

2019 Annual Dam and Dike Inspection Report

Cardinal Plant Fly Ash Dams 1, 2 & Bottom Ash Complex



Cardinal Operating Company
306 County Rd. 7E
Brilliant, Ohio 43913

Project Number 60613809

January 2, 2020





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Mr. Nick Kasper
Environmental Compliance Specialist
Buckeye Power, Inc.
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Columbus, OH 43229

**Subject: 2019 Annual Dam and Dike Inspection Report
Cardinal Plant Fly Ash Dams 1 and 2 and Bottom Ash Complex
Brilliant, Ohio**

Dear Mr. Kasper:

AECOM is pleased to present this report presenting inspection findings for Fly Ash Dams 1 and 2, and the dams of the Bottom Ash Complex at the Cardinal Plant. The report presents AECOM's inspection findings, observations, photographs, conclusions, and recommendations. The report also includes a bathymetric and topographic survey of Fly Ash Reservoir 2, completed in November 2019 by Jack A. Hamilton & Associates.

Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Sincerely,

A handwritten signature in blue ink, appearing to read "Vikram K. Gautam".

Vikram K. Gautam, P.E.
Geotechnical Practice Leader

VKG/vkg
Enclosure
cc: File 60613809

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Table of Contents

1.	Introduction.....	5
2.	Descriptions of Impoundments	5
3.	Regulatory Requirements	6
4.	Review of Available Information.....	7
5.	Inspection	8
6.	Summary of Findings.....	22

Appendix A : Photographs – Fly Ash Dam 1

Appendix B : Photographs – Fly Ash Dam 2

Appendix C : Photographs – Bottom Ash Complex

Appendix D : Bathymetric Surveys

Appendix E : Figures and Drawings

Appendix F : Seepage Collection Drains

1. Introduction

The Cardinal Power Plant is located at 306 County Road 7 East, Brilliant, OH, 43913, in Jefferson County. It is jointly owned by Buckeye Power, Inc. and AEP Generation Resources (“AEP”), and is operated by the Cardinal Operating Company. Dam structures operated by the Plant include:

- Fly Ash Dam 1 (FAD 1), ODNR Dam No. 0205-009
- Fly Ash Dam 2 (FAD 2), ODNR Dam No. 0205-010, and
- The Bottom Ash Pond (BAP) Complex dam, ODNR Dam No. 0105-004.

AECOM was retained by Buckeye Power to complete the 2019 annual inspection of the dams and to perform inclinometer and survey monument readings on FAD 2 every 28-days. This scope was previously completed by AEP as part of their Dam Inspection and Maintenance Program (DIMP), but was assigned to AECOM starting in August 2018.

This report was prepared by AECOM Technical Services, Inc. (“AECOM”), to fulfill requirements of 40 CFR 257.83, the Ohio Department of Natural Resource (ODNR) Division of Water and to provide Cardinal Operating Company and Cardinal Plant with an evaluation of the facility. This report contains the inspection findings, observations, photographs, conclusions, and maintenance recommendations for each of the above dam facilities.

The inspections were performed by Mr. Vikram Gautam, P.E. of AECOM who was accompanied by Mr. Erik Bogen, P.E. (FAD 2 and BAP) or Mr. Tom George (FAD 1) also of AECOM. Mr. Randy Sims, P.E., of Cardinal Operating Company accompanied AECOM staff during the inspections. The FAD 1 inspection was performed on October 18, 2019 and the FAD 2 and BAP inspections were performed on November 22, 2019. On the day of the FAD 1 inspection, the weather was partly cloudy to sunny, with a high of approximately 55 degrees. On the day of the FAD 2 and BAP inspections, weather conditions were cloudy with a high of approximately 40 degrees. Light rain had fallen in the early morning prior to the start of the inspection.

2. Descriptions of Impoundments

2.1 Fly Ash Dam 1

FAD 1 is the plant’s original fly ash retention dam constructed in the early 1970’s. The dam is an earth and rockfill dam with a final design crest elevation of 1001.5 ft. MSL. The dam has slopes of approximately 2.5 Horizontal to 1 Vertical on both the upstream and downstream sides. When ash placement behind FAD 1 reached its maximum allowed level, Cardinal FAD 2 was constructed and began operating in the late 1980’s. FAD 1 is still listed with the ODNR as an active dam. However, its reservoir area was re-permitted by the Ohio EPA as a solid waste landfill (PTI permit # 06-07993, dated May 11, 2007) for the disposal of synthetic gypsum generated by the scrubbers constructed at the Cardinal Plant to capture sulfur dioxide air emissions (See Figure 1 in Appendix E). In addition to gypsum, there are stockpiles of earthen materials (to be used in future cell construction) over a portion of FAD 1 (at substantial distance from the dam). The materials are being used as a pre-load to increase the overburden stress on the underlying ash to induce consolidation settlement prior to developing the area for the permitted landfill cell.

2.2 Fly Ash Dam 2

FAD 2 became operational in the 1980s and has been raised twice during its service life, the first raising performed in 1997, and the most recent raising being in 2013. Currently, FAD 2 has a design crest elevation of 983 feet, a maximum reservoir operating elevation of 974 feet, and a dam height of approximately 250 ft. The 2013 raising of Fly Ash Dam 2 was completed using back to back mechanically stabilized earth (MSE) walls which were constructed over the then-existing crest placed during the 1997 dam raising, which was made using roller-compacted concrete (RCC). The emergency overflow spillway was raised using mass concrete to a minimum elevation of 974.5 as part of the second dam raising. The FAD II dam has a deformation review completed every 28 days (to meet the 30-day instrumentation monitoring requirement of CCR Rule Section 257.83 (a) (1)) which includes inclinometer and survey analysis of the dam for potential deformation. The dam currently shows no signs of instability based on the 28-day deformation analyses.

A plan view of FAD 2 is provided in Figure 2A of Appendix E and a general cross section of FAD 2 showing the final dam raising is presented in Figure 2B of Appendix E.

2.3 Bottom Ash Complex

The Bottom Ash Complex at the Cardinal Plant consists of a Bottom Ash Pond (BAP) and a Recirculation Pond (RCP), located at the southern end of the plant (south of the Unit 3 powerhouse) and directly west of the Ohio River. The BAP is directly north of the RCP separated by a bottom ash divider dike. Flow from the Bottom Ash Pond is directed to the RCP through an overflow conduit with an inlet elevation of approximately 665.5 ft. The overflow conduit runs through the divider dike discharging at the north end of the RCP. The overflow conduit controls the water level in the Recirculation Pond. The Bottom Ash Complex is retained by an exterior dike with a crest elevation of approximately 670 ft. The eastern dike of the pond is against the Ohio River.

The arrangement of BAP Complex is shown in Figure 3 of Appendix E.

3. Regulatory Requirements

This annual inspection report is completed to meet both the Federal Coal Combustion Residuals (CCR) rule and ODNR regulatory requirements. In order to comply with ODNR requirements the Dam Safety Inspection Reports for both Cardinal Fly Ash No.1 Dam (File Number 0205-009, Inspected June 16, 2014) and Cardinal Fly Ash No. 2 Dam (File Number 0205-010, Inspected November 29, 2017) were reviewed.

In addition to the ODNR requirements, the annual inspection also included the criteria specified in CCR Rule Section 257.83(b) (1) which at a minimum includes:

- (i) A review of available information regarding the status and condition of the CCR unit, including, but not limited to, files available in the operating record (e.g., CCR unit design and construction information required by §§ 257.73(c)(1) and 257.74(c)(1), previous periodic structural stability assessments required under §§ 257.73(d) and 257.74(d), the results of inspections by a qualified person, and results of previous annual inspections);
- (ii) A visual inspection of the CCR unit to identify signs of distress or malfunction of the CCR unit and appurtenant structures; and

- (iii) A visual inspection of any hydraulic structures underlying the base of the CCR unit or passing through the dike of the CCR unit for structural integrity and continued safe and reliable operation.

In addition to the annual inspections, 7-day inspections and 30-day instrumentation monitoring per CCR Rule Section 257.83 (a) (1) are completed by Cardinal Operating Company and are documented in the facility operating record per § 257.105(g)(5). AECOM is provided with and regularly reviews reports of these inspections.

Once the annual inspection has been completed, the CCR Rule Section 257.83(b) (2) requires the qualified professional engineer to prepare a report following each inspection that addresses the following:

- (i) Any changes in geometry of the impounding structure since the previous annual inspection;
- (ii) The location and type of existing instrumentation and the maximum recorded readings of each instrument since the previous annual inspection;
- (iii) The approximate minimum, maximum, and present depth and elevation of the impounded water and CCR since the previous annual inspection;
- (iv) The storage capacity of the impounding structure at the time of the inspection;
- (v) The approximate volume of the impounded water and CCR at the time of the inspection;
- (vi) Any appearances of an actual or potential structural weakness of the CCR unit, in addition to any existing conditions that are disrupting or have the potential to disrupt the operation and safety of the CCR unit and appurtenant structures;
- (vii) Any other change(s) which may have affected the stability or operation of the impounding structure since the previous annual inspection.

4. Review of Available Information (257.83(b)(1)(i))

Pursuant to CCR Rule Section 257.83(b)(1)(ii) and prior to performing the field inspections, AECOM reviewed available information regarding the status and condition of FAD 1, FAD 2, and the BAP Complex. This information includes files available in the operating record, such as design and construction information, previous structural stability and safety factor assessments, previous 7 day inspection reports, previous 30-day inspection reports, and previous annual inspections.

The available periodic structural stability and safety factor assessments, which were completed as part of the CCR Rule and posted to the Buckeye Power's CCR Compliance Website, indicate that the impoundments meet all pertinent requirements of the CCR Rule.

The Cardinal Operating Company 7-day inspections provide a visual review of the impoundments for signs of distress, sparse vegetation, animal burrows, erosion, and other common maintenance requirements for dams. The Cardinal Operating Company 30 –day inspections are more detailed than the 7-day inspections and include water level measurements of piezometers and monitoring wells, measurement of seepage flows at dedicated monitoring locations, and a more thorough visual inspection. Additionally, slope inclinometers and deformation monuments at FAD 2 are surveyed on a 28-day frequency, separate from the 30-day dam inspections. Tiltmeters on the MSE wall at the crest of FAD 2 are read annually.

Based on our review of the 7-day and 30-day inspection reports and the 28-day deformation survey reports for the previous year, no conditions of concern have been identified at the impoundments.

The previous 2018 annual inspection of FAD 1, FAD 2, and the BAP was completed by AECOM. No deficiencies, signs of structural weakness, or signs of disruptive conditions that would require additional investigation or remedial action were observed at the time of that inspection at any of the dams. For FAD 2, The RCC step section of FAD 2's emergency spillway was noted to be in fair to poor condition, and the RCC was in a friable/weathered state. Recommendations included addressing some minor maintenance items and to continue the monitoring program at FAD 2.

5. Inspection (257.83(b)(1)(ii))

5.1 Definitions of Visual Observations and Deficiencies

This summary of the visual observations uses terms to describe the general appearance or condition of an observed item, activity or structure. The terms are defined as follows:

<u>Good:</u>	A condition or activity that is generally better than what is minimally expected or anticipated based on design criteria and maintenance performed at the facility.
<u>Fair/Satisfactory:</u>	A condition or activity that generally meets what is minimally expected or anticipated based on design criteria and maintenance performed at the facility.
<u>Poor:</u>	A condition or activity that is generally below what is minimally expected or anticipated based on design criteria and maintenance performed at the facility.
<u>Minor:</u>	An observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is minimally expected, but does not currently pose a threat to structural stability.
<u>Significant:</u>	An observed deficiency (e.g. erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is minimally expected, and could pose a threat to structural stability if not addressed.
<u>Excessive:</u>	An observed deficiency (e.g., erosion, seepage, vegetation, etc.) where the current maintenance condition is below what is minimally expected, and which the ability of the observer to properly evaluate the structure or particular area being observed or which poses a threat to structural stability.

This report also uses the definition of a “deficiency” as referenced in the CCR rule section §257.83(b)(5) Inspection Requirements for CCR Surface Impoundments. This definition has been assembled using the CCR rule preamble as well as guidance from the US Mine Safety and Health Administration (MSHA), “Qualifications for Impoundment Inspection” CI-31, 2004. These guidance documents further elaborate on the definition of deficiency. Items not defined as deficiencies are considered maintenance or items to be monitored.

A “deficiency” is some evidence that a dam has developed a problem that could impact the structural integrity of the dam. There are four general categories of deficiencies. These four categories are described below:

1. **Uncontrolled Seepage:** Uncontrolled seepage is seepage that is not behaving as the design engineer has intended. An example of uncontrolled seepage is seepage that comes through or around the embankment and is not picked up and safely carried off by a drain. Seepage that is collected by a drain can still be uncontrolled if it is not safely collected and transported. Seepage that is not clear and is turbid would also be considered as uncontrolled. Seepage that is unable to be measured and/or observed is considered uncontrolled seepage.

Note: Wet or soft areas are not considered as uncontrolled seepage, but can lead to this type of deficiency. These areas should be monitored more frequently.

2. **Displacement of the Embankment:** Displacement of the embankment is large scale movement of part of the dam. Common signs of displacement are cracks, scraps, bulges, depressions, sinkholes and slides.
3. **Blockage of Control Features:** Blockage of Control Features is the restriction of flow at spillways, decant or pipe spillways, or drains.
4. **Erosion:** Erosion is the gradual movement of surface material by water, wind or ice. Erosion is considered a deficiency when it is more than a minor routine maintenance item.

5.2 Fly Ash Dam 1

5.2.1 Changes in Geometry since Last Inspection (257.83(b)(2)(i))

No modifications have been made to the geometry of FAD 1 since the 2018 annual inspection, beyond minor maintenance that included some clearing of brush on the right abutment. The geometry of the impoundment has remained essentially unchanged.

5.2.2 Changes That Effect Stability or Operation(257.83(b)(2)(vii))

Based on interviews with plant personnel and field observations there were no changes to FAD 1 since the last annual inspection that would affect the stability or operation of the impounding structure.

5.2.3 Instrumentation (257.83(b)(2)(ii))

No instrumentation data is available for Fly Ash Dam I, as the reservoir was drained and the site is now permitted to receive residual solid waste. The permit application submitted to the Ohio EPA to license this area as a residual waste landfill was approved on May 11, 2007 (Ohio EPA PTI # 06-07993).

5.2.4 Impoundment Characteristics (257.83(b)(2)(iii, iv, v))

When ash placement behind FAD 1 reached its maximum allowed level in the late 1980's, FAD 2 was constructed to the east of FAD 1 and began operating soon after. Currently, the dam is inundated on its downstream side by Fly Ash Reservoir 2 (FAR 2) and only a limited portion of the original FAD 1 dam height remains exposed above the water line

5.2.5 Visual Inspection (257.83(b)(2)(i))

A visual inspection of FAD 1 was conducted to identify any signs of distress or malfunction of the

impoundment and appurtenant structures. Specific items inspected included all structural elements of the dam such as inboard and outboard slopes, crest, toe (at the FAR 2 waterline), and abutment groins.

Results of the visual inspection of FAD 1 performed on October 18, 2019 are provided below (photos are presented in Appendix A):

1. The crest of the dam was in good condition, with no signs of significant erosion, rutting, or misalignment (Photograph No. 5). The crest of the dam supports a heavy duty concrete roadway that is accessed by haul trucks. The roadway was in good condition.
2. No sloughs, slumps, scarps, or other signs of slope instability were observed on the downstream slope.
3. No seeps were observed on the downstream slope.
4. The downstream dam surface is sparsely vegetated (brushy vegetation), but is covered with rock fill material. As noted in the 2018 inspection, the rock fragments are broken up or deteriorating in some cases, but the material is still protecting the surface of the dam. Overall, the rock fill protection is in fair condition and has not adversely changed since 2018 (Photograph No. 1 and 2).
5. No significant erosion was observed along the downstream slope of the dam. As in 2018, some minor erosion gullies were observed, originating on the crest and running downslope. These gullies form up to about 1 ft deep depressions relative to the surrounding slope. The gullies appear to be formed by run-off from the crest and over the dam. Some of the gullies may have expanded to a slight degree since 2018, but none are perceived to be a structural issue for the dam.
6. No woody vegetation was observed on the downstream slope of the dam. Some shrubby vegetation is present at the toe of the exposed slope at the FAR 2 waterline. Shrubby vegetation is also present along the left groin, making access and visibility for inspection somewhat difficult (Photo 3).
7. No significant erosion was observed along the groin areas of the downstream slope (Photograph No. 1, 3 and 4). Both right and left abutments are protected with rock fill/rip-rap that is in good condition. Some brush was present near the right abutment of the dam, and some small trees were present near (not on) the left abutment.
8. As noted in 2018, a surface water drain pipe discharges near the crest of the right abutment (Photograph No. 1). The flow line is well protected with large rip-rap and no signs of erosion or deterioration has been noted.

Overall, the facility is in good condition. The impoundment is functioning as intended, with no signs of incipient or potential structural issues that would affect its stability or safe operation.

5.3 Fly Ash Dam 2

5.3.1 Changes in Geometry since Last Inspection (257.83(b)(2)(i))

No modifications have been made to the geometry of FAD 2 since the 2018 annual inspection. The geometry of the impoundment has remained essentially unchanged.

5.3.2 Changes That Affect Stability or Operation (257.83(b)(2)(vii))

Based on interviews with plant personnel and field observations there were no changes to FAD 2 since the last annual inspection that would affect the stability or operation of the impounding structure. The pond stage at FAD 2, at approximate El. 968.3, has remained essentially constant since the previous annual inspection.

5.3.3 Instrumentation (257.83(b)(2)(ii))

The location and type of instrumentation at FAD 2 is shown on Figure 2A in Appendix E. The results of the measurements of various piezometers are presented in Figure 5b through 5n in Appendix E. The maximum recorded readings of each instrument since the previous annual inspection is shown in Table 1.

Table 1. FAD 2 Maximum Recorded Piezometer Readings Since the Previous Annual Inspection

Piezometer Water Level Data Fly Ash Dam 2			
Instrument	Type	Location*	Maximum Reading Since Last Annual Inspection
P-1A	Piezometer	Face of Dam, Zone IV	762.9
P-2A	Piezometer	Face of Dam, Zone IV	782.5
P-3A	Piezometer	Face of Dam, Zone II	804.1
P-3B	Piezometer	Face of Dam, Zone II	784.5
P-1BE	Piezometer	Face of Dam, Zone IIIC	731.5
P-1BW	Piezometer	Face of Dam, Zone IIIC	738.9
P-2BE	Piezometer	Face of Dam, Zone IIIC	762.5
P-2BW	Piezometer	Face of Dam, Zone IIIC	733.9
P-2C	Piezometer	Face of Dam, Zone IIIB	713.1
P-5A	Piezometer	Upstream Face of Dam, Zone I	903.9
P-8A	Piezometer	Face of Dam, Zone IV	805.3
P-8B	Piezometer	Face of Dam, Zone IV	780.2
P-9	Piezometer	Face of Dam, Zone IV	787.4
P-10	Piezometer	Face of Dam, Zone IV	777.6
P-11A	Piezometer	Face of Dam, Zone IV	810.7
P-11B	Piezometer	Face of Dam, Zone IV	798.8
MW-7	Monitoring Well	Top of Dam near left groin	968.6

*Locations shown in plan view in Figure 2A and profile view in Figures 6A and 6B of Appendix E.

PIEZOMETERS

A total of Sixteen (16) pneumatic piezometers and one monitoring well are installed in the foundation and throughout the dam to monitor total hydraulic head. The piezometers' locations are shown in Appendix E in plan view in Figure 2A and in cross-sections (Figures 7A-7B). Precipitation is measured at the plant and continues to be within the normal ranges measured over the last five (5) years (Appendix E, Figure 4). Historical records of the piezometer and observation borehole water elevations are presented as graphs in Figure 5 in Appendix E.

1. Figure 5a shows a composite of all hydrographs. Generally, all piezometers showed piezometric head levels that were very similar to the 2018 annual inspection measurements.
2. Water levels in the shallow (P-8A, P-11A), intermediate (P-8B, P-11B), and deep foundation (P-9, P-10) piezometers were consistent with historical readings (Figures 5c and 5d).
3. Water levels along the center of the dam are presented in composite on Figure 5e, and are divided into hydrographs for each clustered piezometer site (Figures 5f through 5i). Water levels in the downstream shell (P-1A) showed a trend of minor decrease in piezometric head (Figure 5i) relative to 2018 readings; P-5A (upstream shell), and P-1BW showed a slight increasing trend. Other centerline piezometers did not show appreciable trends relative to 2018.
4. 2019 measurements for piezometers and monitoring wells at the dam's right abutment (P-1BW, FA-7, FA-8, M-10, M-11, and S-9) did not show significant changes relative to 2018 or from historical trends.
5. MW-7, a standpipe piezometer, was installed in 2014 in to the left abutment to monitor potential seepage (Figure 5n). The most recent measurements for MW-7 are similar to the current pond stage and are not appreciably changed relative to the 2018 readings.

In general, a review of the data contained on the FAD 2 static water elevation plots did not indicate any new developing trends or issues.

SEEPAGE COLLECTION DRAINS

A total of sixteen (16) drainage collection points were installed at the dam to monitor seepage. The discharge from the right abutment seepage as measured at the V-notched weir has risen to a maximum of 343 gpm and as low as 60 gpm. In 2019, the discharge was relatively constant and generally between 120 and 150 gpm.

The most recent flow volumes are presented in tables in Appendix F, along with the locations of the seepage drains in Figure 7. Figure 5b presents historical pond discharge at the Parshall Flume (Drain No. 14) versus the pond stage. Discharge rates in 2019 have generally been within the previously observed range.

During 2018, seepage flows measured near the Emergency Spillway (drain nos. 9 thru 12) were observed to be increasing relative to previous measurements. 2019 data suggest that these flows have stabilized to some degree. On the date of the 2019 inspection, only minor flows were observed in this area, and the flows were not observed to be turbid or erosive. The abutment showed no signs of instability or apparent changes since the 2018 inspection.

VERTICAL AND HORIZONTAL DEFORMATION MONUMENTS

The most recent 28-day AECOM Deformation Review Report of Survey was prepared on November 13, 2019 for vertical and horizontal deformation monuments for FAD2. The deformation review survey reports were started in October 2015 by DLZ Industrial, LLC. Since July 2018, the monthly surveys and reports have been prepared by AECOM.

33 top of dam monuments (29901 thru 29933) were abandoned due to the 2013 dam raising. 33 new monuments (1401 thru 1433) were installed on top of the dam in 2014, and a base measurement was established. In addition, 12 tilt meters were installed at the MSW wall concrete panels.

Vertical and horizontal deformation measurements are made for 33 top of dam monuments (1401 thru 1433), 23 face of dam monuments (i.e. 29936 thru 29958), 2 additional monuments located at the emergency spillway (i.e. 29934 and 29935) and 9 additional deformation monuments on the west side of the dam (i.e. 29959 to 29966). The location of all the monuments is surveyed on a 28-day basis and the data is analyzed for deformation and stability.

