Attachment A
DISCIPLINE QUALITY CHECK & REVIEW CERTIFICATION

The Geosystems Branch of the Jacksonville Engineering Division has completed the Discipline Quality Checks and Reviews for the *2019 HHD Instrumentation Report*. This review was conducted in compliance with EC 1165-2-209, Civil Works Review Policy dated 31 January 2010, ER 1110-1-12, Quality Management dated 30 September 2006 and 02611-SAJ Quality Management of In-House Products: Civil Works PED. The Discipline Quality Checks and Reviews included a comprehensive evaluation of: correct application of methods; adequacy of basic data and assumptions; correctness of calculations; quantity estimates; testing, modeling, assumptions, calculations, text, and graphic presentations in all documents are complete, satisfy appropriate design criteria, and utilize sound engineering practice; compliance with guidance; standards, regulations, and laws; biddability, constructability, operability, and environmental issues; and completeness of documentation. All comments and/or issues raised during the Discipline Quality Checks and Review of the *2019 HHD Instrumentation Report* have been resolved. The Discipline Review Checklists used during this review are attached and include the following:

Prepared By: Raoaa F. Essa, P.E.

Date Submitted for Review: 05/05/2019

Technical Review By: Bradley R. Cox, P.E.

Date Reviewed & Returned: 05/30/2019

Date Corrections Made
And Submitted to Chief: 06/28/2019

Discipline Specific Quality Control Team Authorization

Primary Review, Dams and Levee Section — Date: 7/24/19

Secondary Review, Dam Safety Program Manager — Date: 7/30/2019

Chief, Dams and Levee Section — Date: 7/30/2019

Chief, Geosystems Branch — Date: 07/30/2019

US Army Corps of Engineers®

2019

HERBERT HOOVER DIKE (FL36001)

INSTRUMENTATION REPORT NO. 17

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EXECUTIVE SUMMARY

The discussion and analysis of instrumentation readings contained within this year's Herbert Hoover Dike (HHD) Instrumentation Report (calendar year 2018) includes individual analyses and observations from 44 lines of piezometers. These piezometer lines are made up of 190 individual open standpipe piezometers placed along the HHD alignment for the purpose of monitoring the piezometric response of the dam, with regards to seepage and piping failure modes. In addition, 28 staff gauges have been installed at piezometer lines throughout Reaches 1, 2, 3, 4 and 6. Provided within this Executive Summary is a generalized discussion of observations, changes, and action items, as they relate to the monitoring program as a whole. This Instrumentation Report includes an additional year of data collected since the previous published annual report; the additional year of data is from 1 January 2018 to 1 January 2019.

Review of the data collected since last year's instrumentation report indicates there are no alarming conditions that require immediate corrective action. Assessments of the tail water staff gauges are included within the analysis for each piezometer line and are also accompanied by (where applicable) horizontal and vertical gradient calculations to assist with estimating the dam performance. With time, the continual collection of tailwater measurements will permit more concise assessment of dam performance at these piezometer lines and as they become better understood, the assessments will be improved and expanded. Addition of this information also appears to have changed historic understanding of performance at several piezometer lines. As the timeframe the site specific tailwater responses increases, analysis and understanding of performance is increased.

An overall project map that includes reach designations is included as Figure 1. This map of Lake Okeechobee and HHD is also useful for identifying pertinent information related to the instrumentation program; including, piezometer line locations, population centers, reaches, structures, canals, and completed cutoff wall task orders. Also, an overall project map that includes the Common Inundation Zones (CIZ) is included as Figure 2.

At the start of 2018, the lake was just above elevation (El) 15. Typically, from January to May the lake slowly recedes until the start of the wet season (May). Lake stages from this year followed this typical trend. On May 12, 2018, the lake bottomed out just below El 12.84. The lake slowly increased in elevation during the wet season to an El of 14.8 on September 16, 2018. Following the peek, the lake steadily receded the remainder of the year, to approximately El 12.7 feet. Unless otherwise noted, all elevations in this report are reported in feet with respect to the National Geodetic Vertical Datum of 1929 (NGVD29).

An additional year's worth of data was collected for the 56 piezometers (12 piezometer lines) installed and began reading in April 2013 for the Dam Safety Modification Study (DSMS). From review of the available data for the DSMS piezometers, no alarming conditions that require immediate corrective action have been identified. Collection of this data further improves our understanding of piezometric response in these areas and continues to provide useful insight, particularly for predicting embankment and foundation performance during high pools.

Analyses of all the instrumentation data, with consideration of past performance, indicates that many areas of HHD exhibit conditions that show cause for concern, should the lake exceed pool elevations higher than approximately El 16.5. However, given that the lake reached El 17.2 feet in October 2017, there were no additional concerns that arose from prior stages between El 16.0 and El 17.2. Reaches 2 and 3 are still of concern and exhibited signs of seepage (clear flowing water, saturated toe or berm and standing water), as no permanent remedial actions have been completed. Reaches 2 and 3 remain the most vulnerable to seepage and piping problems. Reach 1 did not exhibit any signs of distress when the lake reached El 17.2 in October 2017.

Although no alarming conditions have been identified as a result of this year's review, monitoring of all piezometers should continue as currently prescribed. Continual collection and interpretation of piezometric data in locations where cutoff wall has not been installed will continue to increase our understanding of the embankment and foundation response under reservoir loading. This will allow the establishment of a baseline against which performance can be monitored once remediation actions are implemented, for predicting dam performance at higher pools, and for establishing/monitoring reading thresholds. In areas where the cutoff wall has been installed, continual monitoring is essential to understanding long term performance of the cutoff wall. To review detailed and location-specific information regarding piezometric response and analysis for each piezometer line, reference Sections 6 through 10 of this report.

HHD Piezometer Program Action Items and Improvements

Over the past couple of years, the efforts made to correct reported deficiencies, improve the piezometer report analyses and supporting documentation, streamline the instrumentation program, and improve data management and field verification/inspection have been fully realized. Completion of many action items, improvements, and maintenance tasks was made possible and was successful due to effective communication and coordination between Jacksonville District Engineering Division (SAJ-EN) and the South Florida Operations Office (SFOO). As a result of these efforts, the notable improvements to the HHD Instrumentation Program have been implemented in the field and with data management and analysis. With exception of improvements to analysis and interpretation, no additional notable improvements have been made this year. Overall, the HHD instrumentation program is in acceptable condition.

Although major efforts have been accomplished and the program is in acceptable condition, several maintenance efforts remain. The most important of the tasks include: flushing of the DSMS PZs and addressing piezometer pads/lids that are too close to the riser pipe and subject the riser pipes to damage. Information regarding the remedial work performed to date is discussed in Section 4.4.2 History of Completed Maintenance and Action Items. Additional work necessary to maintain the current program is discussed in Section 11 Conclusions And Recommendations. It is recommended that these activities be reviewed and prioritized by the team, as necessary to identify FY funding for accomplishing these tasks in a timely manner.

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1. PROJECT DESCRIPTION

Herbert Hoover Dike (HHD) is an earthen embankment system located along the perimeter of Lake Okeechobee, a 730 square-mile freshwater lake in south Florida (see Figure 1 below). Components of the HHD embankment system have been constructed intermittently since the early 1900s. Federal involvement began in the 1930s with the construction of dikes for storm damage risk reduction along portions of the north and south shores (known today as Reaches 1, 2, 3, 4, and 5 or Common Inundation Zones (CIZ) A, B, and F). Construction of HHD was accomplished by a combination of blasting and dredging from borrow areas located parallel to the HHD alignment. These borrow areas can be seen on the cross section drawings in Appendix C as deep pits adjacent to the embankment and are referred to herein as the borrow canal(s), navigation canal(s), and/or borrow source. These borrow sources can be landside or lakeside of the HHD embankment. Generally speaking, for the northern half of Lake Okeechobee, the borrow source resides landside of the embankment and for the southern half, the borrow source is situated lakeside of the embankment.

HHD was constructed in two phases. The 1930s construction marked the first federal involvement in Lake Okeechobee and was initiated after devastating hurricanes breached the levees constructed by local and state interests. The second phase of construction (1960s) was planned and executed under the Central and Southern Florida Project (C&SF, authorized by congress in 1948), which included raising the embankment that bordered the north and south shores and constructing new embankments on the northwest and northeast shores (known today as Reaches 4, 6, 7, and 8 or CIZ's B, C, D, E, and G). After completion of construction in the 1960s, the HHD system fully encircled Lake Okeechobee, with exception of Fisheating Creek on the western shore where "tie-back" embankments tie the system into higher ground. The lake, embankment system, and related features are integral components of the complex C&SF Project with functions that are related to storm damage risk reduction, navigation, agricultural and municipal water supply, prevention of saltwater intrusion, recreation, and the enhancement of environmental resources.

The existing embankment is approximately 143 miles in length, with the typical crest height ranging from approximately 15 to 30 feet above the adjacent land surface. In addition to the earthen embankments, the HHD system also includes numerous water control structures (e.g. culverts, spillways, locks, and pump stations) along its length. Although HHD was originally authorized and constructed as a levee, it is now classified as a dam and is included in the National Inventory of Dams (NID). In 2005, the USACE reviewed HHD under the Screening Portfolio for Risk Analysis (SPRA) method of review and documentation. In 2006, the assessment of HHD under the SPRA method determined that HHD be classified as a Dam Safety Action Classification 1 (DSAC 1) - Urgent and Compelling, which is the highest urgency rating of the five DSAC ratings.

As of 2013, HHD has been the subject matter of a Dam Safety Modification Study (DSMS) in order to estimate the Annual Probability of Failure (APF) and Average Annualized Life Loss (AALL) for the potential failure modes identified at the HHD. The report has also identify risk reduction measures to implement at specific locations where risk is above USACE tolerable risk guidelines. After implementation of the Dam Safety Modification Report's (DSMR) proposed risk reduction measures, it is anticipated that the DSAC rating of the dam will change.

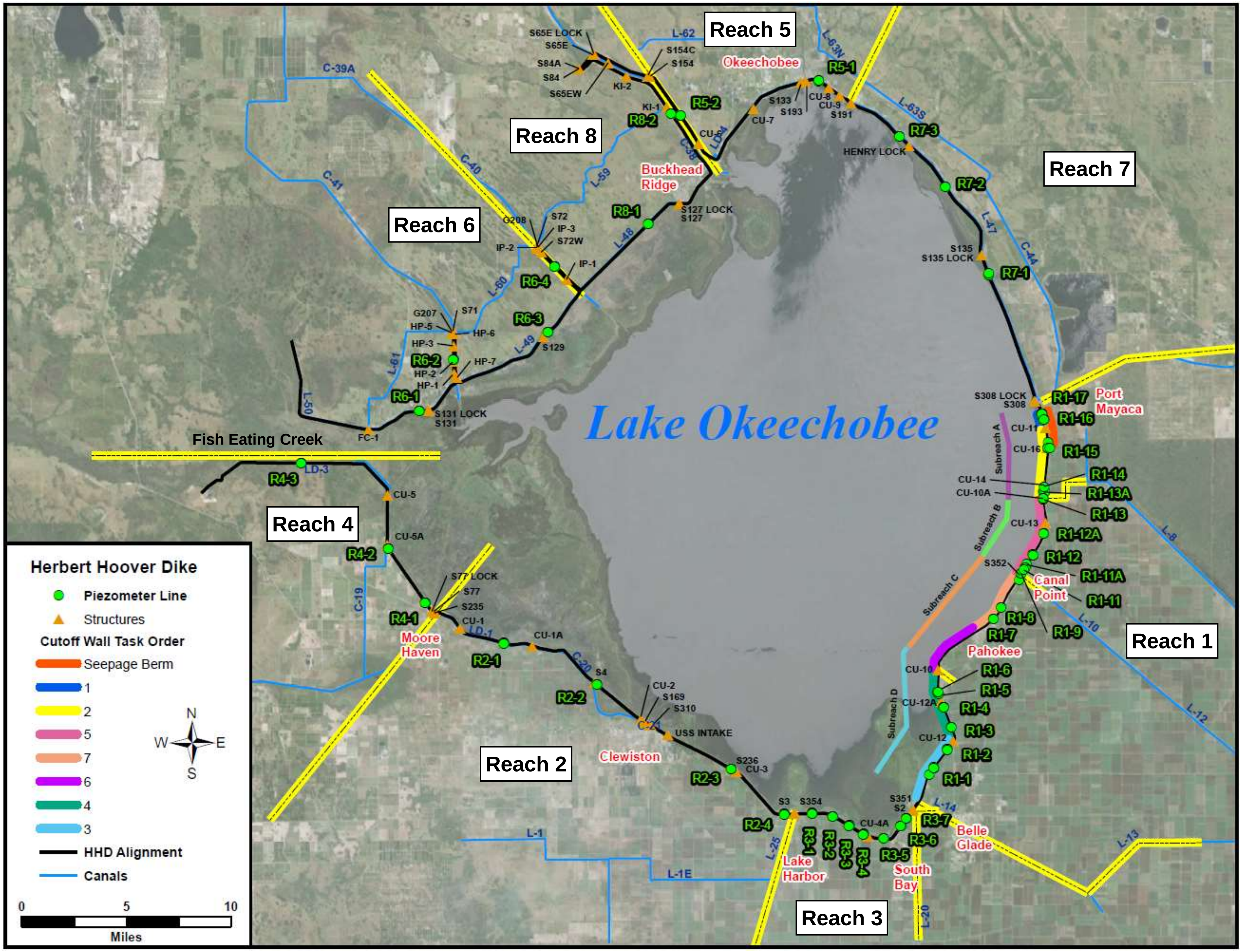

Figure 1: HHD Reach and Piezometer Line Location Map

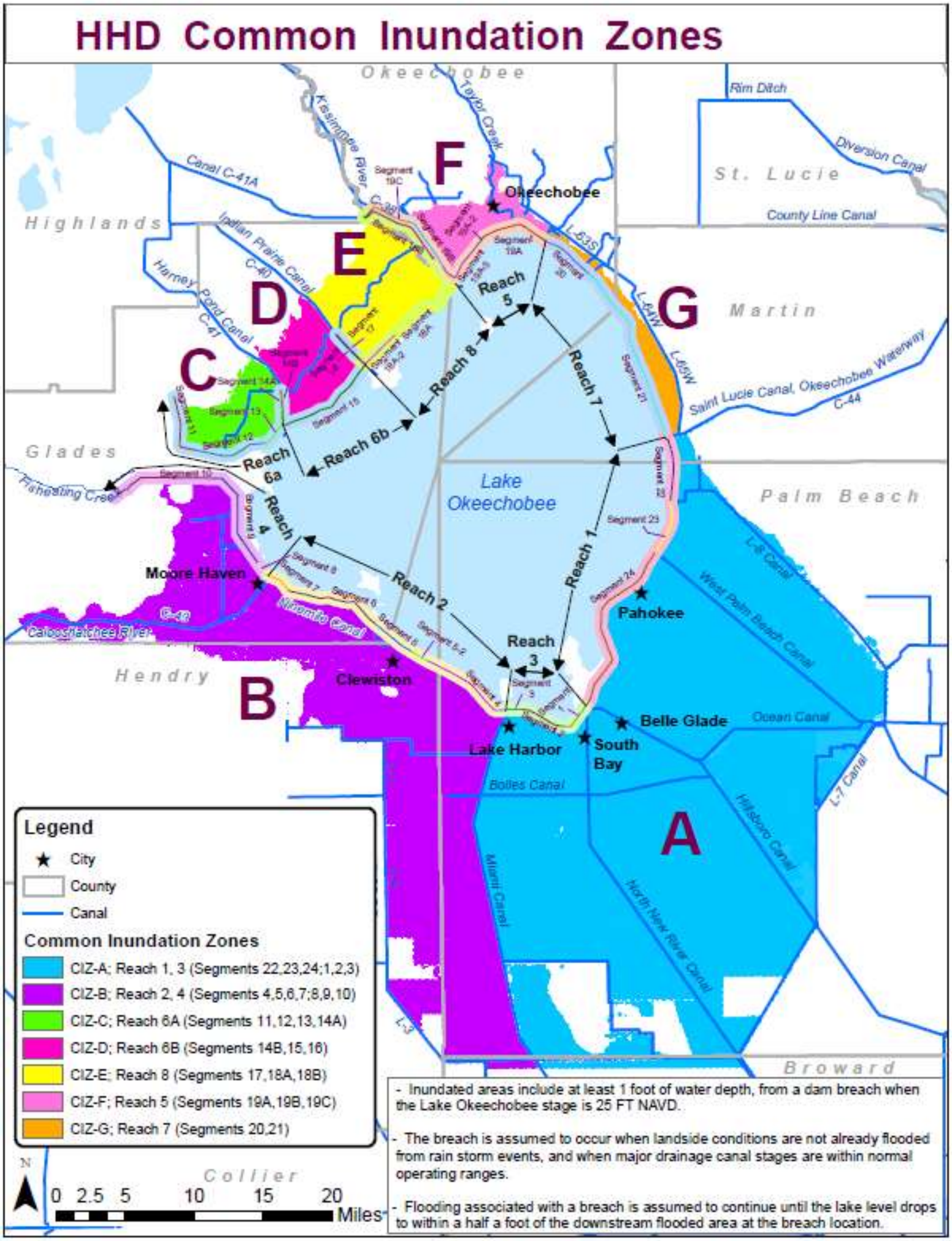

Figure 2: HHD Reach and Common Inundation Zones

2. BACKGROUND

Since focused monitoring began at HHD, the lake stage at which initiation of internal erosion and/or sand boils occur is lower than previously recorded. Initiation at lower lake stages indicates that the conditions have not been self-healing and the problem will continue to deteriorate the embankment and foundation over time, especially during high water events. The majority of the piezometers installed at HHD were installed because of the observance of internal erosion and/or sand boils, thus the instrumentation program at HHD was initiated as a result of growing concerns over the aging embankment system and initial signs of instability from through seepage and underseepage.

Beginning in 1994, piezometers were installed in various locations around HHD to monitor the embankment phreatic surface and underlying foundation pressures. Approximately 19 lines of piezometers were installed in poor-performing areas of HHD (Reaches 1, 2, 3, and 7 or CIZs A, B, and G) between 1994 and 1999. These original piezometer lines were also studied and documented in the Major Rehabilitation and Evaluation Report dated 2000 (MRR 2000).

An additional 13 lines of piezometers were installed between 1999 and 2010, the purpose of these varies – the purpose of many are not well documented; some were installed in areas having historic poor performance and others to monitor the aging culvert structures or the Reach 1 cutoff wall.

The 32 lines of piezometers installed between 1994 and 2010 are made up of 134 individual open standpipe piezometers. The data collected from these piezometers is utilized to monitor the performance of the dam with respect to changing lake levels. In turn, this information is used for engineering analyses/monitoring, predicting the performance of HHD during high water events, and for design of future remediation measures to address seepage and piping failure modes. Since the cutoff wall has been installed in Reach 1, data collected in this location is also used to assess the long term performance of the cutoff wall.

Initiated in 2012 and completed in 2013, 12 additional piezometer lines (56 piezometers) were installed as a part of the HHD DSMS to gather data, and to begin monitoring piezometric responses in reaches previously unmonitored.

To date, there are a total of 44 lines of piezometers (190 individual piezometers) along the HHD alignment that are maintained and read at predefined intervals. Each reach at HHD now has at least two lines of piezometers. The greatest concentration of piezometers remains within the poorest performing areas of HHD (Reaches 1, 2, and 3 or CIZ’s A and B), as these areas have the longest history of seepage/piping during high water events.

The discussion and analysis of instrumentation readings contained within this report includes individual analyses and observations for each of the piezometer lines at HHD.

2.1. Essential Information about this Instrumentation Report

Since the scope of the instrumentation program is wide reaching and complex due to the number of piezometers installed, the long history of HHD, and varying conditions across nearly 730 square miles the program extends, the following is provided to assist the reader in navigating this report and the information discussed within.

Provided in Figure 1 above is a map of Lake Okeechobee and HHD with pertinent information related to the instrumentation program. This map is useful for identifying piezometer line locations, population centers, reaches, structures, canals, completed cutoff wall task orders, and rainfall and tailwater monitoring points. In addition to the location map, Figure 4 below shows a profile of the

Reach 1 cutoff wall tip elevations, task order limits with cutoff wall contractor, locations of cutoff wall gaps around structures, piezometer line locations, subreaches, and focus areas (focus areas – areas that were identified as critical locations to perform interim repairs (i.e. toe ditch backfill and quarry backfill), per the HHD Interim Risk Reduction Measures Plan). Together, these figures provide spatial reference information that is useful for understanding discussions and interpretations within this report.

To interpret and document the performance of HHD, time-history plots, hysteresis plots, and cross sections of each piezometer line are provided in the appendices. For the HHD Instrumentation Report, five years of piezometer data is provided on the time-history plots, while period of record data is included on the hysteresis plots. For historical accuracy, citations of the historic conditions present at the piezometer lines are maintained, even if the event timeframe may not be shown on the 5 year window of the time-history plots.

Piezometer Line Cross Sections provided in Appendix C:
- Topographic survey cross section
- Hydrographic survey cross section (where available and applicable)
- Note: Elevations on the Piezometer Line Cross Sections are in NGVD29.
- Subsurface information from borings, including boring designation, material classification, and N-values
- Piezometer names with graphical representation of screened/monitoring interval
- Tailwater Staff Gage, when applicable.
- Aerial view of the piezometer line showing the piezometers and adjacent lakeside and landside features

Data range dates for this report:
- Time-History Plots (Appendix D) – 5 years, January to January of report year
- Hysteresis Plots (Appendix E) – From inception to January of report year (period of record)

Piezometer Line Naming Conventions: Piezometer lines follow a naming convention based on which reach of HHD they were installed in and take the format of R# - #
- "R#*" refers to "HHD reach number"*
- " - #" refers to the piezometer line number within that reach
- For Example: R2-3 refers to the third piezometer line in Reach 2
- "-TW" indicates tailwater staff gauge

Boring and Piezometer Naming Convention:
When borings are performed at HHD or when piezometers are installed, a naming convention which indicates their location with respect to the embankment has generally been followed. This naming convention of core borings and piezometers typically follows an "ABC" concept, as explained below and shown in Figure 3.
- Borings or Piezometers with letter A, B, or C toward the end of their name:
    - "A"- Located lakeside or upstream of the crest
    - "B"- Located in the centerline of the embankment. In areas where cutoff wall is installed, these piezometers are generally located upstream of the cutoff wall.
    - "C"- Located at the landside toe or downstream of the crest
- Historic borings (generally any boring performed before 1990) do not adhere to this naming convention.

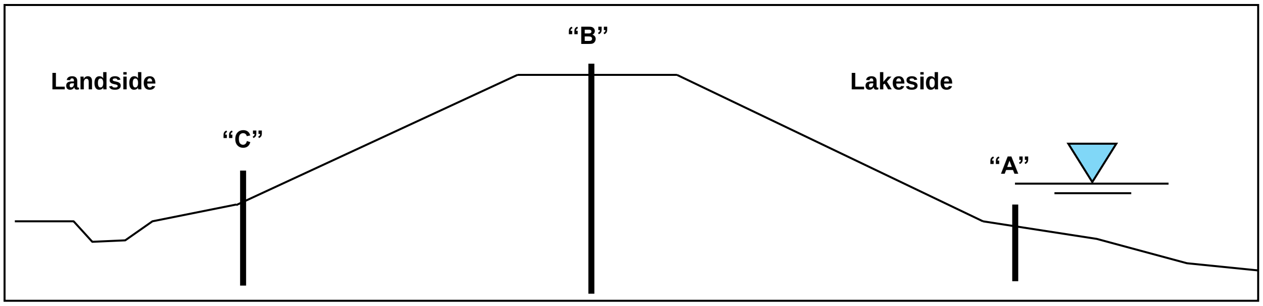

Figure 3: Naming Conventions of Core Borings and Piezometers

Vertical Datum used in this Report:
Unless otherwise noted, all elevations in this report are reported in feet with respect to the National Geodetic Vertical Datum of 1929 (NGVD29). Much of the surface water stage data used in this report is maintained by South Florida Water Management District (SFWMD), in corporation with the USACE. All of the operation schedules for the C&SF Project and the database that houses surface water data remain in NGVD29. NGVD29 is not the preferred datum; however, since the USACE and SFWMD still utilize the legacy datum, all surface water data presented in this report will remain in this legacy datum until the C&SF Project is updated.

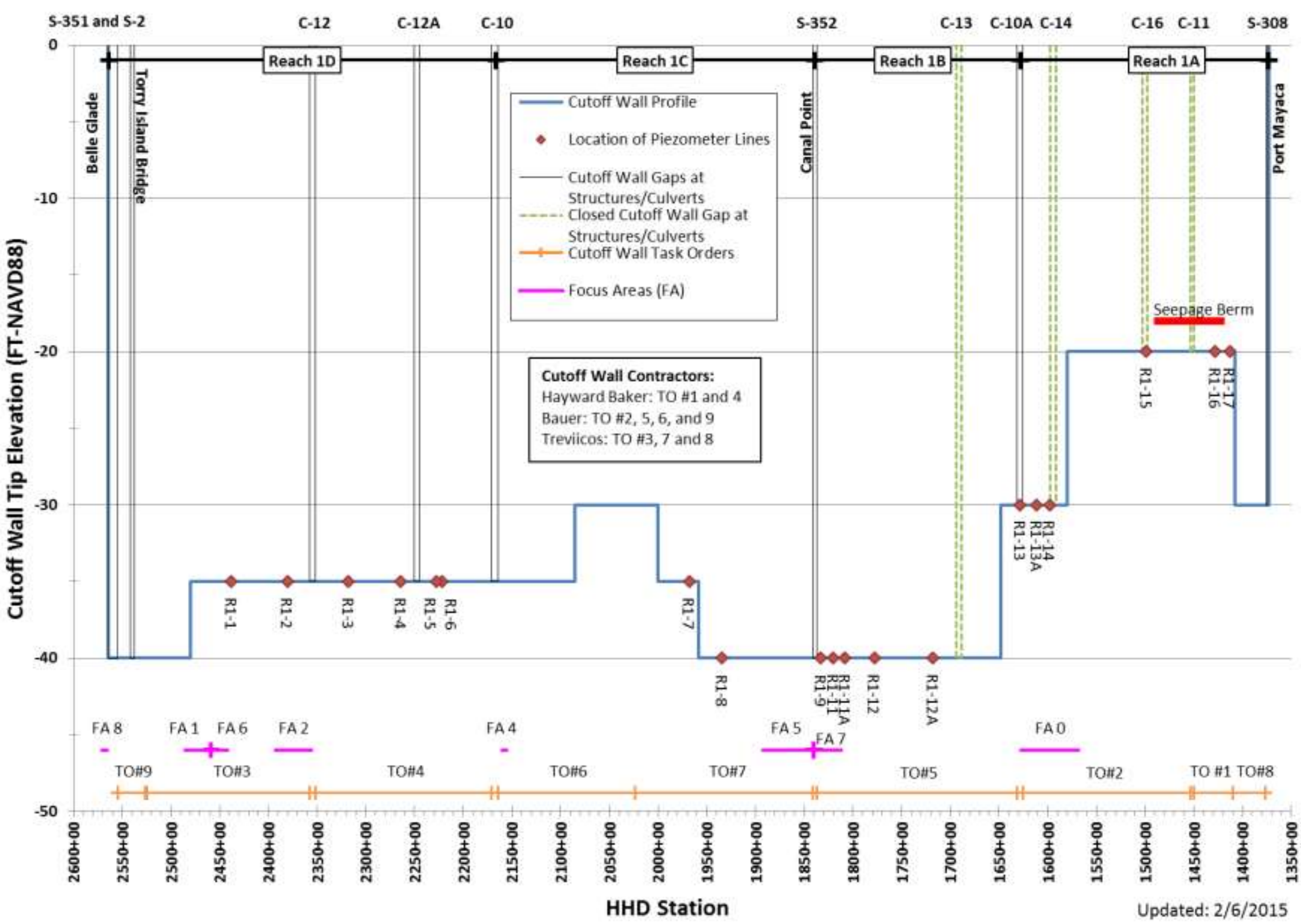

Figure 4: HHD Reach 1 Cutoff Wall Tip Profile, Piezometers, and Other Relevant Information

3. GENERAL GEOLOGY DESCRIPTION

Most of the geologic history significant to the current study of HHD has occurred in the last one million years. The Lake Okeechobee region is part of the Florida Carbonate Platform that is a stable structure 400 miles wide and 600 miles long. The Lake Okeechobee region has historically been a local depression within that structure. The driving force for the history of the region is the four major and numerous minor, glacial episodes that have occurred in the last million years. As each glacial episode developed, sea levels fell and the Lake Okeechobee basin became a fresh water lake in which fresh water sediments were deposited. When the glaciers retreated, sea levels rose and covered the Okeechobee Basin resulting in the deposition of marine sediments. The rising and falling sea levels resulted in accretion and then erosion of the Florida Carbonate Platform and created the current configuration of the Florida coastline. As this process repeated, freshwater and saltwater mixed and exchanged positions. This exacerbated the in-situ weathering, decomposition, and solutioning, and in some cases altering the marine carbonates into “honeycombed” limestone and residual soils consisting of sands, silts, and clays, sometimes referred to as marls.

The reoccurring glacial episodes carved several different coastal scarps across Florida as rising and falling ocean levels engaged the landmass at different elevations. The resulting “steps” or terraces were the catalyst for subsequent surface erosion and the origin of terrestrial material redeposited as alluvial sands, silts, clays, and shells. The continuous changes in sea level led to conditions that encouraged the formation of caliche, hard pans, and cap rocks within the sediments. This process has created hardened seams, stringers, and rock-like layers within the sediments near Lake Okeechobee. The general topography of the Lake Okeechobee region gently slopes from the north-northwest to the south. The most recent alluvial deposits are derived from the upland ridges and terraces to the north and west of Lake Okeechobee. The Kissimmee River and Fisheating Creek carry sands and silts down gradient along the drainages, ultimately depositing the material along the northern and western lakeshores.

Within the past five thousand years, organic soils accumulated in the Lake Okeechobee- Everglades Basin in shallow ponds, lakes, and swamps. Organics one to 15 feet thick have been observed in the Lake Okeechobee area. They are composed of brown to black, fibrous peat, silt, and organic material consisting of terrace sand and silt.

Reaches 1, 2, 3, and 7 of Lake Okeechobee are characterized by a peat layer that approximates the top of natural ground, and with depth, the clay and silt content of the peat increases. This layer acts as a surficial confining unit. Underlying the peat layer is a hard to soft, thin rock-and-shell lens, known as the Lake Flirt Marl limestone formation, also referred to as the upper limestone layer. The limestone layer is generally underlain (but sometimes overlain or intermixed) by a layer of silty and clayey soil that can act as a surficial semi-confining or confining layer. Below these strata are layers of sand and limestone/sandstone that transitions into a silty, shelly sand with depth. Within the northern end of Reach 7 and western Reach 2, the peat layers become thin or nonexistent.

It is noted that the natural topography of the region has been significantly altered from its original condition by numerous features including roadway fill, railroad fill, ditch excavation, navigation channel excavation, borrow canals, water control structures, farming activities, and the construction of HHD. These alterations, contribute to the high degree of variability in subsurface conditions seen near the predevelopment ground surface. In general, the topography on the landside of HHD is lowest (by a few feet) along the southeast side of Lake Okeechobee.

4. HHD INSTRUMENTATION PROGRAM

As mentioned previously, the instrumentation program at HHD was initiated as a result of growing concerns over the aging embankment system and initial signs of instability as a result of through seepage and underseepage. Since inception, the program has been evolving to include additional goals and objectives. The goals and objectives of HHD Instrumentation Plan include monitoring and documenting embankment and foundation piezometric response throughout the entire system for the purpose of:

- Monitoring identified potential failure modes (internal erosion through the embankment and internal erosion through the foundation)
- Predicting future performance under high pools and extreme pools (SPF/PMF);
- Calculating gradients and determining the head at which seepage and piping are likely to initiate and use this information to set limits/trigger points on critical piezometers for identifying issues at the time of or before they are observed by inspection;
- Calibrating seepage models for the design of remediation measures;
- Monitoring the long term performance of the Reach 1 cutoff wall;
- Establishing a baseline for evaluating the effect of future remediation measures; and
- Developing an understanding of the performance of the embankment and foundation in areas that have been less explored and have yet to exhibit seepage and piping problems (DSMS Piezometers), for the purpose of supporting probability of failure estimates and the necessity for remediation.

4.1. Instrumentation Sections

To accomplish these goals, the 44 piezometer lines (each with multiple open standpipe piezometers) that exist along the HHD alignment are analyzed annually and documented within this report. For developing a macro understanding of the trends observed at each piezometer line, the piezometer lines have been grouped into five sections:

Section A: Reaches 2 & 3 – Includes Piezometer Lines R2-1 through R3-7
Section B: Reaches 1C & 1D – Includes Piezometer Lines R1-1 through R1-8
Section C: Reaches 1A & 1B – Includes Piezometer Lines R1-9 through R1-17
Section D: Reach 7 – Includes Piezometer Lines R7-1 and R7-2
Section E: DSMS Piezometers – Includes all Piezometer Lines in Reaches 4, 5, 6, and 8, and Piezometer Line R7-3

Individual piezometer names, staff gauges and associated piezometer lines and sections are shown in Table 1 through Table 5 below.

Table 1: Section A – Individual Piezometers and Piezometer Lines

Section A – Reaches 2 & 3 (CIZ A & B)			
R2-1 (CIZ B) PZ-R2-A-A PZ-R2-A-B1 PZ-R2-A-B2 PZ-R2-A-C S235_H	R2-2 (CIZ B) PZ-R2-B-A PZ-R2-B-B1 PZ-R2-B-B2 R2-2-TW S4_H	R2-3 (CIZ B) PZ-R2-E-A PZ-R2-E-B1 PZ-R2-E-B2 R2-3-TW S236_H	R2-4 (CIZ B) PZ-R2-F-A PZ-R2-F-B1 PZ-R2-F-B2 PZ-R2-F-C E2-4-TW
R3-1 (CIZ A) PZ-R3-D-A1 PZ-R3-D-A2 PZ-ER3-D-B PZ-R3-D-C1 PZ-R3-D-C2 R3-1-TW	R3-2 (CIZ A) PZ-MRR3-SH-B1 PZ-MRR3-SH-B1A PZ-MRR3-SH-B2 PZ-MRR3-SH-C1 PZ-MRR3-SH-C2 R3-2-TW	R3-3 (CIZ A) PZ-R3-C-A1 PZ-R3-C-A2 PZ-R3-C-B PZ-R3-C-C1 PZ-R3-C-C2 R3-3-TW	R3-4 (CIZ A) PZ-R3-E-A1 PZ-R3-E-A2 PZ-ER3E-B PZ-R3-E-B2 PZ-R3-E-C1 PZ-R3-E-C2 R3-4-TW
R3-5 (CIZ A) PZ-R3-B-B1 PZ-R3-B-B2 PZ-HHD16-R3-3C R3-5-TW	R3-6 (CIZ A) PZ-R3-F-A1 PZ-R3-F-A2 PZ-ER3P4-B1 PZ-ER3P4-B2 PZ-ER3P4-C PZ-HHD16-R3-2C R3-6-TW	R3-7 (CIZ A) PZ-R3-G-A1 PZ-R3-G-A2 PZ-R3-G-B1 PZ-R3-G-B2 PZ-HHD16-R3-1C R3-7-TW	

Table 2: Section B – Individual Piezometers and Piezometer Lines

Section B – Reaches 1C & 1D			
R1-1 (CIZ A) PZ-HHDR1-4B2 PZ-HHDR1-4B1 PZ-HHDR1-4C2 PZ-HHDR1-4C1 R1-1-TW	R1-2 (CIZ A) PZ-HHDR1-6B2 PZ-HHDR1-6B1 PZ-HHDR1-6C2 PZ-HHDR1-6C1	R1-3 (CIZ A) PZ-HHDR1-7B PZ-HHDR1-7C2 R1-3-TW	R1-4 (CIZ A) PZ-1 PZ-4 PZ-7 PZ-2 PZ-5 PZ-8 PZ-3 PZ-6 PZ-9 R1-4-TW
R1-5 (CIZ A) PZ-HHDR1-10B1 PZ-HHDR1-10B2 PZ-HHDR1-10C2 PZ-HHDR1-10C1 R1-5-TW	R1-6 (CIZ A) PZ-ER1-PAC-B1 PZ-ER1-PAC-B2 PZ-ER1-PAC-C2 PZ-ER1-PAC-C1 R1-6-TW	R1-7 (CIZ A) PZ-ERIM-B1 PZ-ERIM-B2 PZ-ERIM-C R1-7-TW	R1-8 (CIZ A) PZ-R1-S42-B2 PZ-R1-S42-B1 PZ-GPPS-2 R1-8-TW

Table 3: Section C – Individual Piezometers and Piezometer Lines

Section C – Reaches 1A & B			
R1-9 (CIZ A) PZ-ER1352-3B1 PZ-ER1352-3B2 PZ-ER1352-3C R1-9-TW S352_T	R1-11 (CIZ A) PZ-ER1352-4C PZ-ER1352-5B1 PZ-ER1352-5B2 PZ-ER1352-5C1 PZ-ER1352-5C2 R1-11-TW	R1-11A (CIZ A) PZ-URS-05-1B PZ-URS-05-1C R1-11A-TW	R1-12 (CIZ A) PZ-R1-25-B1 PZ-R1-25-B2 PZ-R1-25-C1 PZ-R1-25-C2 R1-12-TW
R1-12A (CIZ A) PZ-URS-05-2B PZ-URS-05-2C R1-12A-TW	R1-13 (CIZ A) PZ-C10A-1 PZ-C10A-2 PZ-C10A-3 PZ-C10A-4 PZ-C10A-5 CULV10A_H	R1-13A (CIZ A) PZ-HHDR1A-2A PZ-HHDR1A-2C1 PZ-HHDR1A-2C2 PZ-HHDR1A-2C3 PZ-HHDR1A-2D R1-13A-TW	R1-14 (CIZ A) PZ-R1-31-B1 PZ-R1-31-C R1-14-TW
R1-15 (CIZ A) HHDR1A06-06 HHDR1A06-07 PZ-HHDR1A-1C PZ-HHDR1A-1D	R1-16 (CIZ A) R1A-PZA1-1428 R1A-PZA2-1428 R1A-PZA3-1428 R1A-PZB0-1428 R1A-PZB1-1428 R1A-PZB2-1428 R1A-PZB3-1428 R1A-PZC1-1428 R1A-PZC2-1428 R1A-PZC3-1428 R1-16-TW S153_T	R1-17 (CIZ A) R1A-PZA1-1413 R1A-PZA2-1413 R1A-PZA3-1413 R1A-PZB0-1413 R1A-PZB1-1413 R1A-PZB2-1413 R1A-PZB3-1413 R1A-PZC1-1413 R1A-PZC2-1413 R1A-PZC3-1413 S153_T	

Table 4: Section D – Individual Piezometers and Piezometer Lines

Section D – Reach 7	
R7-1 (CIZ G) PZ-R7-A-B PZ-R7-A-B2 PZ-R7-A-C1 PZ-R7-A-C2 S-135_H	R7-2 (CIZ G) PZ-R7-B-A PZ-R7-B-B1 PZ-R7-B-B2 S135_H

Table 5: Section E – Individual Piezometers and Piezometer Lines

Section E – DSMS Piezometers			
R4-1 (CIZ B) HHD12-R4-PZ-1B HHD12-R4-PZ-1B1 HHD12-R4-PZ-1B2 HHD12-R4-PZ-1C HHD12-R4-PZ-1C1 R4-1-TW S235_T	R4-2 (CIZ B) HHD12-R4-PZ-2B HHD12-R4-PZ-2B1 HHD12-R4-PZ-2B2 HHD12-R4-PZ-2C HHD12-R4-PZ-2C1 R4-2-TW CUL5A_T	R4-3 (CIZ B) HHD12-R4-PZ-4B HHD12-R4-PZ-4B1 HHD12-R4-PZ-4B2 HHD12-R4-PZ-4C HHD12-R4-PZ-4C1	R5-1 (CIZ B) HHD12-R5-PZ-7B HHD12-R5-PZ-7B1 HHD12-R5-PZ-7B2 HHD12-R5-PZ-7C HHD12-R5-PZ-7C1 S133_H
R5-2 (CIZ F) HHD12-R5-PZ-2B HHD12-R5-PZ-2B1 HHD12-R5-PZ-2B2 HHD12-R5-PZ-2C HHD12-R5-PZ-2C1	R6-1 (CIZ C) HHD12-R6-PZ-4B HHD12-R6-PZ-4B1 HHD12-R6-PZ-4B2 HHD12-R6-PZ-4C HHD12-R6-PZ-4C1 S131_H	R6-2 (CIZ D) HHD12-R6-PZ-7B HHD12-R6-PZ-7B1 HHD12-R6-PZ-7B2 HHD12-R6-PZ-7C HHD12-R6-PZ-7C1	R6-3 (CIZ D) HHD12-R6-PZ-10B HHD12-R6-PZ-10B1 HHD12-R6-PZ-10B2 HHD12-R6-PZ-10C HHD12-R6-PZ-10C1 S129_H
R6-4 (CIZ D) HHD12-R6-PZ-12B HHD12-R6-PZ-12B1 HHD12-R6-PZ-12B2 HHD12-R6-PZ-12C HHD12-R6-PZ-12C1 R6-4-TW	R7-3 (CIZ G) HHD12-R7-PZ-2B HHD12-R7-PZ-2B1 HHD12-R7-PZ-2C S135_H	R8-1 (CIZ E) HHD12-R8-PZ-4B HHD12-R8-PZ-4B1 HHD12-R8-PZ-4C S127_H	R8-2 (CIZ E) HHD12-R8-PZ-9B HHD12-R8-PZ-9B1 HHD12-R8-PZ-9B2 HHD12-R8-PZ-9C HHD12-R8-PZ-9C1 G34_H

4.2. Dam Safety Considerations and Performance Metrics

Given that HHD is a DSAC 1 dam, monitoring the piezometric levels in and around HHD is vital to maintaining and monitoring the embankment system. During high water events in particular, visual inspection and reading piezometers on a regular interval may provide an indication of a problem in enough time to perform corrective action to avoid an emergency situation or failure. The HHD Surveillance Plan (maintained in the HHD Emergency Action Plan) varies the frequency of piezometer readings based on the past and present observed conditions occurring in the vicinity of the piezometers (see Section 4.3). This surveillance plan was developed based on past experience and was targeted to aid in locating and monitoring excessive or detrimental seepage that may manifest as pipes/boils, as well as identify areas that may require corrective action.

