Dam Failure Analysis and 2016 Initial Hazard Potential Classification

Brunner Island Ash Basin No. 6

Prepared for:
Brunner Island, LLC

September 29, 2016

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1 Executive Summary

This report presents the dam failure analysis and initial hazard potential classification for the Brunner Island Ash Basin No. 6 facility. This report was prepared by HDR Engineering, Inc. (HDR) in accordance with the requirements of the U.S. Environmental Protection Agency (USEPA) 40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities, April 17, 2015 (USEPA 2015) (CCR Final Rule). The CCR Final Rule establishes nationally applicable minimum criteria for the safe disposal of CCR in landfills and surface impoundments and requires that the owner or operator of each CCR unit demonstrate and document that the CCR unit complies with these criteria.

Brunner Island Ash Basin No. 6 is an operating Coal Combustion Residual (CCR) surface impoundment, referred to as an ash basin, which is owned and operated by Brunner Island, LLC, a division of Talen Energy (Talen). The ash basin is formed by an earthen embankment perimeter dike with a maximum height of approximately 30 feet. The ash basin is, therefore, required to have a dam failure analysis and to have the hazard potential periodically classified by a qualified engineer in accordance with the CCR Final Rule. This is the initial (first) Periodic Hazard Potential Classification performed in accordance with the CCR Final Rule. The ash basin is also subject to regulation by the Pennsylvania Department of Environmental Protection (PADEP) and has been previously classified as Size B, Hazard Classification 3 under the PADEP Dam Safety Guidelines, corresponding to a medium-sized, significant-hazard-potential dam. This report does not replace previous design flood or hazard classification analyses performed for the project, but provides additional analysis specific to USEPA criteria.

Ash Basin No. 6 is somewhat unique from a dam safety perspective, in that the ash basin is elevated with respect to the surrounding ground and is totally self-contained, with no contributing inflow from outside of the basin. The ash basin is also located immediately adjacent to the Susquehanna River, which will inundate much of the area surrounding the basin during flooding. As noted in the Inflow Design Flood Control System Plan (HDR 2016), the Inflow Design Flood (IDF) for the ash basin is the 1,000-year flood, in accordance with USEPA criteria for a significant-hazard-potential CCR impoundment, and the IDF control system can safely pass the IDF without overtopping, providing that the system is operated and maintained as designed.

Dam breaches were simulated with a two-dimensional (2D) hydrodynamic routing model using the United States Army Corps of Engineering (USACE) Hydrologic Engineering Center's River Analysis System (HEC-RAS) version 5.0.1. The breach size and formation rate was estimated in accordance with the Federal Emergency Management Agency (FEMA 2013), a reference recognized by the CCR Final Rule. Areas of potential inundation adjacent to and downstream of Ash Basin No. 6 were estimated for both Sunny Day and IDF (1,000-year storm event) conditions. For modeling purposes, the fly ash material impounded within Ash Basin No. 6 was conservatively simulated as impounded water.

A hazard inundation map for the areas potentially flooded was developed based on the peak flood elevations resulting from the dam failure analysis, overlaid on publicly available aerial photography. Since a failure anywhere along the perimeter of the ash basin could result in flooding, the inundation map includes a composite hazard inundation area, showing the area of hazard inundation of two feet or more of incremental rise in water surface elevation resulting from potential breaches of the Ash Basin No. 6 impoundment in several areas along the 8,300-foot-long perimeter dike, all shown on one map. The map shows the hazard inundation zones for both the IDF and Sunny Day scenarios, as well as the flood data, including peak flood flow and elevations for each scenario. This analysis indicates that there are no occupied structures or regularly occupied areas within the hazard inundation zone; therefore, there is no probable loss of human life indicated as a result of a failure of the Ash Basin No. 6 perimeter dike. A failure of the ash basin could result in significant economic loss as a result of damage to the basin and interference with plant operations, environmental damage as a result of inflow of ash to the Susquehanna River, or disruption of lifeline facilities as a result of erosion damage to the adjacent transmission line towers or natural gas supply line to the Brunner Island Steam Electric Station. Ash Basin No. 6 is, therefore, classified as having a significant hazard potential in accordance with the requirements of the CCR Final Rule. This is consistent with the classification determined by the USEPA in their Round 10 Dam Assessment Final Report, prepared by GZA Environmental, Inc., dated December 20, 2012 (GZA 2012).The IDF corresponding to the 1,000-year flood, as initially assumed for this analysis, is appropriate. The inundation map prepared for this study can be used to support the future development of an Emergency Action Plan (EAP), in accordance with the USEPA Final Rule.

2 Project Background

2.1 Existing Project Facilities

Ash Basin No. 6 is located between Black Gut Creek and the Susquehanna River at the southern end of Brunner Island in East Manchester Township, York County, Pennsylvania. Brunner Island is located along the western shore of the Susquehanna River and can be located on the York Haven U.S. Geological Survey (USGS) 7.5 Minute Quadrangle Map at 40°04′59″N, 76°40′58″W. An aerial view and drawings of Ash Basin No. 6 are provided in Appendix A.

Ash Basin No. 6 consists of a main basin with a polishing pond at the southern end. The ash basin has a total area of 76.4 acres and is surrounded by a perimeter dike with a nominal crest elevation of 290 feet referenced to National Geodetic Vertical Datum of 1929 (NGVD 29), which is also Plant Datum. All elevations in this report are referenced to the NGVD 29, which is also Plant Datum, unless specified otherwise. The northern end of the main basin has been filled with ash to near the crest of the dike. The open pool at the southern end of the main basin has an area of 9.4 acres, and is controlled by a stoplog weir in the outlet structure. The top-of-stoplog elevation was lowered to 283.5 feet during the summer of 2015, providing a normal water surface elevation of approximately 284.2 feet and a normal freeboard of 5.8 feet. The main basin is separated from the polishing pond by an intermediate dike, with the main basin outlet structure connecting the two basins with a 48-inch-diameter buried pipe, with a Komax mixing chamber located at the outlet of the main basin. The polishing pond is used for final treatment of the ash basin water before it is discharged to the Susquehanna River.

The polishing pond has an area of 2.7 acres and is controlled by twin-baffled, morning glory outlet structures, with top-of-weir elevations of 268.0 feet, which both discharge into a single 48-inch-diameter pipe to the river. A flap gate is provided at the river end of the discharge pipe to prevent river water from entering the ash basin during high tailwater conditions. The water elevation in the polishing pond is normally maintained at slightly above elevation 268.0 feet.

The perimeter dike is constructed with random earth fill and includes a 10-foot-thick clay liner covering the upstream slope from bedrock to elevation 287.5 feet. The maximum height of the dike is about 30 feet. Overall, the perimeter dike is approximately 8,300 feet long.

2.2 Spillway Capacity

The ash basin must comply with the Inflow Design Flood Control System requirements of the CCR Final Rule, which stipulates that the inflow design flood control system shall adequately manage flow into and from the surface impoundment during and following the peak discharge of the IDF. Selection of the IDF in accordance with the CCR Final Rule is dependent on the hazard classification, but the hazard classification may be dependent on the magnitude of the IDF. Based on previous analyses of the basin, including the determination by USEPA (GZA 2012) discussed above, HDR initially assumed that the ash basin had a significant hazard classification. The IDF was, therefore, assumed as the 1,000-year precipitation event in accordance with the CCR Final Rule. The classification assumption was verified as discussed later in this report.

A Spillway Design Flood Analysis stormwater model was developed in 2016 (HDR 2016), in HydroCAD Version 9.0, to analyze peak stage during the 1,000-year precipitation from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14 per USEPA CCR Final Rule regulations. To comply with the USEPA regulations, the dam failure hydraulic model simulated the full 24-hour, 1,000-year storm, with a total precipitation of 12.4 inches.

Table 2.2-1 Spillway Design Flood Analysis Summary – 1,000-Year Storm with Main Basin Starting Elevation 284.2 Feet

Main Basin	
Peak Stage, feet	286.93
Peak Discharge, cubic feet per second (cfs)	92.95
Time to Peak Stage, hours	12.77
Time to Peak Discharge, hours	12.38
Polishing Pond	
Peak Stage, feet	280.46
Peak Discharge, cfs	89.75
Time to Peak Stage, hours	13.84
Time to Peak Discharge, hours	13.84

Source: Inflow Design Flood Control System Plan (HDR 2016).

3 Dam Failure Analysis

A dam failure analysis was performed in accordance with FEMA Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures (FEMA 2013) to address the USEPA CCR Final Rule criteria that the potential downstream hazard associated with the failure of the Ash Basin No. 6 embankment perimeter dike be assessed under existing Project conditions. A two-dimensional (2D) hydrodynamic routing model using the USACE HEC-RAS version 5.0.1 was developed to perform the dam failure analysis. The hydraulic model utilized detailed Light Detection and Ranging (LiDAR) derived raster digital terrain data to provide enhanced topography to route the flood wave resulting from perimeter dike dam failure from Ash Basin No. 6 to the downstream extent of incremental impacts from the postulated breach.

The perimeter dike was simulated to fail under both the Sunny Day conditions and at peak conditions for the 1,000-year flood event. The dam failure analysis considers incremental flooding for base flow and stage conditions under both normal (sunny day) conditions and under flood conditions of the Susquehanna River coincident with the ash basin IDF. The Ash Basin No. 6 polishing pond directly discharges to the Susquehanna River and would be affected by the backwater of the Susquehanna River during a major flood. Because the size and hydrologic timing of the drainage areas for Ash Basin No. 6 and the Susquehanna River differ greatly, a 100-year flood was assumed to be occurring concurrently on the Susquehanna River during the Ash Basin No. 6 IDF scenario, which results in a peak stage of 278.8 feet for the Susquehanna River adjacent to Ash Basin No. 6 as reported on Federal Emergency Management Agency Flood Insurance Risk Map (FEMA FIRM) 42071C0283F effective April 5, 2016, which is included for reference in Appendix B. Note that NGVD 29 is approximately 0.8 feet higher than the North American Vertical Datum of 1988 (NAVD 88) at Ash Basin No. 6, and the FEMA FIRM provides elevations in NAVD88 which have been converted to NGVD29 for reporting purpose.

It is important to recognize that uncertainties in flood mapping and modeling can be attributed to multiple sources related to both the digital terrain model (DTM) and the hydraulic model. Uncertainties arising from the DTM include elevation accuracy and assumptions made about hydraulic connectivity. Hydraulic model uncertainties include computational approximations inherent in the unsteady flow model, choice of conveyance parameters, and simulation of breach progression. Therefore, the flood extents and incremental flooding estimated from simulated hypothetical failure scenarios represent an approximation of potential impacts to downstream structures based on sound engineering judgment.

3.1 Terrain data

The digital terrain data obtained from the Pennsylvania Mapping Program, PAMAP, during April 2016 (PADNCR 2009) was LiDAR-derived raster digital elevation model blocks and 2-foot contour information. The LiDAR data references elevations to the NAVD88. Horizontal control is referenced to the NAD 83 Pennsylvania State Plane, North Zone, U.S. Foot coordinate system. All Project structure elevations and water surface elevations were converted from NGVD29 (Plant Datum) to NAVD88, which is approximately 0.80 feet lower than the Plant Datum. Note that all hydraulic model results were converted from NAVD88 to NGVD29 for reporting purposes.

3.2 Hydraulic Model

The sequential steps of a dam break analysis include breach formation, routing of the resulting flood wave downstream, determination of inundation levels, evaluation of changes with respect to base (pre-flood) conditions, and identification of potential hazards. Breach formation is simulated using hydraulic software and implementing physically plausible breach parameters. Next, the hydraulic software simulates routing of the flood wave by solving the equations governing unsteady hydraulics. Finally, as the flood wave is translated and attenuated downstream, inundation levels are determined by correlating flow with stage (i.e., water surface elevation). Routing is continued downstream to a point where the incremental water surface rise due to the dam breach no longer poses a serious threat to life or significant property damage, typically assumed to be an incremental rise of less than 2 feet. Historically, these steps may have been handled by separate software or hand calculations. However, the software package currently in wide use is HEC-RAS. The HEC-RAS software, Version 5.0.1, simulates dam failure and performs two-dimensional steady and unsteady flow hydraulic calculations to dynamically route the flood wave downstream. The unsteady flow calculations are based on conservation of mass and momentum, and the two-dimensional full momentum form of the St. Venant equations of unsteady flow as the dam breach is a highly dynamic flood wave that will rise and fall quickly. The full momentum equation accounts for the change in velocity both spatially and over time. Ash Basin No. 6 and the Susquehanna River channel geometry are defined by digital terrain model elevation values, and Manning's roughness coefficients are input to establish terrain roughness. HEC-RAS calculates the flood wave hydrograph resulting from a dam failure based on input breach parameters.

3.2.1 River Channel Characteristics and Boundary Conditions

Ash Basin No. 6 is located adjacent to the Susquehanna River, surrounded by the main stem of the river to the east and a bifurcation channel to the west. The Susquehanna River is approximately 4,300 feet wide immediately downstream of Ash Basin No. 6. There are no tributaries along the Susquehanna River between Ash Basin No. 6 and the downstream confluence with the Codorus Creek. The reach of the Susquehanna River immediately downstream of the Ash Basin No. 6 has an average slope of approximately 0.00026 feet per foot.