The overall trend in movement for the majority of points since the initiation of monitoring is in a southeasterly direction (roughly downslope). Current readings for most of the horizontal deformation monuments fall within the overall range of historical cumulative displacement showing no signs of significant horizontal displacement.

In terms of vertical movement, all of the monuments at the top of the dam have historically exhibited settlement, which has generally been increasing with time. Most points on the lower half of the face of Dam (including Monuments 29947, 29951, and 29955) have exhibited relatively small upward (heave) movements since 2006 after reaching a maximum depth of settlement. Most monuments at the toe of the dam have experienced heave since the start of monitoring. Current measurements at all vertical deformation monuments fall within historical ranges and trends and no issues affecting stability or integrity of the dam have been identified.

The tiltmeters have detected between -0.8° to 0.6° of tilt recorded to date (Figure 5o). A majority of the locations so little or no change since 2018. Three tiltmeters showed an increase in tilt of less than 0.1 degree. These measurements are not considered to be significant.

SLOPE INCLINOMETERS

Three slope inclinometers, SI-1, SI-2 and SI-3, were installed at the dam site as part of the 1998 dam raising project. The slope indicators are centrally located on the upper half of the dam profile. SI-1 was installed in November 1997, and it is believed SI-2 and SI-3 were installed at a later date (dates not reported in logs). Two additional slope indicators, SI-4 and SI-5, were installed in 2006, and are centrally located on the lower half of the dam. The latest slope indicator SI-8 was installed in June 2015 and is located in the uppermost northwest corner of the earthen dam.

Inclinometers SI-1, SI-2, SI-4, and SI-4 show only small movement relative to the previous months' measurements or relative to the 2015 baseline (generally less than 0.10-inches and up to about 0.25-inches of displacement relative to the baseline at any depth), with no appreciable increases observed in 2019. Readings apart from the trends were initially observed in some inclinometers during the period between May and July 2019, but these readings were attributed to equipment issues which were resolved

later on in the year. At this time, we conclude that the current measurements do not indicate any substantial new pattern or trend in movements relative to the previous data.

Slope Inclinometer SI-5 is centrally located near the toe of the dam. Inclinometer SI-5 has previously shown a small downslope movement of about 0.25-inches, originating at a depth of about 30 ft. The area where this inclinometer is located previously experienced a slope failure (during construction of the 1997 dam raising), and it is possible that a slip plane exists at around 30 ft. depth at this location. While the total displacement persists, no appreciable increase in this movement has been observed throughout the 2019 readings. As there is no significant trend or increase in movement, no corrective actions are considered necessary at this time.

Slope Inclinometer SI-8 is located in the uppermost northwest corner of the earthen dam. This inclinometer has not showed any appreciable movement since the 2015 baseline reading, a trend which continued in 2019.

BATHYMETRIC SURVEYS

AECOM's subcontractor Jack A. Hamilton & Associates, Inc. performed the most recent bathymetric survey in November 2019. Previous bathymetric surveys as part of the annual FAD II inspection were completed under the direction of the AEP Civil Engineering Lab. The Pool Elevation of the FAR 2 facility at the time of the inspection was 968.3 feet above mean sea level (MSL).

The 2019 bathymetric survey shows the bottom of the Fly Ash Reservoir 2 (FAR 2) continues to increase in elevation with sluicing operations. The bottom of pond elevation decreases towards the FAD 2 with the deepest portion of FAR 2 adjacent to FAD 2. In previous surveys, depressions in the ash buildup had been observed near the upstream right abutment of the dam. After review of the bathymetry, no such features are observed at the present time (they were not observed in 2018 either), and the ash delta is propagating into this area in a uniform manner. The table below shows the estimated increase in ash elevation within the CCR impoundment based on bathymetric surveys of FAR II. Appendix D shows the 2019 bathymetric survey results.

<u>Survey Date</u>	<u>Ash Elev.</u>	<u>Thickness Increase</u>	<u>Comment</u>
March 3, 2004	873.7	N/A	Initial bathymetric survey
December 9, 2004	889.3	15.6ft.	from Mar 04 to Dec 04
March 29, 2005	891.8	2.5ft.	from Dec. 04 to Mar. 05
October 19, 2005	898.1	6.3ft.	from Mar. 05 to Oct. 05
October 3, 2006	906.0	7.9ft.	from Oct 05 to Oct 06
September 13, 2007	907.5	1.5ft.	from Oct 06 to Sept 07
September 3, 2008	907.4	-0.1ft.	from Sept 07 to Sept 08
August 31, 2009	909.0	1.6ft.	from Sept 08 to Aug 09
August 30, 2010	908.5	-0.5ft.	from Aug 09 to Aug 10
September 6, 2011	909.0	0.5ft.	from Aug 10 to Sept 11
October 22, 2013	908.4	-0.6 ft.	from Sept 12 to Oct 13
September 3, 2014	918.2	9.8 ft.	from Oct 13 to Sept 14
September 22, 2015	924.0	5.8 ft.	from Sept 14 to Sept 15

September 20, 2016	929.0	5.0 ft.	from Sept. 2015 to Sept. 2016
September 12, 2017	929.5	0.5 ft.	from Sept. 2016 to Sept. 2017
December 12, 2018	933.7	4.2 ft.	from Sept. 2017 to Dec. 2018
November 2019	937.8	3.8 ft.	from Dec. 2018 to Nov. 2019

5.3.4 Impoundment Characteristics (257.83(b)(2)(iii, iv, v))

The approximate minimum, maximum, and present depth and elevation of the impounded water and CCR since the previous annual inspection of the FAR II CCR Surface Impoundment are provided in Table 2 below. The measurements are based on the survey completed by Jack A. Hamilton & Associates, Inc. dated November 2019. The basis for the measurements include: the available measured water surface elevations, the November 2019 bathymetric survey data, and topographic contours above the water level from aerial photos dated March 3, 2005.

Table 2. Summary of Relevant Storage Information FAR 2

IMPOUNDMENT CHARACTERISTICS	
Fly Ash Reservoir 2 (water pool elevation was approximately 968.14)	
Approximate Minimum depth (Elevation) of impounded water since last annual inspection	14.6 ft. (El. 968.4 above MSL)
Approximate Maximum depth (Elevation) of impounded water since last annual inspection	14.86 ft. (El. 968.14 ft. above MSL)
Approximate Present depth (Elevation) of impounded water since last annual inspection	14.86 ft. (El. 968.14 ft. above MSL)
Approximate Minimum depth (Elevation) of CCR since last annual inspection	24.3 ft. (El. 958.7 ft. above MSL)
Approximate Maximum depth (Elevation) of CCR since last annual inspection	70.82 ft. (El. 916.30 ft. above MSL)
Approximate Present depth (Elevation) of CCR since last annual inspection	70.82 ft. (El. 916.30 ft. above MSL)
Storage capacity of impounding structure at the time of the inspection	3,594 ac-ft
Approximate volume of impounded water at the time of the inspection	1,250 ac-ft.
Approximate volume of CCR at the time of the inspection	9,906 ac-ft.

Note: All depth values in the above table are measured relative to the crest of dam, El. 983.

5.3.5 Visual Inspection (257.83(b)(2)(i))

A visual inspection of FAD 2 was conducted to identify any signs of distress or malfunction of the impoundment and associated structures. The inspection also included hydraulic structures underlying the base of the dike. Specific items inspected included all structural elements of the dam such as inboard and outboard slopes, crest, and toe; as well as the outlet structure at FAD 2 and pipe discharge structure.

Results of the visual inspection of FAD 2 performed on November 22, 2019 are provided below (photos are presented in Appendix B):

A. Top of Dam – Mechanically Stabilized Earth Walls and Crest

The crest of the dam has been raised on two separate occasions during its service life. The first raise was performed in an upstream orientation and implemented with roller compacted concrete (RCC), placed against the body of the existing embankment. The RCC extends to approximate El. 970. The second raise was implemented circa 2013 by constructing back-to-back mechanically stabilized earth (MSE) walls over the RCC crest surface, and installing a vinyl sheet pile cut-off wall through the MSE backfill and RCC concrete (using a slurry trench excavation), which extends into the clay core of the dam. It is noted that the current operating pool level in the reservoir is below the base of the MSE walls.

1. The main longitudinal MSE wall and return walls at both left and right ends of the dam were in good condition as shown in Photograph 7 and 31 of Appendix B and as indicated by the tiltmeter data in Figure 5o of Appendix E. There are no signs of differential settlement (no displaced panels, open joints, cracking, etc.) across the length of the wall. As noted in the 2018 inspection, there are relatively small separations at both the southwest and northeast corners of the wall, at the junction of the main longitudinal wall and the orthogonal return wall sections (see Photograph 6). The separations are most pronounced at coping beams at the top of the walls. These separations do not appear to have any adverse effect on serviceability, and it is noted that relative movement at MSE wall corners is a relatively common occurrence. The separations observed in 2019 do not appear to have worsened relative to previous inspections.
2. The RCC crest surface (at El. 970) is mostly covered by the new MSE wall construction and only limited observations were possible. As noted in 2018, the downstream RCC has experienced weathering and is now in fair to poor condition (See Photo 32). At this time, the RCC surface is highly friable and has consistency closer to a hard soil than to concrete. No cracking or seepage was observed at the dam RCC at this time on the downstream side of the dam, and the visible portion of the upstream RCC appeared to be stable with no signs of erosion from wave action, slumping, significant cracking, or settlement (see photograph #7), though only a small amount of RCC is visible on that side. While the RCC is currently performing its intended function, some risk of flow-through seepage likely exists if the reservoir level is raised in the future.
3. The gravel access roadway at the crest of the dam (which is supported between the MSE Walls) was in good condition, with little to no rutting and no standing water observed (Photo No. 1).

B. Top of Dam – Emergency Spillway:

The emergency spillway consists of the following components (from top to bottom): A plain concrete overflow section at the crest of the dam; a plain concrete stepped spillway; a RCC stepped spillway section, and; an earthen exit channel (which is constructed on rock) at the base of the RCC steps and extending several hundred feet downstream. The crest, plain concrete step, and RCC step sections are bounded at right and left by reinforced concrete sidewalls.

1. The concrete sidewalls of the spillway are in fair condition. Cracking was observed at the wall stem intermittently (especially at the eastern wall) away from wall joints (See Photo 33). Cracks are generally 1/8" or less. No relative displacement has occurred at cracks. The cracking does not appear to adversely affect function of the wall.
2. The plain concrete overflow section at the crest is in good condition with only minor cracking (similar to what was observed in 2018) (Photo Nos. 2 and 35)
3. The plain concrete stepped section is in good condition structurally, with only minor cracking noted (cracks are either hairline, or less than 3/16-inch). Signs of seepage (efflorescence) was noted coming through cracks in some cases (Photograph No. 29). The condition of the cracking has not deteriorated since 2018.
4. The RCC step section is in poor condition (Photograph Nos. 30 and 34). The steps were originally designed as 2-ft high, but in most cases have weathered and worn down to only a few inches high. The exposed RCC is in a very friable condition. The condition of the steps has been noted in previous inspection reports, as well as by the ODNR. The condition observed in the current inspection is not fundamentally different relative to the 2018 inspection, but deterioration appears to be ongoing.

The condition of the steps is monitored by Cardinal staff per ODNR request. This monitoring should be continued. It should also be noted that while the RCC section may continue to provide erosion/scour protection under flows, the steps are unlikely to provide any significant hydraulic energy dissipation, since they no longer retain their intended geometric shape due to weathering.

5. The emergency spillway channel is cut through natural high ground. The channel's left slope continues to have bank seepage that is conveyed to a shallow ditch along the toe of the slope which drains into Seepage Collection Drain No. 12 at the mouth of the emergency spillway channel. The seepage originates from the rock slope that forms the left valley wall of the exit channel, and specifically from a location that is just downstream of the left sidewall of the emergency spillway. The seepage flows into an earthen ditch that runs along the floor of the exit channel and is therefore relatively well controlled. Previous conversations with Cardinal personnel indicated that the rate of this seepage had been increasing over the years, but currently the rate appears to be stabilizing. Significant seepage was not occurring on the date of the 2019 inspection. During our inspection, the seepage was observed to be clear and of relatively low velocity.
6. The rock slope at the left abutment appeared to be in a stable condition, despite the seepage. No visible signs of slumping, significant rock fall, or significant erosion were observed (Photograph No. 10).
7. The Emergency Spillway channel floor is well vegetated but was in a wet condition at places, due to the aforementioned seepage. No signs of erosion, uplift, or other issues were noted. Overall the exit channel is in good condition. (Photograph No. 11).

C. Downstream Slope of Dam

1. Overall, the downstream slope of the dam appeared to be in good condition with healthy vegetative growth (Photograph No. 15, 16, 18, 20). No significant signs of erosion, sloughing or seepage were observed at any location and the slopes appeared to be stable.
2. As noted in 2018 the upper one-third or so of the dam (vertically) shows signs of minor creep movement (presenting as lightly hummocky ground observed intermittently over the face of the dam). There are no signs of significant slope movement, and the creep features may partially be due to the action of the mowing equipment and seasonal frost heave. The condition was not worsened from the previous inspection and does not represent a deficiency of the dam.
3. The surface water collection channels running across the body of the dam appear to be in generally good condition. Rip-rap is present in all channels and shows only minor deterioration. No significant bare, unprotected areas were observed, and the channels appear to be clean and well maintained. Erosion rills (perhaps 6-inches in width) were intermittently observed at the channel crest (Photo No. 27) but are minor and are not considered to require action at this time.
4. As observed in 2018, an approximately 8 ft x 8 ft area of dead vegetation was observed on the upper half of the downstream face of the dam between the center of the dam and the left abutment (Photograph No. 25). No flowing seepage or erosion was observed on the day of the inspection, but it is possible that some minor water flow is occurring in the area. There is no evidence of internal erosion. The size and condition of this area has not worsened since the 2018 inspection and no remedial measures appear to be necessary at this time. Cardinal Operating Company is aware of the area and monitors it during the 7 and 30-day inspections.
5. The downstream slope and buttress (lower berm) appeared to be in good condition with good vegetative growth (Photograph No. 16). There were signs of minor ponding of water (less than 1" deep) at the time of the inspection due to the flat grades on the top of the buttress (Photo No. 16). Similar ponding has been observed in past inspections, but the condition has not worsened.

D. Dam Abutments:

1. The right downstream groin ditch was in generally good condition (Photographs No. 17 and 18). The rip rap showed only minor weathering or deterioration. The discharges from the several seepage drains that are monitored in the area were clear and no sediment deposits were observed in the pooling area (see Photo No. 28 as an example). The groin appeared to be well maintained (no woody or brushy vegetation was present) and was generally in good condition (Photograph No. 17).
2. The left groin ditches and dam discharge pipe were observed to be in good condition. No seepage or erosion was observed (Photo No. 20).

E. Hydraulic Structures:

1. The principal spillway structure at the upstream dam crest appeared to be in good condition, with no obstructions at the stop-log structure and no signs of instability on the riser or staircase, as shown in Photograph No. 4. There was no visual evidence of significant differential movement of the structure/skimmer chute or steps. The principal spillway access walkway, stairways, depth gauge, and other metal structures were in good condition (Photograph Nos. 4 and 5).
2. At the base of the dam, the energy dissipater structure, concrete flume (NPDES Permit Outfall # 019), and downstream channel appeared to be in good condition, with no signs of distress, obstructions to operation, or other issues noted. The exit channel downstream of the energy dissipater appeared to be in good condition (Photograph Nos. 19, 21, and 22). The condition of these features was essentially the same as was observed in 2018.

Overall, the facility is considered to be in good condition. The impoundment is functioning as intended, with no signs of potential structural issues that would affect its stability or safe operation.

5.4 Bottom Ash Pond Complex

5.4.1 Changes in Geometry since Last Inspection (257.83(b)(2)(i))

No modifications have been made to the geometry of the BAP Complex since the 2018 annual inspection. The geometry of the impoundment has remained essentially unchanged. The water level in the pond on the day of the inspection appeared to be lower than what was observed in 2018.

5.4.2 Changes That Effect Stability or Operation (257.83(b)(2)(vii))

Based on interviews with plant personnel and field observations there were no changes to the BAP Complex since the last annual inspection that would affect the stability or operation of the impounding structure.

5.4.3 Instrumentation (257.83(b)(2)(ii))

Instrumentation at the BAP complex consists of a network of five piezometers. The location of this instrumentation is shown on Figure 3 of Appendix E. The results of the measurements of the piezometers are shown in Figure 5p. Piezometers 3-S and B-0902 are located on the east perimeter road of the Recirculation Pond. Piezometer 2-N is on the west perimeter road adjacent to the Bottom Ash Pond. B-0904 and B-0905 are located on the upstream and downstream slope of the east perimeter road, respectively. The maximum operating elevation of the Bottom Ash Pond is El. 670, but was substantially lower than this on the date of the inspection. The maximum recorded readings of each instrument since the previous annual inspection is shown in Table 3 below.

Table 3. BAP Complex Maximum Recorded Instruments Reading Since the Previous Annual Inspection

Instrumentation Data Bottom Ash Pond Complex		
Instrument	Type	Maximum Reading Since Last Annual Inspection
2-N	Piezometer	665.12
3-S	Piezometer	660.82
B-0902	Piezometer	662.29
B-0904	Piezometer	655.16
B-0905	Piezometer	645.74

The piezometers are measured on monthly basis and showed very little to no change in average piezometric head or trends relative to 2018 and earlier historical readings (shown in Appendix E Figure 5p). It is noted that the highest reading at B-0902 (662.29) was an outlier, recorded on 10/22/19. All other readings at this piezometer in 2019 were EI. 656.89 ft or lower, and similar to readings observed in 2018. In general, a review of the data contained on the BAP static water elevation plot showed that all piezometers exhibited water level trends that have been historically observed, indicating no significant changes have occurred to the subsurface water levels since the previous annual inspection.

5.4.4 Impoundment Characteristics (257.83(b)(2)(iii, iv, v))

Table 4 summarizes the minimum, maximum, and present depth and elevation of the impounded water and CCR since the previous annual inspection; the storage capacity of the impounding structure at the time of the inspection; and the approximate volume of the impounded water and CCR at the time of the inspection. The Bottom Ash is dredged from the ponds as part of the Cardinal Station Operations to maintain the impoundment storage characteristics from year to year; therefore there is little change to the summary of storage information present in Table 4 below.

Table 4. Summary of Relevant Storage Information BAP Complex

IMPOUNDMENT CHARACTERISTICS	
Bottom Ash Complex (Bottom Ash Pond Elevation = 664.5 at time of inspection)	
Approximate Minimum depth (Elevation) of impounded water since last annual inspection	5 ft. (663) ft.
Approximate Maximum depth (Elevation) of impounded water since last annual inspection	10 ft. (665) ft.
Approximate Present depth (Elevation) of impounded water since last annual inspection	7.5 ft. (664) ft.
Approximate Minimum depth (Elevation) of CCR since last annual inspection	8 ft. (655) ft.
Approximate Maximum depth (Elevation) of CCR since last annual inspection	11 ft. (658) ft.
Approximate Present depth (Elevation) of CCR since last annual inspection	11 ft. (658) ft.

Storage capacity of impounding structure at the time of the inspection	324 ac-ft.
Approximate volume of impounded water at the time of the inspection	160 ac-ft.
Approximate volume of CCR at the time of the inspection	164 ac-ft.

5.4.5 Visual Inspection (257.83(b)(2)(i))

A visual inspection of the BAP Complex was conducted to identify any signs of distress or malfunction of the impoundment and associated structures. Specific items inspected included all structural elements of the dikes such as inboard and outboard slopes, crest, and toe; as well as the outlet structure at the BAP Complex and pipe discharge structure.

Results of the visual inspection of the BAP Complex performed on November 22, 2019 are provided below (photos are presented in Appendix C):

At the time of the inspection the overflow structure between the Bottom Ash Pond and Recirculation Pond was in good condition and was operating as designed.

1. The west dike of the pond is un-vegetated and has a surface protected by rock fill, slag, and other granular material. There are no signs of surface erosion, sloughs, slumps, or toe bulges, and the west dike is in good condition. The condition of the dike surface was similar to that observed in 2018. See photographs 1 and 2 of Appendix C.
2. Flowing water was observed at the toe of the west embankment, as was the case in 2018 and previous inspections. The toe of the embankment has a V-shaped ditch or channel running over a portion of its length, and the water collects and is conveyed by this ditch to a drainage structure located at the northwest corner of the pond. The ditch has a relatively flat slope, and sluice pipes run within and adjacent to it, so ponding water is also intermittently observed along its length (Photograph 3).

The water within the ditch is likely a combination of seepage from the pond and surface water that drains into the ditch. The flows were not turbid on the date of the inspection and have not been observed to be turbid during the regular inspections performed throughout the year. The face of the western dike does not show any signs of free seepage faces or instability. Similar to 2018, our conclusion at this time is that the observed water is not affecting stability of the dike. Monitoring should be continued but no corrective actions are deemed necessary.

3. The splitter dike between the BAP and RCP was in good condition, with no signs of wave action, erosion, or slope instabilities on either inboard or outboard slopes. See Photograph No. 10.
4. The outlet structure from the BAP to the RCP was unobstructed and generally in good condition. As in 2018, the metal walkway is showing some signs of rust/weathering and is in good to fair condition, but its condition does not appear to have worsened. See Photograph No. 11.

5. The western and southern sides of the RCP are incised slopes cut into natural ground. In 2018, numerous erosion gullies were intermittently present throughout the length of these slopes, due to surface run-off. During the current inspection, the number of gullies/extent of erosion was substantially reduced. Cardinal Operating Company indicated that the surface distortions have been corrected as part of regular maintenance at the pond.
6. The outlet structure and discharge pipe from the RCP (NPDES Outfall 023) were unobstructed and in good condition. See Photograph 14 and 15.
7. The BAP and RCP downstream (eastern dike) slopes along the Ohio River were well vegetated or protected by riprap as typically shown in Photographs Nos. 4 thru 8, and 11. The slopes are in good condition, with no signs of instability.
8. The crest of eastern dike is generally in good condition. Some potholing of the gravel surface was observed intermittently and should be corrected as part of regular maintenance (Photo 9).
9. The two apparent seep areas observed in 2018 were present during the current inspection as well (see Photographs 17 and 18). No flowing seepage is present, but the areas are wet and the vegetation is discolored. The condition in these locations is essentially unchanged from last year, indicating that internal erosion is not occurring and the seepage is not affecting stability. These locations are known to Cardinal Operating Company and are routinely monitored.
10. As noted in 2018, some small/medium sized trees are present at the toe of the slope along the Ohio River (for example, see Photograph 7). These trees are located well below the BAP/RCP proper and are growing on the river bank. Removal of the trees is not considered necessary, and they are likely adding protection for the river bank.
11. Similar to 2018, a few erosion rills are present along the eastern dike, originating at the crest of the slope at the BAP or RCP and extending down the slope towards the River. See Photograph 8. These erosion features should be corrected as part of regular pond maintenance. These erosion rills are most likely caused by storm water runoff from the crest area.

Overall, the facility is in good condition. The impoundment is functioning as intended, with no signs of potential structural issues that would affect the stability or safe operation of the impoundment.

