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2018 Annual Dam and Dike Inspection Report

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

CARDINAL OPERATING COMPANY

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

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Prepared for:

Cardinal Operating Company
306 County Road 7E
Brilliant, Ohio 43913

Prepared by:

AECOM
Vik Gautam
T: 216-622-2447
E: Vik.Gautam@aecom.com

AECOM
1300 East Ninth Street
Suite 500
Cleveland, OH 44114
aecom.com

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1. Introduction

This report was prepared by AECOM Technical Services, Inc. ("AECOM"), to fulfill requirements of 40 CFR 257.83 and 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.

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. The facility operates the Fly Ash Dam 1 (FAD 1), Fly Ash Dam 2 (FAD 2), and the Bottom Ash Pond (BAP) Complex dams,. AECOM was retained by Buckeye Power to complete the 2018 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 Maintentance Program (DIMP), but was assigned to AECOM starting in August 2018.

This report contains the inspection findings, observations, photographs, conclusions, and maintenance recommendations for these facilities. This inspection report addresses the FAD 1 (ODNR Dam No. 0205-009), FAD 2 (ODNR Dam No. 0205-010), and the BAP Complex Dam (ODNR Dam No. 0105-004).

Mr. Randy Sims, P.E., of Cardinal Operating Comapny, accompanied Mr. Vik Gautam, P.E. and Mr. Scott Mesi of AECOM during the inspection. The FAD 2 and BAP site inspection was performed on November 19, 2018 and the FAD 1 inspection was completed on December 4 2018. On the day of the FAD 2 and BAP inspections, weather conditions were rainy and cloudy for the full day (0.14-inches of rain were experienced in the area) and the temperature reached a high of 40 degrees. On the date of the FAD 1 inspection, it was cloudy during the day and the termperature reached a high of 35 degrees F. There were 1.06 inches of precipitation during the week prior to the November 20 inspection date, and 0.40 inches of precipitation during the week prior to the December 4 inspection date.

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 repermitted 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). There are stockpiles of earthen materials (to be used in future cell construction) over a portion of FAD 1. The materials are being used as a pre-load to increae the overburden stress on the underlying ash resulting in 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 peformed in 1997, and the most recent rasing 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.

Inspection location plans for FAD 2 are 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 seperated 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. Any requirements and/or orders of the Chief such as repairs, improvements, maintenance, investigations, studies, analyses, tests, or other remedial measures to the dam were inspected and reviewed as documented in Sections 4 and 5 of this report.

In addition to the ODNR requirements, the annual inspection must include 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 Buckeye Power and are documented in the facility operating record per § 257.105(g)(5).

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 2017 annual inspection of FAD 1, FAD 2, and the BAP was completed by American Electric Power (AEP) on November 8, 2017. Findings of that inspection included:

"For FAD 1, no significant erosion or slumping was observed, the downstream slope was well protected with rock fill, and the presence of vegetative growth on rocks was noticed. Some overgrown woody

vegetation was noticed a few feet away from the right and left groins. It was noted under the maintenance items the vegetation control on the outboard slopes should be kept under control by mowing or spraying.

For FAD 2, there were a number of observations including: The weathering of the 2-ft high Rollar Compacted Concrete (RCC) steps in the emergency spillway; Minor separation of the MSE wall in the southeast corner, and minor vegetation growth on the left groin ditch. It was recommend that vegetation control along the left and right groin areas of FAD 2 be kept under control by mowing and chemical spraying. Additionally, the historically observed seepage in the rock faces of the left and right abutments was recommended to be monitored on a weekly basis for changes in the rate or clarity of the seep.

For the BAP complex, the facility was found to be in good condition with no signs of structural weakness. A few erosion rills were noted to be forming at the crest of the east embankment downstream slope. There was also minor erosion noted on the interior of the dike at the corners. Minor seepage was noted along the downstream slope of the eastern dike. It was recommended that the erosion rills at the crest of the east embankment be repaired, and the seepage at the eastern dike slope be monitored on a weekly basis for changes in the rate or clarity of the seep.

Based on the review of the data there were no signs of actual or potential structural weakness or adverse conditions at the dams."

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:

Good:	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.
Fair/Satisfactory:	A condition or activity that generally meets what is minimally expected or anticipated based on design criteria and maintenance performed at the facility.
Poor:	A condition or activity that is generally below what is minimally expected or anticipated based on design criteria and maintenance performed at the facility.
Minor:	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.
Significant:	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.
Excessive:	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 2017 annual inspection. 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.

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, and toe.

Results of the visual inspection of FAD 1 performed on December 4, 2018 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. The downstream dam surface is sparsely vegetated (brushy vegetation), but is covered with rock fill material. 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 (Photograph No. 1 and 2).
3. No significant erosion was observed along the downstream slope of the dam. Some minor erosion gullies were observed, originating on the crest and running downslope. The gullies are formed by run-off from the crest and over the dam.
4. No sloughs, slumps, scarps, or other signs of slope instability were observed on the downstream slope.
5. No seeps were observed on the downstream slope.
6. No woody vegetation was observed on the downstream slope.
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. A surface water drain pipe discharges near the crest of the right abutment (Photograph No. 1). The flow line is protected with rip-rap, but this discharge point is not ideal.

Overall, the facility is in good condition. The impoundment in 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 2017 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 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**	**Date of Reading**
P-1A	Piezometer	Face of Dam, Zone IV	763.6	10/25/18
P-2A	Piezometer	Face of Dam, Zone IV	782.5	10/25/18
P-3A	Piezometer	Face of Dam, Zone II	804.8	10/20/17
P-3B	Piezometer	Face of Dam, Zone II	784.1	9/25/18
P-1BE	Piezometer	Face of Dam, Zone IIIC	731.2	12/15/17
P-1BW	Piezometer	Face of Dam, Zone IIIC	738.9	10/20/17
P-2BE	Piezometer	Face of Dam, Zone IIIC	762.3	9/25/18
P-2BW	Piezometer	Face of Dam, Zone IIIC	733.6	10/20/17
P-2C	Piezometer	Face of Dam, Zone IIIB	714.2	11/21/18
P-5A	Piezometer	Upstream Face of Dam, Zone I	902.8	9/25/18
P-8A	Piezometer	Face of Dam, Zone IV	805.1	10/25/18
P-8B	Piezometer	Face of Dam, Zone IV	779.9	11/21/18
P-9	Piezometer	Face of Dam, Zone IV	787.1	10/25/18
P-10	Piezometer	Face of Dam, Zone IV	777.2	10/25/18
P-11A	Piezometer	Face of Dam, Zone IV	804.4	9/25/18
P-11B	Piezometer	Face of Dam, Zone IV	798.8	9/25/18
MW-7	Monitoring Well	Top of Dam near left groin	968.6	2/9/18

*Locations shown in plain view in Figure 2A and profile view in Figures 7A and 7B 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. All piezometers showed a minor increase or no increase in piezometric head relative to the 2017 annual inspection measurements.

2. Water levels in the shallow, intermediate, and deep foundation were consistent with historical readings, showing little to no apprecaible change in piezometric head. Water levels in P-8A (shallow foundation piezometer) showed a minor decrease in piezometric head. P-8B (intermediate foundation piezometer), P-9 (deep foundation piezometer), P-10 (deep foundation piezometer), P-2A (downstream shell piezometer), and P-2BE (drain piezometer) showed minor increases. The remaining piezometers showed no appreaciable changes.
3. Water levels along the center of the dam are presented in Figure 5e, and are segregated into hydrographs, and are divided into hydrographs for each clustered piezometer site (Figures 5f through 5i). Water levels in the downstream shell (P-1A), the clay core (P-5A), and drain (P-1BW) showed a minor increase in piezometric head (Figure 5f and 5i).
4. Piezometer P-2C, installed within the foundations of the dam showed a minor increase in piezometric head (Figure 5k).
5. Piezometer P-2BE, installed within the drain, reflects a higher-pressure head (about 28.5 ft) in comparison to P-2BW. Most piezometers showed minor increase in piezometric head (Figures 5j, 5l and 5m).
6. Two standpipe type piezometers were installed in 2004 into the right bedrock abutment to monitor seepage (FA-7 & FA-8). Both of these piezometers are installed into the Morgantown Sandstone. Piezometer FA-7 also forms a clustered well site with M-11 (also screened within the Morgantown Sandstone) and S-9 (screened in the Connellsville Sandstone). M-10 is located away from the dam site but is also screened within the Morgantown Sandstone and is used to help illustrate the following trends (Figure 5n). Piezometers S-9, M-10, and M-11 have shown no appreciable trend since the previous annual insepction and the piezometric head has remained relatively constant. The measured piezometric head at these locations is within the range of historical readings.
7. Monitoring wells M-10 & M-11 showed a minor decrease in static water levels. Piezometer FA-7 monitors a 1 inch wide open joint (observed by a borehole camera survey prior to well installation) and reflects a steady decline, followed by a leveling off that closely correlates with the declines observed in the drain piezometer P-1BW, M-10 and M-11 (Figure 5n). Monitoring well S-9 showed a minor increase in static water levels.
8. 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.

In general, a review of the data contained on the FAD 2 static water elevation plots showed that all piezometers exhibit consistent water elevations.

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 205 gpm and as low as 60 gpm.

The most recent flow volumes are presented in tables in Appendix F, along with the locations of the seepage drains in Figure 8. Figure 5b presents historical pond discharge at the Parshall Flume (Drain No. 14) versus the pond stage. Discharge rates since the previous (2017) inspection have been within the

previously observed range. Note at the time of the inspection and seepage measurements it was raining which may correspond to higher flow rates.

Based on comparison of the 30-day inspection flow rate measurements at seepage collection drain Nos. 9, 10, 11, and 12 flows in the vicinity of the emergency spillway have increased; and Cardinal Operating Company staff, Randy Simms, P.E. also indicated that he has visually observed an increase in flow over the past year. During the annual inspection and the 30-day inspections the flows were not observed to be turbid or erosive but should continue to be monitored. The abutment showed no signs of instability or changes since the 2017 inspection; however it should continue to be monitored as part of the regular inspections.

VERTICAL AND HORIZONTAL DEFORMATION MONUMENTS

The most recent 28-day AECOM Deformation Review Report of Survey was prepared on November 20, 2018 for vertical and horizontal deformation monuments for FAD2. The deformation review survey reports were started in October 2015 by DLZ Industrial, LLC then starting in July 2018, the monthly Survey Report are now being 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, with between -0.8° to 0.6° of tilt recorded to date (Figure 5o).

Vertical and horizontal deformation measurements were 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) were made. 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). The 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.

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 no appreciable movement relative to the previous months' measurements or relative to the 2015 baseline. Inclinometer SI-1 showed displacements of approximately 0.25 inches relative to the baseline at a depth of 50 to 60 feet in all 2018 events. The displacements are not considered to be excessive and they are observed to start in the negative A-axis direction then revert to the positive A-axis direction then go back to 0. 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. This movement was detected in the previous events as well, but the displacement relative to the 2015 event has decreased on the A-axis during the September 2018 readings and showed no appreciable movement in the B-axis direction. SI-5 is located near monument 29951 which is showing signs of minor heave. The displacement measured in SI-5 may be associated with the soil movement measured in monument 29951. As there is no significant trend or increase in movement, no actions are considered necessary at this time.

Slope Inclinometer SI-8 is located in the uppermost northwest corner of the earthen dam. This inclinometer showed no appreciable movement during the September 2018 event, nor historically relative to the 2015 baseline.

BATHYMETRIC SURVEYS

AECOM's subcontractor Jack A. Hamilton & Associates, Inc. performed the most recent bathymetric survey in November and December, 2018. 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 968.04 feet above mean sea level (MSL).

The 2018 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. After review of the bathymetry, no depressions or unusual morphological features in the vicinity of the right abutment upstream of the dam are present. Based on interviews with Cardinal Operating Company personnel, this area was a low point in bottom of Pond however, now the ash delta is propagating into this area in a uniform manner and the depressions noted in previous surveys are no longer present. 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 2018 bathymetric survey results.

Survey Date	Ash Elev.	Thickness Increase	Comment
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

In March 2004, AEP and Cardinal Plant began sluicing near the right abutment, increasing fly ash deposition in the vicinity of the mapped depression near the FAD II right abutment. Subsequently, the increased fly ash deposition reversed the hydraulic gradient in the upper portion of the bedrock between the pond stage and S-9 and M-11 (see Figure 6 of Appendix E). The hydraulic gradient shown in Figure 6 represents the difference in pond stage and the static water level at MW-5 divided by the length of the flowpath. The flowpath distance incrementally increases as the elevation of the fly ash delta (previous depression) increases due to fly ash deposition.

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 December 2018. The basis for the measurements include: the available measured water surface elevations, the December 2018 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 968.04)	
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	14.96ft. (El. 968.04 ft. above MSL)
Approximate **Present** depth (Elevation) of impounded water since last annual inspection	14.96 ft. (El. 968.04 ft. above MSL)
Approximate **Minimum** depth (Elevation) of CCR since last annual inspection	17.98 ft. (El. 965.02 ft. above MSL)
Approximate **Maximum** depth (Elevation) of CCR since last annual inspection	68.76 ft. (El. 914.24 ft. above MSL)
Approximate **Present** depth (Elevation) of CCR since last annual inspection	68.76 ft. (El. 914.24 ft. above MSL)
Storage capacity of impounding structure at the time of the inspection	3,953.26 ac-ft
Approximate volume of impounded water at the time of the inspection	1,526.0 ac-ft.
Approximate volume of CCR at the time of the inspection	9,546.74 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 20, 2018 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 #6-8 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.). There are relatively small separations at both the southwest and northeast corners of at the juncture between the main longitudinal wall and the orthogonal return wall sections, primarily seen at the coping beams at the top of the walls (see Photograph 6). These separations have been observed in previous inspections and are routinely monitored. They do not appear to have any adverse effect on serviceability, and it is noted that relative movement at MSE wall corners are a relatively common occurrence.
2. The RCC crest surface (at El. 970) is mostly covered by the new MSE wall construction and only limited observations were possible. The downstream RCC appears to have experienced some weathering and is in fair condition. However, neither significant cracking nor any seepage was observed at the RCC. The visible portion of the upstream RCC appeared to be stable with no signs of erosion from wave action, slumping, cracking, or settlement (see photograph #7).
3. A gravel access roadway is supported at the top surface of the MSE Walls. Concrete jersey barriers are present on either side of the roadway. The roadway is in good condition, with only minor rutting present, and is easily accessible and traversable for small vehicle traffic. The access roadway is covered with a gravel road and appears to be in good condition with no signs of major rutting or settlement as shown in Photographs No. 1 and 2.

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 good condition, with no issues noted.
2. The plain concrete overflow section at the crest shows no signs of cracking or instability and is in good condition (Photograph No. 9).
3. The plain concrete stepped section is in good condition structurally, with only minor cracking noted (cracks are either hairline, or less than 1/8-inch). Some seepage was noted coming through cracks in the lowermost two plain concrete steps (Photograph No. 29).
4. The RCC step section is in fair to poor condition (Photograph No. 12). 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 of the steps is monitored by Buckeye Power 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 (Photograph No. 10). The seepage flows into an earthen ditch that runs along the floor of the exit channel, and is therefore relatively well controlled. Based on conversations with Buckeye Power personnel, the rate of this seepage has been increasing over the years. 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. 10).

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. 13). No significant signs erosion, sloughing or seepage were observed and the slopes appeared to be stable.
2. The upper portion of the face of dam showed signs of very minor creep movement (presenting as minor hummocky ground observed sparsely/intermittently over the face of the dam). There are no signs of significant slope movement, and the creep features may be due to the action of the mowing equipment and seasonal frost heave. Furthermore, the 28-day deformation survey does not show any significant horizontal or vertical movement trends.
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. The channels appear to be clean and well maintained, with only minor erosion as follows:
    a) Surface runoff has led to minor erosion downstream of the surface water collection channel centrally located on the face of the dam (see Photograph No. 27). After discussion with Cardinal Operating Company, a plan has been put into place to repair the channel. The erosion is minor and considered a routine maintenance issue.
4. At the time of the inspection an apparent wet spot was noted on the upper half of the downstream face of the dam between the center of the dam and the left abutment. The vegetation appeared brown in this area (Photograph No. 25) possibly due to seepage of water. However, there is no evidence of internal erosion or flowing seeps. During a follow up inspection by AECOM on December 17, 2018, the area appeared to be dry and the area was well vegetated. The wetness may be attributed to surface water during the rain event on the November 20th inspection. The FAD II is constructed with a fine bottom ash filter acting as a chimney drain to capture any seepage from the upstream face. Therefore seepage on the

downstream face of the dam is unlikely, however, to be prudent the area should continue to be monitored.

5. The downstream slope and buttress (lower berm) appeared to be in good condition with good vegetative growth (Photograph No. 15 and 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.

6. Minor erosion rills are present on the access road adjacent to the principal spillway pipe at the left side of the dam. Cardinal Operating Company has been made aware and is planning the repair/maintenance of the road.

D. Dam Abutments:

1. The right downstream groin ditch was in good condition (Photographs No. 17 and 18). The rip rap is a hard limestone and showed minor weathering or deterioration. The discharges from several seepage drains were clear and no sediment deposits were observed in the pooling area. The groin appeared to be generally in good condition (Photograph No. 17).

2. The left groin ditches and discharge pipe were observed to be in good condition. The vegetation was cut back to the left of the pipeline allowing excellent visual observation of the abutment. No significant uncontrolled seepage along this portion of the abutment or as the discharge pipe enters into the ground prior to its connection to the energy dissipater structure was observed. No significant erosion, slumping or bulges were observed. Minor vegetation growth within the groin ditch needs to be eliminated by frequent cutting or by using spray chemicals (Photograph No. 20).

E. Hydraulic Structures:

1. The discharge structure 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. 3 – 5. There was no visual evidence of significant differential movement of the structure/skimmer chute or steps. The discharge structure's concrete, diagonal joint and steps appeared to be in good condition. The diagonal crack in the underlying RCC is no longer visible due to weathering. The overlying diagonal construction joint in the skimmer chute was caulked and sealed prior to the inspection.

2. The principal spillway access walkway, stairways, depth gauge, and other metal structures were in good condition (Photograph No. 4 and 5).

3. The energy dissipater structure and downstream channel appeared to be in good condition, with no signs of distress, obstructions to operation, or other issues noted (Photograph No. 21). The exit channel downstream of the energy dissipater appeared to be in good condition.

4. The dam's concrete flume (identified as Drain 14 (NPDES Permit Outfall # 019)) was observed to be in good condition and flow was unobstructed (Photograph No. 22).

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

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 2017 annual inspection. The geometry of the impoundment has remained essentially unchanged.

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. 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. 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**	**Date of Reading**
2-N	Piezometer	665.49	8/1/18
3-S	Piezometer	660.56	8/1/18
B-0902	Piezometer	656.82	8/1/18
B-0904	Piezometer	655.28	2/12/18
B-0905	Piezometer	645.43	4/10/18

The piezometers are measured on monthly basis and showed a minor increase or no increase in piezometric head relative to the 2017 annual inspection measurements (shown in Appendix E Figure 5p). Piezometric head in piezometer 2-N mirrored the trends in the elevation of the pond stage. Elevation changes for piezometers B-0902, B-0904, and B-0905 appear to be connected, as they all follow similar trends, and are located on the same road. Changes in piezometric head for piezometer 3-S did not follow patterns shown for other piezometers, and was closer in elevation to the Bottom Ash Pond than the other piezometers. In general, a review of the data contained on the BAP static water elevation plot showed

that all piezometers exhibit consistent water elevations, 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 20, 2018 are provided below (photos are presented in Appendix C):

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. See photograph 1 and 2 of Appendix C.
2. Flowing water was (and has previously been) observed at the toe of the west embankment. 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 appears to collect surface run-off coming from

the west dike, as well as some run-off coming from the railroad tracks located to the west 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. See Photograph 2.