The HEC-RAS 2-D modeling capability uses a finite-volume solution algorithm to allow for 2-D cells to be wet or dry and handle a sudden rush of water, subcritical, supercritical, and mixed-flow regimes. The 2-D computational mesh was developed by drawing a polygon boundary of the 2-D area and then defining the inflow and outflow boundaries. The 2-D mesh was generated with computation point spacing of 15 feet by 15 feet. The inflow boundary was defined as a storage area connection, connecting the storage basin (i.e., Ash Basin No. 6 main basin and polishing pond) to the 2-D mesh, to model the basin elevated perimeter dike. The downstream boundary for the model was established at Ely Island, approximately 1.25 miles downstream of the Ash Basin No. 6, upstream of Codorus Creek confluence and the railroad bridge crossing, as shown on the Hazard

Map provided in Appendix C. The downstream boundary of the modeled 2-D area is defined as normal depth slope of the Susquehanna River. The dam failure analysis key objective is to model the incremental impact of inundation extent between the normal and postulated breach conditions. The Manning's roughness coefficient was not defined in detail for this analysis, but assigned to the full mesh as an average Manning's roughness of the river and overbank as a terrain roughness n-value of 0.06.

3.2.2 Ash Basin Storage Capacity

The following summarizes the assumptions and method for estimating the total Ash Basin No. 6 storage capacity to be used in the breach model, as the model is conservatively simulating impounded fly ash material as water to be included in the breach stored volume.

The original topography drawing for Ash Basin No. 6 shows that the valley elevation where the basin is now located ranged from 285 to 262 feet within the basin footprint (Drawing D-129687-1, included in Appendix A). The original topography was regraded for basin construction, and the cut material was used for the perimeter dike embankment construction. The 2012 GZA Dam Assessment Report (GZA 2012) states that the "original basin storage capacity was approximately 2,600 acre-feet, with a height from top of perimeter dike embankment (elevation 290 feet) to natural ground approximately 30 feet (outside slope) and a depth of approximately 39 feet from the top of perimeter dike to bottom of basin (inside slope)".

An elevation-storage curve was not available for Ash Basin No. 6. To develop a total elevation-storage capacity curve of the impoundment, conservatively including fly ash material impounded within Ash Basin No. 6 as impounded water CCR, the best available drawings were used to estimate the original Ash Basin No. 6 footprint. Talen had conducted geological mapping as part of an assessment of the Ash Basin No. 6 piezometers in 2012 for their groundwater model development, which established cross-sections documenting the elevations of the bedrock, excavated sand and silt native valley material, and the coal fly ash layers. These geological cross-sections, included in Appendix A, show the original footprint of the basin was roughly excavated to elevation 270 feet and show the original basin was further excavated in the areas of the main basin and polishing pond down to the outlet conduit invert elevations of 260 feet in the main pond and 254 feet in the polishing pond. Talen had conducted topographical mapping in 2015 which was assessed in AutoCAD Version 2014 to estimate the volume between the original basin footprint and the existing crest perimeter dike at elevation 290 feet. The total impounded capacity of the ash basin (including fly ash material impounded) below elevation 290 feet was estimated to be approximately 1,525 acre-feet. Table 3.2-1 summarizes the impounded storage rating curve developed for this analysis. The total impounded capacity at the normal pool elevation 284.2 feet was estimated to be 1,093 acre-feet and at the IDF elevation 286.93 feet was estimated to be 1,294 acre-feet.

Table 3.2-1 Ash Basin 6 Impounded Capacity

Elevation, feet	Cumulative Volume (Includes water and impounded fly ash), acre-feet
290.00	1,524.8
288.00	1,374.0
286.00	1,225.2
284.00	1,078.4
282.00	933.7
280.00	790.8
278.00	650.0
276.00	511.1
274.00	374.1
272.00	239.0
270.00	105.9
268.00	45.3
266.00	33.8
264.00	23.0
262.00	13.0
260.00	3.6
258.00	2.2
256.00	1.0
254.00	0

3.2.3 Site Discharge Characteristics

Ash Basin No. 6 is somewhat unique from a hydrological perspective, in that the ash basin is elevated with respect to the surrounding ground and is totally self-contained, with no contributing inflow from outside of the basin. The evaluation summarized in this report addresses the 1,000-year flood occurring as a result of rainfall falling within the basin. This study conservatively assumed that all rainfall that falls within the basin is routed through the basin. The Ash Basin No. 6 polishing pond directly discharges to the Susquehanna River and would be affected by backwater effects of the Susquehanna River during a major flood. For the dam failure simulations, the basin system was assumed to be operating at full hydraulic capacity.

The 1,000-year flood elevation for the Susquehanna River was evaluated previously by Schnabel Engineering (Schnabel 2015), and was found to reach a water surface level of 0.5 feet below the crest of Ash Basin No. 6 and would not overtop the basin. Flooding of the ash basin due to backwater effects from the Susquehanna River was therefore not addressed as part of this report.

The Sunny Day scenario was simulated with the water surface elevation of Ash Basin No. 6 set to normal pond elevation, 284.2 feet. The Susquehanna River was assumed to be at normal baseflow during the Sunny Day scenario, with initial water surface elevation set to the digital terrain water level elevation of 252.8 feet.

As discussed in Section 2.2, a rainfall/storage/discharge model was updated in 2016 per USEPA regulations to model the hydrologic response of Ash Basin No. 6 to a storm corresponding to the 1,000-year precipitation from NOAA Atlas 14 (HDR 2016). To comply with the USEPA Rule, the IDF dam failure hydraulic model simulated the full 24-hour, 1,000-year storm, with a total precipitation of 12.4 inches, resulting in a main basin peak stage of 286.93 feet. The IDF scenario was simulated with the water surface elevation of Ash Basin No. 6 set to the 1,000-year storm peak stage.

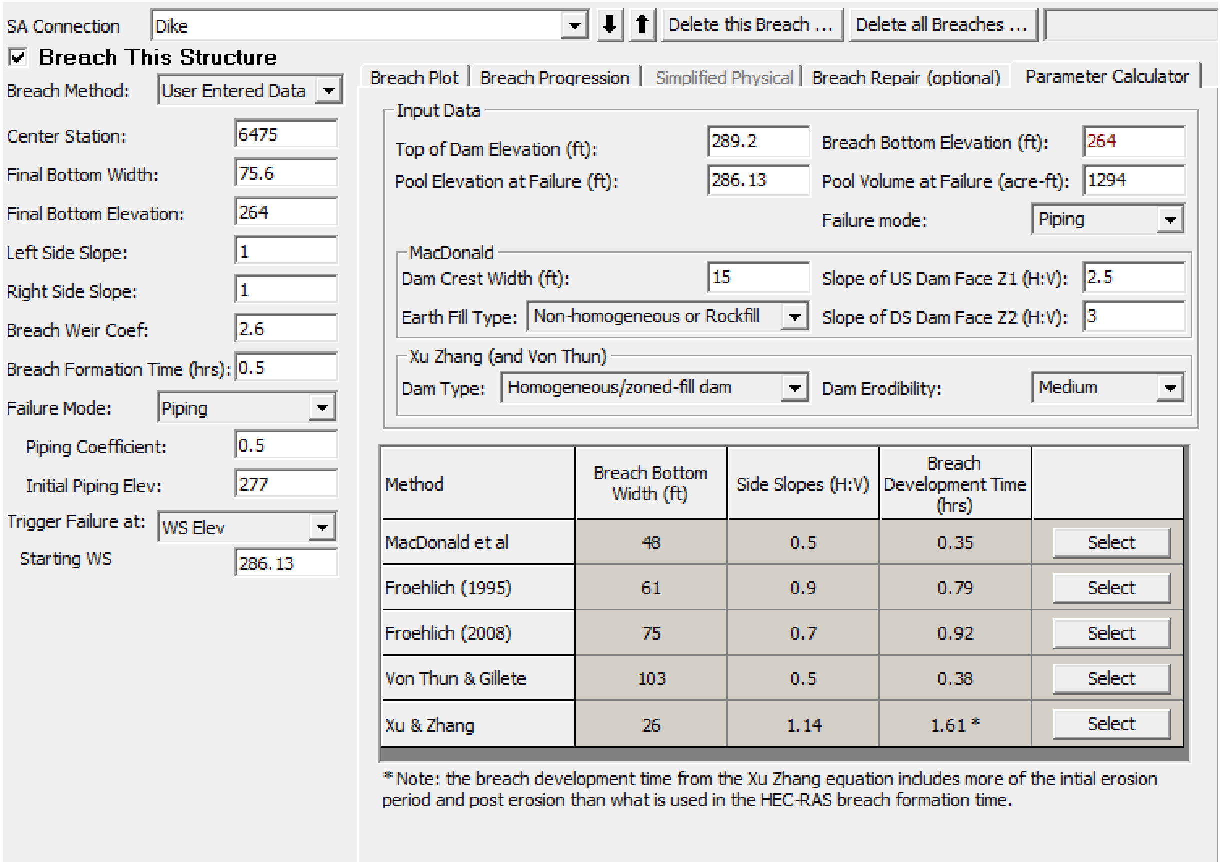
3.2.4 Dam Breach Parameters

The HEC-RAS model estimates breach parameters based on user input of the dam characteristics. The storage area connection defines the breach parameters for the dam failure model. As the crest of the Ash Basin No. 6 perimeter dike is elevation 290 feet, and both the Sunny Day and IDF event peak water surface elevations are lower than the crest, the breach for both the Sunny Day and IDF conditions was defined as a piping breach.

The USEPA Rule does not directly include guidelines on dam breach parameters. The breach size and formation rate was estimated in accordance with the FEMA guidelines (FEMA 2013), a reference recognized by the CCR Final Rule. FEMA is also consistent with the PADEP guidelines, which suggests a breach bottom based on site-specific characteristics or a breach bottom width of 3 times the height of the dam, that breach side slopes have a ratio of 1H:1V and that the breach formation time be 0.5 hours.

Figure 3.2-1 shows the dam characteristics and estimated breach parameters from the HEC-RAS parameter calculator. The HEC-RAS parameter calculator, which offers five different methods for estimating the breach parameters, agrees with the suggested FEMA guidelines. The PADEP breach parameters are more conservative than the Froehlich methods, but correlate well. The Von Thun & Gillete method typically yields an overly conservative breach geometry, the MacDonald et. al method has been found to yield an under-conservative breach geometry, and for earthen embankments, the Xu & Zhang method would require a more-detailed empirical equation calculation based on the dam erodibility parameters. Of these five methods, all but the Xu & Zhang methods are in compliance with the FEMA guidelines.

Figure 3.2-1 HEC-RAS Breach Parameter Calculator



Several breach locations were identified around the elevated perimeter dike, as a sensitivity analysis to assess the worst-case breach locations and to provide a composite flood mapping diagram, since there is no readily apparent or preferential failure location or flow path around the perimeter dike. Simulations were run with a breach occurring at the following locations of the perimeter dike: the northeast corner, the middle of the east embankment, the southeast corner, the southwest corner, the middle of the west embankment and the northwest corner of the perimeter dike. The piping breach parameters used for each of the breach simulations, based on the FEMA breach characteristics and in correlation with the Froehlich breach parameters, were defined as:

- Bottom width = 75.6 feet;
- Final bottom elevation = downstream toe 264 feet;
- Side slopes = 1:1 (H:V);
- Formation time = 0.5 hours.

An additional comparison was conducted to check the HEC-RAS breach parameter estimates, using empirical equations following the breach parameter relations referenced in the United States Bureau of Reclamation 1998 Prediction of Embankment Dam Breach Parameter publication DSO-98-004 (USBR 1998). The empirical equations estimated similar breach geometry as that of the PADEP and the Froehlich 2008 method of the HEC-RAS breach calculator and provided estimated peak breach discharge values between 15,000 to 30,000 cubic feet per second for the IDF simulation and 12,000 to

24,000 cubic feet per second for the Sunny Day simulation, which would be used to check the peak discharge simulated in the HEC-RAS scenarios.

3.3 Results of Dam Failure Analysis

The dam failure simulations for the Sunny Day condition resulted in a localized increase in water surface elevation in the Susquehanna River main stem and bifurcation channel immediately surrounding the Project location. The incremental increase in water surface did not travel downstream of the Project or result in a backwater impact up the bifurcation channel past the project extent. Figure 3.3-1 and Figure 3.3-2 show the Sunny Day breach peak velocity at the northwest and northeast breach locations.