Following the DSAC 1 classification, the Lake Okeechobee Regulation Schedule (LORS, implemented in 2008) was created to define safer normal operational bands of the water level within Lake Okeechobee. Proper management of Lake Okeechobee water levels is necessary to minimize the probability of developing or reactivating internal erosion conditions, as experienced during past high water events.

To assist in identifying potential dam safety issues and/or conditions that warrant further investigation, two systems have been developed to 1) illustrate safe performance and 2) to track performance over time:

1) To illustrate safe performance as piezometer readings are taken, a classification system was developed. This system denotes when individual piezometer readings are in the "Red Zone." A Red Zone reading indicates there may be an issue with the piezometer reading. A reading within the Red Zone would warrant a second review, re-measurement, field

investigation/inspection, and/or increased monitoring. When a Red Zone reading is identified, the responsible geotechnical engineer will conduct an evaluation and determine a suitable reaction. Details of the actions to be taken when responding to unexpected dam performance or seepage distress are beyond the scope of this report. The appropriate actions for responding are detailed in the HHD Emergency Action Plan.

2) To track performance over time — to assist in identifying locations where the performance may be deteriorating over time — hysteresis plots (Appendix E) have been developed for each piezometer. The hysteresis plots developed include period of record data. The hysteresis plots are valuable, as historical trends are easily observed on the plot. Any deviation from historical trends, whether slowly over time or abruptly, is detectable from reviewing the hysteresis plot.

Having these systems in place is essential for achieving the defined goals for the HHD Instrumentation Program. Additional information with respect to the methodology used for defining the Red Zone is discussed below.

4.2.1. Red Zone Methodology

The methodology used to define the Red Zone for piezometers is generally based on visual observations reported during high water events, but also with other considerations, as discussed below. Historically, HHD seepage and piping problems are first observed as a physical reflection of distress (seepage exiting the embankment toe, boil in the toe ditch, etc.), rather than an instrumentation reading that indicates something may be internally wrong with the embankment or foundation. This is related to how the embankment was originally constructed, the fill material used, and the properties of the foundation materials.

In its original configuration, the HHD embankment did not include designed systems (e.g. impermeable cores, foundation cutoffs, or internal drainage systems) that would be typically monitored by piezometers. As mentioned previously, one of the greatest assets to an initial indication of internal instability has been visual observations. Over the life of the instrumentation program, a significant quantity of piezometric data has been collected, including piezometric data for a few high water events; this data was used to define the piezometric reading in which the seepage issue will likely resurface. Using this piezometric data, the historic trends observed, and visual signs of distress noted, Red Zones for key piezometers were defined.

The above methodology applies to the majority of piezometers, as the Red Zone is based on a given piezometric reading that is linked to the lower bound lake stage at which seepage problems are first observed in the area of the piezometer. Figure 5 shows all HHD inspection points (previous locations of distress) plotted at the station they occurred versus the lake stage when they were first discovered. For reference, piezometer line locations, reach designations, population centers, and tieback embankment locations are also included in Figure 5. By linking the corresponding piezometric elevation to historic poor performance observations, inspectors can be notified of areas that require a more comprehensive inspection or additional attention. When applying this methodology, consideration was also given to:

- Gradients between piezometers (centerline to landside);
- Gradients from centerline to the embankment toe; and
- Artesian pressures (head above the ditch bottom for landside piezometers).

Since the gradients that have historically initiated seepage issues are typically horizontal gradients close to 0.1, visual observations of distress generally governed the assigned value for the Red Zone. In addition, due to HHD's length and remediation measures constructed to date, there are some exceptions to this generalized methodology, these exceptions are described below.

Reach 1 Piezometer Red Zones: From analysis of available data, installation of the cutoff wall has had a noticeable and quantifiable effect on piezometric readings as evidenced by the reduction in piezometric head (for downstream piezometers) after installation of the cutoff wall. Because a quantifiable improvement is noted, the Red Zone for Reach 1 piezometers is generally linked to corresponding piezometric head for the upper bound lake stage at which historic problems have been observed. The upper bound lake stage and corresponding piezometric head is reasonable and supported by extrapolation of piezometric readings after installation of the cutoff wall. Based on extrapolation, the Red Zone for Reach 1 piezometers could be set higher; however, since the cutoff wall has yet to be loaded for a lake stage above elevation 17.2 feet, first fill conditions exist that warrant a more conservative approach when defining the Red Zones. Red Zones will be adjusted once the wall has been loaded and tested. It is also noted that a Red Zone was not defined for piezometers that reside upstream of the cutoff wall. For piezometers upstream of the cutoff wall, hysteresis trends will be monitored for degradation of performance over time.

DSMS Piezometer Red Zones: Most of the DSMS piezometers are installed in locations that have not showed signs of seepage distress, up to the pool of record. In addition, the lake stage has not approached pool of record since the installation of these piezometers; therefore, defining the Red Zones for these piezometers is based on extrapolation of available piezometric data with more consideration to gradients between piezometers (centerline to landside), gradients from centerline to the embankment toe, and gradients from the landside toe piezometer to tailwater. Since some of these DSMS piezometers are in reaches that have shown signs of seepage distress at or near the pool of record, the Red Zone was defined based on extrapolated piezometer readings at the pool in which these historic observations were recorded.

Piezometers without a defined Red Zone: Red Zones were only applied to piezometers that are monitoring piezometric head within a stratum that represents a reasonable seepage path and in a position that will be the first indicator for exceeding a threshold. First indicator piezometers include piezometers in the centerline of the embankment monitoring the embankment fill and piezometers at the landside toe monitoring the upper foundation. Piezometers not considered a “first indicator” or have other exceptions as described herein, are not assigned a Red Zone. These exceptions for piezometers without a Red Zone include piezometers located in the following areas:

- At the lakeside toe;
- Deep below the foundation and in the foundation rock;
- Deep below the foundation, well below competent rock layers;
- Upstream of the Reach 1 cutoff wall (hysteresis trends monitored for these); and
- Far from the lake on tieback embankments that have not indicated a landward gradient due to higher ground surface elevations and high tailwater elevations (R4-3, R6-4, R8-2, and R5-2).

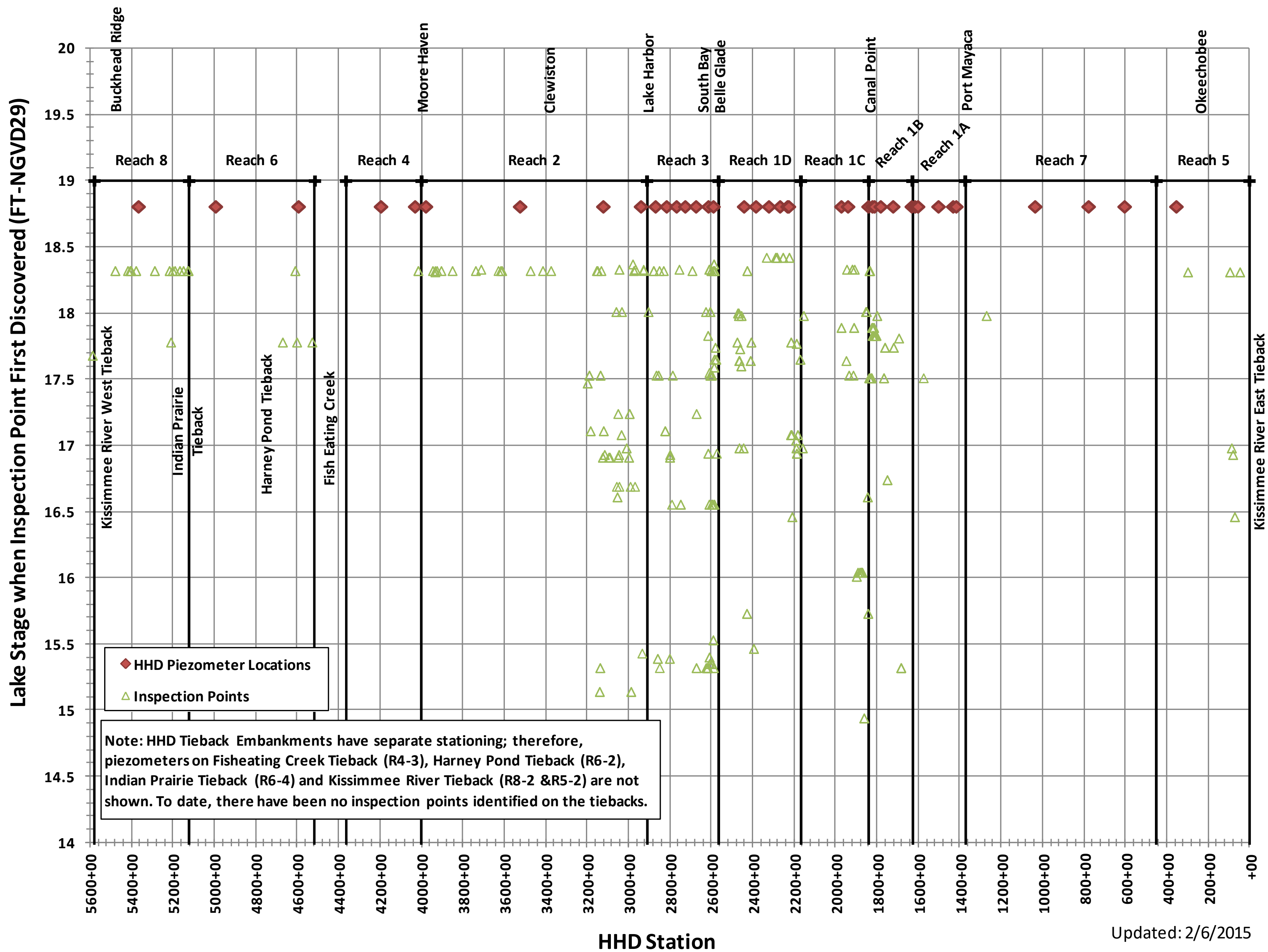

Figure 5: HHD Main Embankment – Inspection Point Location vs. Lake Stage when First Discovered

4.3. Monitoring Surveillance and Data Collection

Piezometers are monitored in accordance with the standard operating procedure laid out in the HHD Emergency Action Plan, Surveillance Plan (see Figure 6 and Figure 7). The monitoring frequency was updated in June 2018. Normal conditions are defined as a lake elevation at or below elevation 16.5 feet. Based on the surveillance plan, the monitoring frequencies are summarized below. Generally, a higher frequency of monitoring is required for the southern reaches (Reaches 1-3) and lower frequency for the northern reaches (Reaches 4- 8).

Reach 1-3

- Below elevation 15.5 feet: 30 days
- Between elevation 15.5 and 16.5 feet : 15 - 30 days
- Between elevation 16.5 and 17.0 feet: 7- 15 days
- Between elevation 17.0 and 17.5 feet: Twice weekly to 7 days
- Above elevation 17.5: daily

Reaches 4-8

- Below elevation 16.5 feet: 30 days
- Between elevation 16.5 and 17.5 feet : 15 days
- Between elevation 17.5 and 18.0 feet: 7 days
- Above elevation 18: daily

The monitoring frequency is subject to increase based on dam safety considerations defined in 4.2 Dam Safety Considerations and Performance Metrics.

High water events (water levels recorded above elevation 17.5 feet) occurred from September through November 1995, February through April 1998, October 1999, and September through October 2004. During the 2004 event, piezometers were monitored weekly. Due to the visual observations during the 2004 event, the piezometer monitoring frequency was increased to daily for lake levels above elevation 17.5 feet, resulting in the pre-2015 monitoring schedule. The (2015) monitoring frequency was created as a result of DSMS completion and substantial completion of Reach 1 cutoff wall and culvert/structure replacement projects.

In the fall of 2017, following Hurricane Irma, Lake Okeechobee rose to a peak of El 17.2 feet NGVD29, the highest level since 2005. Between 06 October 2017 and 05 November 2017, the lake sustained an elevation between 17.0-17.2 feet NGVD29. Several areas of clear seepage were observed in Reaches 2 and 3 (CIZs A and B), but without transport of embankment material (aka piping). This is credited to the landside ditch backfilling and downstream filters installed as IRRMs. No signs of seepage related distress were observed in Reach 1 (CIZ A). Reach 1 has a seepage cutoff wall within the embankment as part of the HHD rehabilitation project, portion completed at that time performed well during this first filling event. Other reaches within HHD showed saturated conditions, which were confirmed to be from seepage due to local rain showers that followed Hurricane Irma. No flowing seepage was observed within Reaches 4 through 8 (CIZs C through G).

The 2018 update to the HHD surveillance plan continues to focus inspection efforts on Reaches 2 and 3 (CIZs A and B) at lower lake stages because cutoff wall construction has not yet been completed and there remain limited performance issues. Because reaches 2 and 3 have seen limited performance issues up to elevation 17.2 feet NGVD29, the update reduces the frequency of inspections between lake stages 16.0 to 17.5.

Another focus area is in Reach 1 (CIZ A) at and above 17.5 feet NGVD29, as this would still be first filling for the more recently constructed seepage cutoff wall. In addition, there are still cutoff wall gaps within Reach 1 (CIZ A) which are currently under contract to be closed.

Reaches 1 and 4 through 8 (CIZs A, and C through G) have seen favorable performance up to elevation 17.2 feet NGVD29; therefore, increased inspection frequency will begin at 16.5 feet NGVD29 (previously at 15.5 feet NGVD29). The surveillance plan update adjusts the frequency of the piezometer instrumentation reading schedules to align with the frequency of embankment inspections. The 2017 HHD Instrumentation Report No. 15 and 2018 HHD Instrumentation Report No. 16 (for the 2017 hurricane/wet season) show consistent correlation data for lake stages up to 16.5-17.2 feet NGVD29, which allows for consistent piezometer readings around HHD.

During the inspection of the embankment, 4 conditions are monitored. The following condition codes are called out in the inspection to categorize the findings:

Condition 1: Saturated soil area
Condition 2: Standing water on surface; no movement.
Condition 3: Active seep site; no soil being moved; clear flow.
Condition 4: Movement of soil; require emergency action.

4.3.1. Reporting of Lake Stage

The lake stage is continually monitored at several structures around Lake Okeechobee. Real-time hydrometeorologic data is retrieved and stored by the Jacksonville District's Water Management and Meteorology Section (SAJ-EN-WW) in coordination with the SFWMD, using HEC Data Storage System (DSS) databases and programs. A daily average lake elevation is calculated from several monitoring stations within the lake and recorded as the official daily lake elevation as an hour 2400 (midnight) instantaneous value. Due to the large size of Lake Okeechobee and the effects of wind setup, it is noted that the lake elevation is not equal at all locations; however, under normal conditions and given the frequency of piezometer readings, the effects of wind setup is not discernible in instrumentation readings; therefore, all plots present the daily official lake stage (instantaneous 2400 value).

4.3.2. Collection of Piezometer Readings

The monitoring records began in 1994 for the earliest installed piezometers, with other piezometers being installed and monitored at later dates. Unfortunately, due to several database migrations, relocation of the District's office in 2002, and several personnel changes, some original data from 1994-1999 cannot be located.

Most of the piezometer data provided within this report is collected manually by SFOO personnel using a water level indicator as few automated collection systems have been used at HHD. Readings collected on a particular date are input into a spreadsheet form by SFOO and e-mailed to the appropriate individuals for data management and importing into the HHD Instrumentation Database. Currently, no piezometers at HHD contain vibrating wire pressure transducers and dataloggers, but a handful have been utilized in the past. When they were utilized, the data collected was manually downloaded in the field from the instrument/datalogger by SAJ-EN-GD geotechnical staff at regular intervals (generally every three to four months) for inclusion in the HHD Instrumentation Database. Unfortunately, due to poor construction of the flush mount well covers, all of the dataloggers have malfunctioned from water intrusion or have been destroyed by mowers, causing a significant amount of data to be lost. Since these unfortunate events, efforts taken to improve electronic data retrieval were successful; however, ultimately, all dataloggers became nonfunctional as a result of moisture. However, future plans exist to properly retrofit and fully automate Reach 3 piezometers.

4.3.3. Tailwater Monitoring

Tailwater conditions around Lake Okeechobee are complex and subdivided across different local drainage districts and basins, each with facilities and operation schedules related to their intent and local interest. Local interests and their intent for managing water are generally related to farming and managing surface water runoff or both. A good portion of the water management throughout the region is controlled by water control structures (pump stations), culverts, spillways, and locks that penetrate the HHD embankment (see Figure 1 above for the locations of these structures around the lake). In addition to the structures shown in Figure 1, numerous other water control features exist throughout the region to facilitate the movement of water across the relatively flat topography. Features adjacent to and away from the lake include levees, canals, ditches, pump stations, culverts, all of which affect tailwater immediately downstream of the dam. Many of these features are operated or controlled by local entities and not by the USACE. Because of the compartmentalization created by these features, tailwater varies significantly around the dam. Understanding the compartmentalization of the system and how tailwater is controlled is essential to analyzing tailwater influences on piezometric response and gradients that are conducive to piping.

Since several piezometer lines are located near canals or large ditches controlled by pumping stations or culverts, daily tailwater stage data is available. Where available and applicable to a piezometer line, tailwater stage data from nearby SFWMD stations is plotted and used for analysis and interpretation (see Table 6 below).

Table 6: SFWMD Stage Monitoring Sites

Station Names	**SFWMD DBKEY**
S235_T (Seg 8)	~~15566~~ 38259
S235_H	38257
CUL5A_T	15009
S133_H	15825
S131_H	15719
S129_H	15821
S127_H	15817
G34_H	TA473
S4_H	15731
S236_H	UA592
S352_T	FF580
S153_T	05763
S135_H	15803
~~L8.441~~ (*)	~~15566~~
CULV10A_H (Replaces L8.441)	15669

(*) L8441 monitoring site has been terminated and was replaced by CULV10A_H

SFWMD DBHYDRO Link:
http://my.sfwmd.gov/dbhydroplsql/show_dbkey_info.web_qry_parameter?v_category=SW&v_category=WEATHER&v_category=GW&v_js_flag=Y

At locations where the embankment is bordered by a farmers toe ditch or roadway toe ditch, tailwater stage data was recently made available (Feb 2016) by the installation of 28 staff gauges. The 28 piezometer lines outfitted with staff gauges are indicated by "-TW" instrument names in section 4.1 Instrumentation Sections.

4.3.4. Rainfall Monitoring

Rainfall monitoring was first utilized in 2008 with the inclusion of daily rainfall amounts on the time-history plots. Rainfall data is retrieved utilizing SFWMD's DBHYDRO database. Rainfall data were chosen from available collection sites located in the vicinity of the piezometer lines. Table 7 presents rainfall monitoring sites associated with each piezometer line. Rainfall data is utilized to complement engineering explanations for piezometric responses and is particularly useful for understanding seemingly anomalous readings for piezometers located near a stormwater conveyance system or above surficial confining units.

Table 7: Rainfall Monitoring Sites

Station Names	**SFWMD DBKEY**
S135_R	16580
S352_R	16693
EASTSHO_R	05835
S2_R	16647
S3_R	16648
~~S4_R~~ (*)	~~05879~~
S77_R	16624
S308_R	16289
CV5_R	16668
S133_R	16576
S129_R	16574
S72_R	16666
S131_R	16575
S71_R	16667
S191_R	~~16669~~ K8662
S127_R	16573
S169_R (Replaces S4_R)	K8653

(*) S4_R monitoring site has been terminated and was replaced by S169_R

HERBERT HOOVER DIKE SURVEILLANCE PLAN

VISUAL INSPECTION (INFORMAL/INTERMEDIATE INSPECTIONS) (1), (2)

Location Description		St Lucie Canal (Port Mayaca) to L-8 Canal (C-10A)	L-8 Canal (C-10A) to WPB Canal (S-352)	WPB Canal (S-352) to C-10	C-10 to Hillsboro/ N. New River Canals (S-351)	Hillsboro/N. New River Canals (S-351) to Miami Canal (S-354)	Miami Canal (S-354) to Industrial Canal (S-310 Lock)	Industrial Canal (S-310 Lock) to Caloosahatchee River (Moore Haven)
DSMR CIZ Designation		CIZ A					CIZ B	
Major Rehabilitation Report Designation		Reach 1A	Reach 1B	Reach 1C	Reach 1D	Reach 3	Reach 2	
C&SF Project Levee Designation		L-D9			L-D2			L-D1
SFOO Inspection Designation		1A	1B	1C	1D	3	2-1	2-2
Inspection Team	**Lake Elevation (3)**	**Inspection Frequency**						
SFOO Personnel (Informal)	to 15.5	30 days (performed as personnel are taking piezometer readings)						
	Above 15.5 to 16.5	30 days (4)				15 days (4)		
SFOO, OD, EN, & SFWMD Personnel (Intermediate)	Above 16.5 to 17.0	15 days (4)				7 days (4)		
	Above 17.0 to 17.5	7 days (4,5)				twice weekly (4,5)		
	Above 17.5	daily						

VISUAL INSPECTION (INFORMAL/INTERMEDIATE INSPECTIONS CONT.) (1), (2)

Location Description		Caloosahatchee River (Moore Haven) to Fisheating Creek	Fisheating Creek (FC-1) to Harney Pond Canal (S-71)	Harney Pond Canal (S-71) to Indian Prairie Canal (S-72)	Indian Prairie Canal (S-72) to Kissimmee River (S-65E)	Kissimmee River (S-65E) to Kissimmee River (SR 78 Bridge)	Kissimmee River (SR-78 N) to Nubbin Slough (S-191)	Nubbin Slough (S-191) to St Lucie Canal (Port Mayaca)
DSMR CIZ Designation		CIZ B	CIZ C	CIZ D	CIZ E	CIZ F		CIZ G
Major Rehabilitation Report Designation		Reach 4	Reach 6		Reach 8	Reach 5		Reach 7
C&SF Project Levee Designation		L-D3	L-50	L-49	L-48	L-D4		L-47
SFOO Inspection Designation		4	6-1	6-2	8	5-1	5-2	7
Inspection Team	**Lake Elevation (3)**	**Inspection Frequency**						
SFOO Personnel (Informal)	to 16.5	30 days (performed as personnel are taking piezometer readings)						
SFOO, OD, EN, & SFWMD Personnel (Intermediate)	Above 16.5 to 17.5	15 days (performed as personnel are taking piezometer readings)						
	Above 17.5 to 18.0	7 days						
	Above 18.0	daily						

PIEZOMETER READINGS (6)

Inspection Team	Lake Elevation (3)	Piezometer Reading Frequency
SFOO Personnel	to 15.5	30 days
	Above 15.5 to 16.5	15 days
	Above 16.5 to 17.0	7 days
	Above 17.0	daily

HURRICANE EMERGENCY PLAN (7)

Inspection Team	Lake Elevation (3)	Pre/Post Hurricane Inspection
SFOO/ SAJ-EN Personnel	Any Lake Elevation	Begin inspection 2 days prior to predicted landfall and reinspect within 2 days after occurrence

VISUAL INSPECTION (FORMAL) (7)

Inspection Team	Lake Elevation (3)	Inspection Frequency
SAJ-EN Personnel	Any Lake Elevation	Annual Embankment Inspection

Notes:

(1) Regardless of lake elevation, if a WATCH CONDITION is issued (Large Quantities of Clear Seepage or Seepage Flow Carrying Materials), daily inspections for the corresponding reach shall be implemented.

(2) Inspection frequencies are subject to change based on observed site conditions, piezometer readings and recommendations by the DSO. In addition, if the following conditions are met: *1) Lake is above 15.5, 2) Lake remains within a given "Lake Elevation" range for more than 30 days, and 3) No inspection points have been identified within a given location description/designation*; the inspection team may recommend a reduced inspection frequency. Written approval from the DSO shall be received before reducing the inspection frequency.

(3) Lake elevations are reported in ft-NGVD29. The average daily lake elevation is used to initiate the frequencies listed in this table.

(4) Inspection shall give particular attention to Culverts/Structures where cutoff wall tie-in at Culverts/Structures is not yet completed.

(5) Based on observations during past high water events, the inspection frequency may change to daily before the lake exceeds 17.5 feet. Reference (1) and (2)

(6) Unless otherwise specified, the listed reading frequency includes all active piezometers in all reaches.

(7) Inspection includes the entire damming surface encircling Lake Okeechobee.

Figure 6: HHD Surveillance Plan Table (Dated: June 1, 2018)

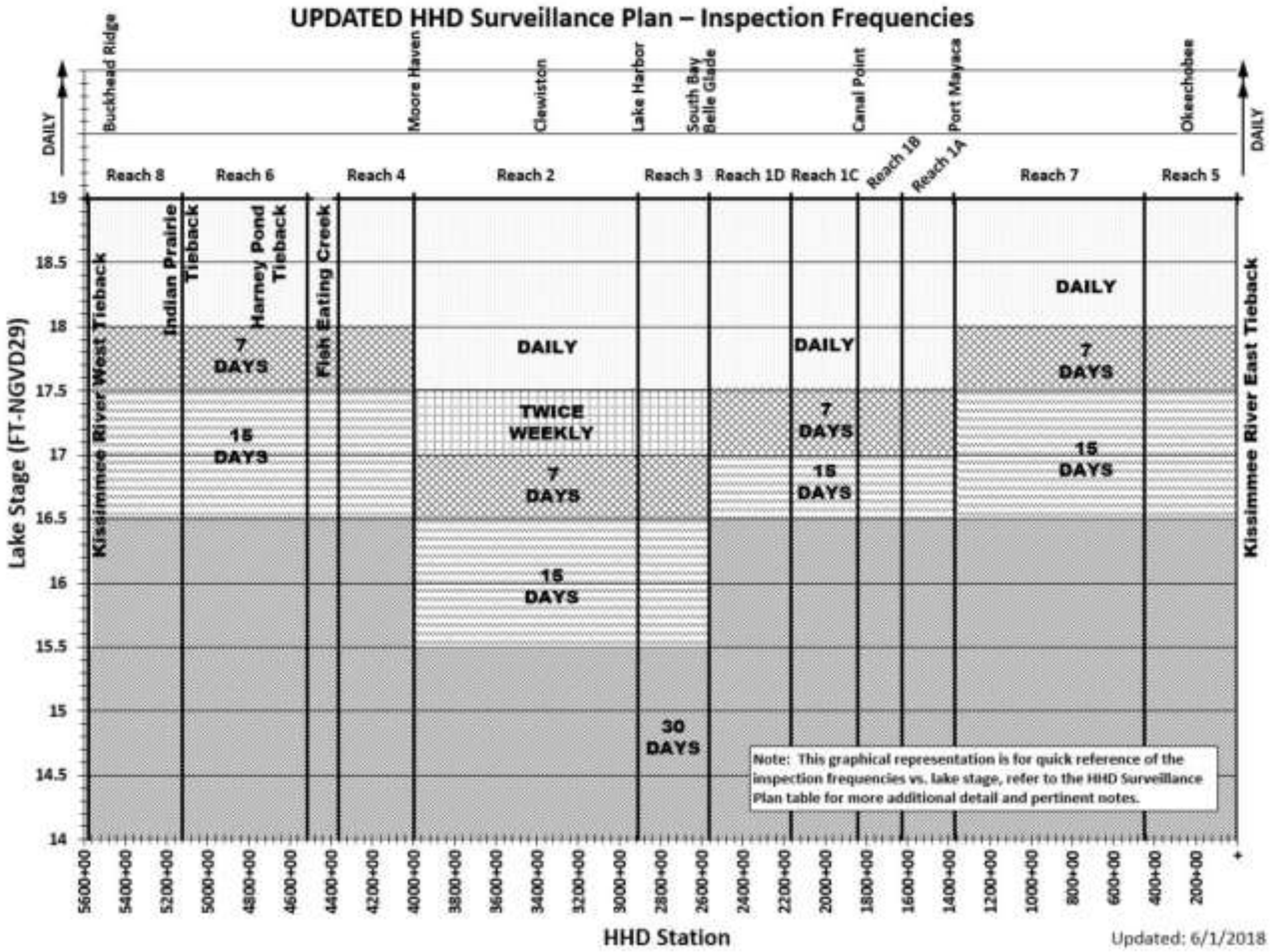

Figure 7: HHD Surveillance Plan Graphic (Dated: June 1, 2018)

4.4. Quality Control and Maintenance

In order to maintain the integrity of the data collected, the condition of the piezometers must be maintained to appropriate conditions and sufficient quality control measures must be in place. The sections below describe the quality control measures that have been implemented and the maintenance/action items completed for maintaining data quality.

4.4.1. Quality Control Measures

Quality control measures implemented for the HHD Instrumentation Program:

- Performing a comprehensive yearly inspection:
  - Measuring depths of each piezometer to verify the piezometer is not accumulating sediment and to identify potentially broken or cut riser pipes for maintaining proper documentation of depths and elevations; Also, in 2016, an 1/8th inch file notch was added to the top of all risers to assist with identifying risers that may have been modified or broken.
  - Inspecting piezometer pads for depressions and settlement that would cause water to pond around the piezometer pads or cause riser pipe interference with well covers; and
  - Inspecting well pads and identifying well pads that need replacement.
- Importing, plotting, and reviewing instrument readings the day they are submitted and recommending a second reading for confirmation of anomalous readings.
  - Reporting of any changed conditions in piezometer reading sheet each time readings are collected.
  - Incorporating typical reading ranges into the SFOO piezometer reading spreadsheet that trigger a warning when an abnormal reading is entered. Depending on the reading, additional checks would be required by SFOO and possibly engineering.

4.4.2. History of Completed Maintenance and Action Items

Many of the wells in the HHD piezometer inventory were installed before the year 2000. For these early piezometers, as-built data, organized field data, and survey documentation was not properly recorded or maintained. Over the years, subtle changes are noted throughout different electronic documents and in the water surface elevations. Because adequate records have not been maintained and regular field maintenance of the piezometers was not occurring, many action items were identified during inspection in July 2013 and the initiation of implementing the quality control procedures described above was achieved.

2017 & 2018 Modifications and Improvements:
No modifications were performed between 2017 and 2018.

2016 Modifications and Improvements:
The September 2015 scope of work for installation of staff gauges to measure tailwater elevation at 28 different piezometer lines was completed. This task also included establishing horizontal and vertical values for each functioning piezometer in accordance with the accuracy requirements for USACE flood control projects. The work was awarded to Michael Baker Jr., Inc. under contract W91278-10-D-102 survey number 15-096. Staff gauge readings were first performed on February 9, 2016. After the staff gauges were installed, the Contractor completed the riser survey; therefore, the instruments in the WinIDP database was updated with the new riser survey information with the completion date of April 4, 2016.

Three new piezometers were installed at piezometer lines R3-5, R3-6 and R3-7, at the landside toe, in accordance with prior year recommendations of this report. Readings for the new piezometers, PZ-HHD16-R3-3C, PZ-HHD16-R3-2C and PZ-HHD16-R3-1C, were performed on September 8, 2016.

2015 Modifications and Improvements:
In September 2015, a scope of work for installation of staff gauges to measure tailwater elevation at 28 different piezometer lines was awarded. The work was awarded to Michael Baker Jr., Inc. under contract W91278-10-D-102 survey number 15-096. This task also included establishing horizontal and vertical values for each functioning piezometer. Although the piezometers were resurveyed in 2014, resurvey was recommended for this scope to obtain accuracy compliance in accordance with survey requirements for USACE flood control projects.

Engraved name plates were affixed to all piezometers to be able to identify individual piezometers and piezometer lines and eliminate the potential for misidentification of a piezometer.

2014 Modifications and Improvements:
After completion of the 2014 HHD Annual Inspection and the 2014 Instrumentation Report, funding was obtained and two scopes of work were developed to address the issues identified. The scopes of work did not address any DSMS Piezometers as they were recently installed and surveyed, with no abnormal deficiencies noted. Provided below is a summary of the work performed. The scopes, deliverables, and detailed information related to each effort are documented in Appendix F of 2014 HHD Annual Inspection Report in an MFR titled *Herbert Hoover Dike Instrumentation Program: Redevelopment, Repair and Resurvey (RRR) of Piezometers in Reaches 1, 2, 3 and 7*.

- The first scope was created to address the physical condition and performance of the individual piezometers in Reaches 1, 2, 3 and 7. This scope was subdivided into three parts: 1) piezometer rejuvenation/redevelopment; 2) piezometer surface feature repair; and 3) replacement of damaged or non-responsive piezometers. Because of the lack of time and funding, Item 3 was never initiated. Work defined under this scope was performed by SAM drill crew led by Bobby Norris, P.G. Work began in August 2014 was completed in October 2014. Under this effort, all operational piezometers were redeveloped, well pads were replaced (with new well covers, where necessary), and fill was added around the well pads (where necessary).
- Because ongoing maintenance and construction tends to interfere with the piezometers (effecting the riser elevations), the second scope of work was developed to obtain riser elevations for all piezometers in Reaches 1, 2, 3, and 7. This work was performed by Jacksonville District’s Operations Division (SAJ-OD) survey crew, under the supervision of Jerry Burchfield and led by James Allison. The survey was performed from 02 to 05 September 2014 (SAJ Survey Number: 14-167).

By performing the work defined in both scopes, all the action items identified in the July 2013 inspection were corrected, with exception to permanently affixing the full PZ name to the riser pipe or well pad.

2013 Modifications and Improvements:
Although some repairs were performed in 2009, it is unknown when the last full field inspection was performed before that time. Before publishing the 2013 inspection report, two geotechnical engineers from SAJ-EN-GS inspected each of the piezometers in Reaches 1, 2, 3, and 7. The DSMS Piezometers had just been installed and therefore, did not require inspection. Any and all action items were noted during the site visit. Starting in 2014, the HHD Annual Inspection team began inspecting every piezometer line and documenting any required piezometer maintenance.