Based on discussions with Buckeye personnel and previous observations made by AECOM, some flowing water is continually observed in the ditch, even on dry days, suggesting that some part of the flow may be seepage. Light rain was falling throughout the day of the inspection, so it was not possible to differentiate seepage from surface run-off. However, no obvious wetted faces, erosional features, or flowing seeps were apparent on the west dike slopes, even though they are un-vegetated and have a surface of relatively coarse-grained material. If seepage contributes to flow in the ditch, the seepage does not appear to be adversely affecting the dike slopes or function of the pond, so no actions other than continued monitoring are considered necessary at this time.

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. 11 and 13.

4. The outlet structure from the BAP to the RCP was unobstructed and generally in good condition. The metal walkway is showing some signs of rust/weathering and is in good to fair condition. See Photograph No. 11 and 18.

5. The western and southern sides of the RCP are incised slopes cut into natural ground. The slopes show no signs of instability, but numerous erosion gullies are intermittently present throughout the length of these slopes. Run-off flows from the flat area to the south of the pond appear to have created these gullies. While most are small, there are a few locations where the erosion has become more severe and should be corrected as part of regular pond maintenance. See Photograph 24. Since the pond is incised in this location, the erosion gullies do not pose any significant risk to operations.

6. The outlet structure and discharge pipe from the RCP were unobstructed and in good condition. See Photograph 6 and 19.

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. 5, 7, 8, and 9. The slopes are in good condition, with no signs of instability.

8. Two apparent seep areas were observed on the face of the eastern dike slope (see Photographs 21 and 22). No flowing seepage is present, but the areas are wet and the vegetation is discolored. These locations are known to Buckeye personnel and are routinely monitored.

9. Some small/medium sized trees are present at the toe of the slope along the Ohio River (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.

10. 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 23 for a

typical rill. 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 in 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 the flow is completely contained.

Fly Ash Dam 2

1. All Owner repairs and remedial measures that were able to be completed since the November 29, 2017 ODNR Dam Safety inspection have been made and are well maintained. It was noted that ODNR requested "Remove trees and brush from the upstream slope. Seed all disturbed areas to establish a proper grass cover." The Cardinal Operating Company has completed these repairs as shown in Appendix B Photograph No. 26. The vegetation shall be mowed as part of normal operations and maintenance in 2019.
2. Repair minor erosion rills on the Access Road adjacent to the principal spillway pipe.
3. Build up the downstream edge of the drainage channel on the face of the dam to contain stormwater to the center of the channel.
4. 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.

Bottom Ash Pond Complex

1. Erosion rills along the western and southern slopes of the RCP, and along the eastern dike crest and slope of the BAP and RCP should be repaired.
2. The SW corner of the Recirculation Pond shows signs of wave erosion as shown in Photo No. 14 of Appendix C. Although the erosion has not caused any instability and the dike remains in satisfactory condition, should the condition worsen during the regular inspections rip rap armoring in this location may be required to prevent further erosion.

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 new 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 upper half of the downstream face of the dam between the center of the dam and the left abutment for seepage or wetness.
4. Continue to monitor the seepage areas observed on the right downstream abutment near the piezometer building for any signs of increased flow, muddy flow, or instability.
5. If the reservoir's operating level is increased by adding stoplogs, piezometers and seepage points should be monitored before and after to document changes that may correlate with the increased pool elevation.

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

AECOM

PHOTOGRAPH LOG

Impoundment Name:	Site Location:	Project No.
Cardinal Fly Ash Dam 1	306 County Road 7 East, Brilliant, OH, 43913	60583548

Photo No.	Date:
1	12/4/18

Direction Photo Taken:
East

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.	Date:
2	12/4/18

Direction Photo Taken:
West

Description:
View of the downstream slope of the FAR 1 dam.

AECOM

PHOTOGRAPH LOG

Impoundment Name:	Site Location:	Project No.
Cardinal Fly Ash Dam 1	306 County Road 7 East, Brilliant, OH, 43913	60583548

Photo No.	Date:
3	12/4/18

Direction Photo Taken:
North

Description:
View of rip rap let down at the left groin area looking upslope.

Photo No.	Date:
4	12/4/18

Direction Photo Taken:
South

Description:
Typical view of the right groin area of the FAR 1 dam.

AECOM

PHOTOGRAPH LOG

Impoundment Name:	Site Location:	Project No.
Cardinal Fly Ash Dam 1	306 County Road 7 East, Brilliant, OH, 43913	60583548

Photo No.	Date:
5	12/4/18

Direction Photo Taken:
West

Description:
View of the ash discharge pipes along the crest of the FAR 1 dam.

Photo No.	Date:
6	12/4/18

Direction Photo Taken:
West

Description:
View of downstream slope of FAD I.

Appendix B : Photographs – Fly Ash Dam 2

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
1	11/20/18

Direction Photo Taken:

East

Description:
View of the access road along the crest of dam looking east. The dam crest appeared in good condition with no signs of settlement, misalignment, rutting, or erosion.

Photo No.	Date:
2	11/20/18

Direction Photo Taken:

East

Description:
View of the crest area looking east. The dam crest appeared in good condition with no signs of settlement, misalignment, rutting, or erosion.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
3	11/20/18

Direction Photo Taken:

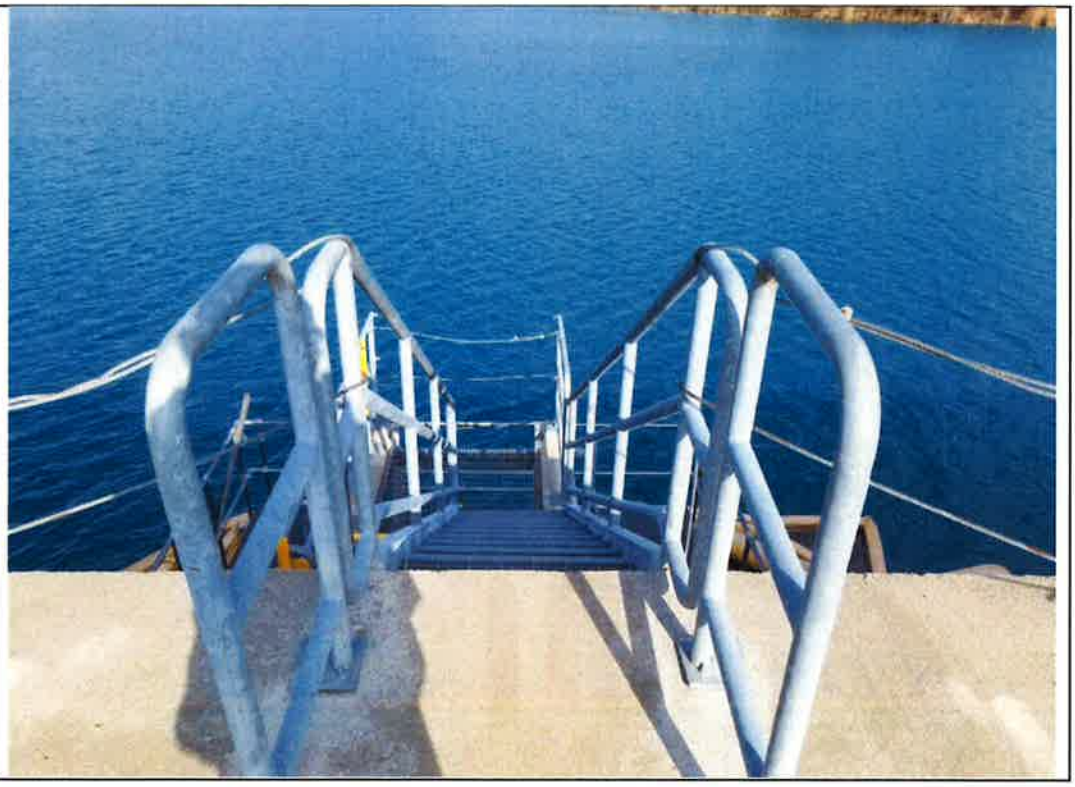
N/A

Description:
View of the unobstructed stoplog primary spillway. Note metal bar grating is in good condition

Photo No.	Date:
4	12/18/18

Direction Photo Taken:

Description:
View of the access stairway leading to the decant structure.



AECOM

PHOTOGRAPH LOG

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

Photo No. 5	Date: 12/18/18

Direction Photo Taken:

Description:
View of the staff gauge on the principal spillway.

Photo No. 6	Date: 11/20/18

Direction Photo Taken:

East

Description:
View of the dow nstream corner of the MSE Wall w here the w all panel meets concrete coping. Note the separation at the corner piece.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
7	11/20/18

Direction Photo Taken:

East

Description:
View of the upstream MSE wall.

Photo No.	Date:
8	11/20/18

Direction Photo Taken:

North

Description:
View of the MSE wall and emergency spillway.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
9	12/18/18

Direction Photo Taken:

Description:
View of the Emergency Spillway crest area.

Photo No.	Date:
10	11/20/18

Direction Photo Taken:

South

Description:
View of the emergency discharge channel. Vegetation is well maintained and the spillway is clear of obstructions.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
11	11/20/18

Direction Photo Taken:

South

Description:
View of the emergency discharge channel.

Photo No.	Date:
12	11/20/18

Direction Photo Taken:

North

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.

AECOM

PHOTOGRAPH LOG

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

Photo No. 13	Date: 11/20/18

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: 11/20/18

Direction Photo Taken:

South

Description:
View of the downstream slope and stormwater collection channel.

AECOM

PHOTOGRAPH LOG

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

Photo No. 15	Date: 11/20/18

Direction Photo Taken:

Northeast

Description:
View of the downstream slope lower berm.

Photo No. 16	Date: 11/20/18

Direction Photo Taken:

South

Description:
View of the downstream slope lower berm bench area.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
17	11/20/18

Direction Photo Taken:

North

Description:
View of right groin ditch.

Photo No.	Date:
18	11/20/18

Direction Photo Taken:

Southeast

Description:
View of right groin ditch and seepage drain.

AECOM

PHOTOGRAPH LOG

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

Photo No. 19	Date: 11/20/18

Direction Photo Taken:

South

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. The seepage has increased at this location but, is still clear.

Photo No. 20	Date: 11/20/18

Direction Photo Taken:

Northeast

Description:
View of the left groin ditch.

AECOM

PHOTOGRAPH LOG

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

Photo No. 21	Date: 11/20/18

Direction Photo Taken:

East

Description:
View of the energy dissipater structure.

Photo No. 22	Date: 11/20/18

Direction Photo Taken:

East

Description:
View of the permit outfall for the main service spillway.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
23	11/20/18

Direction Photo Taken:

East

Description:

View of the permit outfall (parshall flume dow nstream of energy dissipater) for the main service spillw ay.

Photo No.	Date:
24	11/20/18

Direction Photo Taken:

West

Description:

View of the face of dam and dow nstream slope of the MSE w all.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
25	11/20/18

Direction Photo Taken:

Northeast

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.

The vegetation initially appeared to have died in this area. However after a follow up inspection on 12-17-2018, the area was dry and the vegetation is not dead.

Photo No.	Date:
26	12/18/18

Direction Photo Taken:

South

Description:

View of upstream side of the right abutment recently cleared of vegetation and seeded.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
27	11/20/18

Direction Photo Taken:

North

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.	Date:
28	12/18/18

Direction Photo Taken:

South

Description:

Installation of v-notch weir for new seepage drain and seepage zone #17 on the right abutment.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
29	12/18/18

Direction Photo Taken:

North

Description:

View of the lowest stair of concrete portion of the Emergency Spillway after the newest raising. The concrete stair was damp indicating possible seepage through the water stops.

Appendix C : Photographs – Bottom Ash Complex

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
1	11/20/18

Direction Photo Taken:

South

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.	Date:
2	11/20/18

Direction Photo Taken:

Northeast

Description:
View of the exterior slope and ash sluice lines.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
3	11/20/18

Direction Photo Taken:

North

Description:
View of the exterior slope along the toe of the embankment.

Note surface water shown in photos 1 and 2 drain to this location.

Photo No.	Date:
4	11/20/18

Direction Photo Taken:

East

Description:
View of the inverted filter drain extended through this area in late 2009 to control seepage from the pond.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
5	11/20/18

Direction Photo Taken:

North

Description:
View of the rip rap armoring along the embankment.

Photo No.	Date:
6	11/20/18

Direction Photo Taken:

East

Description:
View of the downstream outlet of the RCP discharge pipe.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
7	11/20/18

Direction Photo Taken:

North

Description:
View of the embankment along the Ohio River.

Photo No.	Date:
8	11/20/18

Direction Photo Taken:

South

Description:
View of the exterior slope along the Ohio River and access stairs to the monitoring well.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
9	11/20/18

Direction Photo Taken:

South

Description:
View of the exterior east embankment slope along the Ohio River.

Photo No.	Date:
10	11/20/18

Direction Photo Taken:

South

Description:
View of the crest area of the exterior slope along the Ohio River.

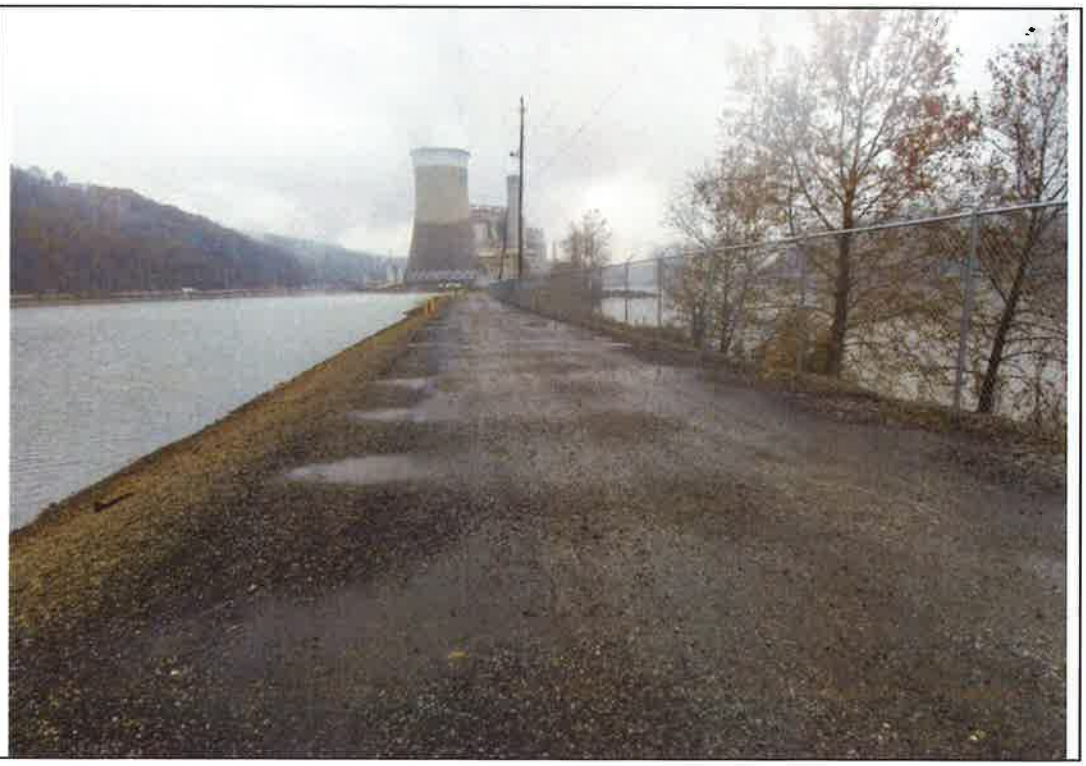
AECOM

PHOTOGRAPH LOG

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

Photo No. 11	Date: 11/20/18
Direction Photo Taken: East	
Description: View of the splitter dike between the Bottom Ash Pond (BAP) and Recirculation Pond (RCP).	

Photo No. 12	Date: 11/20/18
Direction Photo Taken: North	
Description: View of the crest area along the east dike of the Recirculation Pond.	



AECOM

PHOTOGRAPH LOG

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

Photo No. 13	Date: 11/20/18

Direction Photo Taken:

West

Description:
View of the splitter dike between the bottom ash pond and the Recirculation Pond.

Photo No. 14	Date: 11/20/18

Direction Photo Taken:

West

Description:
View of the interior slope of the SW corner of the Bottom Ash Pond.

Note minor wave erosion.

AECOM

PHOTOGRAPH LOG

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

Photo No. 15	Date: 11/20/18

Direction Photo Taken:

West

Description:
View of the interior slope of the Bottom Ash Pond.

Photo No. 16	Date: 11/20/18

Direction Photo Taken:

Northwest

Description:
View of the interior east dike and Access Road of the Recirculation Pond.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
17	11/20/18

Direction Photo Taken:

West

Description:
View of the pump house at the RCP.

Photo No.	Date:
18	11/20/18

Direction Photo Taken:

West

Description:
View of the BAP discharge structure.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
19	11/20/18

Direction Photo Taken:

N/A

Description:
View of the RCP overflow structure.

Photo No.	Date:
20	11/20/18

Direction Photo Taken:

West

Description:
View of the bottom ash pond discharge pipes.

AECOM

PHOTOGRAPH LOG

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

Photo No.	Date:
21	11/20/18

Direction Photo Taken:

North

Description:
View of seepage on the face of the eastern dike slope.

Photo No.	Date:
22	11/20/18

Direction Photo Taken:

N/A

Description:
View of seepage on the face of the eastern dike slope.

AECOM

PHOTOGRAPH LOG

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

Photo No. 23	Date: 11/20/18

Direction Photo Taken:

N/A

Description:
View of erosion rills from runoff from the access road along the east dike of the Recirculation Pond.