6. Summary of Findings

6.1 Maintenance Items

The following maintenance items were identified during the visual inspection:

Fly Ash Dam 1

1. Consideration should be given to modifying the storm sewer pipe that currently discharges over the right groin area. While the pipe does not appear to be causing any erosion or

instability, it would be more appropriate to extend it to the level of the pond, so that the flow is completely controlled.

2. Shrubby vegetation on the left abutment/groin should be sprayed to allow for easier/better visual inspection.
3. Consideration should be given to removing larger trees that are located in close proximity (within 25 to 50 ft) to the dam abutments. While such trees are not on the dam and are unlikely to promote seepage paths, their presence could trigger comments during future inspections by ODNR.

Fly Ash Dam 2

1. Silt and brush is present behind some of the V-notch weirs of the seepage monitoring points. The area immediately upstream of the weirs should be kept clear of obstructions to ensure accurate flow measurements.
2. Consideration should be given to fill/repair cracking on the sidewalls and plain concrete steps of the Emergency Spillway.

Bottom Ash Pond Complex

1. Erosion rills along the along the eastern dike crest and slope of the BAP and RCP should be repaired.
2. Potholes along the crest of the eastern dike should be filled.

6.2 Items to Monitor

Fly Ash Dam 1

1. Continue to monitor erosion rills that are intermittently located along the downstream slope. Correct any features that are observed to grow in size or depth, as part of regular maintenance.

Fly Ash Dam 2

1. Continue to monitor the condition of the RCC section of the emergency spillway for signs of additional erosion or deterioration.
2. Continue to monitor the seepage areas observed on the left earthen cut sidewall of the emergency spillway and on the concrete steps of the emergency spillway for any signs of increased flow, muddy flow, or instability. Continue to closely monitor the condition of the rock slope forming the left wall of the emergency spillway discharge channel.
3. Continue to monitor the approximately 8 ft x 8 ft area of dead vegetation that is located on the upper half of the downstream face of the dam between the center of the dam and the left abutment (Appendix B Photograph No. 25) for any adverse changes and for free flowing seepage.
4. If the reservoir's operating level is increased by adding stoplogs, consideration should be given to the condition of the RCC section near the top of the dam and directly below the MSE walls. The RCC has degraded significantly and currently has a consistency more

similar to a hard soil than to concrete. Currently, we interpret its condition to be adequate in terms of slope stability, but its permeability may have increased as a result of degradation. Raising the hydraulic head that the RCC is subject to could promote seepage to occur. Therefore, any raising of the operating pool should be done slowly and should be followed by thorough and regular inspections of the downstream RCC face, to observe any changes in seepage flow conditions.

Bottom Ash Pond Complex

1. Continue to monitor the apparent seepage entering the ditch at the toe of the west dike slope, and monitor the slope for signs of internal erosion by seepage.
2. Continue to monitor the wet spots/seepage areas on the eastern dike slope above the Ohio River.

6.3 Deficiencies

There were no deficiencies, signs of structural weakness, or signs of disruptive conditions observed at the time of the inspection that would require additional investigation or remedial action. There were no deficiencies noted during any of the periodic 7-day or 30-day inspections.

Appendix A : Photographs – Fly Ash Dam 1

Impoundment Name: Cardinal Fly Ash Dam 1	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60613809
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Photo No. 1	Date: 10/18/19	
Direction Photo Taken: Northeast		
Description: View of the downstream slope of the FAR 1 dam. The surface water discharge pipe crushed concrete erosion control at the right groin is shown at the bottom of the photo.		

Photo No. 2	Date: 10/18/19	
Direction Photo Taken: Southwest		
Description: View of the downstream slope of the FAR 1 dam.		

Impoundment Name: Cardinal Fly Ash Dam 1	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60613809
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Photo No. 3	Date: 10/18/19	
Direction Photo Taken: West		
Description: View of left groin. Rip rap let down is present but not visible through vegetation at right side of photo.		

Photo No. 4	Date: 10/18/19	
Direction Photo Taken: West		
Description: View of the right groin area of the FAR 1 dam.		

Impoundment Name: Cardinal Fly Ash Dam 1	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60613809
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Photo No. 5	Date: 10/18/19
Direction Photo Taken: West	
Description: View of the ash discharge pipes along the crest of the FAR 1 dam.	



Photo No. 6	Date: 10/18/19
Direction Photo Taken: Southwest	
Description: View of downstream slope of FAD I.	



Appendix B : Photographs – Fly Ash Dam 2

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 1	Date: 11/22/19	
Direction Photo Taken: West		
Description: View of the access road along the crest of dam looking west. The dam crest appeared in good condition with no signs of settlement, misalignment, rutting, or erosion.		

Photo No. 2	Date: 11/22/19	
Direction Photo Taken: West		
Description: View of the crest area looking east from top of emergency spillway. The dam crest appeared in good condition with no signs of settlement, misalignment, rutting, or erosion.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 3	Date: 11/22/19	
Direction Photo Taken: N/A		
Description: View of the primary spillway intake structure from above. Note metal bar grating is in good condition		

Photo No. 4	Date: 11/22/19	
Direction Photo Taken: East		
Description: View of upstream side of dam, looking east toward intake structure.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 5	Date: 11/22/19	
Direction Photo Taken: West		
Description: Upstream side of dam crest, looking east. Deterioration of roller-compacted concrete noted.		

Photo No. 6	Date: 11/20/18	
Direction Photo Taken: East		
Description: View of the downstream corner of the MSE Wall where the wall panel meets concrete coping. Note the separation at the corner piece.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No.: 7	Date: 11/22/19	
Direction Photo Taken: West		
Description: View of the upstream MSE wall.		

Photo No.: 8	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of abutment between MSE wall and emergency spillway.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No.: 9	Date: 11/22/19	
Direction Photo Taken: East		
Description: View of the Emergency Spillway crest area.		

Photo No.: 10	Date: 11/22/19	
Direction Photo Taken: South-Southeast		
Description: View of the emergency discharge channel. Vegetation is well maintained and the spillway is clear of obstructions.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 11	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of the emergency discharge channel.		

Photo No. 12	Date: 11/22/19	
Direction Photo Taken: North-Northwest		
Description: View of the Concrete and RCC emergency spillway discharge channel steps. The steps have weathered since construction and are monitored per ODNR inspection comment.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 13	Date: 11/22/19	
Direction Photo Taken: Southwest		
Description: View of the downstream slope. Showing good vegetative cover and no signs of erosion or instability.		

Photo No. 14	Date: 11/22/19	
Direction Photo Taken: Northwest		
Description: View of the downstream slope and stormwater collection channel.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 15	Date: 11/22/19	
Direction Photo Taken: West		
Description: Typical vegetative surface conditions on downstream slope of dam.		

Photo No. 16	Date: 11/22/19	
Direction Photo Taken: Southwest		
Description: View of the downstream slope lower berm bench area. Minor ponding at front of picture.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 17	Date: 11/22/19	
Direction Photo Taken: Northwest		
Description: View of right groin ditch and seepage drain.		

Photo No. 18	Date: 11/22/19	
Direction Photo Taken: Southeast		
Description: View of right groin ditch.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 19	Date: 11/22/19	 A photograph showing a concrete drainage structure with a v-notch weir. Water is flowing through the weir into a pool. The surrounding area is rocky and grassy with some fallen leaves. A black pipe is visible on the right side of the structure.
Direction Photo Taken: West-Northwest		
Description: View of Drain no. 2 that discharges from the right abutment drainage blanket. A v-notch weir just downstream of the baffling is used to measure flow.		

Photo No. 20	Date: 11/20/18	 A wide-angle photograph of a grassy embankment. A concrete drainage ditch runs along the base of the embankment. In the foreground, there is a rocky area with a small pool of water. To the right, there are several large blue and white storage containers.
Direction Photo Taken: Northeast		
Description: View of the left groin ditch.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 21	Date: 11/22/19
Direction Photo Taken: East-Northeast	
Description: View of the energy dissipater structure. Some minor hairline cracks and efflorescence noted in outflow channel wall.	



Photo No. 22	Date: 11/22/19
Direction Photo Taken: North	
Description: View looking upstream from the permit outfall for the main service spillway.	



Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 23	Date: 11/22/19
Direction Photo Taken: East	
Description: View of the permit outfall (Parshall flume downstream of energy dissipater) for the main service spillway.	



Photo No. 24	Date: 11/22/19
Direction Photo Taken: West	
Description: View of the face of dam and downstream slope of the MSE wall.	



Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 25	Date: 11/22/19
Direction Photo Taken: South	
Description: View of wetness and brown grass on face of dam. Location should continue to be monitored. Wetness may be attributed to rain event at time of inspection.	



Photo No. 26	Date: 11/22/19
Direction Photo Taken: West	
Description: View of upstream side of the right abutment.	



Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 27	Date: 11/22/19	
Direction Photo Taken: South		
Description: View of the surface water collection channel on the face of dam. The channel protection was sparse in a section allowing surface water erode the side of the channel. Additional channel protection should be placed to contain surface water to the channel.		

Photo No. 28	Date: 11/22/19	
Direction Photo Taken: West		
Description: V-notch weir from seepage drain and seepage zone on the right abutment.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No. 29	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: View of the concrete portion of the Emergency Spillway after the newest raising. Several cracks 3/16" to 1/8" were noted with efflorescence in some of the cracks, indicating possible seepage through the water stops.		

Photo No. 30	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: Right concrete wall of emergency spillway – occasional cracking in concrete noted full width and depth of wall. Apparent movement of concrete walls not noted.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
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Photo No.: 31	Date: 11/22/19
Direction Photo Taken: Northwest	
Description: Typical condition of MSE Wall at crest of dam.	



Photo No.: 32	Date: 11/22/19
Direction Photo Taken: East	
Description: RCC overlay at dam crest. The RCC is heavily weathered and in fair to poor condition	



Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No.: 33	Date: 11/22/19	
Direction Photo Taken: East		
Description: Cracking in left (east) sidewall of emergency spillway.		

Photo No.: 34	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: Typical condition of RCC steps on emergency spillway. Steps are highly to completely weathered.		

Impoundment Name: Cardinal Fly Ash Dam 2	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No. 60583548
--	---	--------------------------------

Photo No. 35	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: Minor cracking in emergency spillway crest overflow slab.		

Appendix C : Photographs – Bottom Ash Complex

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 1	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of the exterior slope of the west dike. Note ponding water at the toe of the slope during the inspection likely due to the rain event at the time of the inspection. No significant signs of erosion, slumping, boils, or instability were observed.		

Photo No. 2	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of the exterior slope and ash sluice lines.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 3	Date: 11/22/19	
Direction Photo Taken: Southeast		
Description: View of the exterior slope along the toe of the embankment. Note ponded water near toe of slope. Water ponding likely due to combination of seepage and surface water.		

Photo No. 4	Date: 11/22/19	
Direction Photo Taken: South		
Description: View of the inverted filter drain extended through this area in late 2009 to control seepage from the pond.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 5	Date: 11/22/19	
Direction Photo Taken: South		
Description: View of the rip rap armoring along the embankment.		

Photo No. 6	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of the embankment along the Ohio River.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 7	Date: 11/22/19
Direction Photo Taken: South	
Description: View of the exterior slope along the Ohio River and access stairs to the monitoring well. Trees at toe of natural river bank near waterline do not appear to be impacting the dam.	



Photo No. 8	Date: 11/22/19
Direction Photo Taken: South	
Description: View of the exterior east embankment slope along the Ohio River. Several erosion rills noted along top of embankment.	



Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 9	Date: 11/22/19
Direction Photo Taken: North	
Description: View of the crest area of the exterior slope along the Ohio River. Minor potholes were observed intermittently.	



Photo No. 10	Date: 11/22/19
Direction Photo Taken: Northwest	
Description: View of the splitter dike between the Bottom Ash Pond (BAP) and Recirculation Pond (RCP).	



Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 11	Date: 11/22/19	 A wide-angle photograph of a large body of water, likely an ash pond. In the middle ground, there is a blue and yellow metal structure, possibly a gate or outlet. The background shows a hillside with trees in autumn colors. The sky is overcast.
Direction Photo Taken: North		
Description: Outlet structure between BAP and RCP.		

Photo No. 12	Date: 11/22/19	 A photograph showing the interior slope of a pond. The foreground is a gravelly bank with some erosion channels. The water is calm and reflects the sky. In the background, there are trees and a fence line.
Direction Photo Taken: Southeast		
Description: View of the interior slope of the SW corner of the Bottom Ash Pond. Minor erosion channels along top of bank noted.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No.: 13	Date: 11/22/19	
Direction Photo Taken: East		
Description: View of the interior slope of the Bottom Ash Pond. Minor erosion channels along top of bank noted.		

Photo No.: 14	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: View of existing overflow intake structure.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No.: 15	Date: 11/22/19	
Direction Photo Taken: East		
Description: View of interior of overflow sluiceway from overflow structure. Sluiceway appears to be generally clear of obstructions.		

Photo No.: 16	Date: 11/22/19	
Direction Photo Taken: North		
Description: View of the pump house at the RCP.		

Impoundment Name: Cardinal Bottom Ash Pond Complex	Site Location: 306 County Road 7 East, Brilliant, OH, 43913	Project No.: 60583548
--	---	---------------------------------

Photo No. 17	Date: 11/22/19	
Direction Photo Taken: East		
Description: View of seepage on the face of the eastern dike slope.		

Photo No. 18	Date: 11/22/19	
Direction Photo Taken: Northeast		
Description: View of seepage on the face of the eastern dike slope.		

Appendix D : Bathymetric Surveys

BUCKEYE POWER

6677 Busch Boulevard
Columbus, OH 43229
614-846-5757 (phone)

**CARDINAL PLANT
BRILLIANT, OH
CARDINAL FAR II
HYDROGRAPHIC SURVEY**

**ISSUED FOR
CERTIFICATION**

ISSUED FOR BIDDING _____ DATE BY _____

ISSUED FOR CONSTRUCTION _____ DATE BY _____

REVISIONS

NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO: 60583548

DRAWN BY:

DESIGNED BY:

CHECKED BY:

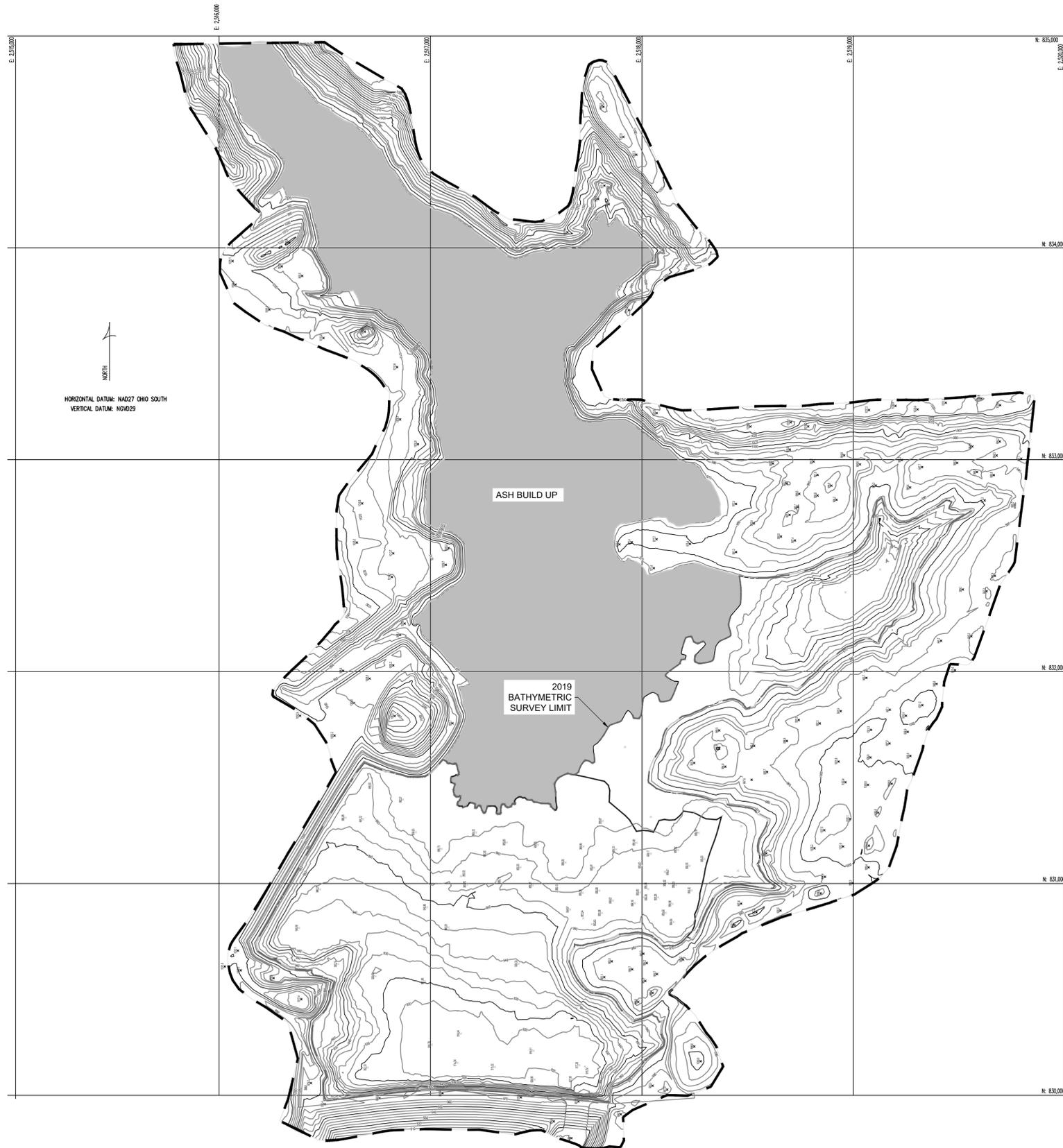
DATE CREATED:

PLOT DATE: 12/20/2019

SCALE:

ACAD VER: 2018

SHEET TITLE



LEGEND

- BATHYMETRIC SURVEY LIMIT
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF FLYASH
- × EXISTING SUBSURFACE SPOT ELEVATION
- 980— EXISTING SURFACE CONTOUR (INDEX)
- 987.0— EXISTING SURFACE CONTOUR (INTERMEDIATE)
- ×987.0 EXISTING SURFACE SPOT ELEVATION

SCALE: 1" = 300'



MAPPING NOTES

- EXISTING SUBSURFACE TOPOGRAPHY SHOWN HEREON OBTAINED FROM BATHYMETRIC SURVEYS PERFORMED IN NOVEMBER, 2019 BY JACK A. HAMILTON AND ASSOCIATES, INC.
- EXISTING EDGE OF WATER LOCATION AND ELEVATION SHOWN HEREON WAS OBTAINED FROM CLIENT PROVIDED DRAWING: CD-170912 FAR II HYDROGRAPHIC SURVEY - CARDINAL PLANT, DATED 10-18-2017. POOL ELEVATIONS SHOWN WERE OBTAINED FROM EDGE OF WATER LOCATIONS AT TIME OF FIELD SURVEY. EDGE OF WATER LOCATION SHOWN ALONG FACE OF FLYASH SLURRY WAS DIGITIZED FROM DRONE ORTHOIMAGERY (IMAGE DATE: 11/02/2019).
- EXISTING SUBSURFACE BREAKLINES SHOWN ARE ASSUMED AND WERE DIGITIZED FROM DRONE ORTHOIMAGERY (IMAGE DATE: 11/02/2019). ASSUMED ELEVATIONS OF TWO (2) FEET BELOW POOL ELEVATIONS WERE ASSIGNED TO THE BREAKLINES. REMOTE CONTROLLED HYDROGRAPHIC SURVEY EQUIPMENT WAS UNABLE TO OBTAIN SUBSURFACE LOCATIONS UPGRADIENT OF BREAKLINES.
- SURFACE TOPOGRAPHY (CONTOURS SHOWN ABOVE THE WATER LEVEL) SHOWN WAS OBTAINED FROM CLIENT PROVIDED DRAWING: CD-170912 FAR II HYDROGRAPHIC SURVEY - CARDINAL PLANT, DATED 10-18-2017.

Appendix E : Figures and Drawings



DRN BY:
DATE:
SCALE: 1"=

CARDINAL POWER STATION
FLY ASH DAM I

DWG NO: FIGURE 1
 AMERICAN ELECTRIC POWER
ACP SERVICE CORP.
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

GENERAL NOTES

1. - EXCAVATE ROCK SURFACE TO ACHIEVE A RIGHT ANGLE CONTACT WITH THE RCC.
2. - THE SOIL OVERBURDEN ON BOTH THE RIGHT & LEFT ABUTMENTS SHALL BE STRIPPED. A 2' BOTTOM ASH DRAINAGE BLANKET SHALL BE PROVIDED OVER THE ENTIRE STRIPPED AREA. ANY SEEPAGE ZONES FOUND DURING STRIPPING SHALL BE DRAINED AS NECESSARY BY A FRENCH DRAIN DAYLIGHTING INTO GROIN DITCH.
3. - ADJUST LOCATION OF GROIN DITCH AS REQUIRED TO CLEAR PIPE SUPPORTS.

- LEGEND - EXISTING
- SPOT ELEVATION
 - INTERMEDIATE CONTOUR
 - INDEX CONTOUR
 - DEPRESSION CONTOUR
 - TREES AND TREELINE
 - STRUCTURE AND BUILDING
 - FENCE
 - POLE
 - ROADS
 - EDGE OF WATER
 - MANHOLES / CATCH BASIN
 - POWER POLE
 - PIPES
 - TOWER

- LEGEND - PROPOSED
- FIN. GRADE SPOT ELEV.
 - FIN. GRADE CONTOUR
 - DRAINAGE DITCH
 - INCLINED BORE HOLES
 - VERTICAL BORE HOLES
 - PIEZOMETER

REFERENCE DRAWINGS

- 13-30041 - FLY ASH DAM II RAISING PROFILE & SECTION.
- 13-30042 - FLY ASH DAM II RAISING SECTIONS & DETAILS SHT. 1.
- 13-30043 - FLY ASH DAM II RAISING SECTIONS & DETAILS SHT. 2.