Action items observed in the 2013 field inspection are documented in an MFR titled *Trip Report HHD Instrumentation Program: Field Inspection of Piezometer Inventory* dated 12 July 2013 (The MFR can be found in 2015 Instrumentation Report). Observed action items from the 2013 field inspection and 2014 Annual Inspection are summarized below:

- Ground subsidence has caused the well pad to settle leaving the PZ riser pipe above the well pad susceptible to damage from mowing equipment
- The ground has settled, but the well pad remains attached to the PZ riser pipe leaving the PZ riser pipe susceptible to damage from mowing equipment
- PZ pad is severely damaged or no longer remains
- Elevation of riser pipe has been modified or was not recorded correctly when first installed
- Measured PZ depths (soundings):
    - PZ measured deeper than what installation documents indicate
    - PZ measured shallower than what installation documents indicate. From sounding the depth, it was noted that many piezometers contained sediment; sediment on the order of several feet was noted in some PZs
- PZ names switched in the field
- Cutoff wall contractor decommissioned PZ
- Full PZ name/identity not listed on riser or pad

2009 Modifications and Improvements:

Prior to the 2013 inspection, the only record of previous modifications or improvements to the piezometers was done in 2009. The purpose of the work was to replace several piezometers beyond repair and to rejuvenate several others. This work was performed by Baltimore District (NAB) drill crew during January and February of 2009. Table 8 below lists the piezometers and corresponding modifications done in 2009.

Table 8: 2009 Piezometer Modifications and Improvements

Piezometer Line	Piezometer ID	Work Performed
R1-1	PZ-HHDR1-4B2	Redeveloped, Well Pad Repaired
R1-3	PZ-HHDR1-7C2	Complete Reinstallation/Replacement
R1-7	PZ-ER1M-B1	Redeveloped, Well Pad Repaired
R1-9	PZ-ER1352-3B2	Complete Reinstallation/Replacement
	PZ-ER1352-3B1	Complete Reinstallation/Replacement
R3-1	PZ-ER3D-B	Redeveloped, Well Pad Repaired
R3-6	PZ-R3-F-A1	Complete Reinstallation/Replacement
	PZ-R3-F-A2	Complete Reinstallation/Replacement
R3-7	PZ-R3-G-A1	Complete Reinstallation/Replacement
R7-1	PZ-R7-A-B	Complete Reinstallation/Replacement
	PZ-R7-A-B2	Complete Reinstallation/Replacement

5. PIEZOMETER ANALYSIS

The following sections of this report include interpretations and discussions of the piezometric readings recorded for each piezometer line. As an aid in the analyses of the piezometer readings, for each piezometer line, a cross section view of the embankment with the piezometer locations (Appendix C), a time-history plot with rainfall data (Appendix D), and a hysteresis plot (Appendix E) were developed.

In the sections below, observations are made with respect to the correlation between a specific piezometer and the lake stage. From review of the hysteresis plots, general correlation verbal descriptors can be used to indicate the strength of the piezometer correlation to the lake stage. Understanding how the lake and the seepage through the geologic formation correlate is useful for conveying the pre- and post-cutoff wall performance, quantifying the level of communication between a particular geologic formation and the lake, and communicating general trends of piezometric response within the embankment and foundation. As an aid to the reader, a graphic with the verbal descriptors used herein has been developed and is provided in Figure 8 below.

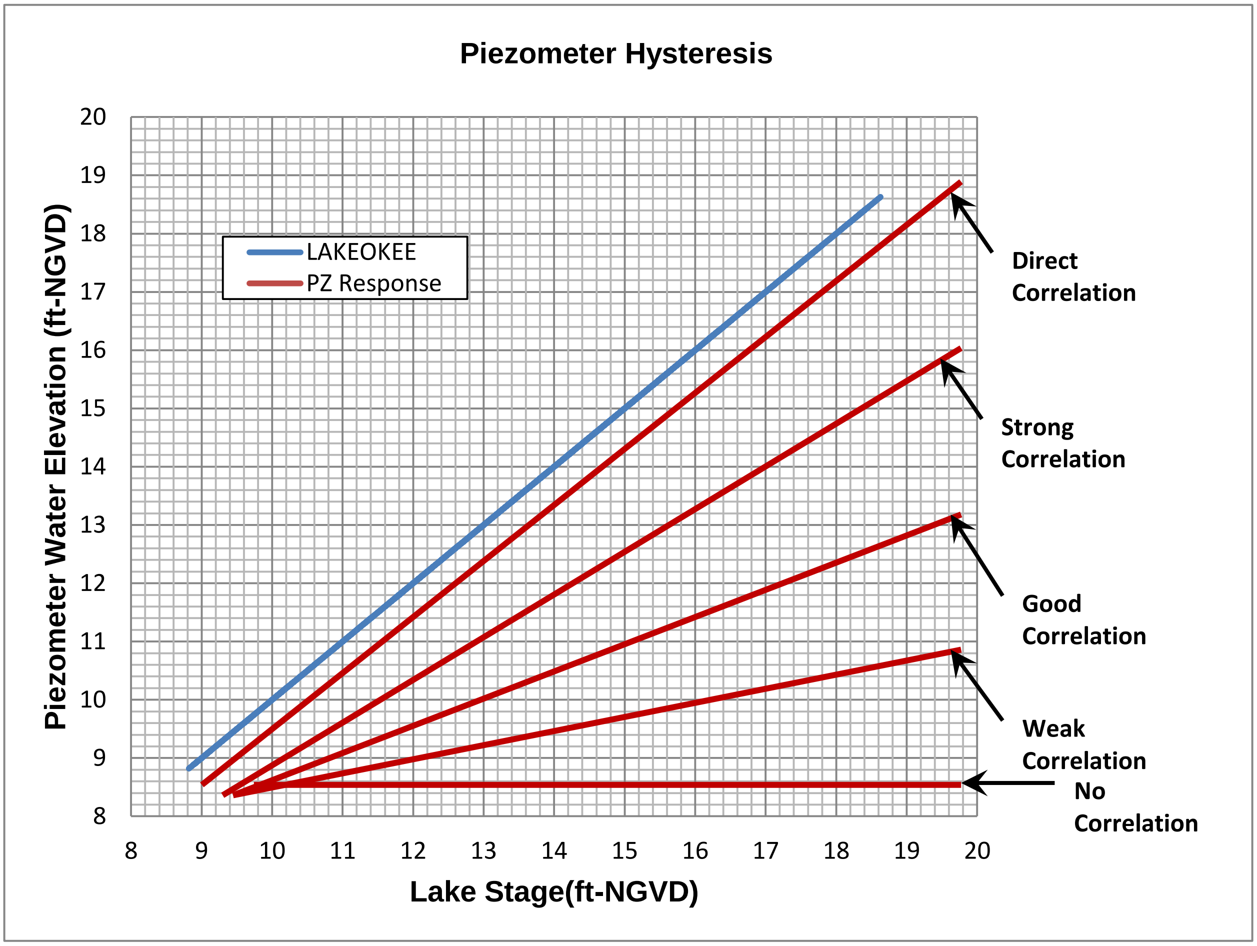

Figure 8: Correlation Descriptors for Hysteresis Plots

5.1. Piezometer Line Analysis – Format Summary

It should be noted that a reasonable attempt is always made to check the piezometer data and plots for accuracy. Abrupt data spikes that remain within the report are sometimes due to human error associated with data transcription and transfer from field notes to computer and cannot always be verified for accuracy. In most cases, the plots have been scrubbed of data spikes not associated with piezometric response. With the implementation of additional quality control measures beginning in 2013, the likelihood of invalid readings being incorporated into the database has been greatly reduced, if not eliminated. Occasionally, spikes can also be attributed to the operation or use of adjacent canals and ditches by local water management districts or farmers, or in other cases is a result of locally heavy rainfall and perched water conditions. Where these data spikes are found not to be anomalous, explanations of the occurrences are included in the analysis of the piezometer in question.

To simplify report organization, documentation and presentation of relevant information, a general format for each piezometer line has been followed in this report. Each write-up for a given piezometer line begins with a table of pertinent information pertaining to the piezometer line being analyzed (Table 9 below provides an explanation of the information provided). After the table, “Data Analysis/Evaluation” of the piezometric response is discussed in bullet format. In some cases, additional explanations are warranted before the piezometric data is evaluated. When warranted, the additional explanations are provided in paragraph format.

Table 9: Explanation of Piezometer Line Pertinent Information

Location	General location description of the piezometer line in relation to known HHD features.
DSMS Segment/CIZ	Segmentation of the HHD, as defined in the HHD Existing Condition Risk Assessment, Risk Reduction Report and DSMR. and the Common Inundation Zones (CIZ)
Date PZ Line in Service	The Month/Year in which the piezometer installation was completed (as documented on as-built records). This date generally does not correspond to the date the first reading is available as there is a lag time between installation completion and initiation of field readings.
Piezometer Maintenance and Repairs	A summary of any maintenance, repairs, or modifications of the piezometer(s).
Lakeside Features	A description of the lakeside features that may contribute to or influence the piezometric response are discussed here. These descriptions can be referenced in conjunction with the cross sections and aerial views provided in Appendix C.
Lakeside PZs	Piezometers that are lakeside of the embankment crest are listed here, as well as their relative location within the embankment/foundation. When multiples exist, they are listed from the highest elevation to the lowest elevation.
Centerline PZs	Piezometers that are located on the embankment crest are listed here, as well as their relative location within the embankment/foundation. When multiples exist, they are listed from the highest elevation to the lowest elevation.
Landside PZs and Tailwater	Piezometers that are landside of the embankment crest are listed here, as well as their relative location within the embankment/foundation. When multiples exist, they are listed from the highest elevation to the lowest elevation. Tailwater measurement names are also listed here. Tailwater measurements can be identified names ending in –TW, _H, or _T.
Landside Features	A description of the landside features that may contribute to or influence the piezometric response are discussed here. These descriptions can be referenced in conjunction with the cross sections and aerial views provided in Appendix C.
Historic Poor Performance	A summary of the conditions observed and documented during high water events at or near the piezometer line is provided here. When available, the point name associated with the observation is provided along with the explanation. Unfortunately, point naming conventions have changed over the years and descriptions of the observed conditions are not always thorough and concise. Although some explanations are not thorough or concise, the descriptions remain unedited, as one can only assume what the original intent may have been. Where detailed information is available, thorough and concise explanations of historic observations are provided.
Emergency/ Permanent Repairs	Changes in piezometric response (short term or long term) or interpretation of the piezometric response may occur as a result of repairs; therefore, a summary of and the month/year of any emergency and/or permanent repair implemented to address the internal erosion failure mode is summarized here.

Following Data Analysis/Evaluation is a table of gradient calculations that utilizes available tailwater data and piezometer readings from applicable piezometers to calculate a horizontal or vertical gradient. Lastly, a summary of the observed conditions, general concerns, or relevant comments associated with the piezometer line in review is provided. The horizontal gradient is calculated using the difference in head between the piezometer and tail water elevation (the elevation levels are determined based on a representative piezometer reading for the highest lake elevation measured by the piezometer). The head difference is then divided by horizontal distance between the piezometer and the tailwater. The vertical gradient is calculated using the difference in head between the piezometer and tail water elevation divided by the vertical distance between the piezometer and the tailwater. The gradient is calculated to estimate the potential for any seepage and piping conditions during high water events.

5.2. Limitations

Although historic problems and specific conditions noted herein may indicate that corrective action is required, this report is not intended to be a mechanism to obtain the funding needed to perform or such actions, nor is it intended to circumvent other reports of documents authorizing corrective actions or modifications to the HHD. This report and subsequent reports should serve as vehicles for comprehensive documentation of embankment and foundation performance in support of studies to determine the necessary of dam safety modifications. The DSMR, completed in FY16 is the vehicle for determining and funding future modifications for all areas of HHD which exceed tolerable risk guidelines.

Additional limitations of this report lie within the interpretation of the data provided and are a result of reading frequency and lake stage. The piezometers are manually read on a predetermined schedule that is dependent on lake stages. The specified piezometer reading interval for ‘normal’ lake stages is every 30 days. Since Lake Okeechobee water elevations generally remain ‘normal,’ readings available for interpretation and analysis are generally coarse (30 day intervals), which adds difficulty to assessing short term trends or seemingly anomalous readings; therefore, given the limited number of readings obtained yearly, piezometric interpretations provided herein have been coupled with historic trends to analyze piezometric response as best as practical. In addition, complete analysis of piezometric response was not made possible until the addition of site specific tailwater staff gauges in 2016. Addition of this information also appears to have changed historic understanding of performance at several piezometer lines. Therefore, until a significant record of site specific tailwater responses is obtained, analysis and understanding of performance may be limited.

6. SECTION A – REACHES 2 & 3

6.1. Piezometer Line R2-1

Location	1.4 Miles West of S-279 (Culvert 1A)
DSMS Segment/CIZ	6/B
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-R2-A-B1 and PZ-R2-A-B2: Fill added around well pad
Lakeside Features	Approximately 25-foot bench to lakeside toe. Lakeside bathymetry is not available at this location; however, the lakeside borrow source resides just upstream of the embankment toe and is assumed to be as deep as the top of CB-LD1-11-R (approximately elevation -2.0 feet).
Lakeside PZs	PZ-R2-A-A (Lower Embankment Fill)
Centerline PZs	PZ-R2-A-B2 (Foundation Upper) PZ-R2-A-B1 (Foundation Lower)
Landside PZs and Tailwater	PZ-R2-A-C (Foundation Upper)
Landside Features	L-D1 Borrow Canal resides downstream and is approximately 30 feet from the embankment toe. Approximate dimensions: Width 130 feet; Invert (from as-builts) elevation -5.0 feet
Historic Poor Performance	Saturated berm and standing water in various locations in the area of this piezometer
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- PZ-R2-A-A correlates directly with the lake stage for lake stages above elevation 12.5 feet. Readings indicate some head loss is occurring from the lake to the piezometer. For lake stages below elevation 11.5 feet, this piezometer is dry. (Between November to December 2018 the piezometer was dry and no readings were recorded).
- For lake stages above elevation 12.0 feet, PZ-R2-A-B2 shows a good correlation. When the lake stage is below elevation 12.0 feet, the L-D1 canal stage closely matches the lake stage and is likely the reason for the direct correlation shown.
- PZ-R2-A-C and PZ-R2-A-B1 show a weak correlation to the lake stage; likely due to the influence from the adjacent landside canal.
- From upstream to downstream, the correlation decreases and the head loss across the foundation increases.

From the piezometer data, the gradient direction of flow at this location is toward the landside; however, there are occurrences where the canal stage is greater than or equal to the lake and the gradient is reversed. Although a significant amount of shell is noted in the borings, considerable amount of head loss is occurring across the embankment and through the foundation during higher lake stages; however, given the porous nature of the foundation at this location, it is possible that the large landside borrow canal is relieving foundation pressures and contributing to the reduction in head seen in the piezometers at higher lake stages.

6.2. Piezometer Line R2-2

Location	2.7 Miles West of Gate at S-278 (Culvert 2)
DSMS Segment/CIZ	5/B
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	No known maintenance and repairs
Lakeside Features	Approximately 25-foot bench to lakeside toe. Lakeside bathymetry is not available at this location; however, the lakeside borrow source resides just upstream of the embankment toe
Lakeside PZs	PZ-R2-B-A (Lower Embankment Fill)
Centerline PZs	PZ-R2-B-B2 (Lower Embankment Fill) PZ-R2-B-B1 (Upper Foundation)
Landside PZs and Tailwater	No PZs installed. At the time of installation, the landside toe was not accessible to the drilling equipment. R2-2-TW
Landside Features	Heavily vegetated wetland with small toe ditch.
Historic Poor Performance	R2-4A 200 sq. ft. of saturated berm
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- PZ-R2-B-A is tipped at approximately elevation 13.6 feet and therefore is dry for lake elevations less than elevation 13.6 feet. At lake elevations above the tip, a direct correlation between PZ-R2-B-A and the lake exists, with the piezometer generally reading the same elevation as the lake. (Between November to December 2018 the piezometer was dry and no readings were recorded).
- Although the tip of PZ-R2-B-B2 is well below elevation 13.0 feet, readings are consistently obtained at this elevation as if it were the piezometer tip. Additionally, this piezometer consistently reads above lake stages. These are likely due to a perched water condition. Records indicate this piezometer is screened above and within fine grained soils. A perched water condition and a blocked seepage exit are possible explanations for the seemingly anomalous readings.
- PZ-R2-B-B1 has a direct to strong correlation with the lake stage. The correlation slightly decreases as the lake stage increases. Above elevation 13.0 feet, the piezometer responds with the rising and falling lake level, but shows a dampened piezometric response indicating greater head loss through the foundation under higher lake levels.
- At a lake stage of 16.0 there is approximately a 1 foot head differential from PZ-R2-B-B1 to the small toe ditch and 2 feet from PZ-R2-B-B2.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R2-B-B2	15.21	14.18	*1.03*	141	*0.073*		
PZ-R2-B-B1	14.17	14.18	*0.01*			12.7	*0.10*

Although landside conditions may be limiting, consideration should be given to the installation of a piezometer at the landside toe. If a confining unit is present and continuous at the surface, an additional piezometer at the landside toe beneath the blanket material would provide insight with respect to pore pressures.

6.3. Piezometer Line R2-3

Location	0.2 Miles West of Gate at Pump Station S-236
DSMS Segment/CIZ	4/B
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	No known
Lakeside Features	Approximately 25-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	PZ-R2-E-A (Embankment Fill)
Centerline PZs	PZ-R2-E-B2 (Embankment Fill) PZ-R2-E-B1 (Upper Foundation, just beneath blanket material)
Landside PZs and Tailwater	No PZs installed due to the limited right-of-way and access constraints between the landside toe and US-27/SR-80. R2-3-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	A saturated berm and standing water at landside toe has been observed throughout the area during high pools. R2-8: 2" sand boil in toe ditch with white discoloration evident R21-05-05: Numerous seeps at the bottom edge of the toe ditch bank for 66 feet. The largest seep has a flow rate of approximately 1 gpm. (2005)
Emergency/ Permanent Repairs	2007 – This piezometer line is located at the western extent of Focus Area 3. Within the limits of the Focus Area, the landside toe ditch was backfilled within one foot of the ground surface with a combination of sand and gravel designed to provide a filtered seepage exit point. (HHD IRRM Plan, 14 July 2010).

Data Analysis/Evaluation:

- PZ-R2-E-A correlates strongly with the lake level and generally reads lake level.
- PZ-R2-E-B2 is tipped near elevation 13.7 feet; therefore many readings are indicating trapped water in the piezometer tip or a perched water table. For lake stages above the piezometer tip, a strong to direct correlation to the lake stage can be seen; however, many readings are above the lake stage. Readings above the lake stage correlate with periods of rainfall and support the possibility of a perched water table and blocked seepage exit.
- PZ-R2-E-B1 shows a good correlation with the lake stage and indicates that some head loss is occurring as seepage enters the foundation limestone. Hydraulic separation is likely from a semi-confining unit such as filter cake or surficial organic material.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R2-E-B2	16.01	11.57	***4.44***	119.4	***0.04***		
PZ-R2-E-B1	12.21	11.57	***0.64***	119.4	***0.01***		

The gradient at this location is from lakeside to landside, as expected. The piezometer data indicates that there are several feet of head loss between the lake level and the underlying limestone strata.

However, there is no piezometer installed on the landside toe at this location. Therefore, it cannot be confirmed that the head loss is continuous to the landside toe.

6.4. Piezometer Line R2-4

Location	0.2 Miles West of Gate at Pump Station S-3 (John Stretch Park)
DSMS Segment/CIZ	4/B
Date PZ Line in Service	September 1995, except for PZ-R2-F-A, August 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-R2-F-A, PZ-R2-F-B1/ PZ-R2-F-B2, and PZ-R2-FC received new well pads and bolted covers. Fill was added to PZ-R2-F-A and PZ-R2-F-C. In 2012, SFOO reported that the well pads for PZ-R2-F-B1 and PZ-R2-F-B2 were broken. The well pads remained broken and no readings were taken from March 2012 to October 2014. In October 2014, the well pads were repaired and readings resumed. June 2015 to July 2016 – PZ-R2-F-B1/ PZ-R2-F-B2 were covered with a trench plate for protection from traffic traveling to Seepage Management Test Facility (SMTF) during SFOO restoration of the SMTF; readings resumed 7/7/2016
Lakeside Features	Approximately 20-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	PZ-R2-F-A (Lower Foundation)
Centerline PZs	PZ-R2-F-B1 (Embankment Fill) PZ-R2-F-B2 (Upper Foundation)
Landside PZs and Tailwater	PZ-R2-FC (Upper Foundation) R2-4-TW
Landside Features	Pond/borrow source (approximately 600 feet wide and 250 feet long) at the landside toe
Historic Poor Performance	A saturated berm, soft toe and standing water at landside toe has been observed during high pools. R2-12: Condition 3: 4 inch boil. Sulfur odor and sulfur traces, 0.5 GPM
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Core boring CB-LD2-30 (not shown on cross section, located in the center of the original 1930's embankment, 300 ft. west) indicates a large amount of limestone fragments as well as shelly layers. The borrow canal borings indicate a large amount of shell and limestone present for use as fill. Gravel and shell layers are likely present in the embankment at this location and will provide a preferential path for water movement.
- PZ-R2-F-B1 shows a direct correlation to the lake; however, some readings are above the lake stage, indicating a perched water level. Readings above the lake stage correlate with periods of prolonged or excessive rainfall.
- PZ-R2-F-A, PZ-R2-F-B2, and PZ-R2-FC show similar responses to the lake level. The correlation from lakeside to landside decreases across the embankment and trends from strong to good. Head loss generally remains consistent from lakeside to landside and is generally about 1 foot. Piezometric readings from PZ-R2-FC tend to dampen (correlation becomes weaker) when the lake stage approaches elevation 15.5. This is likely due to the presence of the pond immediately downstream of the embankment toe.
- During the high lake stage event between beginning of October to the end of November 2017, PZ-R2-F-C the readings were above the groundwater surface, and a 4.25 foot riser was added to collect the water reading at this piezometer. The water readings above ground surface indicate artesian pressures are present beneath the blanket material.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-R2-FC	**12.58**	**11.46**	***1.12***	**51.5**	***0.02***	**8.6**	***0.13***

Given the reported soft embankment toe, little head loss from lakeside to landside, and the deep pond/borrow source on the landside toe, this area should be watched closely for seepage related issues during high water events. Heavy vegetation around the pond make inspection difficult and has been planned for removal in FY16.

6.5. Piezometer Line R3-1

Location	0.7 Miles East of Gate at Spillway S-354
DSMS Segment/CIZ	3/A
Date PZ Line in Service	August 1999, except for PZ-ER3-D-B, September 1995
Piezometer Maintenance and Repairs	PZ-ER3D-B – February 2009 redeveloped, well pad repaired October 2014 – PZ-R3-D-A1 and PZ-R3-D-A2: fill added, new well pads and new bolted covers.
Lakeside Features	Approximately 20-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	PZ-R3-D-A2 (Lower Embankment Fill and Blanket Material) PZ-R3-D-A1 (Lower Foundation)
Centerline PZs	PZ-ER3-D-B (Embankment Fill)
Landside PZs and Tailwater	PZ-R3-D-C2 (Blanket Material/Upper Foundation) PZ-R3-D-C1 (Lower Foundation) R3-1-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	1995 Point 2-1 and 2-2 largest flowing seepage area of the 1995 Lake Harbor Sites. No sulfur smell and no movement of material (Condition 3). Heavy seepage was observed exiting the toe of the embankment. R3-3: Condition 3 Saturated berm with ponding and seepage R3-1: Condition 3 2” seep with flowing water. In 2006, it was noted as approximately 5' deep void with a 2' diameter opening hole.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone to elevation 14. Work included: Excavate 1’ deep x 30’ wide, backfill with filter stone, overexcavate and shape ditch bottom, backfill ditch with filter stone, place 6" topsoil & seed

Data Analysis/Evaluation:

- PZ-R3-D-A2 directly correlates with the lake level and generally reads the same as the lake.
- PZ-ER3-D-B: for lake levels less than elevation 13.2 feet this piezometer is dry. For lake elevations above elevation 13.2 feet, this piezometer seems to correlate well with the lake stage; however, some readings above elevation 13.0 feet may be influenced by perched water and rainfall. From historic observations, it is interesting to note that after construction of the seepage berm the phreatic surface in the embankment rose 1.5 - 2 feet to where it reads approximately lake level at lower lake elevations. During the 1998 High Water Event the phreatic surface lagged about 1 foot behind lake level. Readings indicate that lake levels above 14.0 produce some drainage through the berm. Observations during the 1998 event indicated a saturated berm but no piping.
- PZ-R3-D-A1 and PZ-R3-D-C1 indicate a damped response to changes and a weak correlation to the lake elevation and indicates that the blanket material is continuous and there is considerable amount of filter cake that hydraulically separates the lake and the piezometers. However, little head loss (approximately 1.2 feet for a stage of elevation 17) is observed from lakeside to landside, indicating a highly pervious foundation.
- PZ-R3-D-C1 and PZ-R3-D-C2 read nearly identical which is somewhat unusual considering they are separated by a semi-confining layer consisting of clayey sand. This could indicate that the clayey sand unit was breached during excavation of the lakeside borrow source.
- The toe ditch is typically dry, only a few tailwater reading were obtained between 2016 and 2017 and tailwater was approximately 1.2 feet above C1 and C2.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-ER3-D-B	16.11	11.46	*4.65*	124.5	*0.04*		
PZ-R3-D-C2	11.14	11.46	*-0.32*	29	*-0.01*	7.4	*-0.04*

The piezometer data shows several feet of head loss between the lake and the foundation; however, at higher lake levels, the downstream piezometers are reading close to ground surface elevations, indicating artesian conditions may be present. As there appears to be a true confining layer in this area, through embankment seepage, and embankment underseepage should be closely monitored under high pool elevations. Given the readings observed in PZ-ER3-D-B, the initial concern would likely be seepage/piping at the landside toe or landside toe or face of the toe ditch.

6.6. Piezometer Line R3-2

Location	1.7 Miles East of Gate at Spillway S-354
DSMS Segment/CIZ	2/A
Date PZ Line in Service	PZ-MRR3-SH-B1 and PZ-MRR3-SH-B2 Oct/Nov 1995 PZ-R3-SH-B1A and PZ-R3-SH-C1 and C2 August 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-MRR3-SH-B1/PZ-MRR3-SH-B2: new well pad and bolted cover.
Lakeside Features	Approximately 100–foot, heavily vegetated and overgrown bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	None
Centerline PZs	PZ-MRR3-SH-B1 (Upper Embankment Fill) PZ-R3-SH-B1A (Embankment Fill) PZ-MRR3-SH-B2 (Lower Embankment Fill/Blanket/Upper Foundation)
Landside PZs and Tailwater	PZ-R3-SH-C2 (Lower Embankment Fill) PZ-R3-SH-C1 (Upper Foundation) R3-2-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	During the 1995 High Water Event, the worst damage occurred near this piezometer, over about a 1500 foot length of embankment located midway between S-354 and S-276 (Culvert 4A) (Points LHS-4, LHS-3, LHS-2). “Damage consisted of the toe berm has collapsing in several areas due to piping of embankment foundation material. Piped material exited primarily through the ditch slopes and some through the ditch bottom. Seepage exiting the slopes and ditch bottom had no odor and did not stain the ground white. Therefore, seepage was determined to be coming through the embankment and upper foundation material and not from the limestone below the confining clay layer. A sinkhole appeared in levee crest above areas where piping occurred into toe ditch. The sinkhole was approximately 3 feet in diameter by six feet deep. Probing through the bottom revealed an additional void for another 6 - 9 feet. Additional voids or soft areas were detected several hundred feet further to the east. A seepage berm was installed throughout the area.”
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Excavate 3’ deep x 30’ wide, backfill with filter stone, overexcavate and shape ditch bottom, backfill ditch with filter stone, place 6" topsoil & seed
Decommissioned PZs	PZ-R3-SH-C was installed in the foundation materials beneath the landward toe of the embankment in November 1995 but was destroyed during construction of the seepage berm in spring 1996. (PZ-R3-SH-C1 and PZ-R3SH-C2 were installed to replace PZ-R3-SH-C)

Data Analysis/Evaluation:

- PZ-R3-SH-B1 is screened high within the embankment and is generally dry
- PZ-R3-SH-B1A and PZ-R3-SH-C2 reside in the fill material and show a direct to strong correlation to the lake level. Little head loss from upstream to downstream. This may be exaggerated for lower lake levels as it appears PZ-R3-SH-C2 is responding to tailwater in the ditch as higher readings in PZ-R3-SH-C2 correlate to periods of prolonged rainfall.

- The deep piezometers PZ-R3-SH-B2 and PZ-R3-SH-C1 indicate a dampened response to lake stages; however, they still indicate a good correlation to lake stages. For a stage of elevation 17.0 feet, about 1.2 feet of head loss is occurring between these piezometers.
- The toe ditch is typically dry, no tailwater readings were obtained in 2018, and only a few readings were collected in 2017.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R3-SH-B1A	**17.32**	**14.16**	***3.16***	**117.5**	***0.03***		
PZ-R3-SH-C2	**15.61**	**14.16**	***1.45***	**39**	***0.04***		

The occurrence of a sinkhole on the crest of the embankment makes this a critical area. Piezometer readings at the toe of the embankment also appear to indicate artesian conditions are present. Borings indicate the material at the upstream toe is very soft to soft. The large sinkhole indicates internally unstable materials and that a significant amount of material piped during the 1995 High Water Event. As evidenced from the 1995 High Water Event, the embankment is also very pervious at this location. Given the conditions noted at this location, the landside toe should be closely monitored for signs of distress during high water events.

6.7. Piezometer Line R3-3

Location	1.0 Mile West of S-276 (Culvert 4A)
DSMS Segment/CIZ	2/A
Date PZ Line in Service	August of 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-R3-C-C1 and PZ-R3-C-C2: fill added, new well pad and bolted cover.
Lakeside Features	From aerial photos and available survey, a heavily vegetated bench extends approximately 270 feet from the toe before the lakeside borrow canal begins. The bench is generally about elevation 15.0 feet.
Lakeside PZs	PZ-R3-C-A1 (Lower/Mid Fill) PZ-R3-C–A2 (Foundation Limestone)
Centerline PZs	PZ-R3-C-B (Lower Fill)
Landside PZs and Tailwater	PZ-R3-C-C1 (Fill/Foundation Interface) PZ-R3-C-C2 (Foundation Limestone) R3-3-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	During the 1995 High Water Event, described at the time as Point 6F, this area showed signs of through embankment piping and internal erosion.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone to elevation 15.5. Work included: Excavate 1' deep x 30' wide, backfill with filter stone, overexcavate and shape ditch bottom, backfill ditch with filter stone, place 6" topsoil & seed.

Data Analysis/Evaluation:

- Above a lake elevation of 14.0 feet, piezometers PZ-R3-C-B and PZ-R3-C-A2 (prior to 2018) show direct correlation with the lake level with little to no head loss between the two piezometers.
- PZ-R3-C-A2 was dry between March to December of 2018.
- Deep piezometers: PZ-R3C-A1 shows a strong correlation to the lake level with PZ-R3C-C1 showing a good correlation that is slightly dampened from PZ-R3C-A1 response.
- From the cross section, it appears that PZ-R3-C-C2 is screened within the fine grained material and peat; however, based on its response to lake levels, it is likely that the bottom of the screen and filter pack extends into the porous weathered limestone as PZ-R3C-C2 shows a strong correlation to lake elevations and generally trends similar to PZ-R3-C-A1, with about 1 foot of head loss occurring from upstream to downstream for a lake of elevation 17.0 feet. It is also noted that PZ-R3C-C2 is likely influenced by the tailwater in the roadway ditch, as indicated by the spikes on the time series plots.
- The toe ditch is typically dry, no tailwater readings were obtained in 2018, and only a few readings were collected in 2017.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R3-C-B	17.31	14.06	***3.25***	120	***0.03***		
PZ-R3-C-C2	14.12	14.06	***0.06***	30	***0.00***	2.5	***0.02***

Although a seepage berm was constructed on the downstream face of the embankment, no repairs or improvements to the foundation were included. Due to the documented past performance issues and little head loss observed through the embankment and foundation, this area should be closely monitored during high pools.

6.8. Piezometer Line R3-4

Location	3.5 Miles East of Gate at Spillway S-354
DSMS Segment/CIZ	2/A
Date PZ Line in Service	PZ-ER3E-B, December 1995 Remainder, August 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-R3-E-B2 and PZ-ER3E-B: new well pad
Lakeside Features	From aerial photos and available survey, a heavily vegetated bench extends approximately 270 feet from the toe before the lakeside borrow canal begins. The bench is generally about elevation 15.0 feet.
Lakeside PZs	PZ-R3-E-A2 (Lower Embankment Fill) PZ-R3-E-A1 (Upper Foundation)
Centerline PZs	PZ-R3-E-B2 (Lower Embankment Fill) PZ-ER3E-B (Foundation)
Landside PZs and Tailwater	PZ-R3-E-C2 (Lower Embankment Fill) PZ-R3-E-C1 (Upper Foundation) R3-4-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	In 1995, a sand boil moving material was observed on the downstream berm/embankment toe, this point has been described as Point 5. In 1998, Point R3-7 noted a saturated berm. Also in 1998, Point R3-8 nearby noted a 2" seep. No sulfur odor.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone to elevation 18.1. Work included: Excavate 1' deep x 30' wide, backfill with filter stone, overexcavate and shape ditch bottom, backfill ditch with filter stone, place 6" topsoil & seed.

Data Analysis/Evaluation:

- PZ-R3-E-A2 shows a direct correlation with the lake level, followed by piezometer PZ-R3-E-A1 which shows a slightly dampened response, but strong correlation, likely caused by the buildup of filter cake within the lakeside borrow source and the presence of blanket material separating the two piezometers.
- PZ-R3-E-B2 shows direct correlation with the lake level for lake elevations above 14.0 feet (approximately). Little head loss is noted between PZ-R3-E-A2 and PZ-R3-E-B2. PZ-R3-E-B2 is tipped near elevation 10.0 feet; therefore, for lake levels less than elevation 13.0 feet, the piezometer should be dry; however, considering readings are recorded above the tip when the lake level is lower than the piezometer tip, this piezometer is likely recording a perched water table.
- PZ-ER3E-B and PZ-R3-E-C1 indicate a good correlation to changes in lake stage; less than 0.5 feet head loss is generally observed between the two piezometers.
- During high lake stages, PZ-R3-E-C1 readings approach ground surface elevations indicating artesian pressures are present beneath the blanket material.
- PZ-R3-E-C2 has water level spikes that correlate with rain events. It is likely that this piezometer is responding to the tailwater in the roadway ditch and/or perched water.
- No tailwater readings were obtained in 2018,

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading* (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R3-E-B2				124.5			
PZ-R3-E-C2				33		0.4	

No Tailwater readings available at this time

Considering PZ-R3-E-A1 and PZ-R3-E-B2 indicate little to no head loss across the embankment fill and PZ-R3-E-C1 indicates artesian pressures, this area should be monitored closely for seepage related issues during high water events.

6.9. Piezometer Line R3-5

Location	0.8 Mile East of S-276 (Culvert 4A)
DSMS Segment/CIZ	1/A
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	No known
Lakeside Features	Approximately 10-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	None installed due to 1999 funding limitations.
Centerline PZs	PZ-R3-B-B2 (Embankment Fill) PZ-R3-B-B1 (Upper Foundation)
Landside PZs and Tailwater	Due to 1999 funding limitations, no PZ installed until 2016. PZ-HHD16-R3-3C (Upper Foundation) R3-5-TW
Landside Features	US-27/SR-80 parallels the toe. A drainage ditch for capturing roadway runoff lies between the highway and the embankment toe.
Historic Poor Performance	Points R3-10, R3-9 and R3-7 (1998): saturated berm and ponding water, no flow. This area was investigated during August 2004 during paving of the LOST because the contractor was about to pave over a large crack within the embankment. This crack was extensive, measuring 22 feet long and 14 feet straight down. Exploratory test pits were performed; however, the investigations were inconclusive.
Emergency/ Permanent Repairs	The crack observed during LOST paving was over excavated and backfilled with suitable material before the paving was completed.

Data Analysis/Evaluation:

- PZ-R3-B-B2 seemingly correlates strongly with lake stages greater than elevation 15.0 feet. Below elevation 15.0 feet, it seems that this piezometer responds to perched water as numerous readings higher than the lake are recorded. It is also noted that the lowest perched or bottom of piezometer reading occurred in 2009, since that time, it appears that the lowest occurring readings are increasing, which could mean the piezometer is infilling with sediments. In 2017, it was recommended that the piezometer be flushed to remove any possible sediments; however, in 2018, the piezometer was inspected and no sediments appeared to be present. The response of the piezometer appears to be related to the conditions it's installed and the elevation in which piezometric head is measured.
- PZ-R3-B-B1 indicates a good correlation with lake stage, but with a dampened response. This may indicate the presence of a thick buildup of filter cake or that the original lakeside borrow canal did not deeply penetrate the foundation.
- PZ-R3-B-B1 and PZ-R3-B-B2 are screened above and below the confining unit; given the differences in correlation to lake stage and recorded readings, it seems that the confining unit is intact and continuous from lakeside to the embankment centerline.
- PZ-HHD16-R3-3C and PZ-R3-B-B1 indicate a good correlation with the tailwater and is generally unresponsive to the lake.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-R3-B-B2	**17.17**	**11.76**	***5.41***	**89.5**	***0.06***		
PZ-HHD16-R3-3C	**12.06**	**11.76**	***0.3***	**5**	***0.06***	**5.7**	***0.05***

When the lake is above elevation 14.0 feet, this area should be periodically monitored for signs of seepage distress along the landside toe.