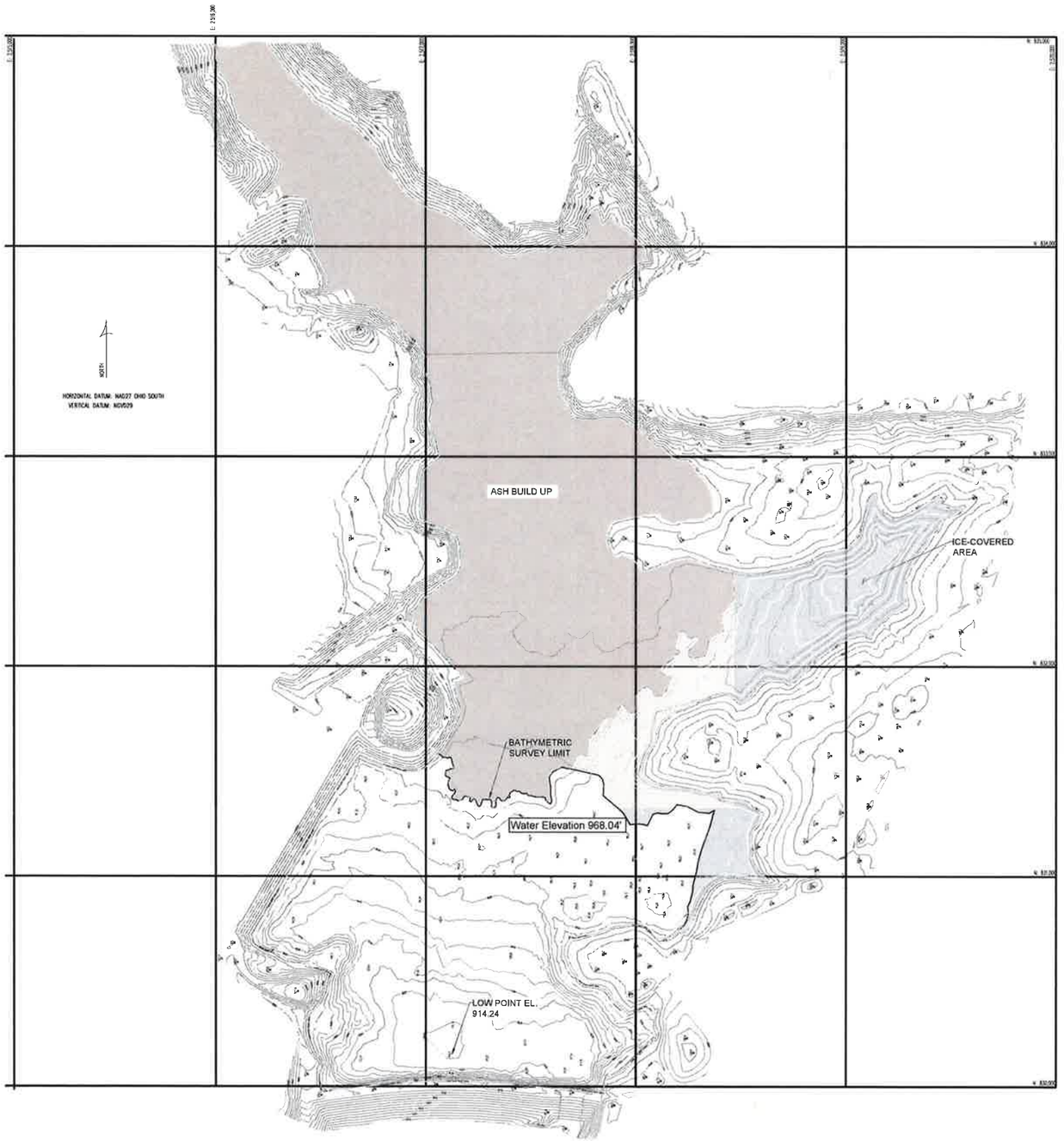
Photo No. 24	Date: 11/20/18

Direction Photo Taken:

East

Description:
View of erosion rills from runoff from the access road along the east dike of the Recirculation Pond.

Appendix D : Bathymetric Surveys



LEGEND

- BATHYMETRIC SURVEY LIMIT
- EXISTING EDGE OF WATER
- EXISTING LIMITS OF FLYASH
- EXISTING LIMITS OF ICE COVERAGE
- EXISTING SUBSURFACE SPOT ELEVATION
- 980 EXISTING SURFACE CONTOUR (INDEX)
- EXISTING SURFACE CONTOUR (INTERMEDIATE)
- 997.0 EXISTING SURFACE SPOT ELEVATION

SCALE: 1" = 300'

0 300 600 900

MAPPING NOTES

- EXISTING SUBSURFACE TOPOGRAPHY SHOWN HEREON OBTAINED FROM BATHYMETRIC SURVEYS PERFORMED IN OCTOBER, NOVEMBER AND DECEMBER, 2018 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.
- ICE COVERED AREA SHOWN DELINEATED HEREON WAS NOT SURVEYED. AN EXTRAPOLATED FLYASH SLOPE OF 15% IS SHOWN TO DAYLIGHT AT THE EXISTING SUBSURFACE TOPOGRAPHY. EXISTING SUBSURFACE TOPOGRAPHY IN THIS AREA WAS OBTAINED FROM CLIENT PROVIDED DRAWING: *CD-170912 FAR II HYDROGRAPHIC SURVEY - CARDINAL PLANT*, DATED 10-18-2017.
- 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.

AECOM
277 West Nationwide Boulevard
Columbus, OH 43215
614-464-4500 (phone)
614-464-0588 (fax)

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

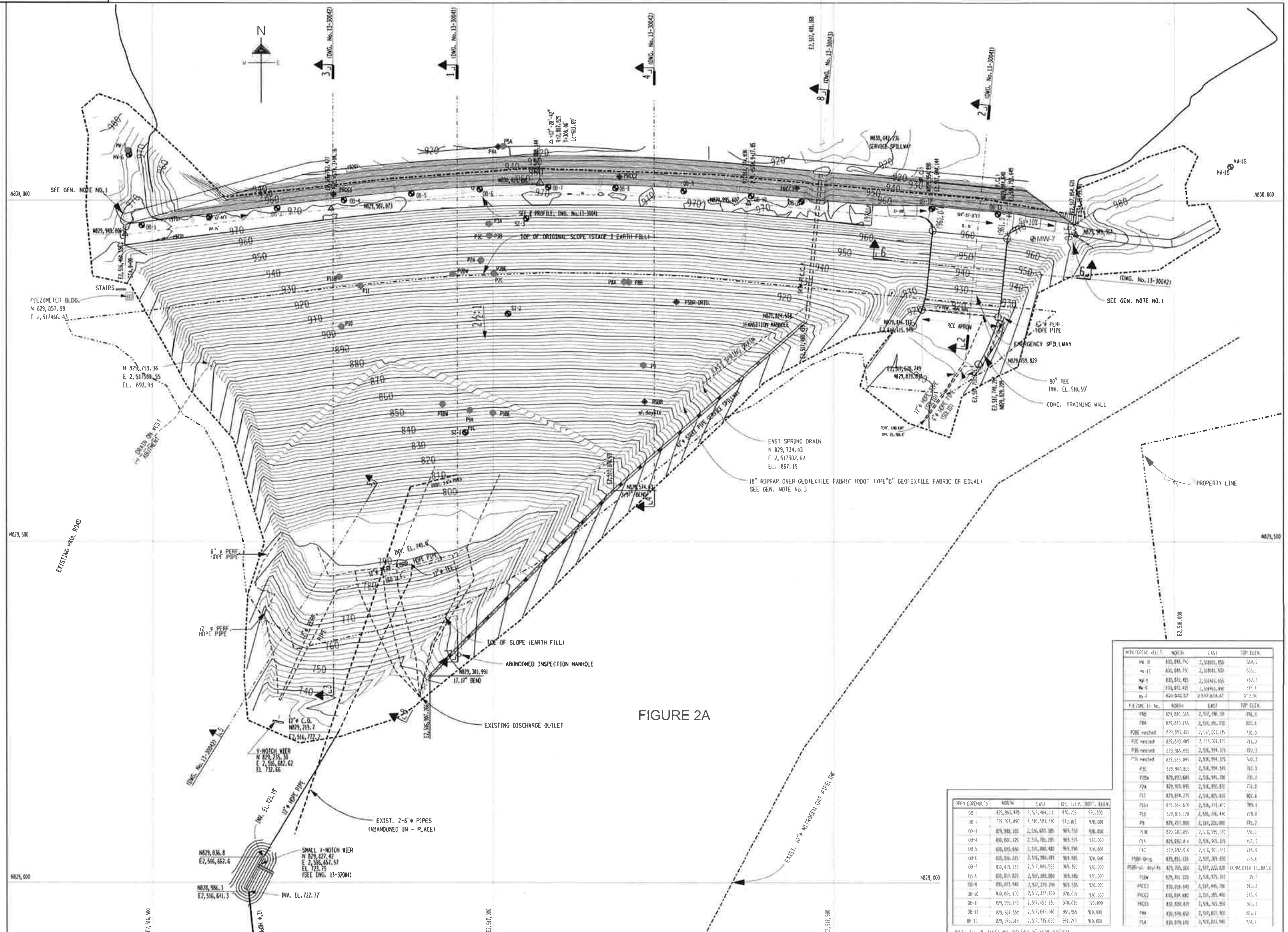
NO.	DESCRIPTION	DATE
△		
△		
△		
△		
△		

AECOM PROJECT NO:	60583548
DRAWN BY:	
DESIGNED BY:	
CHECKED BY:	
DATE CREATED:	
PLOT DATE:	1/4/2019
SCALE:	
ACAD VER:	2017

SHEET TITLE

Appendix E : Figures and Drawings

DRN BY:	CARDINAL POWER STATION	DWG NO: FIGURE 1
DATE:		AEP AMERICAN ELECTRIC POWER / AEP SERVICE CORP. 1 RIVERSIDE PLAZA COLUMBUS, OH 43215
SCALE: 1"=	FLY ASH DAM I	



MONITORING WELLS	NORTH	EAST	TOP ELEV.
MW-1D	830,048.740	2,518001.950	654.5
MW-1S	830,049.780	2,518001.920	526.1
MW-5	830,072.425	2,516463.655	762.2
MW-6	830,072.415	2,516465.990	515.6
MW-7	829,942.57	2,517,624.47	972.50

PIEZOMETER No.	NORTH	EAST	TOP ELEV.
P8B	829,880.365	2,517,198.10	776.0
P8A	829,880.165	2,517,198.730	822.1
P2BE 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	772.1
P3A nested	829,965.095	2,516,994.335	802.3
P3C	829,947.865	2,516,994.545	747.3
P2Bw	[illegible]	[illegible]	781.2
P2A	829,910.995	2,516,892.870	776.0
P11	829,874.275	2,516,805.610	802.6
P10B	829,887.670	2,516,773.430	789.1
P10	829,815.120	2,516,876.440	768.1
P9	829,757.800	2,517,221.900	771.7
P1BE	829,687.855	2,516,959.350	728.0
P1A	829,692.010	2,516,965.335	752.3
P1C	829,692.010	2,516,965.335	714.4
P5BR Orig.	829,851.135	2,517,269.830	775.0
P5BR-sl. daylite	829,765.160	2,517,222.820	CONNECTOR EL. 807.0
P1BW	[illegible]	[illegible]	735.9
PRCC1	830,018.040	2,517,445.790	913.3
PRCC2	830,034.480	2,517,185.490	913.4
PRCC3	830,006.870	2,516,765.950	923.3
P4A	830,049.650	2,517,007.900	801.7
P5A	830,070.170	2,517,013.940	774.7

OPEN BOREHOLES	NORTH	EAST	GR. ELEV.	BOT. ELEV.
OB-1	829,961.975	2,516,484.110	970.235	970.000
OB-2	829,976.090	2,516,583.770	970.015	920.600
OB-3	[illegible]	[illegible]	[illegible]	[illegible]
OB-4	830,000.125	[illegible]	[illegible]	920.300
OB-5	[illegible]	[illegible]	[illegible]	920.400
OB-6	[illegible]	[illegible]	[illegible]	920.600
OB-7	830,019.285	2,517,080.595	969.465	920.300
OB-8	[illegible]	[illegible]	[illegible]	920.300
OB-9	[illegible]	[illegible]	[illegible]	920.300
OB-10	830,006.100	2,517,378.760	970.015	920.300
OB-11	829,998.195	2,517,452.330	970.035	920.000
OB-12	829,937.550	2,517,647.140	961.965	910.000
OB-13	829,975.315	2,517,739.690	961.240	910.000

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

PTS No. 55689

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

+(970.0') FIN. GRADE SPOT ELEV.
—920— 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.
	5	REVISED TO REFLECT AS_BUILT CONDITIONS. FINAL SUBMITTAL TO STATE	
	4	AS_BUILT: REVISED TOPO, DRAIN PIPES, ADDED TABLES, PIEZOMETERS AND OPEN BORE HOLES. REMOVED MONITORING WELLS 4,3, 2D & 2S	
	3	REMOVED INTERMEDIATE CONTOURS. INDICATED CONCRETE TRAINING WALL & GEOTEXTILE FABRIC.	
	2	DELETED DROP MANHOLE & REV. PIPE ALIGNMENT.	
	1	REV. TOE OF DAM TO REFLECT SLIDE REPAIR. RELOCATED DROP MANHOLE & REV. PIPE BEND, 6°30' WAS 6°. ADDED UNDERDRAIN SYSTEM.	
	0	ISSUED FOR CONSTRUCTION.	

REVISIONS

s:/cd/13/geo_hydro_site/30040.dgn

CARDINAL OPERATING COMPANY

CARDINAL PLANT

BRILLIANT OHIO

FLY ASH DAM II RAISING GRADING & DRAINAGE PLAN

DWG. NO. 13-30040-5

SCALE: 1"=50'

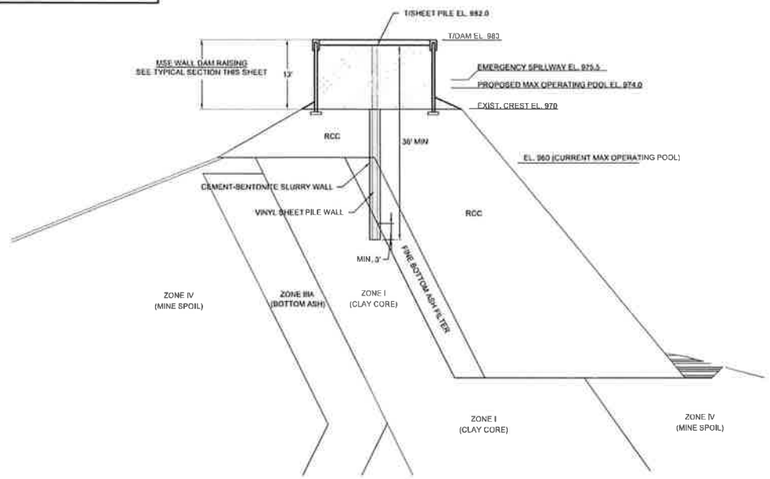
CIVIL ENGINEERING DIVISION

H. Joseph Baber

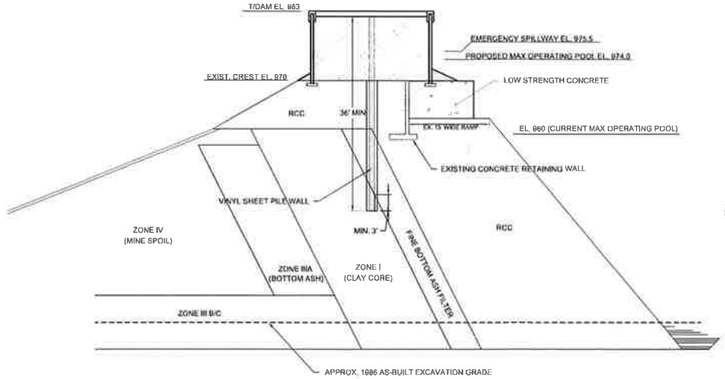
AMERICAN ELECTRIC POWER
1 RIVERSIDE PLAZA
COLUMBUS, OH 43215

0465

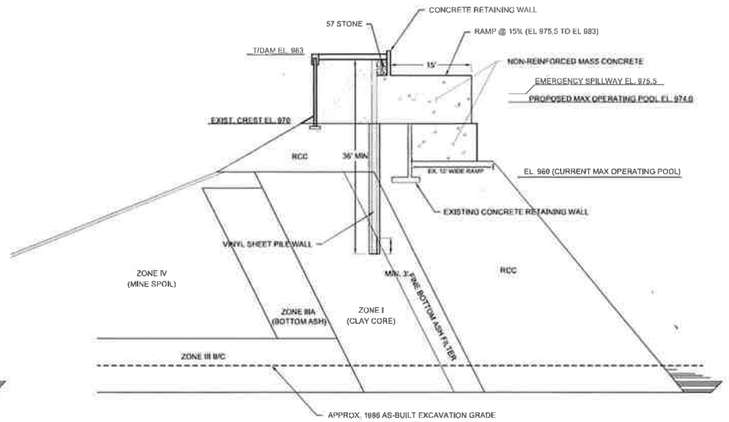
DWG. NO. 13-30087-A



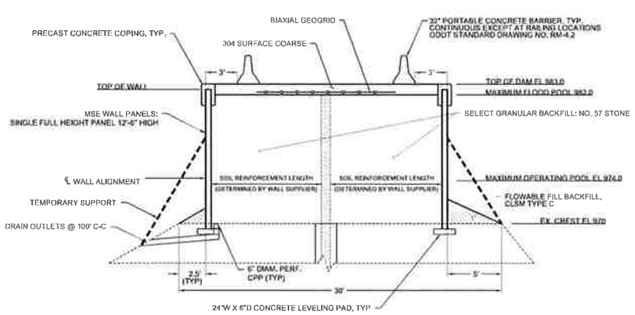
L A TYPICAL SECTION - MAIN DAM
SCALE: 1" = 10'



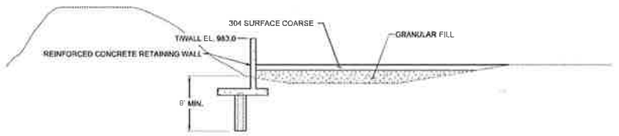
L B1 SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



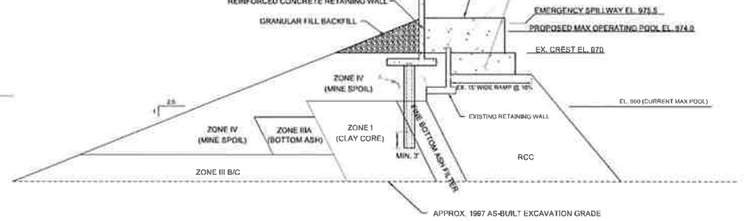
L B2 SECTION THROUGH EXISTING EMERGENCY SPILLWAY RAMP
SCALE: 1" = 10'



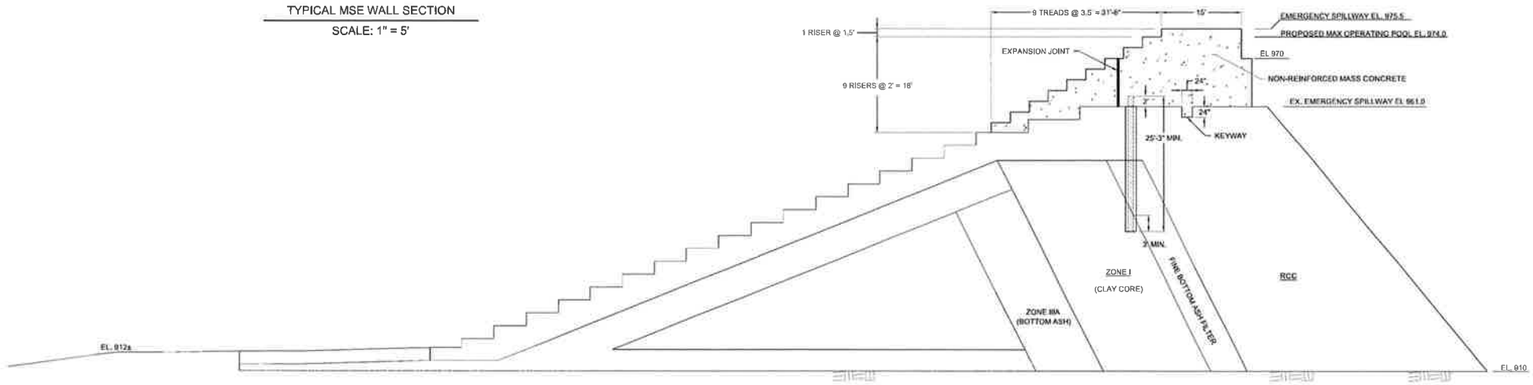
TYPICAL MSE WALL SECTION
SCALE: 1" = 5'



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



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



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

FIGURE 2B

S&ME, INC.
6190 ENTERPRISE COURT
DUBLIN, OH 43016
PHONE: 614-793-2228
FAX: 614-793-2410
www.smeinc.com

