
2. REMOVE ALL SEDIMENT DEPOSITS FROM BENEATH THE FOOTPRINT OF THE PROPOSED EMBANKMENT.
3. REMOVE AND SALVAGE RIPRAP FROM THE EXISTING UPSTREAM AND DOWNSTREAM EMBANKMENT SLOPES FOR USE AS WAVE PROTECTION ON THE PROPOSED UPSTREAM EMBANKMENT SLOPE.
4. PROVIDE LOCALIZED DRAINAGE (I.E., SWALES, DRIVEWAY CULVERTS, ETC.) ALONG THE WEST SIDE OF RESERVOIR ROAD.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

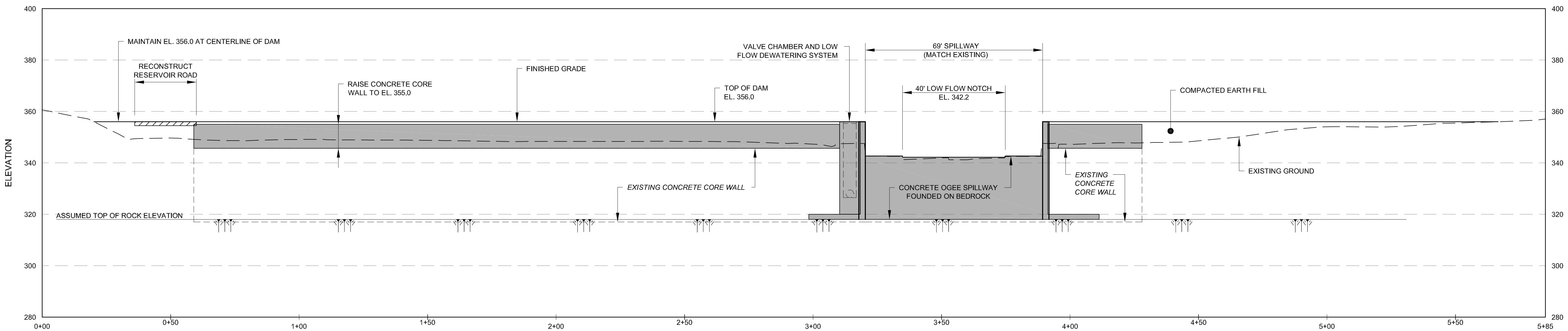
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

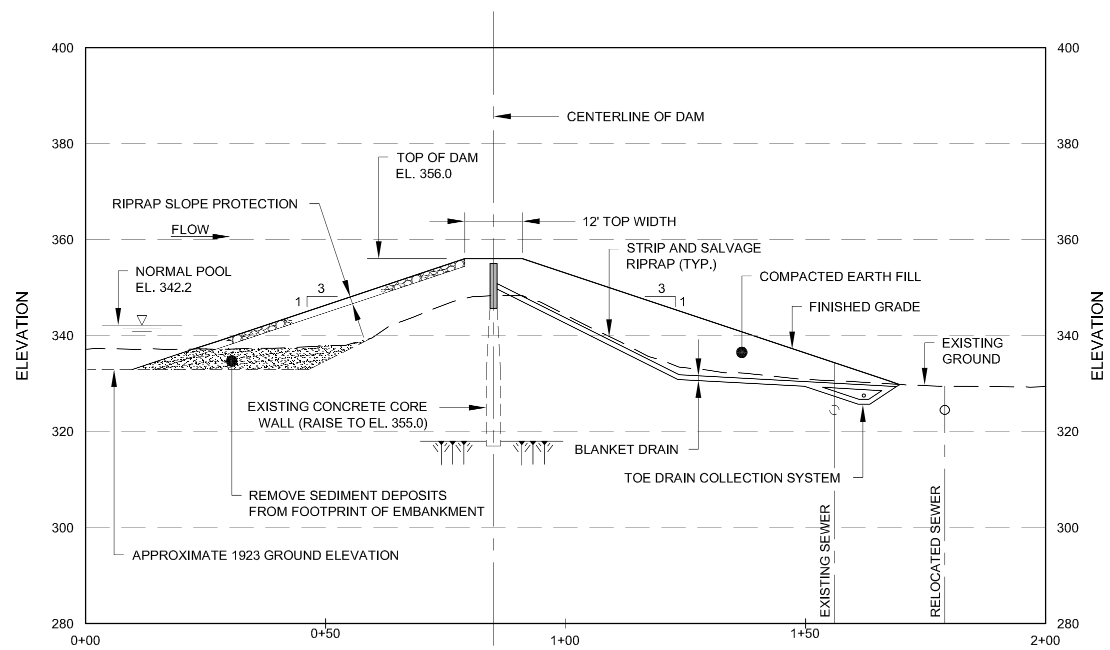
MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 1
INCREASE EMBANKEMNT HEIGHT
PLAN VIEW

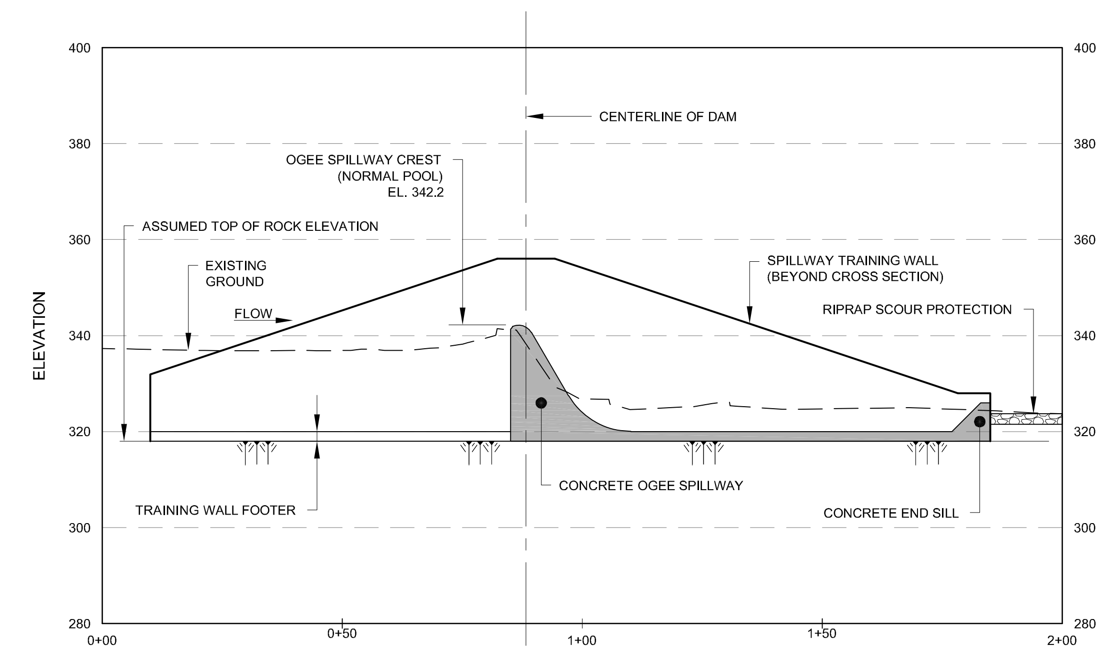
JOB NO.	SHEET NO.
60466	E1-1
DATE	DRAWING NO.
FEB 2016	



CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)
SCALE: 1" = 20'



EMBANKMENT SECTION B-B
SCALE: 1" = 20'



SPILLWAY SECTION C-C
SCALE: 1" = 20'

NOTES:
1. REFER TO SHEET E1-1 FOR ALTERNATIVE 1 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40
SCALE IN FEET

CONCEPT PLAN

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 1.dwg
Plot Date: 2/16/2016 8:18 AM, Plotted By: Nead, Eric C.

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

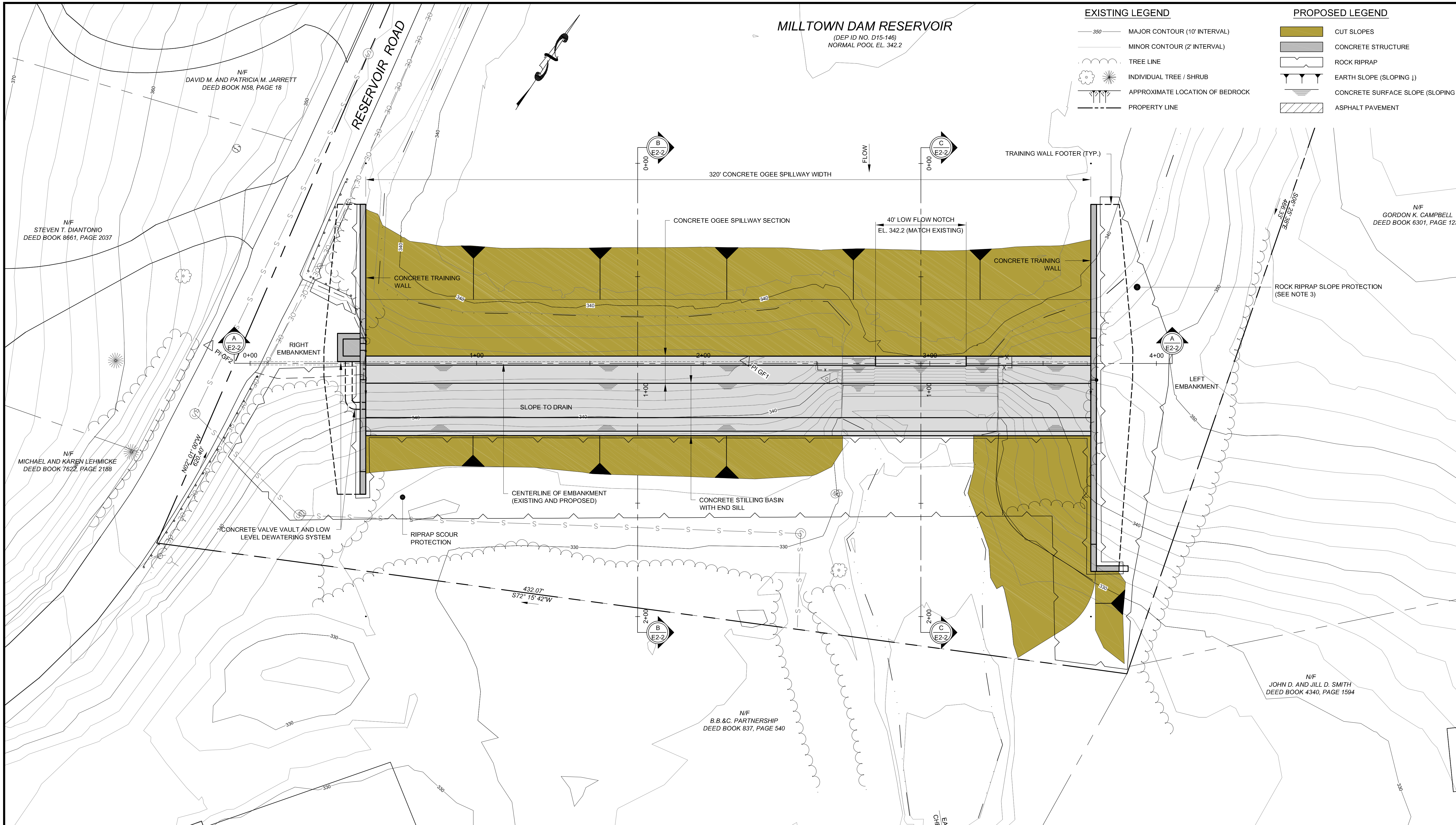
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 1
INCREASE EMBANKEMNT HEIGHT
SECTIONS

JOB NO.	SHEET NO.
60466	E1-2
DATE	DRAWING NO.
FEB 2016	



NOTES:

1. ALTERNATIVE 2 INVOLVES MAINTAINING THE EXISTING NORMAL POOL AND TOP OF DAM ELEVATIONS AND INCREASING THE LENGTH OF THE SPILLWAY TO 320 FEET IN ORDER TO PASS THE SPILLWAY DESIGN FLOOD THROUGH THE SPILLWAY WITHOUT OVERTOPPING THE DAM.
2. CONCRETE OGEE SPILLWAY AND TRAINING WALLS TO BE FOUNDED ON BEDROCK.
3. REMOVE AND SALVAGE RIPRAP FROM THE EXISTING UPSTREAM AND DOWNSTREAM EMBANKMENT SLOPES FOR USE AS SCOUR PROPECTION ON FINAL SLOPES.