Figure 3.3-1 HEC-RAS 2D Dam Failure Simulation – Northwest Sunny Day Breach Scenario

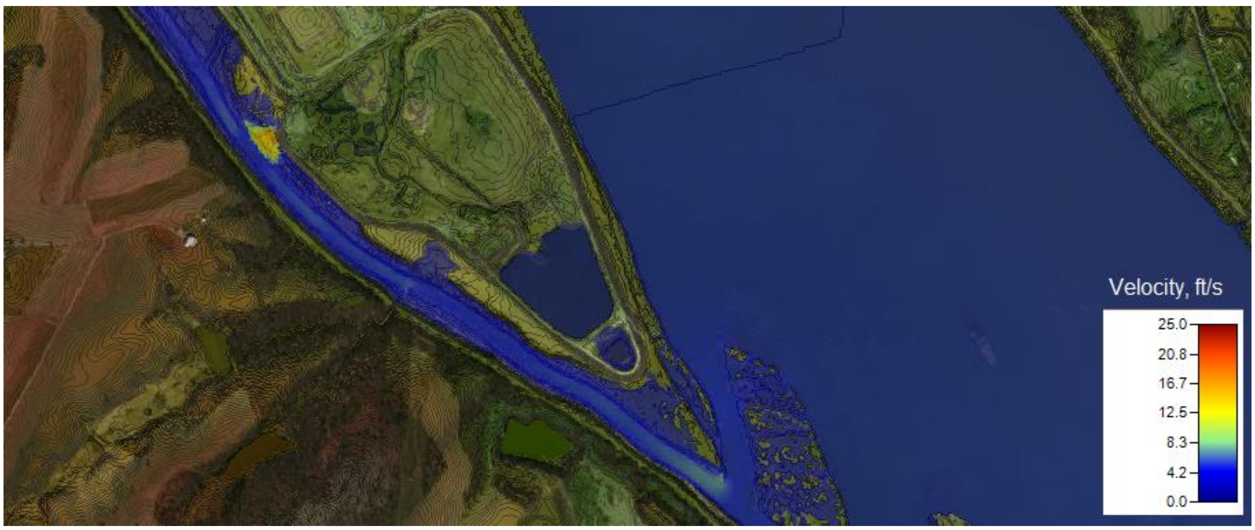
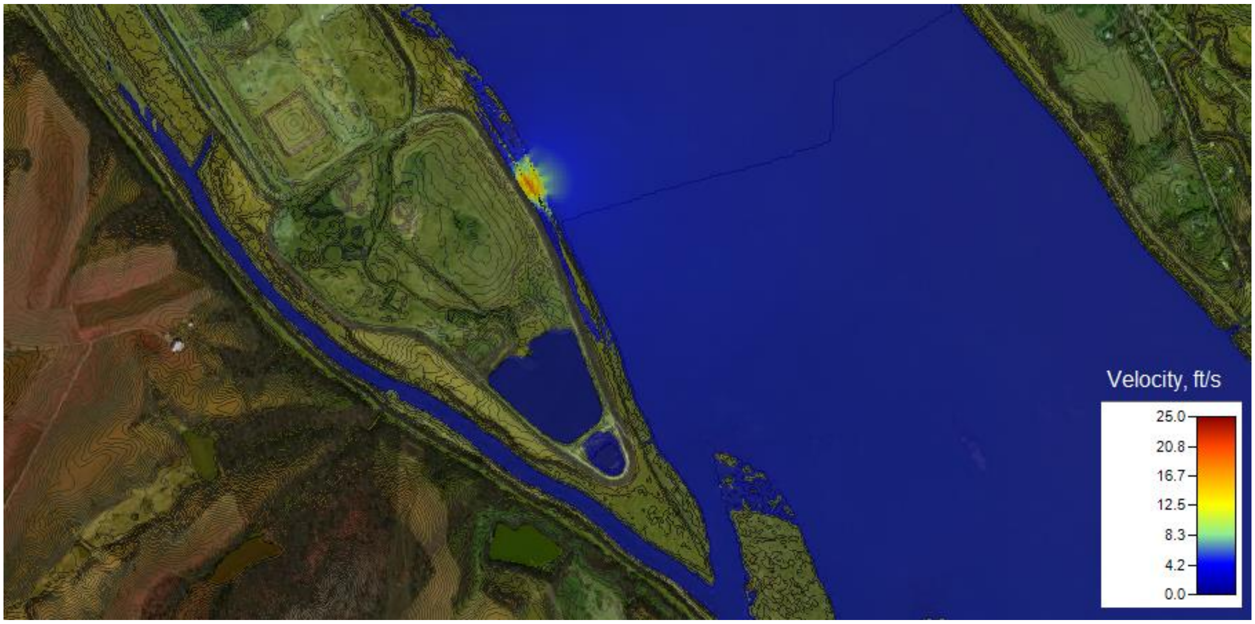


Figure 3.3-2 HEC-RAS 2D Dam Failure Simulation – Northeast Sunny Day Breach Scenario



The dam failure simulations for the IDF condition resulted in increased velocity and increased water surface elevation of less than two feet immediately surrounding the breach location of each simulation, but did not result in an increase in peak water surface elevation in the Susquehanna River main stem of more than a tenth of a foot as the river was already elevated to the 100-year water surface elevation and the IDF breach flood wave was quickly dissipated. Figure 3.3-3 and Figure 3.3-4 show the IDF breach peak velocity at the northwest and northeast breach locations.

Figure 3.3-3 HEC-RAS 2D Dam Failure Simulation – Northwest IDF Breach Scenario

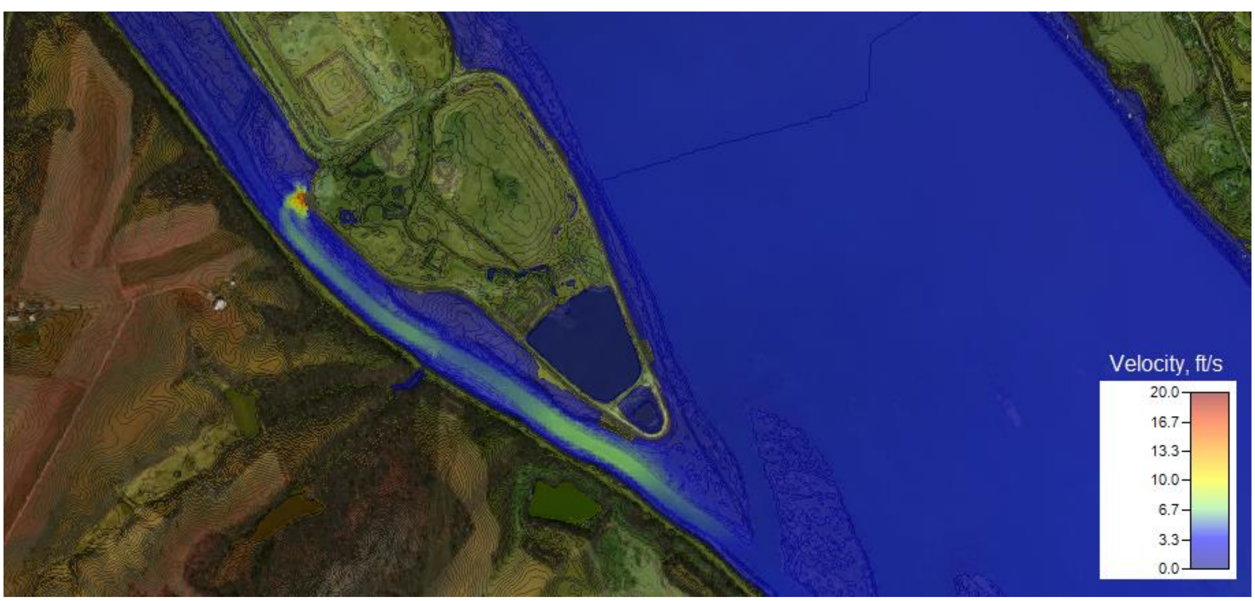
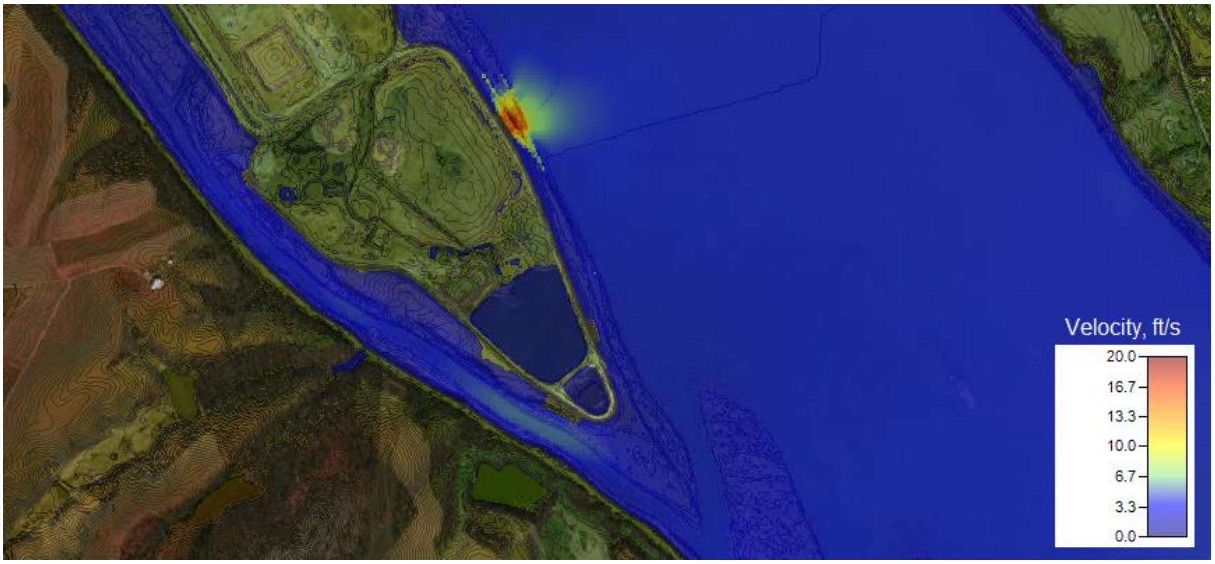


Figure 3.3-4 HEC-RAS 2D Dam Failure Simulation – Northeast IDF Breach Scenario



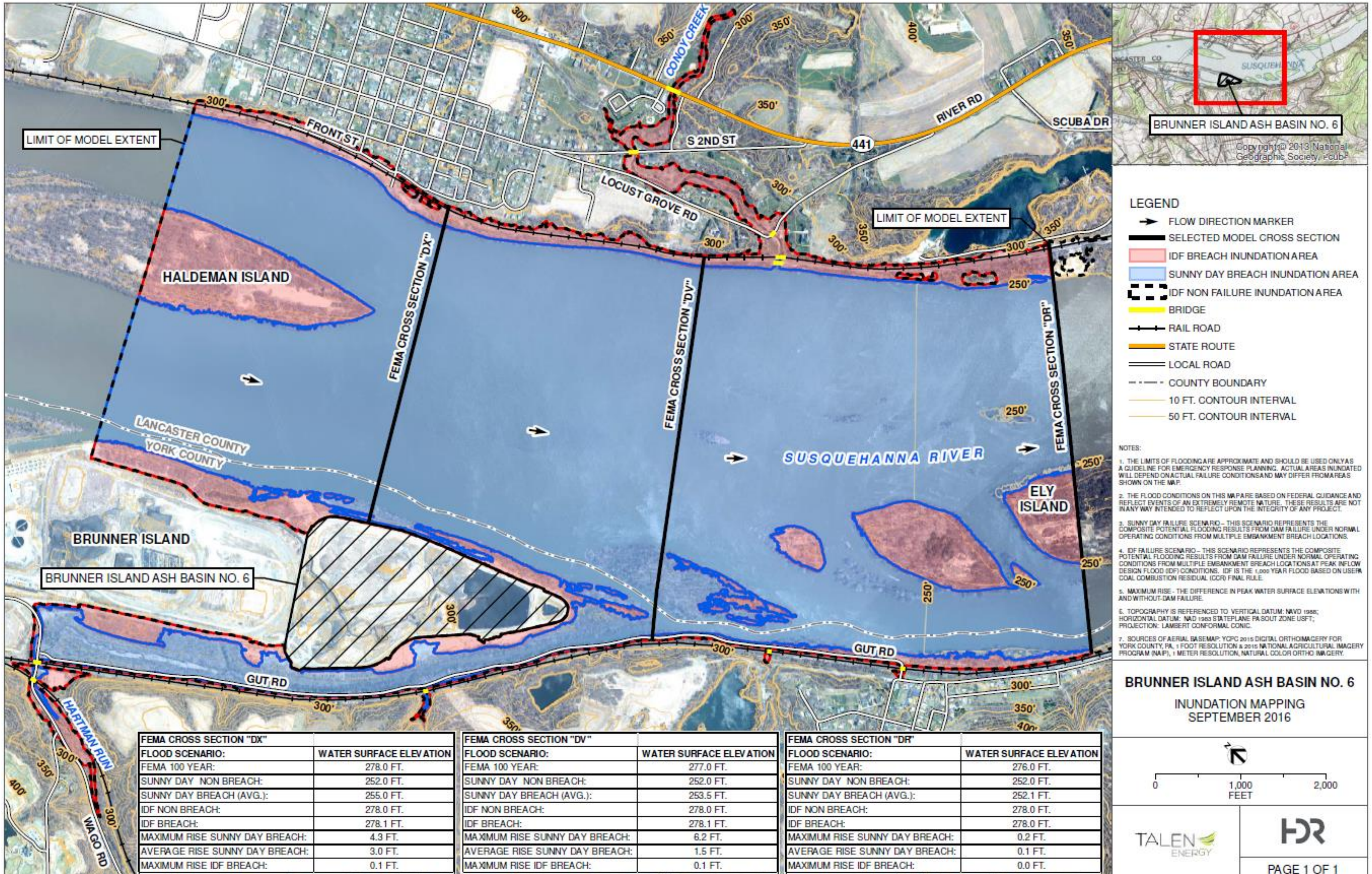
The results of the dam failure simulations for the three locations found to have the "worst-case" breach impact are summarized in Table 3.3-1 for both the Sunny Day and IDF conditions. The modeled peak breach discharge summarized in Table 3.3-1 agrees with the calculated breach discharge.