STATE OF OHIO · MICHAEL GILBERT ROWLAND · E-65559 · REGISTERED · PROFESSIONAL ENGINEER

MICHAEL GILBERT ROWLAND — E-65559 NUMBER — SEPT 28, 2012 DATE

DATE	NO.	DESCRIPTION	APPD.
9/28/12	A	ISSUED FOR BID	SSB MGR

REVISIONS

CARDINAL OPERATING COMPANY
CARDINAL PLANT
BRILLIANT OHIO

DAM RAISING
FLY ASH RETENTION DAM 1
DAM RAISING
TYPICAL SECTIONS

DWG. NO. 13-30087-A

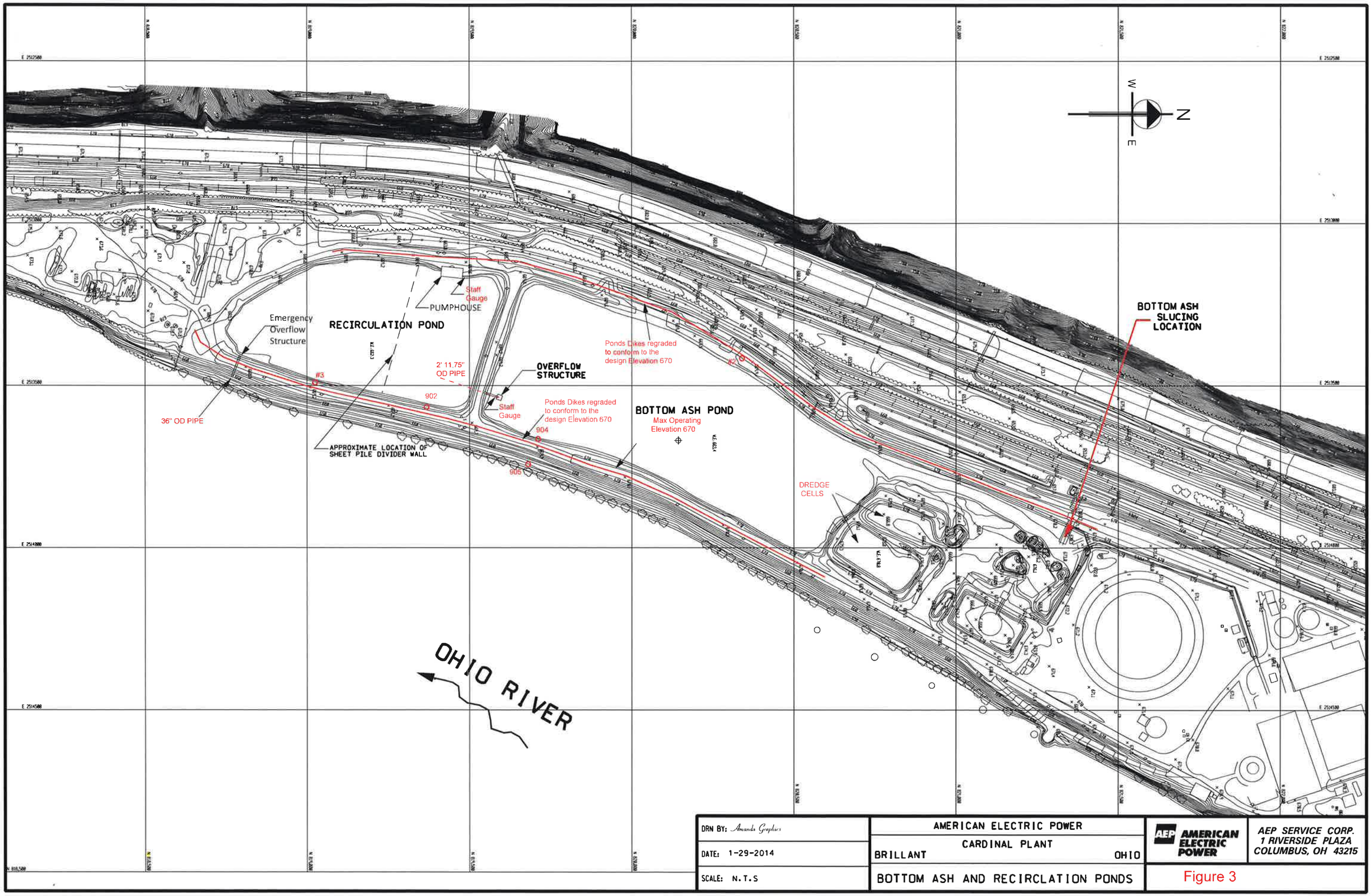
ARCH — ELEC — MECH — STR

SCALE: AS SHOWN — CIVIL ENGINEERING DIVISION

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

S&ME

AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA COLUMBUS, OH 43215



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

Figure 4
Cardinal FAD 2

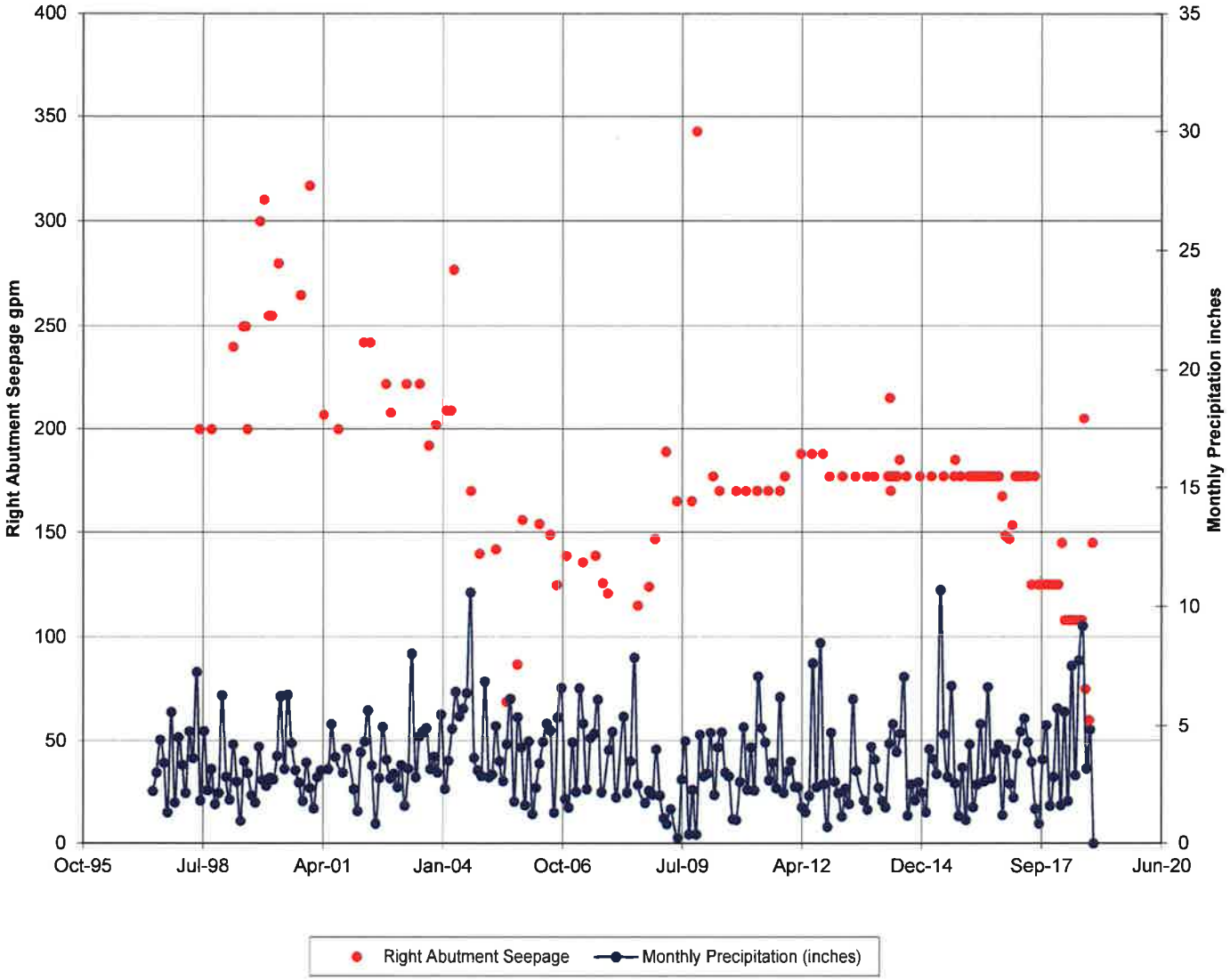