DATE	NO.	DESCRIPTION	APPD.
8/29/09	5	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE	JWB
8/24/09	4	AS-BUILT: REVISED TOPO, DRAIN PIPES, ADDED TABLES, PIEZOMETERS AND OPEN BORE HOLES; REMOVED MONITORING WELLS 4, 3, 20 & 25	JWB
8/22/09	3	REMOVED INTERMEDIATE CONTOURS, INDICATED CONCRETE TRAINING WALL & GEOTEXTILE FABRIC	JWB
8/20/09	2	DELETED DROP MANHOLE & REV. PIPE ALIGNMENT	JWB
8/23/09	1	REV. TOE OF DAM TO REFLECT SLIDE REPAIR, RELOCATED DROP MANHOLE & REV. PIPE BEND, 6" WAS 6" ADDED UNDERDRAIN SYSTEM	JWB
4/29/07	0	ISSUED FOR CONSTRUCTION	JWB

st:\cd\13\geo\hydro\site\30040.dgn

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CARDINAL OPERATING COMPANY
CARDINAL PLANT
 BRILLIANT OHIO

**FLY ASH DAM II RAISING
 GRADING & DRAINAGE PLAN**

DWG. NO. **13-30040-5**

SCALE: 1"=50'

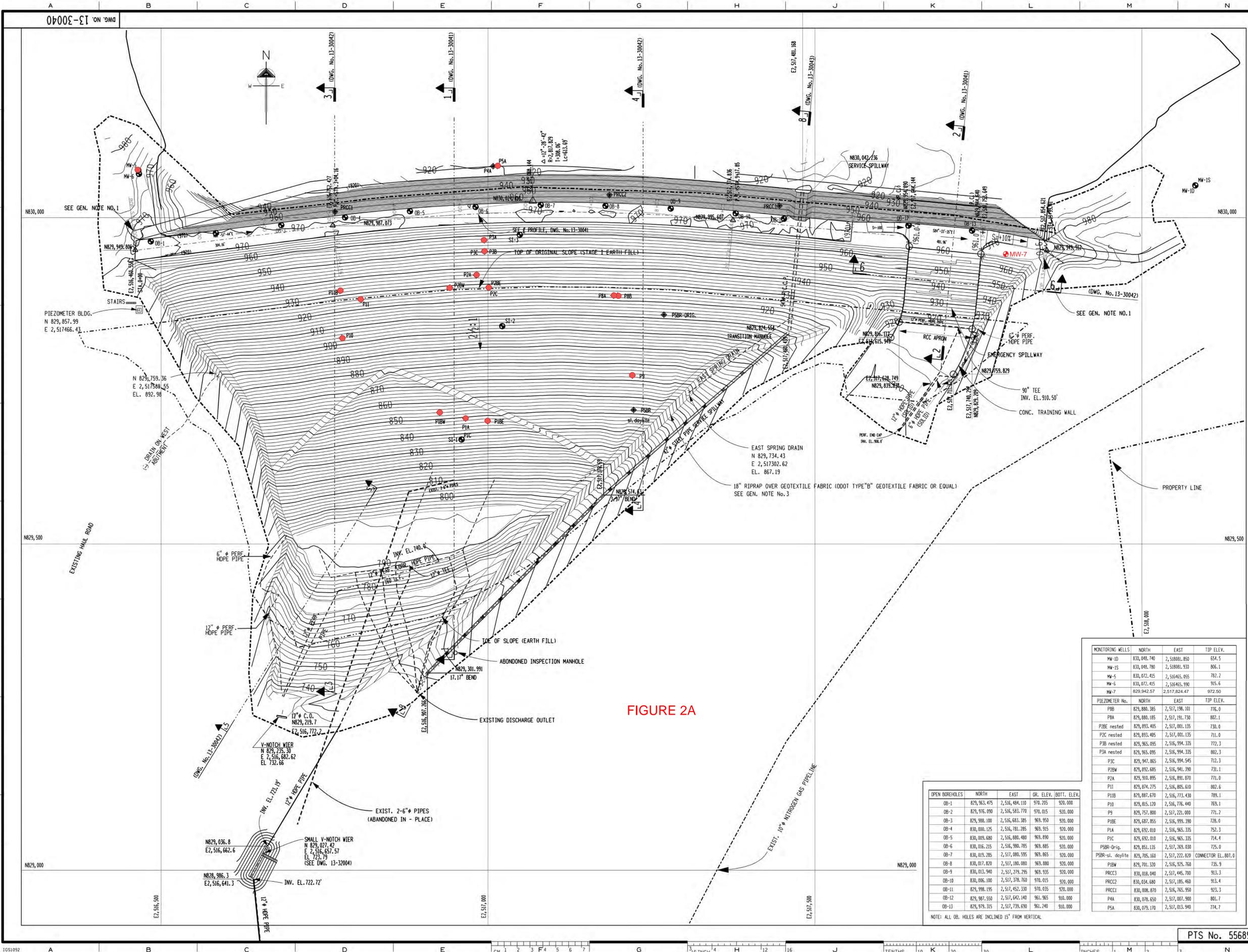
CIVIL ENGINEERING DIVISION

APPROVED BY: *H. Joseph Buhac*

AMERICAN ELECTRIC POWER
 1 RIVERSIDE PLAZA
 COLUMBUS, OH 43215

SYSTEM DATE: 24 JAN 2009
 15:51, P. 0465

FIGURE 2A



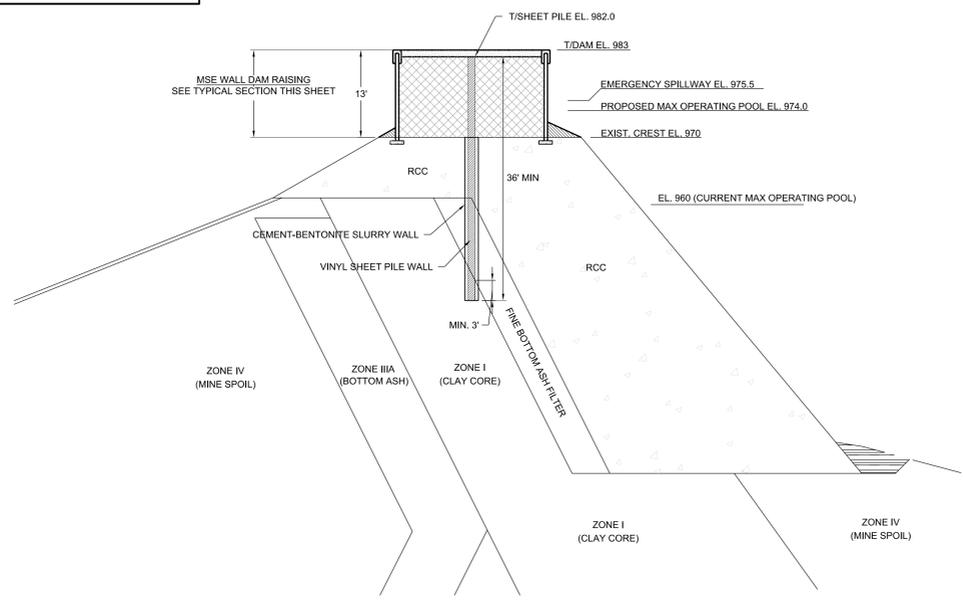
OPEN BOREHOLES	NORTH	EAST	GR. ELEV.	BOIT. ELEV.
OB-1	829,963.475	2,516,464.110	970.205	920.000
OB-2	829,976.090	2,516,503.770	970.015	920.000
OB-3	829,988.100	2,516,563.385	963.950	920.000
OB-4	830,000.125	2,516,781.285	963.915	920.000
OB-5	830,003.600	2,516,880.480	963.890	920.000
OB-6	830,016.215	2,516,980.785	963.865	920.000
OB-7	830,019.285	2,517,080.595	963.865	920.000
OB-8	830,013.940	2,517,180.080	963.880	920.000
OB-9	830,013.940	2,517,279.295	963.935	920.000
OB-10	830,006.100	2,517,378.760	970.015	920.000
OB-11	829,998.195	2,517,452.330	970.035	920.000
OB-12	829,987.550	2,517,642.140	961.965	910.000
OB-13	829,979.315	2,517,739.690	961.240	910.000

MONITORING WELLS	NORTH	EAST	TYP. ELEV.
MW-ID	830,048.740	2,518,881.850	854.5
MW-15	830,048.780	2,518,881.930	806.1
MW-5	830,072.415	2,518,465.895	782.2
MW-6	830,072.415	2,518,465.990	915.6
MW-7	829,942.57	2,517,824.47	972.50

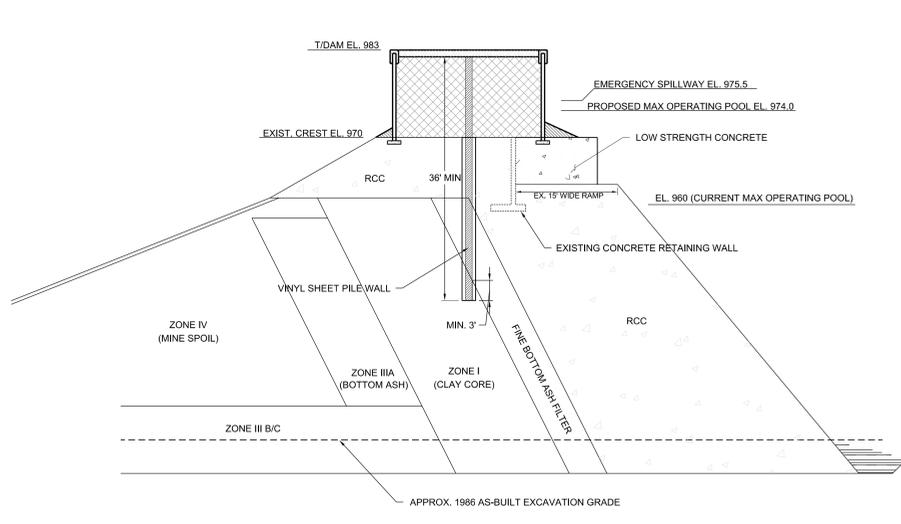
PIEZOMETER No.	NORTH	EAST	TYP. ELEV.
P2B	829,880.385	2,517,198.101	776.0
PBA	829,880.185	2,517,191.730	807.1
P2B nested	829,893.405	2,517,001.135	730.0
P2C nested	829,893.405	2,517,001.135	711.0
P3B nested	829,965.095	2,516,994.335	772.3
P3A nested	829,965.095	2,516,994.335	802.3
P3C	829,947.865	2,516,994.545	712.3
P2Bw	829,892.685	2,516,941.390	731.1
P2A	829,910.995	2,516,891.870	771.0
P11	829,874.275	2,516,805.610	802.6
P11B	829,867.870	2,516,773.430	789.1
P10	829,815.120	2,516,776.440	763.1
P9	829,757.800	2,517,221.000	771.2
P1B	829,687.855	2,516,999.390	728.0
P1A	829,692.010	2,516,965.335	752.3
P1C	829,692.010	2,516,965.335	714.4
P2B-Orig	829,851.135	2,517,269.030	725.0
P2B-Orig	829,705.160	2,517,222.820	CONNECTOR EL. 807.0
P2Bw	829,701.320	2,516,925.760	735.9
PRCC3	830,018.040	2,517,445.700	913.3
PRCC2	830,034.680	2,517,185.460	913.4
PRCC1	830,008.870	2,516,765.950	923.3
P1A	830,978.650	2,517,007.900	801.7
P2A	830,979.170	2,517,013.940	774.7

NOTE: ALL OB. HOLES ARE INCLINED 15° FROM VERTICAL

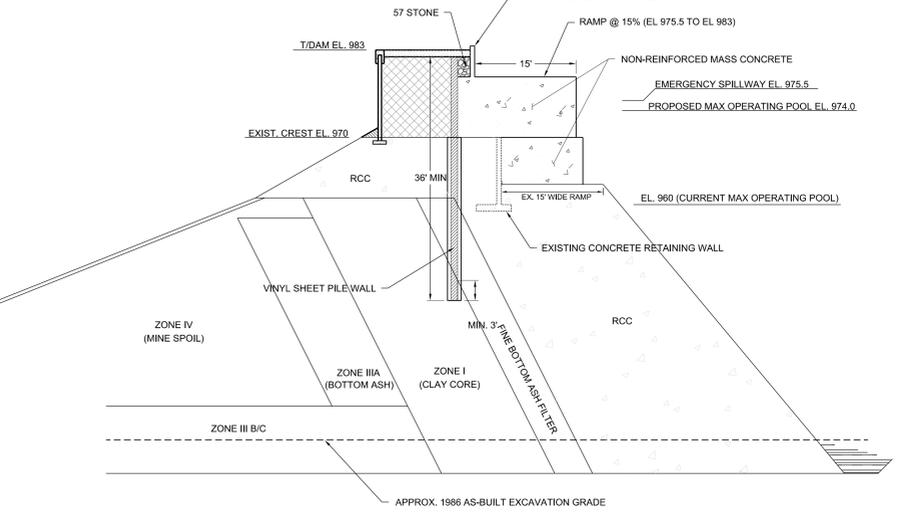
PTS No. 55689



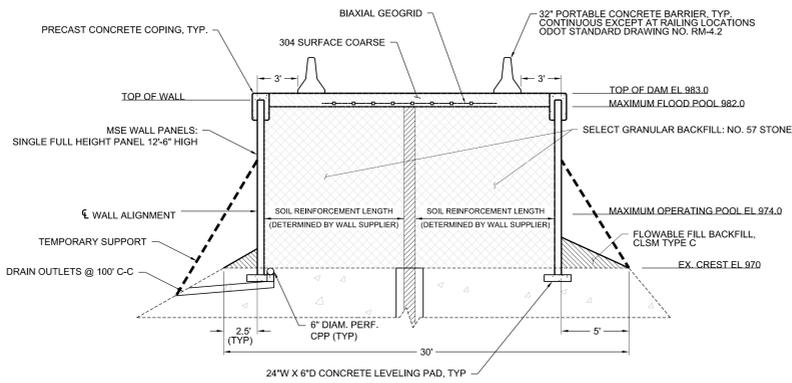
LA TYPICAL SECTION - MAIN DAM
SCALE: 1" = 10'



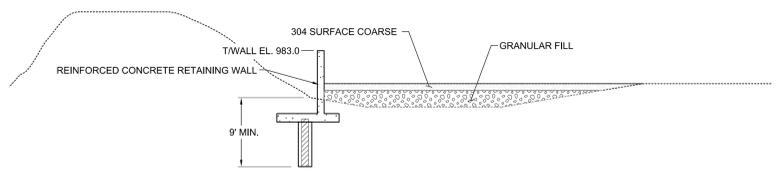
LB1 SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



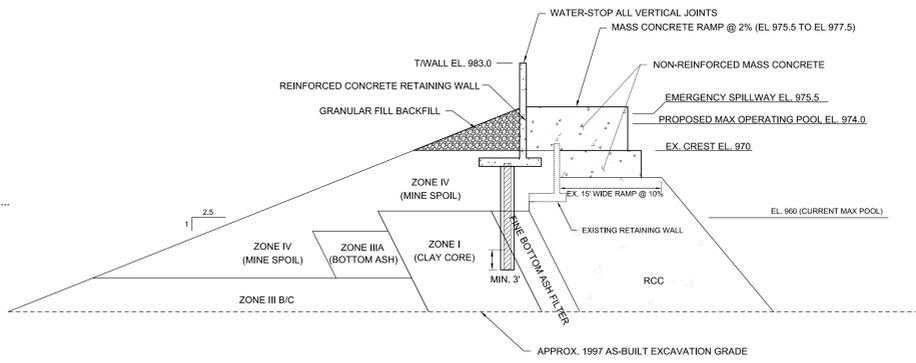
LB2 SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



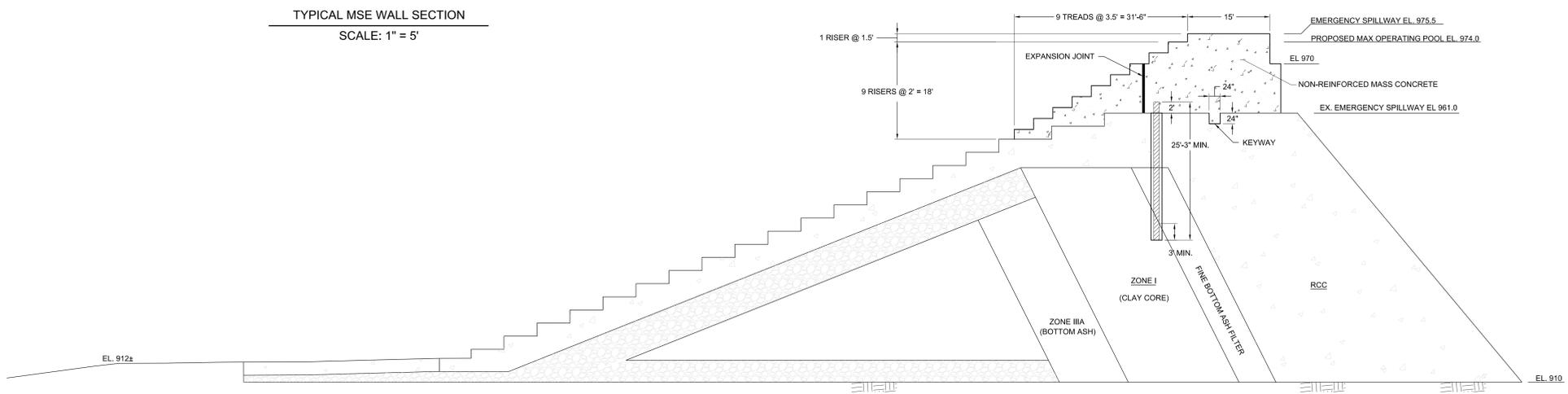
TYPICAL MSE WALL SECTION
SCALE: 1" = 5'



E SECTION E-E
SCALE: 1" = 10'



LD SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



LC SECTION THROUGH EXISTING EMERGENCY SPILLWAY
SCALE: 1" = 10'

FIGURE 2B

S&ME, INC.
6190 ENTERPRISE COURT
DUBLIN, OH 43016
PHONE: 614-793-2226
FAX: 614-793-2410
www.smeinc.com

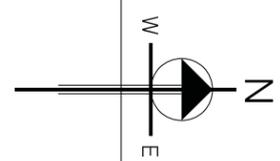
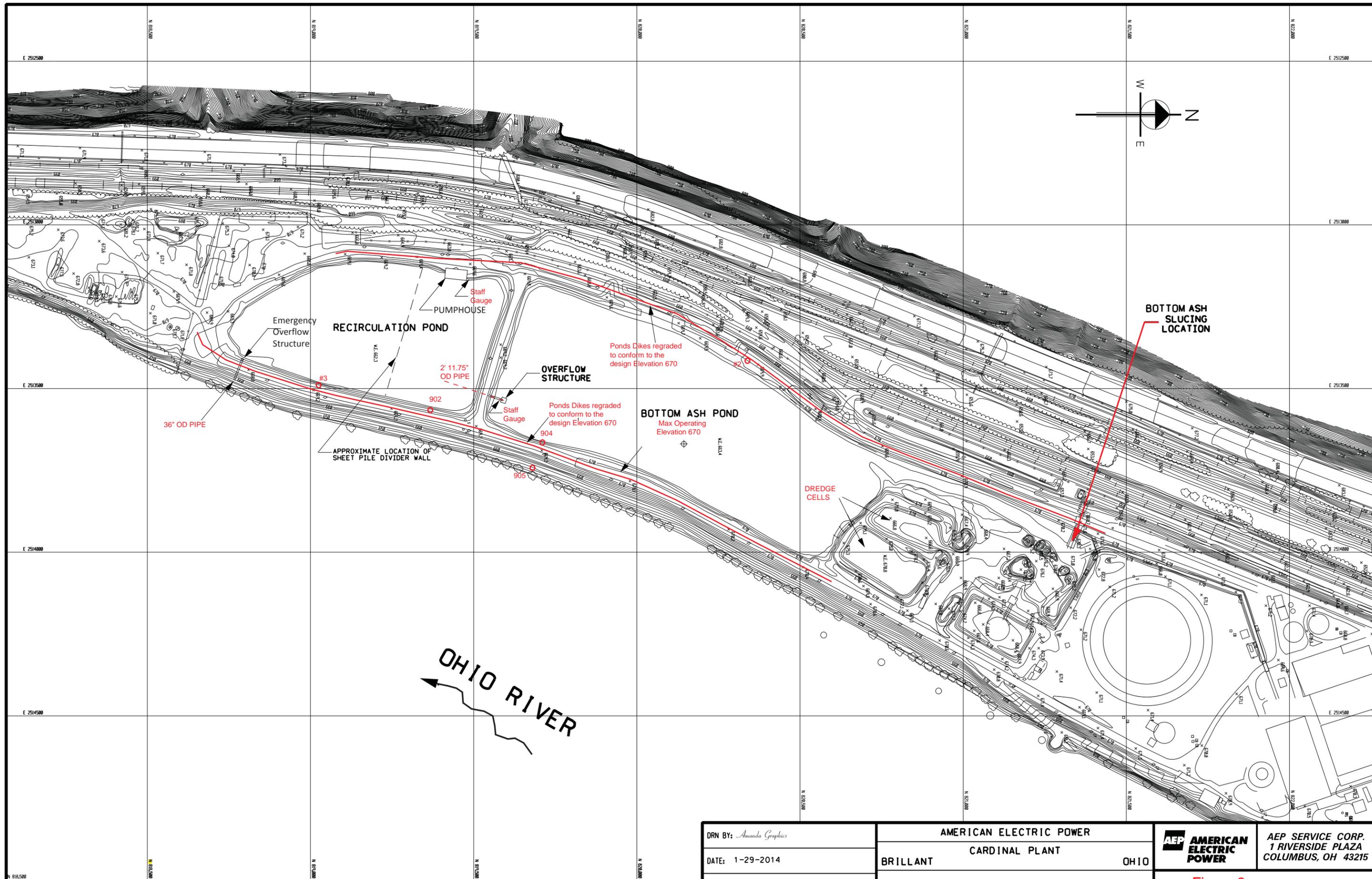


Michael Gilbert Rowland
MICHAEL GILBERT ROWLAND
E-65559
NUMBER
SEPT 28, 2012
DATE

PROJECT NUMBER: 011-11497-042	DRAWN BY: EDV
DRAWING DATE: 9/28/12	ENGINEER: MTR
LAST UPDATED: 9/28/12	APPROVED BY: MGR
	SCALE: AS NOTED



9/28/12	A	ISSUED FOR BID	SSB	MGR
DATE	NO.	DESCRIPTION		APPROV.
REVISIONS				
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CARDINAL OPERATING COMPANY CARDINAL PLANT BRILLIANT OHIO				
DAM RAISING ELY ASH RETENTION DAM II DAM RAISING TYPICAL SECTIONS				
DWG. NO. 13-30087-A				
ARCH	ELEC	MECH	STR	
SCALE: AS SHOWN	CIVIL ENGINEERING DIVISION			
DR				
CHK				
APP'D				
DATE				
S&ME AMERICAN ELECTRIC POWER				
1 RIVERSIDE PLAZA COLUMBUS, OH 43215				



DRN BY: <i>Amanda Graphics</i>	AMERICAN ELECTRIC POWER			AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
DATE: 1-29-2014	BRILLANT CARDINAL PLANT OHIO			
SCALE: N.T.S	BOTTOM ASH AND RECIRCLATION PONDS		Figure 3	