6.10. Piezometer Line R3-6

Location	0.6 Mile North East of South Bay Park Access Gate
DSMS Segment/CIZ	1/A
Date PZ Line in Service	PZ-ER3P4-B1, PZ-ER3P4-B2 and PZ-ER3P4-C April 1996 PZ-R3-F-A1 and PZ-R3-F-A2 August 1999
Piezometer Maintenance and Repairs	PZ-R3-F-A1 was redrilled and reset by NAB in February 2009 October 2014 – PZ-R3-F-A1 and PZ-R3-F-A2: fill added around well pad; also, PZ-ER3P4-B1/ PZ-ER3P4-B2: new well pad and bolted cover
Lakeside Features	The embankment slopes directly into the lake as the lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	PZ-R3-F-A2 (Lower Embankment Fill/Upper Foundation) PZ-R3-F-A1 (Lower Foundation)
Centerline PZs	PZ-ER3P4-B1 (Embankment Fill) PZ-ER3P4-B2 (Lower Embankment Fill/Upper Foundation)
Landside PZs and Tailwater	PZ-ER3P4-C (Mid Foundation) PZ-HHD16-R3-2C (Upper Foundation) R3-6-TW
Landside Features	A farmers toe ditch and sugar cane fields reside immediately downstream of the embankment toe.
Historic Poor Performance	Extensive poor performance history, see discussion below. 1995 Point 4 1998 Points R3-11, R3-05-07, R3-13, R3-30
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Excavate 3' deep x 30' wide, backfill with filter stone, place 6" topsoil & seed Additional repair (trench drain) is discussed below

At this location, the surficial blanket material and the upper limestone unit is breached by the farmers ditches that runs perpendicular and parallel to the embankment at this location which makes it particularly susceptible to seepage and piping problems. This was confirmed during both the 1995 and 1998 High Water Events, as boils were observed in the toe ditch. White staining around the boils indicates the seepage originated from beneath and within the calcareous materials. In 1996, as a result of the 1995 High Water Event, stone column relief wells and a small seepage berm were constructed. During the 1998 High Water Event, boils were again observed in the toe ditch between the relief wells as well as further north. The boils were more numerous and severe than in 1995, indicating cumulative damage had occurred. This area ranked among the locations of greatest concern. Emergency repairs were made in this area in 1999 by over excavating the toe and a constructing semi-pervious berm.

Additional repairs were performed at this location in 2003 when a trench/toe drain (consisting of ASTM C 33 #57 stone wrapped in a geotextile) was constructed throughout the area. The trench penetrates the upper confining layers and upper limestone, a perpendicular component of the trench outfalls to the ditch every 90 feet. This seepage control feature has been observed to produce water even at low lake levels.

This location was under observation again in October 2012 when the lake rose quickly to approximately elevation 16.0 feet. Seepage was observed flowing out of the drain outlets and in between the drain outlets. Although seepage was bypassing the outlets (indicating the spacing was too great) there was little concern for progression of piping as the trench would act as a barrier should piping initiate.

Data Analysis/Evaluation:

- PZ-R3-F-A2 shows a direct correlation with the lake level while PZ-R3-F-A1 shows a weak correlation, likely due its location deeper in the foundation beneath a semi-confining unit.
- PZ-ER3P4-B1 shows a direct correlation above a lake elevation of 14.0 feet. When the lake is below elevation 14.0 feet, this piezometer may be recording a perched water table as the readings seem to be higher during periods of prolonged rainfall.
- PZ-R3-F-A1, PZ-ER3P4-B2, PZ-ER3P4-C, and PZ-HHD16-R3-2C show no correlation to the lake levels, which is not consistent with the trends from this region. It is possible that the limestone is less permeable at this location such that PZ-ER3P4-C is hydraulically separated from the lake or that the downstream farmer's tailwater control has a controlling effect on the readings over the lake. Reviewing the tailwater level within this area, it appears these piezometers correlate better to the tailwater level.
- Based on reviewing the data from the last few years, it was noted PZ-ER3P4-B2 is continuously reading higher than PZ-ER3P4-C which could indicate that the drain layer relieving pressure. However. It is inconclusive as to how much PZ-ER3P4-B2 and PZ-ERP4-C were affected by installation of the drain

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-ER3P4-B1	17.1	7.61	***9.49***	121.6	***0.08***		
PZ-HHD16-R3-2C	9.3	7.61	***1.69***	22	***0.08***		
PZ-ER3P4-C	8.23	7.61	***0.62***			5.5	***0.11***

Considering the reoccurring poor performance history associated with this area, and the horizontal gradient approaching 0.1, this location should be monitored closely during high water events. Additionally, PZ-ER3P4-B2 should be monitored closely as an increase in piezometric head could indicate the geotextile around the drain has begun to clog. To better monitor the performance of the drain, it is recommended to install a piezometer directly upstream of the drain at this location.

6.11. Piezometer Line R3-7

Location	1.0 Mile North East of South Bay Park Access Gate
DSMS Segment/CIZ	1/A
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	PZ-R3-G-A1 redrilled and reset by NAB in February 2009 October 2014 – PZ-R3-G-A1 and PZ-R3-G-A2: fill added around well pad
Lakeside Features	Approximately 25-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	PZ-R3-G-A2 (Lower Embankment Fill/Blanket Material) PZ-R3-G-A1 (Foundation)
Centerline PZs	PZ-R3-G-B2 (Embankment Fill) PZ-R3-G-B1 (Foundation)
Landside PZs and Tailwater	PZ-HHD16-R3-1C (Upper Foundation) R3-7-TW
Landside Features	A farmers toe ditch and sugar cane fields reside immediately downstream of the embankment toe. Points R3-25, R3-4, R3-04-04
Historic Poor Performance	Extensive poor performance history and is consistent with what is discussed for piezometer line R3-6. Points R3-4, R3-25, R3-15, R3-04-04
Emergency/ Permanent Repairs	The same trench/toe drain installed in 2003 (as described in R3-6) continues through this piezometer line. The drain penetrates the upper confining layers and empties into the adjacent ditch. This seepage control feature has been observed to produce water even at low lake levels. Observations and discussions of poor performance and seepage related issues provided in R3-6 also apply to this piezometer line.

Data Analysis/Evaluation:

- Piezometer PZ-R3-G-A2 shows a direct correlation with the lake level.
- Piezometer readings for PZ-R3-G-B2 appear higher than the lake during low lake events because of the piezometer tip location in the embankment. These readings likely represent perched water. This piezometer also appears to be influenced by rainfall. For lake levels less than elevation 13.0 feet the bottom of the piezometer is encountered. The perched water may create wet conditions at the landside toe of the embankment.
- Above a lake elevation of 14.0 feet, piezometer PZ-R3-G-B2 shows a direct correlation to the lake level. Little to no head loss is occurring from PZ-R3-G-A2 to PZ-R3-G-B2
- Piezometers PZ-R3-G-A1, PZ-HHD16-R3-1C, and PZ-R3-G-B1 have weak correlations to the lake level. Reviewing the tailwater level within this area, it appears these piezometers correlate better to the tailwater level.
- Piezometer PZ-HHD16-R3-1C was installed upstream of the drain to better monitor the performance of the drain at this location. PZ-HHD16-R3-1C appears to be influenced by the tailwater.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-R3-G-B2	17.3	8.01	***9.29***	128.2	***0.07***		
PZ-HHD16-R3-1C	8.93	8.01	***0.92***	25.4	***0.04***	0.6	***1.53***

Considering seepage has been observed to bypass the drain during higher lake stages, this area should continue to be monitored during high lake stages.

6.12. Combined Analysis: Section A – Reaches 2 & 3

Reaches 2 and 3 are areas of concern and have been identified to have the greatest probability of failure as estimated by the Existing Condition Risk Assessment. Several piezometer lines within this section are located in areas of past poor performance. Documented conditions have occurred when head differences are as low as 4 feet, as evidenced by a wet embankment toe and saturated berm. Because of the conditions documented during high water events of 1995 and 1998, several areas received emergency repairs.

Observations from 2012 to 2018, when the lake stage reached 16.0 feet indicate these problems continue to occur at head differentials of approximately 5 to 6 feet. Piezometric responses observed during these events and when extrapolated to higher events, indicate that artesian pressures are present beneath the blanket material. Because the blanket material is thin and comprised of low unit weight peat, organic silts and clays, minimal artesian pressure is needed to have a blowout and initiate piping. Additionally, the blanket material is causing seepage and rainwater to perch in the embankment, as evidenced by piezometer readings in the centerline of the embankment that directly correlate to and match the lake stage. Since the blanket material is prohibiting downward drainage into the foundation, the preferred path for seepage through the embankment is horizontal, causing seepage to exit at the embankment toe.

Within this piezometer section, the ground surface elevations are lowest around the lake, and due to the demands of groundwater control with farming, the head differences across the dam are the greatest. Given this, combined with the geologic conditions, documented poor performance and no permanent repairs, these reaches are particularly vulnerable and should be monitored closely for signs of distress.

7. SECTION B – REACHES 1C & 1D (SOUTH OF CANAL POINT)

7.1. Piezometer Line R1-1

Location	1.6 Miles South of S-275 (Culvert 12)
DSMS Segment/	24/A
Date PZ Line in Service	July/August 1995
Piezometer Maintenance and Repairs	PZ-HHDR1-4B2 – Feb 2009 redeveloped, well pad repaired October 2014 – PZ-HHDR1-4C1 and PZ-HHDR1-4C1: fill added, new well pad and bolted cover
Lakeside Features	Approximately 15-foot bench to lakeside toe. The lakeside borrow source resides just upstream of the embankment toe.
Lakeside PZs	None
Centerline PZs	PZ-HHDR1-4B2 (Upper Foundation Organics/Fines) PZ-HHDR1-4B1 (Foundation Within and Just Below Organics/Fines)
Landside PZs and Tailwater	PZ-HHDR1-4C2 (Foundation Just below Organics/Fines) PZ-HHDR1-4C1 (Foundation) R1-1-TW
Landside Features	A farmers toe ditch and sugar cane fields reside immediately downstream of the embankment toe.
Historic Poor Performance	1995: Condition 1 (saturated berm) and Condition 2 (ponding water) observed throughout the region. R1-9 (1999) – Condition 2, ponding water no flow. R1D-05-02 (2005) – Seep along the bottom of the toe ditch bank, Condition 3. R1D-05-08 (2005) – An active seep was observed in this location the seep is running clear. (Condition 3, no notes with regards to embankment or foundation seepage) R1-10 (1998) – (located 0.5 miles NE) indicated a 2 inch diameter seep in upper bank of toe ditch. Flow up to 2GPM was estimated. Records are unclear whether the seep was moving material.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -35 (FT-NAVD88) in November 2009

Data Analysis/Evaluation:

- Before installation of the cutoff wall, PZ-HHDR1-4B1 and PZ-HHDR1-4C1 indicate a similar, dampened response to changes in the lake level. After construction of the cutoff wall, readings from these two piezometers diverge. Water levels increase in PZ-HHDR1-4B1 indicating a stacking of groundwater against the cutoff wall. For a given lake stage 16.0 feet, PZ-HHDR1-4C1 reads approximately 1.6 feet lower than before installation of the cutoff wall.
- PZ-HHDR1-4B2 is screened entirely within fine grained material. Per the recommendation of the 2014 instrumentation report, this piezometer was resurveyed and redeveloped in late summer 2014. Readings taken since the resurvey and redevelopment still read above lake level. It is a possibility that the piezometer is reading a perched water table.
- Piezometer PZ-HHDR1-4C2 shows a weak to no correlation to the lake level before installation of the cutoff wall. The correlation decreased after installation of the cutoff wall and approximately a 1.2 feet drop in head is noted for a lake stage of elevation 16.0 feet.
- Before installation of the cutoff wall, a significant vertical gradient existed between PZ-HHDR1-4C1 and PZ-HHDR1-4C2, after installation of the cutoff wall, the magnitude of the gradient decreased.

- PZ-HHDR1-4C2and PZ-HHDR1-4C1 show direct correlation with tailwater.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-HHDR1-4B2	15.6	7.51	*10.2*	135.5	*0.06*		
PZ-HHDR1-4C2	8.2	7.51	*0.7*	10	*0.07*		
PZ-HHDR1-4C1	10.25	7.51	*2.9*			8.7	*0.31*

While no seepage problems were observed at this location during the 1995, 1998, 1999, or 2004 High Water Events, the landside toe area may be susceptible to seepage related issues because of the geologic material and topographic conditions. Given that cutoff wall is installed, the chance for conditions developing has been decreased and the cutoff wall appears to be effective at reducing piezometric head at this location; however, this location should still be monitored during high water events to evaluate the effectiveness of the cutoff wall at higher lake elevations as any fill above elevation 17.2 feet is considered a first fill.

7.2. Piezometer Line R1-2

Location	½ Mile South of S-275 (Culvert 12)
DSMS Segment/CIZ	24/A
Date PZ Line in Service	July 1995
Piezometer Maintenance and Repairs	PZ-HHDR1-6C1 and PZ-HHDR1-6C2 risers were raised near the completion of Quarry Backfill Operations. PZ-HHDR1-6B1 Riser modified in 2004. PZ-HHDR1-6B1 and PZ-HHDR1-6B2 risers modified after cutoff wall construction.
Lakeside Features	No defined bench exists, the embankment slopes nearly directly into the lakeside borrow source.
Lakeside PZs	None
Centerline PZs	PZ-HHDR1-6B2 (Upper Foundation) PZ-HHDR1-6B1 (Foundation)
Landside PZs and Tailwater	PZ-HHDR1-6C2 (Upper Foundation) PZ-HHDR1-6C1 (Foundation)
Landside Features	A small toe ditch and vacant land where the quarry was located exists downstream of the embankment toe.
Historic Poor Performance	No recorded poor performance; however, the deep quarry adjacent to the foundation was a source of significant concern. (See discussion below)
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -35 (FT-NAVD88) in April 2010. Abandoned quarry backfilled to grade 2010/2011 timeframe, identified as Focus Area 2 (HHD IRRM Plan, 14 July 2010). Organics, fines and debris was removed from the quarry before backfilling with granular material.

Prior to backfilling the quarry, the water level in the quarry lake was monitored via staff gauge at the same time the piezometers were read. It was found that the quarry water level did not fluctuate more than 6 inches, likely due to the quarry lake outfall that previously existed at the south end of the abandoned quarry. Prior to backfilling, the quarry depth was recorded at elevation -14.0 feet. During backfilling of the abandoned quarry, dewatering was conducted, but was not completely successful due to the highly permeable zones in the foundation. Construction of the cutoff wall and the quarry backfill occurred over the same timeframe.

Data Analysis/Evaluation:

- Before installation of the cutoff wall and quarry backfilling in 2010/2011, all the piezometers read within 1 foot of each other (approximately) and showed almost no correlation to the lake level. It is likely the geology that the piezometers are screened in was more connected to the quarry pit than the lake. This is evidenced by the reported 6-inch water level variations in the quarry, regardless of the lake stage and the correlations relationship shown on the hysteresis plots.
- PZ-HHDR1-6B1 and PZ-HHDR1-6B2 show an increase in head after construction of cutoff wall indicating stacking of groundwater on the upstream side of wall. These piezometers now correlate strong/directly with changes in lake levels.
- Before installation of the cutoff wall and backfilling of the quarry, PZ-HHDR1-6C1 and PZ-HHDR1-6C2 showed a weak correlation to changes in lake stage, likely due to the deep quarry pit adjacent to the embankment toe.
- After installation of the cutoff wall and backfilling of the quarry, PZ-HHDR1-6C1 and PZ-HHDR1-6C2 show a similar correlation as before the installation of the cutoff wall and backfilling of the quarry, likely the result of both construction operations and makes the effect

(head loss) from the cutoff wall seem negligible (for a lake stage of elevation 16.0 feet, the head reduction is approximately 0.2 foot for both piezometers). However, the benefit is much greater, as an unfiltered seepage exit face in the foundation has now been eliminated.

- During the high lake stage event between October to November 2017, PZ HHDR1-6C1 and PZ HHDR1-6C2 readings at or near ground surface indicating artesian pressures may be present beneath the blanket material. Since this is the first high lake stage these piezometers experienced after the construction of the cut off wall and the backfilling of the quarry. This could indicate that unfiltered foundation seepage existed in the past; however, since this has been eliminated by filling the quarry, the water had no exit and a rise in the water level was noted at the toe piezometers. Poor surface drainage also exists at the embankment toe and in the immediate area of the piezometers. The lack of surface drainage and ponding water may also be influencing these readings.

Per analysis of the piezometer readings, the cutoff wall has reduced the head at the downstream toe of the dam. Backfilling of the quarry has eliminated the potential for a piping failure to initiate underwater and go unnoticed.

7.3. Piezometer Line R1-3

Location	0.6 Miles North of S-275 (Culvert 12)
DSMS Segment/CIZ	24/A
Date PZ Line in Service	PZ-HHDR1-7B December 1994 PZ-HHDR1-7C2 February 1995
Piezometer Maintenance and Repairs	PZ-HHDR1-7C2 – redrilled and reset by NAB in February 2009
Lakeside Features	A short bench exists before the embankment slopes into the lakeside borrow source
Lakeside PZs	None
Centerline PZs	PZ-HHDR1-7B (Lower Foundation)
Landside PZs and Tailwater	PZ-HHDR1-7C2 (Lower Foundation) R1-3-TW
Landside Features	A small ditch and NW 17th Street parallels the embankment toe. The toe ditch services surface water runoff for the road.
Historic Poor Performance	R1-10M (1998) 5 - 7 small seeps around culvert that flows from toe ditch under hwy 715. No movement of material was observed. Condition 3.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -35 (FT-NAVD88) in August 2011

Data Analysis/Evaluation:

- PZ-HHDR1-7B is upstream of the cutoff wall shows good correlation to lake levels. Correlation has increased to strong since installation of the cutoff wall.
- The correlation between PZ-HHDR1-7C2 and lake stage was good before the installation of the cutoff wall; after installation of the cutoff wall, the correlation became weak. A head reduction of 2 feet for a lake stage of elevation 16.0 feet is noted after installation of the cutoff wall.
- No tailwater readings were collected in 2018 and only a few readings were collected in 2017.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-HHDR1-7C2	9.6	8.5	*1.1*			17.6	***0.06***

This location does not appear to indicate any signs of seepage distress. Per analysis of the piezometer readings, the cutoff wall has reduced the head at the downstream toe of the dam, thereby reducing seepage and piping concerns at this location.

7.4. Piezometer Line R1-4

Location	0.3 Mile South of S-274 (Culvert 12A)
DSMS Segment/CIZ	24/A
Date PZ Line in Service	February/March 1990
Piezometer Maintenance and Repairs	October 2014 – P1/P2 and P3: New well pad and bolted cover
Lakeside Features	A short bench exists before the embankment slopes into the lakeside borrow source. Some material has also been stockpiled on the upstream slope.
Lakeside PZs	None
Centerline PZs	P3 (Mid Embankment Fill) P1 (Within Foundation Organics/Fines) P2 (Lower Foundation)
Landside PZs and Tailwater	Upstream of Ditch (Landside Toe) • P6 (Within Foundation Organics/Fines) • P5 (Just Beneath Foundation Organics/Fines) • P4 (Foundation) Downstream of Ditch • P8 (Within Foundation Organics/Fines and Limestone) • P9 (Just Beneath Foundation Organics/Fines) • P7 (Foundation) R1-4-TW
Landside Features	A farmers toe ditch and sugar cane fields parallel the embankment toe. A separate toe ditch intercepts the toe ditch that parallels the embankment.
Historic Poor Performance	No historic poor performance recorded
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -35 (FT-NAVD88) in August 2009

Data Analysis/Evaluation:

- Historical analysis of the piezometer readings and ditch tailwater elevations indicate there is a good correlation between these readings and the ditch water levels. This would indicate that the confining layer is likely breached and/or the lakeside borrow source entrance likely has low permeable materials or does not penetrate deep into pervious foundation zones. The presence of one or both of these conditions would explain the weak to no correlation observed with the foundation piezometers, as discussed below.
- Before the cutoff wall construction, all piezometers (with the exception of P3 and P1) read within approximately 1 foot of each other for a lake stage of elevation 16.0 feet.
- P1 and P2 are located upstream of the cutoff wall and now show good correlation to the lake level, where before the correlation was weak.
- The tip of P3 was set high (at elevation 16.0 feet). However, some response to lake elevations is noted, new survey elevation data (2014) confirmed the previous elevation was correct. This year’s readings indicates the water level at this piezometer is above the lake water level, which indicate perched water condition exist at this location.
- P4 through P9 show no correlation to the lake level after installation of the cutoff wall and now read consistently within 0.5 feet of each other. Before installation of the cutoff wall, a weak correlation was noted. These piezometers appear to be in direct correlation to the tailwater.

- For a lake stage of 16.0 feet, the downstream piezometers show approximately 0.5 feet head reduction after installation of the cutoff wall.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
P1	14.11	6.68	*7.43*	168.4	*0.04*		
P6	6.64	6.68	*-0.04*	48.3	*-0*		
P8	6.54	6.68	*-0.14*			0.9	*-0.16*

Per analysis of the piezometer readings, the cutoff wall has reduced the head at the downstream toe of the dam and disrupted any communication between the lake and downstream piezometers thereby reducing seepage and piping concerns at this location. According to the borings, a clayey sand is present above the lower limestone and was penetrated by the cutoff wall. It appears that this unit is acting as a confining unit and is contributing to the observed performance of the cutoff wall.

7.5. Piezometer Line R1-5

Location	0.35 Mile North of S-274 (Culvert 12A)
DSMS Segment/CIZ	24/A
Date PZ Line in Service	January 1995
Piezometer Maintenance and Repairs	No known
Lakeside Features	Wide bench (approximately 80 feet) before reaching lakeside riprap protection. Lake is shallow until the lakeside borrow source. Lakeside borrow source is offset approximately 350 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-HHDR1-10B2 (Embankment Fill/Foundation Organics/Fines) PZ-HHDR1-10B1 (Lower Foundation)
Landside PZs and Tailwater	PZ-HHDR1-10C2 (Embankment Fill/Foundation Organics/Fines) PZ-HHDR1-10C1 (Lower Foundation) R1-5-TW
Landside Features	A toe ditch parallels the embankment toe. The Pahokee airport lies downstream of the embankment at this location.
Historic Poor Performance	PA-A (1995) – Condition 3 seepage, many seeps in the area had white staining on ground and sulfur smell indicating seepage was from foundation rock. R1-10T (1998)– 2 inch boil observed in the bottom of the toe ditch, Condition 3
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Lay back ditch slope to 1:2, overexcavate and shape ditch bottom, place 2' filter stone Cutoff Wall installed to elevation -35 (FT-NAVD88) in May 2009

Data Analysis/Evaluation:

- Before installation of the cutoff wall, all four piezometers showed a similar correlation (good) to the lake level. After installation of the cutoff wall, the correlation of PZ-HHDR1-10B1 and PZ-HHDR1-10B2 became strong, as these piezometers are placed upstream of the cutoff wall.
- After installation of the cutoff wall, the correlation of the landside toe piezometers PZ-HHDR1-10C1 and PZ-HHDR1-10C2 remained nearly the same, but with a slight reduction in correlation noted.
- PZ-HHDR1-10C2 is screened within fine grained deposits and a thin lens of weathered limestone. In addition, the zone of influence for this piezometer likely extends into the sand located directly above the screened interval. From boring information, it appears this sand zone extends landward and across the ditch. Readings for this piezometer show a wide range for any given pool; given the screened interval in relation to this sand zone and the ditch, it is likely that tailwater in the ditch is influencing the readings from this piezometer
- In prior reports, for the downstream piezometers (C1 and C2), a head reduction of approximately 1.4 feet is noted for a lake stage of elevation 16.0 feet. In 2018, this reduction may be as low as 0.5 feet for a lake stage of approximately 17 feet. A seemingly less effective piezometric drop from cutoff wall construction may be attributable to rainfall and surface water as the response is seem to deviate from tailwater, then converge, then deviate and converge, while tailwater remains relatively constant. This does not appear to indicate any concern with cutoff wall performance.

- Limited readings of the tailwater was collected in 2018; however, the collected readings appear to correlate with the readings from PZ-HHDR1-10C1.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-HHDR1-10C2	**10.83**	**9.86**	***0.97***	**27.1**	***0.04***	**3.7**	***0.26***

This location does not appear to indicate any signs of seepage distress. Per analysis of the piezometer readings, the cutoff wall has reduced the head at the downstream toe of the dam, thereby reducing seepage and piping concerns at this location.

7.6. Piezometer Line R1-6

Location	0.5 Mile North of S-274 (Culvert 12A) (These piezometers reside approximately 600 feet to the north of piezometer line R1-5)
DSMS Segment/CIZ	24/A
Date PZ Line in Service	May 1996
Piezometer Maintenance and Repairs	October 2014 – PZ-ER1-PAC-C1/PZ-ER1-PAC-C2: fill added, new well pad and bolted cover
Lakeside Features	Wide bench (approximately 70 feet) before reaching lakeside riprap protection. Lake is shallow until the lakeside borrow source. Lakeside borrow source is offset approximately 350 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-ER1-PAC-B1 (Within and Just Below Foundation Organics/Fines) PZ-ER1-PAC-B2 (Lower Foundation)
Landside PZs and Tailwater	PZ-ER1-PAC-C2 (Foundation Organics/Fines) PZ-ER1-PAC-C1 (Lower Foundation) R1-6-TW
Landside Features	A toe ditch parallels the embankment toe. The Pahokee airport lies downstream of the embankment at this location.
Historic Poor Performance	PA-B, PA-C and PA-D (1995) - Condition 3 seepage, many seeps in the area had white staining on ground and sulfur smell indicating seepage was from foundation rock. R1-10V (1998) Condition 3, 4 seeps in toe bank, all about 1 inch in diameter, in 110 yd. area. White staining present. R1D-04-03 Condition 2, Saturated berm and standing water
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Lay back ditch slope to 1:2, overexcavate and shape ditch bottom, place 2' filter stone. Cutoff Wall installed to elevation -35 (FT-NAVD88) in May 2009

Data Analysis/Evaluation:

- Due to the close proximity of this piezometer line to R1-5, the trends observed are nearly identical.
- Correlation between PZ-ER1-PAC-B1 and PZ-ER1-PAC-B2 increased to nearly match the lake stage after installation of the cutoff wall, as these piezometers are located upstream of the cutoff wall, and indicate a direct correlation.
- After installation of the cutoff wall, PZ-ER1-PAC-C1 and PZ-ER1-PAC-C2 indicate a reduction in head approximately 1.4 feet for a lake stage of elevation 16.0 feet. The correlation (weak to good) to lake stage remains consistent, but dampened. However, during high water event lake stage above 17 higher water levels were noted, with no seepage concerns. Both piezometers indicate what appear to be random spikes with during the high water event while tailwater remains consistent as no observations were noted that would indicate poor performance.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-ER1-PAC-C2	**11.58**	**10.26**	***1.32***	**22.5**	***0.06***	**2.7**	***0.49***

This location does not appear to indicate any signs of seepage distress. Per analysis of the piezometer readings, the cutoff wall has reduced the head at the downstream toe of the dam, thereby reducing seepage and piping concerns at this location.

7.7. Piezometer Line R1-7

Location	0.7 Mile North East of Pahokee Park Access Gate
DSMS Segment/CIZ	24/A
Date PZ Line in Service	April 1996
Piezometer Maintenance and Repairs	PZ-ER1M-B1 – February 2009 Redeveloped, well pad repaired
Lakeside Features	Bench (approximately 50 feet) before reaching lakeside riprap protection. Lake is shallow until the lakeside borrow source. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-ERIM-B1 (Lower Embankment Fill/ Foundation Organics/Fines) PZ-ERIM-B2 (Lower Foundation)
Landside PZs and Tailwater	PZ-ERIM-C (Lower Foundation) R1-7-TW
Landside Features	A toe ditch parallels the embankment toe. Residential property lies immediately downstream of the toe ditch. The “footbridge” crosses the toe ditch at this location. The “footbridge” is noted as it is referenced in some historic documents and inspection points.
Historic Poor Performance	Miller Site-A and Miller Site-B (1995) – Condition 4. Damage to landside slope of toe ditch at three points around the footbridge across the ditch. Estimated 2 – 3 ft^3 of material piped. No odor or white staining. R1C-04-09 Condition 3- Seepage Was observed flowing into the ditch. 0.75 GPM was estimated. No sulfur smell noted.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Excavate 3’ deep x 30’ wide, backfill with filter stone, place 6" topsoil & seed Cutoff Wall installed to elevation -35 (FT-NAVD88) in November 2011

Data Analysis/Evaluation:

- Core borings indicate the embankment in this area is on a very soft layer of peat. The toe has very little strength (approaching quick condition) likely due to water from the lake flowing through the limestone layer.
- PZ-ERIM-B1 has a direct correlation with the lake level before and after the installation of the cutoff wall. Readings recorded above the lake level are likely due to water perched above the peat layer and influenced by rainfall events.
- PZ-ERIM-B2 shows a strong correlation to lake levels after installation of the cutoff wall as this piezometer is installed upstream of the wall.
- PZ-ERIM-C strongly correlated with lake levels before installation of the cutoff wall and still correlates strongly with the lake level; however, a head reduction of approximately 1 foot is noted after installation of the cutoff wall. Water level spikes in this piezometer are likely due to the influences from surface water runoff collected in the adjacent ditch.
- Tailwater is also directly correlated to PZ-ERIM-C which is also correlate to the lake levels.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-ERIM-C	14.43	13.59	***0.84***			16.4	***0.05***

Although PZ-ERIM-C still correlates well with the lake level, a head reduction is noted after installation of the cutoff wall. It appears that the direct connection has been cutoff and the wall is causing head loss to occur. Because the correlation remained similar before and after the cutoff wall was installed, it is concluded that a semi-confining layer is not present at this location. This location does not appear to indicate any signs of seepage distress.

7.8. Piezometer Line R1-8

Location	1.8 Miles South West of Spillway S-352
DSMS Segment/CIZ	24/A
Date PZ Line in Service	PZ-GPPS-2 February 1995 Remainder August 1995
Piezometer Maintenance and Repairs	October 2014 – PZ-GPPS-2: fill added, new well pad and bolted cover
Lakeside Features	Bench (approximately 50 feet) before reaching lakeside riprap protection. Lake is shallow until the lakeside borrow source. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-R1-S42-B2 (Lower Embankment Fill/Foundation Organics/Fines) PZ-R1-S42-B1 (Foundation)
Landside PZs and Tailwater	PZ-GPPS-2 (Lower Foundation) R1-8-TW
Landside Features	A toe ditch parallels the embankment toe. Residential property lies immediately downstream of the toe ditch.
Historic Poor Performance	R1-1 (1998) Standing water and saturated soil in an area 100' x 10' This area was selected for geophysical trials due to the wet, soft toe observed at a lake elevation of approximately 16.4.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -40 (FT-NAVD88) in September 2011

Data Analysis/Evaluation:

- Core borings descriptions indicate the presence of coarse grained sand sized shell and gavel sized shell in the embankment and foundation. Piezometer readings and trends suggest the foundation and embankment is highly permeable at this location.
- PZ-R1-S42-B2 reads about lake level and occasionally above. The piezometer is screened within the peat and fines unit; it is likely that this piezometer is reading a perched water table. PZ-R1-S42-B1 shows similar trends, but does not appear to be influenced by perched water
- Up to pool elevation 12.0 feet and before the installation of cutoff wall, piezometer PZ-R1-S42-B1 shows a direct correlation with the lake level. Above pool elevation 12.0 feet, the piezometer response tends to be slightly dampened, but still shows a strong correlation. Additionally, very little head loss was occurring between PZ-R1-S42-B1 and PZ-GPPS-2. PZ-R1-S42-B1 now correlates well with lake stages as it is placed upstream of the cutoff wall.
- Downstream piezometer PZ-GPPS-2 had a strong correlation to lake levels and tail water level, and showed little head loss from upstream to downstream before installation of cutoff wall; this is an indication that the foundation material that this piezometer is screened in is highly permeable material and in direct connection with the lake. Additionally, piezometric readings for PZ-GPPS-2 approached ground surface elevations; considering the thickness of the blanket material and the ground surface elevations at this location, it appears that artesian pressures were present. After installation of the cutoff wall, a head reduction of approximately 1.4 feet is noted for a lake stage of elevation 16.0 feet; the correlation between the lake and piezometric response is reduced, but remains relatively the same.
- Tailwater is also directly correlated to PZ-GPPS-2 which is also correlate to the lake levels.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
PZ-GPPS-2	**13.48**	**12.55**	***0.93***			**18.8**	***0.05***

After installation of the cutoff wall, a significant head reduction was noted in the downstream piezometer PZ-GPPS-2; however, downstream piezometric elevations remain relatively high at this location. Therefore, it is recommended that this area be watched closely during high water events as any lake stage above elevation 16.0 feet will be a first-fill condition for the cutoff wall; therefore, this section should still be closely monitored.

7.9. Combined Analysis: Section B – Reach 1C & 1D

All of the piezometer lines within this section were installed because of the documented poor performance and Interim Risk Reduction Measures (IRRM) were implemented in response to the 1995, 1988, 1999, and 2004 High Water Events. IRRMs implemented within this section include seepage berms and toe ditch backfilling with granular material. Permanent repairs throughout this section include installation of a cutoff wall.

Core borings indicate large amounts of coarse grained shell, gravel sized shell and limestone/sandstone throughout Reach 1C & 1D. These materials, originating from the foundation, found themselves in the embankment as fill material during construction of the embankment. When these materials are noted within the core of the embankment, little to no head loss is observed from lake to centerline of the embankment. To construct the embankment, these materials were placed on top of highly compressible organic material that can be up to 10 feet thick. Consolidation settlement of the embankment was greatest in the centerline of the embankment, creating a “bowl” in which seepage and rainwater perches on top of organic material, as indicated by the centerline of embankment piezometers screened above the organics. The foundation materials present beneath the organics are known to be highly permeable and provide preferential paths for water movement. Past investigations and studies for this section has documented numerous seepage-related performance issues at foundation and embankment exit points.

After installation of the cutoff wall, noticeable changes in piezometric response are seen in the piezometers. Piezometers installed upstream of the cutoff wall now correlate either strongly or directly with changes in lake stage, indicating the cutoff wall is acting as a barrier to seepage. For piezometers downstream of the cutoff wall, the piezometric response has decreased (less correlation to changes in lake stage) and head has decreased. This also indicates the cutoff wall is acting as a barrier to seepage and since head is reduced, it confirms that the risk to initiation of piping has also been reduced.

When considering the data collected for all of the downstream piezometers throughout the section, some downstream piezometers indicate that the cutoff wall penetrates a significant semi-confining unit causing piezometric responses to become nearly non-responsive to changes in lake levels. Other downstream piezometers lines still indicate weak correlation to strong correlations to changes in lake levels; however, in these cases, head reduction is still noted.

In support of the claims above, it is noted that no seepage related issues have been reported up to a lake stage of elevation 17.2 feet, while before installation of cutoff wall, seepage issues would begin to arise. Now that the cutoff wall has been completed in this section (with the exception of gaps at structures); it appears that many of the historic problems have been mitigated for pool levels experienced post construction; however, it should be noted that any lake stage above elevation 17.2 feet is considered a first-filling and therefore wall performance should be monitored appropriately. Continued monitoring of piezometric levels in this area is also critical to continuing the evaluation of cutoff wall effectiveness. Although no performance related issues have been reported since installation of the cutoff wall, monitoring of this section is recommended during higher than normal lake stages as the cutoff wall remains unproven for an SPF loading.

8. SECTION C – REACH 1A & 1B (NORTH OF CANAL POINT)

8.1. Piezometer Line R1-9

Location	Just North of Spillway S-352
DSMS Segment/CIZ	23/A
Date PZ Line in Service	April 1996
Piezometer Maintenance and Repairs	PZ-ER1352-3B1 and PZ-ER1352-3B2 In 2002 these piezometers were covered over by the LOST paving contractor. They were redrilled and reset by NAB in January 2009. October 2014 – PZ-ER1352-3C: fill added, new well pad and bolted cover
Lakeside Features	Bench (approximately 50 feet) before reaching lakeside riprap protection and shoreline vegetation. Lake is shallow until the lakeside borrow source. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	Downstream of Cutoff Wall PZ-ER1352-3B1 (Foundation) PZ-ER1352-3B2 (Lower Foundation)
Landside PZs and Tailwater	PZ-ER1352-3C (Foundation) R1-9-TW
Landside Features	A toe ditch parallels the embankment toe. Landside of the toe ditch, the Florida East Coast Railroad and Lakeshore Drive (US-98) parallels the embankment
Historic Poor Performance	#2 North and #3 North (1995) – Condition 3 seepage; however, some small caverns in the berm just above toe ditch were noted. No sulfur or white staining indicating through seepage. R1B-3 Seepage through berm flowing into toe ditch. R1B-4 Seepage flowing from ditch. Condition 4. On 4/1/1998 There was increased flow. Wide-spread across berm. R1B-04-12 Ponding, no flow. MRR2000 page H6-19 – Boils in the ditch bottom and seepage exiting the slope of the toe ditch in 1995 and 1998.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Excavate 3' deep x 30' wide, backfill with filter stone, place 6" topsoil & seed 2007 – This piezometer line is located within Focus Area 7. Within the limits of the Focus Area, the landside toe ditch was backfilled within one foot of the ground surface with a combination of sand and gravel designed to provide a filtered seepage exit point. (HHD IRRM Plan, 14 July 2010). Cutoff Wall installed to elevation -40 (FT-NAVD88) in August 2012.

Data Analysis/Evaluation:

- All piezometers at this line are downstream of the cutoff wall. The cutoff wall terminates for the S-352 gap at STA 1836+50, terminating approximately 350 feet beyond this piezometer line.
- A 1.4 foot reduction in head is noted for PZ-ER1352-3B1 and PZ-ER1352-3B2 after installation of the cutoff wall, for a lake stage of elevation 16.0 feet.
- PZ-ER1352-3C after installation of the cutoff wall, for a lake stage of elevation 16.0 feet, a 1.2 foot reduction in head is noted.

- From 2002 to 2009 (not shown in the Appendices), these piezometers read within 0.5 feet of each other.
- After PZ-ER1352-3B1 and PZ-ER1352-3B2 were reinstalled in 2009 and after installation of the cutoff wall, the piezometers have read nearly the same. Since all piezometers in this line are downstream of the wall and they all read essentially the same, there is no gradient from the "B" piezometers to the "C" piezometer.
- Tailwater readings have been collected since 2016. The piezometers appear to have a good correlation with the tailwater readings rather than the lake level.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-ER1352-3B1	13.49	12.58	***0.91***	106.9	***0.01***		
PZ-ER1352-3C	13.51	12.58	***0.93***	31.1	***0.03***	15.2	***0.06***

Since the cutoff wall terminates near this piezometer line, it is possible that more head reduction could be realized after the cutoff wall gap at Spillway S-352 is closed. Since a gap in the cutoff wall remains at Spillway S-352 and this piezometer line is at the termination point of the wall; seepage flow around the end of the wall may make this area subject to seepage issues during high water events; therefore, this section should still be closely monitored during high water events.