Table 3.3-1 HEC-RAS 2D Breach Results Summary

Scenario	Breach Location Along Basin Perimeter Dike	Peak Breach Discharge, cfs	Time to Peak from Breach Initiation, hrs	Maximum Breach Velocity, ft/s
Sunny Day	NW	14,590	0.45	17.3
	SW	14,590	0.45	17.6
	NE	14,590	0.45	19.4
IDF	NW	17,181	0.43	13.9
	SW	17,346	0.43	12.3
	NE	17,381	0.43	12.2

The key objective of inundation mapping is to depict and delineate the extent of potential flooding as a result of the selected hydraulic conditions. Incremental flooding, defined as the rise in water surface elevation from the base (normal) condition to the maximum stage that is associated with the failure of a hydraulic structure, identifies the areas downstream of the hydraulic structure that may result in potential population at risk. Figure 3.3-55 shows the water surface inundation extent for the Sunny Day and IDF conditions under both normal inundation and breach scenario inundation. The Sunny Day inundation extent is the same for both normal and postulated breach scenarios, staying within the river bank. The IDF inundation extent is also the same for both normal and postulated breach scenarios. Under the IDF inundation the river is already inundated to the 100-year flood limits, and the postulated IDF breach does not inundate further inland than the 100-year flood limits. There is no increase to the inundation area under both the Sunny Day and IDF conditions resulting from a postulated breach of the Ash Basin No. 6.

Figure 3.3-5 Inundation Mapping Resulting from Dam Failure Analysis



FEMA CROSS SECTION "DX"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	278.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
SUNNY DAY BREACH (AVG.):	255.0 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.1 FT.
MAXIMUM RISE SUNNY DAY BREACH:	4.3 FT.
AVERAGE RISE SUNNY DAY BREACH:	3.0 FT.
MAXIMUM RISE IDF BREACH:	0.1 FT.

FEMA CROSS SECTION "DV"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	277.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
SUNNY DAY BREACH (AVG.):	253.5 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.1 FT.
MAXIMUM RISE SUNNY DAY BREACH:	6.2 FT.
AVERAGE RISE SUNNY DAY BREACH:	1.5 FT.
MAXIMUM RISE IDF BREACH:	0.1 FT.

FEMA CROSS SECTION "DR"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	276.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
SUNNY DAY BREACH (AVG.):	252.1 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.0 FT.
MAXIMUM RISE SUNNY DAY BREACH:	0.2 FT.
AVERAGE RISE SUNNY DAY BREACH:	0.1 FT.
MAXIMUM RISE IDF BREACH:	0.0 FT.

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4 Hazard Analysis

A hazard inundation map was developed to evaluate the potential incremental impacts downstream of Ash Basin No. 6, included as Appendix C. The key objective of the hazard inundation map is to show areas of potential incremental impact where the water surface elevation is increased greater than two feet from the normal scenario to the postulated breach scenario hydraulic model results. Both the FEMA and FERC guidelines identify “acceptable consequences” of failure to be when the incremental impact of failure on downstream structures are approximately two feet or less. The hazard inundation area, as defined where the water surface elevation is increased greater than two feet and has been superimposed and geo-referenced onto a base map set, allows assessment of the hazard area to identify if the postulate breach may impact structures, infrastructure, or may pose a potential loss of life.

4.1 Existing Downstream Structures

The area adjacent to and downstream of Ash Basin No. 6 was reviewed using aerial photographs available from York County Planning Commission (YCPC 2015 digital orthoimagery one-foot resolution), National Agriculture Imagery Program (NAIP 2015 orthoimagery, one-meter resolution), and digital terrain mapping obtained from PAMAP to identify structures and infrastructure within the limits of this study. Detailed structural survey information was not available. There are several residential structures that line the Susquehanna River banks along the river reach between Ash Basin No. 6 and the Codorus Creek tributary downstream. There is a railroad and a minor road that parallel the river bifurcation to the west of Ash Basin No. 6 on the western bank of the bifurcation creek. There is a railroad and several minor roads that parallel the main stem of the river on the eastern river bank. There are a few structures identified on the islands located immediately downstream of the Project, just upstream of the railroad crossing bridge.

4.2 Downstream Limits of Potential Impact

The downstream limits of potential hazard impact, as determined by an incremental rise in water surface elevation greater than two feet between the normal and the postulated breach condition for the Sunny Day scenario, terminates immediately downstream of Ash Basin No. 6 where the bifurcation creek and the main stem of the Susquehanna River converge.

The downstream limits of potential hazard impact for the IDF scenario terminates immediately surrounding the Ash Basin No. 6 perimeter dike breach. The model results do not show a significant downstream potential hazard impact under the IDF conditions, as the Susquehanna River is assumed to be at the 100-year flood water surface elevation and the breach volume dissipates to the river.

The breach incremental impact is summarized in Table 4.2-1 at three FEMA FIRM designated cross sections within the study limit, for both the Sunny Day and the IDF scenarios.

Table 4.2-1 Dam Breach Incremental Impact Summary

Scenario	Location[1]	Non-breach Water Surface Elevation, feet NGVD29	Maximum Peak[2] Breach Water Surface Elevation, feet NGVD29	Incremental Rise
Sunny Day	FEMA Cross Section DX (Adjacent to Ash Basin No. 6, where the northeast breach is simulated)	252	255.0	3.0
	FEMA Cross Section DV (Immediately Downstream of River Bifurcation Confluence)	252	253.5	1.5
	FEMA Cross Section DR (Ely Island)	252	252.1	0.1
IDF	FEMA Cross Section DX (Adjacent to Ash Basin No. 6)	278	278.1	0.1
	FEMA Cross Section DV (Immediately Downstream of River Bifurcation Confluence)	278	278.1	0.1
	FEMA Cross Section DR (Ely Island)	278	278	0

1 FEMA Cross Section Locations as identified on FEMA FIRM 42071C0283F effective April 5, 2016, (FEMA 2016) which is included as reference in Appendix B.

2 The Peak Breach Water Surface Elevation is the maximum water surface elevation across the FEMA Cross Section of all breach locations for that scenario and is the average water surface across the river cross section location as the 2-D model calculates the flood wave so the elevation nearest the breach will be slightly higher than the elevation of the river on the opposite bank along the same river cross section.

4.3 Evaluation of Downstream Potential Impact

Model results indicate that there are no significant downstream impacts to occupied structures or regularly occupied areas that result from incremental rise in breach condition that are not already inundated during the normal conditions for both the Sunny Day and IDF scenarios. Therefore, a failure of the ash basin will probably not result in a loss of human life. For the Sunny Day scenario, depending on the breach location along the perimeter dike, there may be potential hazard impacts in the immediate areas near the Ash Basin No. 6 perimeter dike if a breach were to occur, including possible damage to the transmission towers located immediately downstream of the dike on the northeast and middle of the west sides of the basin and the natural gas line adjacent to the west side of the basin, and potential impacts to recreational use of the Susquehanna River and river bank. There is little warning time, as the peak breach discharge is estimated to occur within 0.45 hours from time of a breach initiation, so evacuating this area of the river during a breach of the perimeter dike might be difficult.

The railroad that parallels the river bifurcation to the west of Ash Basin No. 6 on the western bank of the bifurcation creek remains outside of the inundation extent for all simulated scenarios. The minor road that parallels the river bifurcation to the west of Ash Basin No. 6 is inundated by less than a two-foot increase in water surface elevation between the Sunny Day normal and postulated breach scenarios. This road is inundated by more than 2 feet during the IDF, prior to the breach.

The railroad and several minor roads that parallel the main stem of the Susquehanna River on the eastern river bank are inundated during both the pre-failure and the postulated breach scenarios for the IDF condition. The structures identified on the islands located immediately downstream of Ash Basin No. 6, just upstream of the railroad crossing bridge, and several structures located along the river banks are also inundated during both the pre-failure and the postulated breach scenarios for the IDF condition.

As a hazard analysis focuses on the incremental impacts that result from the rise in breach conditions, there is no increased hazard to structures or human life identified as a result of the postulated breaches of the Ash Basin No. 6 perimeter dike. The hazard inundation area is contained within the river banks, surrounding the immediate vicinity of Ash Basin No. 6, as shown on the Hazard Inundation Map included in Appendix C. A failure of the ash basin could result in significant economic loss as a result of damage to the basin and interference with plant operations, environmental damage as a result of inflow of ash to the Susquehanna River, or disruption of lifeline facilities as a result of erosion damage to the adjacent transmission line towers or natural gas supply line to the Brunner Island Steam Electric Station. Therefore, the Ash Basin No. 6 has a significant-hazard-potential classification, as defined by the FEMA guidelines (FEMA 2013) and in compliance with the USEPA CCR Rule, as there is no probable loss of human life but failure can cause economic loss, environmental damage, or disruption of lifeline facilities.

5 Conclusions and Certification

The USEPA stipulates that the inflow design flood control system for coal ash storage impoundments shall adequately manage flow into and from the surface impoundment during and following the peak discharge of the IDF. The USEPA requires that an EAP be developed and include a map which delineates the downstream area which would be affected in the event of a CCR surface impoundment failure.

The 2D hydrodynamic routing model was developed and dam failure breach scenario routines were simulated to estimate potential hazard inundation of areas downstream of Ash Basin No. 6 for the postulated breach under Sunny Day and IDF conditions. For hydraulic model dam failure breach simulation and routing purposes, the fly ash material impounded within Ash Basin No. 6 was conservatively simulated as impounded water.

The potential downstream hazard, based on incremental rise on structures and/or populated areas downstream of Ash Basin No. 6, resulting from dam failure and associated hazard potential is greater during the Sunny Day postulated breach than it is during the IDF postulated breach.

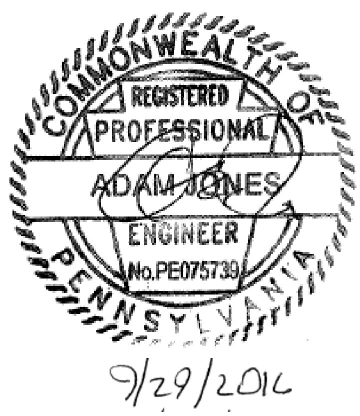
A hazard inundation map for the areas potentially flooded was developed, based on the peak flood elevations resulting from the dam failure analysis. Since a failure anywhere along the perimeter of Ash Basin No. 6 could result in flooding, the inundation map includes a composite hazard inundation area, showing the area of hazard inundation of two feet or more of incremental rise in water surface elevation resulting from potential breaches of the Ash Basin No. 6 impoundment in several areas along the 8,300-foot-long perimeter dike, all shown on one map.

This analysis indicates that there are no occupied structures or regularly occupied areas within the hazard inundation zone; therefore, there is no probable loss of human life indicated as a result of a failure of the Ash Basin No. 6 perimeter dike. A failure of the ash basin could result in significant economic loss as a result of damage to the basin and interference with plant operations, environmental damage as a result of inflow of ash to the Susquehanna River, or disruption of lifeline facilities as a result of erosion damage to the adjacent transmission line towers or natural gas supply line to the Brunner Island Steam Electric Station. Ash Basin No. 6 is, therefore, classified as having a significant hazard potential in accordance with the requirements of the CCR Final Rule. The IDF corresponding to the 1,000-year flood, as initially assumed for this analysis, is appropriate. The inundation map prepared for this study can be used to support the future development of an EAP, in accordance with the USEPA Final Rule.

Based on the information currently available, I certify to the best of my knowledge, information, and belief that this Dam Failure Analysis and Hazard Classification Report meets the requirements of CCR Rule §257.73(a) Structural Integrity Criteria for Existing CCR Surface Impoundments, in accordance with professional standards of care for similar work. HDR appreciates the opportunity to assist Talen with this project. Please contact us if you have any questions or comments.