Figure 5a
Cardinal FAD 2

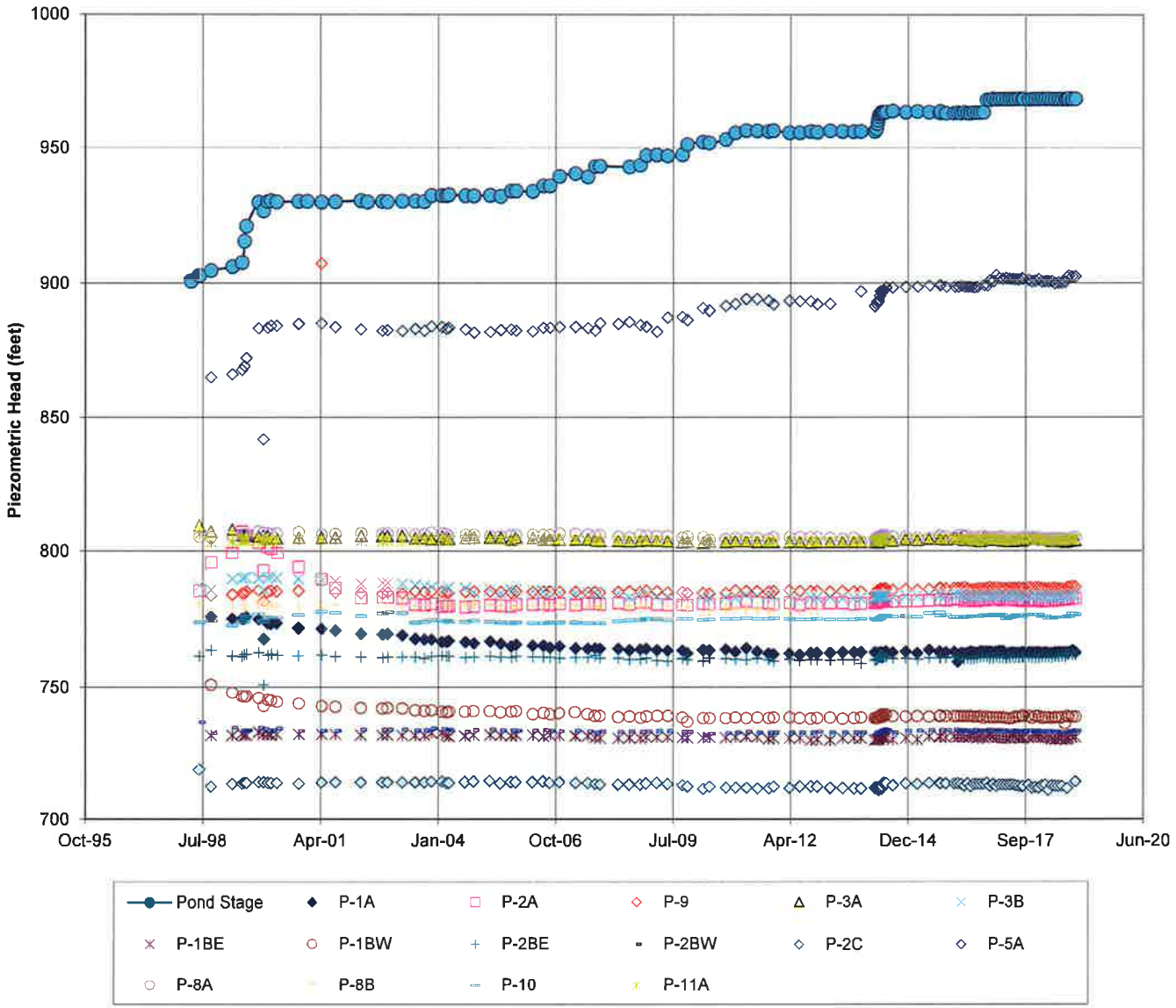


Figure 5b
Pool Stage verses Discharge
Cardinal FAD 2

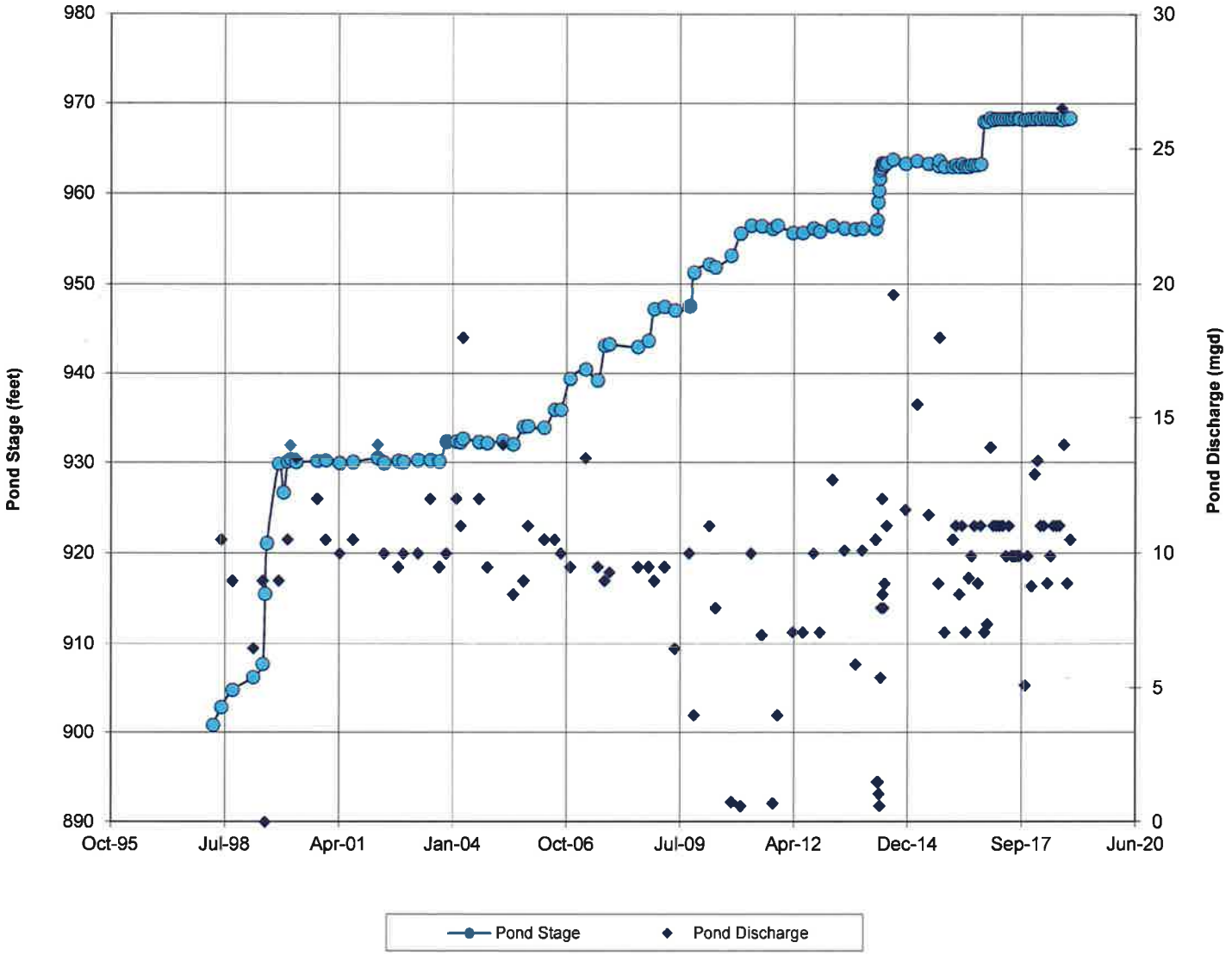


Figure 5c
Cardinal FAD 2
Right of Center
Foundation Piezometers

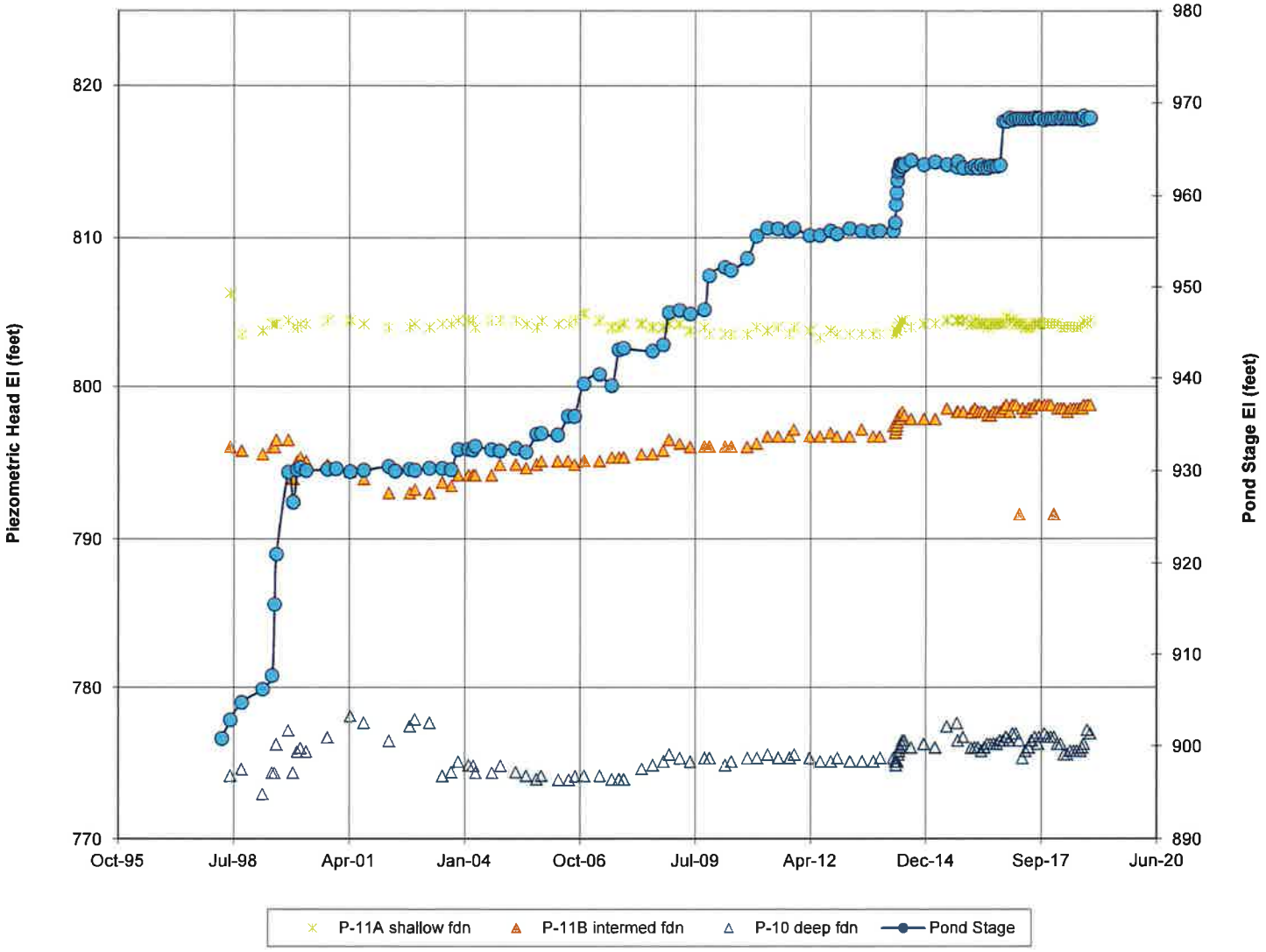


Figure 5d
Cardinal FAD 2
Left of Center
Foundation Piezometers

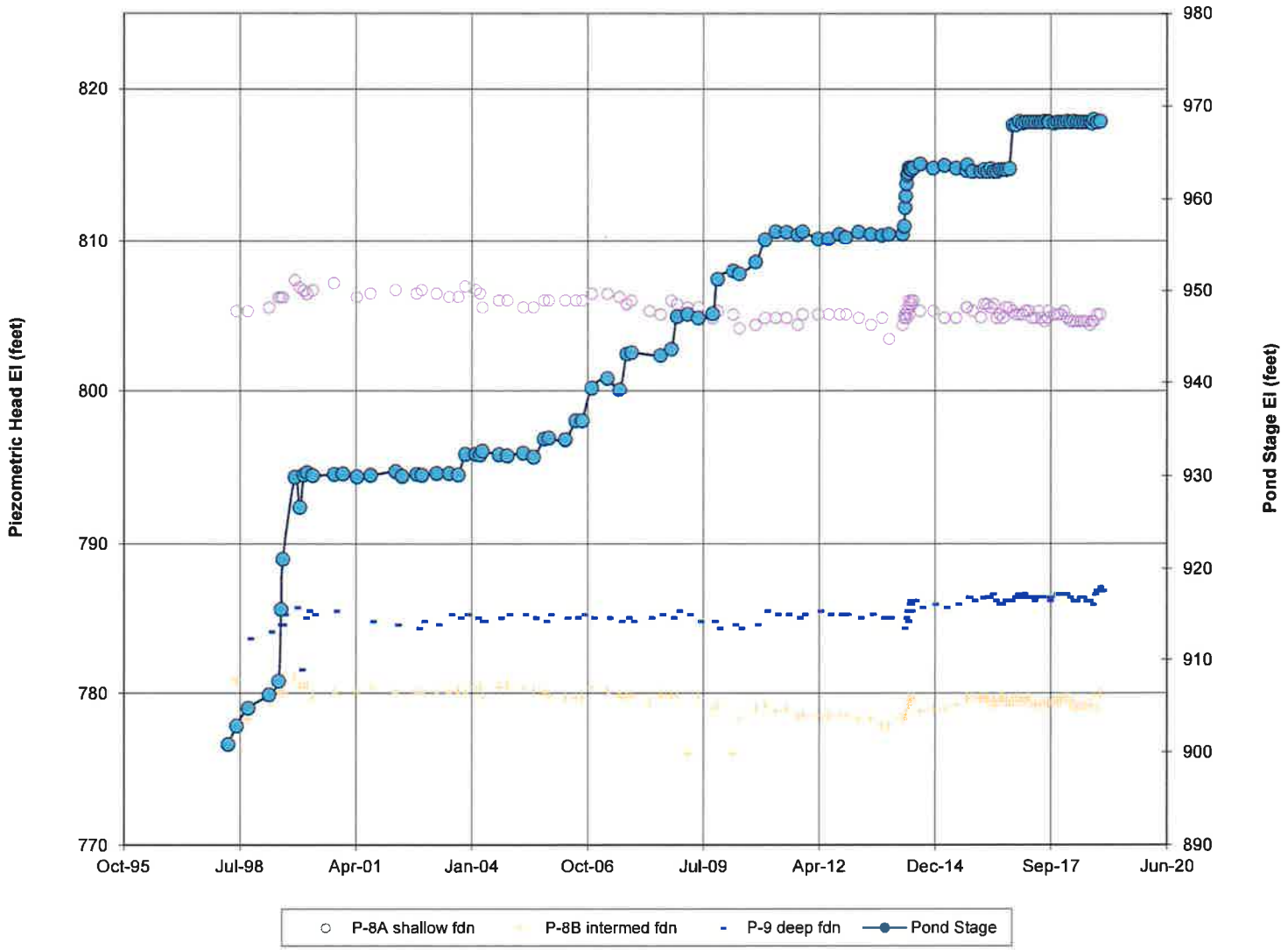


Figure 5e
Cardinal FAD 2
Centerline of Dam

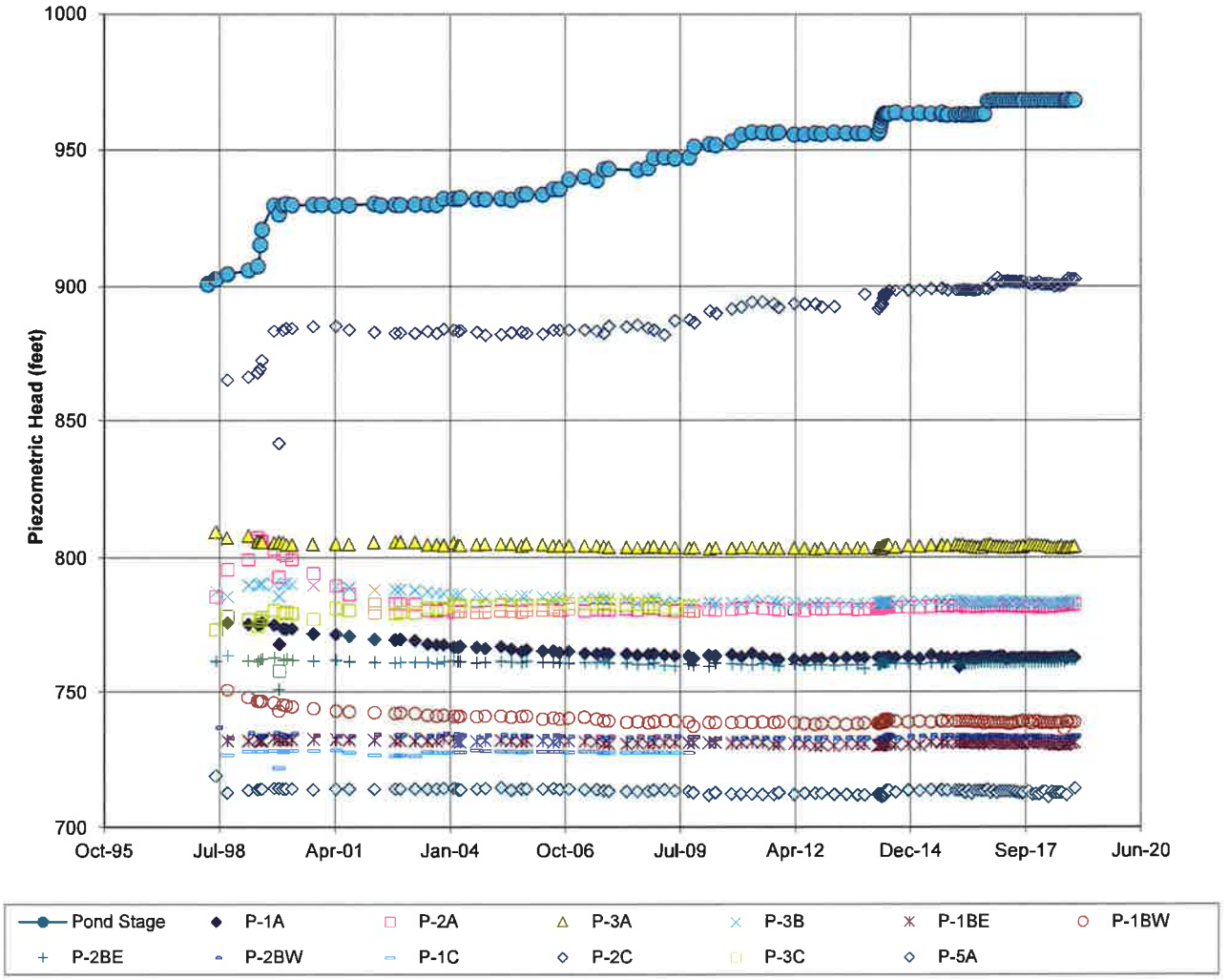


Figure 5f
Cardinal FAD 2
Centerline of Dam

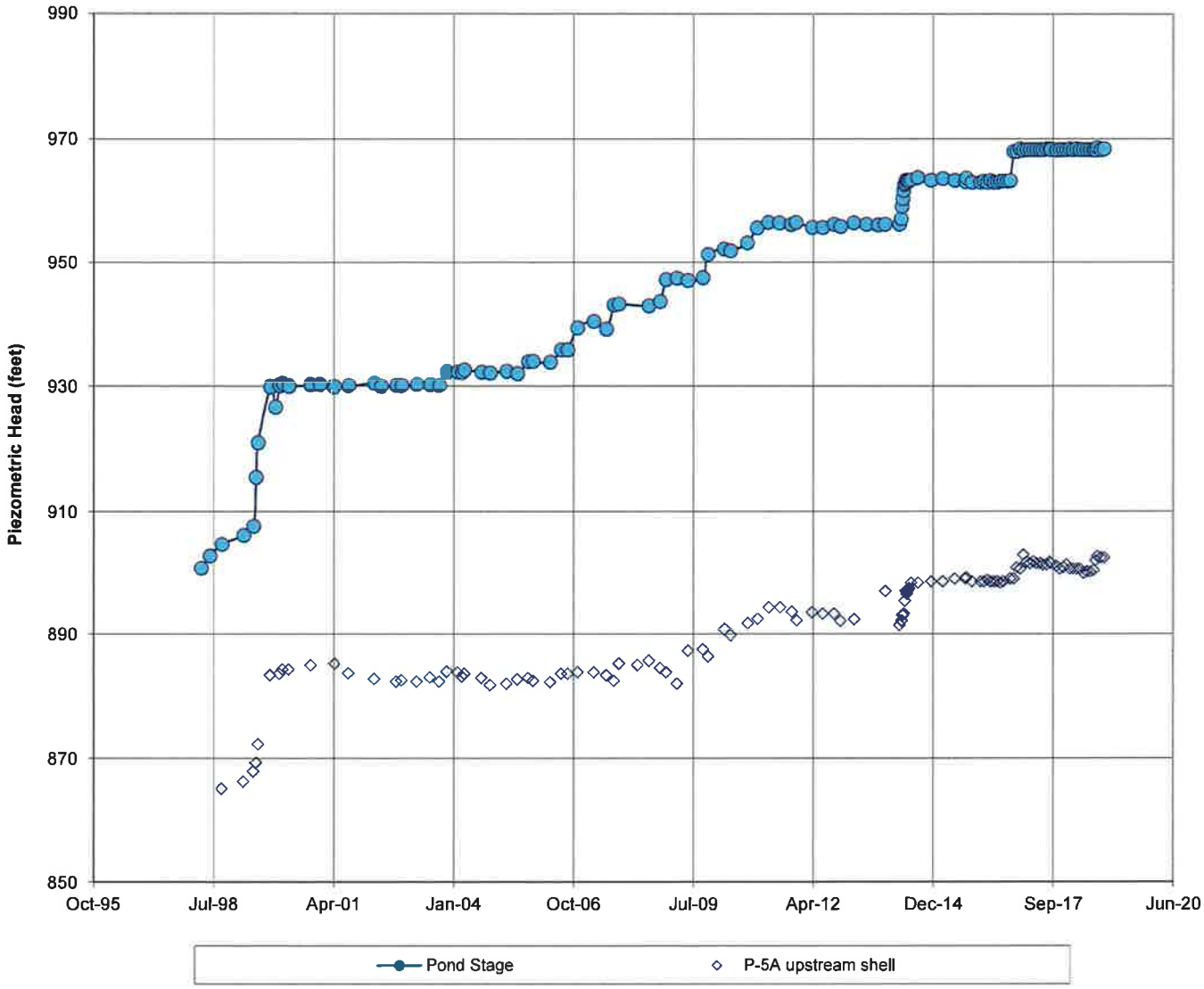


Figure 5g
Cardinal FAD 2
Centerline of Dam
Clustered Piezometer Site

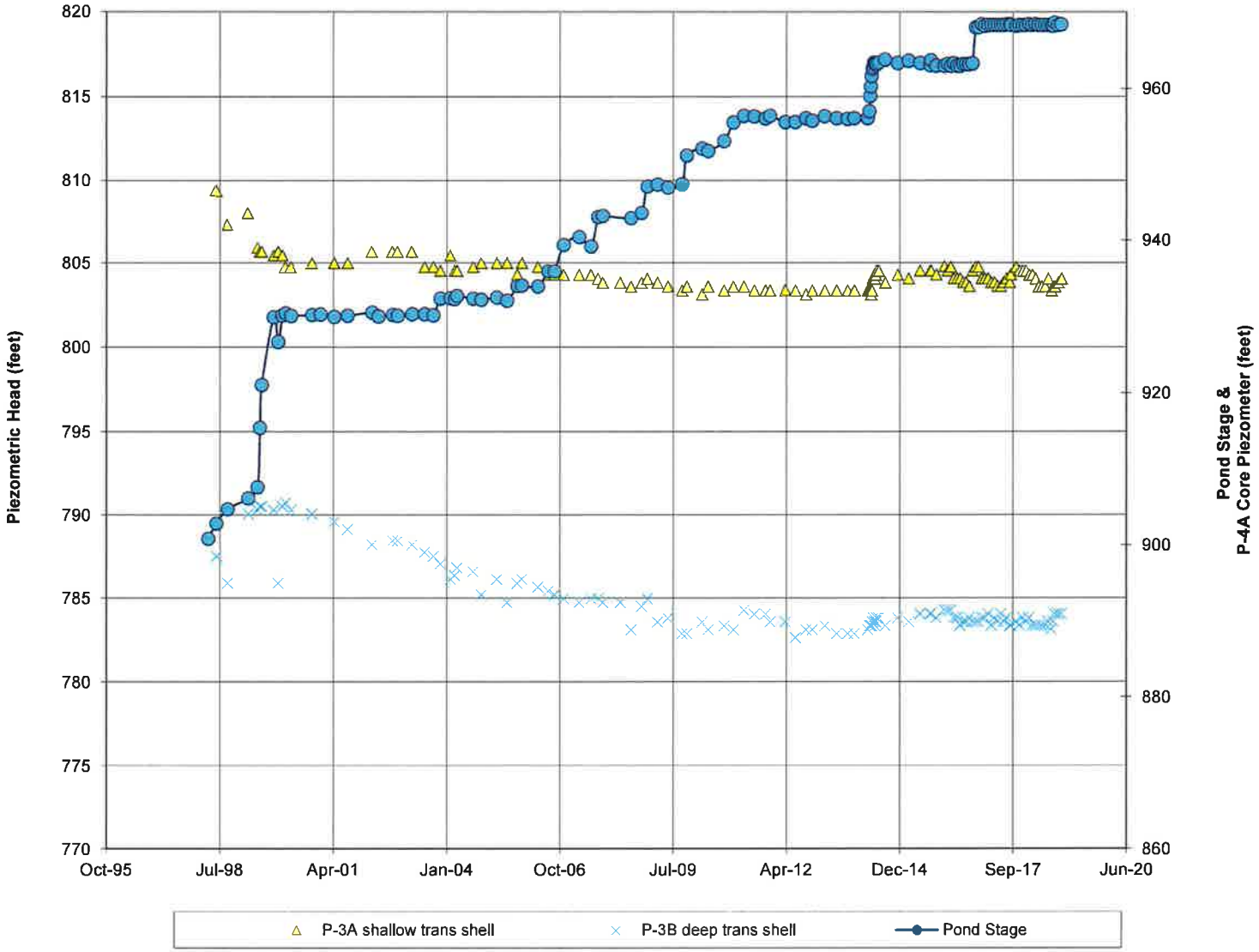


Figure 5h
Cardinal FAD 2
Centerline of Dam