8.2. Piezometer Line R1-11

Location	0.4 Miles North of Spillway S-352
DSMS Segment/CIZ	23/A
Date PZ Line in Service	April/May 1996
Piezometer Maintenance and Repairs	October 2014 – PZ-ER1352-5C1 and PZ-ER1352-5C2: fill added, new well pad and bolted cover
Lakeside Features	Bench (approximately 45 feet) before reaching lakeside riprap protection. Lake is shallow with shoreline vegetation. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-ER1352-5B1 (Upper Foundation) destroyed during cutoff wall installation, last reading 12/7/2011 PZ-ER1352-5B2 (Foundation) destroyed during cutoff wall installation, last reading 12/7/2011
Landside PZs and Tailwater	PZ-ER1352-5C2 (Within and Just Below Foundation Organics) PZ-ER1352-5C1 (Upper Foundation) Approximately 550 feet Southwest of 5C2 and 5C1 PZ-ER1353-4C (Foundation) R1-11-TW
Landside Features	A toe ditch parallels the embankment toe. Landside of the toe ditch, the Florida East Coast Railroad and Lakeshore Drive (US-98) parallels the embankment
Historic Poor Performance	Point #4 North and Point #6 North - Condition 3 seepage; however, some small caverns in the berm just above toe ditch were noted. No sulfur or white staining indicating through seepage. R1-29 (1998) – Condition 3 Seepage 17 small seepage areas along 66 feet of the toe canal. One of the seepage locations has a white residue.
Emergency/ Permanent Repairs	In response to the 1995 High Water Event, a seepage berm was constructed of ASTM #10 stone. Work included: Excavate 3’ deep x 30’ wide, backfill with filter stone, place 6" topsoil & seed. 2007 – This piezometer line is located within Focus Area 7. Within the limits of the Focus Area, the landside toe ditch was backfilled within one foot of the ground surface with a combination of sand and gravel designed to provide a filtered seepage exit point. (HHD IRRM Plan, 14 July 2010). Cutoff Wall installed to elevation -40 (FT-NAVD88) in June 2012

Data Analysis/Evaluation:

- PZ-ER1352-5B1 and PZ-ER1352-5B2 were removed during cutoff wall installation. Before they were removed, they showed a strong correlation with changes in the water levels.
- PZ-ER1352-5C1, PZ-ER1352-5C2, and PZ-ER1353-4C show the same strong correlation to the lake level before cutoff wall installation. After installation of the cutoff wall, the response is dampened to good. After installation of the cutoff wall and for a lake stage of 16.0 feet, PZ-ER1352-5C1 and PZ-ER1352-5C2 show about 2 feet reduction in head, while PZ-ER1353-4C shows a 2.5 feet reduction in head.
- It is interesting to note the elevation difference in head measured at PZ-ER1353-4C (550 feet) from PZ-ER1352-5C1 and PZ-ER1352-5C2. Although screened in similar material, PZ-ER1353-4C has always read the highest (approximately 0.5 to 1.3 feet higher than PZ-

ER1352-5C1 and PZ-ER1352-5C2). It is likely that PZ-ER1353-4C is screened in a higher permeability material that has a more direct connection to the lake.

- Tailwater readings have been collected since 2016. The tailwater readings appear to show a good correlation to the piezometers when the tailwater level is above El. 11.5.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-ER1352-5C2	11.39	12.14	***-0.75***			9.5	***-0.08***

During the 1995 High Water Event, boils were noted in the bottom of the toe ditch and seepage was exiting the slope of the ditch. In 2017 when the lake rose to approximately elevation 17.2 feet, no performance related issues were documented at this location. Given the head reduction noted in the downstream piezometers after installation of the cutoff wall and the performance of this area during the past few years, it appears that the cutoff wall is performing well. It is recommended that PZ-ER1352-5B1 and PZ-ER1352-5B2 be reinstalled to monitor the performance of the cutoff wall over time.

8.3. Piezometer Line R1-11A

Location	0.6 Miles North of Spillway S-352
DSMS Segment/CIZ	23/A
Date PZ Line in Service	October 2005
Piezometer Maintenance and Repairs	October 2014 – PZ-URS-05-1C: fill added, new well pad, and bolted cover
Lakeside Features	Bench (approximately 45 feet) before reaching lakeside riprap protection. Lake is shallow with shoreline vegetation. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-URS-05-1B (Deep Foundation) destroyed during cutoff wall installation, last reading 12/7/2011
Landside PZs and Tailwater	PZ-URS-05-1C (Foundation Organics) R1-11A-TW
Landside Features	A toe ditch parallels the embankment toe. Landside of the toe ditch, the Florida East Coast Railroad and Lakeshore Drive (US-98) parallels the embankment
Historic Poor Performance	R1B-04-05 – 60 feet of the toe canal there are five small seepage locations.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -40 (FT-NAVD88) in April 2012

Data Analysis/Evaluation:

- Before installation of the cutoff wall, PZ-URS-05-1B followed the lake level with a dampened response. During installation of the cutoff wall, this piezometer was removed. To monitor the performance of the cutoff wall PZ-URS-05-1B should be reinstalled.
- Before installation of the cutoff wall, PZ-URS-05-1C showed good correlation with the lake level. After installation of the cutoff wall, the piezometric response seems to have changed. Considering this piezometer is screened within the semi-permeable peat layer, the pore pressure readings within this layer do not appear to clearly indicate the effect of the cutoff wall on piezometric response. To better evaluate the cutoff wall performance, it is recommended that a piezometer be installed just below the peat layer at the downstream toe.
- Tailwater readings appear to have a direct correlation to PZ-URS-05-1C.

Gradient Table:

Piezometer	**PZ Reading (ft.)**	**Tailwater Reading (ft.)**	**ΔH (ft.)**	**Horizontal Distance (ΔL_h) (ft.)**	**Horizontal Gradient $\Delta H/\Delta L_h$**	**Vertical Distance (ΔL_v) (ft.)**	**Vertical Gradient $\Delta H/\Delta L_v$**
PZ-URS-05-1C	12.73	12.54	***0.19***			1.3	***0.15***

Due to the screened interval of the downstream piezometer (PZ-URS-05-1C), it is difficult to assess the performance of the cutoff wall. An additional piezometer is recommended to be installed at the landside toe, to be screened just below the peat layer. PZ-URS-05-1B was removed during cutoff wall installation and is recommended to be replaced.

8.4. Piezometer Line R1-12

Location	1.1 Miles North of Spillway S-352
DSMS Segment/CIZ	23/A
Date PZ Line in Service	August 1995
Piezometer Maintenance and Repairs	October 2014 – PZ-R1-25-C1 and PZ-R1-25-C2: fill added, new well pad and bolted cover
Lakeside Features	Bench (approximately 40 feet) before reaching lakeside riprap protection. Lake is shallow with shoreline vegetation. A trough exists lakeside of the riprap and is thick with overgrown grasses and woody vegetation. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-R1-25-B2 (Foundation Organics/Fines) Destroyed during cutoff wall installation, last reading 9/16/2011 PZ-R1-25-B1 (Foundation Limestone) Destroyed during cutoff wall installation, last reading 9/16/2011
Landside PZs and Tailwater	PZ-R1-25-C2 (Foundation Organics/Fines) PZ-R1-25-C1 (Foundation Limestone) R1-12-TW
Landside Features	A toe ditch parallels the embankment toe. Landside of the toe ditch, a small tract of farmland exists.
Historic Poor Performance	R1B-1 9 (Old R1-3) Condition 4 light flow of muckish material from bottom of toe ditch. Water high and murky in toe ditch.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -40 (FT-NAVD88) in December 2011

Data Analysis/Evaluation:

- Before installation of the cutoff wall, all four piezometers respond closely with the lake elevation; a dampened response is noted from upstream to downstream as well as upper to lower. PZ-R1-25-B1 and PZ-R1-25-B2 readings stopped before December 2011. The cutoff wall contractor removed these piezometers during the construction. These piezometers are recommended for replacement.
- After installation of the cutoff wall, PZ-R1-25-C2 and PZ-R1-25-C1 show the same correlation to lake levels (good to strong). These piezometers indicate a small reduction in head, approximately 0.6 feet for lake stage of elevation 16.0 feet.
- Water levels in piezometer PZ-R1-25-B2 were occasionally higher than the water levels in the lake which appears to reflect the low permeability of the peat unit allowing for perched water above this material.
- Tailwater readings appear to have a good correlation to the lake and the piezometers.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R1-25-C2	13.67	12.09	***1.58***			5.6	***0.28***

The reduction of head after installation of cutoff wall is less than areas with similar wall tip elevations. However, given the small reduction in head noted in the downstream piezometers, when compared to other piezometer lines, it is likely that the limestone and foundation materials at this location are more porous. Additionally, any lake stage above elevation 17.2 feet will be a first-fill condition for the cutoff wall; therefore, this section should be closely monitored. The upstream piezometers should be reinstalled to properly monitor cutoff wall performance.

8.5. Piezometer Line R1-12A

Location	2.2 miles North of S-352, 0.5 miles South of S-272 (Culvert 13)
DSMS Segment/CIZ	23/A
Date PZ Line in Service	October 2005
Piezometer Maintenance and Repairs	No known
Lakeside Features	Bench (approximately 40 feet) before reaching lakeside riprap protection. Lakeside of the riprap, the embankment shoreline is overgrown with grasses and woody vegetation. Lakeside borrow source is offset approximately 400 feet from centerline.
Lakeside PZs	None
Centerline PZs	PZ-URS-05-2B (Bottom of Foundation Organics) destroyed during cutoff wall installation, , last reading 2/16/2011
Landside PZs and Tailwater	PZ-URS-05-2C (Deep Foundation) R1-12A-TW
Landside Features	A toe ditch parallels the embankment toe. A thick stand of trees boarders the downstream bank of toe ditch.
Historic Poor Performance	R1B-04-01 (Old R1A-01) Condition 3 Seep
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -40 (FT-NAVD88) in May 2011

Data Analysis/Evaluation:

- Both piezometers respond to changes in lake elevation (good correlation) and track within about 0.25 feet of each other.
- Piezometer PZ-URS-05-2B was removed during the construction of the cutoff wall and is recommended to be replaced.
- After the installation of the cutoff wall, piezometer PZ-URS-05-2C appears to be reading approximately over 3 feet lower at a lake stage of 16.0 feet.
- The correlation between the lake level and the piezometer for PZ-URS-05-2C appears to be changed from good to weak around August of 2013.
- Tailwater readings have been collected since 2016. The tailwater does not appear to correlate to the lake or piezometers.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-URS-05-2C	11.45	12.76	***-1.31***			49	***-0.03***

PZ-URS-05-2B should be replaced to effectively monitor the cutoff wall performance. It would be beneficial to install another piezometer downstream of the cutoff wall, just beneath the organic layer.

8.6. Piezometer Line R1-13

Location	At Culvert S-271 (Culvert 10A) PZ-C10A-1 and PZ-C10A-2 are 50 foot south of C-10A centerline PZ-C10A-3, PZ-C10A-4, and PZ-C10A-5 are 50 foot north of C-10A centerline
DSMS Segment/CIZ	22-23/A
Date PZ Line in Service	1996 to April 1999? (See discussion below)
Piezometer Maintenance and Repairs	No known
Lakeside Features	Culvert 10A Channel (L-8 Canal)
Lakeside PZs	None
Centerline PZs	None
Landside PZs and Tailwater	PZ-C10A-5 (Upper Embankment Fill) PZ-C10A-4 (Embankment Fill/Foundation Organics) PZ-C10A-2 (Foundation Organics) PZ-C10A-3 (Just Below Foundation Organics/Fines) PZ-C10A-1 (Foundation Sands/Limestone)
Landside Features	Culvert 10A Channel (L-8 Canal)
Historic Poor Performance	Condition 2 Seepage noted in the area, specific location and details not able to be located
Emergency/ Permanent Repairs	Within cutoff wall gap at C-10A (STA 1625+50 thru 1631+00). Cutoff Wall was installed to elevation -30 (FT-NAVD88) in June 2010 (North of C-10A, STA 1631+00) and October 2010 (South of C-10A, STA 1625+50)

R1-13 piezometers were removed during the construction of Culvert C-10A. No readings have been collected since January 2016. Once construction is completed we recommend replacing these piezometers.

The history of this piezometer line is somewhat peculiar. Readings for these piezometers go back to 1996; however, the readings recorded in 1996, up to April 1999 in no way correlate to any reasonable or practical phreatic surface given the depths installed and elevations of the riser pipes. In addition, although these piezometers were installed in 1996, no survey information was collected for this piezometer line until fall 2014. Because survey data was not collected, this piezometer line was not analyzed or reviewed until 2015, even though depth to water has been collected since 1996.

After survey information was collected, the elevations were added to the database, and the elevation of the water surface was calculated and plotted. Many strange anomalies were discovered; it appeared the names of the piezometers had been switched in the field several times and as they are situated today, as built depths do not correspond to the field depths. It is possible that these were originally installed as flush mount, whereas shortly after installation in 1996, the approximately 4-foot risers were added. Adding to the confusion, there is evidence that some of the riser pipes have been broken and repaired in the field.

After reviewing the available data and conditions of the risers in the field, it was determined that PZ-C10A-1 and PZ-C10A-2 risers were likely not altered or changed since 1998, as no abrupt changes in water elevation are observed for a consistent elevation from 1998 to present. The same can be said for PZ-C10A-4; however, in 2006, this piezometer stopped responding to the lake. It is assumed that PZ-C10A-4 collected sediment over time. Redevelopment records of PZ-C10A-4 from fall 2014 confirmed that this piezometer was producing very little water; fine grained sediments and sand were removed during redevelopment. Review of PZ-C10A-5 showed consistent water elevation trends from 1998 to 2006, then an abrupt downward shift occurred and the trends remained consistent from 2006 to present. In the field, there is evidence that the PZ-C10A-5 riser has been raised. In addition, since 2006, PZ-C10A-5 has read the same as PZ-C10A-1 and PZ-C10A-2; therefore, it is likely that the riser was shorter prior to 2006. Based on this information, PZ-C10A-5 riser elevation was adjusted downward by approximately 1.9 feet prior to the 2006 readings. Although this assumption may be questionable, no other activities have taken place that would cause such an abrupt and consistent downward shift in the measured water elevation.

Because of the anomalies observed and assumptions taken when evaluating approximately 19 years of questionable data, care should be taken when using the data associated with this piezometer line. For certain, data from fall 2014 forward can be considered reliable as new survey, redevelopment, and field verifications were performed. Future trends may increase certainty with data collected prior to 2014; however, future data collection will be limited as construction contracts for replacement of Culvert 10A are forthcoming (FY2015 or 2016).

Data Analysis/Evaluation:

- PZ-C10A-3 was screened high within the embankment (~elevation 25.0 feet) and has been dry since installation.
- PZ-C10A-4 was screened within the fine grained material in the upper foundation (organics and fines) and embankment fill; pre-2006 trends indicate a direct correlation with the lake stage. It appears that after 2006, the piezometer likely silted in and stopped responding to the lake stage. Since this piezometer was redeveloped in fall 2014 only a few readings have been taken, with trends appearing to have resumed historical trends; however, the piezometer will continue to be monitored to confirm this observation.
- PZ-C10A-1, PZ-C10A-2, and PZ-C10A-5 all respond the same and indicated a strong correlation to the lake stage. When compared to the lake stage and the tailwater in the L-8 Canal, it seems the foundation is responding equally to changes in lake stage and canal stage, which is possible, considering the L-8 Canal stage is similar to the lake stage the majority of the time. What is interesting to note however, the direction of flow appears to be from the lake into the foundation and the canal into the foundation as the tailwater is higher than the head in the foundation. Therefore, the majority of the time seepage likely travels laterally along the embankment (north and south) and exits to the adjacent toe ditches (north and south) where tailwater is lower than the head in the foundation. From observation of tailwater stage data, foundation underseepage into the canal would only exit into the adjacent canal when water demand from Culvert 10A is low, usually from the end of the wet season into springtime.

8.7. Piezometer Line R1-13A

Location	0.3 Mile North of S-271 (Culvert 10A) or 0.3 miles south of Culvert 14 location (now removed)
DSMS Segment/CIZ	22/A
Date PZ Line in Service	PZ-HHDR1A-2A and PZ-HHDR1A-2C November 2008 Remainder August 2009/November 2009 Regular readings of these piezometers did not occur until the beginning of 2010
Piezometer Maintenance and Repairs	October 2014 – PZ-HHDR1A-2A and PZ-HHDR1A-2C1/ PZ-HHDR1A-2C3: new well pad and bolted cover. Fill was also added around PZ-HHDR1A-2A.
Lakeside Features	Bench (approximately 40 feet) before reaching lakeside riprap protection. Lakeside of the riprap, the embankment shoreline is overgrown with grasses and woody vegetation. Lakeside borrow source is offset approximately 380 feet from centerline, but is not distinct.
Lakeside PZs	PZ-HHDR1A-2A (Foundation Limestone) Automated
Centerline PZs	None
Landside PZs and Tailwater	PZ-HHDR1A-2C (Just Below Foundation Organics in Limestone) Automated, destroyed by mowers in 2013, 5/3/2010 is last automated reading. PZ-HHDR1A-2C1 (Lower Foundation) PZ-HHDR1A-2C2 (Deep Foundation) PZ-HHDR1A-2C3 (Deep Foundation) PZ-HHDR1A-2D and "_DL" (Foundation Organics/Limestone on outskirts of Farmers Field) Automated, but not functional. The piezometer is compromised as riser pipe has become disconnected from the well screen, unable to retrieve vibrating wire piezometer from well to correctly configure instrument and datalogger; therefore, as of 3-12-2015, this piezometer is now manually read. R1-13A-TW
Landside Features	A toe ditch parallels the embankment toe. A thick stand of trees boarders the downstream toe ditch bank to the Florida East Coast Railroad.
Historic Poor Performance	Condition 2 Seepage noted in the area, specific location and details not able to be located
Emergency/ Permanent Repairs	2007 – This piezometer line is located within Focus Area 0. Within the limits of the Focus Area, the landside toe ditch was backfilled within one foot of the ground surface with a combination of sand and gravel designed to provide a filtered seepage exit point. (HHD IRRM Plan, 14 July 2010). Cutoff Wall installed to elevation -30 (FT-NAVD88) in August 2011. Cutoff wall gap at C-14 has been closed as of October 2012.

Automated dataloggers and piezometers were placed in PZ-HHDR1A-2A, PZ-HHDR1A-2C, and PZ-HHDR1A-2D in 2009. PZ-HHDR1A-2C malfunctioned after installed; however, after several attempts in the field and several attempts back in the office, data was able to be retrieved. Some automated data was collected from PZ-HHDR1A-2A in December 2011, while no data was collected from PZ-HHDR1A-2D as it had also malfunctioned. These piezometers were not read or serviced at regular intervals; therefore valuable data was lost after installation of the automated device. At the time of the download in December 2011, no data quality checks or configuration file checks were performed.

In addition to data gaps, there was a constant battle with configuration files, cable length, manufactures calibration sheets, moisture, datalogger settings, and regular reading intervals. As of May 2013, and after several unsuccessful attempts, efforts to debug issues related to the collection of the automated data and implementation of quality checks before and after data download seemed to be improving. During collection of the automated data in May 2013, manual water level measurements were obtained. When converted to elevation, these manual water level readings did not match readings collected by the dataloggers. PZ-HHDR1A-2A was unable to be field verified as the datalogger malfunctioned sometime in September 2012. PZ-HHDR1A-2D varied by 0.86 feet on the day the data was downloaded; data collected by the datalogger indicated a water surface elevation 0.86 feet lower than what was manually read. Because the configuration file settings and zero readings were suspect, it was concluded that the data could be adjusted up by 0.86 feet. As PZ-HHDR1A-2A could not be verified and PZ-HHDR1A-2D had to be adjusted, the automated elevation data reported should be taken as an approximation; however, the trends shown are considered reliable. In 2013, it was discovered that PZ-HHDR1A-2C had been destroyed by mowers. The datalogger and vibrating wire piezometer were not found on site. Also, in 2013, when attempting to reconfigure PZ-HHDR1A-2D, the piezometer was unable to be retrieved from down hole; it is suspected the PVC couplings have become disconnected. Since the vibrating wire piezometer remains in the casing and below the water level, it cannot be reconfigured.

PZ-HHDR1A-2A was downloaded on 1/20/2015. The download covered data recorded between 3/13/2014 to 1/20/2015. Accuracy of piezometric data was checked on the day of download, manual water elevation readings were within 0.1 feet of automated water elevation readings; therefore, these readings are considered reliable.

Multiple attempts to download data for PZ-HHDR1A-2A failed on 12/16/2015. The datalogger and transducer were removed and due to the previously described issues with dataloggers and moisture, there are no plans to replace until units that are not susceptible to failure in moist conditions can be obtained.

Data Analysis/Evaluation:

- In August 2011, piezometer PZ-HHDR1A-2C3 experienced a sharp drop in head while piezometers PZ-HHDR1A-PZ-2C1 and PZ-HHDR1A-2C2 experienced a similar rise of approximately 0.75 feet. Since then, all three piezometers have tracked relatively close to each other. Culvert C-14 resided within 1,600 feet of this piezometer line and was being removed during this timeframe. For the removal of C-14, well point dewatering was used to facilitate the work. In conjunction with C-14 dewatering, cutoff wall construction passed through this area. The sharp rise and fall of the piezometers are likely due to low lake levels during the cutoff wall installation, coupled with C-14 dewatering. Additionally, the volume of water being pumped from the foundation of C-14 during dewatering combined with an apparent drop in PZ-HHDR1A-2C3 is indicative of the high transmissivity of the aquifer at these depths.
- After the cutoff wall gap closure at C-14 in May 2013 until September 2015, the deep aquifer, as measured by PZ-HHDR1A-2C3 read as high as PZ-HHDR1A-2A and appears to be artesian. PZ-HHDR1A-2C3 correlated strongly with the lake but the head value can vary greatly. It is possible that this unit is connected to another influencing source or is just not stabilizing after completion of culvert C-14 removal.
- During the high lake stage event between October to November 2017, PZ-HHDR1A-2C1, PZ-HHDR1A-2C2, and PZ-HHDR1A-2C3 readings were not collected as the groundwater was at or above ground surface indicating artesian pressures are present beneath the blanket material.
- Readings from 2018 indicated a good correlation between PZ-HHDR1A-2C1, PZ-HHDR1A-2C2, and PZ-HHDR1A-2C3 and the lake level; however, approximately a 1 foot reduction in

head was noted. The head reduction could be due to the cutoff wall gap closure at Culvert 14. Automated instrumentation for PZ-HHDR1A-2A was collecting reliable data until attempted to download on 12/16/2015 when the datalogger was found to be non-responsive; as such, PZ-HHDR1A-2A, PZ-HHDR1A-2C and PZ-HHDR1A-2D are no longer contain automated instrumentation. Reinstallation of PZ-HHDR1A-2C is not recommended at this time. Instead of resetting PZ-HHDR1A-2D, it is recommended that it be read manually by SFOO. Data from PZ-HHDR1A-2A is not being collected at this time.

- Tailwater readings appear to be directly correlated to the lake stage. The tailwater readings are higher than the piezometer readings.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-HHD-R1A-2D	**10.57**	**16.62**	***-6.05***	**325**	***-0.02***	**6.9**	***-0.88***

8.8. Piezometer Line R1-14

Location	0.1 Mile South of Culvert 14 location (Abandoned by removal)
DSMS Segment/CIZ	22/A
Date PZ Line in Service	September 1995
Piezometer Maintenance and Repairs	February 19, 2010 – PZ-R1-31-B1: Riser was repaired after cutoff wall construction. New riser is ~0.3 feet shorter than old riser. October 2014 – PZ-R1-31-C: fill added, new well pad and bolted cover
Lakeside Features	Bench (approximately 50 feet) before reaching lakeside riprap protection. Lakeside of the riprap, the embankment shoreline is overgrown with grasses and woody vegetation. Lakeside borrow source is offset approximately 420 feet from centerline, but is not distinct.
Lakeside PZs	None
Centerline PZs	PZ-R1-31-B1 (Foundation) Downstream of Cutoff Wall
Landside PZs and Tailwater	PZ-R1-31-C (Foundation) R1-14-TW
Landside Features	A toe ditch parallels the embankment toe. A thick stand of trees boarders the downstream toe ditch bank to the Florida East Coast Railroad.
Historic Poor Performance	Condition 1 and 2 Seepage noted in the area, specific location and details not able to be located
Emergency/ Permanent Repairs	2007 – This piezometer line is located within Focus Area 7. Within the limits of the Focus Area, the landside toe ditch was backfilled within one foot of the ground surface with a combination of sand and gravel designed to provide a filtered seepage exit point. (HHD IRRM Plan, 14 July 2010). Cutoff Wall installed to elevation -30 (FT-NAVD88) in April 2010. After installation of the cutoff wall, these piezometers remained approximately 200 feet from the 500 foot long cutoff wall gap at C-14. Cutoff wall gap at C-14 has been closed as of October 2012.

Data Analysis/Evaluation:

- The confining layer (peat) in this area is relatively thick. Separation of upper and lower piezometric zones should be expected; however, there is no piezometer placed above the peat layer to confirm. Visual inspection should be performed at the downstream toe during high pools.
- Contrary to other sections, PZ-R1-31-B1 is installed downstream of the cutoff wall. Both piezometers track within about 0.5 feet of each other and show a weak to good correlation with the lake level.
- After installation of the cutoff wall, both piezometers have read the same.
- For a lake stage of 16.0 feet, both piezometers indicate a 1.2 foot reduction in head after installation of the cutoff wall (i.e. there is no gradient from B1 to C)
- Tailwater readings appear to be directly correlated to the lake stage and are typically about three feet higher than the piezometer readings and about 4.5 feet higher during the high lake stages in 2017.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
PZ-R1-31-C	12.14	16.68	***-4.54***			15.8	***-0.29***

Because only a small amount of head loss is noted after installation of the cutoff wall and before closure of the cutoff wall gap at Culvert 14, it appears that the open gap had a noticeable effect on seepage flow and gradients in the foundation. Since the gap has been closed, the head reduction noted is comparable to the cutoff wall in other areas of Reach 1. Monitoring of cutoff wall performance will continue. Since the tailwater is above the level of water in the piezometer, gradients are downward, and piping is not a concern until the water level in the piezometer is higher than the tail water.

8.9. Piezometer Line R1-15

Location	S-270 (Culvert 16)
DSMS Segment/CIZ	22/A
Date PZ Line in Service	HHDR1A06-06 and HHDR1A06-06 May 2006 PZ-HHDR1A-1C and PZ-HHDR1A-1D November 2008
Piezometer Maintenance and Repairs	No known
Lakeside Features	Bench (approximately 65 feet) before reaching lakeside riprap protection. Lakeside of the riprap, the embankment shoreline is overgrown with grasses and woody vegetation. Lakeside borrow source is offset approximately 430 feet from centerline, but is not distinct.
Lakeside PZs	None
Centerline PZs	HHDR1A06-07 (Foundation) abandoned for C-16 Construction, decommissioned 6/28/2012 HHDR1A06-06 (Lower Foundation) abandoned for C-16 Construction, decommissioned 6/28/2012
Landside PZs and Tailwater	PZ-HHDR1A-1C (Foundation) automated, destroyed during C-16 Construction, last reading 7/8/2013 PZ-HHDR1A-1D (Foundation On Property Downstream of Railroad) Automated – 12/16/2015 Datalogger and transducer not responding for download, moisture inside electronics, datalogger failed no data recovered. Last automated reading 1/20/2015
Landside Features	A toe ditch parallels the embankment toe. The toe ditch tailwater is connected to the C-16 exit channel, which extends perpendicular to the embankment and toe ditch.
Historic Poor Performance	No historic poor performance recorded
Emergency/ Permanent Repairs	A Cutoff Wall was installed to elevation -20 (FT-NAVD88); however a gap was left at C-16. North of C-16 at STA 1497+50 cutoff wall installed Dec 2009. South of C-16 at STA 1503+00 cutoff wall was part of test section, installed October 2008. Culvert 16 was removed and replaced from April 2013 to 2016 (Substantially complete as of 2016 report) About Summer of 2014 (~June), the cutoff wall beneath the C-16 culvert barrel was installed. June/July 2015, the cutoff wall gap was closed.

HHDR1A06-06 and HHDR1A06-07 fall within the footprint of the construction contract for Culvert C-16 replacement and have been decommissioned as of June 2012. The last updated readings are from January 2015. The data and evaluation listed below is based on the last updated readings.

PZ-HHDR1A-1C and PZ-HHDR1A-1D have been automated with a vibrating wire pressure transducer attached to a datalogger in early 2009. Data and maintenance issues similar to those experienced with the automated piezometers at line R1-13A. Quality and accuracy of the data is questionable. In July 2011, data was retrieved from PZ-HHDR1A-1C and PZ-HHDR1A-1D; however, some data was overridden due to the limitations of available data storage on the datalogger. Additionally, water surface elevations recorded by the datalogger and transducer were not field verified. In May 2013, data download was attempted again. At that time, PZ-HHDR1A-1C was unable to be located in the field, but data was retrieved for PZ-HHDR1A-1D and a manual water level reading was taken. When comparing the automated data collected to the manual water level reading taken on the day of download, the manual water elevation was 1.67 feet higher; therefore, all of the automated readings for PZ-HHDR1A-1D downloaded in May of 2013 (data from December 2011 to May 2013) were adjusted by 1.67 feet. It is noted that there is an obvious shift in water surface elevations for the two separate data sets for PZ-HHDR1A-1D. Because the earlier data set (May 2009 to April 2010) was not field verified, the data recorded by the datalogger and piezometer remain unedited; however, it is suspected that these readings should also be shifted up. Because PZ-HHDR1A-1C was unable to be located in the field, the validity and accuracy of the readings for the single available data set reported is unknown. The elevation data reported by the automated piezometers should be taken as an approximation; however, the trends shown are considered reliable.

After further investigation, it appears that PZ-HHDR1A-1C was destroyed by the C-16 Contractor when installing the landside cofferdam. The datalogger and vibrating wire piezometer were never recovered. At this time, there are no plans to reinstall/replace PZ-HHDR1A-1C. As a result, only PZ-HHDR1A-1D remains operational.

PZ-HHDR1A-1D was downloaded on 1/20/2015. The download covered data recorded between 3/13/2014 to 1/20/2015. Accuracy of piezometric data was checked on the day of download, manual water elevation readings were within 0.1 feet of automated water elevation readings; therefore, these readings are considered reliable.

On 12/16/2016, multiple attempts to download data for PZ-HHDR1A-1D failed. The datalogger and transducer were removed and due to the previously described issues with dataloggers and moisture and no data was recoverable. There are no plans to replace until units that are not susceptible to failure in moist conditions can be obtained.

Data Analysis/Evaluation:

- HHDR1A06-6 and HHDR1A06-7 read essentially the same and track within 1 foot of the lake level. When the lake level falls below elevation 12.0 feet, both piezometers consistently show higher groundwater levels than the lake elevation. This is likely due to the water surface elevation maintained within the toe ditch. During nearby construction that was occurring in May 2007, the field crews reported that the pump station at C-16 was turned on which flooded the toe ditches. The effect of this activity is reflected in the piezometer response.
- With the limited data available, a strong to direct correlation is noted for PZ-HHDR1A-1C.
- Piezometric response does not appear to be affected by the cutoff wall to the north and south of C-16 (i.e. C-16 cutoff wall gap was open).
- PZ-HHDR1A-1D shows a dampened response to changes, but overall a good correlation to changes in lake stage.
- In April 2014, major dewatering efforts in support of C-16 construction can be observed in the piezometric respond for PZ-HHDR1A-1D. As a result of dewatering at C-16, PZ-HHDR1A-1D appears to have stopped responding to changes in lake stage. Although limited data is available, it appears that a 2-foot reduction occurred with dewatering efforts. Since datalogger failure occurred during while dewatering was ongoing and the cutoff wall gap was closed, the effect of piezometric response change as a result of cutoff wall gap closure is unknown.
- The piezometers show little head loss across the embankment. Additionally, the fact that the piezometers react so quickly with toe ditch indicates that the confining layer has been breached in the toe ditch, which increases the potential for seepage related problems at this location. With the replacement of culvert C-16 and cutoff wall gap closure, it is anticipated that this problem has been mitigated. However, no data is available for verification.

Due to equipment failure, the effect of cutoff wall gap closure at C-16 is unknown; however, the effect dewatering influence on PZ-HHDR1A-1D could be observed. Since December 2015 removal of failed equipment in PZ-HHDR1A-1D, no data is being collected. Due to the location of this piezometer it is difficult to access for inclusion in the manual reading schedule performed by SFOO. However, this is only operating piezometer that is offset far downstream of the cutoff wall; therefore, collection of data from this piezometer would be considered valuable, as the long term far field piezometric response in an area with cutoff wall installed could be monitored. It is recommended that an investment be made in water resistant logging equipment in order to capture and report such data.

8.10. Piezometer Line R1-16

Location	0.9 mile South of S-308 (Port Mayaca Lock and Spillway)
DSMS Segment/CIZ	22/A
Date PZ Line in Service	October 2010
Piezometer Maintenance and Repairs	October 2014 – All piezometers, except for PZC1 received new well pads.
Lakeside Features	Breach repair material is stockpiled on the upstream slope. The embankment slopes into the lake and the lake bottom elevation remains consistent from offset 200 and beyond. The location of the original borrow source is not distinct.
Lakeside PZs	Just Upstream of Cutoff Wall HHD10-R1A-PZA1-1428 (Upper Foundation) HHD10-R1A-PZA2-1428 (Foundation) HHD10-R1A-PZA3-1428 (Lower Foundation)
Centerline PZs	Just Downstream of Cutoff Wall HHD10-R1A-PZB0-1428 (Lower Embankment Fill/Foundation) HHD10-R1A-PZB1-1428 (Upper Foundation) HHD10-R1A-PZB2-1428 (Foundation) HHD10-R1A-PZB3-1428 (Lower Foundation)
Landside PZs and Tailwater	HHD10-R1A-PZC1-1428 (Lower Embankment Fill/Foundation) HHD10-R1A-PZC2-1428 (Foundation) HHD10-R1A-PZC3-1428 (Lower Foundation) R1-16-TW
Landside Features	The seepage berm exits into the landside toe ditch that boarders the embankment toe.
Historic Poor Performance	No historic poor performance recorded. These piezometers were installed to monitor the performance of the cutoff wall.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -20 (FT-NAVD88) in June 2008 A 3,000 foot seepage berm with a two stage chimney and blanket was also constructed. The seepage berm and cutoff wall were both part of the original identified risk reduction measures to be constructed throughout Reach 1.

Data Analysis/Evaluation:

- This piezometer line is located where rehabilitation features (including cutoff wall and a landside earthen buttress and drain) have been constructed. The readings suggest that there has not been much hydraulic separation between piezometric levels across the cutoff wall.
- Tailwater readings have been collected since 2016. The tailwater readings directly correlate to the lake and piezometers.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
HHD10-R1A-PZC1-1428	16.6	16.8	*-0.2*	38.4	*-0.01*		
HHD10-R1A-PZC2-1428	16.4	16.8	*-0.4*			9.2	*-0.04*

From observation of the tailwater conditions in the area, the adjacent ground surface elevations and the topography, it seems reasonable to assume that the effect of the cutoff wall is not fully realized due to higher tailwater conditions in the region.

8.11. Piezometer Line R1-17

Location	0.6 mile South of S-308 (Port Mayaca Lock and Spillway)
DSMS Segment/CIZ	22/A
Date PZ Line in Service	September/October 2010
Piezometer Maintenance and Repairs	No known
Lakeside Features	The embankment slopes into the lake and the lake bottom elevation remains consistent from offset 200 feet. The location of the original borrow source is not distinct.
Lakeside PZs	Just Upstream of Cutoff Wall HHD10-R1A-PZA1-1413 (Upper Foundation) HHD10-R1A-PZA2-1413 (Foundation) HHD10-R1A-PZA3-1413 (Lower Foundation)
Centerline PZs	Just Downstream of Cutoff Wall HHD10-R1A-PZB0-1413 (Lower Embankment Fill/Foundation) HHD10-R1A-PZB1-1413 (Upper Foundation) HHD10-R1A-PZB2-1413 (Foundation) HHD10-R1A-PZB3-1413 (Lower Foundation)
Landside PZs and Tailwater	HHD10-R1A-PZC1-1413 (Upper Foundation) HHD10-R1A-PZC2-1413 (Upper Foundation) HHD10-R1A-PZC3-1413 (Lower Foundation) R1-16-TW (utilized for analysis due to close proximity)
Landside Features	A toe ditch parallels the embankment toe. Immediately downstream of the toe ditch, a thick stand of trees exists.
Historic Poor Performance	No historic poor performance recorded. These piezometers were installed to monitor the performance of the cutoff wall.
Emergency/ Permanent Repairs	Cutoff Wall installed to elevation -20 (FT-NAVD88) in February 2008

Data Analysis/Evaluation:

- The readings also indicate that there has not been much hydraulic separation between piezometric levels across the cutoff wall. As with Piezometer Line R1-16, (although no internal drainage system has been installed here) tailwater conditions in this region appear to be high. From observation of the tailwater conditions in the area, the adjacent ground surface elevations and the topography, it seems reasonable to assume that the effect of the cutoff wall is not fully realized due to higher tailwater conditions in the region.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
HHD10-R1A-PZC1-1413	16.39	16.99	***-0.6***	26.2	***-0.02***		

8.12. Combined Analysis: Section C – Reach 1A and 1B

Piezometer lines within this section were installed because of observed poor performance of the embankment, for the monitoring the cutoff wall gaps at structures, or for monitoring the cutoff wall after construction was complete. As with piezometers in Section B, many piezometer lines within this section benefitted from the implementation of IRRMs such as toe ditch backfilling and seepage berm construction in response to the 1995, 1998, 1999, and 2004 High Water Events. In addition to IRRMs, cutoff wall construction is substantially complete within this section, including cutoff wall gap closures at Culverts C-11, C-16, and C-14; however, the gaps at S-308, C-13, and C-10A still remain.