Adam N. Jones, P.E.
Senior Engineer

Jennifer N. Gagnon, P.E.
Associate Engineer



6 References

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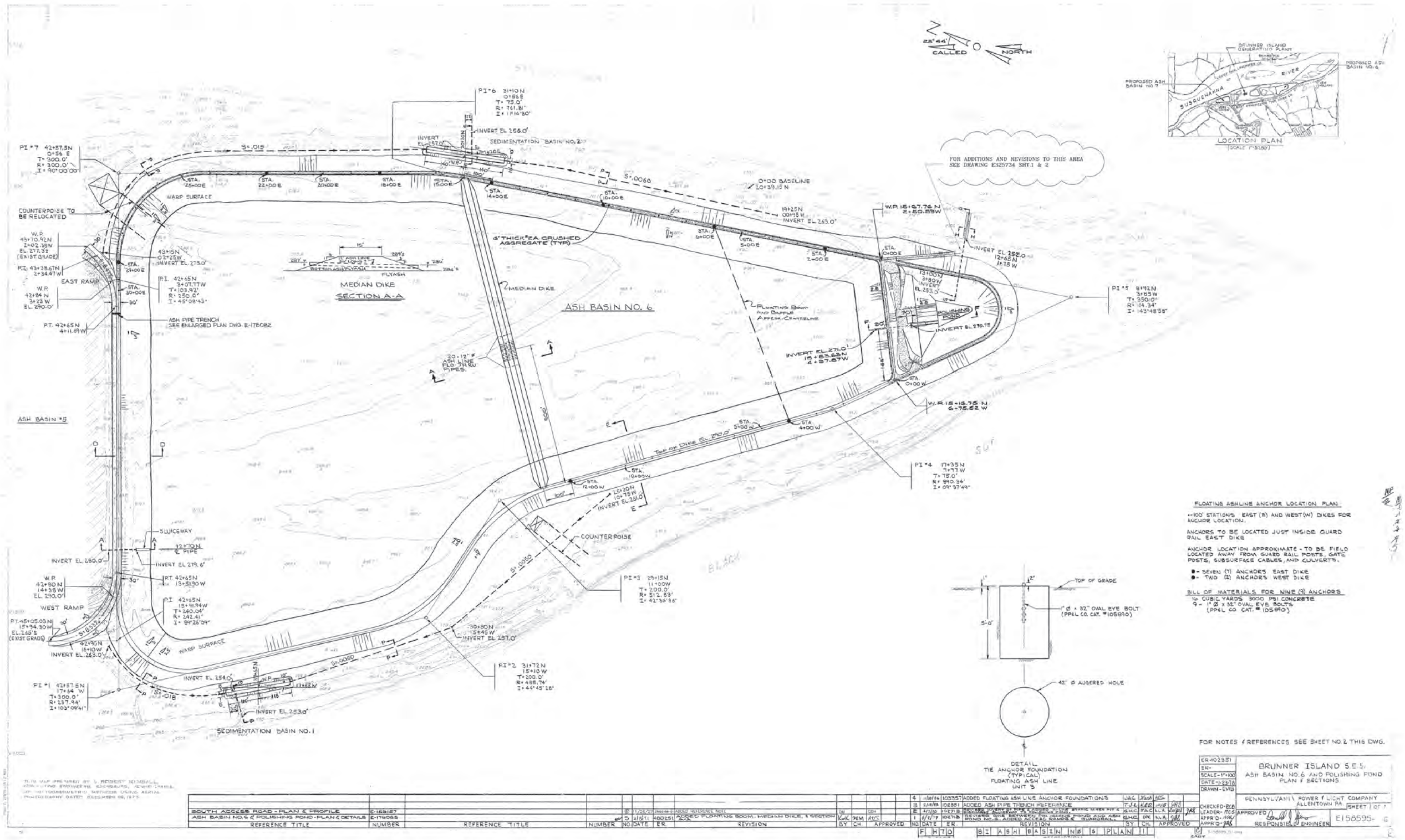
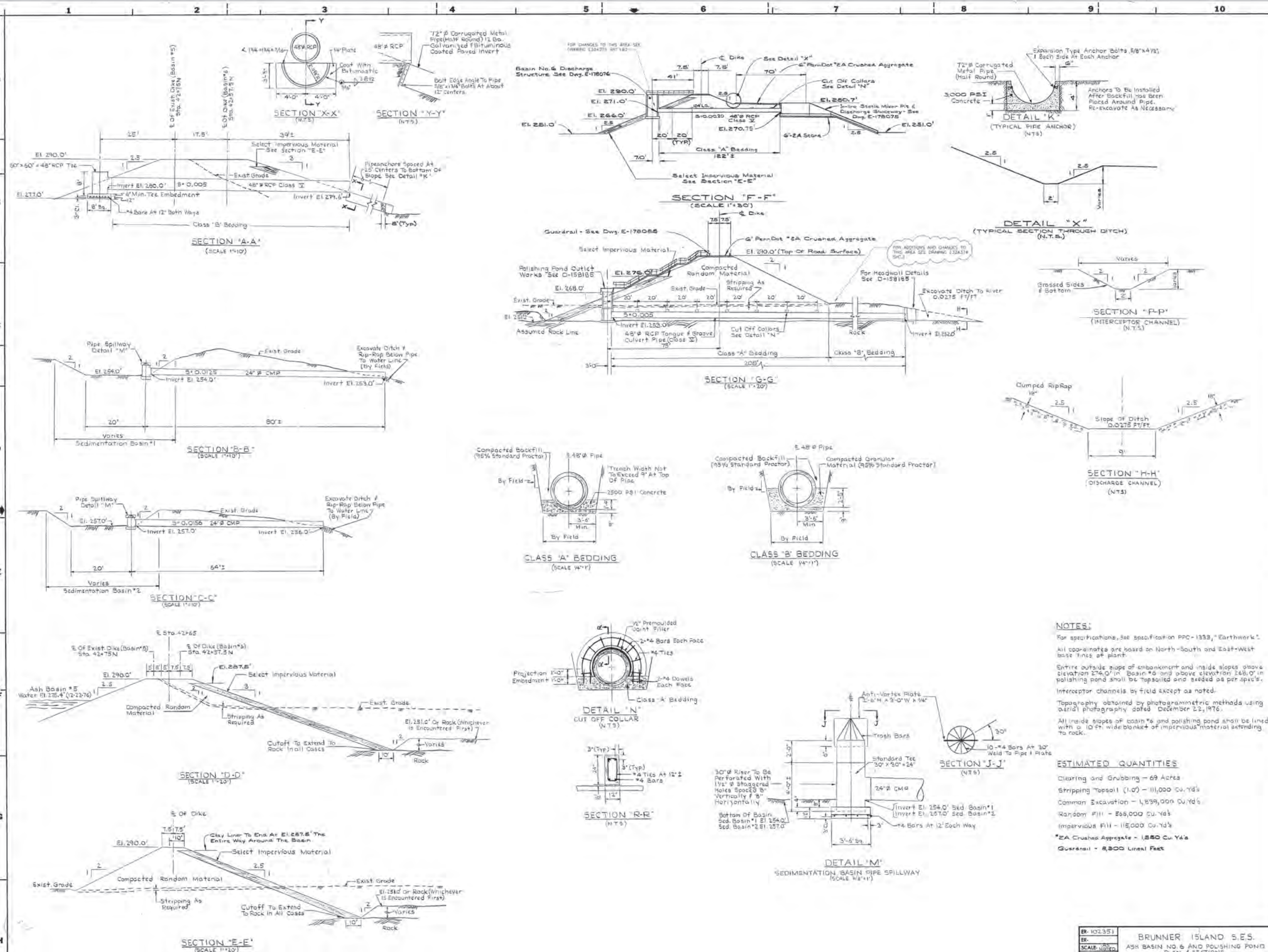
Appendix A. Project Drawings


CALLED NORTH
LOCATION PLAN
SUSQUEHANNA RIVER
FOR ADDITIONS AND REVISIONS TO THIS AREA SEE DRAWING E325734 SHT.1 & 2
ASH BASIN NO. 6
ASH BASIN #5
MEDIAN DIKE
SECTION A-A
SEDIMENTATION BASIN NO. 1
SEDIMENTATION BASIN NO. 2
EAST RAMP
WEST RAMP
WARP SURFACE
SLUICEWAY
COUNTERPOISE
TOP OF DIKE EL. 270.0'
FLOATING ASHLINE ANCHOR LOCATION PLAN
+-100' STATIONS EAST (E) AND WEST (W) DIKES FOR ANCHOR LOCATION.
ANCHORS TO BE LOCATED JUST INSIDE GUARD RAIL EAST DIKE
ANCHOR LOCATION APPROXIMATE - TO BE FIELD LOCATED AWAY FROM GUARD RAIL POSTS, GATE POSTS, SUBSURFACE CABLES, AND CULVERTS.
●- SEVEN (7) ANCHORS EAST DIKE
●- TWO (2) ANCHORS WEST DIKE
BILL OF MATERIALS FOR NINE (9) ANCHORS
16 CUBIC YARDS 3000 PSI CONCRETE
9 - 1" Ø x 32" OVAL EYE BOLTS (PP&L CO CAT. # 105890)
DETAIL TIE ANCHOR FOUNDATION (TYPICAL) FLOATING ASH LINE UNIT 3
FOR NOTES & REFERENCES SEE SHEET NO. 2 THIS DWG.
BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 AND POLISHING POND PLAN & SECTIONS
SCALE - 1"=100
DATE - 1-23-78
PENNSYLVANIA POWER & LIGHT COMPANY ALLENTOWN PA.
SHEET 1 OF 7
E158595-6

Appendix A-2



NOTES:

For specifications, see specification PPC-1339, "Earthwork".

All coordinates are based on North-South and East-West base lines of plant.

Entire outside slope of embankment and inside slopes above elevation 274.0' in Basin #6 and above elevation 268.0' in polishing pond shall be topsoiled and seeded as per spec's.

Interceptor channels by field except as noted.

Topography obtained by photogrammetric methods using aerial photography dated December 22, 1976.

All inside slopes of basin #6 and polishing pond shall be lined with a 10 ft. wide blanket of impervious material extending to rock.