Figure 4
Cardinal FAD 2

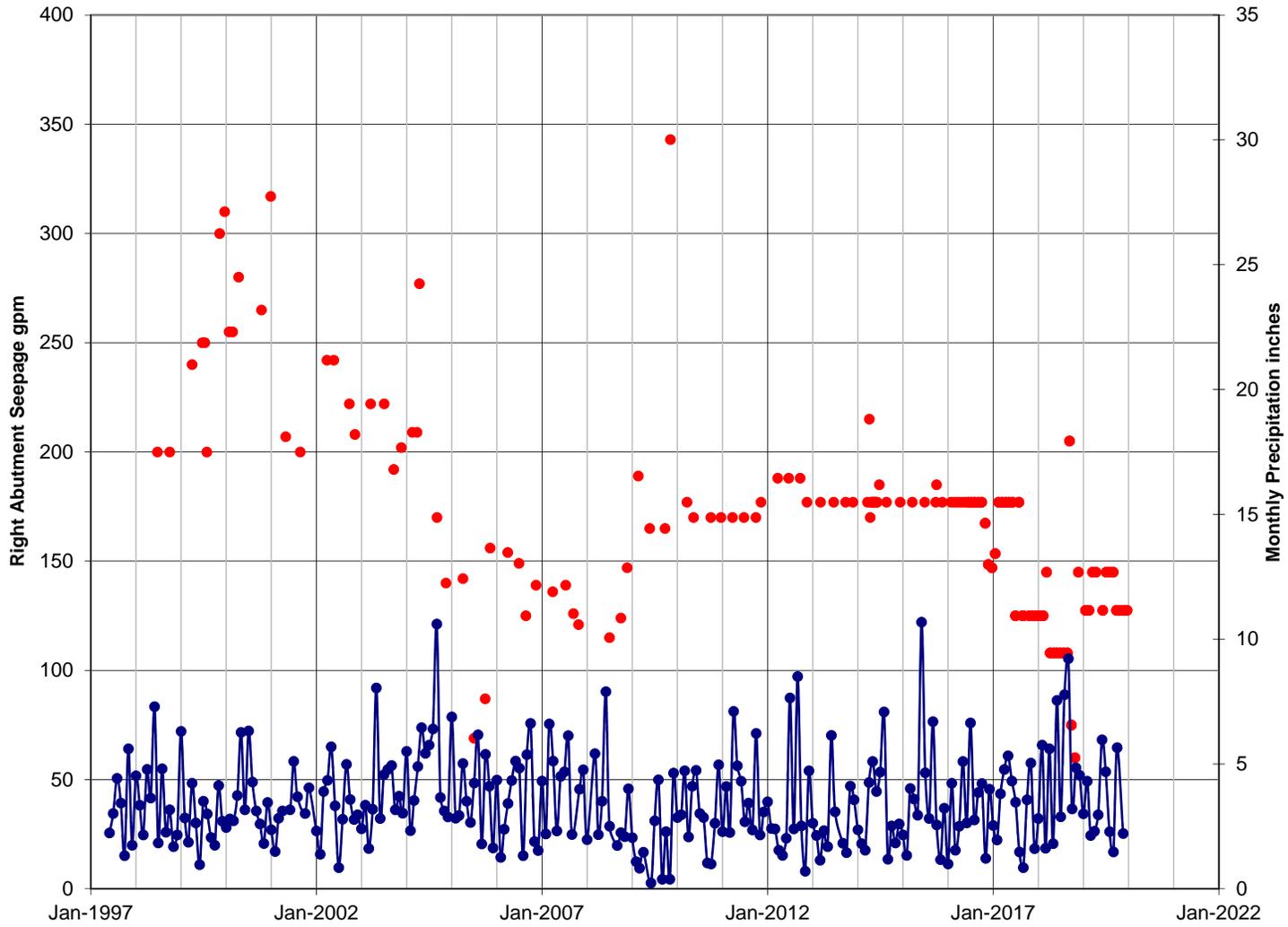


Figure 5a
Cardinal FAD 2

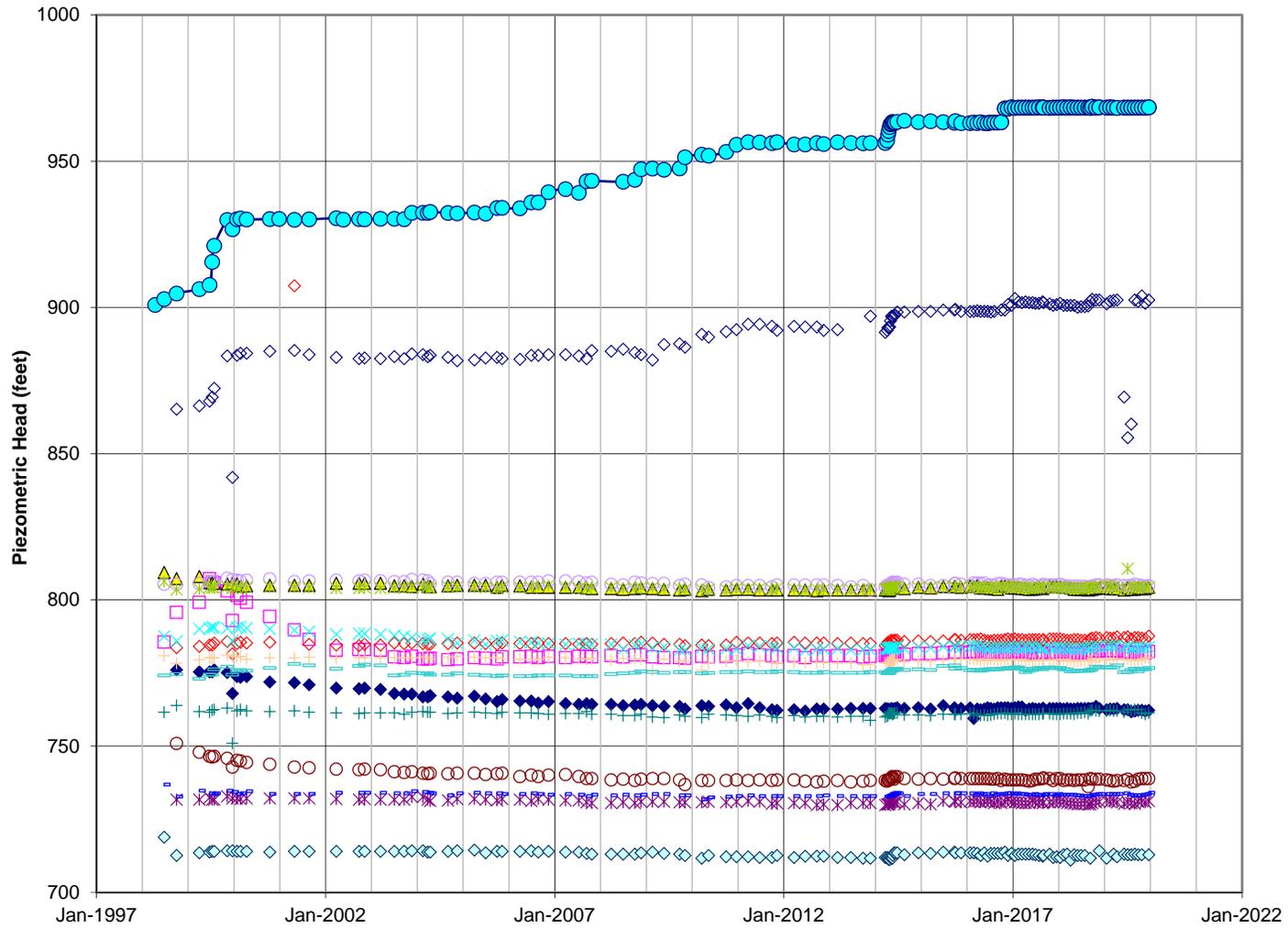


Figure 5b
Pool Stage versus Discharge
Cardinal FAD 2

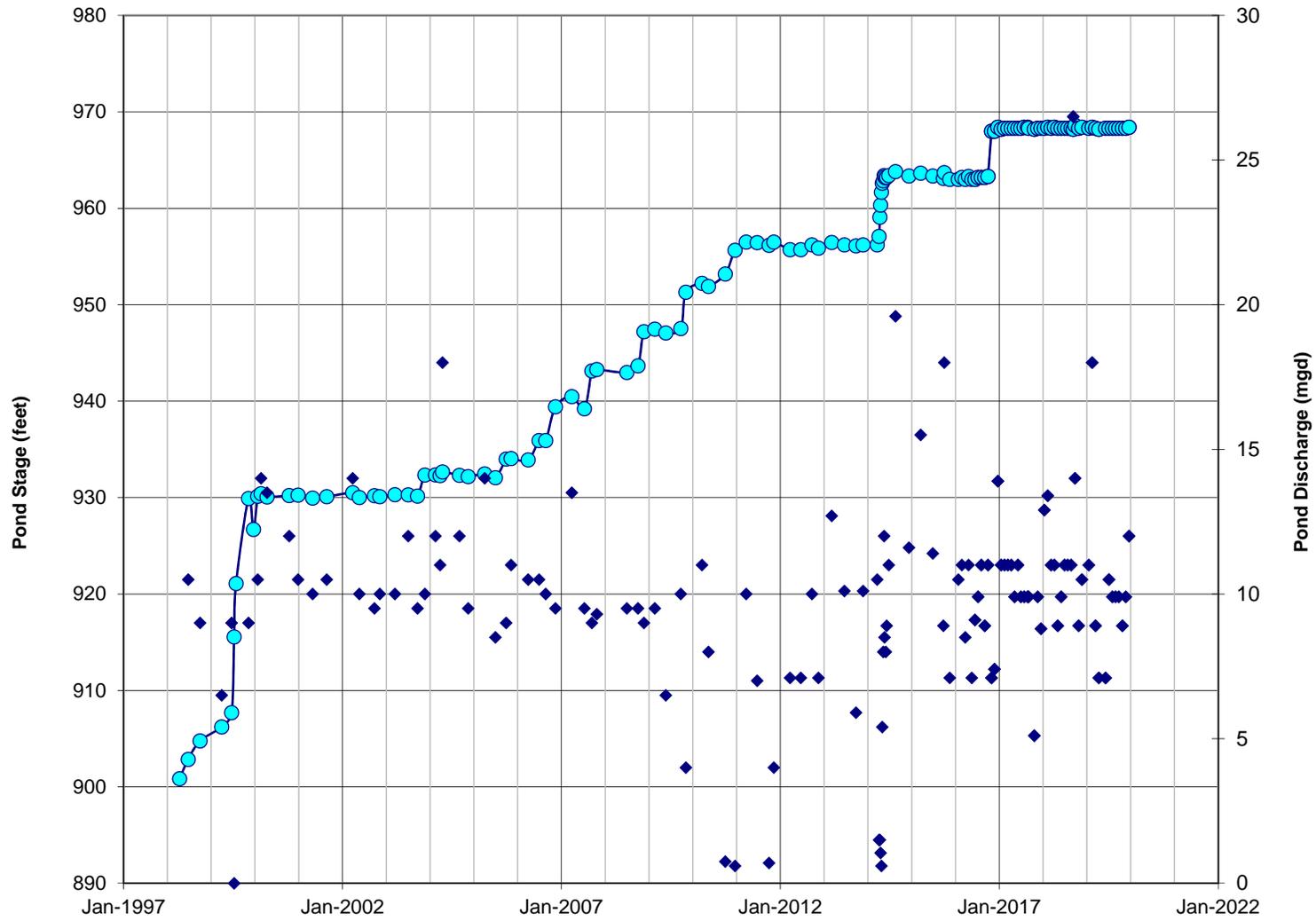


Figure 5c
Cardinal FAD 2
Right of Center
Foundation Piezometers

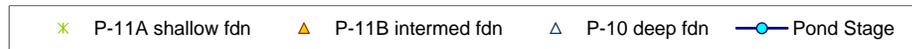
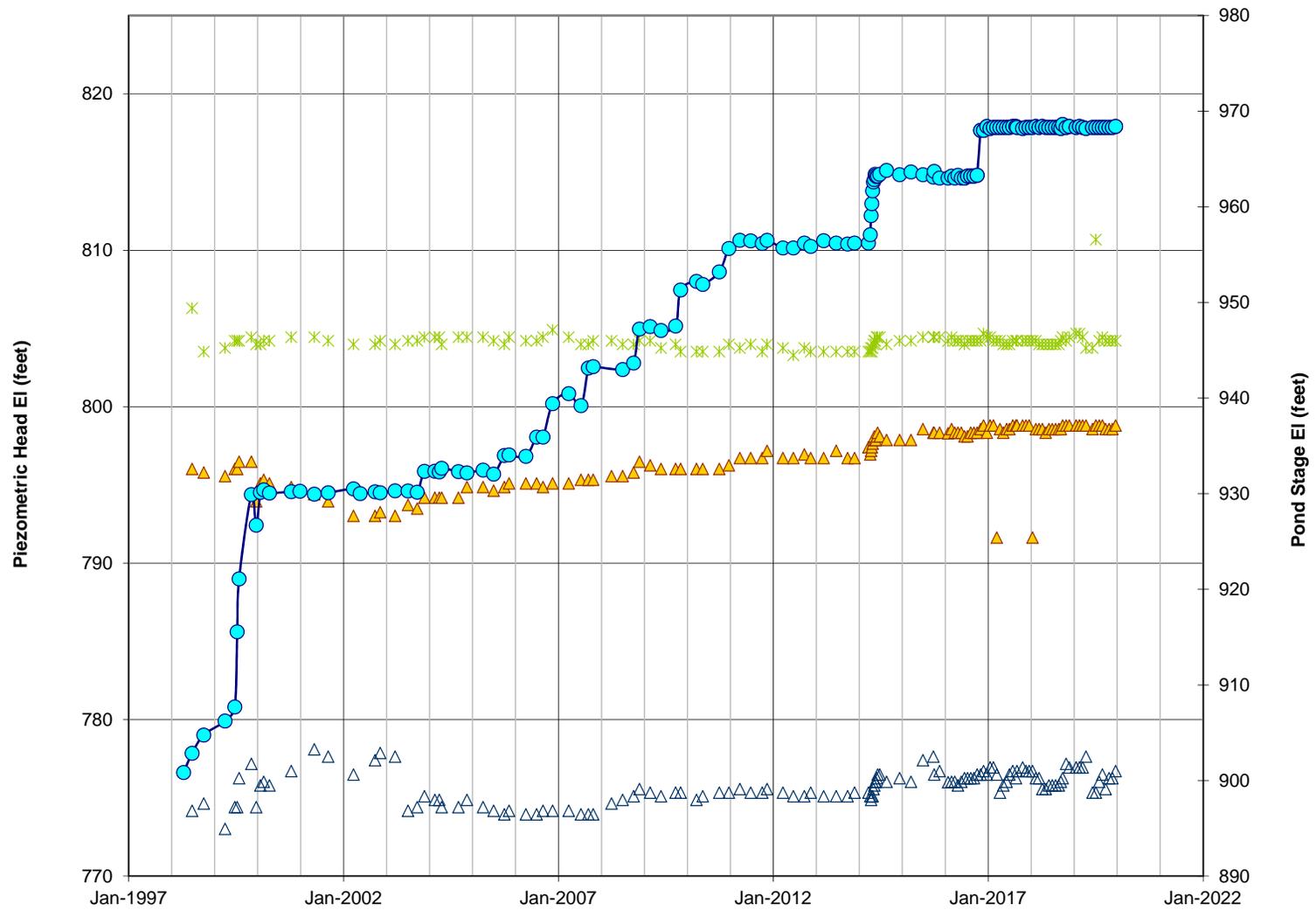


Figure 5d
Cardinal FAD 2
Left of Center
Foundation Piezometers

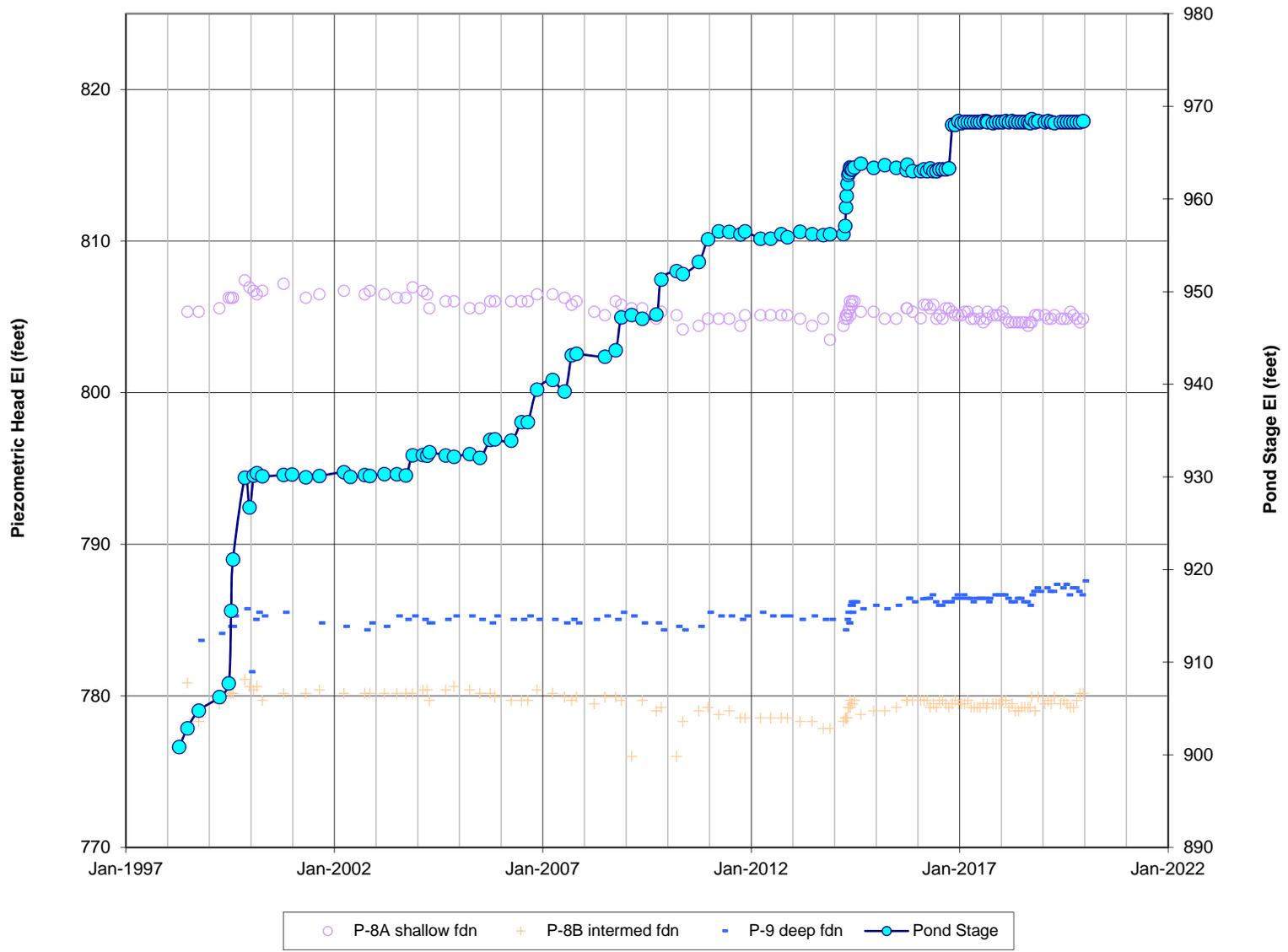


Figure 5e
 Cardinal FAD 2
 Centerline of Dam

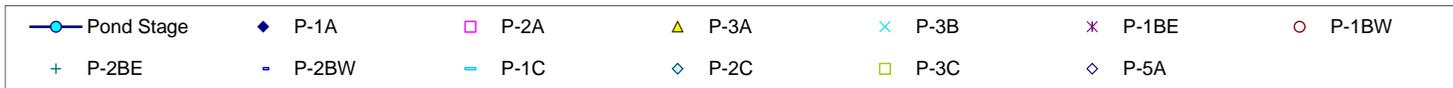
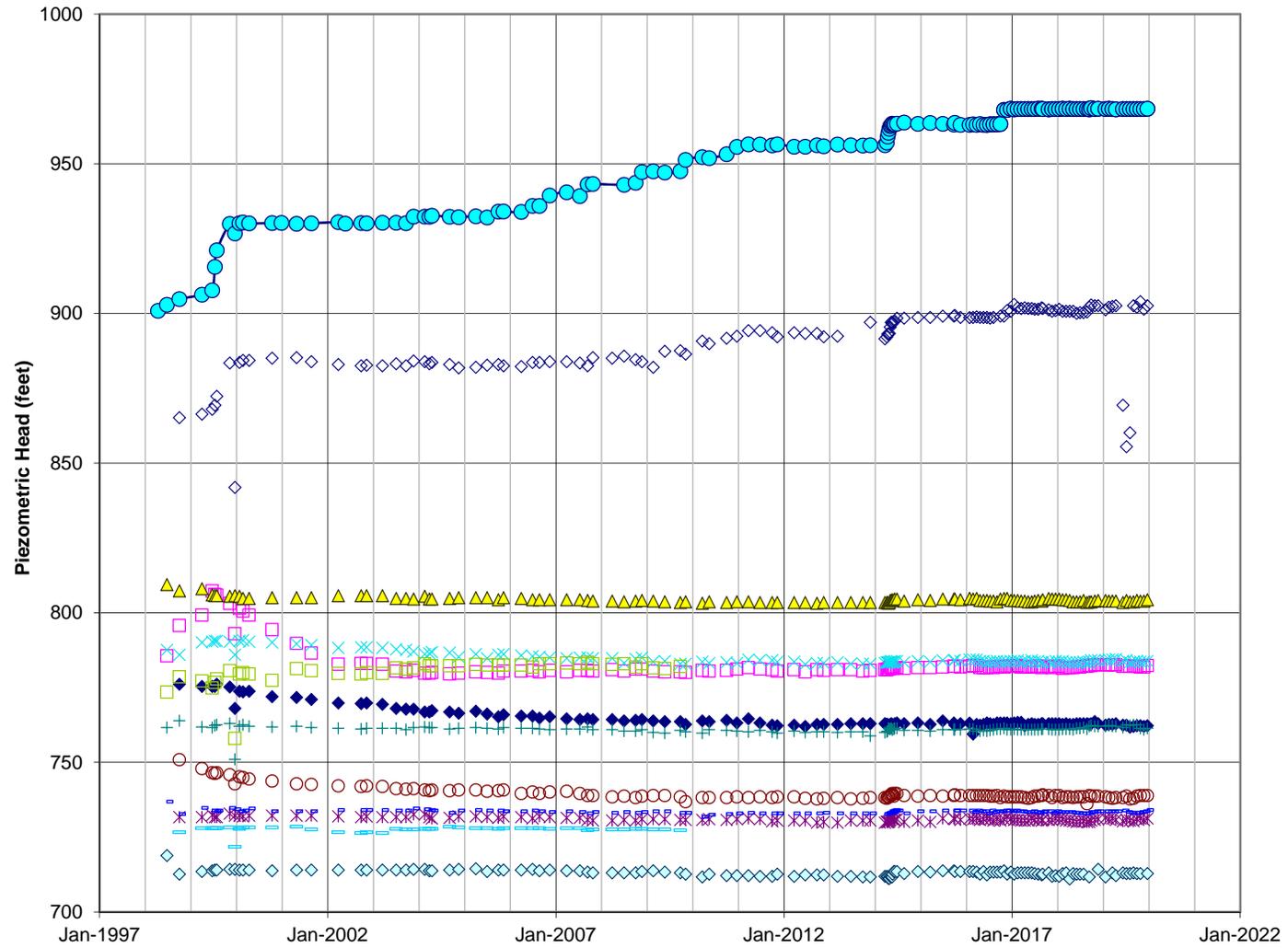