CONCEPT PLAN

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 2.dwg
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NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

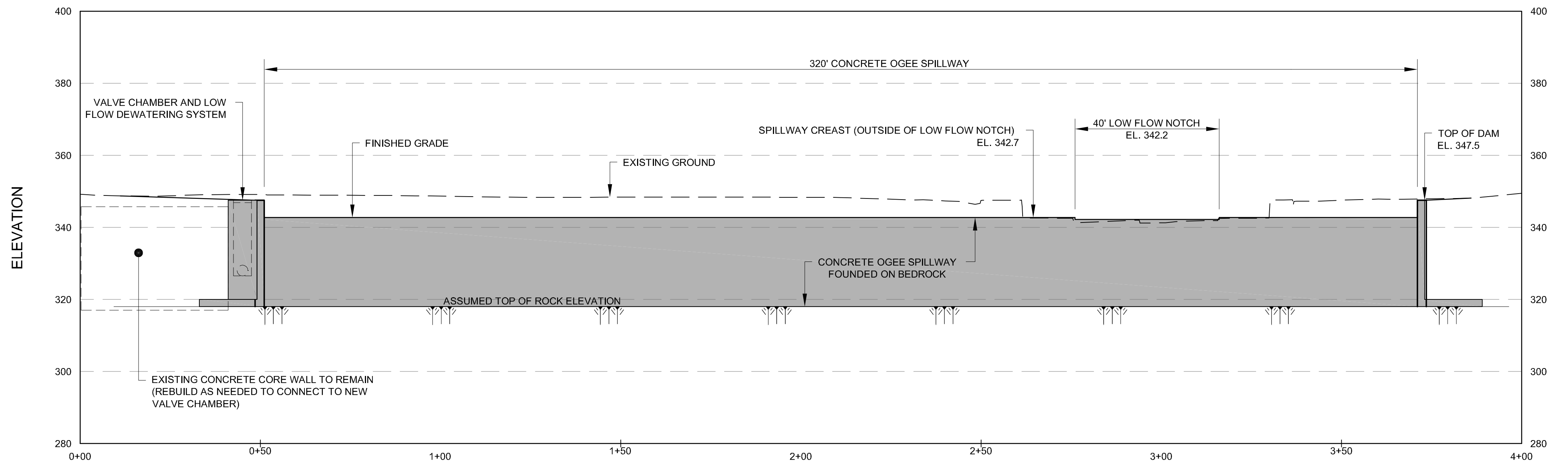
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

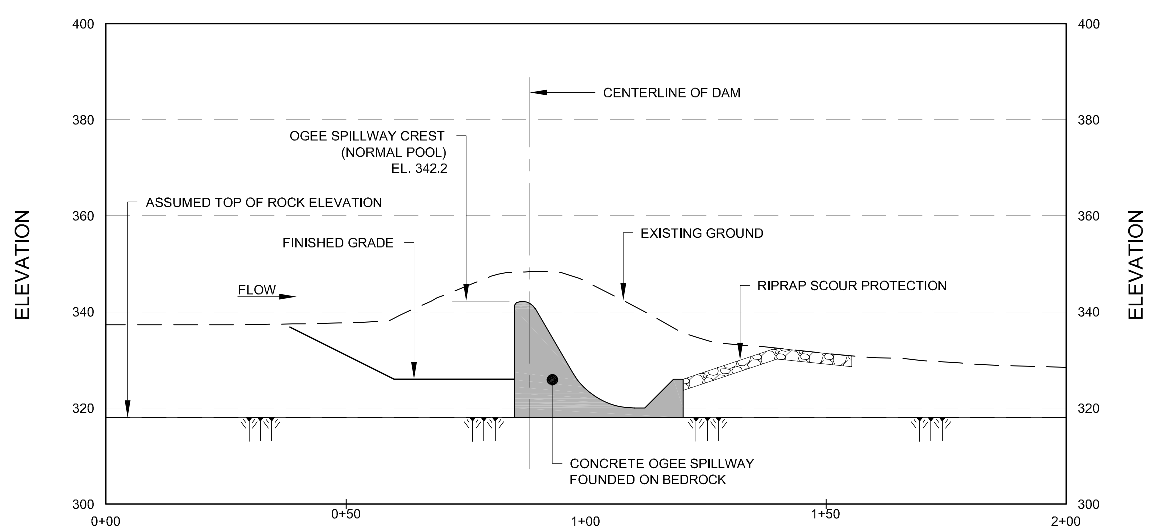
ALTERNATIVE 2
INCREASE SPILLWAY LENGTH
PLAN VIEW

JOB NO.	SHEET NO.
60466	E2-1
DATE	DRAWING NO.
FEB 2016	



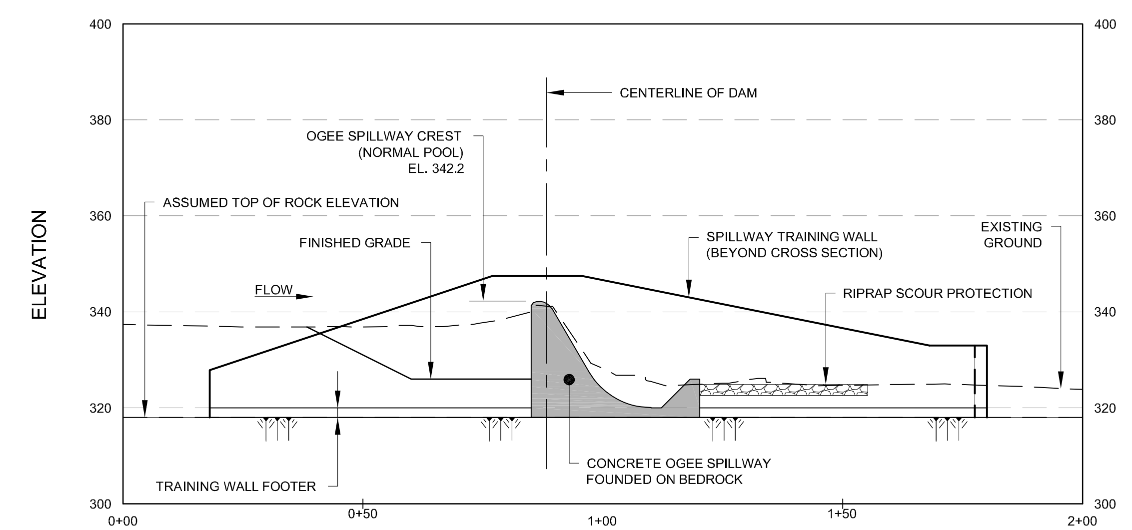
CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)

SCALE: 1" = 20'



SPILLWAY SECTION B-B

SCALE: 1" = 20'



SPILLWAY SECTION C-C

SCALE: 1" = 20'

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CONCEPT PLAN

NOTES:
1. REFER TO SHEET E2-1 FOR ALTERNATIVE 2 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40
SCALE IN FEET

NO.	DESCRIPTION	DATE	BY
REVISIONS			

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

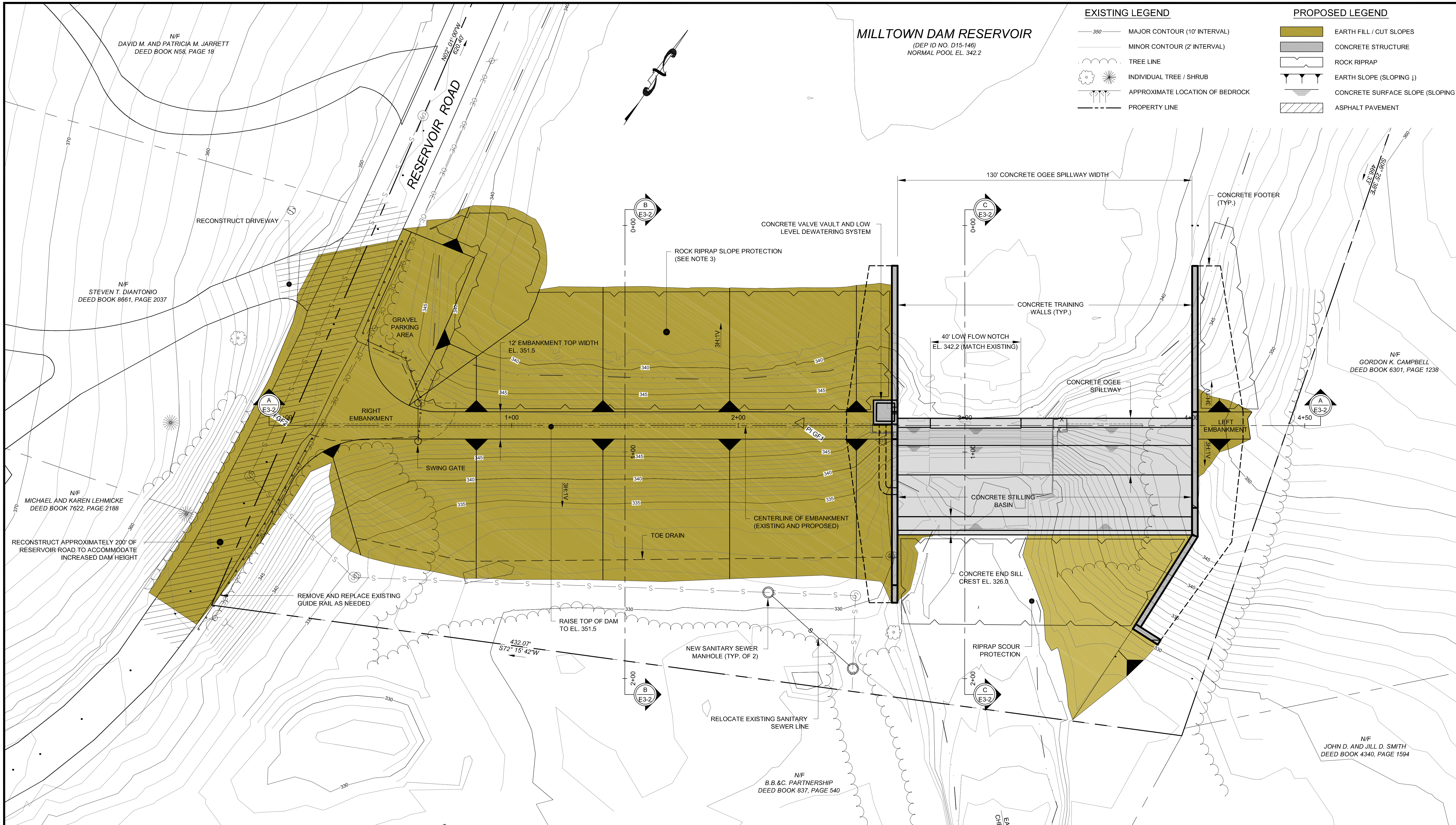
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 2
INCREASE SPILLWAY LENGTH
SECTIONS

JOB NO.	SHEET NO.
60466	E2-2
DATE	DRAWING NO.
FEB 2016	



NOTES:

1. ALTERNATIVE 3 INVOLVES A COMBINATION OF RAISING THE TOP OF DAM TO EL. 351.5 AND INCREASING THE LENGTH OF THE SPILLWAY TO 130 FEET IN ORDER TO PASS THE SPILLWAY DESIGN FLOOD THROUGH THE SPILLWAY WITHOUT OVERTOPPING THE DAM.
2. REMOVE ALL SEDIMENT DEPOSITS FROM BENEATH THE FOOTPRINT OF THE PROPOSED EMBANKMENT.
3. REMOVE AND SALVAGE RIPRAP FROM THE EXISTING UPSTREAM AND DOWNSTREAM EMBANKMENT SLOPES FOR USE AS WAVE PROTECTION ON THE PROPOSED UPSTREAM EMBANKMENT SLOPE.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 3
INCREASE EMBANKMENT HEIGHT & SPILLWAY LENGTH - PLAN VIEW

JOB NO.	SHEET NO.
60466	E3-1
DATE	DRAWING NO.
FEB 2016	

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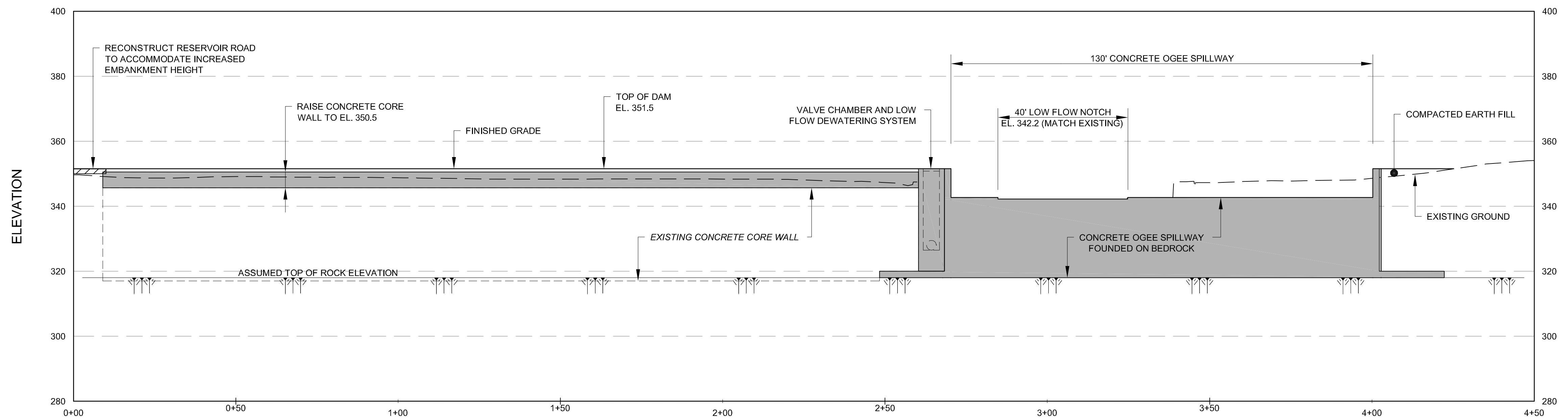
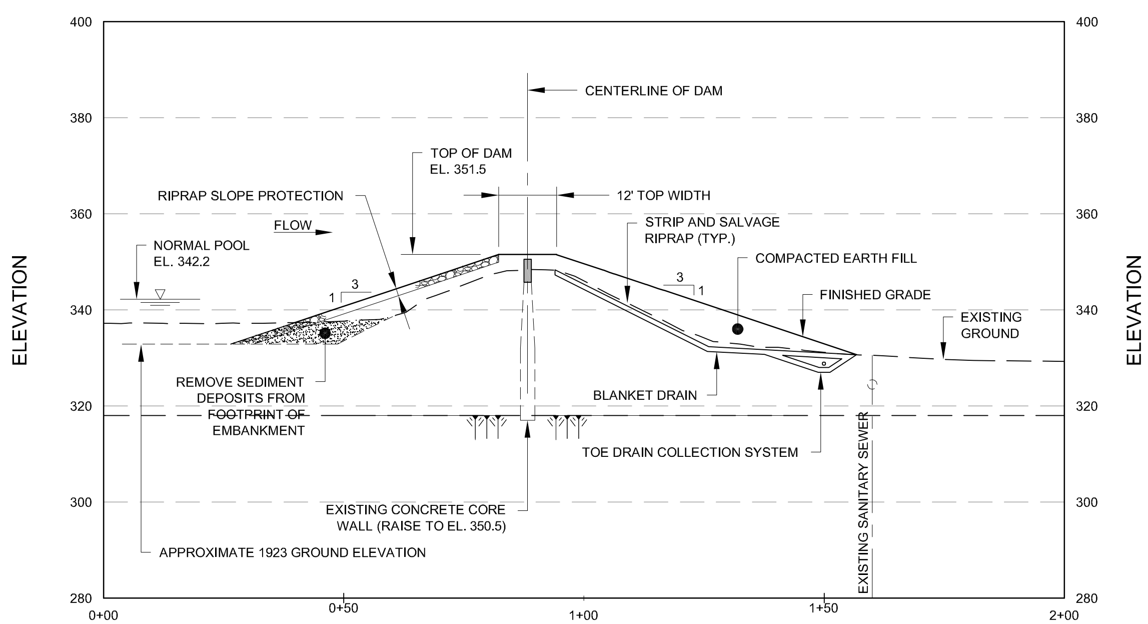
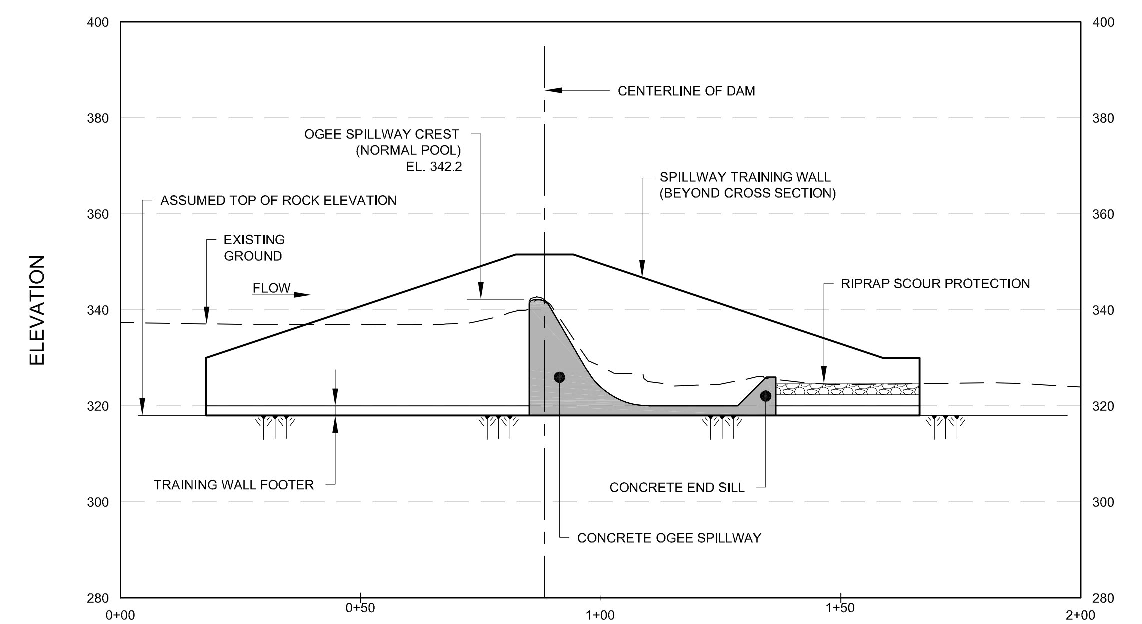


CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)
SCALE: 1" = 20'



EMBANKMENT SECTION B-B
SCALE: 1" = 20'



SPILLWAY SECTION C-C
SCALE: 1" = 20'

CONCEPT PLAN

NOTES:
1. REFER TO SHEET E3-1 FOR ALTERNATIVE 3 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40
SCALE IN FEET

NO.	DESCRIPTION	DATE	BY
REVISIONS			

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

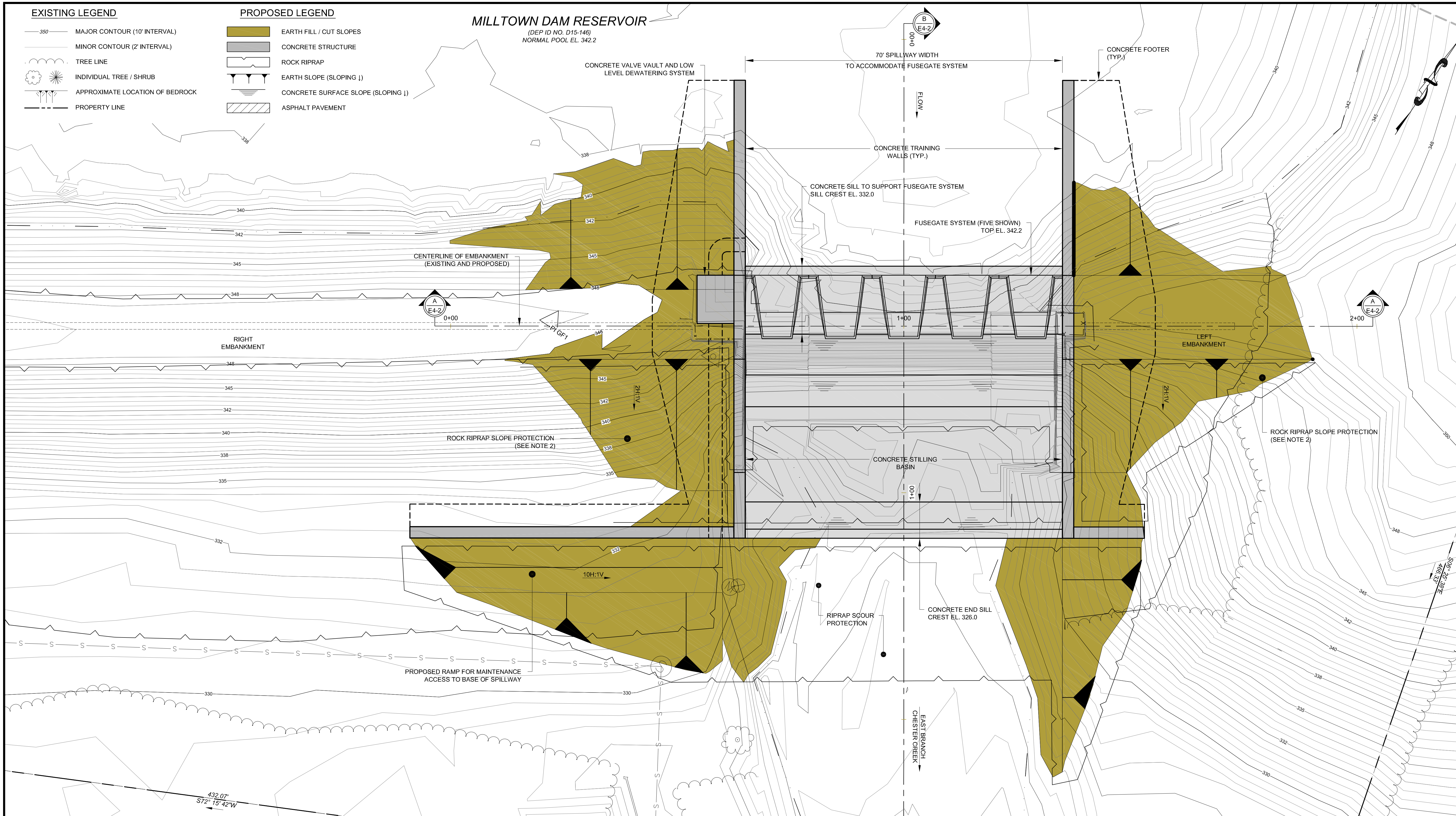
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 3
INCREASED EMBANKMENT HEIGHT & SPILLWAY LENGTH - SECTIONS

JOB NO.	SHEET NO.
60466	E3-2
DATE	DRAWING NO.
FEB 2016	



NOTES:

1. ALTERNATIVE 4 INVOLVES RECONSTRUCTING THE PRINCIPAL SPILLWAY TO ACCOMMODATE A FUSEGATE SYSTEM. WITH ALL FUSEGATES TIPPED, THE RESULTING OPENING IN THE SPILLWAY WILL ALLOW THE SPILLWAY DESIGN FLOOD TO PASS THROUGH THE SPILLWAY WITHOUT OVERTOPPING THE DAM.

2. PROVIDE LOCALIZED GRADING OF DOWNSTREAM EMBANKMENT SLOPES RESULTING IN A 2H:1V (MINIMUM) FINISHED GRADE AND STABILIZE WITH RIPRAP.

10 -0- 10 20
SCALE IN FEET

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 4
FUSEGATE SPILLWAY
PLAN VIEW

JOB NO.	SHEET NO.
60466	E4-1
DATE	DRAWING NO.
FEB 2016	

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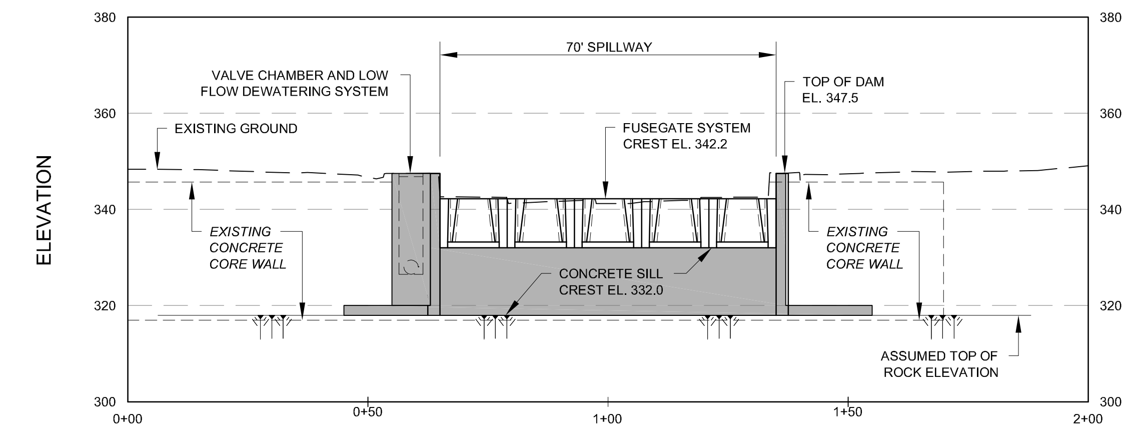
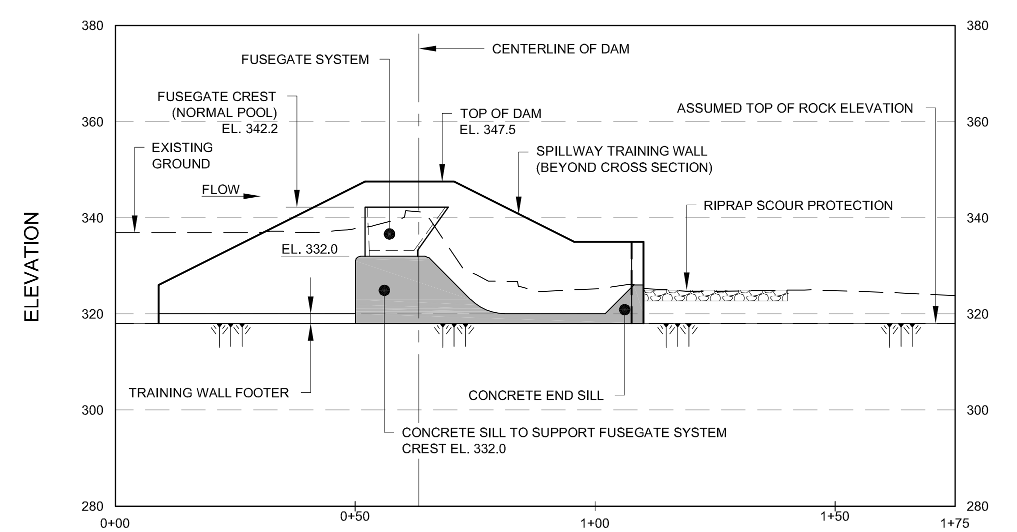


CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)
SCALE: 1" = 20'



SPILLWAY SECTION B-B
SCALE: 1" = 20'

NOTES:
1. REFER TO SHEET E4-1 FOR ALTERNATIVE 4 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40
SCALE IN FEET

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 4
FUSEGATE SPILLWAY
SECTIONS

JOB NO.	SHEET NO.
60466	E4-2
DATE	DRAWING NO.
FEB 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 4.dwg
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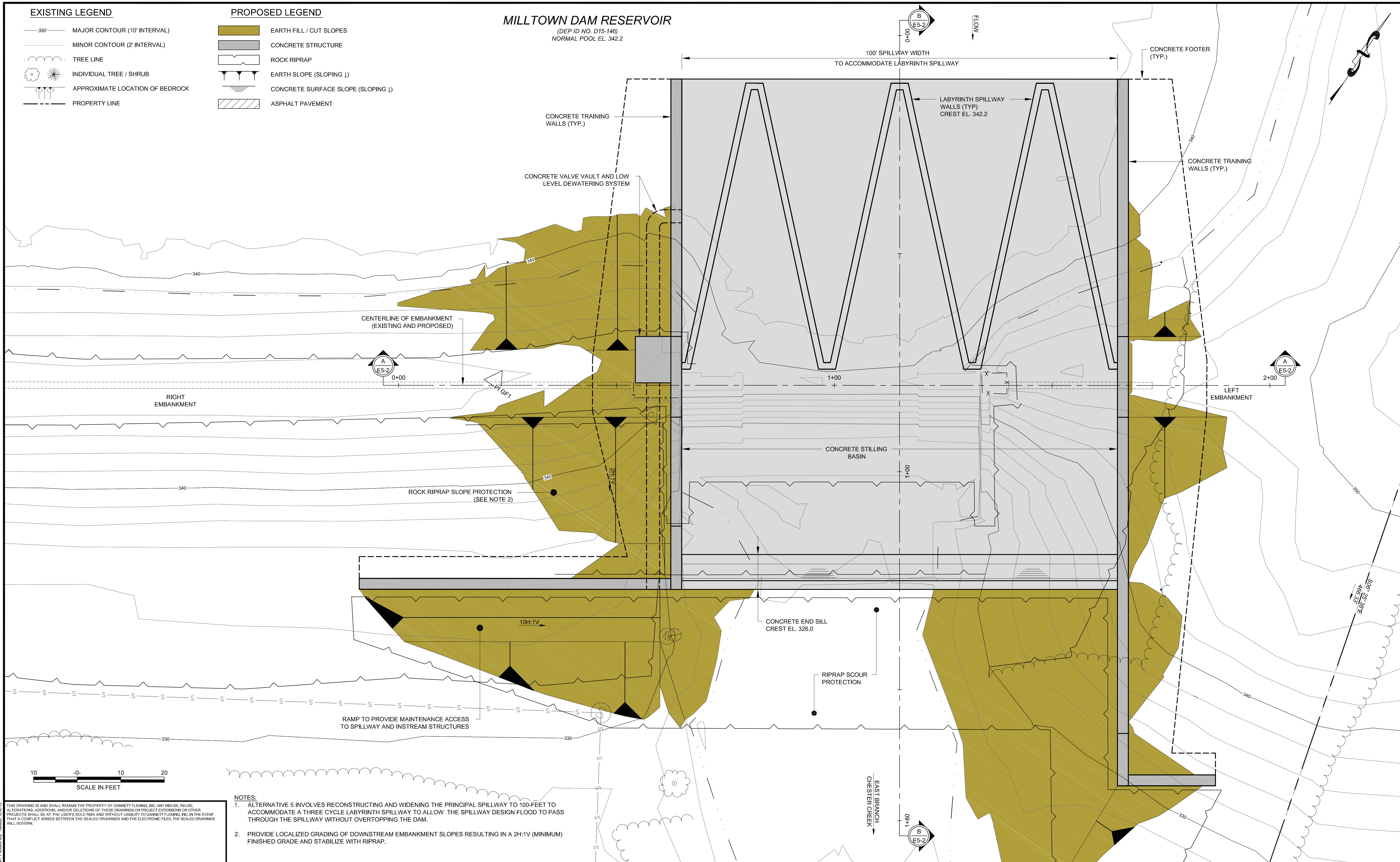