ESTIMATED QUANTITIES

Clearing and Grubbing – 69 Acres

Stripping Topsoil (1.0') – 111,000 Cu. Yd's

Common Excavation – 1,839,000 Cu. Yd's

Random Fill – 568,000 Cu. Yd's

Impervious Fill – 115,000 Cu. Yd's

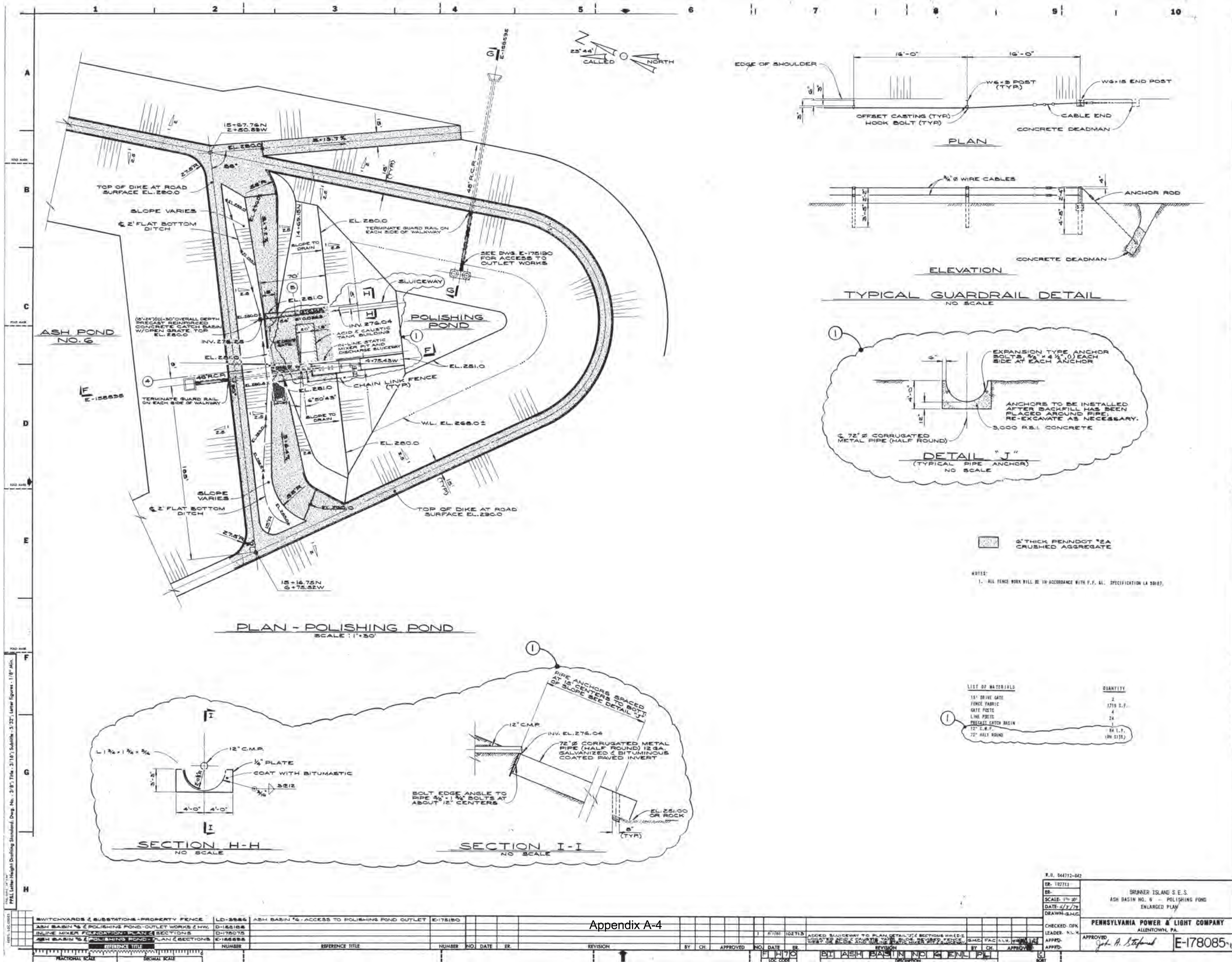
#2A Crushed Aggregate – 1,580 Cu. Yd's

Guardrail – 8,300 Lineal Feet

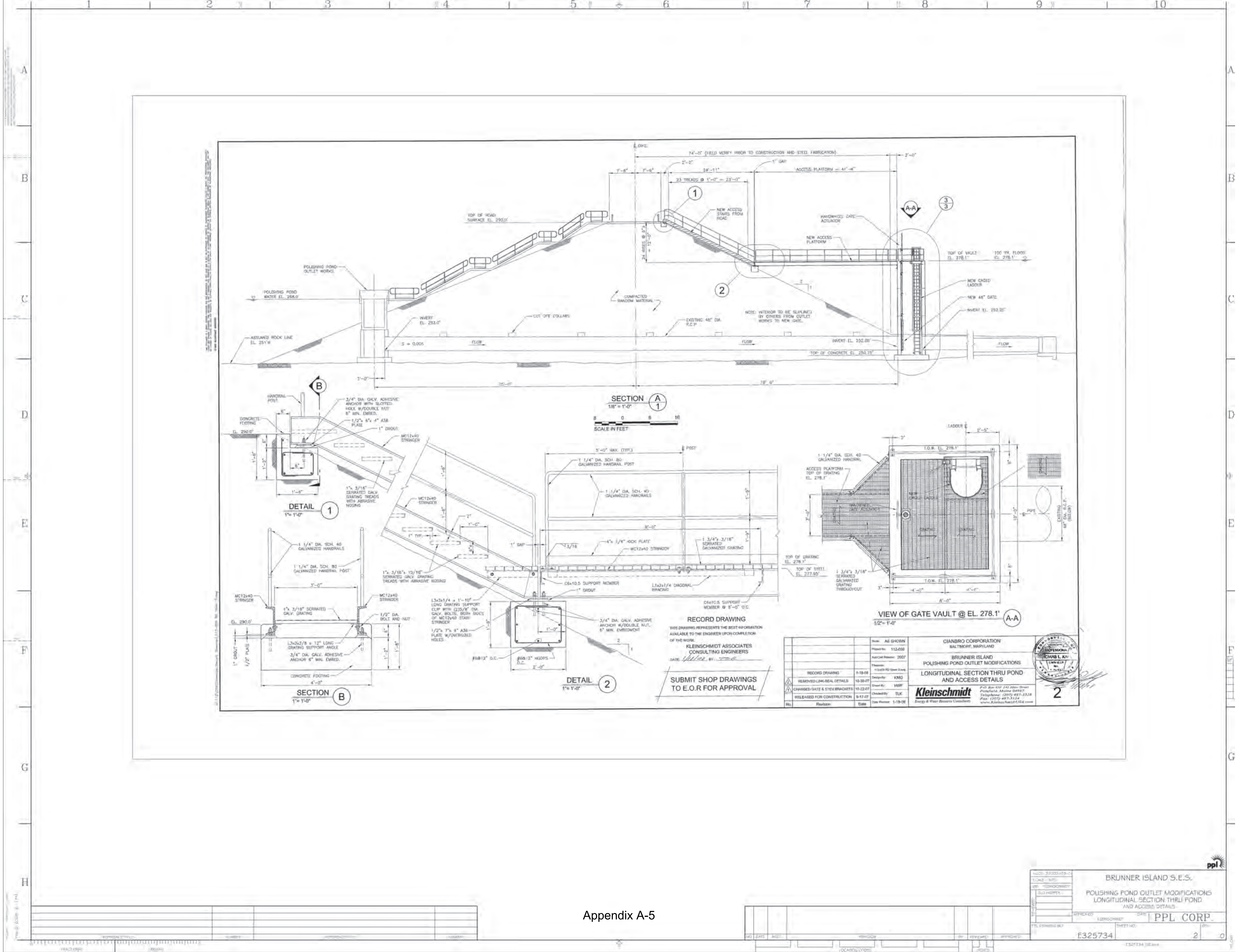
ER-102351	BRUNNER ISLAND S.E.S.
ER-	ASH BASIN NO. 6 AND POLISHING POND
SCALE- AS NOTED	PLAN & SECTIONS
DATE- 1-23-78	
DRAWN- EMB	PENNSYLVANIA POWER & LIGHT COMPANY
CHECKED- RCB	ALLENTOWN, PA. SHEET 2 OF 2
LEADER- RGS	RESPONSIBLE ENGINEER
APPR'D- NMJ	E158595-4
APPR'D- JAS	

REFERENCE TITLE	NUMBER
ASH STORAGE AREAS #4 & #5 - PLAN	LF-75333
ASH BASIN #6 / POLISHING POND - OUTLET WORKS & HEADWALL	C-158185
ASH BASIN #7 - PLAN & SECTIONS	E-157640
ASH BASIN #6 - LOCATION & LOG OF CORE DRILL HOLES	D-129687

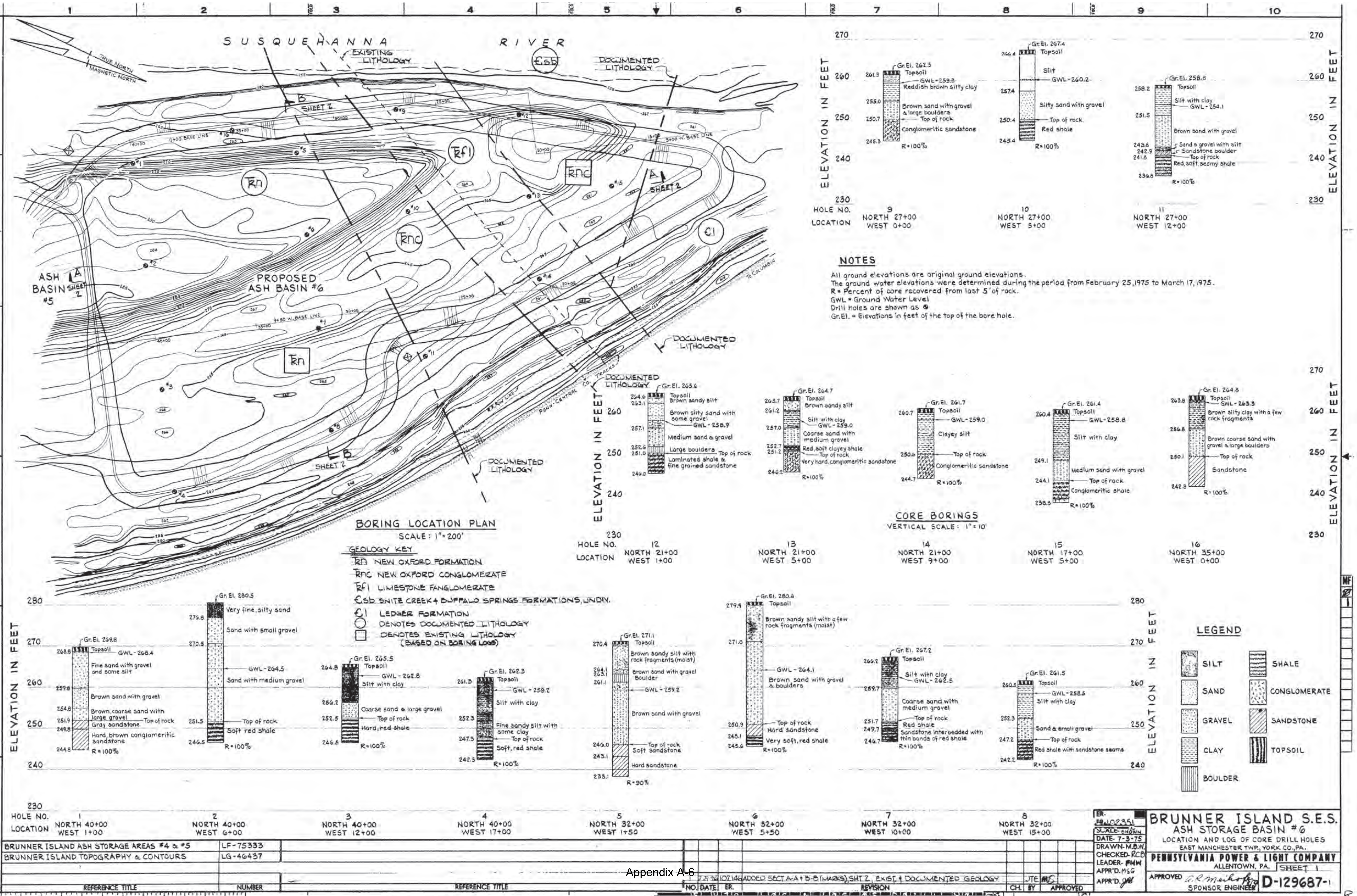
Appendix A-3



PLAN - POLISHING POND
SCALE : 1"=30'
ASH POND NO. 6
POLISHING POND
TOP OF DIKE AT ROAD SURFACE EL. 280.0
SLOPE VARIES
℄ 2' FLAT BOTTOM DITCH
EL. 280.0
TERMINATE GUARD RAIL ON EACH SIDE OF WALKWAY
SLOPE TO DRAIN
SEE DWG. E-175190 FOR ACCESS TO OUTLET WORKS
SLUICEWAY
EL. 281.0
INV. 276.04
ACID & CAUSTIC TANK BUILDING
IN-LINE STATIC MIXER PIT AND DISCHARGE SLUICEWAY
EL. 281.0
CHAIN LINK FENCE (TYP)
W.L. EL. 268.0±
INV. 276.25
48" R.C.P.
15+67.76N 2+50.83W
15+16.75N 6+75.82W
4+75.43W
CALLED
NORTH
TYPICAL GUARDRAIL DETAIL
NO SCALE
PLAN
ELEVATION
EDGE OF SHOULDER
16'-0"
16'-0"
W6×8 POST (TYP)
W6×15 END POST
OFFSET CASTING (TYP)
HOOK BOLT (TYP)
CABLE END
CONCRETE DEADMAN
3/4" Ø WIRE CABLES
ANCHOR ROD
CONCRETE DEADMAN
DETAIL "J"
(TYPICAL PIPE ANCHOR)
NO SCALE
EXPANSION TYPE ANCHOR BOLTS, 5/8" × 4 1/2", (1) EACH SIDE AT EACH ANCHOR
ANCHORS TO BE INSTALLED AFTER BACKFILL HAS BEEN PLACED AROUND PIPE; RE-EXCAVATE AS NECESSARY.
℄ 72" Ø CORRUGATED METAL PIPE (HALF ROUND)
3,000 P.S.I. CONCRETE
6" THICK PENNDOT #2A CRUSHED AGGREGATE
NOTES:
1. ALL FENCE WORK WILL BE IN ACCORDANCE WITH P.P. &L. SPECIFICATION LA 50187.
LIST OF MATERIALS
QUANTITY
15' DRIVE GATE
FENCE FABRIC
GATE POSTS
LINE POSTS
PRECAST CATCH BASIN
72" C.M.P.
72" HALF ROUND
SECTION H-H
NO SCALE
12" C.M.P.
1/4" PLATE
COAT WITH BITUMASTIC
4'-0"
4'-0"
SECTION I-I
NO SCALE
PIPE ANCHORS SPACED AT 15' CENTERS TO BOTTOM OF SLOPE. SEE DETAIL "J"
12" C.M.P.
INV. EL. 276.04
72" Ø CORRUGATED METAL PIPE (HALF ROUND) 12 GA. GALVANIZED & BITUMINOUS COATED PAVED INVERT
BOLT EDGE ANGLE TO PIPE 5/8" × 1 3/4" BOLTS AT ABOUT 12" CENTERS
EL. 251.00 OR ROCK
8" (TYP)
SWITCHYARDS & SUBSTATIONS - PROPERTY FENCE
ASH BASIN #6 & POLISHING POND - OUTLET WORKS & MW.
INLINE MIXER FOUNDATION - PLAN & SECTIONS
ASH BASIN #6 & POLISHING POND - PLAN & SECTIONS
ASH BASIN #6 - ACCESS TO POLISHING POND OUTLET
E-175190
REFERENCE TITLE
NUMBER
REVISION
BRUNNER ISLAND S.E.S.
ASH BASIN NO. 6 - POLISHING POND
ENLARGED PLAN
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.
E-178085



SECTION A 1
1/8" = 1'-0"
SCALE IN FEET
DETAIL 1
1" = 1'-0"
SECTION B
1" = 1'-0"
DETAIL 2
1" = 1'-0"
VIEW OF GATE VAULT @ EL. 278.1' A-A
RECORD DRAWING
KLEINSCHMIDT ASSOCIATES
CONSULTING ENGINEERS
SUBMIT SHOP DRAWINGS
TO E.O.R FOR APPROVAL
CIANBRO CORPORATION
BALTIMORE, MARYLAND
BRUNNER ISLAND
POLISHING POND OUTLET MODIFICATIONS
LONGITUDINAL SECTION THRU POND
AND ACCESS DETAILS
Kleinschmidt
2
BRUNNER ISLAND S.E.S.
POLISHING POND OUTLET MODIFICATIONS
LONGITUDINAL SECTION THRU POND
AND ACCESS DETAILS
PPL CORP.
E325734