Clustered Piezometer Site

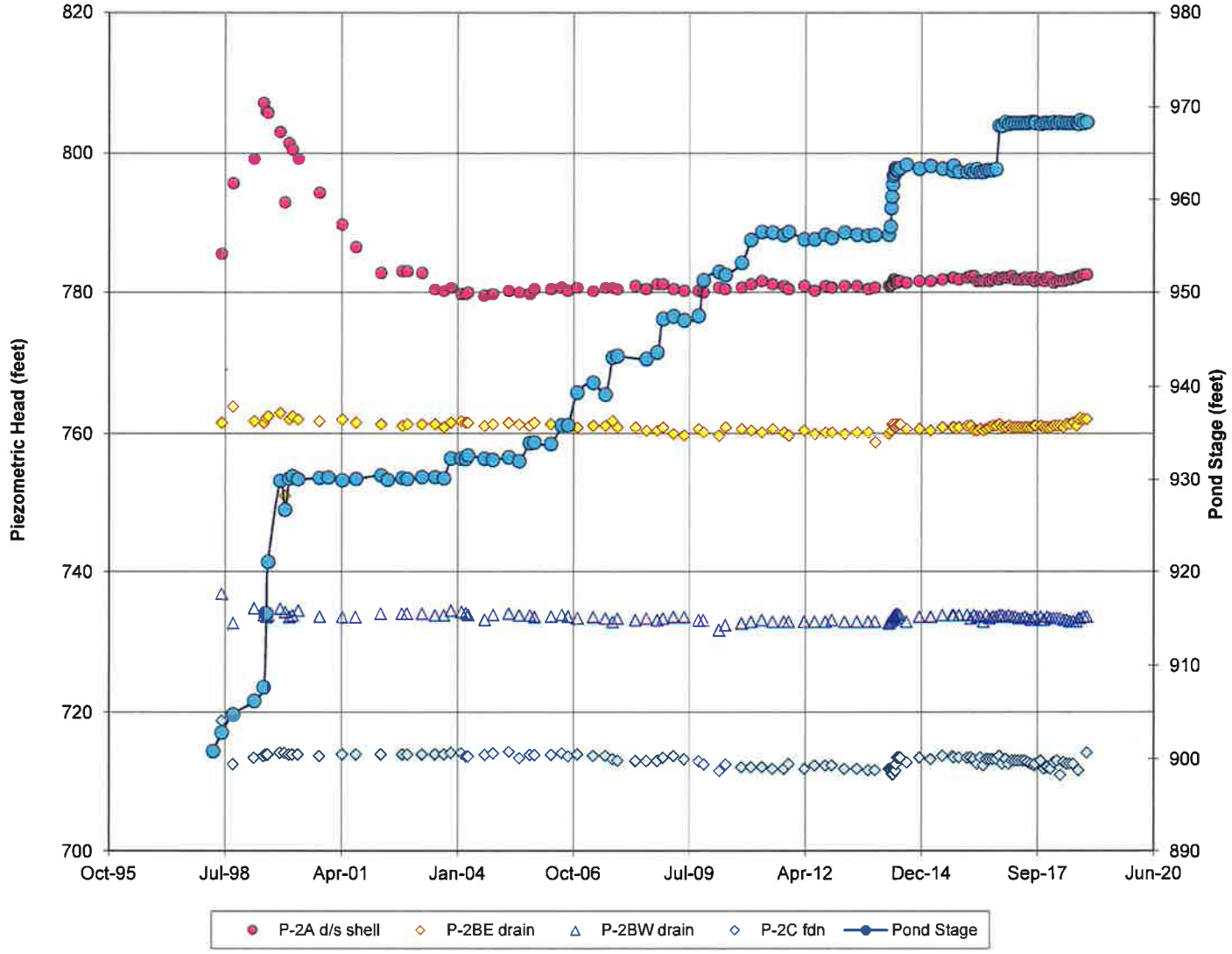


Figure 5i
Cardinal FAD 2
Centerline of Dam
Clustered Piezometer Site

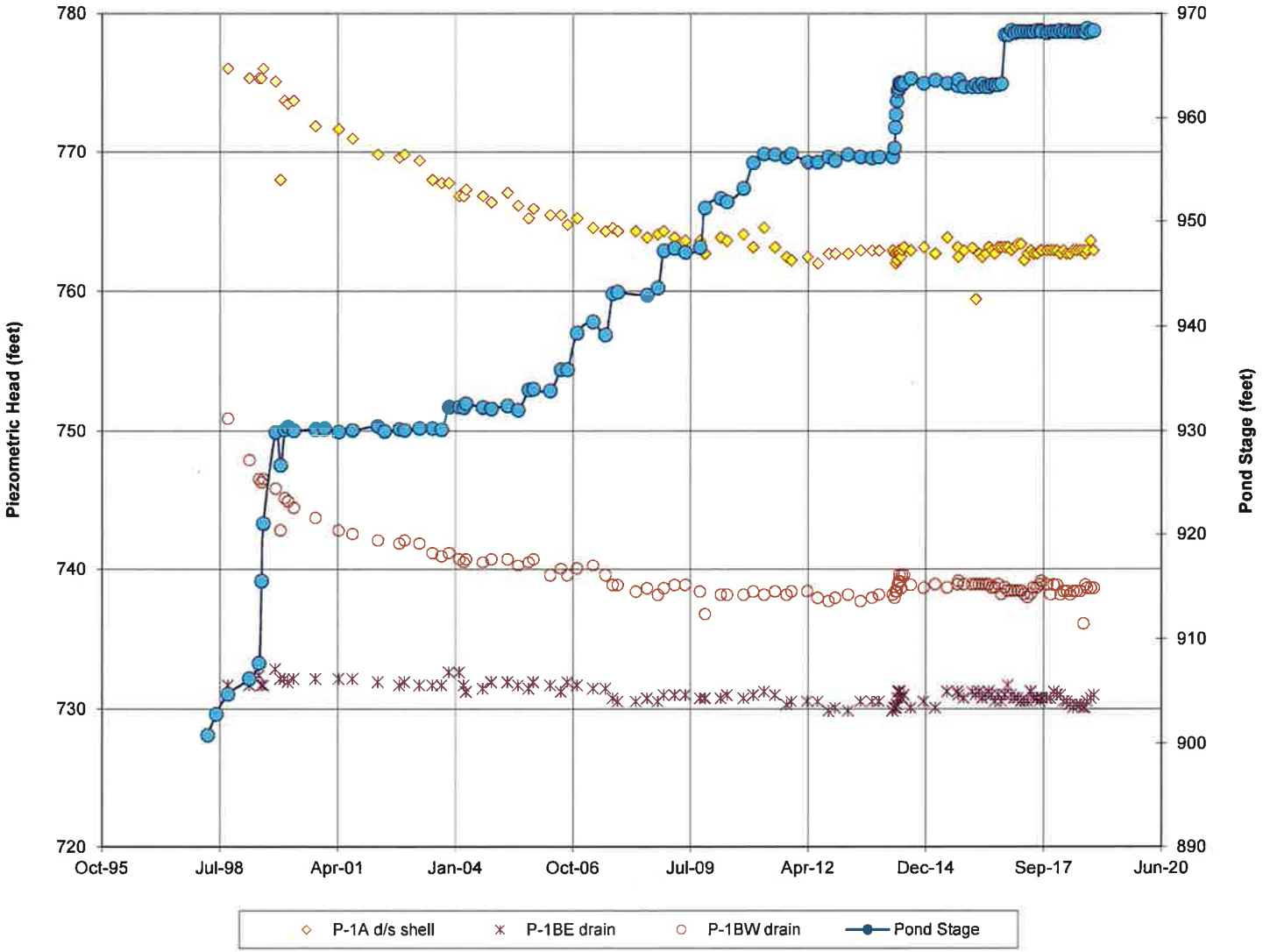


Figure 5j
Cardinal FAD 2
Centerline of Dam
Drain Piezometers

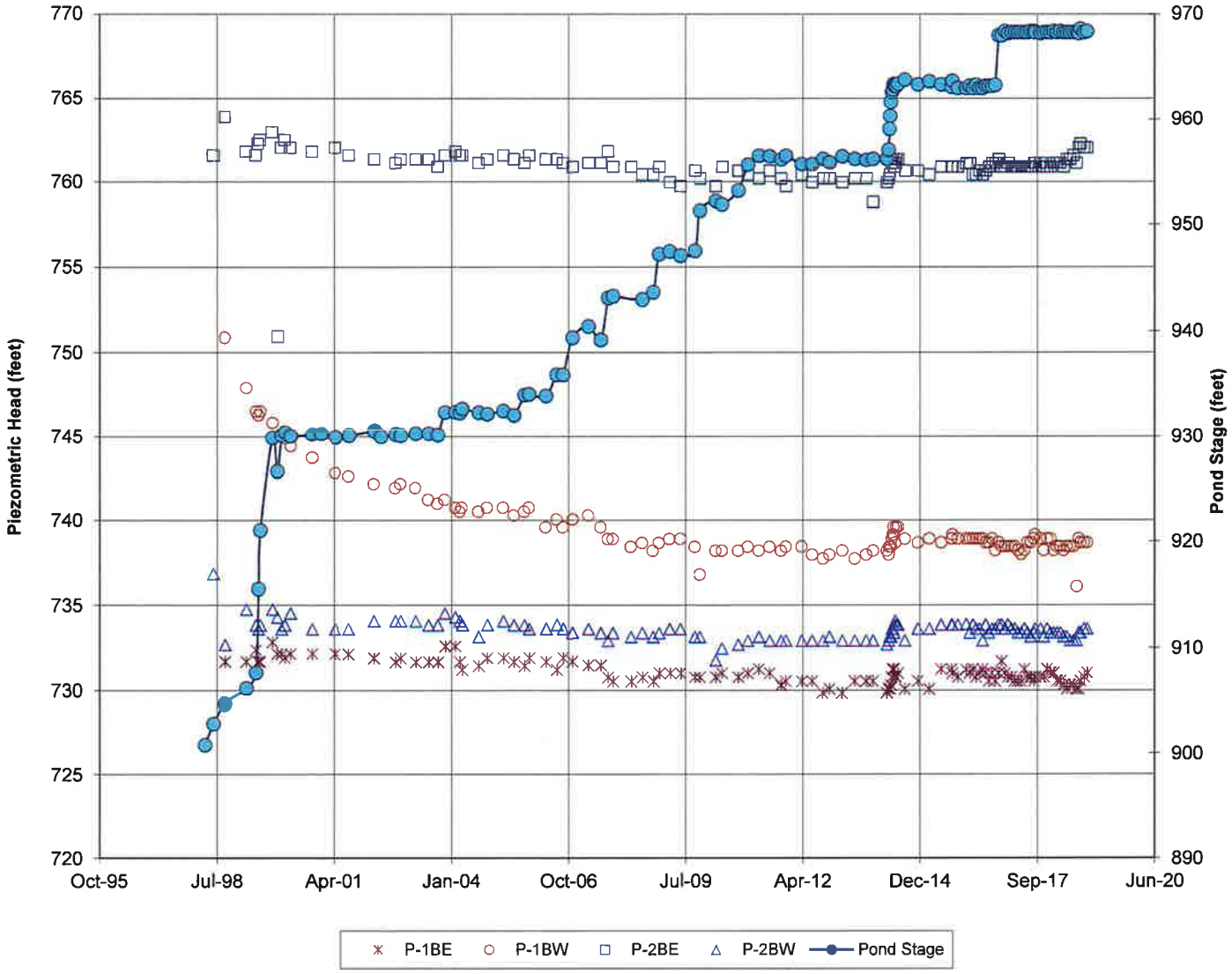


Figure 5k
Cardinal FAD 2
Centerline of Dam
Foundation Piezometers

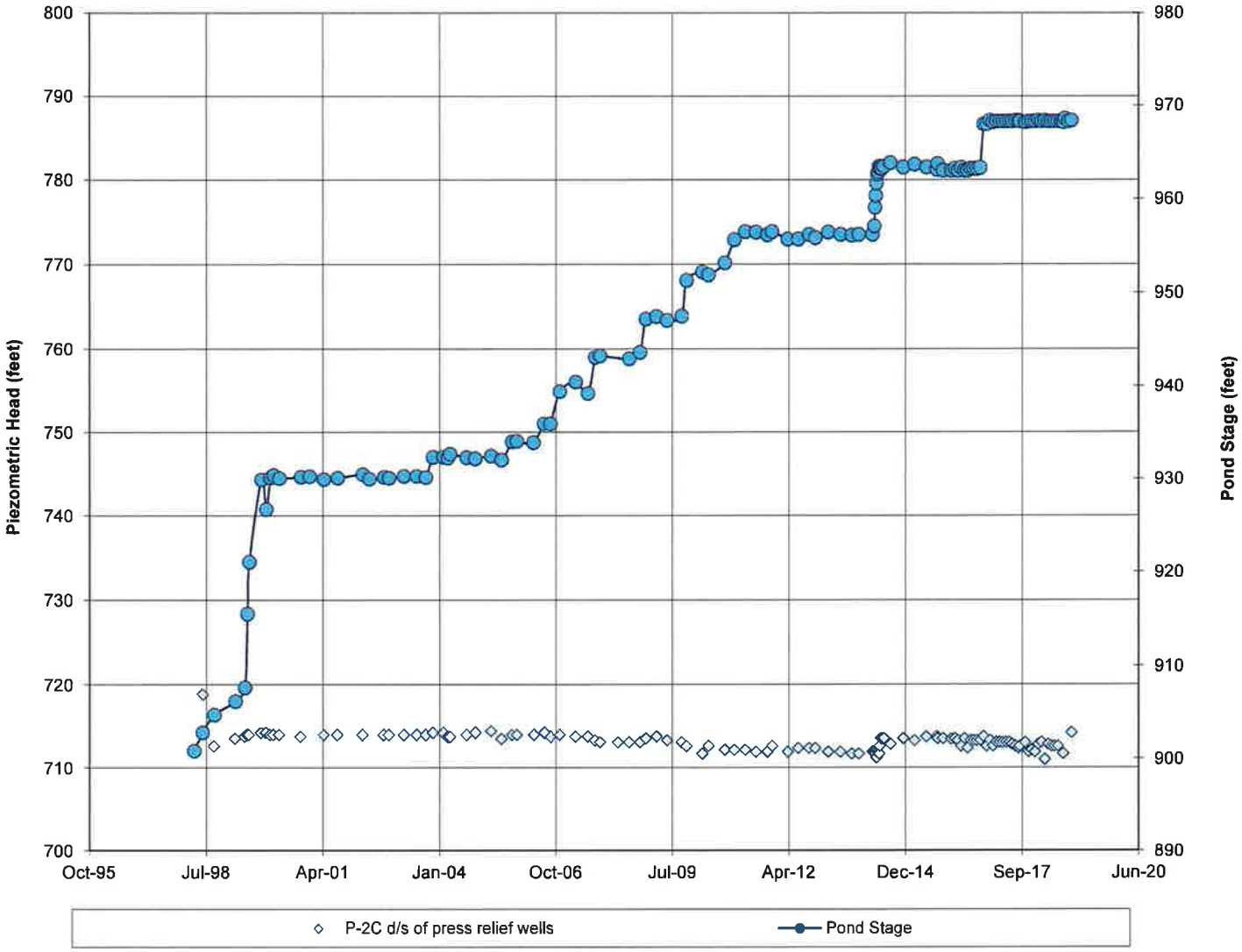


Figure 5l
Cardinal FAD 2
Centerline of Dam
Drain Piezometers & Discharge

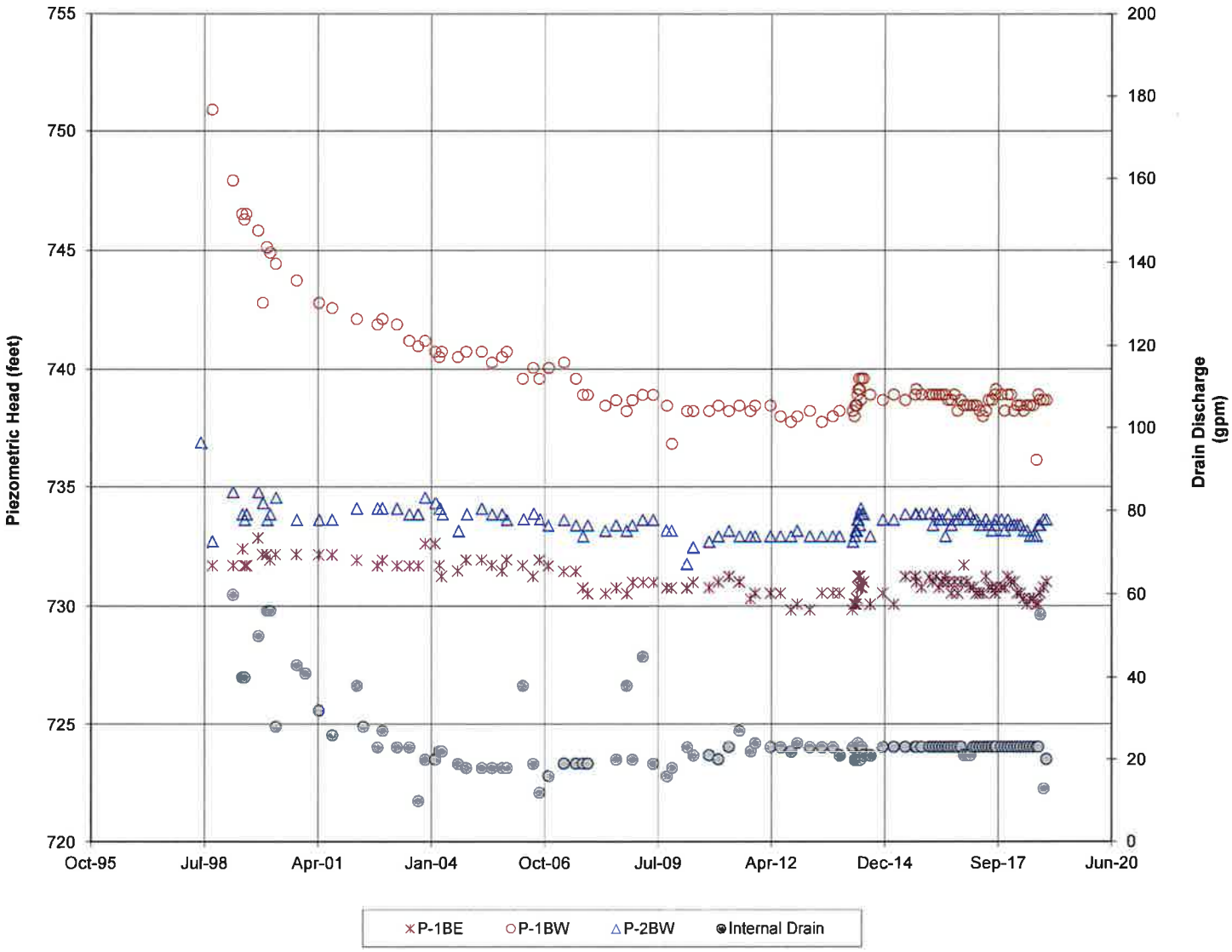


Figure 5m
Cardinal FAD 2
Centerline of Dam
Drain Piezometers & V-Notched Weir Discharge

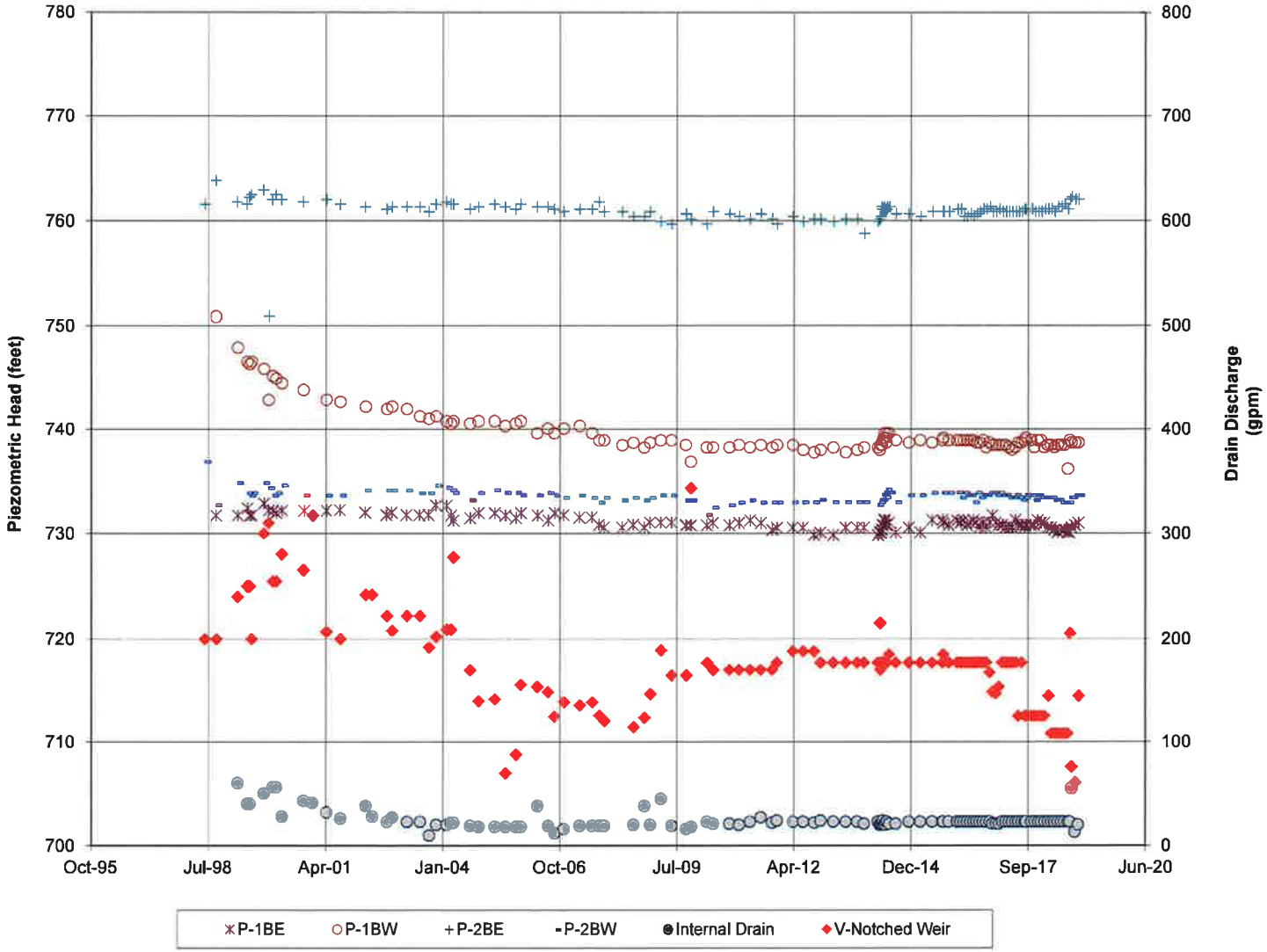


Figure 5n
Cardinal FAD 2
Centerline of Dam
Drain Piezometers & Right Abutment Piezometers