NOTES:

1. ALTERNATIVE 5 INVOLVES RECONSTRUCTING AND WIDENING THE PRINCIPAL SPILLWAY TO 100-FEET TO ACCOMMODATE A THREE CYCLE LABYRINTH SPILLWAY TO ALLOW THE SPILLWAY DESIGN FLOOD TO PASS THROUGH THE SPILLWAY WITHOUT OVERTOPPING THE DAM.
2. PROVIDE LOCALIZED GRADING OF DOWNSTREAM EMBANKMENT SLOPES RESULTING IN A 2H:1V (MINIMUM) FINISHED GRADE AND STABILIZE WITH RIPRAP.

CONCEPT PLAN

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 5.dwg
Plot Date: 2/16/2016 9:01 AM, Plotted By: Neast, Eric C.

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

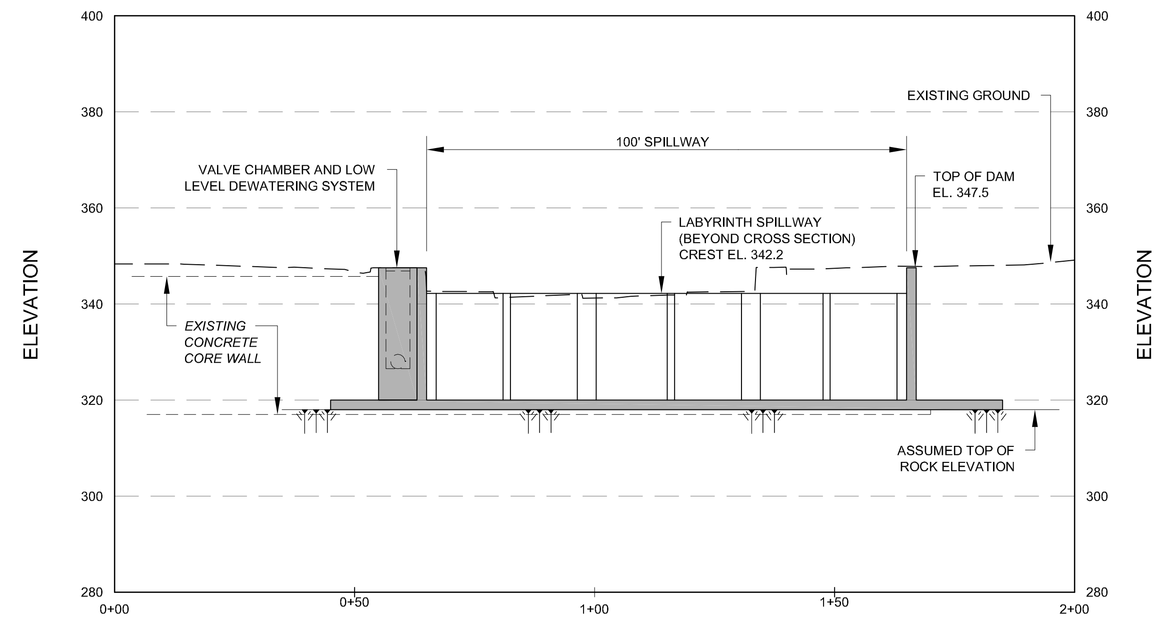
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

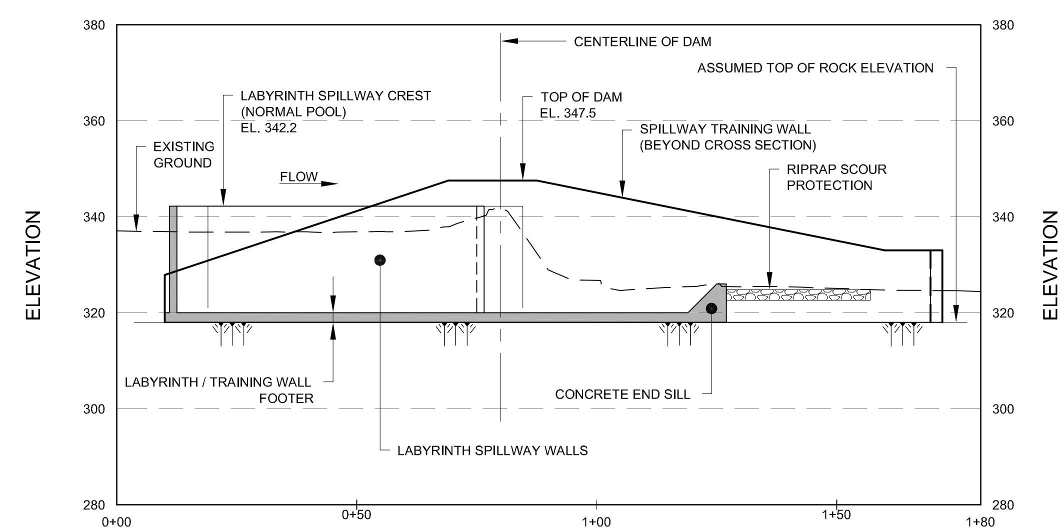
ALTERNATIVE 5
LABYRINTH SPILLWAY
PLAN VIEW

JOB NO.	SHEET NO.
60466	E5-1
DATE	DRAWING NO.
FEB 2016	



CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)

SCALE: 1" = 20'



SPILLWAY SECTION B-B

SCALE: 1" = 20'

NOTES:

1. REFER TO SHEET E5-1 FOR ALTERNATIVE 5 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40

SCALE IN FEET

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 5
LABYRINTH SPILLWAY
SECTIONS

JOB NO.	SHEET NO.
60466	E5-2
DATE	DRAWING NO.
FEB 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 5.dwg
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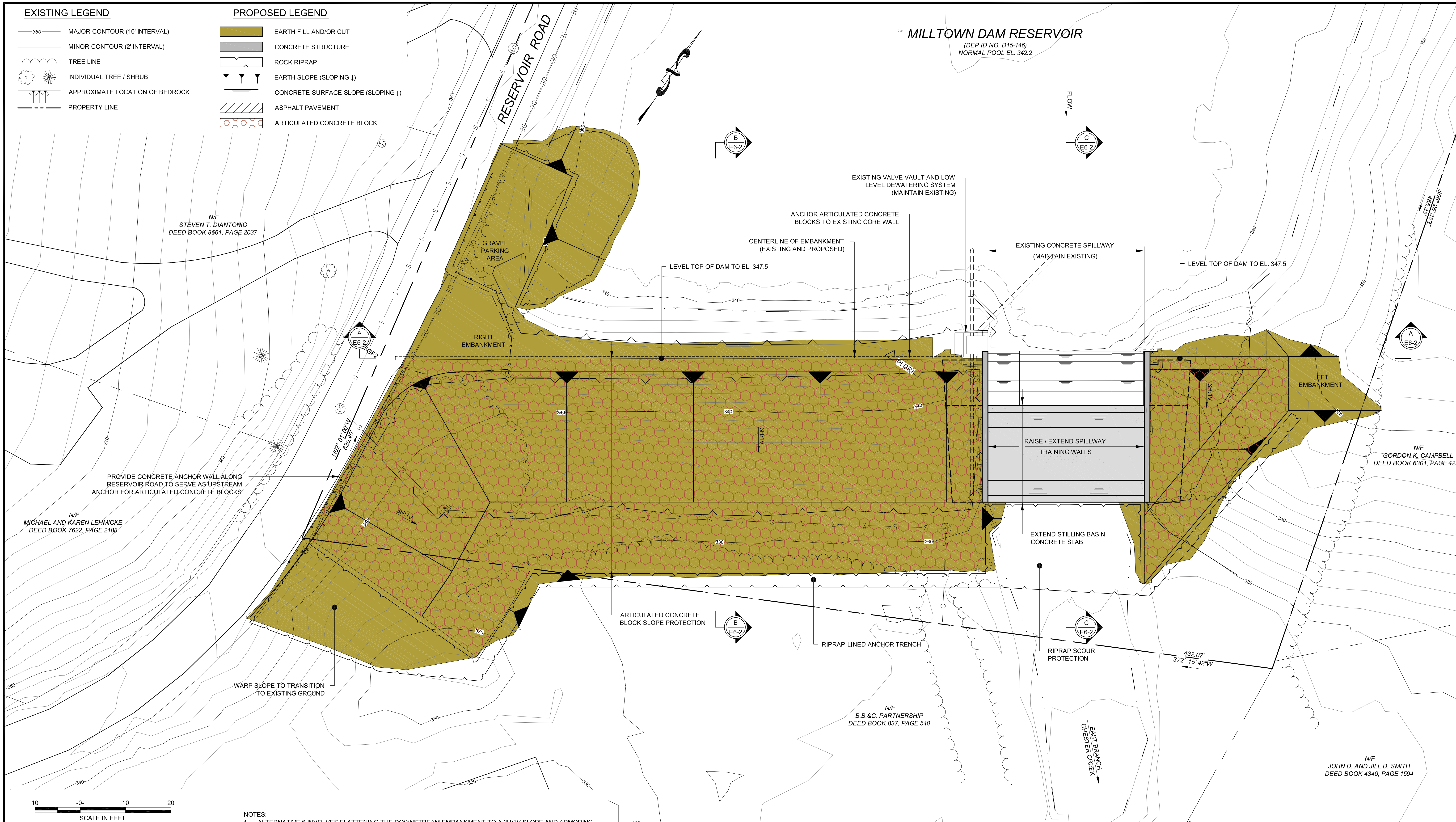

NOTES:
1. ALTERNATIVE 6 INVOLVES FLATTENING THE DOWNSTREAM EMBANKMENT TO A 3H:1V SLOPE AND ARMORING SAID SLOPE WITH ARTICULATED CONCRETE BLOCKS (ACB'S) TO ALLOW THE SPILLWAY DESIGN FLOOD TO SAFELY PASS OVER THE EMBANKMENT.
2. RAISE AND/OR EXTEND THE EXISTING SPILLWAY TRAINING WALLS AS NEEDED TO ACCOMMODATE THE FLATTENED DOWNSTREAM EMBANKMENT SLOPES.
3. REMOVE AND SALVAGE RIPRAP FROM THE EXISTING DOWNSTREAM EMBANKMENT SLOPE FOR USE IN THE ACB ANCHOR TRENCH.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 6
ACB OVERTOPPING PROTECTION
PLAN VIEW