Core borings indicate large amounts of coarse grained shell, gravel sized shell and limestone/sandstone throughout Reach 1A & 1B. These materials, originating from the foundation, found themselves in the embankment as fill material during construction of the embankment. When these materials are noted within the core of the embankment, little to no head loss is noted from lake to centerline of the embankment. To construct the embankment, these materials were placed on top of highly compressible organic material that can be up to 10 feet thick. Consolidation settlement of the embankment was greatest in the centerline of the embankment, creating a “bowl” in which seepage and rainwater perches on top organic material, as indicated by the centerline of embankment piezometers screened above the organics. The foundation materials present beneath the organics are known to be highly permeable and provide preferential paths for water movement. Past investigations and studies for this Section have documented numerous seepage related performance issues at foundation and embankment exit points.

By observation of piezometric data and known geologic conditions, it is apparent that the foundation materials throughout this section are highly permeable; the high permeability foundation material and lakeside borrow canal contribute to numerous piezometers showing strong correlations to lake levels. Additionally, the time-history plots show little head reduction from upstream to downstream, also indicating a highly permeable foundation with a possible direct entry or little filter cake buildup on the lakeside.

After installation of the cutoff wall, noticeable changes in piezometric response are seen in some of the piezometers. Piezometers installed upstream of the cutoff wall now correlate either strongly or directly with changes in lake stage, indicating the cutoff wall is acting as a barrier to seepage. For piezometers downstream of the cutoff wall, the piezometric response has decreased (less correlation to changes in lake stage) and head has decreased. This also indicates the cutoff is acting as a barrier to seepage and since head is reduced, it confirms that the risk to initiation of piping has also been reduced.

When comparing the downstream piezometers responses to cutoff wall in this Section to Section B, it would appear that cutoff wall performance is better in Section B, generally due to greater head losses recorded and more noticeable decrease in correlation to lake stage. For Section C, the slight differences contributing to this observation are likely due to the following factors:

- The slight differences in geology (no significant semi-confining unit in Section C and head reduction after cutoff wall construction is observed; however, no appreciable change in correlation),
- Slightly higher tailwater/different tailwater controls in Section C,
- Variation of cutoff wall depths (much of Section C wall is shallower), and
- More piezometer lines located close to cutoff wall gaps around structures (Since gap closures occur after completion of the cutoff wall along the mainline embankment, additional time is required to make full assessment of the effects of the gap in relation to piezometer location. However, from initial data review, it appears the effect can be significant for a piezometer line located within about ¼ mile of a gap.

Although Section B piezometric responses appear to be more prominent, analysis of the piezometric data in this section indicates the cutoff wall is effective at reducing the probability of initiation and progression of internal erosion.

In support the claims above, it is noted that no seepage related issues have been reported up to a lake stage of elevation 16.0 feet, where before installation of the cutoff wall, seepage issues would begin to arise. Now that cutoff wall has been completed in this Section (with the exception of gaps at noted structures); it appears that many of the historic problems have been mitigated for pool levels experienced post construction; however, it should be noted that any lake stage above elevation 16.0 feet is considered a first filling. Continued monitoring of piezometric levels in this area is also critical to continued evaluation of the cutoff wall's effectiveness. Although no performance related issues have been reported since installation of the cutoff wall with lake stage as high as El 17.2, monitoring of this section is recommended during higher than normal lake stages as the cutoff wall remains unproven for an SPF loading.

9. SECTION D – REACH 7

9.1. Piezometer Line R7-1

Location	1 Mile South of S-135 Pump Station and Lock
DSMS Segment/CIZ	21/G
Date PZ Line in Service	PZ-R7-A-B October 1995 Remainder August 1999
Piezometer Maintenance and Repairs	PZ-R7-A-B and PZ-R7-A-B2 redrilled and re-set by NAB in January 2009 October 2014 – PZ-R7-A-C1 and PZ-R7-A-C2: new well pad and bolted cover
Lakeside Features	Littoral zone/shallow pool
Lakeside PZs	None due to site access.
Centerline PZs	PZ-R7-A-B2 (Embankment Fill/Foundation) PZ-R7-A-B (Foundation) old name was PZ-HHDR7A-B
Landside PZs and Tailwater	PZ-R7-A-C2 (Embankment Fill/Foundation) PZ-R7-A-C1 (Foundation)
Landside Features	L-47 Canal approximately 50 feet from embankment toe
Historic Poor Performance	A sinkhole was encountered during the 1998 High Water Event indicating the presence of internally unstable material in the embankment at this location (MRR 2000 H6-21).
Emergency/ Permanent Repairs	None

Piezometers PZ-R7-A-B and PZ-R7-A-B2 were apparently destroyed in early 2005 and were redrilled in early 2009.

Data Analysis/Evaluation:

- All piezometers within this section have a very strong correlation to the lake level for lake levels below approximately elevation 13.5 feet. Above elevation 13.5, the correlation quickly tapers off, where PZ-R7-A-B show weak correlation and PZ-R7-A-C1 and PZ-R7-A-C2 show almost no correlation. Because the L-47 canal penetrates deep into the foundation of the embankment, the canal acts as a drain and lowers foundation pressures.

Although foundation pressures are significantly relieved by the canal, the canal exit face is an unprotected seepage exit face and is not a reliable method for controlling pressures within the dam. Additionally, the rock layers and cohesive materials in the foundation provide roof support for a pipe to progress to the reservoir. As the pressure relief from the centerline of embankment to the exit face of the canal increases, so does the potential for piping. Because it is difficult to detect a pipe below the water level of the canal, initiation and progression of a pipe may remain unseen until too late. When lake elevations rise to levels above elevation 17.0, the L-47 canal should be checked for any cloudy water that may be a sign of piping.

9.2. Piezometer Line R7-2

Location	3.7 Miles North of S-135 Pump Station and Lock
DSMS Segment/CIZ	21/G
Date PZ Line in Service	August 1999
Piezometer Maintenance and Repairs	October 2014 – PZ-R7-B-B1 and PZ-R7-B-B2: new well pad and bolted cover
Lakeside Features	Wide littoral zone
Lakeside PZs	PZ-R7-B-A (Embankment Fill/Foundation)
Centerline PZs	PZ-R7-B-B2 (Embankment Fill/Foundation) PZ-R7-B-B1 (Foundation)
Landside PZs and Tailwater	None due to funding limitations in 1999
Landside Features	L-47 Canal approximately 170 feet from embankment toe
Historic Poor Performance	None
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- There is only a minimal amount of head dissipation from PZ-R7-B-A to PZ-R7-B-B1 and PZ-R7-B-B2, and not a significant amount of head loss between the lake and PZ-R7-B-A. Since midyear 2006, all three piezometers have read nearly the same.
- Below a lake stage of approximately elevation 13.5 feet, correlation to lake stages is direct on all piezometers. The correlation slightly diminishes as the lake stage increases above elevation 13.5 feet due to the L-47 canal.
- A significant portion of the total head loss occurs from PZ-R7-B-B1 and PZ-R7-B-B2 to the outside the L-47 canal. Piping initiation is a concern if the head dissipation at the exit face of the L-47 canal approaches the critical gradient of the canal embankment and foundation materials.

The conditions at this piezometer line are consistent with those as described in piezometer line R7-1. For this reason, this area should be watched closely when the lake is above elevation 17.0 feet. A piezometer should be installed at the downstream toe of the embankment to monitor the gradient from the downstream toe into the L-47 Canal.

9.3. Combined Analysis: Section D – Reach 7

The geology and geometry of the embankment and canal in this region provides an environment conducive to piping as unfiltered seepage exit faces (with exposed roof-supporting materials) have been created by excavation of the adjacent canal. From analysis of the piezometric data, it is apparent that the lake, the foundation, and the L-47 canal are in direct communication with each other. The fact that the ground elevation in this area is high (elevation 15.0 feet and higher) has kept the highest sustained head to below 4 feet. Higher lake elevations could produce drastically different performance in this portion of the embankment. The deep canal and the murky water within, makes it difficult to observe performance issues; close observation of this region is will be necessary to identify potential problems.

10. SECTION E – DSMS PIEZOMETERS

10.1. Piezometer Line R4-1

Location	0.5 mi northwest of S-77 (Moore Haven Lock and Spillway)
DSMS Segment/CIZ	8/B
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	Bench (approximately 550 feet) to lakeside borrow source.
Lakeside PZs	None
Centerline PZs	HHD12-R4-PZ-1B1 (Embankment Fill) HHD12-R4-PZ-1B2 (Upper Foundation) HHD12-R4-PZ-1B (Foundation)
Landside PZs and Tailwater	HHD12-R4-PZ-1C1 (Upper Foundation) HHD12-R4-PZ-1C (Foundation) R4-1-TW
Landside Features	A toe ditch parallels the embankment toe and is approximately 35 feet from the landside toe. The downstream bank of the toe ditch is lined with trees. The toe ditch is connected to the Caloosahatchee River (C-43 Canal), which is approximately 0.5 miles southeast.
Historic Poor Performance	Installed for obtaining information and understanding piezometric response for the DSMS; however in the vicinity of this piezometer line, Point R4-1 (1998) cites very light seeps and standing water on the berm. Condition 2.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- HHD12-R4-PZ-1B1 plots above the lake level at all times, likely indicating a perched groundwater table in the fill. This is likely due to rainwater ponding and infiltration on the wide bench that exists upstream of the embankment.
- Below a lake level of elevation 13 feet, the other four piezometers closely follow the S-235 tailwater elevation. Above elevation 13 feet, they diverge slightly with piezometers HHD12-R4-PZ-1C and HHD12-R4-PZ-1C1 lagging behind piezometers HHD12-R4-PZ-1B and HHD12-R4-PZ-1B2 by about 0.5 feet.
- Above elevation 15.0 feet, there is as much as a 3.5 feet head differential between the lake level and HHD12-R4-PZ-1B and HHD12-R4-PZ-1B2 indicating there is significant head loss occurring from the lake to the centerline of the embankment.
- Tailwater readings appear to correlate with the piezometers readings.

With the exception of piezometer HHD12-R4-PZ-1B1, the readings from the other four piezometers are consistent with 2D finite-element seepage modeling results for this section of the embankment and show a dampened response with respect to the lake level. The large head reduction seen from the lake to centerline is likely due to the distance from the borrow canal to the centerline of HHD. Since the ground surface adjacent to the lakeside toe is approximately elevation 16.5 feet, the embankment is not loaded for typical lake operation schedules.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL_h) (ft.)	Horizontal Gradient $\Delta H/\Delta L_h$	Vertical Distance (ΔL_v) (ft.)	Vertical Gradient $\Delta H/\Delta L_v$
HHD12-R4-PZ1C1	**12.56**	**11.46**	***1.1***	**30**	***0.04***		

10.2. Piezometer Line R4-2

Location	1,000 ft. south of S-281 (Culvert 5A)
DSMS Segment/CIZ	9/B
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	Bench (approximately 500 feet) to lakeside borrow source.
Lakeside PZs	None
Centerline PZs	HHD12-R4-PZ-2B2 (Embankment Fill) HHD12-R4-PZ-2B1 (Embankment Fill/Foundation) HHD12-R4-PZ-2B (Foundation)
Landside PZs and Tailwater	HHD12-R4-PZ-2C1 (Upper Foundation) HHD12-R4-PZ-2C (Foundation) R4-2-TW
Landside Features	A toe ditch parallels the embankment toe and approximately 20 feet from the landside toe. See discussion below.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Prior to Nov 2014, all five piezometers closely follow the lake elevation (within 1.5 feet) and there is very good correlation between the water levels recorded by each piezometer and the lake elevation. Very little head dissipation is shown across this piezometer line, with the difference between the "C" piezometers (HHD12-R4-PZ-2C1 and HHD12-R4-PZ-2C) and the "B" piezometers (HHD12-R4-PZ-2B, HHD12-R4-PZ-2B1, and HHD12-R4-PZ-2B2) being only as much as 0.5 feet (approximately).
- In November 2014, dewatering operations began at Culvert 5A for culvert replacement, which accounts for the sharp drop in head across all piezometers at this line. It is noted the construction of culvert 5A has been completed, and the dewatering has been shut down.

Under normal operation (no dewatering in the area) data analysis/evaluation of this piezometer is made difficult due to several influencing factors located near this piezometer line (see Figure 9 below):

- A landfill located downstream of HHD--It is suspected that operation of the landfill includes control of the tailwater in the ditch located between HHD and the landfill. Tailwater in the ditch/canal is controlled by a stop block riser located at the southeast end of the landfill.
- Although as-built drawings indicate a 30-inch single barrel, steel culvert exists under the L-41 levee, the connection of the ditch/canal to Culvert 5A tailwater was not seen during a field inspection. In addition, the culvert replacement operations at Culvert 5A have placed a substantial amount of fill across this ditch location for construction equipment access, affirming that a connection no longer exists.
- A wetland/depression exists immediately upstream of the embankment and before the lake. It is possible that rainwater is perching there, causing readings to appear artificially high, and indicating no head loss.
- Tailwater readings appear to correlate with the piezometers readings.

Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
HHD12-R4-PZ2C1	**14.74**	**14.15**	***0.59***	**34.6**	***0.02***		

Note: The figure shows the pre-construction condition at C-5A. The portion of L-41 with PC-06 has been replaced with a construction access ramp. During construction, Construction Division indicated the Contractor did not remove the culvert. Therefore, it was either already removed by SFWMD without USACE knowledge, was previously crushed or further buried/crushed when the access ramp was constructed. Either way, the hydraulic connection has been severed.

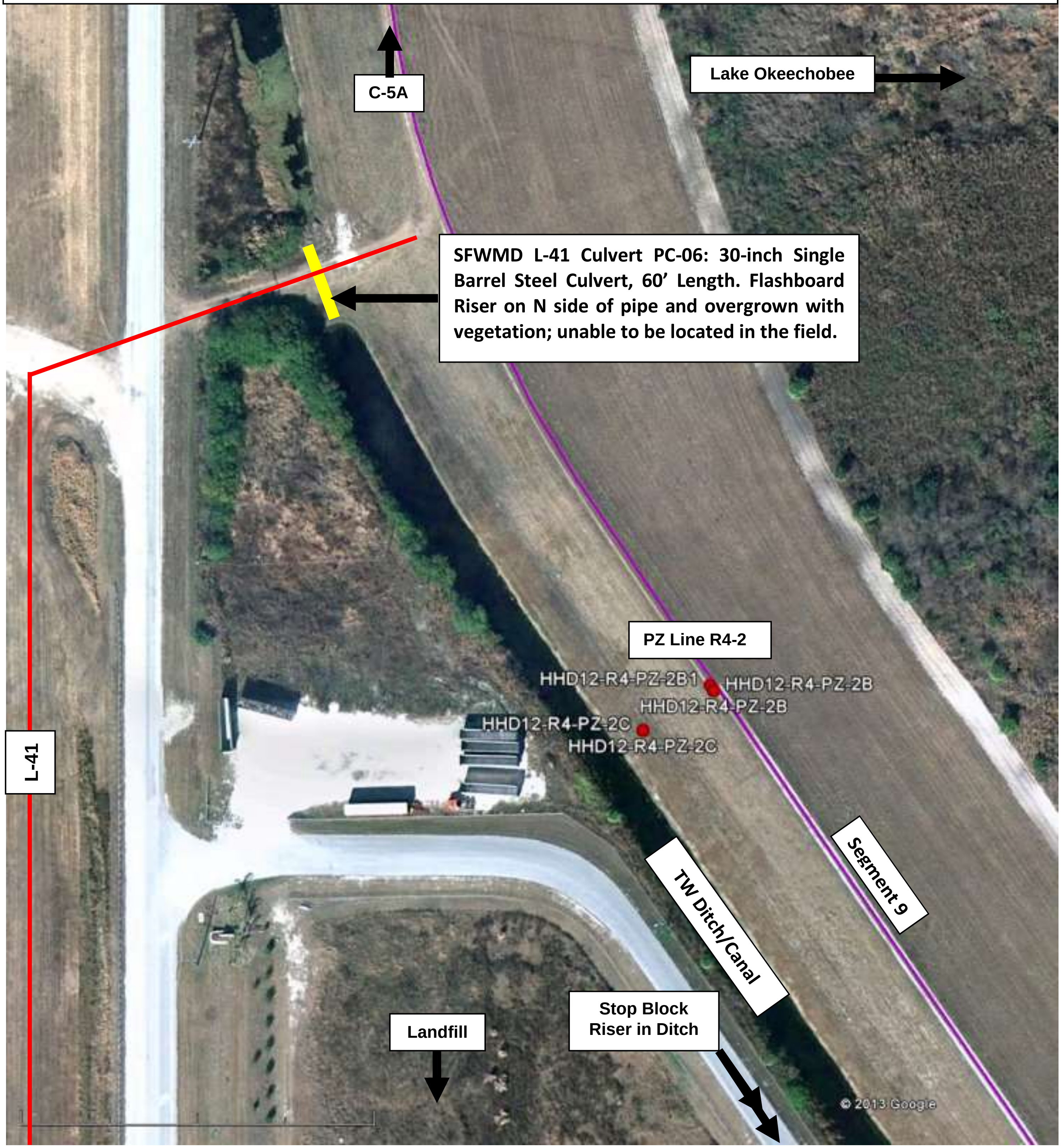

Figure 9: Site at Piezometer Line R4-2

10.3. Piezometer Line R4-3

Location	Fish Eating Creek South Tieback, 5 mi NW of Hwy 78 L-D3 Extension Gate
DSMS Segment/CIZ	10/B
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	Fish Eating Creek lies far upstream of the embankment toe. Lakeside ground surface is high and generally dry (only influenced by Lake Okeechobee Stage under extreme pools)
Lakeside PZs	None
Centerline PZs	HHD12-R4-PZ-4B1 (Embankment Fill) HHD12-R4-PZ-4B2 (Upper Foundation) HHD12-R4-PZ-4B (Foundation)
Landside PZs and Tailwater	HHD12-R4-PZ-4C1 (Upper Foundation) HHD12-R4-PZ-4C (Foundation)
Landside Features	In 2014, a Ditch/Canal was constructed at the downstream toe. The Ditch/Canal is part of the Lykes Brothers Nicodemus Slough Wetland Mitigation project.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- As the Fish Eating Creek (FEC) Tieback progresses westward, ground surface elevations increase. As a result, these piezometers are primarily influenced by the water level in the creek and lie upland (and up gradient) of the lake.
- Stage data from the creek is currently not available for plotting; however, in September 2017, hurricane Irma caused fish eating creek to stage up to the HHD embankment toe.
- Nicodemus Slough canal stage is managed at approximately elevation 19 feet.
- HHD12-R4-PZ-4B2, HHD12-R4-PZ-4B, HHD12-R4-PZ-4C1, and HHD12-R4-PZ-4C read approximately the same and above the lake level due to their location in relation to Lake Okeechobee.
- HHD12-R4-PZ-4B1 tip elevation is at El. 23.04 and been reading dry for the majority of times.

Figure 10 – FEC Stage at toe of tieback

Until installation of these piezometers for the DSMS, there was little understanding of tailwater and piezometric response in this segment. Due to the high ground surface elevations, it is expected that the tieback embankment at this location would not experience loading from the lake, rather it would experience loading from Fish Eating Creek. Appropriate daily stage data for comparison of fish eating creek elevation to this set of piezometer data is not currently available. Although the readings obtained to date seem uneventful, the data collected is valuable for defining the existing conditions and aid in making informed decisions with respect to the performance of this segment under high lake stages. Changes in the piezometric head across the tieback will continue to be monitored by these piezometers.

10.4. Piezometer Line R6-1

Location	0.1 mi South of S-131 Pump Station and Lock
DSMS Segment/CIZ	12/C
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	A littoral zone exists upstream. Approximately 250 feet from the lakeside toe, a small canal exists, followed by a wide littoral zone.
Lakeside PZs	None
Centerline PZs	HHD12-R6-PZ-4B2 (Embankment Fill) HHD12-R6-PZ-4B1 (Upper Foundation) HHD12-R6-PZ-4B (Foundation)
Landside PZs and Tailwater	HHD12-R6-PZ-4C1 (Upper Foundation) HHD12-R6-PZ-4C (Lower Foundation)
Landside Features	The L-50 Canal is approximately 55 feet from the landside toe.
Historic Poor Performance	Installed for obtaining information and understanding piezometric response for the DSMS; however, in 1998, (Point R6-1A, Condition 2) cites seepage where levee meets road, flowing onto road, 400 feet long. Additionally, in 1999 a condition 2 seepage point, (Point R6-3 located nearby) cites multiple patches of standing water. A saturated berm and ponding has also been noted at a few locations in the vicinity.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- SPT and CPT data from the area indicates the embankment and foundation contains a high percentage of clay. The data also suggests the embankment material is not homogeneous and is highly stratified. The readings from piezometer HHD12-R6-PZ-4B2, which plot above the lake level, likely indicate perched water trapped in the fill, as a result of the stratified deposits.
- Piezometers HHD12-R6-PZ-4C and HHD12-R6-PZ-4C1 follow the rise and fall of the lake and read below the lake elevation by 1 to 2 feet.
- Piezometers HHD12-R6-PZ-4B and HHD12-R6-PZ-4B1 also follow the rise and fall of the lake, but appear to read perched water following periods of heavy rainfall.
- HHD12-R6-PZ-4B2 tip elevation is at El. 14.91 and been reading dry since December 2017.

Excluding piezometer HHD12-R6-PZ-4B2, these piezometers indicate only a limited reduction in head through the foundation. During high lake levels, conditions along the near edge of the L-50 Canal should be monitored for signs of seepage exiting through the highly stratified foundation. Additionally, since subsurface investigations also indicate a highly stratified embankment fill, it should also be monitored when the embankment is loaded.

10.5. Piezometer Line R6-2

Location	Harney Pond Canal West Tieback, 0.1 mi North of S-287 (Culvert HP-2). HP-2 is under replacement construction and because of the proximity of culvert construction to the piezometer line; the piezometer line will be demolished and abandoned during construction.
DSMS Segment/CIZ	14A/C
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	Harney Pond Canal (C-41) is approximately 50 feet from the lakeside toe. C-41 has an open connection to Lake Okeechobee
Lakeside PZs	None
Centerline PZs	HHD12-R6-PZ-7B2 (Embankment Fill) HHD12-R6-PZ-7B1 (Upper Foundation) HHD12-R6-PZ-7B (Foundation)
Landside PZs and Tailwater	HHD12-R6-PZ-7C1 (Upper Foundation) HHD12-R6-PZ-7C (Foundation)
Landside Features	Harney Pond Culvert HP-2 supply ditch lies immediately downstream of the embankment
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- The piezometers at R6-2 readings have not been collected since the February 2016, due to the construction of HP-2.
- These piezometers are primarily influenced by the water level in the downstream canal that connects to the lake through HP-2.
- Much of the time, the downstream canal has a higher tailwater than the lake as HP-2 provides gravity drainage into the lake when the lake is low.
- All five piezometers, with the exception of HHD12-R6-PZ-7B2 between the period of 7/1/2013 to 1/1/2016, read approximately the same and above the lake level for lake level below 16, by as much as 1 foot.
- Replacement of HP-2 is began in FY2015; however, the contractor had not elected to abandon the piezometers at the start of construction and excavation, as of February 2016, the effects of dewatering have yet to be observed in the piezometric response.

Until installation of these piezometers for the DSMS, there was little understanding of tailwater and piezometric response in this segment. Although the readings obtained to date seem uneventful, the data collected is valuable for defining the existing conditions and aid in making informed decisions with respect to the performance of this segment under high lake stages. Changes in the piezometric head across the tieback will continue to be monitored by these piezometers.

10.6. Piezometer Line R6-3

Location	0.5 mi Northeast of Pump Station S-129
DSMS Segment/CIZ	15/D
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	A wide littoral zone. Approximately 250 feet from the lakeside toe, a ditch exists.
Lakeside PZs	None
Centerline PZs	HHD12-R6-PZ-10B2 (Embankment Fill) HHD12-R6-PZ-10B1 (Upper Foundation) HHD12-R6-PZ-10B (Foundation)
Landside PZs and Tailwater	HHD12-R6-PZ-10C1 (Upper Foundation) HHD12-R6-PZ-10C (Foundation)
Landside Features	The L-49 Canal is approximately 65 feet from the landside toe.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- HHD12-R6-PZ-10B2 has been dry since installation; however, it is interesting to note that readings are consistently obtained that show readings several feet above the lake. This piezometer either has sediment in it or is reading a perched water table. Records show that this well was never developed; therefore, a combination of the two (perched water and sediment) is the likely cause of the high readings. This piezometer should be flushed with clean water.
- Piezometers HHD12-R6-PZ-10B and HHD12-R6-PZ-10B1 follow the rise and fall of the lake and read approximately 0.5 to 1.5 feet lower than the lake level and show a strong correlation to changes in lake stage.
- Piezometers HHD12-R6-PZ-10C and HHD12-R6-PZ-10C1 closely follow the canal stages, thus having a weak correlation to the lake.

Excluding piezometer HHD12-R6-PZ-10B2, these piezometers indicate only a limited reduction in head across the embankment (~ 1 foot); conditions along the near edge of the L-49 Canal should be monitored during high water events for signs of seepage and piping.

10.7. Piezometer Line R6-4

Location	Indian Prairie Canal West Tieback, 1.5 mi northwest of Indian Prairie Canal junction
DSMS Segment/CIZ	16/D
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	Indian Prairie Canal (C-40) is approximately 25 feet from the lakeside toe. C-40 has an open connection to Lake Okeechobee.
Lakeside PZs	None
Centerline PZs	HHD12-R6-PZ-12B2 (Embankment Fill) HHD12-R6-PZ-12B1 (Upper Foundation) HHD12-R6-PZ-12B (Lower Foundation)
Landside PZs and Tailwater	HHD12-R6-PZ-12C1 (Upper Foundation) HHD12-R6-PZ-12C (Foundation/Lower Foundation) R6-4-TW
Landside Features	Heavily vegetated toe ditch parallels the embankment toe.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Ground surface elevations (and tailwater elevations) increase as the tieback diverges from the HHD mainline embankment. Tailwater conditions landward of the piezometer line are influenced by the stages in ditches and canals that are located adjacent to the tieback embankment.
- The data indicates that, at least for lake levels between elevation 12.0 to 15.0 feet, tailwater varies with a southeastward (predominately lakeward) gradient. The tailwater ranges in elevation 14.5 to 16.5 feet at Canal L-60 and decreases to elevation 11.5 to 12.0 feet near the main dam. The southeastward tailwater gradient may decrease or reverse for lake levels much higher than elevation 15.0 feet as a result of the tailwater rises along the mainline embankment.
- For the period of record (lake stages 17.2 feet and less), groundwater flow is from landside to lakeside, but at times is static (equal head in lake and downstream of lake)
- Beyond the initial reading for piezometer HHD12-R6-PZ-12B2, this piezometer uniformly reads above the lake level. This reading represents the tip of the piezometer, is not representative of piezometric head, and is a result of error from the manual reading of this piezometer.
- Tailwater reading is higher than the lake for lake level below 15, and correlate to the lake level at an El. above 15.

Until installation of these piezometers for the DSMS, there was little understanding of tailwater and piezometric response in this segment. Although the readings obtained to date seem uneventful, the data collected is valuable for defining the existing conditions and aid in making informed decisions with respect to the performance of this segment under high lake stages.

Changes in the piezometric head across the tieback will continue to be monitored by these piezometers.
Gradient Table:

Piezometer	PZ Reading (ft.)	Tailwater Reading (ft.)	ΔH (ft.)	Horizontal Distance (ΔL$_h$) (ft.)	Horizontal Gradient ΔH/ΔL$_h$	Vertical Distance (ΔL$_v$) (ft.)	Vertical Gradient ΔH/ΔL$_v$
HHD12-R6-PZ12C1	**16.88**	**16.67**	***0.21***	**33**	***0.01***		

10.8. Piezometer Line R8-1

Location	1.8 mi southwest of S-127 Pump Station and Lock
DSMS Segment/CIZ	18A/E
Date PZ Line in Service	January 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	A wide littoral zone
Lakeside PZs	None
Centerline PZs	HHD12-R8-PZ-4B1 (Embankment Fill) HHD12-R8-PZ-4B (Lower Foundation)
Landside PZs and Tailwater	HHD12-R8-PZ-4C (Foundation/Lower Foundation)
Landside Features	The L-48 Canal is approximately 60 feet from the landside toe.
Historic Poor Performance	Installed for obtaining information and understanding piezometric response for the DSMS; however, in 1998, ponding and a saturated berm was noted in the vicinity of this piezometer line.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Between lake stage elevations 13.0 and 14.0 feet, the tailwater is nearly equal to the lake; as such, HHD12-R8-PZ-4C and HHD12-R8-PZ-4B read close to the lake and the tailwater, as expected.
- When the lake is above the tailwater, HHD12-R8-PZ-4C has a weak correlation to the lake level and is more likely influenced by the L-48 Canal stage.
- For a lake stage of elevation 16.0 feet, approximately 1.5 feet of head loss is occurring from the lake to HHD12-R8-PZ-4B. Approximately 0.5 feet of head loss is occurring from HHD12-R8-PZ-4B to HHD12-R8-PZ-4C. Approximately 0.5 feet of head loss is also occurring from HHD12-R8-PZ-4C to the L-48 Canal.
  HHD12-R8-PZ-4B1 uniformly reads above the lake level by as much as 1 foot and represents the tip of the piezometer. The readings were verified during the inspection and it appear to be wet near the bottom of the piezometer.

From the embankment centerline to the L-48 Canal, head loss through the foundation is uniform. From the lake to the centerline, the head loss is much greater, which is likely a result of the littoral zone maintaining a separation from the lake. During higher lake stages, it is expected that less head loss will occur from the lake to the centerline piezometer. Although tailwater conditions are higher at this location, continual monitoring of this piezometer line is recommended such that a better understanding can be developed.

10.9. Piezometer Line R8-2

Location	Kissimmee River West Tieback, 3.1 mi Northwest of Hwy 78 & Kissimmee
DSMS Segment/CIZ	18B/E
Date PZ Line in Service	February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	The Channelized Kissimmee River (Canal C-38) resides approximately 580 feet from the lakeside toe.
Lakeside PZs	None
Centerline PZs	HHD12-R8-PZ-9B2 (Embankment Fill) HHD12-R8-PZ-9B1 (Upper Foundation) HHD12-R8-PZ-9B (Foundation/Lower Foundation)
Landside PZs and Tailwater	HHD12-R8-PZ-9C1 (Embankment Fill/Upper Foundation) HHD12-R8-PZ-9C (Foundation)
Landside Features	A toe ditch parallels the embankment toe. The historic (before the Kissimmee River was channelized (C-38)) river bed of the Kissimmee River resides far downstream. The historic Kissimmee River still flows towards Lake Okeechobee; however, it is no longer directly connected to the lake.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- As the Kissimmee River Tieback progresses northwest, ground surface elevations increase. As a result, these piezometers are primarily influenced by the water levels landside of the tieback.

Until installation of these piezometers for the DSMS, there was little understanding of tailwater and piezometric response in this segment. Although the readings obtained to date seem uneventful, the data collected is valuable for defining the existing conditions and aid in making informed decisions with respect to the performance of this segment under high lake stages. Changes in the piezometric head across the tieback will continue to be monitored by these piezometers.

10.10. Piezometer Line R5-1

Location	1.5 mi northeast of S-267 (Culvert 6) L-D4 Extension
DSMS Segment/CIZ	19A/ F
Date PZ Line in Service	January/February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	A 450 foot littoral zone
Lakeside PZs	None
Centerline PZs	HHD12-R5-PZ-7B2 (Embankment Fill) HHD12-R5-PZ-7B1 (Upper Foundation) HHD12-R5-PZ-7B (Foundation)
Landside PZs and Tailwater	HHD12-R5-PZ-7C1 (Upper Foundation) HHD12-R5-PZ-7C (Foundation)
Landside Features	The L-D4 Canal is approximately 35 feet from the landside toe.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Piezometers HHD12-R5-PZ-7C and HHD12-R5-PZ-7C1 are heavily influenced by the L-D4 Canal and show a weak correlation to the lake stage above El 13.5.
- Piezometers HHD12-R5-PZ-7B and HHD12-R5-PZ-7B1 show a weak to good correlation to the lake stage. Due to the distance from the embankment toe to the lake, this trend would be expected to change for lake stages above elevation 14.5 feet.
- HHD12-R5-PZ-7B2 is tipped high in the embankment fill and has been dry since installation. In 2017, the lake stage exceeded the piezometer tip and it appears this piezometer remained unresponsive or at times responding to perched water.

Trends seen in this piezometer line are similar to R8-1. Continual monitoring of this piezometer line should continue such that a better understanding can be developed.

10.11. Piezometer Line R5-2

Location	Kissimmee River East Tieback, North of S-268 (Culvert 8)
DSMS Segment/CIZ	19B/F
Date PZ Line in Service	January 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	The embankment toe is not distinct as the embankment and adjacent land gently slopes to the Kissimmee River (C-38), which is offset by approximately 380 feet from the centerline of the embankment. C-38 has an open connection to Lake Okeechobee.
Lakeside PZs	None
Centerline PZs	HHD12-R5-PZ-2B2 (Embankment Fill) HHD12-R5-PZ-2B1 (Embankment Fill/Upper Foundation) HHD12-R5-PZ-2B (Lower Foundation)
Landside PZs and Tailwater	HHD12-R5-PZ-2C1 (Upper Foundation) HHD12-R5-PZ-2C (Foundation)
Landside Features	The embankment toe is heavily vegetated with woody vegetation. Downstream of the vegetation, a toe ditch exists.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency /Permanent Repairs	None

Data Analysis/Evaluation:

- As the Kissimmee River Tieback progresses northwest, ground surface elevations increase. As a result, these piezometers are primarily influenced by the water levels landside of the tieback and fluctuating canal stages in the C-38 Canal during inflow from the Kissimmee Basin.
- A comparison was made between the official daily lake stages and the daily stages in Canal C-38 to determine why the gradient in the piezometers is from centerline to downstream, but above the recorded lake elevation. From observation of the stage data, the canal stages do not significantly deviate from the daily reported lake stages. Deviations of 0.5 feet are possible (as observed during the comparison); however, in August of 2013, the centerline piezometers deviated from the lake stage by about 1.5 feet. From the canal and lake stage data, this deviation is beyond the anticipated variation. This could indicate one of two things:
    - A survey error
    - High stages in the historic Kissimmee River (landward of the Kissimmee River Restoration (KRR) West Tieback) are influencing these piezometers landward of the KRR East Tieback.

During development of the DSMS, the possibility of a survey error was examined. Different elevation data sets (LIDAR data, borehole survey, and piezometer survey data) suggest the elevations are correct. When comparing the trends of R8-2 to R5-2, the possibility of pressures landward of the KRR West Tieback influencing the piezometer readings landward of the KRR East tieback is reasonable, as the heads in the surficial aquifer on the west side of the tieback have been 7 feet higher than the lake stage in August of 2013. Given the presence of a confining layer at elevation -20.0 feet that is overlain by sands, the hypothesis that high stages in the historic Kissimmee River are influencing these piezometers is well supported.

Changes in the piezometric surface across Kissimmee River East Tieback will continue to be recorded by these piezometers. Until installation of these piezometers for the DSMS, there was little understanding of groundwater conditions as they relate to the dam in this segment. Changes in the piezometric head across the tieback will continue to be monitored by these piezometers.

10.12. Piezometer Line R7-3

Location	2.9 miles southeast of Spillway S-191
DSMS Segment/CIZ	20/G
Date PZ Line in Service	January/February 2013
Piezometer Maintenance and Repairs	None
Lakeside Features	A wide littoral zone.
Lakeside PZs	None
Centerline PZs	HHD12-R7-PZ-2B1 (Embankment Fill) HHD12-R7-PZ-2B (Foundation)
Landside PZs and Tailwater	HHD12-R7-PZ-2C (Foundation)
Landside Features	The L-47 Canal is approximately 75 feet from the landside toe.
Historic Poor Performance	None. Installed for obtaining information and understanding piezometric response for the DSMS.
Emergency/ Permanent Repairs	None

Data Analysis/Evaluation:

- Piezometers HHD12-R7-PZ-2C and HHD12-R7-PZ-2B read nearly the same up to a lake level of elevation 14.0 feet, after that the two piezometers diverge slightly (~0.25 feet) with piezometer HHD12-R7-PZ-2B reading higher than piezometer HHD12-R7-PZ-2C. Both piezometers also read close to the lake level up to elevation 14.0 feet and then read below the lake by as much as 1.5 feet. These observations suggest the influence of the L-47 Canal controls for lake stages less than 14.0 feet.
- Piezometer HHD12-R7-PZ-2B1 uniformly reads near the lake level when the lake level fluctuated between elevation 15.5 and 16.0 feet. It is possible that this piezometer is reflecting the presence of trapped water inside the standpipe and not piezometric changes.

Above a lake level of elevation 14.0 feet, piezometers HHD12-R7-PZ-2C and HHD12-R7-PZ-2B indicate a 1 to 1.5-foot reduction in head across the embankment. During high water events, the near edge of the L-47 Canal should be monitored for signs of seepage and piping.

10.13. Combined Analysis: Section E – DSMS Piezometers

Unlike piezometers in other sections of this report, these piezometers were installed for the purposes of obtaining new information, not for the purposes of monitoring areas of poor performance. As a result of installing these piezometers, a new understanding of the embankment and foundation performance—in response to changing lake stages—has been developed and will continue to develop. Because of the uniqueness of each site for these piezometers (tiebacks, mainline embankments, deep canals, and littoral zones) no overarching conclusions related to the trends of the piezometers in this Section can be made. However, it is noted that this data is essential to developing a better understanding of the effects of lake stages on the various subsurface strata and will serve as a valuable source of data when performing final design of risk reduction measures for the various segments of HHD.

11. CONCLUSIONS AND RECOMMENDATIONS

As discussed at the beginning of this report, the HHD embankment was constructed via hydraulic fill and/or dragline methods. In either case, embankment fill was obtained from borrow excavated adjacent to the embankment. Given the nature of the geology in the region, the embankment is generally comprised of sandy, shelly, and highly porous materials. Poor construction practices (lack of compaction, segregation of materials, stratification of soils, and inclusion of gravel to boulder size material) have created embankment layers/zones with high permeability and preferential pathways for seepage. Observation of the piezometric data indicates little to no head loss is occurring from the lake to the centerline of the embankment (predominately in Reaches 2 and 3, but also noted in Reaches 4 and 6).