Figure 5f
Cardinal FAD 2
Centerline of Dam

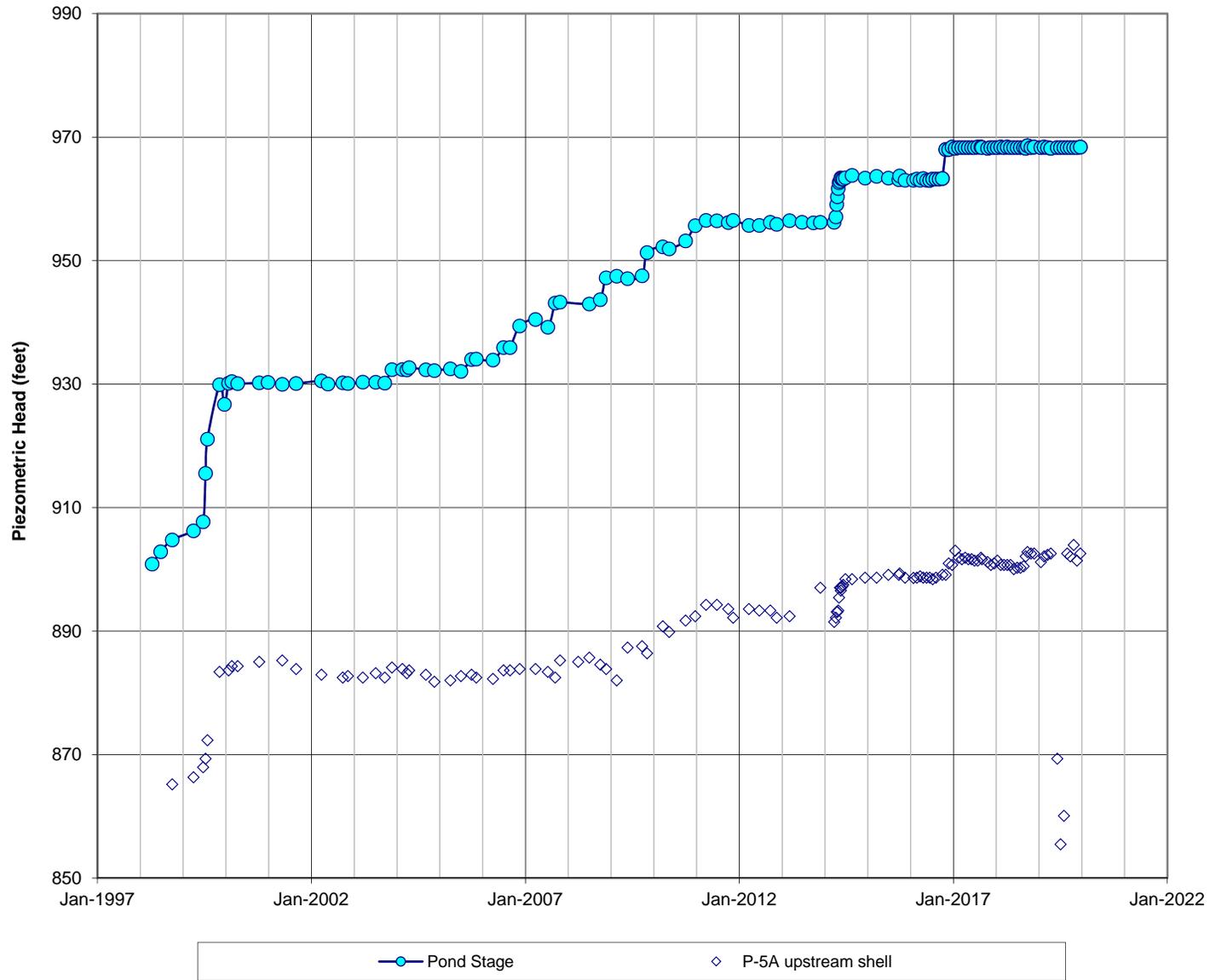


Figure 5g
 Cardinal FAD 2
 Centerline of Dam
 Clustered Piezometer Site

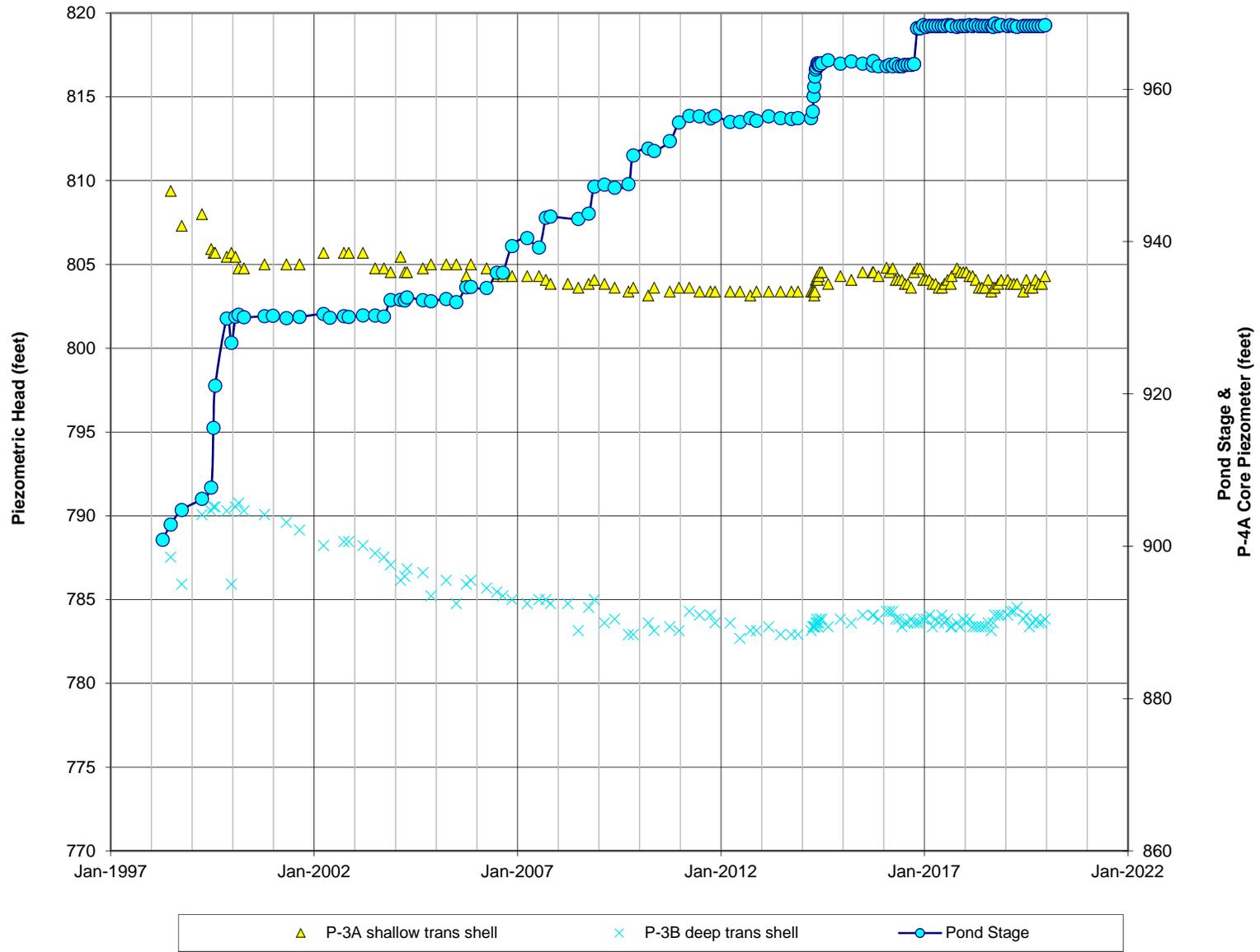


Figure 5h
Cardinal FAD 2
Centerline of Dam
Clustered Piezometer Site

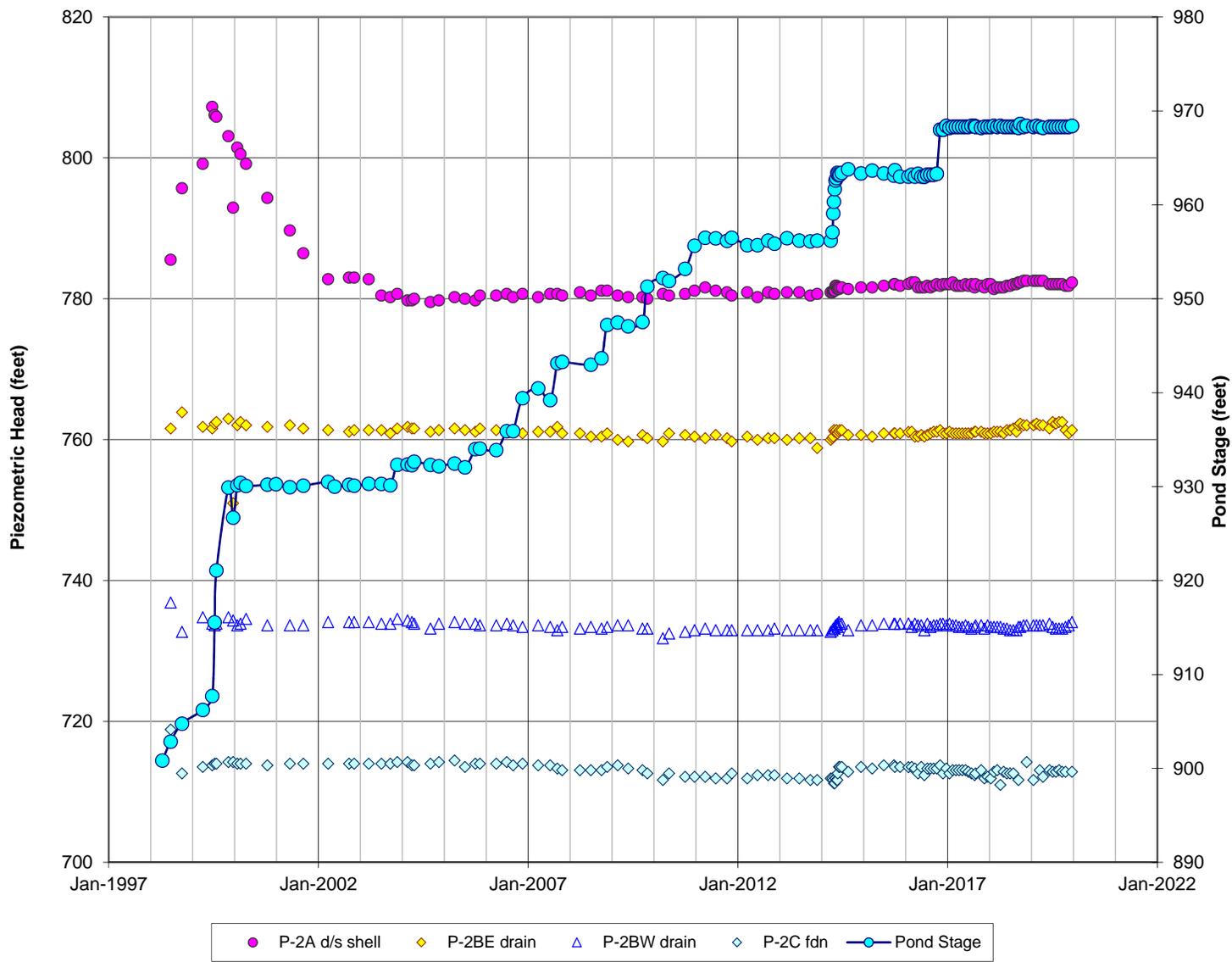


Figure 5i
Cardinal FAD 2
Centerline of Dam
Clustered Piezometer Site

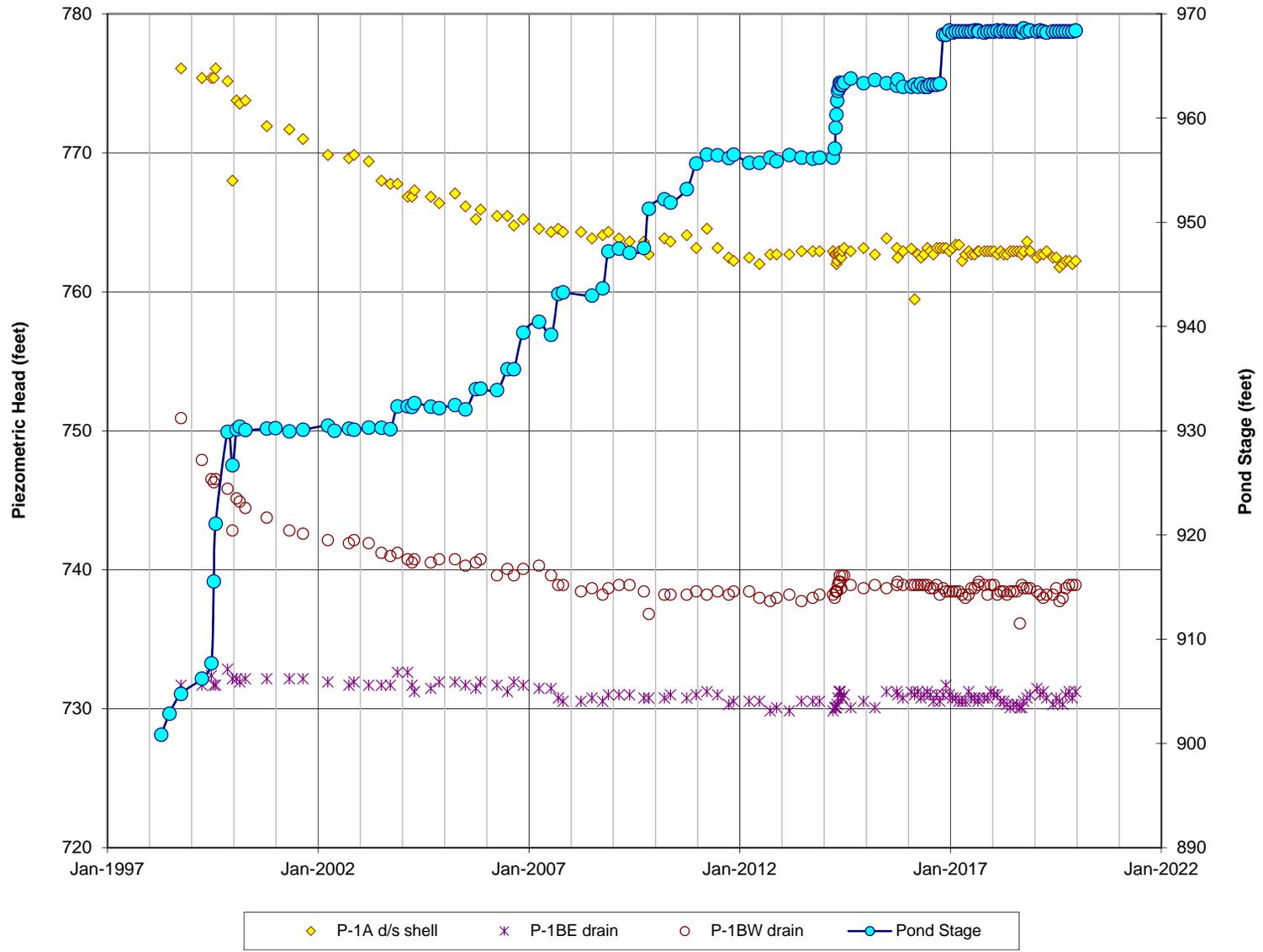
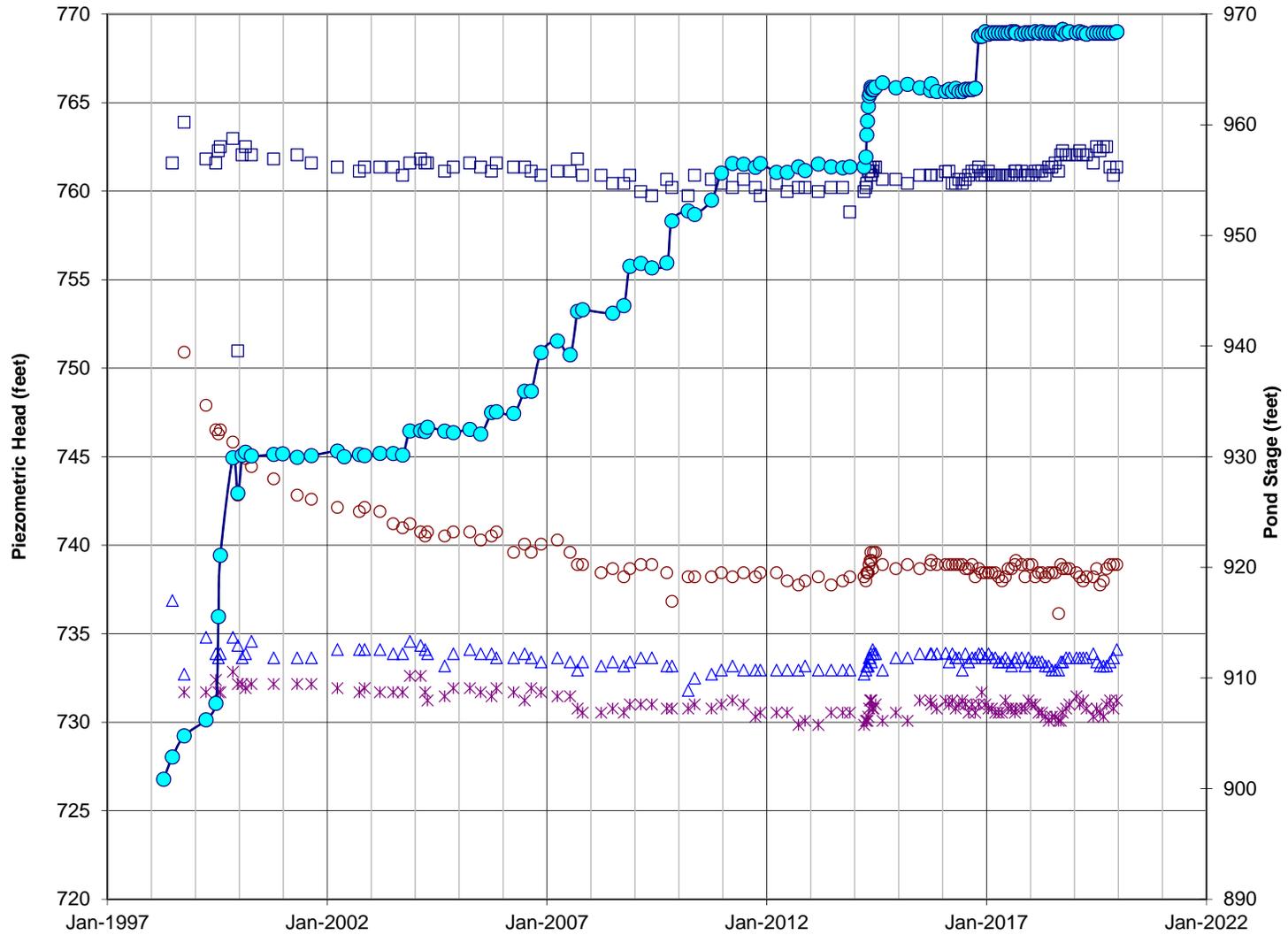