JOB NO.	SHEET NO.
60466	E6-1
DATE	DRAWING NO.
FEB 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 6.dwg
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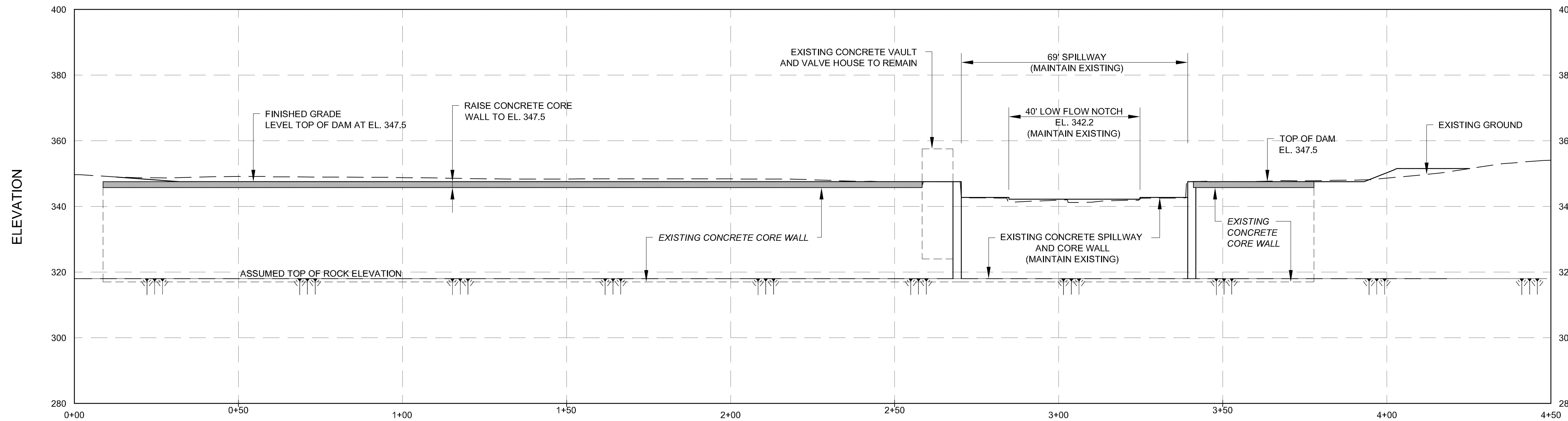
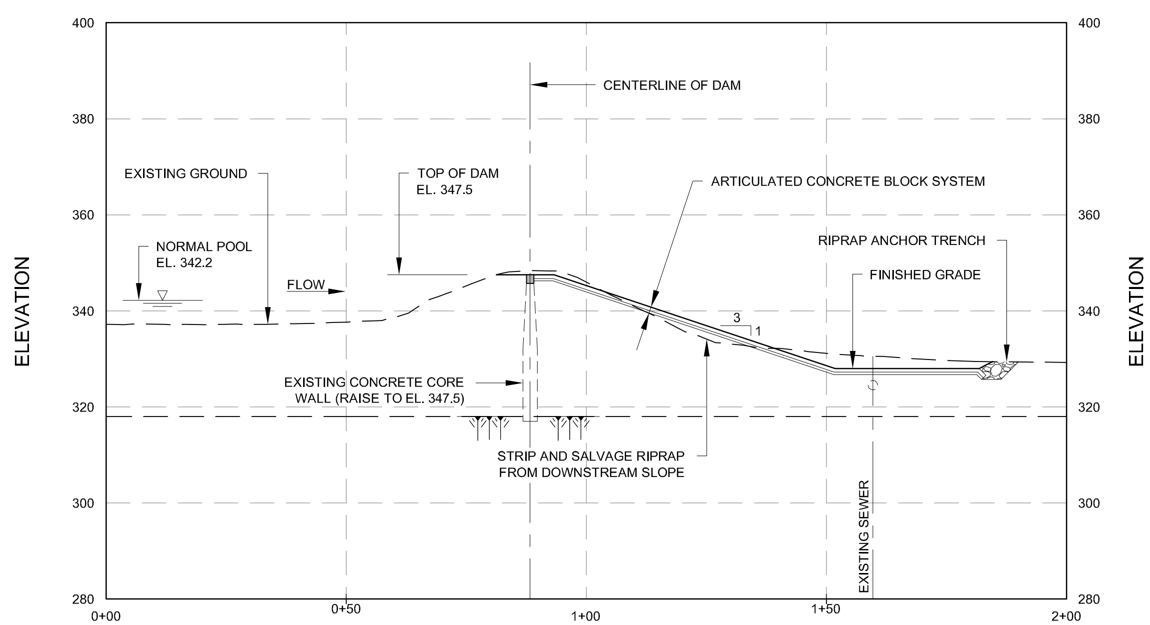


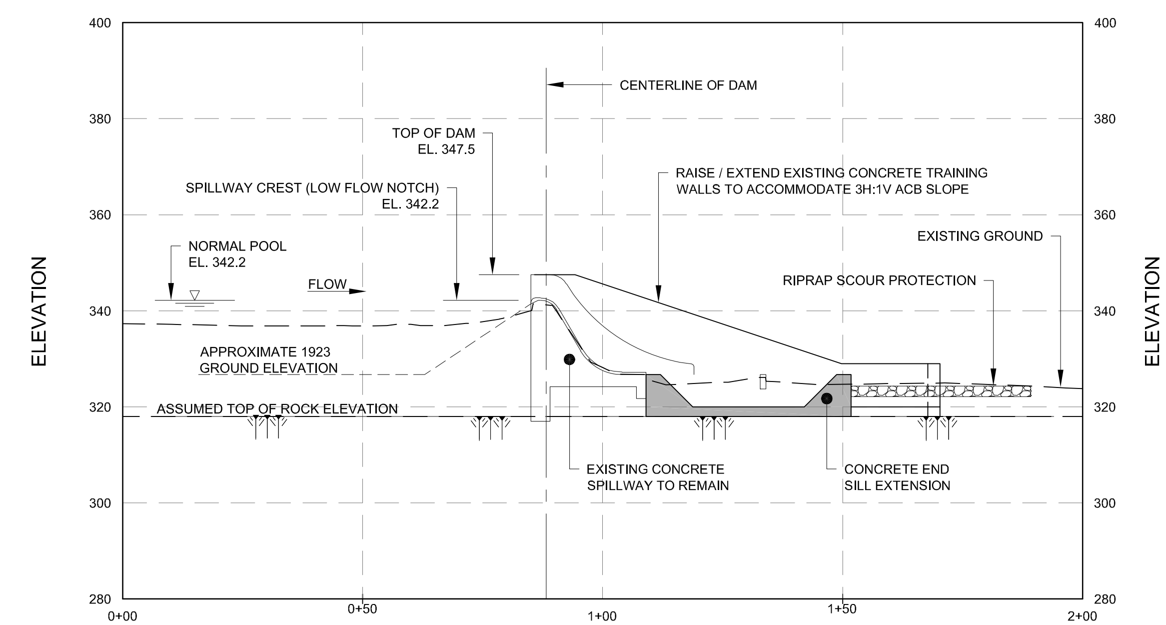
CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)

SCALE: 1" = 20'



EMBANKMENT SECTION B-B

SCALE: 1" = 20'



SPILLWAY SECTION C-C

SCALE: 1" = 20'

NOTES:
1. REFER TO SHEET E6-1 FOR ALTERNATIVE 6 PLAN VIEW AND CROSS SECTION LOCATIONS.

SCALE IN FEET: 20 -0- 20 40

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 6
ACB OVERTOPPING PROTECTION
SECTIONS

JOB NO.	SHEET NO.
60466	E6-2
DATE	DRAWING NO.
FEB 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 6.dwg
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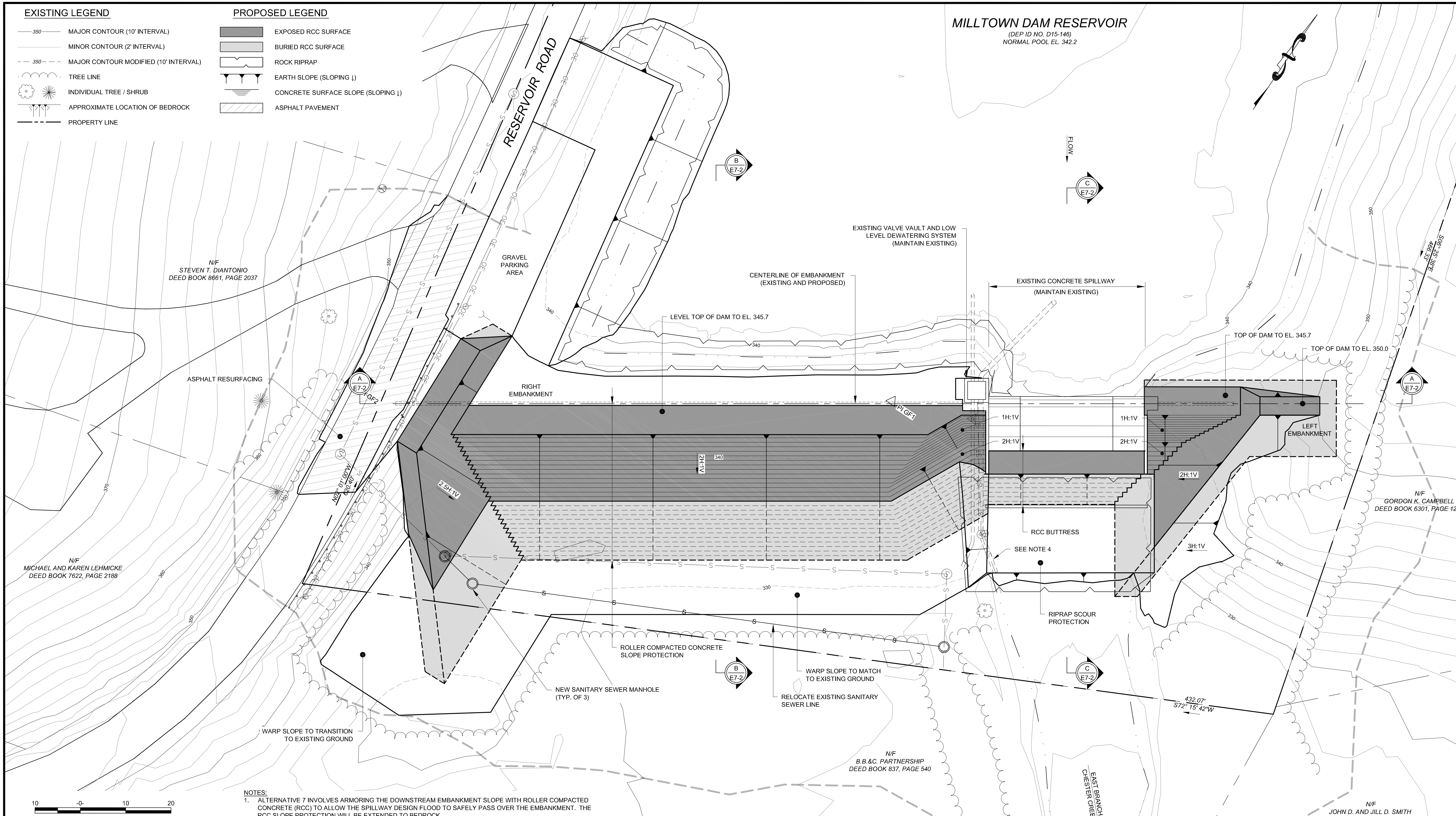


NOTES:

1. ALTERNATIVE 7 INVOLVES ARMORING THE DOWNSTREAM EMBANKMENT SLOPE WITH ROLLER COMPACTED CONCRETE (RCC) TO ALLOW THE SPILLWAY DESIGN FLOOD TO SAFELY PASS OVER THE EMBANKMENT. THE RCC SLOPE PROTECTION WILL BE EXTENDED TO BEDROCK.
2. BUTTRESS THE DOWNSTREAM END OF THE EXISTING CONCRETE STILLING BASIN WITH RCC.
3. REMOVE AND SALVAGE RIPRAP FROM THE EXISTING DOWNSTREAM EMBANKMENT SLOPE FOR USE AS SCOUR PROTECTION ONCE THE RCC IS BACKFILLED TO EXISTING GRADE.
4. REMOVE AND ABANDONED THE 16" PIPE. EXTEND THE 24" PIPE THROUGH THE RCC AND OUTLET INTO THE STREAM CHANNEL.
5. ENCASE SANITARY SEWER IN CONCRETE AT LOCATION WHERE SEWER PENETRATES RCC OVERTOPPING PROTECTION.

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 7.dwg
Plot Date: 2/16/2016 10:03 AM, Plotted By: Neast, Eric C.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

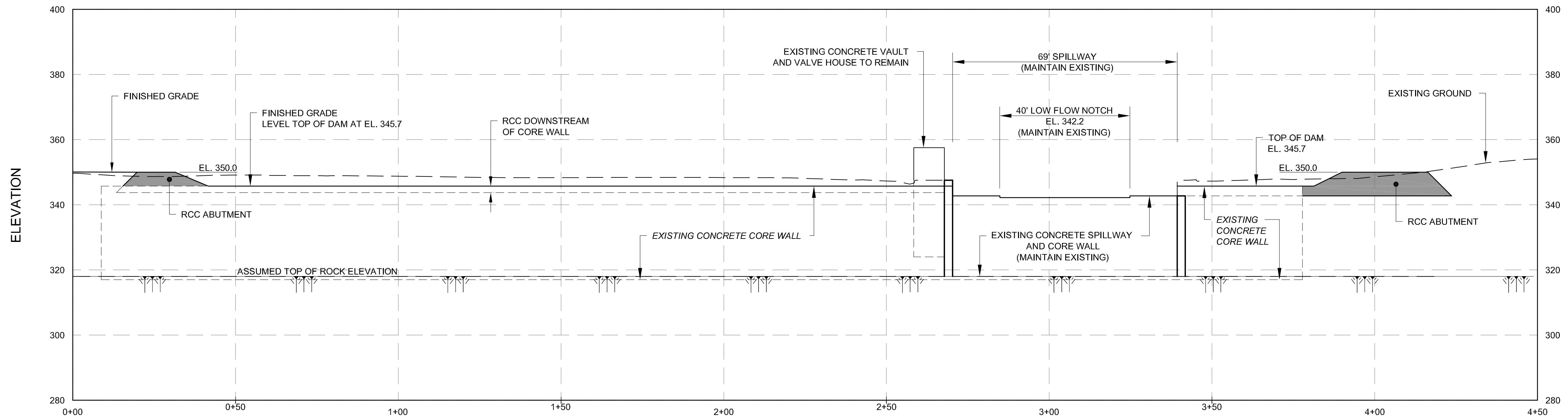
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

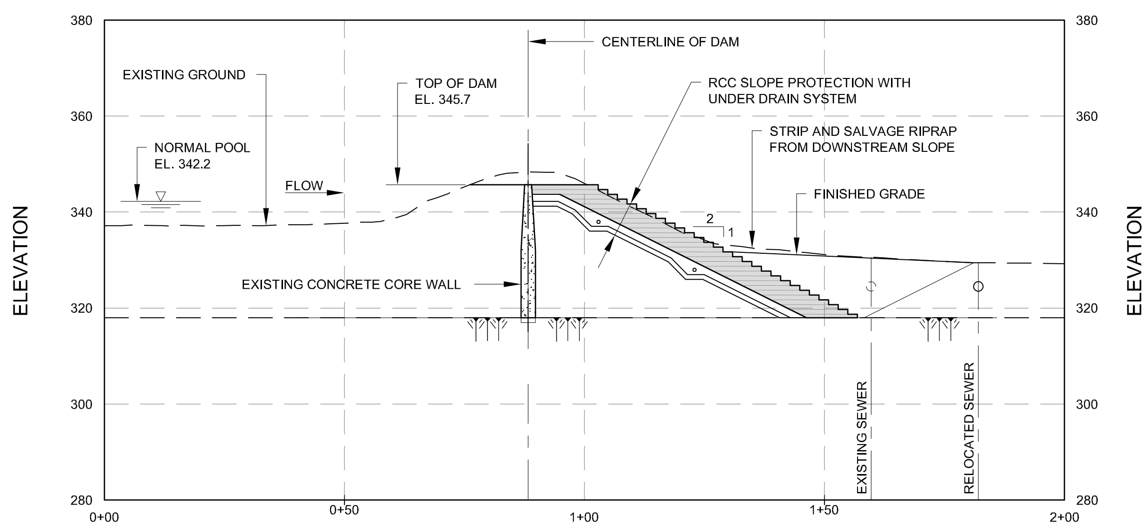
MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 7
RCC OVERTOPPING PROTECTION
PLAN VIEW