In addition to the poor construction practices for embankment construction, much of the embankment was placed on top of native surficial materials that are soft, compressible, and have a relatively low permeability. By constructing the embankment atop these materials, a “bowl” has been formed at the predevelopment ground surface which allows rainwater and seepage to perch on top. Because of this condition, along with the lack head loss observed to the centerline of the embankment and the lack of initial implementation of an engineered seepage exit point or barrier, initiation of piping along the embankment exit face has been a concern along the majority of the HHD embankment. For this report year, lake stages remained low enough that none of these conditions were observed in the field and none of the piezometers had reached Red Zone readings.

In areas where a shallow toe ditch does not exist (Part of Reach 2 and Reaches 5, 6, 7, and 8), the embankment is paralleled by a deep borrow/drainage canal. Piezometric responses in these locations indicate that the canal stage has a significant impact on piezometric response. These borrow/drainage canals penetrate deep into the foundation and are effectively relieving foundation pressure and seepage; however, a safe, filtered exit for seepage is not provided. This causes concern for initiation and progression of piping that is possibly hidden from proper inspection beneath the water in the canal. Although a concern, it is noted that no performance related issues at these locations were observed during this report year.

Historically, few performance issues have been noted in areas where the DSMS Piezometers were installed (Section E Piezometers). From collection and interpretation of the new data, it is apparent that the lack of poor performance data is due to higher tailwater and ground surface elevations seen throughout the area. Although historic poor performance has not been recorded, piezometric trends and the measured head loss at some sections indicates these areas are anticipated to show signs of distress at lake stages at or above the pool of record.

Approximately 21 miles of cutoff wall has been constructed in Reach 1. With the exception of 500 foot long gaps left around the culverts (C10, C12A, C10A), structures S-308, S-352, Torry Island, S351 and S-2 (AKA: Reach 1 Gap Closure Project). The construction of the culverts and gap closures is ongoing.

Where cutoff wall has been completed, sufficient data has now been gathered and the initial effects of the cutoff wall can be assessed. The piezometric data indicates that the cutoff wall is in fact acting as a barrier to seepage. This is evidenced by piezometer readings increasing on the upstream side of the wall and decreased on the downstream side of the wall after construction of the cutoff wall. The data also indicates that the downstream head reduction seen is variable across the region and is dependent on geology, depth of the cutoff wall, and tailwater conditions. Downstream head reductions ranging from 0.5 to 2.2 feet, for a lake stage of elevation 17.2 feet, are observed throughout Reach 1. Continual monitoring of the upstream head increase and downstream head decrease over time is necessary to document and monitor the performance of the wall, as changes in piezometric response are the only indicator for degradation of cutoff wall performance.

Throughout Reach 3 and the majority of Reach 2 a shallow toe ditch exists landside of the embankment. Several of the piezometers in these locations are indicating artesian pressures beneath the surficial blanket material; potentially more piezometers will show the same trend should higher lake levels occur. This condition is of greatest concern where the cap rock is fractured or solution-riddled and the blanket layer is thin, as little uplift pressure is required to blowout the material. In areas where this is a concern, the blanket material, limestone, and/or the cemented sand layers will allow for roof support, facilitating the progression of piping and potentially the failure of HHD. With the exception of emergency repairs, no permanent remediation has been constructed in Reaches 2 and 3. Adding to the concern, the probability of failure within these reaches is the highest, according to the estimates from the HHD Potential Failure Modes Analysis and Risk Assessment (March 2014). Given the newly available tailwater data, and as a result of emergency repairs and ditch inverts that were raised to elevations above tailwater; the lake stage at which seepage/piping could occur appears to be higher than previously thought.

This shallow toe ditch, as discussed in the paragraph above, also exists throughout Reach 4 and along portions of Harney Pond, Indian Prairie, and Kissimmee River Tieback embankments. However, the surficial blanket material and cap rock tapers out just west of Clewiston; therefore, the conditions observed within Reaches 2 and 3 are not observed at these other locations where the shallow toe ditch exists. Although the conditions are different, the foundation seepage flowing through the sandy material and exiting into the toe ditch in these areas is still of concern as no filtered exit exists. Tailwater measurements in this area also indicate that higher lake stages would be necessary to initiate the internal erosion.

Although it may seem that HHD is simply a 143 mile long mound of soil, the dynamics of water movement, tailwater control, and varying geologic conditions creates a challenging environment for predicting and acting on locations exhibiting signs of poor performance. Even though the system may be challenging and complex, the HHD Instrumentation Program has been implemented and managed to appropriately monitor system wide performance. With the greatest concentration of piezometers located in areas with poor performance history, the chances for identifying potential issues are increased. In addition, now that piezometers are included in locations that were previously unmonitored, the chances of identifying developing issues or deteriorating performance have been substantially increased. The addition of 28 tailwater staff gauges will continue to increase our understanding of the dam performance. The initial assessment was made possible at these piezometer lines. With time, the continual collection of tailwater measurements will allow more concise assessment of dam performance at these piezometer lines and as they become better understood, the assessments will be improved and expanded. Addition of this information also appears to have changed historic understanding of performance at several piezometer lines. Therefore, until a significant record of site specific tailwater responses is obtained, analysis and understanding of performance may be limited.

Since HHD is classified as a DSAC 1 dam, all reaches of HHD require appropriate consideration for instrumentation, as per the HHD Instrumentation Program, and should be monitored and inspected thoroughly in accordance with the HHD Emergency Action Plan. Until such conditions occur that warrant adding or decommissioning additional instruments above and beyond what is documented herein, it is recommended that the HHD Instrumentation Program continue to operate as currently planned. Discussed below are recommendations, maintenance, and action items deemed necessary to meet all goals of the HHD Instrumentation Program.

11.1. Piezometer Maintenance, Replacement and Action Items

To ensure the HHD instrumentation stays in proper operating order, periodic maintenance is required. Listed below are required actions necessary to maintain the integrity of the piezometer data collected. The piezometer maintenance and action items listed herein are issues identified during field inspection of each piezometer. Field related inspection issues are also documented in the HHD Annual Inspection Report that is published at the same time as this report. Should personnel have questions or concerns regarding maintenance and action items, the appropriate contacts are provided at the beginning of this report under the Executive Summary, as well as the items which would be considered highest priority.

Inspection Findings:

- The majority of DSMS PZs felt as if sediment was accumulating in the bottom of the piezometers. Many depth soundings of the wells returned what appeared to be bentonite on the sounding tip. Recommend flushing of all DSMS PZs.
- R1-1 (PZ-HHDR1-4C1) Well pad is above adjacent ground surface, making pad susceptible to being hit by mowers. Recommend bringing in fill to raise adjacent ground surface.
- R1-3 (PZ-HHDR1-7C2) Well pad is above adjacent ground surface, making pad susceptible to being hit by mowers. Recommend bringing in fill to raise adjacent ground surface.
- R3-4 (PZ-R3-E-C1 and PZ-R3-E-C2) well casing is broken at the surface. The surrounding grading is approximately 6 inches higher than the top of the piezometer well cover.
- R1-6 (PZ-ER1-PAC-C1 and PZ-ER1-PAC-C2) Well pad is above adjacent ground surface, making pad susceptible to being hit by mowers. Recommend bringing in fill to raise adjacent ground surface.
- R1-16 (HHD10-R1A-PZA1-1428 and HHD10-R1A-PZA3-1428) – New well pad has been crushed by construction traffic and HHD10-R1A-PZA3-1428 riser has been broken just below ground surface. Recommend well pads be replaced, riser needs to be repaired, and the well needs to be flushed with clean water.
- R1-17 (HHD10-R1A-PZC1-1413) concrete pad is cracked and broken. The piezometer observed to be slightly loose.
- R2-3 PZ-R2-E-A: ground surface around the piezometer casing is approximately 6 inches higher than top cover plate.
- R2-4-TW require clearing around the staff gauge.
- R2-4 (PZ-ER3E-B and PZ-ER3E-B2) plates are missing
- R3-6 (PZ-R3-F-A1 and PZ-R3-F-A2) piezometer riser caps are too close to the well cover which causing the cap to be riding on the cover. This may cause damage to the top of the piezometer.
- R4-2 (HHD12-R4-PZ-2B, HHD12-R4-PZ-2B1 and HHD12-R4-PZ-2B2) plates were missing.
- R4-3 (HHD12-R4-PZ-4C1) some sediments were observed at the bottom of the piezometer.

- R5-1 (HHD12-R5-PZ-7C) the well cover and plate were covered with soil and weed. Cleaning of the piezometer is needed.
- R5-1 (HHD12-R5-PZ-7C1) – Riser pipe is very close to lid making it susceptible to breaking. Recommend modifying riser and adjust riser elevation appropriately.
- R6-1 (HHD12-R6-PZ-4C) – Riser pipe is very close to lid making it susceptible to breaking. Recommend modifying riser and adjust riser elevation appropriately.
- R6-1 (HHD12-R6-PZ-4C1) – There is sediment around the riser pipe. Recommend sediment be removed.
- R6-2 (HHD12-R6-PZ-7C and HHD12-R6-PZ-7C1) – Riser plug cap is touching lid making it susceptible to breaking. Recommend modifying riser and adjust riser elevation appropriately.
- R6-3 (HHD12-R6-PZ-10B2) has been dry since installation; however, it is interesting to note that readings are consistently obtained that show readings several feet above the lake. This piezometer either has sediment in it or is reading a perched water table. Records show that this well was never developed; therefore, a combination of the two (perched water and sediment) is the likely cause of the high readings. Recommend this piezometer be flushed with clean water.
- R6-4 (HHD12-R6-PZ-12B) Piezometer riser is damaged close to the ground surface.
- R6-4 (HHD12-R6-PZ-12B1 and HHD12-R6-PZ-12B2) plates were missing.
- R6-4 (HHD12-R6-PZ-12C and HHD12-R6-PZ-12C1) the well covers were covered with soil and weed. Cleaning of the piezometer is needed.
- R7-1 (PZ-R7-A-C2) – Riser pipe spins in ground. Suspect riser is broken just beneath ground surface. Recommend removing soil around riser until the broken riser can be seen, repair with coupling and replace soil around riser. Take before and after depth measurements to ensure the repaired elevation is the same as the existing elevation.
- R7-3 (HHD12-R7-PZ-2B1) some sediments were observed at the bottom of the piezometer.

During construction of the Reach 1 cutoff wall, several piezometers were removed or destroyed by the cutoff wall and culvert replacement contractors; these piezometers have been documented herein and it is recommended that these be replaced in order to properly monitor the performance of the cutoff wall. Table 11 below summarizes the piezometers recommended to be replaced.

Table 10: Replacement Piezometers

PZ Line	Location	OLD PZ Name	Depth of PZ (ft)	Geologic Unit	Comments/Justification	Priority
R1-9	U/S Crest	PZ-ER1352-3B1	37.7	Fill/Above Organics	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-9	U/S Crest	PZ-ER1352-3B2	44.5	Limestone/ Sand	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-11	U/S Crest	PZ-ER1352-5B1	36.0	Fill/Above Organics	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-11	U/S Crest	PZ-ER1352-5B2	44.0	Limestone/ Sand	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-12	U/S Crest	PZ-R1-25-B1	50.0	Limestone/ Sand	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-12	U/S Crest	PZ-R1-25-B2	37.0	Fill/Above Organics	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Low
R1-11A	D/S Crest	URS-05-1B	79.2	Limestone/ Sand	Removed during cutoff wall installation. Recommended to assess performance of cutoff wall	Medium
R1-12-A	U/S Crest	URS-05-2B	36.1	Fill/Above Organics	Recommended to assess pressures upstream of cutoff wall	Low
R1-15	U/S Crest	MW-HHDR1A06-6	56	Limestone/ Sand	Recommended to assess pressures upstream of cutoff wall and drain at C-16	Medium
R1-15	U/S Crest	MW-HHDR1A06-7	31	Limestone/ Sand	Recommended to assess pressures upstream of cutoff wall and drain at C-16	Medium
R1-15	Landside Toe	PZ-HHDR1A-1C	28	Limestone/ Sand	Destroyed by C-16 construction activity. Recommended to assess downstream performance of CW and C-16 after replacement	Medium
R1-13A	Landside Toe	PZ-HHD-R1A-2C	23	Limestone	Destroyed by mowers. Reinstall. Recommended for monitoring the performance of the cutoff wall	Low
R1-15	Landside Toe	PZ-HHD-R1A-1D	28	Limestone/ Sand	Transducer is stuck in the well and can't be retrieved to apply appropriate settings. Suspect casing has separated and wedged the transducer in the well.	Medium

11.2. Installing New Piezometers

In areas outside of Reach 1, several piezometer lines lack piezometers at the downstream toe, the most critical location for assessing gradients and initiation of piping. To fully understand the behavior of the foundation at these locations, it is recommended that piezometers be installed at these locations identified; however, none of the requested piezometers have a “high” priority. Table 11 or below summarizes the piezometers recommended to be added.

Table 11: New Piezometers

PZ Line	Location	Depth of PZ (ft)	Geologic Unit	Comments/Justification	Priority/ Completion Note
R1-1	U/S Crest	24	fill	Recommended to assess performance of cutoff wall.	Low
R1-3	U/S Crest	24	Fill/Above organics	Recommended to assess performance of cutoff wall.	Low
R1-7	U/S Crest	24	Fill/Above organics	Recommended to assess performance of cutoff wall.	Low
R1-11A	Landside Toe	28	Limestone/ Sand	Recommended to assess pressures at downstream toe of embankment to aid in assessing performance of cutoff wall	Low
R1-13A	U/S Crest	30	Limestone	Recommended to assess performance of cutoff wall.	Low
R7-2	Landside Toe	13	Limestone/ Sand	Recommended to assess pressures at downstream toe of embankment	Low
R3-5	Landside Toe	15.0	Limestone/ Sand	Recommended to assess pressures at downstream toe of embankment	Complete. 1st readings 9/2016
R3-6	Landside Toe	10.0	Limestone/ Sand, just behind	Recommended to monitor longterm performance of drain	Complete. 1st readings 9/2017
R3-7	Landside Toe	20.0	Limestone/ Sand	Recommended to assess pressures at downstream toe of embankment and longterm performance of drain	Complete. 1st readings 9/2018

11.3. Automating Data Collection

In an effort to collect more frequent data and reduce the number of manually read piezometers, automating the data acquisition at certain locations should be considered. One way to “automate” any chosen piezometer would be to place an absolute pressure sensor (see Figure 11) within the open standpipe. This type of sensor has a datalogger built into the sensor body and is not at risk to the elements – as are many aboveground dataloggers that cannot tolerate any appreciable amount of water intrusion.

A data cable may be attached to the top end of the sensor body and the sensor is simply lowered down the standpipe to the desired elevation. Prior to installation, the sensor would be programmed to take readings at the frequency of choice, and data retrieval would occur every three months, or as often as needed. Transferring data from the sensor is accomplished by attaching the upper end of the data cable to a laptop or handheld data recorder. By choosing a sensor such as the one represented below, retrofitting of the well pads, standpipes, and well covers is not required. Well accessories such as those shown in Figure 12 are available to suspend the instrument at the desired elevation.

Figure 11: In-Situ Inc 300 Level Troll

Figure 12: Well Accessories

Automation of piezometers at HHD will allow for monitoring pressures during rapid loading events, such as wind setup during high pools, increase our understanding of changes in piezometric response with respect to changes in pool, and at some locations, better understanding of perched water conditions observed within the embankment.

Considering the benefits, the following distribution of automated instruments around Lake Okeechobee is recommended:

- 2 Piezometer Lines in Reach 1
  - To monitor two unique sections where cutoff wall is installed
- 1 Piezometer Lines in Reach 3
  - To monitor a critical area
- 2 Piezometer Lines in Reach 2
  - To monitor two unique critical areas (i.e. a piezometer line with a shallow ditch downstream and a piezometer line with a borrow/drainage canal downstream
- 2 additional Piezometer Lines
  - One in the north quadrant of Lake Okeechobee and one in the west quadrant of Lake Okeechobee

With the proposed layout, the North, South, East, and West quadrants of Lake Okeechobee would be monitored with these automated systems and would be capable of providing a finer data set that would assist in understanding changes piezometric response. Collectively, Reaches 1, 2, and 3 would have more automated instruments as the geology is inherently more complex, cutoff wall has been recently installed (Reach 1), and they contain the greatest concentration of areas that have experienced seepage related issues during high water events. The proposed layout would require the purchase of approximately 35 instruments.

11.4. Estimated Costs

The following cost estimate assumes using USACE labor and capabilities, with the exception of name plate engravings which will be contracted out. Expected costs below include labor, equipment, and travel costs, where necessary.

Table 12: Estimated Costs for Piezometer Maintenance and Action Items

Maintenance Action Item	Notes	Rough Cost	Funding Responsibility	Capable Office
Section 11.1 Piezometer Maintenance, Replacement and Action Items	Miscellaneous field repairs, assume travel, time and materials	$10,000	Operations	SAJ-EN-G
Replace Destroyed Piezometers from CW Construction	13 PZs, approximately 530 LF of drilling	$110,000	Project Management/ CG Funds	SAS, NAB, or SAM
Install New Piezometers	6 PZs, 145 LF of Drilling	$60,000	Operations	SAS, NAB, or SAM
Automation	35 instruments. Each costing approximately $1,500 + Labor for field placement and configuration	$82,000	Operations	SAJ-EN-G
Clean/Flush DSMS PZs (Reaches 4, 5, 6, 7 and 8)	56 piezometers	$80,000	Operations	SAS, NAB, or SAM

APPENDIX A: GLOSSARY

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Artesian Pressure – Water levels in the piezometer are higher than the groundwater table.

ASTM #10 Stone – Fine aggregate from ASTM D488 Sizes of Aggregate for Road and Bridge Construction, Table 1. Standard Sizes of Processed Aggregate. Nominal size of aggregate ranges from the No. 4 sieve to quarry screenings. Specified Gradation: 85 to 100 percent passing No.4 and 10 to 30 percent passing No. 100. This material was used to construct a seepage berm at various locations along the embankment during the 1995 High Water Event.

Blocked exit – Relatively impervious (not free draining) zone at the downstream toe of the embankment which holds the phreatic surface high within the embankment.

Blown toe or ditch – The toe of the embankment or toe ditch bottom at the toe has heaved and or hydro-fractured and the piezometers indicate a direct connection between the phreatic surface above the confining layer and the piezometric surface below.

Clayey upstream toe / blocked entrance – Relatively impervious zone at the upstream toe of the embankment which holds the phreatic surface low within the embankment.

Confining Layer – The calcareous silt / clay layer below the peat present along most of the southern and eastern portion of the embankment. The significance of this layer is that it acts as an aquaclude and separates the upper phreatic surface from the lower piezometric surface.

Cutoff Wall – Refers to the cutoff wall constructed at HHD. Cutoff wall at HHD is considered a 'hanging wall' as it does not tie into a confining unit. The cutoff wall is approximately 2 feet thick and consists of Soil-Cement-Bentonite (SCB) vertical panels that were installed through the crest of the embankment. Tip elevations of the cutoff wall vary from -15 to -40 feet NAVD88.

Ditch drawdown – Water in ditch can be drawn down by pumps or other means outside of COE control.

Embankment – Any fill material placed above the natural ground surface

Filtercake – Filtercake is the deposit of fines on the upstream borrow canal side slopes and bottom forming a relatively impervious layer. Filtercake isolates piezometers deep in the limestone from lake by dampening response.

First Fill – Any lake stages greater than lake stages previously recorded. Lake Stages are considered to "reset" after remediation efforts are compete. For example, after installation of the cutoff wall, any lake staged greater than the lake stage during the time of construction is considered a first fill.

Foundation – Top of natural peat formation and below embankment fill.

Gravel layers in embankment – Presence of gravel sized particles (or larger) in centerline ("B") boring of shell or limestone deposited in a relatively homogenous layer by either hydraulic fill or dragline casting. Generally associated with large deposits of shell or limestone in the borrow canal. These layers form a "short circuit" for both flow and head.

Loose zones in embankment – Presence of low SPT values (N generally 0 – 3) in the embankment in centerline ("B") boring for 2 or more consecutive runs (more than three feet).

LOST – Refers to Lake Okeechobee Scenic Trail. The construction of this trail began is 2004 and involved, among other features, an asphalt–paved lane atop the crest of the HHD. During clearing and paving operations, numerous piezometers were lost when they were covered over or suffered damage to the PVC casings.

Lower Piezometers – Piezometers whose tip is set below the confining layer.

LS / Peat problem – There is clear evidence the section has the Lake Flirt Marl limestone formation under the peat layer. For the purposes of this report this formation will be designated as ls-p.

Natural ground surface – Top of deposition of natural material, usually identified as the top of natural peat formation

Pervious upstream toe – Presence of gravel noted in borings upstream of centerline.

Piping – Internal loss of embankment or foundation material caused by seepage when the hydraulic gradient exceeds a critical threshold.

Quick toe – Quick condition caused by artesian pressure

Sinkholes – A depression in the crest or slope resulting from the loss of material underlying the surface. In this case the crest has a crust about –one to 2 feet thick resulting from the deposition of calcareous road base material which bridges the void until it Reaches sufficient size that the crust collapses. In many cases the only visible manifestation is a depression in the crest such as a rut from vehicle traffic. Some of these depressions were probed and a void or very loose material was encountered.

Soft toe / springs – Saturated embankment toe due to blocked exit. Generally associated with the presence of low SPT values (N generally 0 - 3) in the toe ("C") boring for 2 or more consecutive runs (more than three feet). Springs are the visible manifestation of the phreatic surface exiting the embankment.

Soft zones in foundation – Presence of low SPT values (N generally 0 - 3) in the foundation material in centerline ("B") boring for 2 or more consecutive runs (more than three feet).

Spillover @ Lake = 18.5 – Situation where the piezometers read differently (higher) due to overtopping of a blocked entrance condition. Since there have not been any sustained lake elevations higher than elevation 18.5 (approximately), this condition can not be confirmed at higher elevations.

Tailwater – Surface water on the land side of the embankment.

Upper Piezometers – Piezometers whose tip is set above the confining layer.