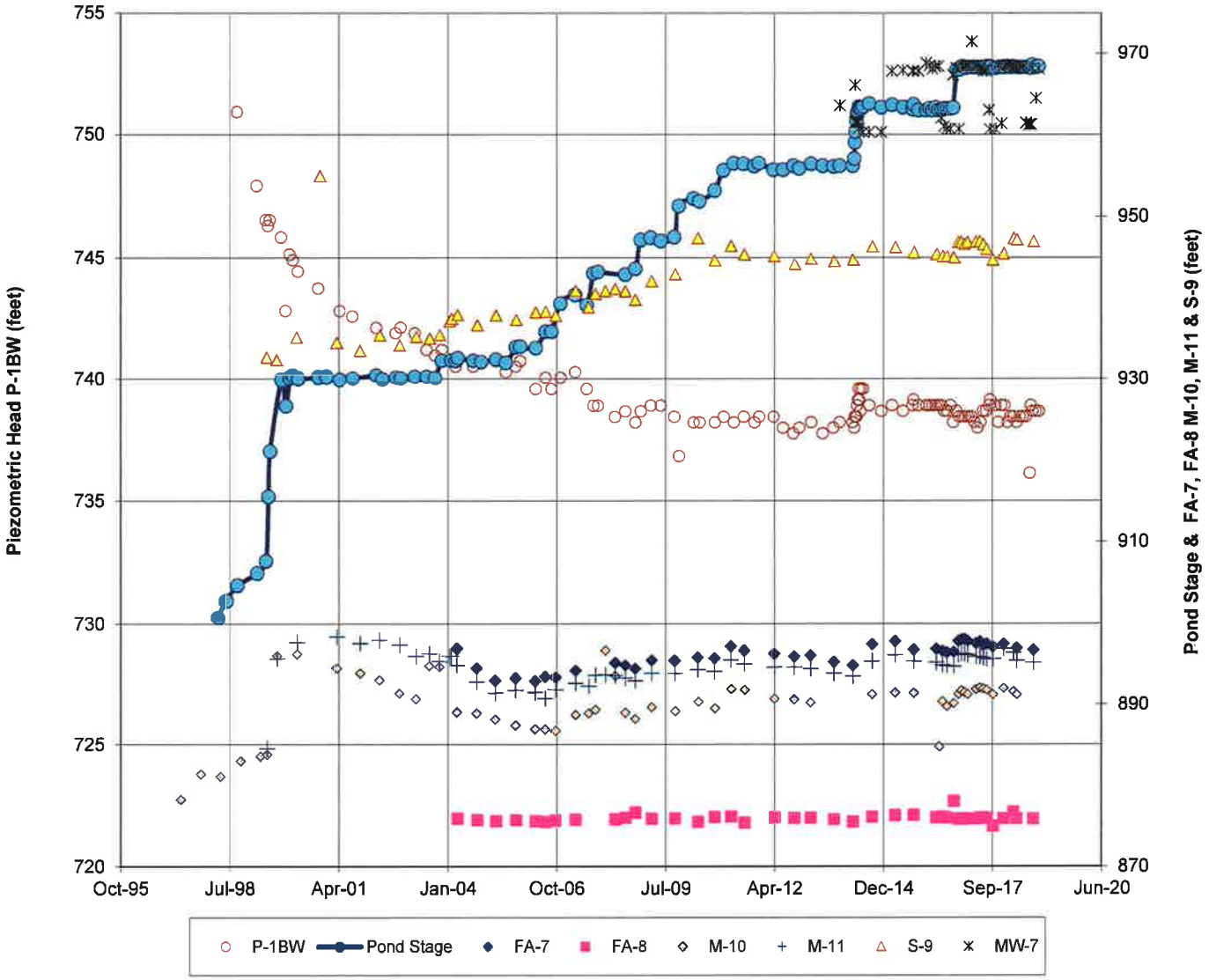


Figure 5o
Cardinal Far 2
Centerline of Dam
Tiltmeters at MSE Wall Concrete Pannels

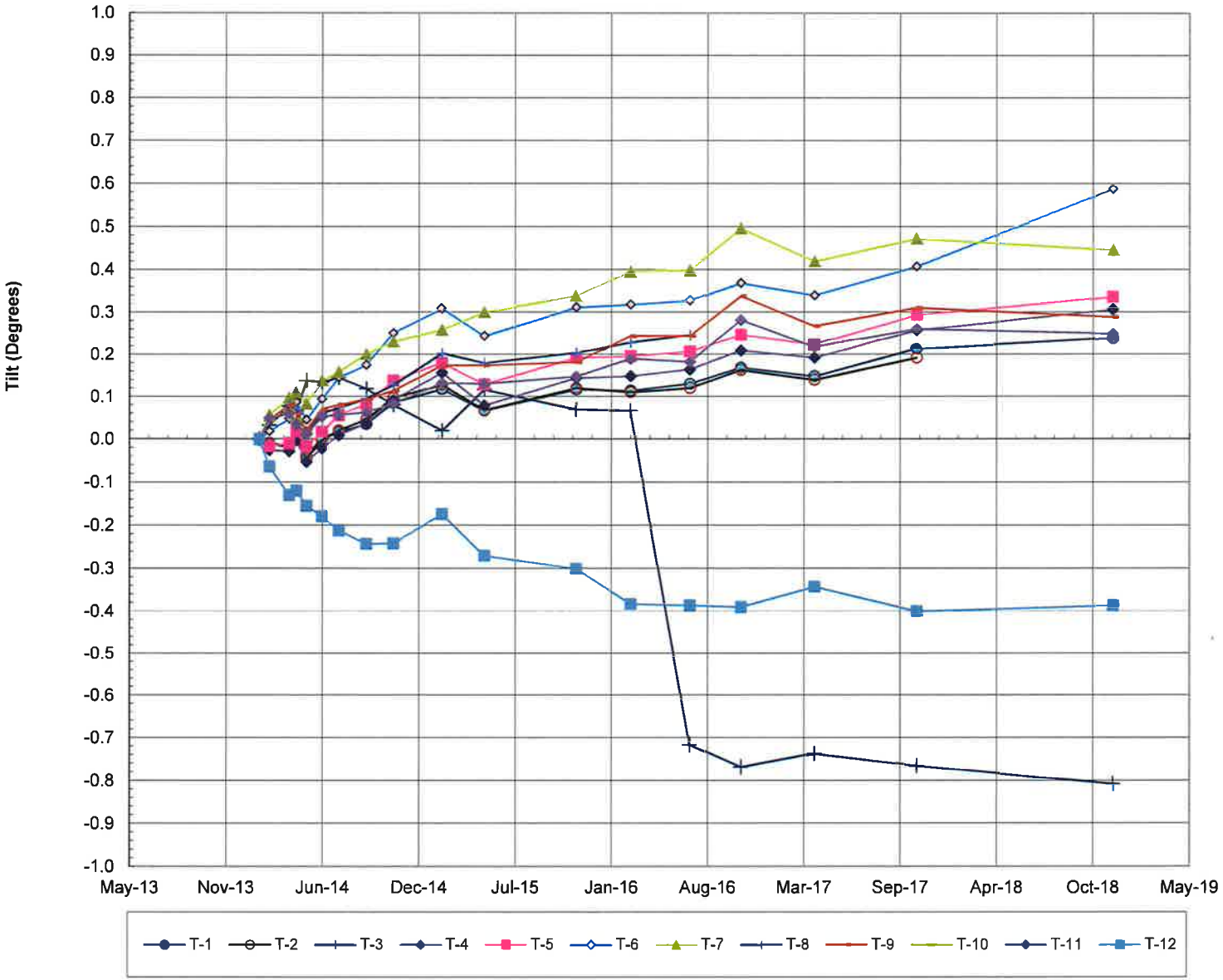


Figure 5p
Bottom Ash Pond Complex
Piezometers & Ponds Stages

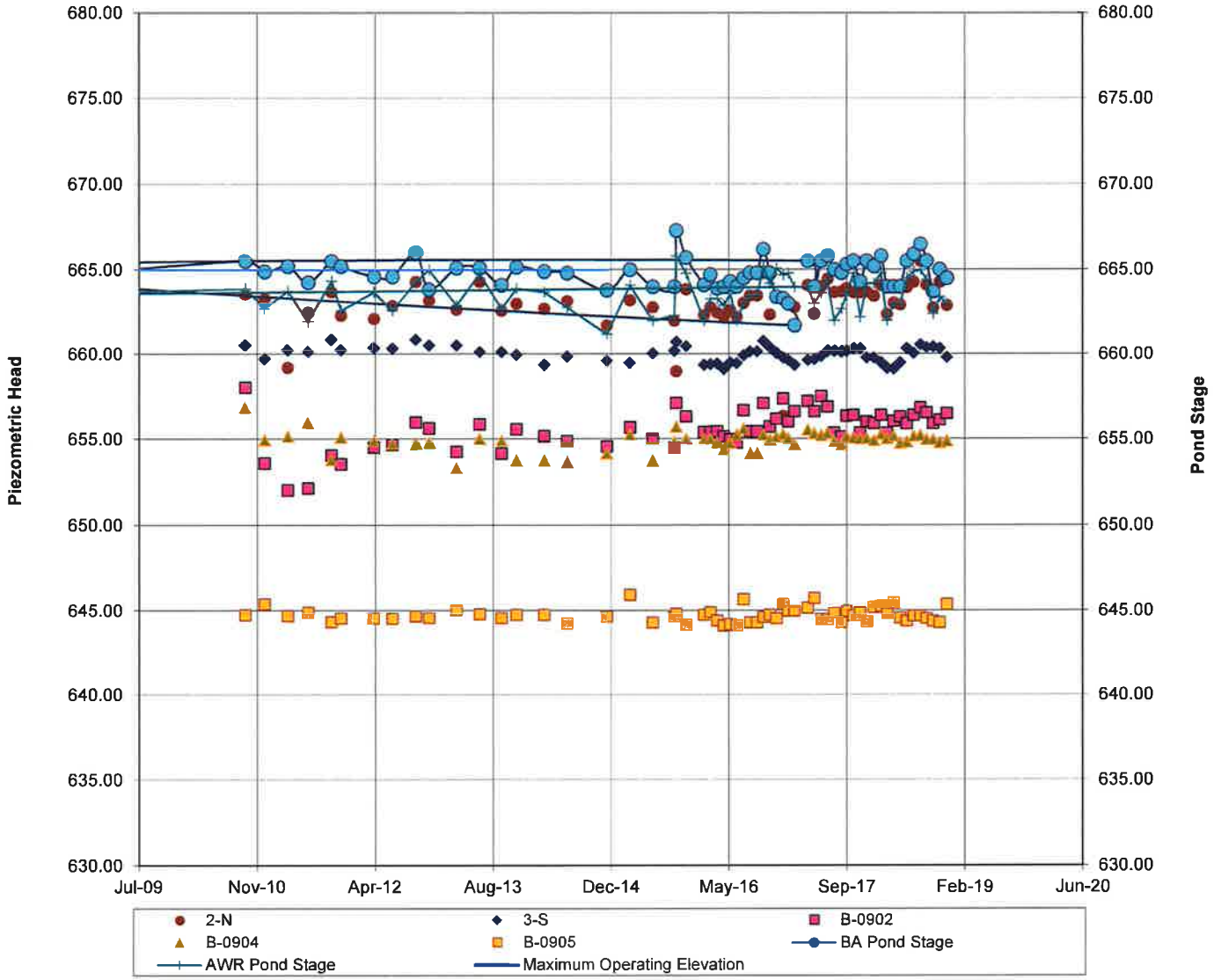
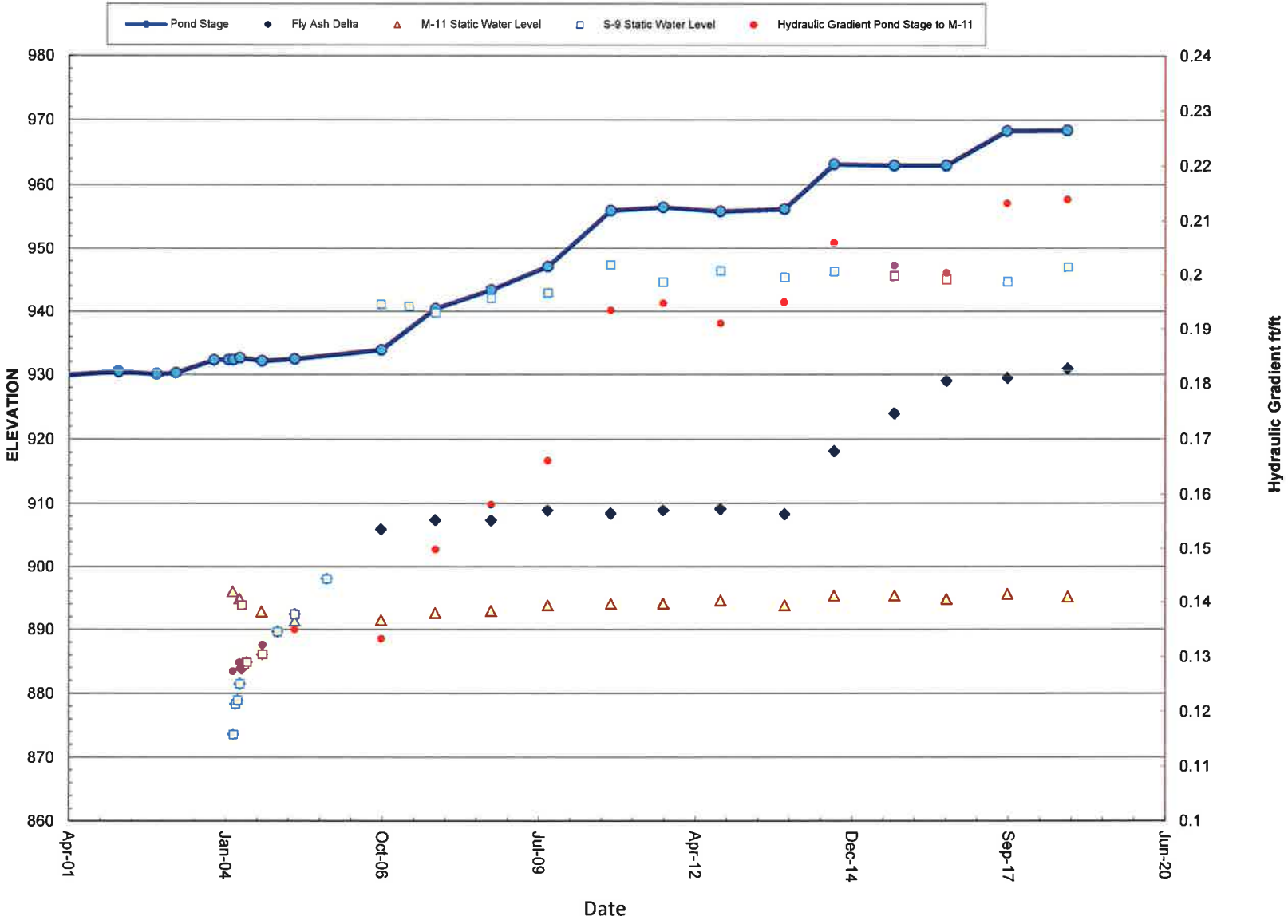
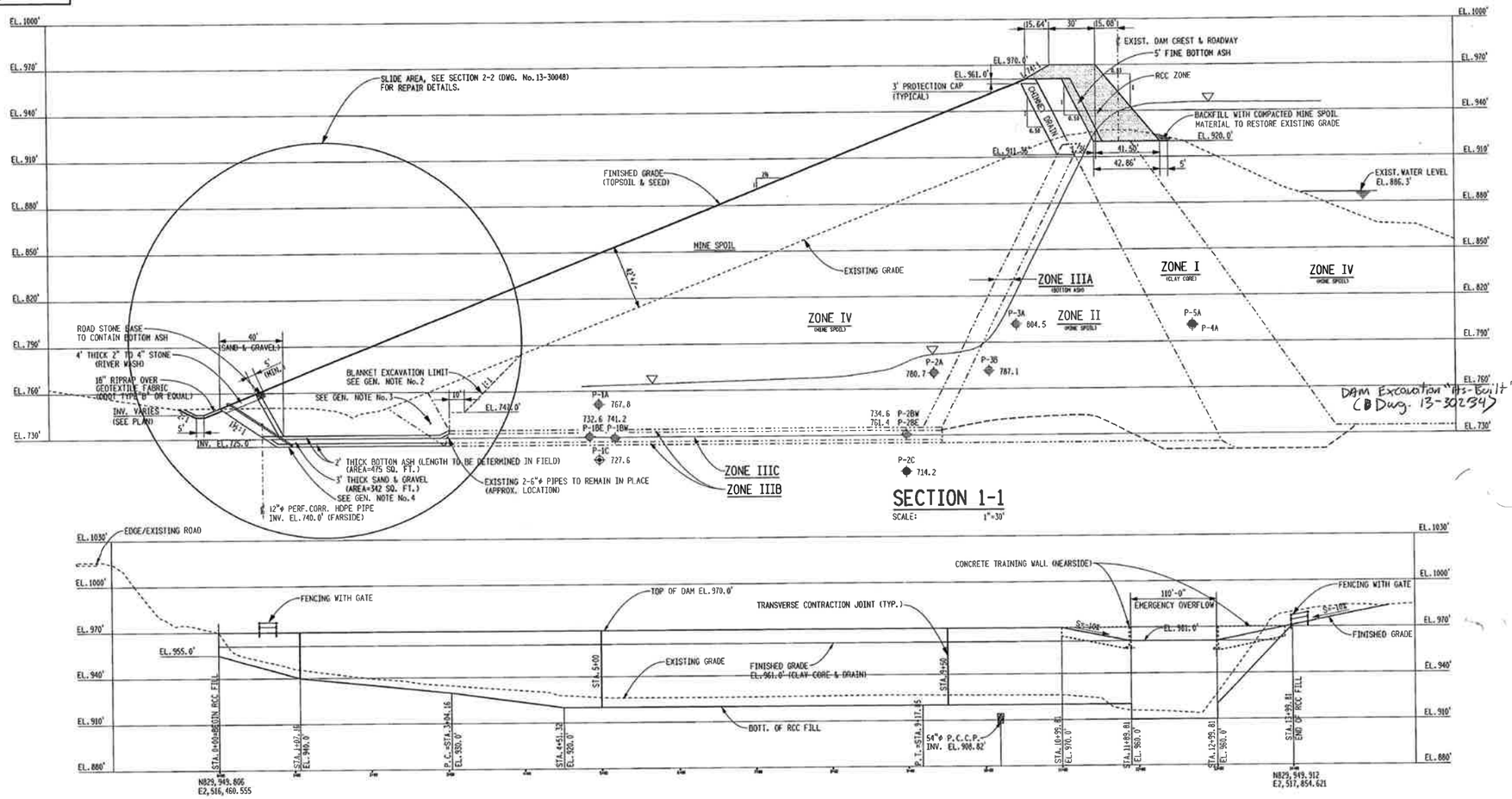