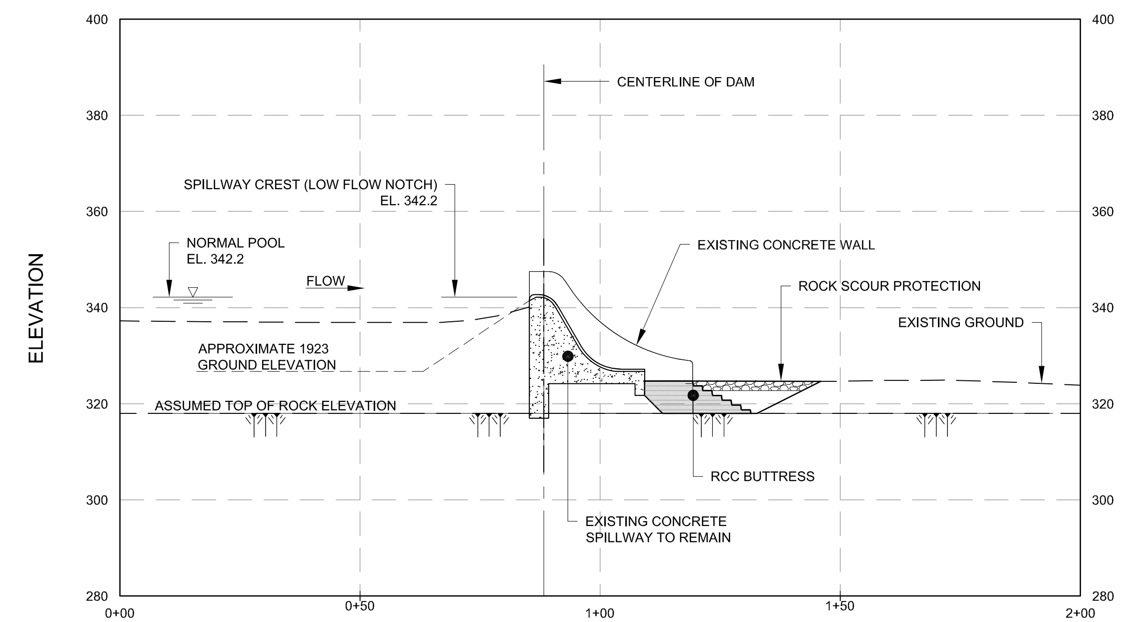
JOB NO.	SHEET NO.
60466	E7-1
DATE	DRAWING NO.
FEB 2016	



CENTERLINE OF EMBANKMENT SECTION A-A (LOOKING UPSTREAM)
SCALE: 1" = 20'



EMBANKMENT SECTION B-B
SCALE: 1" = 20'



SPILLWAY SECTION C-C
SCALE: 1" = 20'

NOTES:
1. REFER TO SHEET E7-1 FOR ALTERNATIVE 7 PLAN VIEW AND CROSS SECTION LOCATIONS.

20 -0- 20 40
SCALE IN FEET

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 7.dwg
Plot Date: 2/16/2016 10:07 AM, Plotted By: Neast, Eric C.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

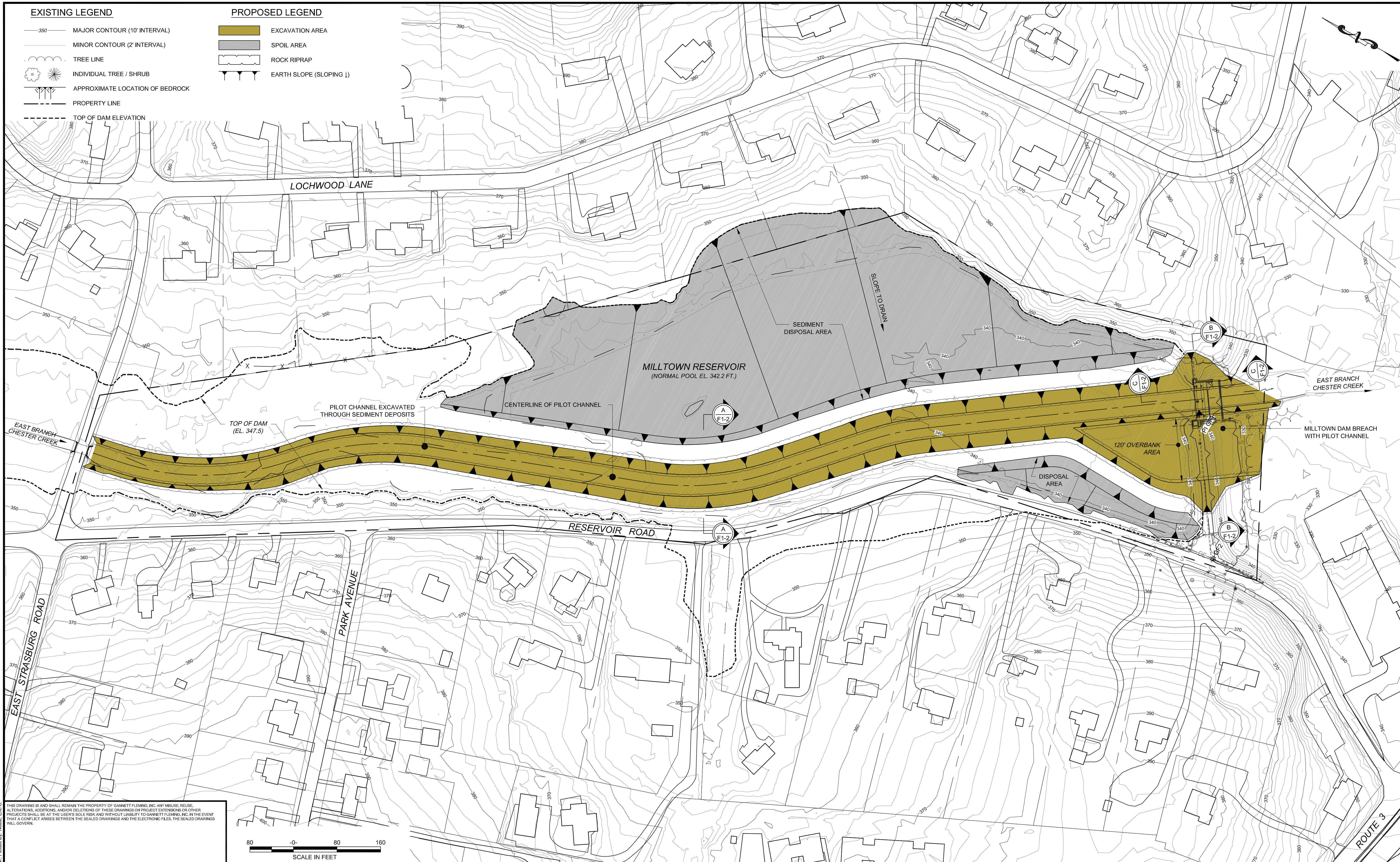
EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 7
RCC OVERTOPPING PROTECTION
SECTIONS

JOB NO.	SHEET NO.
60466	E7-2
DATE	DRAWING NO.
FEB 2016	

APPENDIX F
CONCEPTUAL DESIGN DRAWINGS FOR BREACHING MILLTOWN DAM



CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 8
FULL BREACH
PLAN VIEW

JOB NO.	SHEET NO.
60466	F1-1
DATE	DRAWING NO.
FEB. 2016	

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 8.dwg
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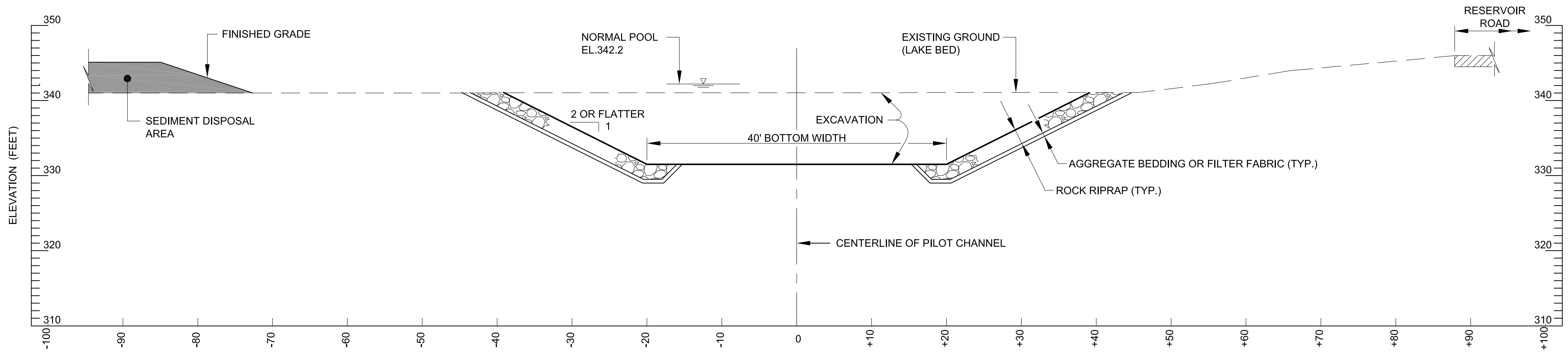
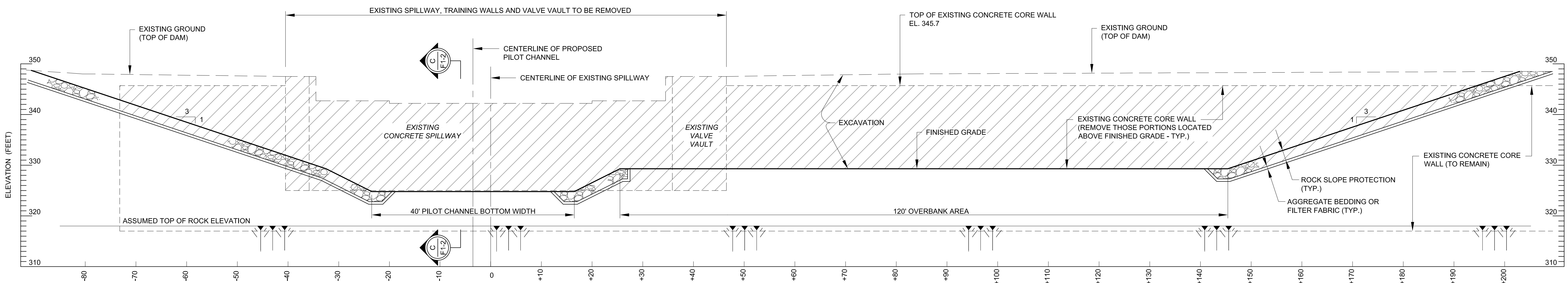


TYPICAL PILOT CHANNEL CROSS SECTION - SECTION A-A (LOOKING DOWNSTREAM)

SCALE: 1" = 10'

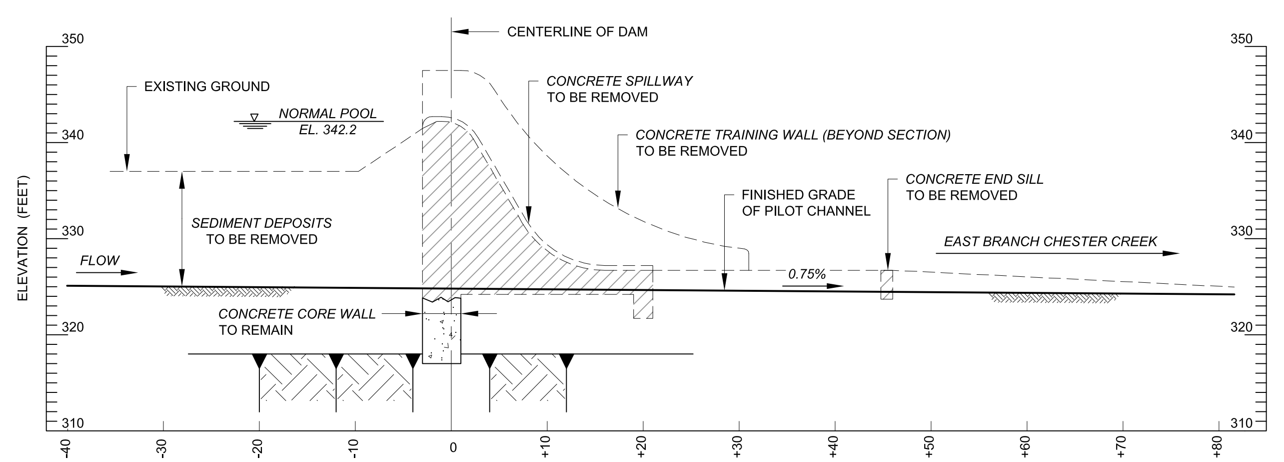


EMBANKMENT CENTERLINE CROSS SECTION - SECTION B-B (LOOKING DOWNSTREAM)

SCALE: 1" = 10'

SHEET NOTES:

1. REFER TO SHEET F1-1 FOR LOCATION OF CROSS SECTIONS.



CROSS SECTION THROUGH EXISTING SPILLWAY - SECTION C-C

SCALE: 1" = 10'

10 -0- 10 20

SCALE IN FEET

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 8.dwg
Plot Date: 2/25/2016 9:33 AM, Plotted By: Neast, Eric C.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