SUSQUEHANNA RIVER
EXISTING LITHOLOGY
DOCUMENTED LITHOLOGY
TRUE NORTH
MAGNETIC NORTH
PROPOSED ASH BASIN #6
ASH BASIN #5
SHEET 2
PENN CENTRAL CO. TRACKS
TO COLUMBIA
BORING LOCATION PLAN
SCALE: 1" = 200'
GEOLOGY KEY
Ꞧn NEW OXFORD FORMATION
Ꞧnc NEW OXFORD CONGLOMERATE
Ꞧfl LIMESTONE FANGLOMERATE
Ꞓsb SNITZ CREEK & BUFFALO SPRINGS FORMATIONS, UNDIV.
Ꞓl LEDGER FORMATION
DENOTES DOCUMENTED LITHOLOGY
DENOTES EXISTING LITHOLOGY (BASED ON BORING LOGS)
NOTES
All ground elevations are original ground elevations.
The ground water elevations were determined during the period from February 25, 1975 to March 17, 1975.
R = Percent of core recovered from last 5' of rock.
GWL = Ground Water Level
Drill holes are shown as ⊗
Gr.El. = Elevations in feet of the top of the bore hole.
CORE BORINGS
VERTICAL SCALE: 1" = 10'
ELEVATION IN FEET
HOLE NO.
LOCATION
9 NORTH 27+00 WEST 0+00
10 NORTH 27+00 WEST 5+00
11 NORTH 27+00 WEST 12+00
12 NORTH 21+00 WEST 1+00
13 NORTH 21+00 WEST 5+00
14 NORTH 21+00 WEST 9+00
15 NORTH 17+00 WEST 5+00
16 NORTH 35+00 WEST 0+00
1 NORTH 40+00 WEST 1+00
2 NORTH 40+00 WEST 6+00
3 NORTH 40+00 WEST 12+00
4 NORTH 40+00 WEST 17+00
5 NORTH 32+00 WEST 1+50
6 NORTH 32+00 WEST 5+50
7 NORTH 32+00 WEST 10+00
8 NORTH 32+00 WEST 15+00
Topsoil
Top of rock
R=100%
R=90%
LEGEND
SILT
SAND
GRAVEL
CLAY
BOULDER
SHALE
CONGLOMERATE
SANDSTONE
TOPSOIL
BRUNNER ISLAND ASH STORAGE AREAS #4 & #5 LF-75333
BRUNNER ISLAND TOPOGRAPHY & CONTOURS LG-46437
REFERENCE TITLE
NUMBER
ADDED SECT A-A + B-B (MARKS), SHT 2, EXIST & DOCUMENTED GEOLOGY
NO. DATE ER. REVISION CH. BY APPROVED
SCALE: SHOWN
DATE: 7-3-75
DRAWN: M.B.W.
CHECKED: R.C.B.
LEADER: F.H.W.
APPR'D: M.S.G.
BRUNNER ISLAND S.E.S.
ASH STORAGE BASIN #6
LOCATION AND LOG OF CORE DRILL HOLES
EAST MANCHESTER TWP., YORK CO., PA.
PENNSYLVANIA POWER & LIGHT COMPANY
ALLENTOWN, PA.
SHEET 1
SPONSOR ENGINEER
D-129687-1

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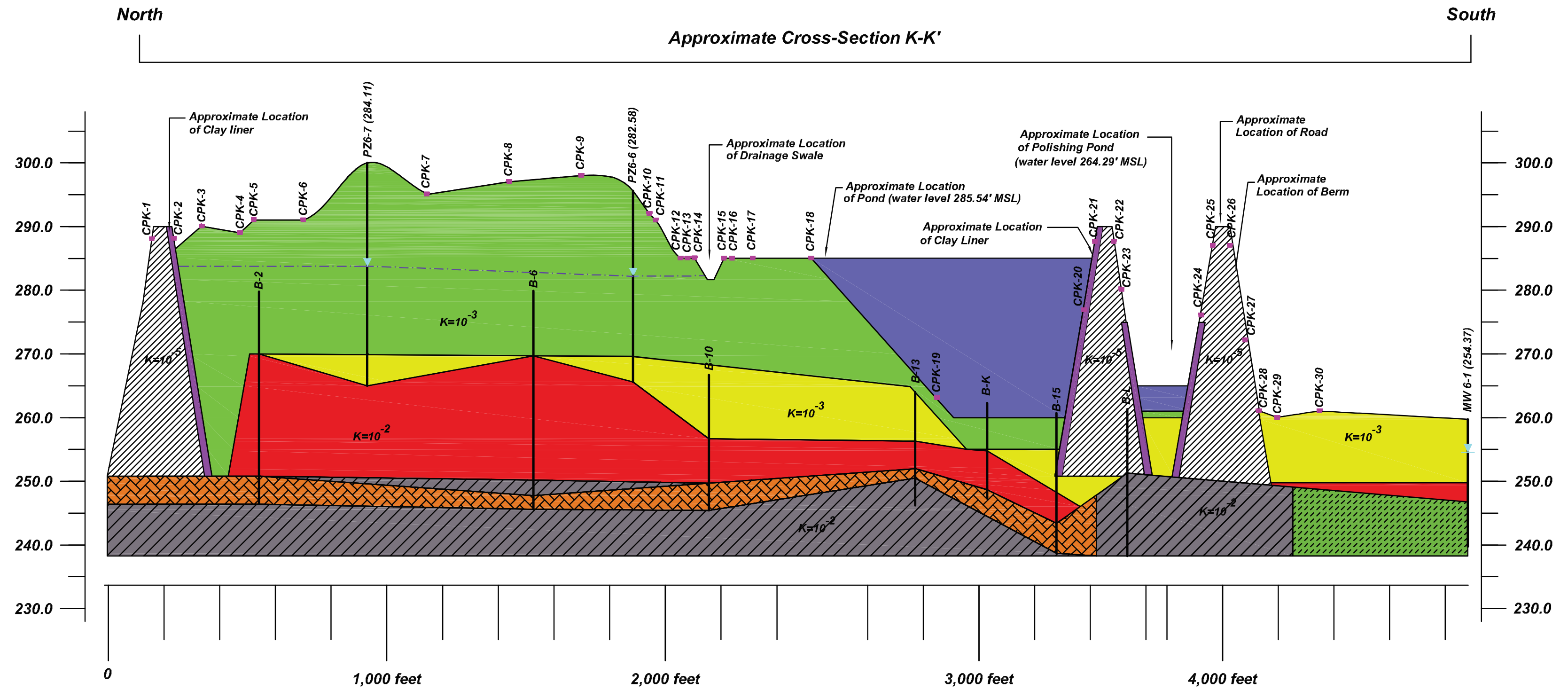


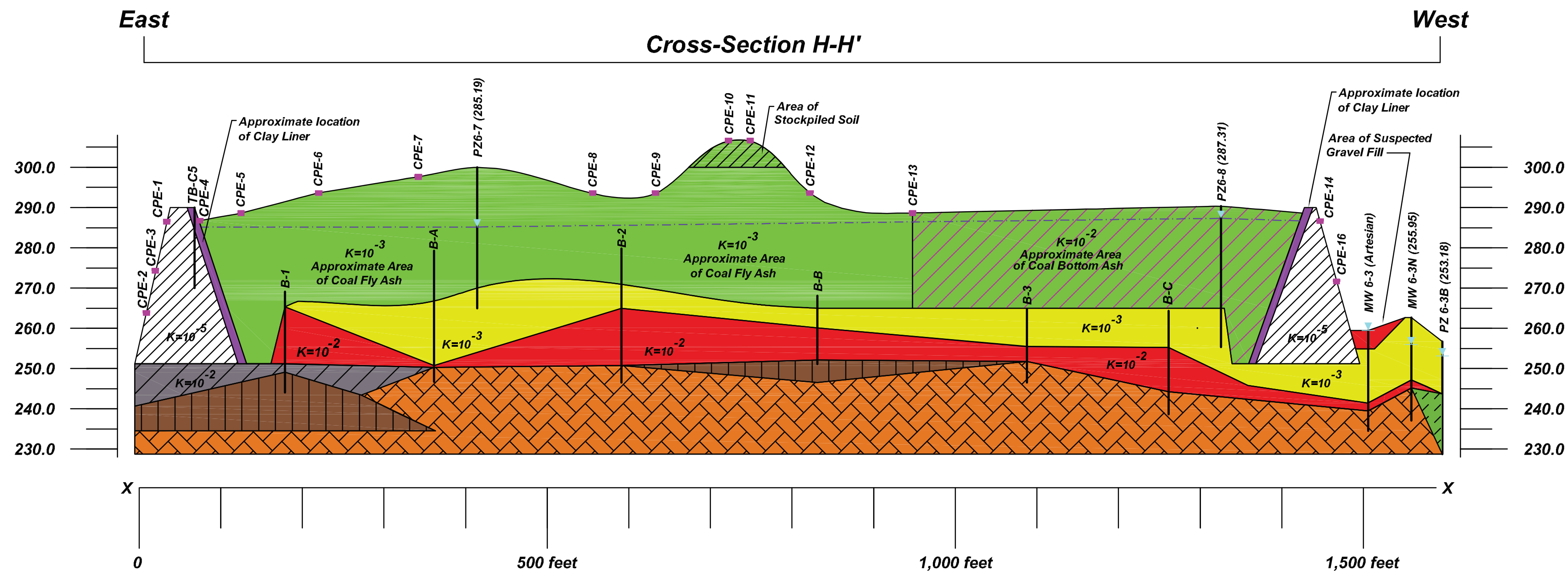
Note:
1. Contour Points obtained from PPL May 2011 Survey.
2. B Location borings obtained from a 1977 PPL investigation of foundation conditions for ash storage Basins 6 and 7.
3. PZ6–6 and PZ6–7 installed by Ish Inc. in September 2011 and fly ash deposit found to a depth of 270' MSL.
4. Cross–Section based on limited data and subject to change.
5. According to PPL construction drawings the interior slope of the berms are lined with 10 feet of clay.
6. Based on PPL information from 1980 and 1996, the bottom of the south pond is 255 MSL. Approximately 5 –feet of ash is deposited in the pond.
7. Scale as shown

LEGEND

- Silt, Clayey Silt, and/or Clay
- Coal Fly Ash
- Shale
- Monitoring Well Groundwater Elevation 12/11 and 01/12
- Sand, Sand and Gravel, and/or Gravel
- Sandstone
- Dolomite
- Approximate Water Elevation
- CPK–1 PPL Contour Point 05/2011
- 300.0 Elevatoin in Feet Above MSL
- (284.11) Groundwater Elevatoin in Feet Above MSL

BISES Ash Basin 6
PPL Brunner Island, LLC
York Haven, PA

Project: BISES	Client: PPL	Ish Inc./META	
Figure 5–2 Approximate North–South Geological Cross–Section K–K'			
Filename: Cross–Sections	Drawn by: BJM	Approved by: IPM	Date: 05/22/12



Note:
1. Contour Points obtained from PPL May 2011 Survey.
2. B Location borings obtained from a 1977 PPL investigation of foundation conditions for ash storage Basins 6 and 7.
3. Boring location TB–C5 installed by Advantage Engineerson in September 2011.
4. PZ6–7 and PZ6–8 installed by Ish Inc. in September 2011 and fly ash deposit found to a depth of 270' MSL.
5. Cross–Section based on limited data and subject to change.
6. According to PPL construction drawings the interior slope of the berms are lined with 10 feet of clay.
7. Scale as shown