Figure 5j
Cardinal FAD 2
Centerline of Dam
Drain Piezometers



* P-1BE o P-1BW □ P-2BE △ P-2BW ● Pond Stage

Figure 5k
Cardinal FAD 2
Centerline of Dam
Foundation Piezometers

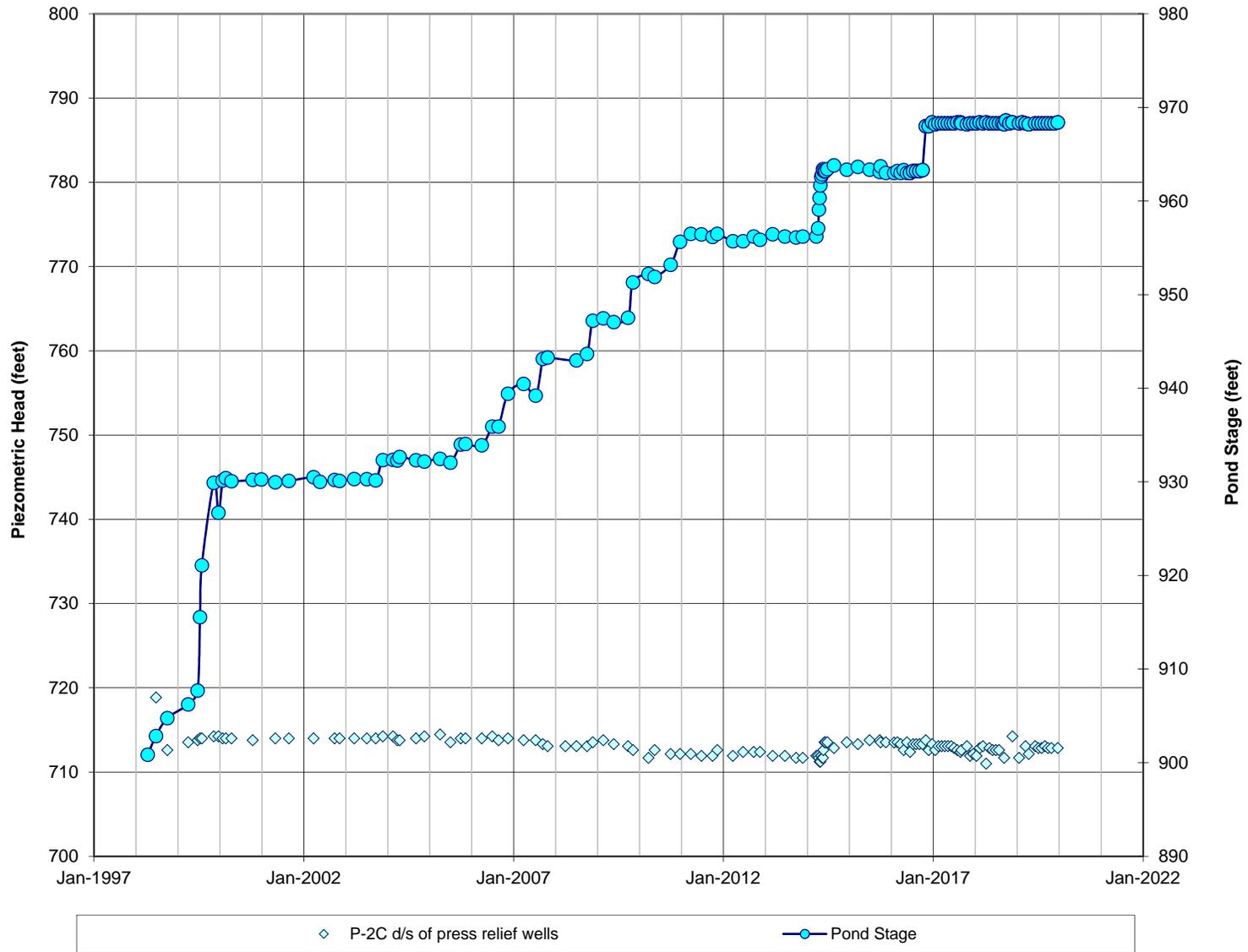
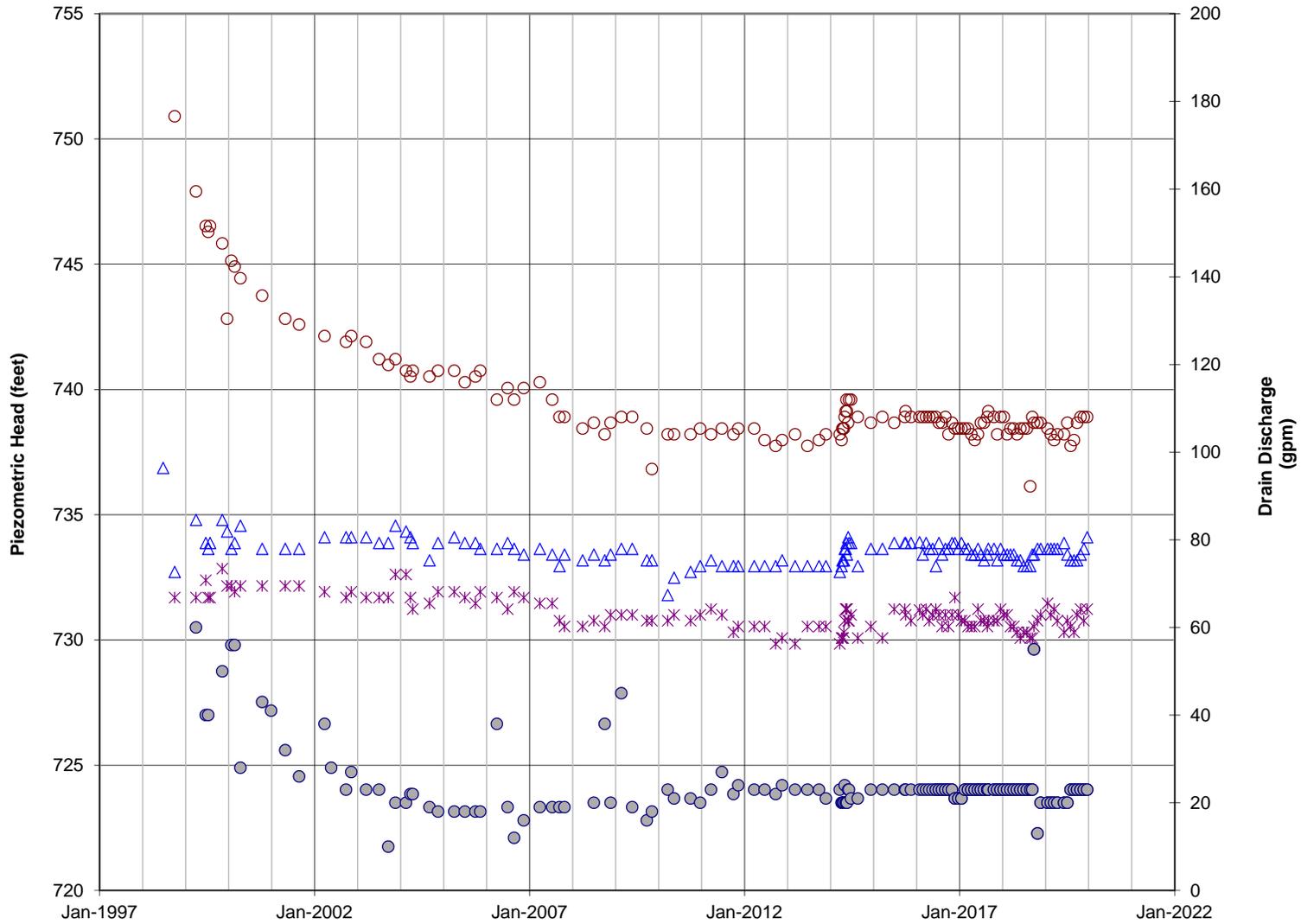


Figure 51
Cardinal FAD 2
Centerline of Dam
Drain Piezometers & Discharge



* P-1BE o P-1BW Δ P-2BW ● Internal Drain

**Figure 5m
Cardinal FAD 2
Centerline of Dam
Drain Piezometers & V-Notched Weir Discharge**

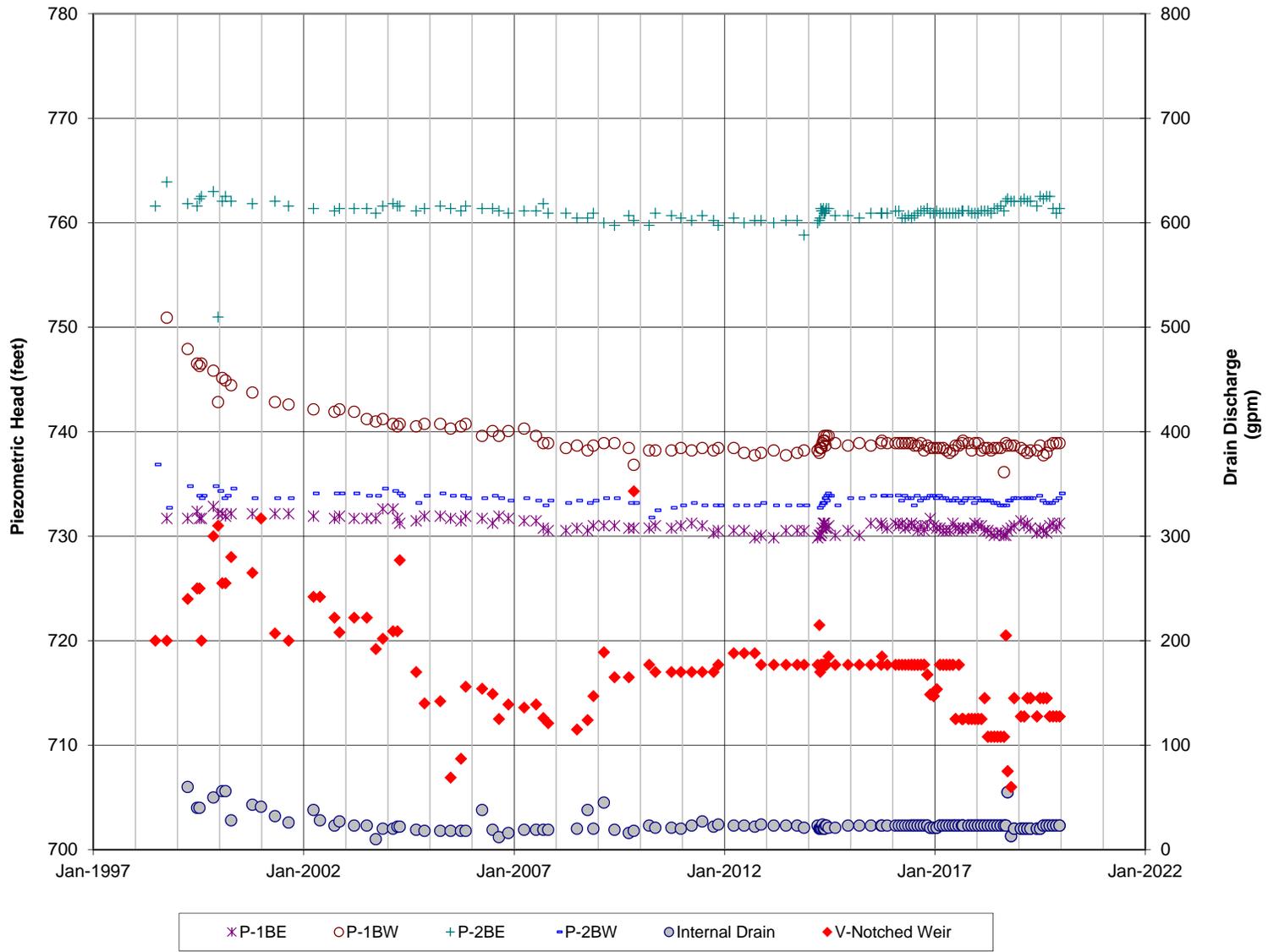


Figure 5n
 Cardinal FAD 2
 Centerline of Dam
 Drain Piezometers & Right Abutment Piezometers

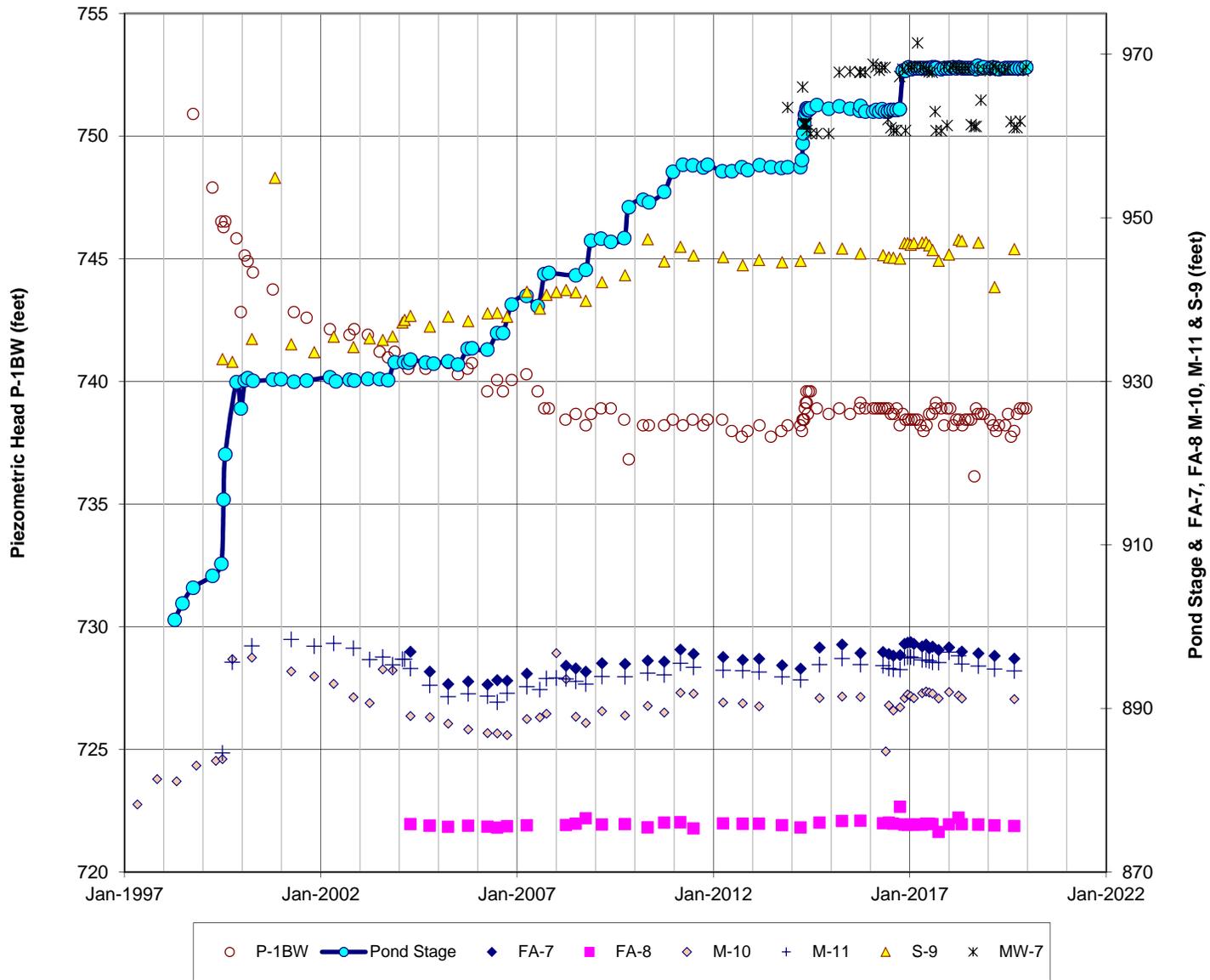
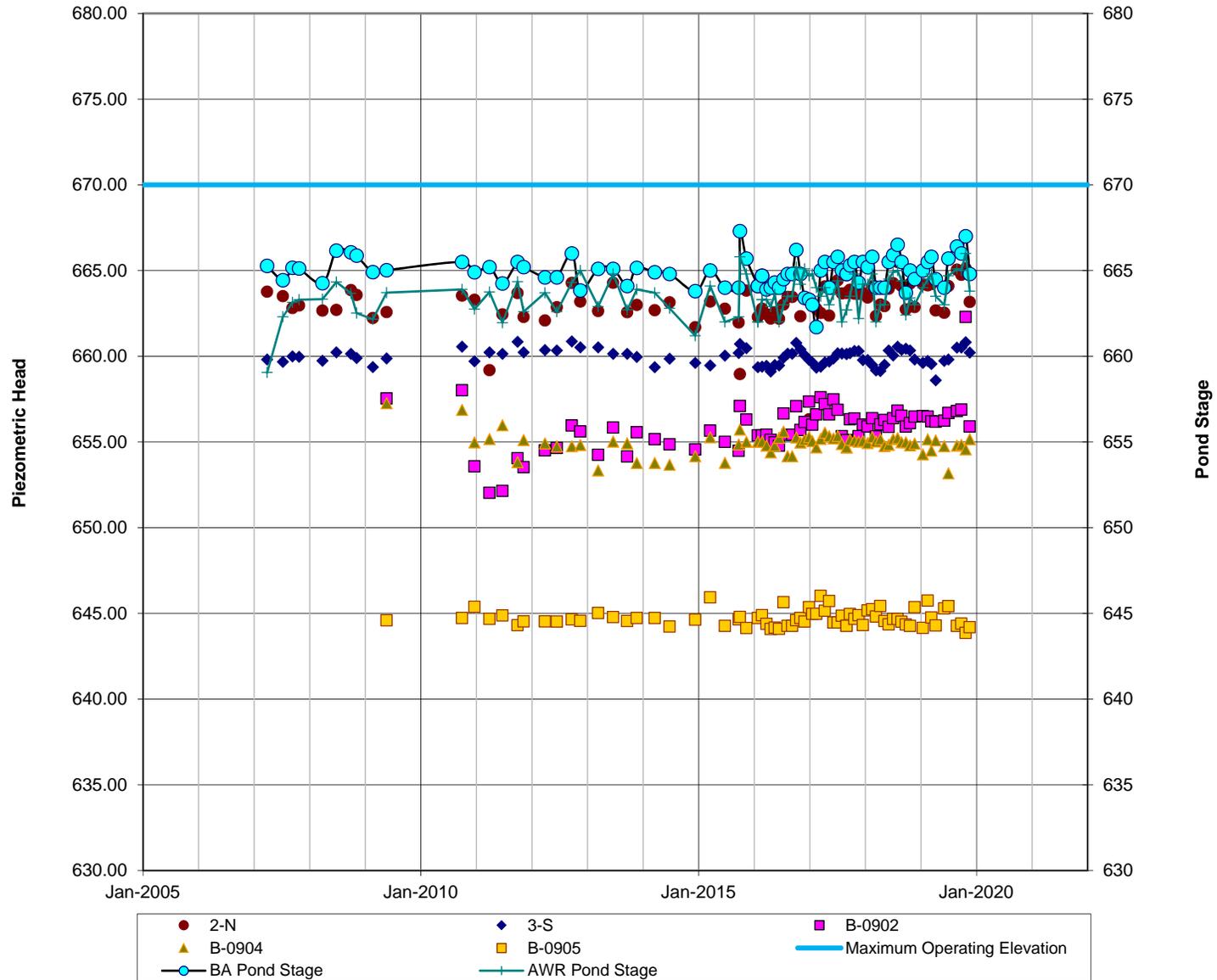
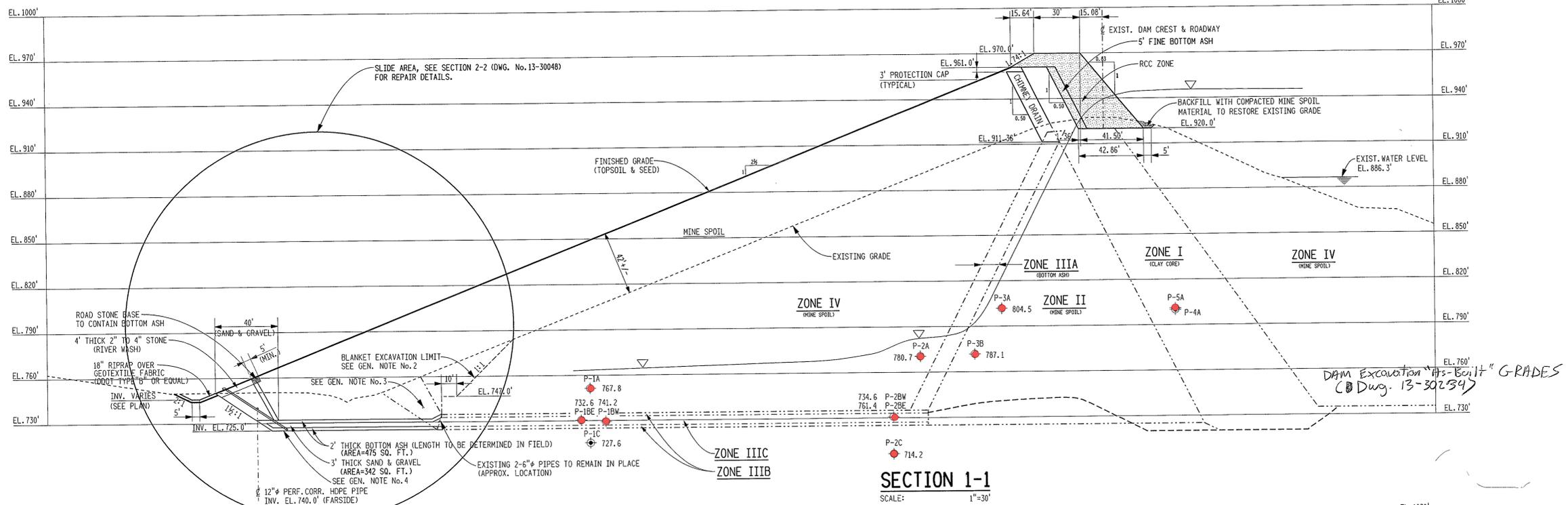


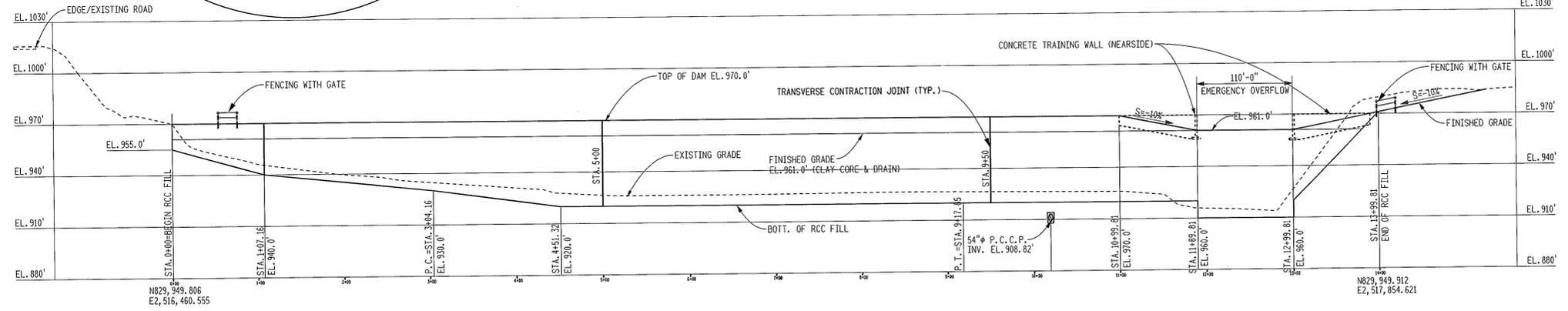
Figure 5p
 Bottom Ash Pond Complex
 Piezometers & Ponds Stages



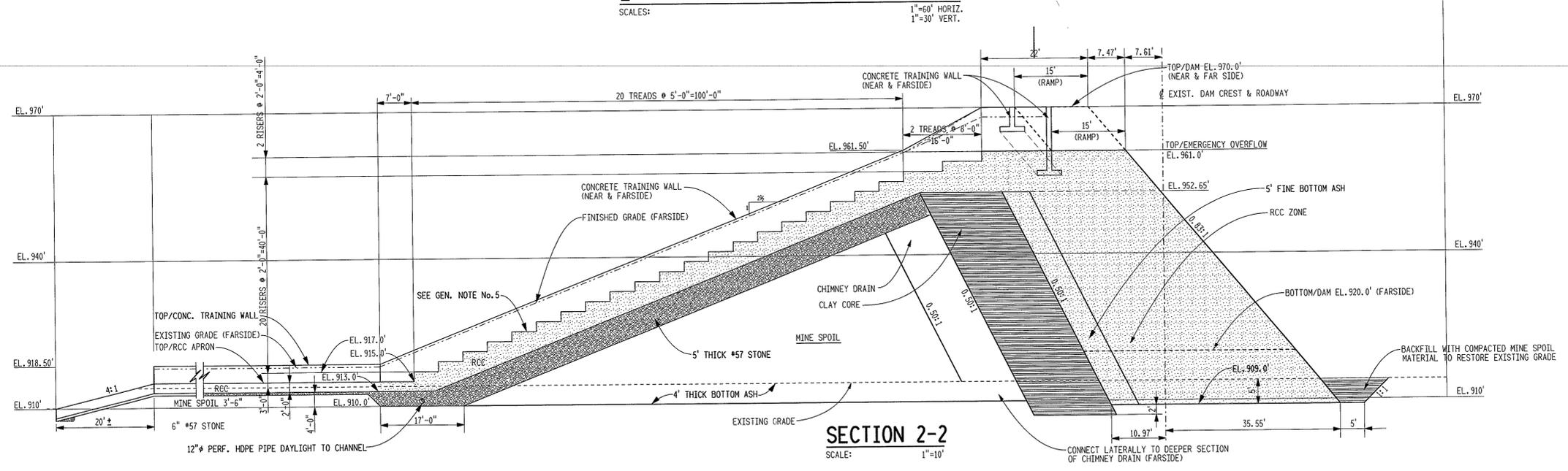
13-30041 ON 9MD



SECTION 1-1
SCALE: 1"=30'



PROFILE - EARTH FILL/RCC DAM
SCALE: 1"=60' HORIZ. 1"=30' VERT.



SECTION 2-2
SCALE: 1"=10'

GENERAL NOTES

- FOR SECTIONS LOCATION, SEE DWG. No. 13-30040.
- LIMIT WIDTH OF EXCAVATION SECTIONS ALONG THE TOE OF THE DAM TO 20 FEET. PROVIDE SOIL SUPPORT AS REQUIRED.
- REMOVE EXISTING 12" PIPE. STOCKPILE REMOVED SAND & GRAVEL MATERIAL AND RE-USE ONLY A CLEAN PORTION OF MATERIAL TO EXTEND DRAINAGE BLANKET.
- REMOVE SOIL OVERBURDEN & CLEAN THE SURFACE OF THE ROCK.
- SEAL JOINTS BETWEEN RCC AND TRAINING WALL WITH JOINT FILLER.