Figure 6
CARDINAL FAR 2
Fly Ash Deposition

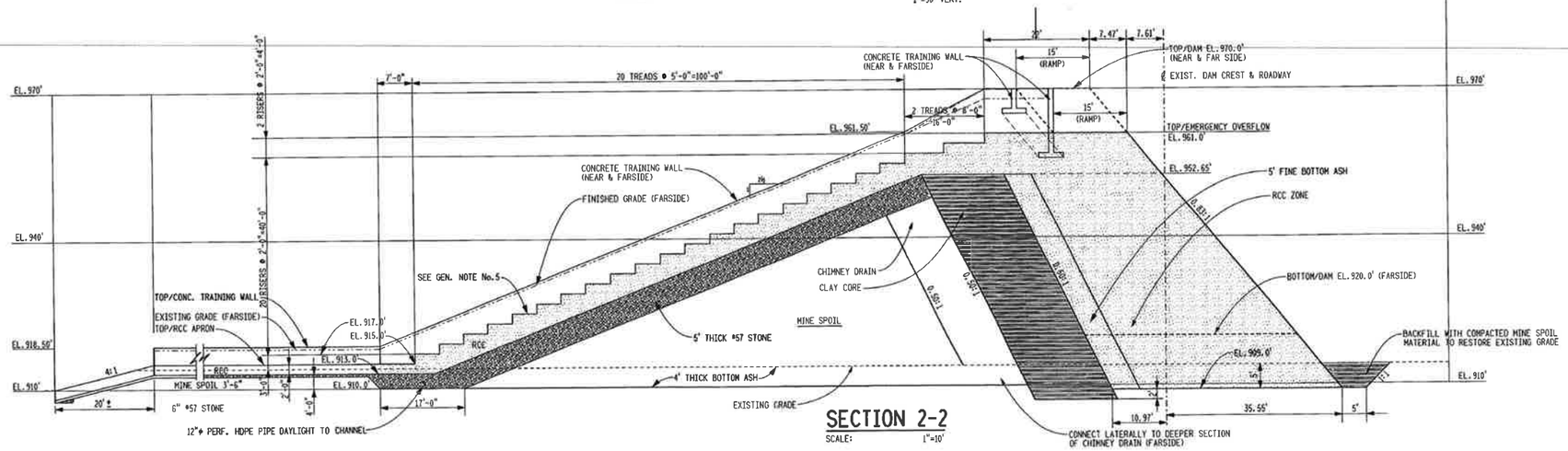


DWG. NO. 13-30041



SECTION 1-1
SCALE: 1"=30'

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



SECTION 2-2
SCALE: 1"=10'

FIGURE 7A

PTS No. 55689

GENERAL NOTES

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

REFERENCE DRAWINGS

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

DATE NO.	NO.	DESCRIPTION	APPD.
	6	REVISED TO SHOW INSTALLATION DEPTH OF PNEUMATIC PIEZOMETER, AND DWA "AS-BUILT" EXCAVATION GRADES.	
30900	5	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE	BRK
60999	4	AS-BUILT: REVISED TOE AREA OF SECTION 2-2	MJ
60296	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'.	MJ
59998	2	REV. SECT.2-2, INDICATED RCC APRON & BOTTOM ASH BLANKET DRAIN THICKNESS.	MJ
60398	1	REV. SECT.1-1, SECT. 2-2 & ℄ PROFILE.	MJ
60297	0	ISSUED FOR CONSTRUCTION.	MJ

REVISIONS

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CARDINAL OPERATING COMPANY

CARDINAL PLANT

BRILLIANT OHIO

FLY ASH DAM II RAISING PROFILE & SECTIONS

DWG. NO. 13-30041-6

SCALE:AS NOTED | CIVIL ENGINEERING DIVISION

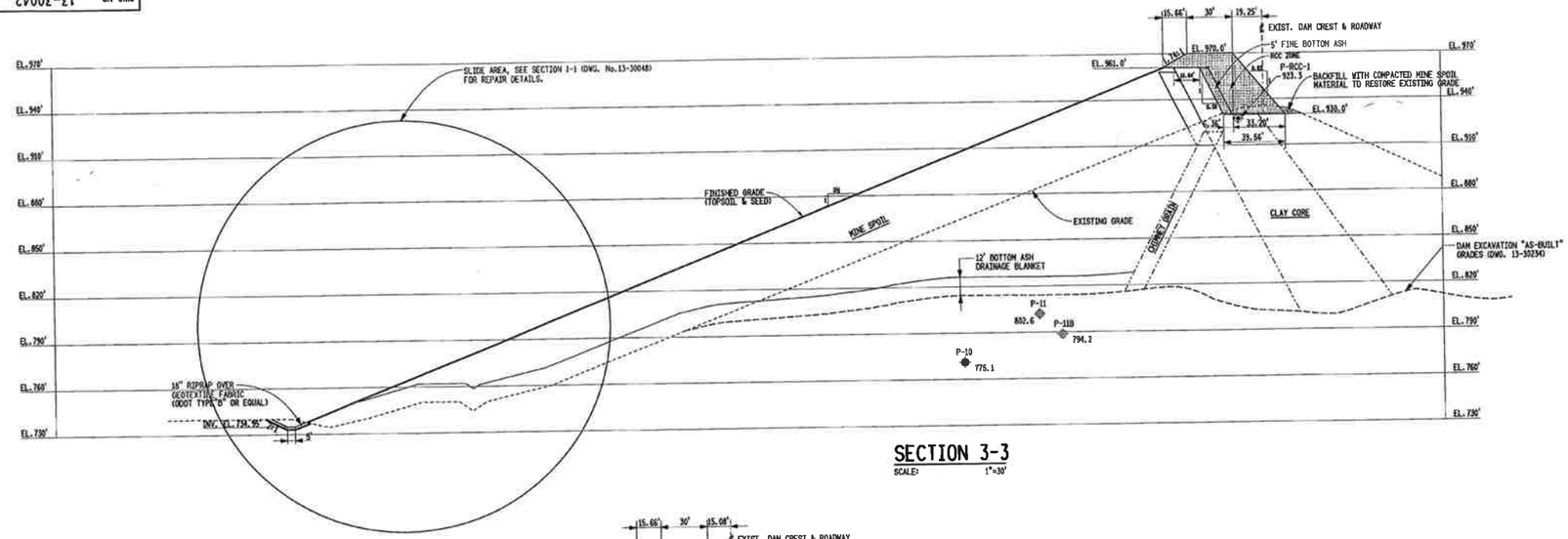
DRN: CHK: DESIGN: PROJ. ENGR: DATE:

APPROVED BY:

AEP AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

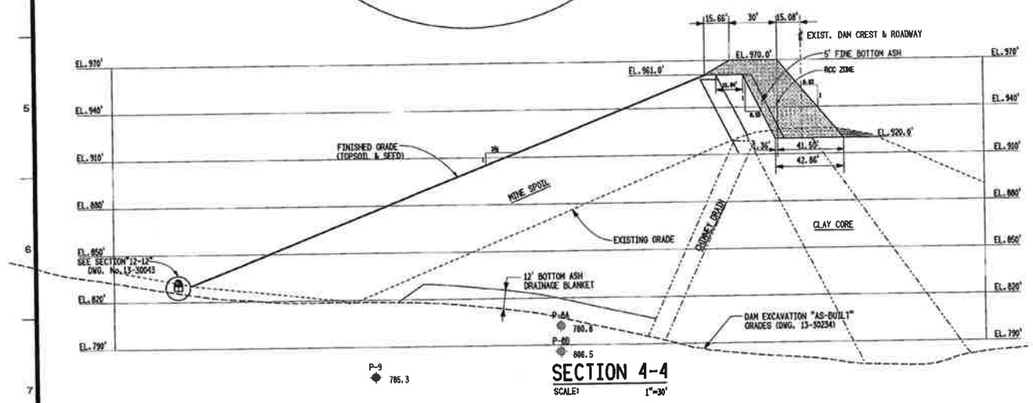
SYSTEM DATE: 17 MAY 2006 SYSTEM TIME: 09:45:55 RSVN FILE: CCD

DWG. NO. 13-30042



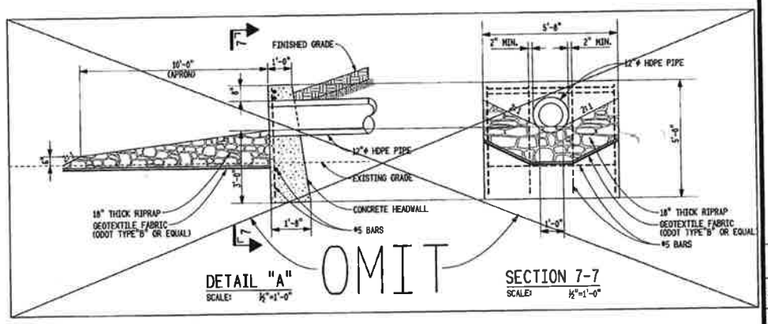
SECTION 3-3

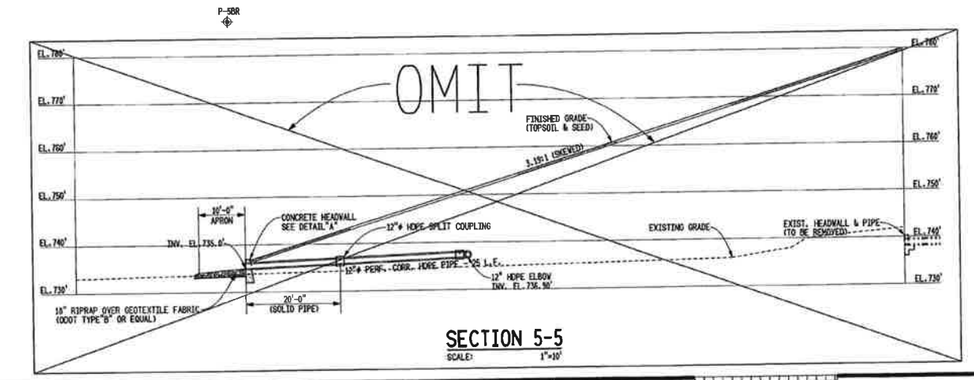
SCALE: 1"=30'



SECTION 4-4

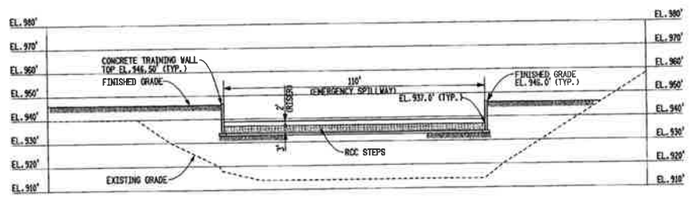
SCALE: 1"=30'





SECTION 5-5

SCALE: 1"=10'



SECTION 6-6

SCALE: 1"=20'

GENERAL NOTES

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

REFERENCE DRAWINGS

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

REVISIONS			
4	REVISED TO SHOW INSTALLATION DEPTH OF PNEUMATIC PIEZOMETER, AND DAM "AS-BUILT" EXCAVATION GRADES.		
3	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE.		BAK
2	REMOVED HIGHER & LOWER RCC FACING & ZONE.		JBP
1	REV. SECTS. "3-3" & "4-4", OMITTED SECT. "5-5", "7-7" AND DETAIL "A".		JBP
0	ISSUED FOR CONSTRUCTION.		AMT
DATE NO.	DESCRIPTION		APPD

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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

SCALE: AS NOTED — CIVIL ENGINEERING DIVISION

DR: BAK
CH:
ENGR:
PROJ ENGR:
DATE:

APPROVED

AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

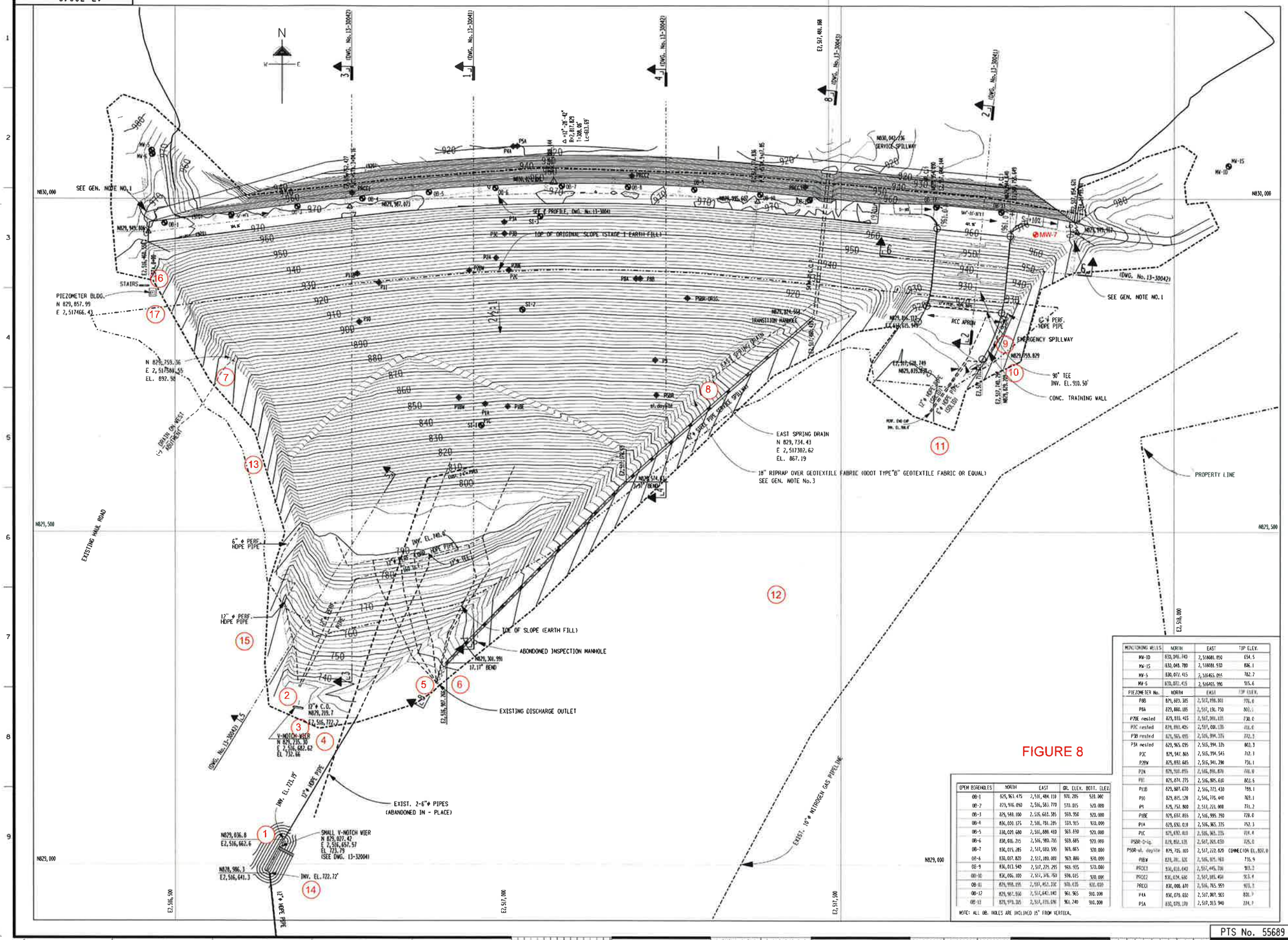
PTS No. 55689

FIGURE 7B

Appendix F : Seepage Collection Drains

Cardinal Fly Ash Dam II - Drains and Seepage Zones				
	Date of Inspection:	11/21/2018		
Drain Number & Location	**Drain Source**	**Outlet Size**	**Amount (GPM)**	**Clarity**
1. D/S Open Weir	Chimney / toe drain system	12" Dia.	20gpm	Clear
2. D/S Right Abutment	Right abutment valley	12" Dia.	145 gpm	Clear
3. D/S Right Abutment	Slag Buttress / right abutment	12" Dia.	<1gpm	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.	20gpm	Clear
6. Stilling Basin / Left Side	East side of stilling basin	6" dia.	15gpm	Clear
7. Right Groin Ditch	West Bedrock abutment 900' elevation	12" Dia.	27.3gpm	Clear
8. Left Groin Ditch	East Tributary valley abutment 905"elevation	6" dia.	7.5gpm	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	4gpm	Clear
12. E/S Outlet Channel	Total Seepage within Emergency Spillway	10: Dia.	30gpm	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	105MGD	Clear

DWG. NO. 13-30040



OPEN BOREHOLES	NORTH	EAST	GR. ELEV.	BOTT. ELEV.
OB-1	829,961.475	2,516,484.118	970.205	920.000
OB-2	829,916.090	2,516,583.778	970.005	920.000
OB-3	829,968.100	2,516,683.385	969.950	920.000
OB-4	830,030.175	2,516,784.289	969.915	920.099
OB-5	830,029.680	2,516,884.468	969.850	920.000
OB-6	830,016.215	2,516,983.785	969.685	920.000
OB-7	830,015.285	2,517,083.590	969.665	920.000
OB-8	830,037.820	2,517,180.000	969.886	920.000
OB-9	830,813.940	2,517,229.295	969.935	920.000
OB-10	830,686.100	2,517,376.750	970.015	920.000
OB-11	829,958.295	2,517,452.330	970.035	920.000
OB-12	829,967.550	2,517,642.140	961.965	910.000
OB-13	829,973.305	2,517,775.690	961.240	910.000

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

MONITORING WELLS	NORTH	EAST	TIP ELEV.
MW-10	830,048.740	2,516681.856	654.5
MW-15	830,048.780	2,516888.933	806.1
MW-5	830,077.415	2,516465.094	782.2
MW-6	830,077.415	2,516465.396	915.6
PIEZOMETER No.	NORTH	EAST	TIP ELEV.
P3B	829,603.365	2,517,198.301	796.8
P8A	829,866.185	2,517,176.750	860.1
P7DC nested	829,933.465	2,517,398.435	830.0
P3C nested	829,894.425	2,517,600.135	755.0
P3B nested	829,565.695	2,516,394.335	792.3
P3A nested	829,965.095	2,516,394.335	802.3
P3C	829,947.865	2,516,394.545	712.3
P2BV	829,892.665	2,516,341.290	736.1
P2A	829,910.895	2,516,286.870	748.0
P1C	829,674.275	2,516,805.610	802.5
P1B	829,887.670	2,516,173.430	769.1
P1C	829,815.120	2,516,776.640	769.1
P5	829,752.800	2,517,221.008	771.2
P1BE	829,697.855	2,516,995.390	728.0
P1A	829,592.010	2,516,965.335	752.3
P1C	829,692.010	2,516,965.335	719.4
PSBR-Orig.	829,852.135	2,517,265.630	825.0
PSBR-ml. daylite	829,705.160	2,517,222.629	CONNECTION EL.820.0
P8BW	829,781.826	2,516,875.980	735.9
P9DEE	830,618.643	2,517,445.236	903.3
P9DEE	830,634.686	2,517,385.459	903.4
P8DEE	830,098.879	2,516,765.969	903.3
P4A	830,078.656	2,517,007.963	830.3
P5A	830,098.139	2,517,013.946	834.9

FIGURE 8

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

- +(970.0') FIN. GRADE SPOT ELEV.
- 920 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.
9/18/09	5	REVISED TO REFLECT AS-BUILT CONDITIONS. FINAL SUBMITTAL TO STATE	MJH
3/19/09	4	AS-BUILT REVISED TOPO, DRAIN PIPES , ADDED TABLES, PIEZOMETERS AND OPEN BORE HOLES. REMOVED MONITORING WELLS 4, 5, 20 & 25	MJH
4/23/08	3	REMOVED INTERMEDIATE CONTOURS. INDICATED CONCRETE TRAINING WALL & GEOTEXTILE FABRIC.	MJH
3/28/08	2	DELETED DROP MANHOLE & REV. PIPE ALIGNMENT.	MJH
6/23/06	1	REV. TOE OF DAM TO REFLECT SLIDE REPAIR. RELOCATED DROP MANHOLE & REV. PIPE BEND, 6"30° WAS 6" ADDED UNDERDRAIN SYSTEM.	MJH
10/17	0	ISSUED FOR CONSTRUCTION.	JCW

REVISIONS

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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

DES. PCS | DRWN. CC | CHKD. DJW | PROJ. ENGR. | DATE: 4/2007 | APPROVED: M. Joseph Bubac

AEP AMERICAN ELECTRIC POWER — 1 RIVERSIDE PLAZA COLUMBUS, OH 43215

PTS No. 55689

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