LEGEND

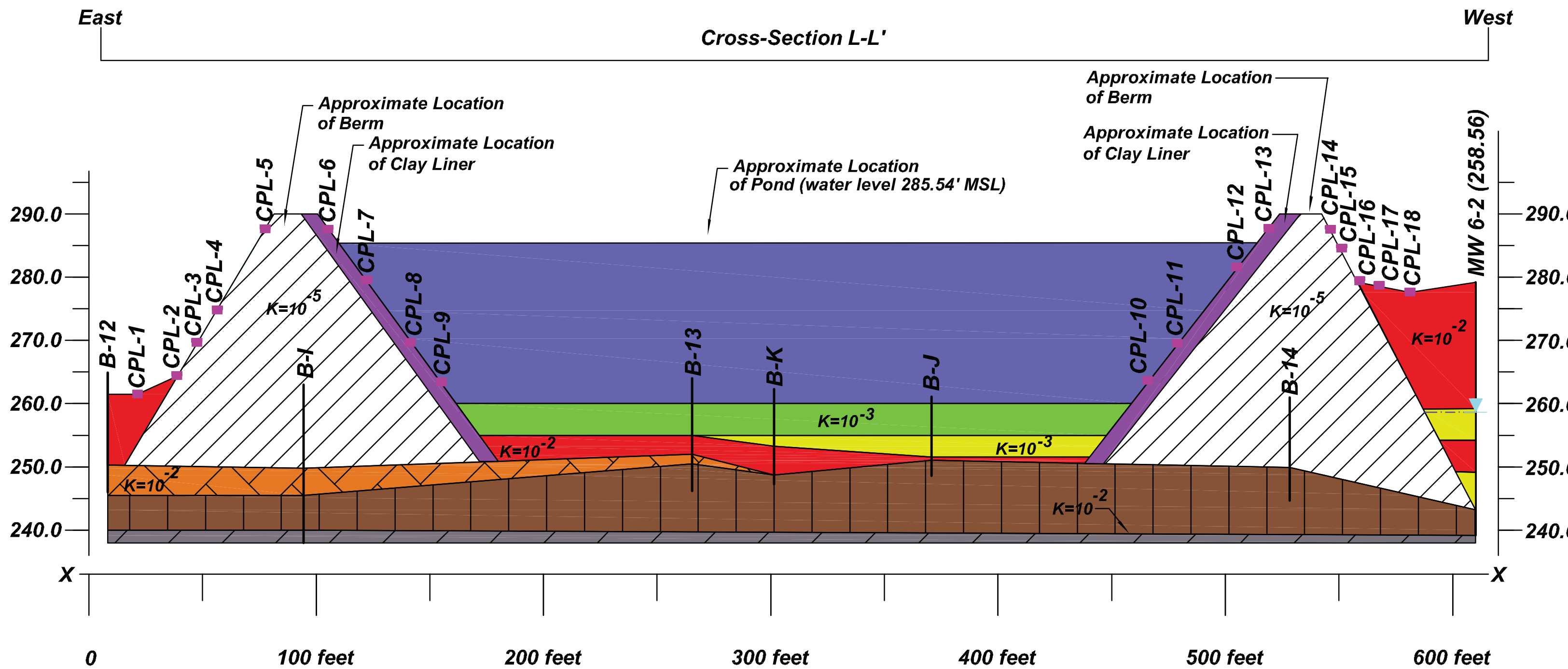
- Silt, Clayey Silt, and/or Clay
- Coal Fly Ash
- Shale
- Conglomerate
- Sand, Sand and Gravel, and/or Gravel
- Sandstone
- Siltstone/Mudstone
- Coal Bottom Ash
- CPK–1 PPL Contour Point 05/2011
- 300.0 Elevatoin in Feet Above MSL
- (285.19) Groundwater Elevatoin in Feet Above MSL 12/2011
- Approximate Water Elevation
- Monitoring Well Groundwater Elevation 12/11

BISES Ash Basin 6
PPL Brunner Island, LLC
York Haven, PA

Project: BISES	Client: PPL	Ish Inc./META

Figure 5–3
Approximate East–West
Geological Cross–Section H–H'

Filename:	Drawn by:	Approved by:	Date:
Cross–Sections	BJM	IPM	05/22/12



Note:

1. Contour Points obtained from PPL May 2011 Survey.
2. B Location borings obtained from a 1977 PPL investigation of foundation conditions for ash storage Basins 6 and 7.
3. Cross–Section based on limited data and subject to change.
4. According to PPL construction drawings the interior slope of the berms are lined with 10 feet of clay.
5. The first 20 feet of lithology for MW 6–2 is unknown. Therefore, the shown lithology for this location is approximate.
6. Based on PPL information from 1980 and 1996, the bottom of the south pond is 255 MSL. Approximately 5 –feet of ash is deposited in the pond.
6. Scale as shown

LEGEND

- Silt, Clayey Silt, and/or Clay
- Coal Fly Ash
- Shale
- Conglomerate/ Sandstone Conglomerate
- Sand, Sand and Gravel, and/or Gravel
- Sandstone
- Approximate Water Elevation
- Monitoring Well Groundwater Elevation 12/11
- CPL–1 PPL Contour Point 05/2011
- 300.0 Elevatoin in Feet Above MSL
- (288.56) Groundwater Elevatoin in Feet Above MSL 12/2011

BISES Ash Basin 6
PPL Brunner Island, LLC
York Haven, PA

Project: BISES	Client: PPL	Ish Inc./META	
Figure 5–4 Approximate East–West Geological Cross–Section L–L'			
Filename: Cross–Sections	Drawn by: BJM	Approved by: IPM	Date: 05/22/12

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Appendix B. FEMA FIRM Reference

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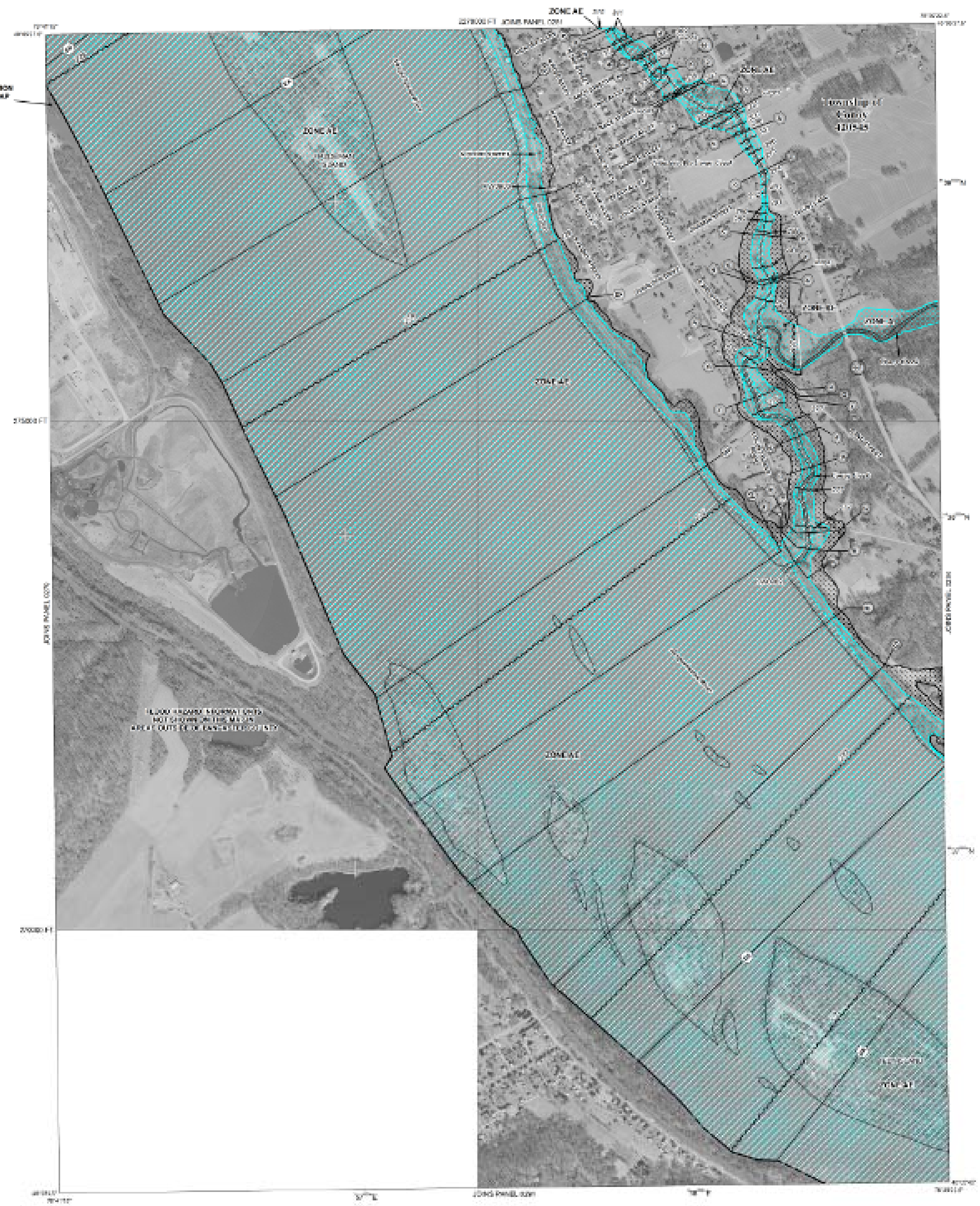
NOTES TO USERS



LEGEND

SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

OTHER AREAS

COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

OTHERWISE PROTECTED AREAS (OPAs)

MAP SCALE 1" = 500'

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0283F

FIRM

FLOOD INSURANCE RATE MAP

LANCASTER COUNTY, PENNSYLVANIA

(ALL JURISDICTIONS)

PANEL 283 OF 780

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

MAP NUMBER 42071C0283F

MAP REVISED APRIL 5, 2016

Federal Emergency Management Agency

Appendix B-1

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Appendix C. Inundation Map

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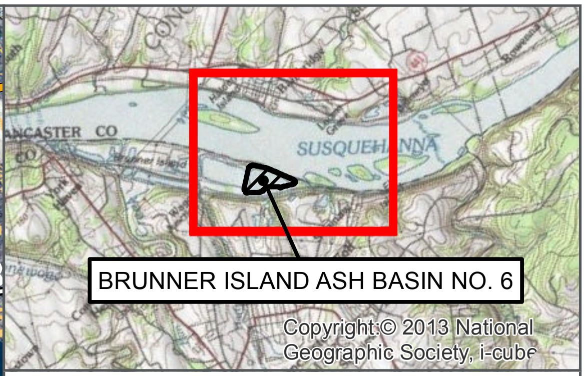

LEGEND

- FLOW DIRECTION MARKER
- SELECTED MODEL CROSS SECTION
- SUNNY DAY BREACH HAZARD AREA (> 2FT. INCREMENTAL RISE)
- BRIDGE
- RAIL ROAD
- STATE ROUTE
- LOCAL ROAD
- COUNTY BOUNDARY
- 10 FT. CONTOUR INTERVAL
- 50 FT. CONTOUR INTERVAL

NOTES:

1. THE LIMITS OF FLOODING ARE APPROXIMATE AND SHOULD BE USED ONLY AS A GUIDELINE FOR EMERGENCY RESPONSE PLANNING. ACTUAL AREAS INUNDATED WILL DEPEND ON ACTUAL FAILURE CONDITIONS AND MAY DIFFER FROM AREAS SHOWN ON THE MAP.

2. THE FLOOD CONDITIONS ON THIS MAP ARE BASED ON FEDERAL GUIDANCE AND REFLECT EVENTS OF AN EXTREMELY REMOTE NATURE. THESE RESULTS ARE NOT IN ANY WAY INTENDED TO REFLECT UPON THE INTEGRITY OF ANY PROJECT.

3. SUNNY DAY FAILURE SCENARIO – THIS SCENARIO REPRESENTS THE COMPOSITE POTENTIAL FLOODING RESULTS FROM DAM FAILURE UNDER NORMAL OPERATING CONDITIONS FROM MULTIPLE EMBANKMENT BREACH LOCATIONS.

4. IDF FAILURE SCENARIO – THIS SCENARIO REPRESENTS THE COMPOSITE POTENTIAL FLOODING RESULTS FROM DAM FAILURE UNDER NORMAL OPERATING CONDITIONS FROM MULTIPLE EMBANKMENT BREACH LOCATIONS AT PEAK INFLOW DESIGN FLOOD (IDF) CONDITIONS. IDF IS THE 1,000 YEAR FLOOD BASED ON USEPA COAL COMBUSTION RESIDUAL (CCR) FINAL RULE.

5. MAXIMUM RISE - THE DIFFERENCE IN PEAK WATER SURFACE ELEVATIONS WITH AND WITHOUT-DAM FAILURE.

6. TOPOGRAPHY IS REFERENCED TO VERTICAL DATUM: NAVD 1988; HORIZONTAL DATUM: NAD 1983 STATEPLANE PA SOUT ZONE USFT; PROJECTION: LAMBERT CONFORMAL CONIC.

7. SOURCES OF AERIAL BASEMAP: YCPC 2015 DIGITAL ORTHOIMAGERY FOR YORK COUNTY, PA, 1 FOOT RESOLUTION & 2015 NATIONAL AGRICULTURAL IMAGERY PROGRAM (NAIP), 1 METER RESOLUTION, NATURAL COLOR ORTHO IMAGERY.

FEMA CROSS SECTION "DX"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	278.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.1 FT.
MAXIMUM RISE SUNNY DAY BREACH:	4.3 FT.
AVERAGE RISE SUNNY DAY BREACH:	3.0 FT.
MAXIMUM RISE IDF BREACH:	0.1 FT.

FEMA CROSS SECTION "DV"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	277.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.1 FT.
MAXIMUM RISE SUNNY DAY BREACH:	6.2 FT.
AVERAGE RISE SUNNY DAY BREACH:	1.5 FT.
MAXIMUM RISE IDF BREACH:	0.1 FT.

FEMA CROSS SECTION "DR"	
FLOOD SCENARIO:	WATER SURFACE ELEVATION
FEMA 100 YEAR:	276.0 FT.
SUNNY DAY NON BREACH:	252.0 FT.
IDF NON BREACH:	278.0 FT.
IDF BREACH:	278.0 FT.
MAXIMUM RISE SUNNY DAY BREACH:	0.2 FT.
AVERAGE RISE SUNNY DAY BREACH:	0.1 FT.
MAXIMUM RISE IDF BREACH:	0.0 FT.

BRUNNER ISLAND ASH BASIN NO. 6

HAZARD INUNDATION MAPPING
SEPTEMBER 2016

N
0 1,000 2,000
FEET

TALEN ENERGY

HDR

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