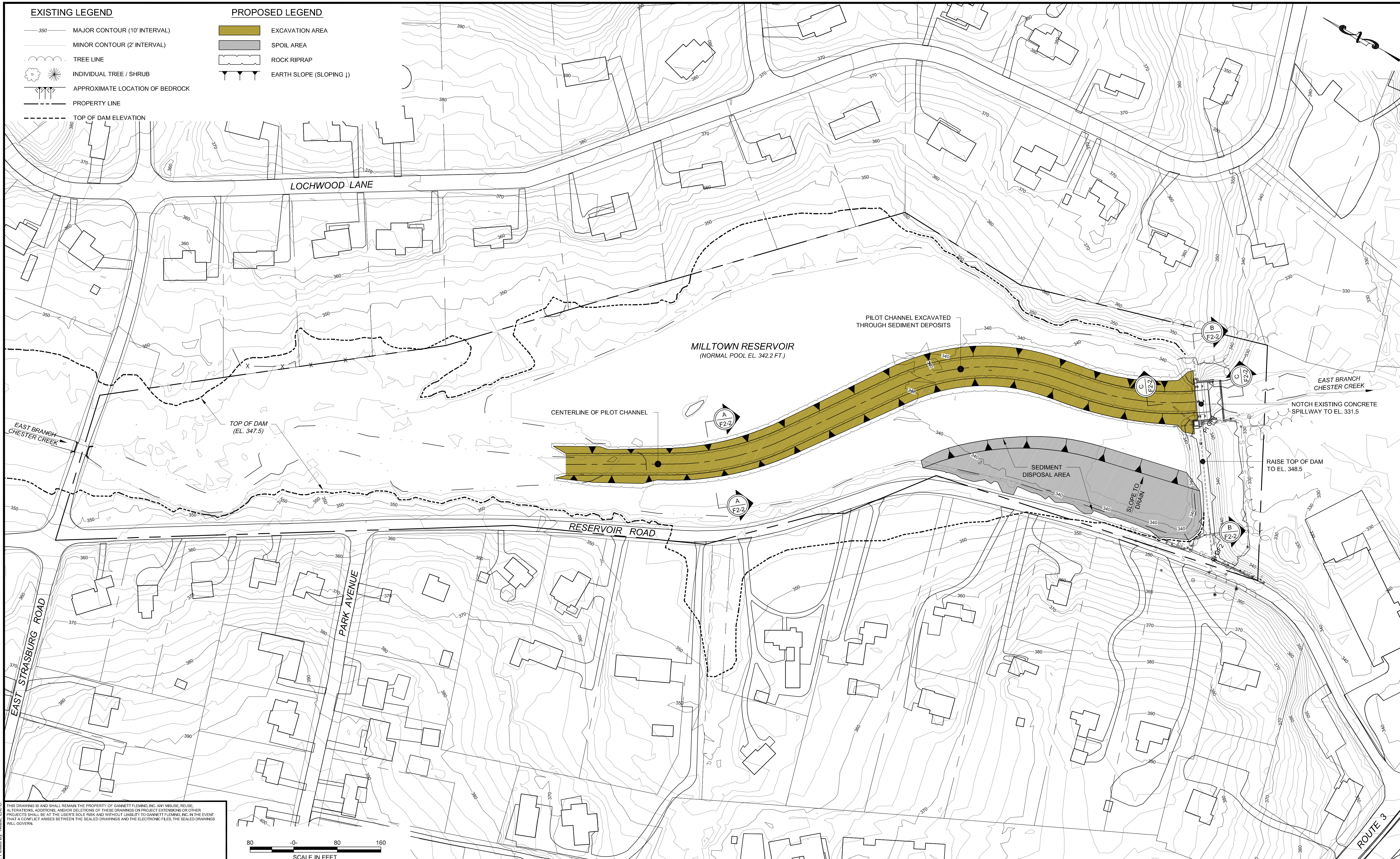
Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 8
FULL BREACH
SECTIONS

JOB NO.	SHEET NO.
60466	F1-2
DATE	DRAWING NO.
FEB. 2016	



THIS DRAWING IS AND SHALL REMAIN THE PROPERTY OF GANNETT FLEMING, INC. ANY MISUSE, REUSE, ALTERATIONS, ADDITIONS, AND/OR DELETIONS OF THESE DRAWINGS ON PROPOSED PROJECT EXTENSIONS OR OTHER PROJECTS SHALL BE AT THE USER'S SOLE RISK AND WITHOUT LIABILITY TO GANNETT FLEMING, INC. IN THE EVENT THAT A CONFLICT ARISES BETWEEN THE SEALED DRAWINGS AND THE ELECTRONIC FILES, THE SEALED DRAWINGS WILL GOVERN.

CONCEPT PLAN

NO.	DESCRIPTION	DATE	BY

REVISIONS

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 9
PARTIAL BREACH
PLAN VIEW

JOB NO.	SHEET NO.
60466	F2-1
DATE	DRAWING NO.
FEB. 2016	

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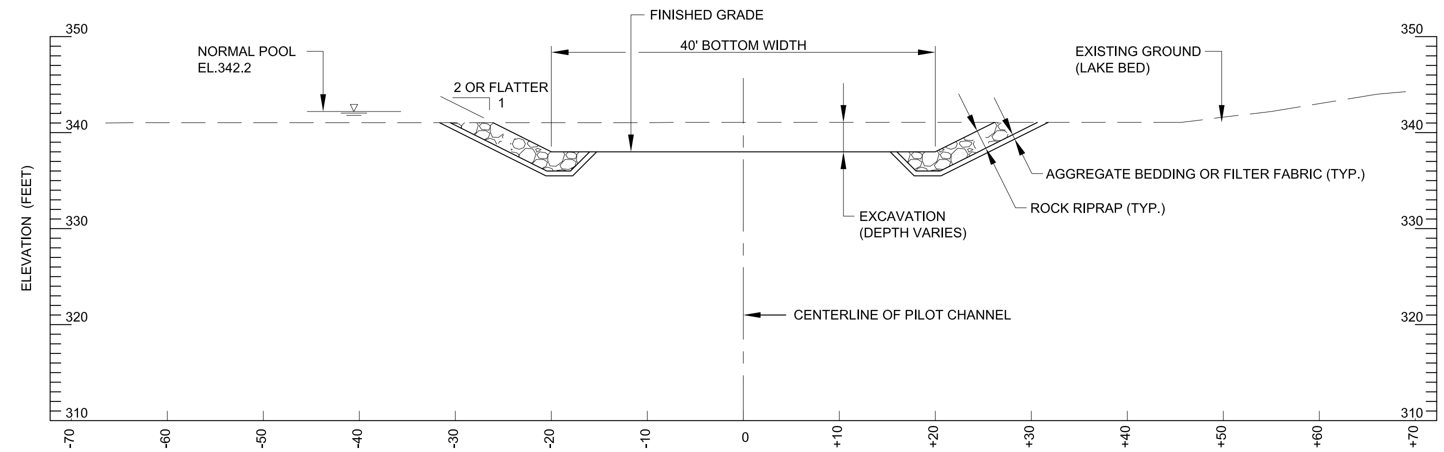
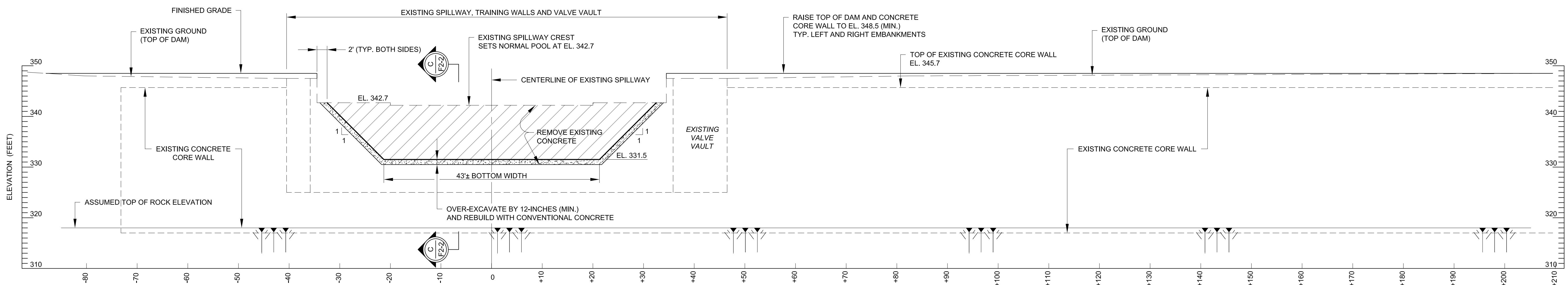
Plot Date: 2/25/2016 9:41 AM, Plotted By: Nead, Eric C.



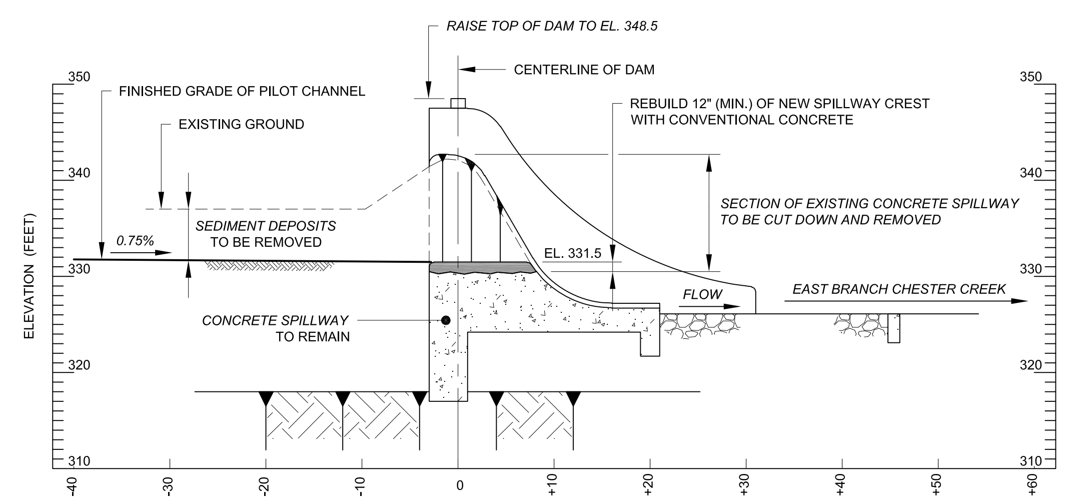
TYPICAL PILOT CHANNEL CROSS SECTION - SECTION A-A (LOOKING DOWNSTREAM)

SCALE: 1" = 10'



CROSS SECTION THROUGH CENTERLINE OF EMBANKMENT WITH PARTIAL BREACH - SECTION B-B (LOOKING DOWNSTREAM)

SCALE: 1" = 10'



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

SCALE: 1" = 10'

SHEET NOTES:

1. REFER TO SHEET F2-1 FOR LOCATION OF CROSS SECTIONS.

10 -0- 10 20

SCALE IN FEET

CONCEPT PLAN

W:\426\Active Jobs\60466 - East Goshen Township\05 Working\CADD\Design Set\Proposed Plan - Option 9.dwg
Plot Date: 2/25/2016 9:42 AM, Plotted By: Nead, Eric C.

NO.	DESCRIPTION	DATE	BY
	REVISIONS		

DESIGNED	CADD	SCALE
ECN	TDT	AS SHOWN
DRAWN	CHECKED	APPROVED
TDT	ECN	PGS

Gannett Fleming

EAST GOSHEN TOWNSHIP
WEST CHESTER, PENNSYLVANIA

MILLTOWN DAM
DEP ID NO. D15-146

ALTERNATIVE 9
PARTIAL BREACH
SECTIONS

JOB NO.	SHEET NO.
60466	F2-2
DATE	DRAWING NO.
FEB. 2016	

APPENDIX G
MEETING MINUTES AND CORRESPONDENCE

East Goshen Township
Milltown Dam (DEP ID No. D15-146)
Review Meeting with DEP Division of Dam Safety

MEETING MINUTES

Purpose of Meeting:	Discuss Conveyance Capacity Options for Milltown Dam GF Project No. 060466
Date of Meeting:	Thursday, March 3, 2016
Meeting Location:	DEP, Division of Dam Safety Rachel Carson State Office Building Harrisburg, PA 17105-8460 Conference Room 5A
Meeting Time:	1:30 P.M. – 3:30 P.M.
Meeting Attendees:	As shown below

Name	Affiliation	Phone Number	Email Address
Roger Adams	DEP Dam Safety	717.772.5951	roadams@pa.gov
Desmond Reynolds	DEP Dam Safety	717.772.5957	dgreynolds@pa.gov
Ron Mease	DEP Dam Safety	717.772.5947	rmease@pa.gov
Heath Maines	DEP Dam Safety	717.772.5960	hemaines@pa.gov
Rick Smith	East Goshen Township	610.692.7171	rsmith@eastgoshen.org
Paul Schweiger	Gannett Fleming	717.763.7212	pschweiger@gfnet.com
Chad Hoover	Gannett Fleming	717.763.7212	choover@gfnet.com
Eric Neast	Gannett Fleming	717.763.7212	eneast@gfnet.com

Purpose of Meeting:

Under cover letter dated June 17, 2014, the Pennsylvania Department of Environmental Protection (DEP), Division of Dam Safety notified East Goshen Township (Township) that Milltown Dam (DEP ID No. D15-146) has inadequate spillway capacity. On June 16, 2015, the Township secured the services of Gannett Fleming to assist with evaluating options for increasing conveyance capacity along with decommissioning options. The purpose of the meeting is to review Gannett Fleming's findings with DEP prior to presenting this information to the Township Board of Supervisors.

General Discussions:

1. Milltown Dam is owned and operated by East Goshen Township as a recreational facility. Located in East Goshen Township, Chester County, the dam is located on and discharges to the East Branch Chester Creek which is tributary to the Delaware River.

2. The dam is approximately 350-feet long and 20-feet high at the maximum section.
   a) The left and right embankments are earth fill structures containing a concrete core wall for seepage control.
   b) The principal spillway is a 69-foot long concrete structure with an ogee shaped crest containing a 40-foot long, 6-inch-deep "notch" in the center of the spillway to channelize low flows.
   c) A low level dewatering structure is located at the right spillway abutment and consists of a stone masonry valve house situated over a concrete valve vault. Two pipes (a 16-inch and a 24-inch cast iron pipe) convey flows from the reservoir into the valve house which each pipe controlled by a sluice gate within the valve vault. Two pipes (a 16-inch and a 24-inch cast iron pipe) discharge from the valve vault. The 16-inch discharge line is abandoned and the sluice gate which controls this pipe is inoperable and frozen in the closed position. The 24-inch line discharges to the East Branch Chester Creek approximately 80 feet downstream of the dam. The sluice gate which controls this pipe is inoperable and frozen in the open position.