REFERENCE DRAWINGS

13-30040 - FLY ASH DAM II RAISING GRADING & DRAINAGE PLAN.

NO.	DESCRIPTION	APPROV.
6	REVISED TO SHOW INSTALLATION DEPTH OF PNEUMATIC PIEZOMETER, AND DAM "AS-BUILT" EXCAVATION GRADES.	
5	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE.	
4	AS-BUILT: REVISED TOE AREA OF SECTION 2-2.	
3	EXTENDED CONC. TRAINING WALL REMOVED HIGHER & LOWER RCC STRENGTH FACING & ZONE. ADDED GEN. NOTE NO. 5. 2' DIM ON SECT. 2-2 WAS 5'.	
2	REV. SECT. 2-2, INDICATED RCC APRON & BOTTOM ASH BLANKET DRAIN THICKNESS.	
1	REV. SECT. 1-1, SECT. 2-2 & PROFILE.	
0	ISSUED FOR CONSTRUCTION.	

DATE: 08/21/13
DESCRIPTION: DAM RAISING
APPROV.: [Signature]

CARDINAL OPERATING COMPANY
CARDINAL PLANT
BRILLIANT OHIO

FLY ASH DAM II RAISING PROFILE & SECTIONS

DWG. NO. **13-30041-6**
SCALE: AS NOTED
DIV: **CIVIL ENGINEERING DIVISION**

DESIGNED BY: [Signature]
CHECKED BY: [Signature]
DRAWN BY: [Signature]
DATE: [Signature]

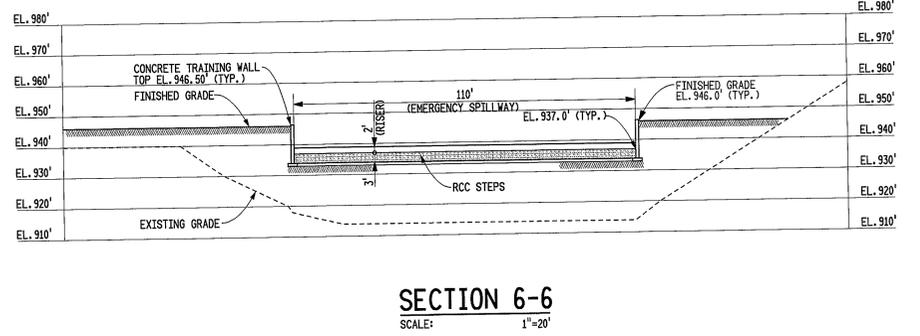
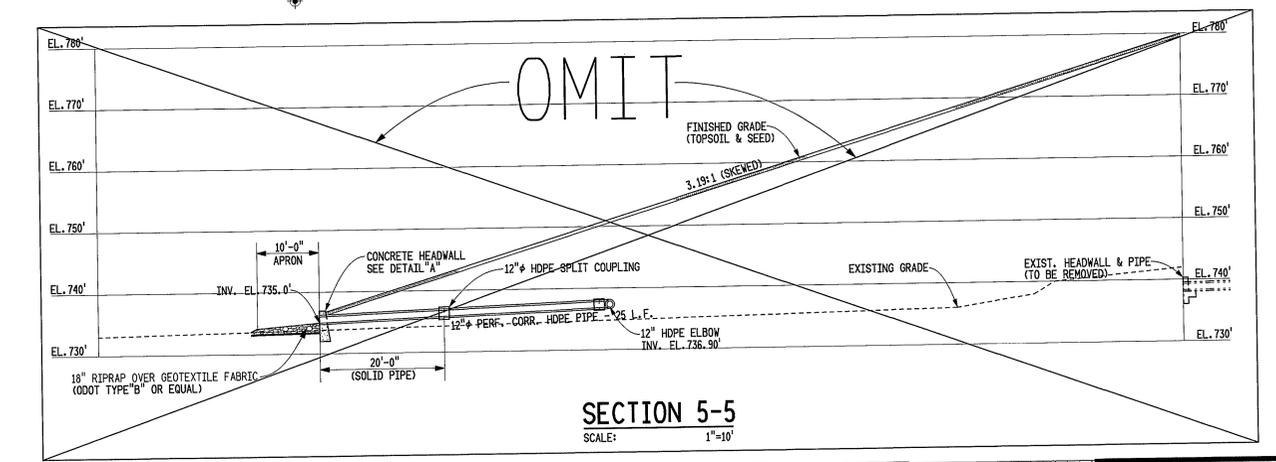
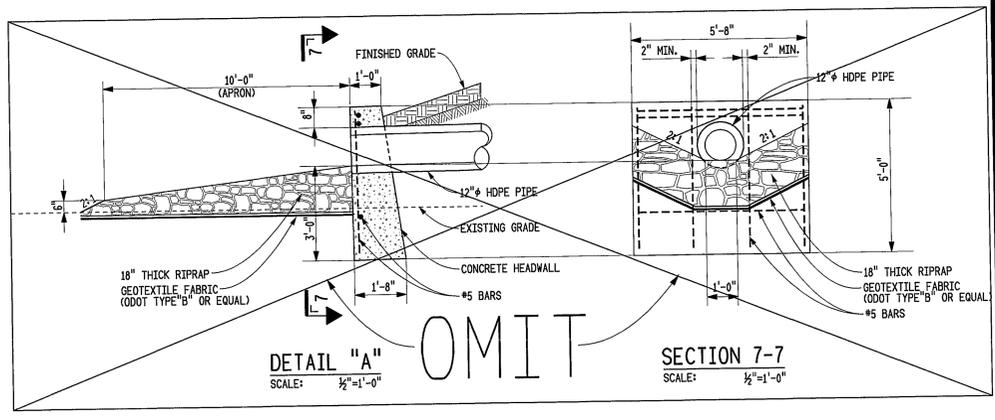
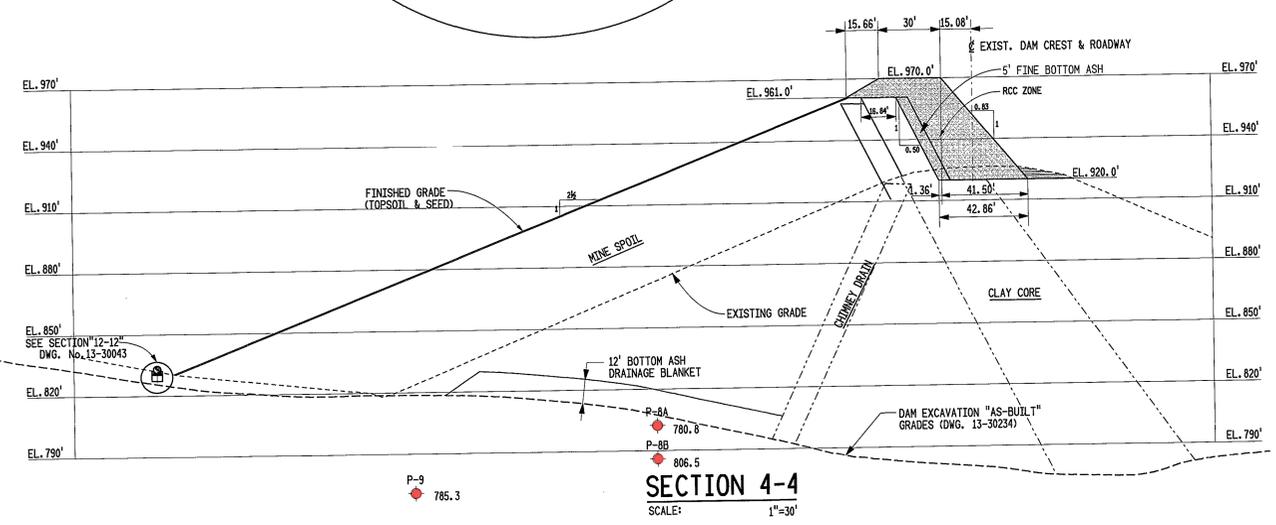
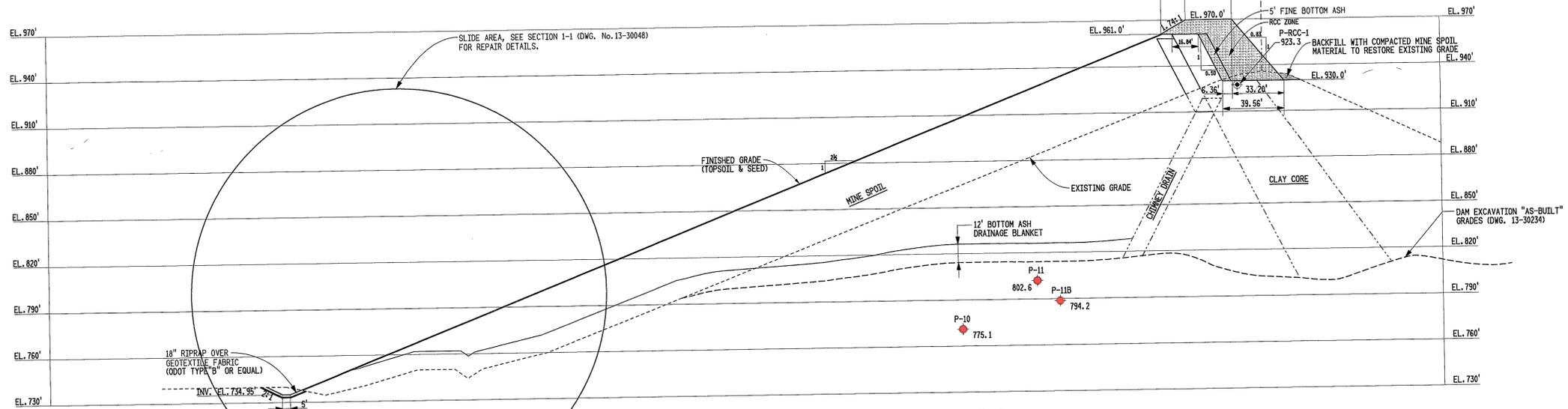
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

FIGURE 6A

PTS No. 55689

GENERAL NOTES

1.- FOR SECTIONS LOCATION, SEE DWG. No.13-30040.



REFERENCE DRAWINGS

13-30040 - FLY ASH DAM II RAISING GRADING & DRAINAGE PLAN.

NO.	DATE	DESCRIPTION	APP'D.
4		REVISED TO SHOW INSTALLATION DEPTH OF PNEUMATIC PIEZOMETER, AND DAM "AS-BUILT" EXCAVATION GRADES.	
3	3/30/00	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE.	AKC
2	4/22/99	REMOVED HIGHER & LOWER RCC FACING & ZONE.	JAG
1	1/15/99	REV. SECTS. "3-3" & "4-4". OMITTED SECT. "5-5", "7-7" AND DETAIL "A".	JAG
0	4/29/97	ISSUED FOR CONSTRUCTION.	JAG

REVISIONS
s:/cd/13/geo_hydro_site/30042.dgn
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CARDINAL OPERATING COMPANY
CARDINAL PLANT
BRILLIANT OHIO

FLY ASH DAM II RAISING SECTIONS & DETAILS SHT. 1

DWG. NO. 13-30042-4

CIVIL ENGINEERING DIVISION

APPROVED BY: [Signature]

1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

FIGURE 6B

PTS No. 55689

Appendix F : Seepage Collection Drains

Cardinal Fly Ash Dam II - Drains and Seepage Zones

Date of Inspection: 11/22/2019

Drain Number & Location	Drain Source	Outlet Size	Amount (GPM)	Clarity
1. D/S Open Weir	Chimney / toe drain system	12" Dia.	23gpm	Clear
2. D/S Right Abutment	Right abutment valley	12" Dia.	127.5gpm	Clear
3. D/S Right Abutment	Slag Buttress / right abutment	12" Dia.	<1 gpm	Clear
4. D/S Right Abutment	Slag Buttress / Trench in Center	12" Dia.	<1 gpm	Clear
5. Stilling Basin / Right Side	West side of stilling basin	6" dia.	0	Clear
6. Stilling Basin / Left Side	East side of stilling basin	6" dia.	7.5	Clear
7. Right Groin Ditch	West Bedrock abutment 900' elevation	12" Dia.	30gpm	Clear
8. Left Groin Ditch	East Tributary valley abutment 905"elevation	6" dia.	6gpm	Clear
9. Left D/S E/W	Emergency Spillway drainage blanket	12" Dia.	<1 gpm	Clear
10. Left D/S E/W	E/S Left training wall	6" dia.	<1 gpm	Clear
11. E/S 300' D/S Left	E/S Channel left 900" elevation	Seep Zone	3gpm	Clear
12. E/S Outlet Channel	Total Seepage within Emergency Spillway	10: Dia.	16.7gpm	Clear
13. Right Abutment Hillside	Right Abutment Hillside near 920' elevation	Two - 6" dia.	<1 gpm	Clear
14. D/S Channel / Parshall flume	Total Flow (spillway / seepage combination)	Open Channel	9.9MGD	Clear
15. Right Hillside Jules Verne Weir-3	Right Hillside Jules Verne near 770' elevation	V-noch	75gpm	Clear
16. Right Groin Pipe-2	Right groin 6" pipe 930' elevation	6" dia.	0.25gpm	Clear
17 <i>Weir Below Piezometer Building</i>	<i>Seepage from right groin hillside</i>	<i>V-Notch</i>	<i><0.3 gpm</i>	<i>Clear</i>

- EXCAVATE ROCK SURFACE TO ACHIEVE A RIGHT ANGLE CONTACT WITH THE RCC.
- THE SOIL OVERBURDEN ON BOTH THE RIGHT & LEFT ABUTMENTS SHALL BE STRIPPED. A 2' BOTTOM ASH DRAINAGE BLANKET SHALL BE PROVIDED OVER THE ENTIRE STRIPPED AREA. ANY SEEPAGE ZONES FOUND DURING STRIPPING SHALL BE DRAINED AS NECESSARY BY A FRENCH DRAIN DAYLIGHTING INTO GROIN DITCH.
- ADJUST LOCATION OF GROIN DITCH AS REQUIRED TO CLEAR PIPE SUPPORTS.

- LEGEND - EXISTING**
- SPOT ELEVATION
 - INTERMEDIATE CONTOUR
 - INDEX CONTOUR
 - DEPRESSION CONTOUR
 - TREES AND TREELINE
 - STRUCTURE AND BUILDING
 - FENCE
 - POLE
 - ROADS
 - EDGE OF WATER
 - MANHOLES / CATCH BASIN
 - POWER POLE
 - PIPES
 - TOWER
- LEGEND - PROPOSED**
- FIN. GRADE SPOT ELEV.
 - FIN. GRADE CONTOUR
 - DRAINAGE DITCH
 - INCLINED BORE HOLES
 - VERTICAL BORE HOLES
 - PIEZOMETER

- REFERENCE DRAWINGS**
- 13-30041 - FLY ASH DAM II RAISING PROFILE & SECTION.
 - 13-30042 - FLY ASH DAM II RAISING SECTIONS & DETAILS SHT. 1.
 - 13-30043 - FLY ASH DAM II RAISING SECTIONS & DETAILS SHT. 2.

- REVISIONS**
- | NO. | DATE | DESCRIPTION | APP'D. |
|-----|---------|---|--------|
| 5 | 8/23/09 | REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE. | JAF |
| 4 | 8/20/09 | AS-BUILT: REVISED TOPO, DRAIN PIPES, ADDED TABLES, PIEZOMETERS AND OPEN BORE HOLES. REMOVED MONITORING WELLS 4, 3, 20 & 25. | JAF |
| 3 | 8/22/09 | REMOVED INTERMEDIATE CONTOURS. INDICATED CONCRETE TRAINING WALL & GEOTEXTILE FABRIC. | JAF |
| 2 | 8/20/09 | DELETED DROP MANHOLE & REV. PIPE ALIGNMENT. | JAF |
| 1 | 8/23/09 | REV. TOE OF DAM TO REFLECT SLIDE REPAIR. RELOCATED DROP MANHOLE & REV. PIPE BEND, 6" 30" WAS 6" ADDED UNDERDRAIN SYSTEM. | JAF |
| 0 | 8/29/07 | ISSUED FOR CONSTRUCTION. | JAF |

MONITORING WELLS

WELL ID	NORTH	EAST	TIP ELEV.
MW-ID	830,048.740	2,518,081.850	654.5
MW-15	830,048.780	2,518,081.530	806.1
MW-5	830,072.415	2,516,465.055	782.2
MW-6	830,072.415	2,516,465.990	915.6

PIEZOMETER No.

PIEZOMETER No.	NORTH	EAST	TIP ELEV.
P8B	829,800.385	2,517,198.101	776.0
P8A	829,800.185	2,517,191.730	802.1
P2B nested	829,893.405	2,517,001.135	730.0
P2C nested	829,893.405	2,517,001.135	711.0
P3B nested	829,965.095	2,516,994.335	772.3
P3A nested	829,965.095	2,516,994.335	802.3
P3C	829,947.865	2,516,994.545	772.3
P2BW	829,892.685	2,516,941.390	731.1
P2A	829,910.895	2,516,891.870	771.0
P11	829,874.275	2,516,805.610	802.6
P11B	829,887.670	2,516,773.430	789.1
P10	829,815.120	2,516,776.440	769.1
P9	829,757.800	2,517,221.000	771.2
P1BE	829,687.855	2,516,999.390	728.0
P1A	829,692.810	2,516,965.335	752.3
P1C	829,692.810	2,516,965.335	714.4
PSBR-Orig	829,851.135	2,517,269.030	725.0
PSBR-sl. doyleite	829,705.160	2,517,222.820	CONNECTOR EL. 807.0
P1BW	829,701.310	2,516,925.760	735.9
PRCC3	830,018.940	2,517,445.700	913.3
PRCC2	830,034.680	2,517,185.460	913.4
PRCC1	830,008.870	2,516,785.950	923.3
P4A	830,076.650	2,517,007.900	801.7
PSA	830,079.170	2,517,013.940	774.7

OPEN BOREHOLES

OB-#	NORTH	EAST	GR. ELEV.	BOTT. ELEV.
OB-1	829,963.475	2,516,484.110	970.205	920.000
OB-2	829,976.090	2,516,583.770	970.015	920.000
OB-3	829,988.100	2,516,583.385	969.950	920.000
OB-4	830,000.125	2,516,781.285	969.915	920.000
OB-5	830,009.680	2,516,880.480	969.890	920.000
OB-6	830,016.215	2,516,980.785	969.885	920.000
OB-7	830,013.285	2,517,080.595	969.865	920.000
OB-8	830,017.820	2,517,180.090	969.880	920.000
OB-9	830,013.940	2,517,279.295	969.935	920.000
OB-10	830,006.100	2,517,378.750	970.015	920.000
OB-11	829,998.135	2,517,478.140	961.965	910.000
OB-12	829,987.550	2,517,577.140	961.965	910.000
OB-13	829,979.315	2,517,676.690	961.240	910.000

NOTE: ALL OB. HOLES ARE INCLINED 15° FROM VERTICAL

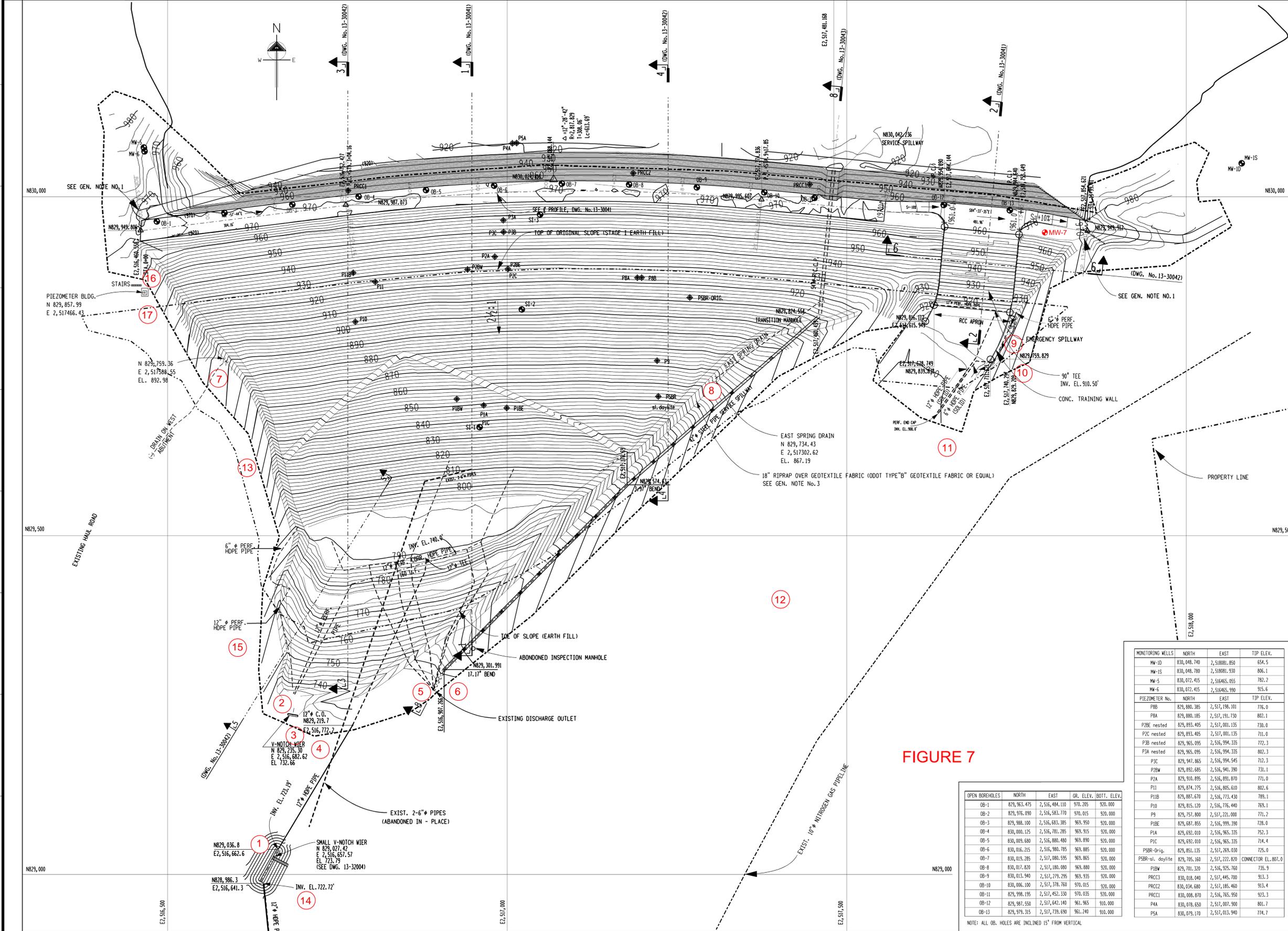


FIGURE 7

CARDINAL OPERATING COMPANY
CARDINAL PLANT
BRILLIANT OHIO

FLY ASH DAM II RAISING
GRADING & DRAINAGE PLAN

DWG. NO. 13-30040-5
SCALE: 1"=50'
CIVIL ENGINEERING DIVISION
APPROVED BY: H. Joseph Buhac

AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

PTS No. 55689