3. Milltown Dam is classified as a C-1 high hazard structure. The size category "C" is assigned to structures that impound less than 1,000 acre-feet and are less than 40 feet in height. The hazard potential category "1" is assigned to structures that have a substantial population at risk and/or the potential for excessive economic loss should the structure fail.
   a) The hazard classification is supported by the 2010 Emergency Action Plan which identifies 39 homes and 5 business establishments within the downstream inundation area.
   b) An incremental breach analysis performed by DEP in 2014 confirms the spillway design flood to be the 1/2 Probable Maximum Flood (PMF).
   c) Roger Adams noted that Township Line Dam on Airport Road must pass the full PMF due to the downstream consequences. Downstream "hazard creep" (i.e., new development) can often result in an increased spillway design flood.

4. Milltown Dam was constructed in 1923-1924 by the Borough of West Chester as a water supply reservoir. At some point, ownership was transferred to the West Chester Area Municipal Authority (WCAMA). Over time, heavy sedimentation reduced the functionality of the reservoir and in 1984 the WCAMA transferred ownership of the dam to a Mr. Robert Wiggins. In 1985, Mr. Wiggins grants a 19+ acre parcel containing the Milltown Dam and reservoir to East Goshen Township for the sum of one dollar.
   a) Roger Adams noted that the dam was poorly maintained prior to the Township taking ownership in 1985.

5. The original construction drawings from 1923 along with construction photographs were reviewed. Key design features of the dam are as follows:
   a) The left and right embankments are earth fill structures, each containing a concrete core wall. The design drawings indicate that this wall does not contain steel reinforcing. The core wall extends to bedrock and is 36-inches wide below native ground and tapers to 18-inches wide at the top of the core wall which is set approximately 1.8-feet below the design top of dam elevation. Photographs and

inspection reports indicate that the core wall was of good quality and constructed with care. Roger Adams noted that the concrete core wall is not reinforced and utilizes the surrounding earth fill as support. Should this earth material be lost due to erosion, the core wall would likely fail.

b) The embankment top width is 8-feet wide by design. Based on construction photographs, the left embankment was built to a top width less than 8-feet.

c) The downstream embankments are graded to a 2H:1V slope with the areas immediately adjacent to the spillway graded to slopes as steep as 1.5H:1V. The Township reports movement of the surface riprap in these areas and slush grouting has been used downstream of the valve house in an attempt to stabilize the riprap.

d) The 1923 construction drawings indicate that the concrete spillway and the valve vault are founded on approximately 7-feet of erodible material.

e) The riprap scour protection downstream of the spillway was hand placed and reported to be grouted in place. This riprap has a history of scour and movement and was replaced in 1985.

f) The 16-inch CIP leaving the valve vault conveyed flow from the reservoir to the downstream water treatment plant. This pipe has since been abandoned.

g) Roger Adams noted that “puddle” material was placed upstream of the dam. This is a clay material that was saturated to the point where it could be sluiced into place. Said material was placed as a seepage control measure.

6. Several modifications have been made to the dam since its original construction in 1923-1924.

a) 1985: Work included armoring the embankments with riprap, concrete repairs to the spillway and replacement of missing riprap immediately downstream of the spillway. Based on construction photographs, it appears that aggregate bedding was not placed on the embankment slopes under the riprap which is contrary to the contract drawings. Rodger Adams stated that DEP inspections during the 1985 construction project indicated that the size of the installed riprap was smaller than the rock size shown on the drawings.

b) 1997: Addition of trash racks on the upstream end of the 16-inch and 24-inch low level dewatering pipes. Photographs of this work confirm the presence of sediment deposits within the reservoir.

c) 2008: Left embankment raised 18-inches by adding riprap. Rick Smith noted that impervious material was not used to build up the core of the embankment prior to placing riprap.

d) 2012: Slush grouting of the riprap on the downstream right embankment slope below the valve house.

e) 2013: Liquid urethane coating applied to the downstream face of the spillway. Original application did not adhere to the spillway in many areas and the product was reapplied in the fall of 2015.

f) 2015: Replaced valve stem and guides on the 24-inch sluice gate which controls the upstream 24-inch CIP low level dewatering pipe.

7. Gannett Fleming performed a high level review of Milltown Dam to identify potential areas of risk. This review was based on historic documents held by both the Township and DEP, a visual inspection of the dam performed on August 4, 2015, a topographic survey of the dam and a bathymetric survey of the reservoir performed by Gannett Fleming in July 2015. The following areas of risk were identified:
   a) Inadequate Spillway Capacity. DEP performed an incremental breach analysis in 2014 that identified the Spillway Design Flood (SDF) as the 1/2 PMF with a peak inflow rate of 12,700 cfs. The existing capacity of the spillway is approximately 3,080 cfs. The dam is overtopped by approximately 4.1 feet during the SDF. It was also noted that the dam provides a negligible attenuation of the 100-year storm event (approximately a 6.5% reduction in peak rates of runoff).
   b) It was noted water is impounded on 14 properties upstream of the dam when the water elevation reaches the top of dam elevation. During the SDF, which overtops the dam by approximately four feet, water would be impounded on 29 upstream properties.
   c) If the erodible material under the spillway is lost, either through scour, internal piping or some other form of erosion, the spillway could fail, resulting in a sudden release of the impounded water.
   d) Steep slopes on the downstream embankment pose a surface stabilization concern and would be at risk of erosion during an overtopping event. The spillway training walls require raising to match the 2H:1V slopes of the embankment.
   e) Reservoir sedimentation. A bathymetric survey performed by Gannett Fleming in July 2015 found that over 60 percent of the storage volume has been lost to sedimentation when compared against the contours shown on the 1923 construction drawings. Water depths which once exceeded 15-feet have been reduced to less than 5-feet in the vicinity of the spillway. Water depths in the upper end of the reservoir are less than 12-inchs in many areas.
   f) No internal seepage collection system is present within the existing embankment. Past inspections of the dam have not identified seepage as a concern. Consequently, it appears that the concrete core wall is adequately controlling seepage through the embankment. While a seepage collection system is not a requirement at Milltown Dam, it was noted that earth embankment dams constructed today would contain such a system.
   g) Limited access to the left embankment for maintenance/repair activities. The Township currently has access to the right embankment crest and the toe of the right embankment via an easement from the downstream property owner. Likely access routes to the left embankment may be from the parking lot at the public pool or via a ford crossing of East Branch Chester Creek.
   h) Fill at the crest of the left embankment. The current riprap placement at the left embankment crest will allow flow to move through the riprap and over the downstream face of the dam prior to the reservoir reaching the top of dam elevation. This condition could lead to saturation and erosion of the underlying soils on the downstream embankment, destabilizing the riprap slope protection.
   i) Additional site security and public safety measures. Several public safety improvements were identified, including additional signage and fencing along the spillway training walls as a fall protection measure.

8. Gannett Fleming evaluated five alternatives for increasing spillway capacity. Each option maintains normal pool at its current elevation.
   a) Alternative 1 - Increasing the height of the dam. For this option, the spillway width is held at 69-feet and the height of the dam raised by 8.5 feet in order to pass the SDF through the spillway without overtopping the dam. This configuration increases the stored water behind the dam, increasing the downstream consequences should the dam fail. Consequently, the breach analysis will require updating which may determine that the SDF must be increased. Upstream properties are also impacted by the increased water elevations within the reservoir. Design/construction costs are estimated at $6.6 million.
   b) Alternative 2 - Increasing the length of the spillway. For this option, the top of dam elevation is held and the length of the spillway increased from 69-feet to 320-feet in order to pass the SDF without overtopping the dam. This alternative converts the entire dam into a spillway. This option lowers the reservoir water elevation during the SDF by approximately 4 feet, reducing upstream impacts. Slight increases in peak rates of runoff can be expected for storm events more frequent than the 100-year event. Design /construction costs are estimated at $9.6 million.
   c) Alternative 3 - Combination of increased dam height and increased spillway length. For this option, the top of dam elevation is raised by 4-feet and the spillway is widened from 69-feet to 130-feet in order to pass the SDF without overtopping the dam. This option does not increase upstream water levels within the reservoir during the SDF. Consequently, no additional upstream properties are impacted for this option. This configuration increases the stored water behind the dam, increasing the downstream consequences should the dam fail. Consequently, the breach analysis will require updating which may determine that the SDF must be increased. Design/construction costs are estimated at $6.8 million.
   d) Alternative 4 - Install fusegates. For this option the spillway crest is lowered and fusegates installed to maintain the normal pool elevation. During a large storm event, the fusegates tip at predetermined water elevations, increasing the conveyance capacity of the spillway. With all fusegates tipped, the spillway has adequate capacity to pass the SDF. Design/construction costs are estimated at $5.8 million.
   e) Alternative 5 - Install labyrinth spillway. For this option the spillway length is increased from 69-feet to 100-feet and a three cycle labyrinth spillway is installed. This option can pass the SDF without overtopping the dam and will reduce the upstream water elevations by approximately 4-feet during the SDF. Design/construction costs are estimated at $6.7 million.

9. Gannett Fleming evaluated two overtopping protection options which involve placing a protective “shell” over the downstream embankment so that the dam can be overtopped without compromising the integrity of the structure.
   a) Alternative 6 - ACB overtopping protection. ACBs are pre-fabricated concrete blocks cabled together to form a “mat” of concrete. These mats are placed side-by-side and joined together with pigtail connections to form one continuous mat of concrete blocks over the entire downstream face of the dam. The ACBs are underlain with a drainage layer that prevents uplift pressure from developing under

the blocks. The downstream embankment will be flattened to a 3H:1V slope and the spillway training walls will be raised/extended to match the downstream embankment slope. A concrete stilling basin is added for scour protection and to encapsulate the erodible material under the spillway. Design/construction costs are estimated at $3.2 million. It was noted that the anticipated overtopping depth of 4-feet is at the maximum design limit for ACB overtopping protection.

b) Alternative 7 - RCC overtopping protection. This option involves the creation of a concrete shell over the downstream embankment. The RCC is founded on bedrock and placed in 12-inch layers to create a "stepped" surface. The exposed face of each step can be formed to give a neat appearance to the RCC or it can be left unformed. The top of dam is lowered by 1.8-feet to the top of the core wall and Reservoir Road is raised by approximately one foot. These adjustments to the top of dam will contain the SDF over the RCC slope protection and prevent flow from bypassing the dam along Reservoir Road. The RCC will buttress the existing spillway, encapsulating the erodible material under the spillway. It was noted that RCC overtopping protection can pass flows in excess of the SDF. Roger Adams pointed out the lowering of the dam crest will activate overtopping events more frequently than the 100-year storm. Consequently, the RCC overtopping protection essentially serves as a secondary spillway and would need to perform for a wide range of storm events. Design/construction costs are estimated at $2.6 million.

10. Gannett Fleming evaluated one decommissioning option (Alternative 8). This option represents a full breach and involves excavating a 40-wide x 4.5-foot deep pilot channel and a 120-foot wide overbank area through the embankment. Due to sedimentation of the reservoir, the pilot channel is extended through the reservoir on an alignment and grade that attempts to mimic the pre-dam conditions. The excavation for the breach and pilot channel results in approximately 51,000cy of material which is spoiled along the edges of the reservoir. Design/construction costs are estimated at $3.1 million. Over half of these costs are associated with sediment management.

a) Roger Adams noted that a dredging project was recently performed at the nearby Westtown Lake. Rick Smith stated that he would inquire into this project. ***After meeting note: Rick Smith spoke with the Fleet Manager at Westtown School who confirmed that approximately 68,000cy of silt was removed from the Westtown Lake and deposited onsite. Water depths were increased by 3 to 4 feet. Work remains to be completed on this project.***

11. In an attempt to manage the amount of sediment removal required under the decommissioning option, variations were evaluated that allow the majority of the sediment to be left in place. These "partial breach" options involve cutting down the spillway to an elevation at or near the sediment level, creating a dry pond. For these options, the dam would remain a regulated structure; however, the intent would be to reduce the storage capacity of the structure to the point where it can be reclassified as a low hazard dam as confirmed by an incremental breach analysis.

a) Alternate 9 assumes that the dam remains a high hazard structure, requiring the 1/2 PMF to pass through the spillway without overtopping the dam. Design/construction costs are estimated at $1.3 million.

b) Alternate 10 assumes that the dam can be reduced to a low hazard structure, reducing the spillway design flood to the 100-year event. Design/construction costs are estimated at $0.8 million.

c) With either Alternate 9 or 10, additional excavation could be performed within the reservoir to create areas of open water. However, such activities would need to be taken into consideration when performing the incremental breach analysis.

12. The RCC Overtopping Protection option is the preferred alternative for increasing conveyance capacity as this option is the most economical of the conveyance capacity options and can provide protection for storm events which exceed the SDF. The partial breach alternatives represent the lowest cost solutions; however, additional analysis is needed to determine the modifications required to convert the dam into a low hazard structure. The decommissioning alternative is similar in cost to the RCC Overtopping alternative and eliminates long term operation and maintenance costs. This is the only option that offers the opportunity to receive outside funding from other entities who may be looking for environmental credits.

13. DEP took no exception to the options presented with the understanding that additional engineering and analysis may be required depending on the selected alternative.

    a) Roger Adams stated that he will check with Jack Kraeuter to identify any concerns associated with spoiling sediment in the reservoir and allowing sediment releases during the partial breach (i.e., is there a need for a constructed pilot channel or can the pilot channel be allowed to occur naturally over a period of years by cutting down the spillway in increments).

14. Rick Smith questioned DEP on their expected timeframe for the Township to address inadequate spillway capacity at Milltown Dam. Roger Adams stated that the Department typically expects action to be taken within five years from the first notification letter (June 17, 2014 in the case of Milltown Dam). Consequently, DEP would expect action to be taken sometime within the next three years.

Any authorized persons who take exception to any statement in this report shall notify East Goshen Township or Gannett Fleming, in writing, within five (5) days from the date of receipt of this report, stating in detail the correction or omission. Otherwise, this report shall be considered correct and final.