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R2-1	PZ-R2-A-A	645895.1	902835.0	21.42	1.36	20.1	10.06	9.65	10.4	11.8	1 1/4	5		08/10/99	
R2-1	PZ-R2-A-B1	645860.8	902744.2	39.32	1.36	38.0	39.96	39.76	-1.8	-0.4	1 1/4	5		08/10/99	
R2-1	PZ-R2-A-B2	645853.9	902746.2	39.35	1.36	38.0	30.06	30.00	8.0	9.4	1 1/4	5		08/27/99	
R2-1	PZ-R2-A-C	645850.9	902642.8	13.26	1.36	11.9	9.66	9.47	2.4	3.8	1 1/4	5		08/27/99	
R2-2	PZ-R2-B-A	669359.5	892316.4	23.45	1.35	22.1	9.75	9.74	12.4	13.7	1 1/4	5		08/27/99	
R2-2	PZ-R2-B-B1	669317.7	892261.1	34.12	1.35	32.8	40.15	40.08	-7.3	-6.0	1 1/4	5		08/27/99	
R2-2	PZ-R2-B-B2	669309.1	892268.2	34.11	1.35	32.8	24.35	24.55	8.2	9.6	1 1/4	5		08/27/99	
R2-2	R2-2-TW	669263.8	892086.1	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R2-3	PZ-R2-E-A	703193.9	871084.4	18.39	1.39	17.0	8.99	8.81	8.2	9.6	1 1/4	5		08/27/99	
R2-3	PZ-R2-E-B1	703140.8	870956.6	38.86	1.39	37.5	40.12	39.88	-2.4	-1.0	1 1/4	5		08/27/99	
R2-3	PZ-R2-E-B2	703132.9	870961.0	38.71	1.39	37.3	25.06	24.83	12.5	13.9	1 1/4	5		08/27/99	
R2-3	R2-3-TW	703071.5	870853.1	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R2-4	PZ-R2-F-A	716568.3	859692.0	18.18	1.40	16.8	29.98	29.68	-12.9	-11.5	1 1/4	5		08/26/99	
R2-4	PZ-R2-F-B1	716586.6	859551.6	40.06	1.40	38.7	27.20	27.97	10.7	12.1	1 1/4	5		09/15/95	
R2-4	PZ-R2-F-B2	716586.8	859551.7	40.04	1.40	38.6	39.30	38.73	-0.1	1.3	1 1/4	5		09/15/95	
R2-4	PZ-R2-FC	716566.6	859451.3	12.27	1.40	10.9	14.50	13.70	-2.8	-1.4	1 1/4	5		09/14/95	
R2-4	R2-4-TW	716559.3	859376.0	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-1	PZ-ER3D-B	723632.1	859701.4	40.96	1.40	39.6	27.60	27.49	12.1	13.5	1 1/4	5		02/13/95	
R3-1	PZ-R3-D-A1	723637.8	859832.1	21.24	1.40	19.8	35.10	34.87	-15.0	-13.6	1 1/4	5		08/27/99	
R3-1	PZ-R3-D-A2	723644.0	859832.6	21.03	1.40	19.6	14.60	14.54	5.1	6.5	1 1/4	5		08/27/99	
R3-1	PZ-R3-D-C1	723630.0	859606.9	14.07	1.40	12.7	30.20	29.98	-17.3	-15.9	1 1/4	5		08/27/99	
R3-1	PZ-R3-D-C2	723624.9	859605.6	14.10	1.40	12.7	10.00	9.82	2.9	4.3	1 1/4	5		08/27/99	
R3-1	R3-1-TW	723631.0	859575.7	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-2	PZ-MRR3-SH-B1	728768.9	859013.2	41.77	1.41	40.4	21.30	21.13	19.2	20.6	1 1/4	5		10/26/95	
R3-2	PZ-MRR3-SH-B2	728768.9	859013.4	41.79	1.41	40.4	40.20	39.38	1.0	2.4	1 1/4	5		10/26/95	
R3-2	PZ-R3-SH-B1A	728781.3	859009.2	41.77	1.41	40.4	30.10	29.74	10.6	12.0	1 1/4	4		08/27/99	
R3-2	PZ-R3-SH-C1	728728.1	858946.0	19.56	1.41	18.2	24.80	24.33	-6.2	-4.8	1 1/4	4		08/27/99	
R3-2	PZ-R3-SH-C2	728733.0	858944.5	19.61	1.41	18.2	9.80	9.66	8.5	10.0	1 1/4	4		08/27/99	
R3-2	R3-2-TW	728714.5	858913.8	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-3	PZ-R3-C-A1	733041.0	856710.6	23.54	1.41	22.1	24.80	24.71	-2.6	-1.2	1 1/4	5		08/27/99	
R3-3	PZ-R3-C-A2	733047.7	856707.7	23.59	1.41	22.2	9.50	9.25	12.9	14.3	1 1/4	5		08/27/99	
R3-3	PZ-R3-C-B	732982.0	856620.1	42.06	1.41	40.7	30.00	29.62	11.0	12.4	1 1/4	5		08/27/99	
R3-3	PZ-R3-C-C1	732922.5	856552.3	16.39	1.41	15.0	21.80	21.55	-6.6	-5.2	1 1/4	5		08/27/99	
R3-3	PZ-R3-C-C2	732914.0	856557.5	16.37	1.41	15.0	10.00	9.80	5.2	6.6	1 1/4	5		08/27/99	
R3-3	R3-3-TW	732905.2	856531.4	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R3-4	**PZ-ER3E-B**	736572.1	854457.4	**42.12**	1.41	*40.7*	45.00	44.69	*-4.0*	**-2.6**	1 1/4	5.5		12/04/95	
R3-4	**PZ-R3-E-A1**	736636.1	854590.7	**20.60**	1.41	*19.2*	20.10	19.94	*-0.8*	**0.7**	1 1/4	5		08/27/99	
R3-4	**PZ-R3-E-A2**	736631.3	854595.0	**20.55**	1.41	*19.1*	9.90	9.86	*9.3*	**10.7**	1 1/4	5		08/27/99	
R3-4	**PZ-R3-E-B2**	736574.8	854452.2	**42.04**	1.41	*40.6*	29.60	29.38	*11.3*	**12.7**	1 1/4	5		08/27/99	
R3-4	**PZ-R3-E-C1**	736528.8	854372.0	**18.05**	1.41	*16.6*	20.00	19.84	*-3.2*	**-1.8**	1 1/4	5		08/27/99	
R3-4	**PZ-R3-E-C2**	736524.0	854375.3	**18.00**	1.41	*16.6*	9.80	9.63	*7.0*	**8.4**	1 1/4	5		08/27/99	
R3-4	**R3-4-TW**	736524.6	854364.3	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-5	**PZ-R3-B-B1**	741642.9	853328.4	**42.26**	1.41	*40.9*	39.60	39.46	*1.4*	**2.8**	1 1/4	5		08/27/99	
R3-5	**PZ-R3-B-B2**	741634.8	853329.4	**42.27**	1.41	*40.9*	29.80	29.61	*11.3*	**12.7**	1 1/4	5		08/27/99	
R3-5	**PZ-HHD16-R3-3C**	741632.0	853239.3	**14.76**	1.41	*13.4*	11.98	11.98	*1.4*	**2.8**	2	5		08/15/16	
R3-5	**R3-5-TW**	741627.2	853199.1	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-6	**PZ-ER3P4-B1**	746047.8	856518.6	**42.25**	1.41	*40.8*	32.00	31.65	*9.2*	**10.6**	1 1/4	5.5		04/18/96	
R3-6	**PZ-ER3P4-B2**	746047.8	856518.8	**42.17**	1.41	*40.8*	41.00	40.61	*0.1*	**1.6**	1 1/4	5.5		04/18/96	
R3-6	**PZ-ER3P4-C**	746143.6	856450.1	**11.48**	1.41	*10.1*	16.21	15.50	*-5.4*	**-4.0**	1 1/4	5.5		04/04/96	
R3-6	**PZ-R3-F-A1**	745939.2	856600.1	**18.22**	1.41	*16.8*	29.50	29.18	*-12.4*	**-11.0**	2	5	20/30 Silica	8/27/1999 & 2/4/2000	
R3-6	**PZ-R3-F-A2**	745935.4	856593.5	**18.23**	1.41	*16.8*	10.07	10.12	*6.7*	**8.1**	2	5	20/30 Silica	8/27/1999 & 2/2/2000	
R3-6	**PZ-HHD16-R3-2C**	746130.3	856462.4	**13.20**	1.41	*11.8*	9.06	9.06	*2.7*	**4.1**	2	5		08/15/16	
R3-6	**R3-6-TW**	746150.9	856423.6	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R3-7	**PZ-R3-G-A1**	747358.5	858536.4	**18.62**	1.41	*17.2*	24.50	24.21	*-7.0*	**-5.6**	2	5	20/30 Silica	8/27/1999 & 2/4/2000	
R3-7	**PZ-R3-G-A2**	747363.3	858527.5	**20.24**	1.41	*18.8*	10.50	10.23	*8.6*	**10.0**	1 1/4	5		08/27/99	
R3-7	**PZ-R3-G-B1**	747442.9	858448.0	**43.40**	1.41	*42.0*	50.70	50.12	*-8.1*	**-6.7**	1 1/4	5		08/27/99	
R3-7	**PZ-R3-G-B2**	747449.4	858458.4	**43.52**	1.41	*42.1*	29.80	29.36	*12.8*	**14.2**	1 1/4	5		08/27/99	
R3-7	**PZ-HHD16-R3-1C**	747532.7	858396.7	**13.17**	1.41	*11.8*	12.02	12.02	*-0.3*	**1.2**	2	5		08/15/16	
R3-7	**R3-7-TW**	747547.9	858379.4	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-1	**PZ-HHDR1-4B1**	754245.1	871363.4	**39.75**	1.29	*38.5*	45.00	43.87	*-5.4*	**-4.1**	1 1/4	5		07/28/95	
R1-1	**PZ-HHDR1-4B2**	754238.5	871354.6	**39.75**	1.29	*38.5*	36.10	35.03	*3.4*	**4.7**	1 1/4	5		07/31/95	
R1-1	**PZ-HHDR1-4C1**	754343.0	871284.7	**10.75**	1.29	*9.5*	17.60	15.92	*-6.5*	**-5.2**	1 1/4	5		08/01/95	
R1-1	**PZ-HHDR1-4C2**	754334.2	871275.0	**11.01**	1.29	*9.7*	8.00	7.45	*2.3*	**3.6**	1 1/4	5		08/10/95	
R1-1	**R1-1-TW**	754355.8	871270.8	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-2	**PZ-HHDR1-6B1**	757670.3	875962.5	**38.17**	1.29	*36.9*	56.70	54.83	*-18.0*	**-16.7**	1 1/4	5		07/25/95	
R1-2	**PZ-HHDR1-6B2**	757663.3	875953.0	**37.74**	1.29	*36.5*	45.00	43.79	*-7.3*	**-6.1**	1 1/4	5		07/19/95	
R1-2	**PZ-HHDR1-6C1**	757786.4	875887.2	**11.15**	1.29	*9.9*	29.50	30.50	*-20.6*	**-19.4**	1 1/4	5		07/26/95	
R1-2	**PZ-HHDR1-6C2**	757780.3	875878.5	**11.12**	1.29	*9.8*	21.00	22.30	*-12.5*	**-11.2**	1 1/4	5		07/27/95	
R1-3	**PZ-HHDR1-7B**	758655.6	881431.4	**37.49**	1.27	*36.2*	55.80	54.18	*-18.0*	**-16.7**	1 1/4	5		12/06/94	
R1-3	**PZ-HHDR1-7C2**	758750.8	881470.1	**12.42**	1.27	*11.2*	27.00	26.81	*-15.7*	**-14.4**	2	5	20/30 Silica	2/7/1995 & 2/2/2000	
R1-3	**R1-3-TW**	758770.5	881475.5	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R1-4	P1	756711.9	886502.4	37.56	1.27	36.3	36.80	36.02	0.3	1.5	1 1/4	5		02/23/90	
R1-4	P2	756712.2	886502.4	37.62	1.27	36.4	55.60	55.45	-19.1	-17.8	1 1/4	5		02/23/90	
R1-4	P3	756712.7	886498.7	37.57	1.27	36.3	21.20	21.53	14.8	16.0	2	5		02/23/90	
R1-4	P4	756823.2	886543.2	12.63	1.27	11.4	25.60	27.31	-16.0	-14.7	1 1/4	4		02/27/90	
R1-4	P5	756823.4	886542.9	12.56	1.27	11.3	16.10	17.69	-6.4	-5.1	1 1/4	4		02/27/90	
R1-4	P6	756822.3	886546.3	12.74	1.27	11.5	9.50	11.58	-0.1	1.2	2	5		02/27/90	
R1-4	P7	756881.5	886657.0	13.8	1.27	12.5	24.60	26.75	-14.2	-13.0	1 1/4	4		03/02/90	
R1-4	P8	756881.3	886565.9	13.9	1.27	12.6	12.60	15.03	-2.5	-1.2	1 1/4	4		03/02/90	
R1-4	P9	756881.9	886564.2	13.8	1.27	12.5	18.50	20.84	-8.3	-7.1	2	5		03/02/90	
R1-4	R1-4-TW	756872.9	886539.7	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-5	PZ-HHDR1-10B1	755487.1	889844.0	37.82	1.27	36.6	50.00	47.44	-10.9	-9.6	1 1/4	5.5		01/01/95	
R1-5	PZ-HHDR1-10B2	755484.8	889850.2	37.78	1.27	36.5	37.00	35.78	0.7	2.0	1 1/4	5.5		01/01/95	
R1-5	PZ-HHDR1-10C1	755567.0	889869.8	20.26	1.27	19.0	32.90	29.64	-10.7	-9.4	1 1/4	5.5		01/01/95	
R1-5	PZ-HHDR1-10C2	755568.5	889867.0	20.38	1.27	19.1	20.00	19.67	-0.6	0.7	1 1/4	5.5		01/01/95	
R1-5	R1-5-TW	755597.8	889878.8	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-6	PZ-ER1-PAC-B1	755286.9	890426.9	37.81	1.27	36.5	38.10	37.89	-1.4	-0.1	1 1/4	2		05/16/96	
R1-6	PZ-ER1-PAC-B2	755286.9	890426.8	37.78	1.27	36.5	49.50	46.62	-10.1	-8.8	1 1/4	2		05/16/96	
R1-6	PZ-ER1-PAC-C1	755371.1	890447.5	19.77	1.27	18.5	32.50	31.92	-13.4	-12.2	1 1/4	2		05/16/96	
R1-6	PZ-ER1-PAC-C2	755371.3	890447.6	19.77	1.27	18.5	18.50	18.03	0.5	1.7	1 1/4	2		05/16/96	
R1-6	R1-6-TW	755402.5	890454.9	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-7	PZ-ERIM-B1	769357.7	908900.3	39.02	1.24	37.8	34.13	33.61	4.2	5.4	1 1/4	5		04/04/96	
R1-7	PZ-ERIM-B2	769357.8	908900.5	39.03	1.24	37.8	54.63	53.20	-15.4	-14.2	1 1/4	2		04/04/96	
R1-7	PZ-ERIM-C	769427.5	908829.0	16.75	1.24	15.5	28.20	28.54	-13.0	-11.8	1 1/4	2		04/04/96	
R1-7	R1-7-TW	769402.8	908777.0	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-8	PZ-GPPS-2	771349.9	911652.6	16.47	1.24	15.2	30.33	28.95	-13.7	-12.5	1 1/4	5		02/14/95	
R1-8	PZ-R1-S42-B1	771270.8	911696.6	38.48	1.24	37.2	45.50	45.15	-7.9	-6.7	1 1/4	5		08/14/95	
R1-8	PZ-R1-S42-B2	771262.7	911676.1	38.48	1.24	37.2	29.00	29.53	7.7	9.0	1 1/4	4		08/11/95	
R1-8	R1-8-TW	771377.8	911619.8	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-9	PZ-ER1352-3B1	776328.0	920380.7	38.34	1.24	37.1	40.00	39.98	-2.9	-1.6	1 1/4	5	20/30 Silica	4/25/1996 8	
R1-9	PZ-ER1352-3B2	776332.1	920386.3	38.50	1.24	37.3	49.30	48.76	-11.5	-10.3	1 1/4	5	20/30 Silica	4/25/1996 8	
R1-9	PZ-ER1352-3C	776390.5	920339.6	19.19	1.24	18.0	26.00	25.05	-7.1	-5.9	1 1/4	2		04/25/96	
R1-9	R1-9-TW	776425.7	920328.0	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-11	PZ-ER1353-4C	777073.0	921328.5	17.55	1.24	16.3	24.33	24.09	-7.8	-6.5	1 1/4	2		04/11/96	
R1-11	PZ-ER1352-5C1	777368.2	921771.1	17.35	1.24	16.1	24.33	25.09	-9.0	-7.7	1 1/4	2		05/09/96	
R1-11	PZ-ER1352-5C2	777368.3	921771.3	17.31	1.24	16.1	17.03	17.37	-1.3	-0.1	1 1/4	2		05/09/96	
R1-11	R1-11-TW	777381.5	921759.6	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R1-11A	URS-05-1C	777790.7	922411.7	14.73	1.24	13.5	10.10	10.11	3.4	4.6	2	5.5		10/13/05	
R1-11A	R1-11A-TW	777813.4	922398.0	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-12	PZ-R1-25-C1	779342.4	924973.2	16.24	1.24	15.0	28.00	27.50	-12.5	-11.3	1 1/4	5		08/23/95	
R1-12	PZ-R1-25-C2	779348.8	924983.7	16.31	1.24	15.1	17.00	16.27	-1.2	0.0	1 1/4	5		08/23/95	
R1-12	R1-12-TW	779357.8	924969.4	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-12A	URS-05-2C	782084.8	930298.5	18.57	1.17	17.4	60.70	59.23	-41.8	-40.7	1 1/4	5.5		10/12/05	
R1-12A	R1-12A-TW	782115.1	930301.1	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-13	PZ-C10A-1	781935.4	939136.0	32.23	1.37	30.86	42.50	42.46	-11.6	-10.2	1 1/4	3	Silica Sanc	04/20/98	
R1-13	PZ-C10A-2	781934.9	939140.1	32.20	1.37	30.83	33.35	29.91	0.9	2.3	1 1/4	3	Silica Sanc	04/20/98	
R1-13	PZ-C10A-3	781926.8	939276.1	33.68	1.37	32.31	4.45	8.50	23.8	25.2	1 1/4	2	Silica Sanc	04/20/98	
R1-13	PZ-C10A-4	781926.4	939282.7	34.12	1.37	32.75	24.10	25.45	7.3	8.7	1 1/4	3	Gravel	04/20/98	
R1-13	PZ-C10A-5	781926.5	939287.6	34.12	1.37	32.75	37.75	42.40	-9.7	-8.3	1 1/4	3	Silica Sanc	08/27/02	
R1-13A	HHDR1A-PZ-2C1	782058.6	940956.5	15.86	1.37	14.5	45.45	44.80	-30.3	-28.9	2	10		08/17/09	
R1-13A	HHDR1A-PZ-2C2	782059.2	940961.9	15.77	1.37	14.4	93.70	#N/A	#N/A	#N/A	2	10		11/17/09	
R1-13A	HHDR1A-PZ-2C3	782058.3	940956.6	15.78	1.37	14.4	118.40	#N/A	#N/A	#N/A	2	10		08/17/09	
R1-13A	PZ-HHDR1A-2D	782403.5	940869.3	19.67	1.37	18.3	26.50	#N/A	#N/A	#N/A	2	10		08/17/09	
R1-13A	R1-13A-TW	782080.8	940949.8	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-14	PZ-R1-31-B1	782104.3	942189.7	36.40	1.37	35.0	42.00	44.63	-9.6	-8.2	1 1/4	5		09/26/95	
R1-14	PZ-R1-31-C	782177.1	942151.3	17.66	1.37	16.3	23.50	23.36	-7.1	-5.7	1 1/4	5		09/26/95	
R1-14	R1-14-TW	782199.3	942149.7	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R1-16	HHD10-R1A-PZA1-1428	781978.2	959094.4	36.59	1.16	35.4	34.25	34.69	0.7	1.9	2	5		10/26/10	
R1-16	HHD10-R1A-PZA2-1428	781979.5	959088.9	36.58	1.16	35.4	42.35	42.18	-6.8	-5.6	2	5		10/26/10	
R1-16	HHD10-R1A-PZA3-1428	781978.4	959094.4	36.61	1.16	35.5	65.30	65.15	-29.7	-28.5	2	5		10/26/10	
R1-16	HHD10-R1A-PZB0-1428	781996.0	959093.1	36.40	1.16	35.2	26.30	26.19	9.1	10.2	2	5		10/26/10	
R1-16	HHD10-R1A-PZB1-1428	781994.2	959098.0	36.34	1.16	35.2	35.25	35.20	0.0	1.1	2	5		10/26/10	
R1-16	HHD10-R1A-PZB2-1428	781995.9	959093.4	36.37	1.16	35.2	42.25	42.11	-6.9	-5.7	2	5		10/22/10	
R1-16	HHD10-R1A-PZB3-1428	781994.5	959098.2	36.36	1.16	35.2	66.05	65.72	-30.5	-29.4	2	5		10/20/10	
R1-16	HHD10-R1A-PZC1-1428	782073.9	959116.9	24.12	1.16	23.0	14.25	14.15	8.8	10.0	2	5		10/27/10	
R1-16	HHD10-R1A-PZC2-1428	782076.1	959111.9	23.99	1.16	22.8	26.90	26.80	-4.0	-2.8	2	5		10/27/10	
R1-16	HHD10-R1A-PZC3-1428	782074.1	959116.8	24.12	1.16	23.0	53.20	53.09	-30.1	-29.0	2	5		10/25/10	
R1-16	R1-16-TW	782109.4	959123.4	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R1-17	**HHD10-R1A-PZA1-1413**	781546.1	960520.4	**36.81**	1.16	*35.7*	31.00	30.95	*4.7*	**5.9**	2	5		09/21/10	
R1-17	**HHD10-R1A-PZA2-1413**	781547.6	960514.8	**36.72**	1.16	*35.6*	40.50	40.39	*-4.8*	**-3.7**	2	5		09/30/10	
R1-17	**HHD10-R1A-PZA3-1413**	781545.9	960520.4	**36.80**	1.16	*35.6*	65.78	65.65	*-30.0*	**-28.9**	2	5		09/18/10	
R1-17	**HHD10-R1A-PZB0-1413**	781567.2	960522.4	**36.32**	1.16	*35.2*	25.40	24.81	*10.4*	**11.5**	2	5		09/22/10	
R1-17	**HHD10-R1A-PZB1-1413**	781565.7	960526.5	**36.76**	1.16	*35.6*	30.35	30.95	*4.7*	**5.8**	2	5		09/25/10	
R1-17	**HHD10-R1A-PZB2-1413**	781567.3	960522.7	**36.39**	1.16	*35.2*	40.10	40.32	*-5.1*	**-3.9**	2	5		10/19/10	
R1-17	**HHD10-R1A-PZB3-1413**	781565.9	960526.6	**36.62**	1.16	*35.5*	65.35	65.32	*-29.9*	**-28.7**	2	5		10/21/10	
R1-17	**HHD10-R1A-PZC1-1413**	781643.5	960549.9	**18.61**	1.16	*17.5*	19.30	19.33	*-1.9*	**-0.7**	2	5		09/28/10	
R1-17	**HHD10-R1A-PZC2-1413**	781644.2	960544.6	**18.63**	1.16	*17.5*	20.80	20.77	*-3.3*	**-2.1**	2	5		10/21/10	
R1-17	**HHD10-R1A-PZC3-1413**	781643.3	960550.1	**18.64**	1.16	*17.5*	48.25	48.21	*-30.7*	**-29.6**	2	5		09/27/10	
R7-1	**PZ-R7-A-B**	768128.4	995616.5	**38.28**	1.25	*37.0*	48.30	48.04	*-11.0*	**-9.8**	2	5	20/30 Silica	8/26/1998	
R7-1	**PZ-R7-A-B2**	768124.1	995628.4	**38.21**	1.25	*37.0*	29.30	29.01	*8.0*	**9.2**	2	6	20/30 Silica	10/1/1998	
R7-1	**PZ-R7-A-C1**	768216.6	995651.1	**16.35**	1.25	*15.1*	25.00	24.79	*-9.7*	**-8.4**	1 1/4	5		08/26/99	
R7-1	**PZ-R7-A-C2**	768214.0	995658.0	**16.38**	1.25	*15.1*	9.70	9.52	*5.6*	**6.9**	1 1/4	5		08/26/99	
R7-2	**PZ-R7-B-A**	757117.8	1017807.2	**18.87**	1.27	*17.6*	9.90	9.68	*7.9*	**9.2**	1 1/4	5		08/26/99	
R7-2	**PZ-R7-B-B1**	757255.8	1017893.5	**39.49**	1.27	*38.2*	39.70	40.13	*-1.9*	**-0.6**	1 1/4	5		08/26/99	
R7-2	**PZ-R7-B-B2**	757253.0	1017897.7	**39.58**	1.27	*38.3*	29.70	29.41	*8.9*	**10.2**	1 1/4	5		08/26/99	
R7-3	**HHD12-R7-PZ-2B**	745596.1	1030530.7	**40.41**	1.27	*39.1*	44.45	44.67	*-5.5*	**-4.3**	2	5		01/21/13	
R7-3	**HHD12-R7-PZ-2B1**	745596.1	1030530.4	**40.41**	1.27	*39.1*	24.88	25.02	*14.1*	**15.4**	2	5		01/21/13	
R7-3	**HHD12-R7-PZ-2C**	745663.6	1030591.4	**17.20**	1.27	*15.9*	18.50	18.71	*-2.8*	**-1.5**	2	5		02/07/13	
R5-2	**HHD12-R5-PZ-2B**	690407.3	1035855.6	**33.03**	1.16	*31.9*	45.50	45.16	*-13.3*	**-12.1**	2	5		01/29/13	
R5-2	**HHD12-R5-PZ-2B1**	690404.3	1035860.5	**33.25**	1.16	*32.1*	20.25	20.48	*11.6*	**12.8**	2	5		01/29/13	
R5-2	**HHD12-R5-PZ-2B2**	690407.5	1035855.8	**33.06**	1.16	*31.9*	14.24	14.32	*17.6*	**18.7**	2	5		01/29/13	
R5-2	**HHD12-R5-PZ-2C**	690464.6	1035900.1	**19.04**	1.16	*17.9*	16.45	16.57	*1.3*	**2.5**	2	5		01/29/13	
R5-2	**HHD12-R5-PZ-2C1**	690467.3	1035895.8	**19.12**	1.16	*18.0*	5.05	5.15	*12.8*	**14.0**	2	2.5		01/29/13	
R5-1	**HHD12-R5-PZ-7B**	725243.2	1044509.3	**39.76**	1.28	*38.5*	38.81	39.30	*-0.8*	**0.5**	2	5		01/28/13	
R5-1	**HHD12-R5-PZ-7B1**	725238.5	1044511.2	**39.85**	1.28	*38.6*	31.25	31.35	*7.2*	**8.5**	2	5		01/29/13	
R5-1	**HHD12-R5-PZ-7B2**	725243.3	1044509.7	**39.84**	1.28	*38.6*	24.26	24.35	*14.2*	**15.5**	2	5		01/28/13	
R5-1	**HHD12-R5-PZ-7C**	725277.6	1044596.4	**14.96**	1.28	*13.7*	12.25	12.39	*1.3*	**2.6**	2	5		02/13/13	
R5-1	**HHD12-R5-PZ-7C1**	725282.3	1044594.6	**15.04**	1.28	*13.8*	5.25	5.52	*8.2*	**9.5**	2	5		02/13/13	
R8-1	**HHD12-R8-PZ-4B**	682356.4	1008504.9	**35.50**	1.24	*34.3*	44.52	44.65	*-10.4*	**-9.2**	2	5		01/30/13	
R8-1	**HHD12-R8-PZ-4B1**	682356.2	1008505.0	**35.51**	1.24	*34.3*	19.40	19.39	*14.9*	**16.1**	2	5		01/30/13	
R8-1	**HHD12-R8-PZ-4C**	682293.3	1008566.0	**15.36**	1.24	*14.1*	17.40	17.53	*-3.4*	**-2.2**	2	5		01/30/13	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R8-2	HHD12-R8-PZ-9B	688073.7	1036314.4	32.98	1.16	31.8	38.85	39.00	-7.2	-6.0	2	5		02/13/13	
R8-2	HHD12-R8-PZ-9B1	688071.3	1036317.4	33.04	1.16	31.9	24.89	25.03	6.9	8.0	2	5		02/13/13	
R8-2	HHD12-R8-PZ-9B2	688073.5	1036314.4	32.99	1.16	31.8	14.77	14.93	16.9	18.1	2	5		02/13/13	
R8-2	HHD12-R8-PZ-9C	688023.8	1036277.3	27.88	1.16	26.7	24.74	24.89	1.8	3.0	2	5		02/14/13	
R8-2	HHD12-R8-PZ-9C1	688023.5	1036277.4	27.88	1.16	26.7	10.13	10.29	16.4	17.6	2	5		02/14/13	
R6-1	HHD12-R6-PZ-4B	624538.2	961206.5	39.13	1.36	37.8	37.95	38.10	-0.3	1.0	2	5		02/15/13	
R6-1	HHD12-R6-PZ-4B1	624544.1	961207.9	39.22	1.36	37.9	31.85	31.95	5.9	7.3	2	5		02/15/13	
R6-1	HHD12-R6-PZ-4B2	624538.2	961206.8	39.21	1.36	37.9	24.20	24.30	13.6	14.9	2	5		02/15/13	
R6-1	HHD12-R6-PZ-4C	624536.7	961305.8	15.43	1.36	14.1	27.80	27.96	-13.9	-12.5	2	5		02/15/13	
R6-1	HHD12-R6-PZ-4C1	624531.5	961306.1	15.40	1.36	14.0	8.32	8.46	5.6	6.9	2	5		02/15/13	
R6-2	HHD12-R6-PZ-7B	633215.4	974131.8	38.00	1.34	36.7	34.69	34.67	2.0	3.3	2	5		02/09/13	
R6-2	HHD12-R6-PZ-7B1	633215.3	974136.7	38.10	1.34	36.8	27.12	27.24	9.5	10.9	2	3		02/09/13	
R6-2	HHD12-R6-PZ-7B2	633215.1	974131.7	38.10	1.34	36.8	21.78	21.90	14.9	16.2	2	5		02/09/13	
R6-2	HHD12-R6-PZ-7C	633092.1	974127.4	17.71	1.34	16.4	18.69	18.76	-2.4	-1.1	2	5		02/08/13	
R6-2	HHD12-R6-PZ-7C1	633092.0	974127.2	17.68	1.34	16.3	8.18	8.28	8.1	9.4	2	5		02/08/13	
R6-3	HHD12-R6-PZ-10B	657049.1	981153.3	35.33	1.21	34.1	46.04	46.19	-12.1	-10.9	2	5		02/21/13	
R6-3	HHD12-R6-PZ-10B1	657052.8	981156.4	35.34	1.21	34.1	27.32	27.44	6.7	7.9	2	5		02/21/13	
R6-3	HHD12-R6-PZ-10B2	657048.8	981153.4	35.28	1.21	34.1	19.80	19.23	14.8	16.1	2	5		02/21/13	
R6-3	HHD12-R6-PZ-10C	656974.2	981237.9	16.25	1.21	15.0	19.78	20.10	-5.1	-3.9	2	5		02/21/13	
R6-3	HHD12-R6-PZ-10C1	656970.0	981233.7	16.20	1.21	15.0	8.79	9.00	6.0	7.2	2	3		02/21/13	
R6-4	HHD12-R6-PZ-12B	658641.9	997711.8	31.61	1.30	30.3	43.87	44.09	-13.8	-12.5	2	5		02/15/13	
R6-4	HHD12-R6-PZ-12B1	658639.8	997714.2	31.55	1.30	30.3	22.80	21.99	8.3	9.6	2	5		02/15/13	
R6-4	HHD12-R6-PZ-12B2	658641.6	997711.8	31.64	1.30	30.3	14.95	15.10	15.2	16.5	2	5		02/15/13	
R6-4	HHD12-R6-PZ-12C	658593.4	997675.4	17.00	1.30	15.7	25.05	25.22	-9.5	-8.2	2	5		02/14/13	
R6-4	HHD12-R6-PZ-12C1	658593.3	997675.2	16.90	1.30	15.6	7.91	8.10	7.5	8.8	2	2		02/14/13	
R6-4	R6-4-TW	658571.0	997648.4	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R4-1	HHD12-R4-PZ-1B	626062.7	912978.9	37.05	1.35	35.7	39.42	39.58	-3.9	-2.5	2	5		02/14/13	
R4-1	HHD12-R4-PZ-1B1	626063.1	912979.0	36.96	1.35	35.6	21.20	20.35	15.3	16.6	2	5		02/14/13	
R4-1	HHD12-R4-PZ-1B2	626057.0	912988.0	37.06	1.35	35.7	31.25	31.44	4.3	5.6	2	5		02/14/13	
R4-1	HHD12-R4-PZ-1C	625986.2	912922.5	15.49	1.35	14.1	15.31	15.51	-1.4	0.0	2	5		02/14/13	
R4-1	HHD12-R4-PZ-1C1	625981.2	912930.5	15.36	1.35	14.0	8.09	8.25	5.8	7.1	2	5		02/14/13	
R4-1	R4-1-TW	625976.7	912909.3	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	

HHD Piezometer/Well Inventory Table

PZ Line	Piezometer ID	X (NAD83)	Y (NAD83)	Z Elev. (NGVD29)	NAVD88 to NGVD29 Conversion[2]	Z Elev. (NAVD88)	As-Built Depth (ft)	PZ Depth 12/16/15	PZ Tip Elev. (NAVD88)	PZ Tip Elev. (NGVD29)	PZ Riser Diameter (in)	Length of Well Screen (ft)[1]	Filter Pack	Date Developed (In Service)	Decommissioned
R4-2	HHD12-R4-PZ-2B	616698.9	926484.6	36.14	1.29	34.9	36.32	36.48	-1.6	-0.3	2	5		02/14/13	
R4-2	HHD12-R4-PZ-2B1	616695.7	926488.9	36.11	1.29	34.8	25.18	25.30	9.5	10.8	2	5		02/14/13	
R4-2	HHD12-R4-PZ-2B2	616698.6	926484.4	36.16	1.29	34.9	21.20	21.30	13.6	14.9	2	5		02/14/13	
R4-2	HHD12-R4-PZ-2C	616638.9	926450.9	18.74	1.29	17.5	17.97	18.15	-0.7	0.6	2	5		02/14/13	
R4-2	HHD12-R4-PZ-2C1	616638.8	926451.1	18.74	1.29	17.5	8.70	8.88	8.6	9.9	2	2.5		02/14/13	
R4-2	R4-2-TW	616603.5	926432.3	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	02/09/16	
R4-3	HHD12-R4-PZ-4B	594717.6	948142.4	33.23	1.29	31.9	27.11	27.55	4.4	5.7	2	5		02/14/13	
R4-3	HHD12-R4-PZ-4B1	594717.7	948142.1	33.22	1.29	31.9	9.90	10.18	21.8	23.0	2	5		02/14/13	
R4-3	HHD12-R4-PZ-4B2	594711.1	948142.3	33.18	1.29	31.9	20.90	21.05	10.8	12.1	2	5		02/14/13	
R4-3	HHD12-R4-PZ-4C	594711.7	948093.3	24.41	1.29	23.1	15.78	15.90	7.2	8.5	2	5		02/14/13	
R4-3	HHD12-R4-PZ-4C1	594714.4	948092.8	24.31	1.29	23.0	9.92	10.10	12.9	14.2	2	3		02/14/13	
R1-13A	PZ-HHDR1A-2A	781856.1	940981.5	23.88	1.24	22.6	32.70	32.22	-9.6	-8.3	2	10		11/22/08	Not Being Read
R1-15	PZ-HHDR1A-1D	783603.8	951932.5	19.32	1.24	18.1	28.00	28.27	-10.2	-9.0	2	10		11/19/08	Not Being Read
NA	HHD08-R1A-MW-11	783,161.1	953,385.5	20.60	1.24	19.4	126.00		-106.6	-105.4	2	100		08/02/08	Date Unknown
NA	HHD08-R1C-MW-8D	775,896.1	918,662.1	17.13	1.24	15.9	182.70		-166.8	-165.6	2	150		11/21/08	Date Unknown
NA	HHD08-R1D-MW-5D	753,135.4	869,591.8	11.65	1.32	10.3	160.00		-149.7	-148.3	2	145		11/08/08	Date Unknown
R1-13	HHD09-C10A-CB-1B	781894.0	939155.0	36.80	1.30	35.5	46.70		-11.2	-9.9	?	10		03/16/09	Never Located in Field
R1-15	HHDR1A06-06	782932.0	952086.0	29.00	1.52	27.5	46.75		-19.3	-17.8	1 1/4	2		05/21/06	06/28/12
R1-15	HHDR1A06-07	782932.0	952086.0	29.01	1.52	27.5	30.90		-3.4	-1.9	1 1/4	2		05/21/06	06/28/12
R1-11	PZ-ER1352-5B1	777269.0	921820.9	38.30	1.49	36.8	36.00		0.8	2.3	1 1/4	2		05/07/96	12/07/11
R1-11	PZ-ER1352-5B2	777269.0	921820.9	38.30	1.49	36.8	44.00		-7.2	-5.7	1 1/4	2		05/07/96	12/07/11
R1-15	PZ-HHDR1A-1C	783161.0	951892.0	18.56	1.24	17.3	27.60		-10.3	-9.0	2	10		11/21/08	07/08/13
R1-13A	PZ-HHDR1A-2C	782058.3	940938.4	15.75	1.24	14.5	23.30		-8.8	-7.6	2	10		11/23/08	07/09/13
R1-12	PZ-R1-25-B1	779248.0	925043.8	37.70	1.49	36.2	50.00		-13.8	-12.3	1 1/4	5		08/16/95	09/16/11
R1-12	PZ-R1-25-B2	779231.7	925049.8	37.80	1.49	36.3	37.00		-0.7	0.8	1 1/4	5		08/17/95	09/16/11
R1-11A	URS-05-1B	777695.8	922660.2	36.30	1.49	34.8	79.20		-44.4	-42.9	1 1/4	5.5		10/11/05	12/07/11
R1-12A	URS-05-2B	782008.1	930341.1	36.10	1.49	34.6	35.10		-0.5	1.0	1 1/4	5.5		10/14/05	02/16/11

Notes:
1. When "Length of Well Screen" is listed as 5.5 feet, the as-built well screen was unable to be verified.
2. All surveys performed in NAVD88 and converted to NGVD29.
3. XY locations for "-TW" staff gages were converted from lat long.

Red Piezometer ID indicates piezometer is not in service.

Nested PZ- Constructed in a single borehole with another PZ

NAVD88 to NGVD29 conversions prior to 2015 survey and post processing to establish conversion based on adjacent historic HHD structure/survey monuments.

Key to Well Pad Type:

1 Flush mount concrete pad with cast iron lid
2 Above ground, PVC Riser, no concrete pad
3 Above ground, concrete pad, steel well casing with lid and protection ballards
4 Flush mount concrete pad with cast iron lid, name stamped on metal and cast into concrete, well cover has stamped name place

APPENDIX C: PIEZOMETER LINE CROSS SECTIONS

Note: The cross sections herein have been updated from what was provided in the 2018 HHD Instrumentation Report Update. The updated cross sections are plotted to NGVD29.

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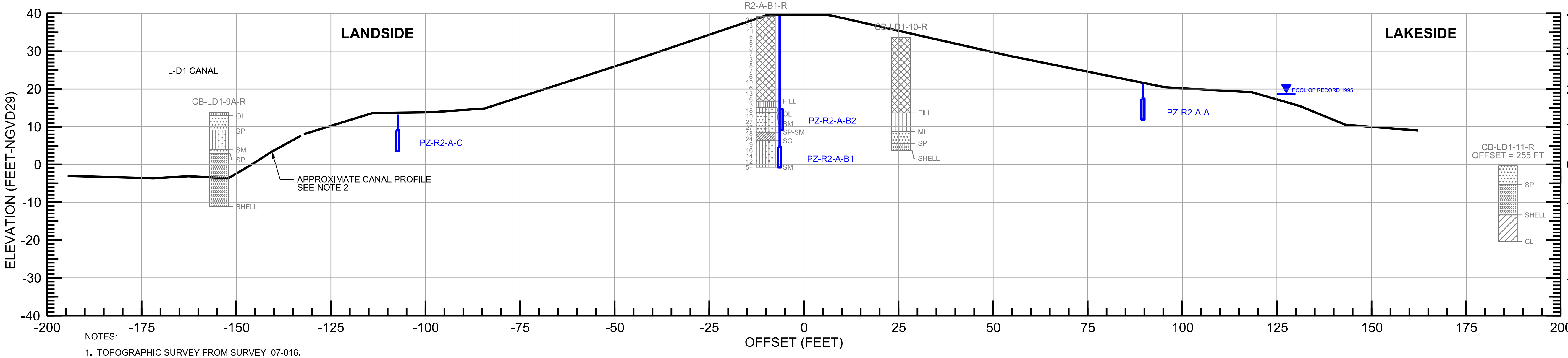
PIEZOMETER LINE DETAILS

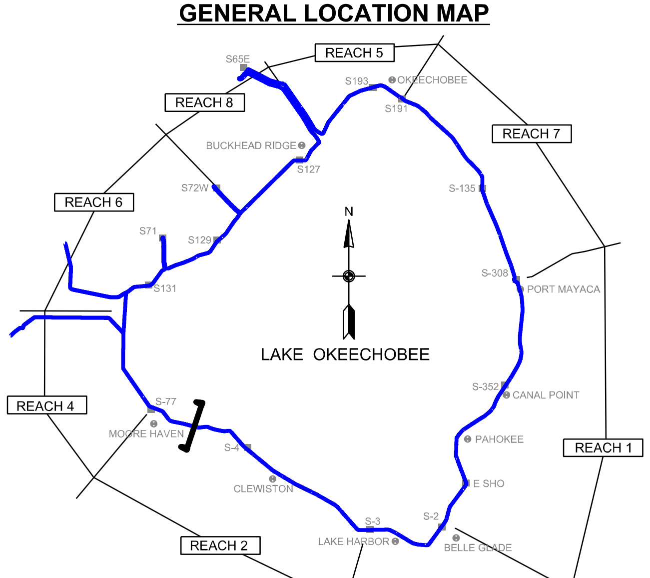
PIEZOMETER LINE: R2-1
HHD STATION: HHD 3794+00
LEVEE DESIGNATION: L-D1 120+00
REACH: 2
SEGMENT/ CIZ: 6/ B



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. TOPOGRAPHY AND INVERT OF THE L-D1 CANAL WAS ESTIMATED USING 1960S AS-BUILT. D.O. FILE NO. 483-28,669.

GENERAL LOCATION MAP

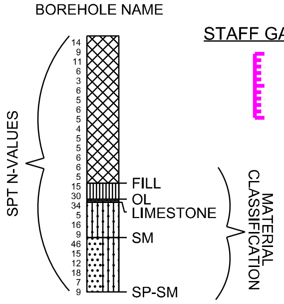


SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

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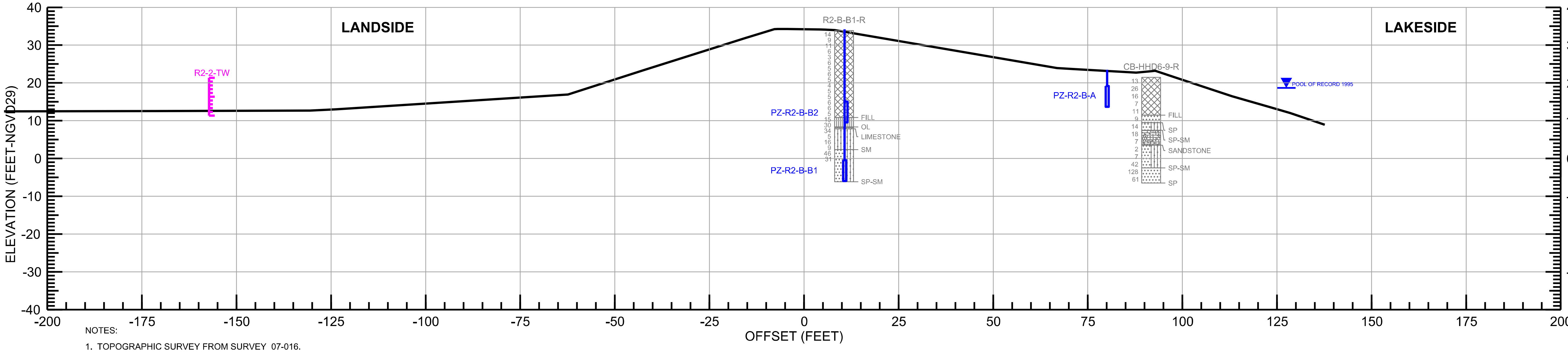
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R2-1

PIEZOMETER LINE DETAILS

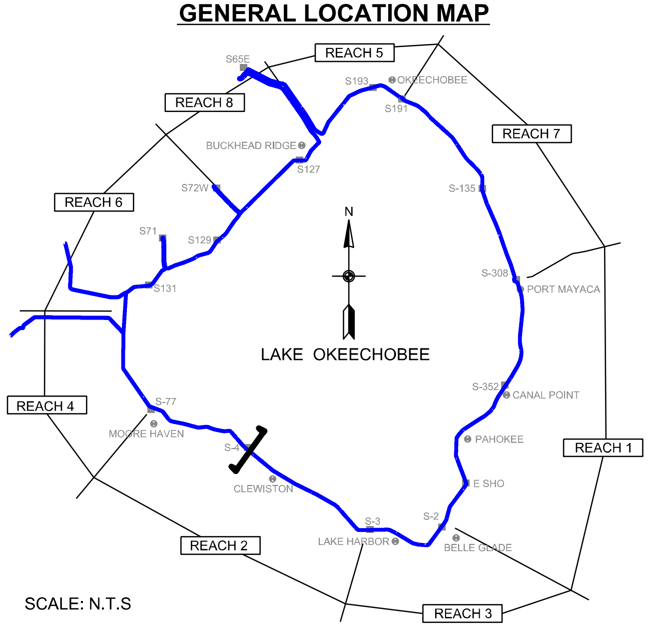
PIEZOMETER LINE:	R2-2
HHD STATION:	HHD 3520+00
LEVEE DESIGNATION:	L-D1 396+00
REACH:	2
SEGMENT/ CIZ:	5/ B



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.

GENERAL LOCATION MAP



SCALE: N.T.S

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

MATERIAL CLASSIFICATION

FILL

OL

LIMESTONE

SM

SP-SM

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
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- (SP-SM) POORLY GRADED SILTY SAND
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- (OH) ORGANIC CLAY
- (PT) PEAT
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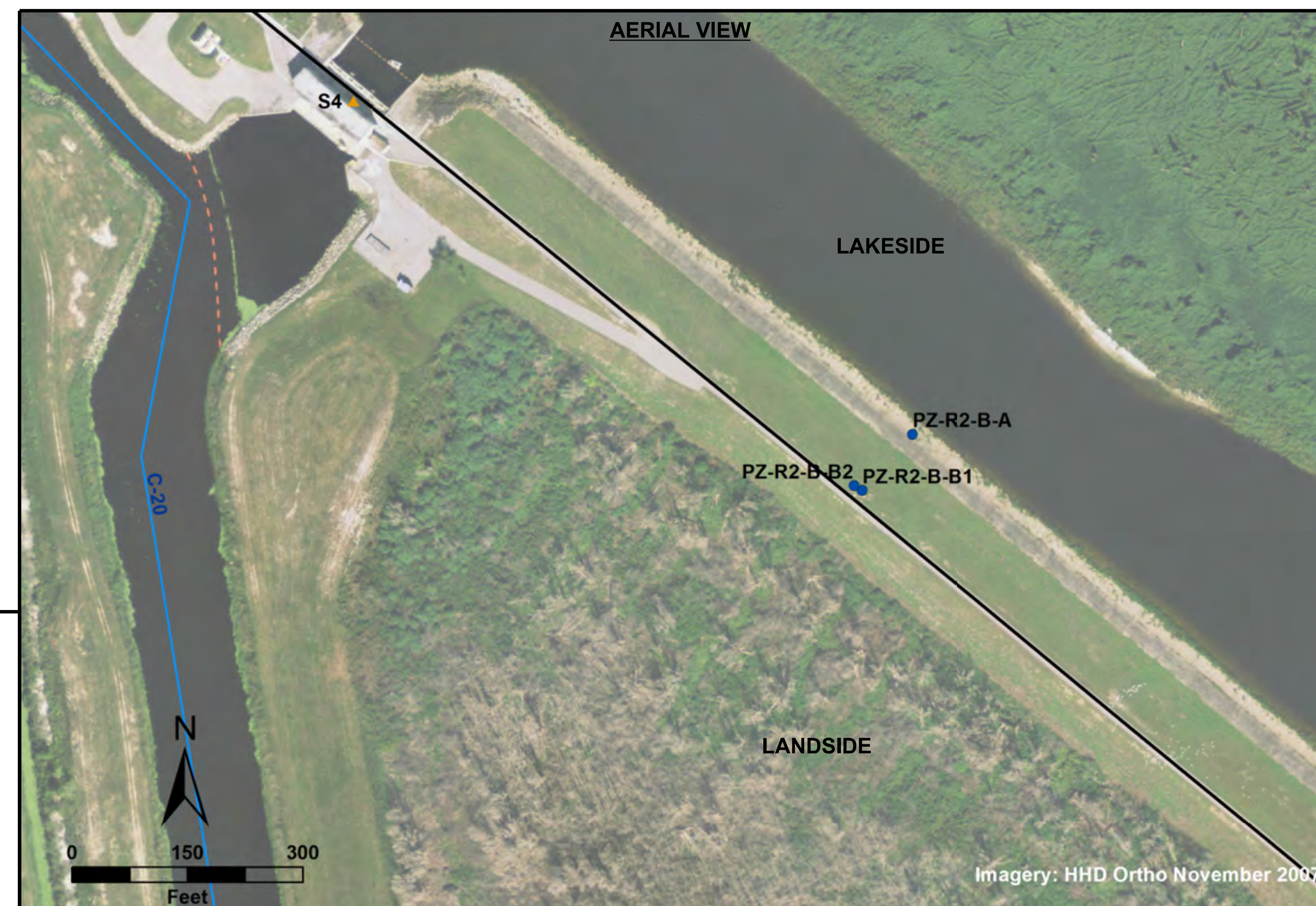
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

AERIAL VIEW



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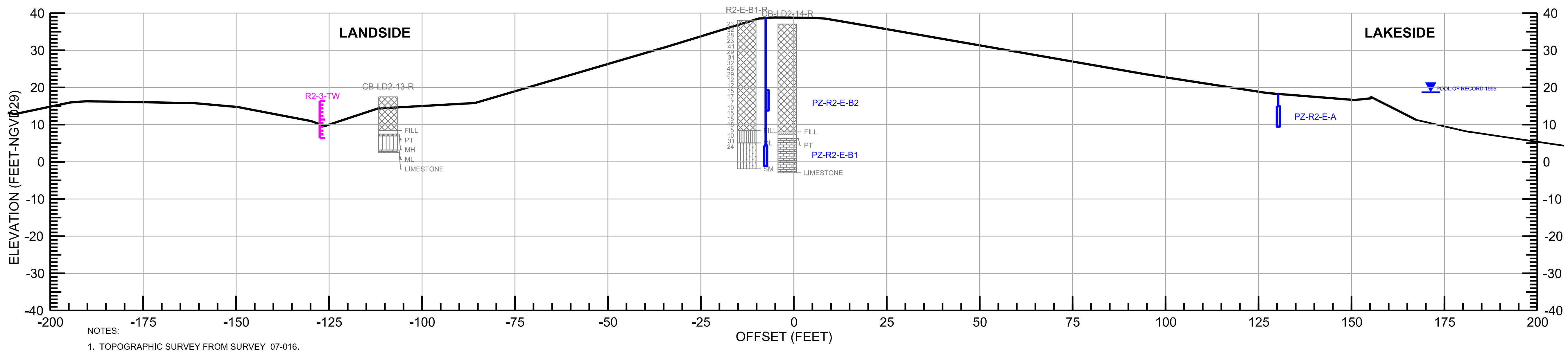
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R2-2

PIEZOMETER LINE DETAILS

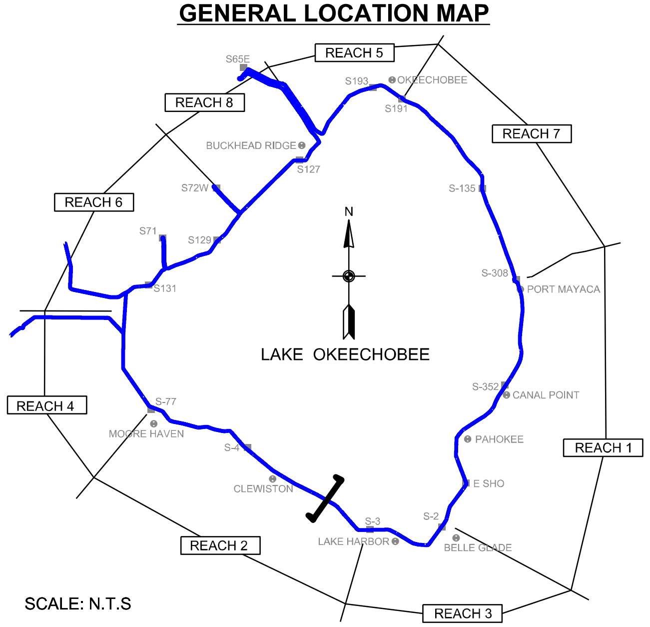
PIEZOMETER LINE:	R2-3
HHD STATION:	HHD 3118+00
LEVEE DESIGNATION:	L-D2 240+00
REACH:	2
SEGMENT/ CIZ:	4/ B



NOTES:

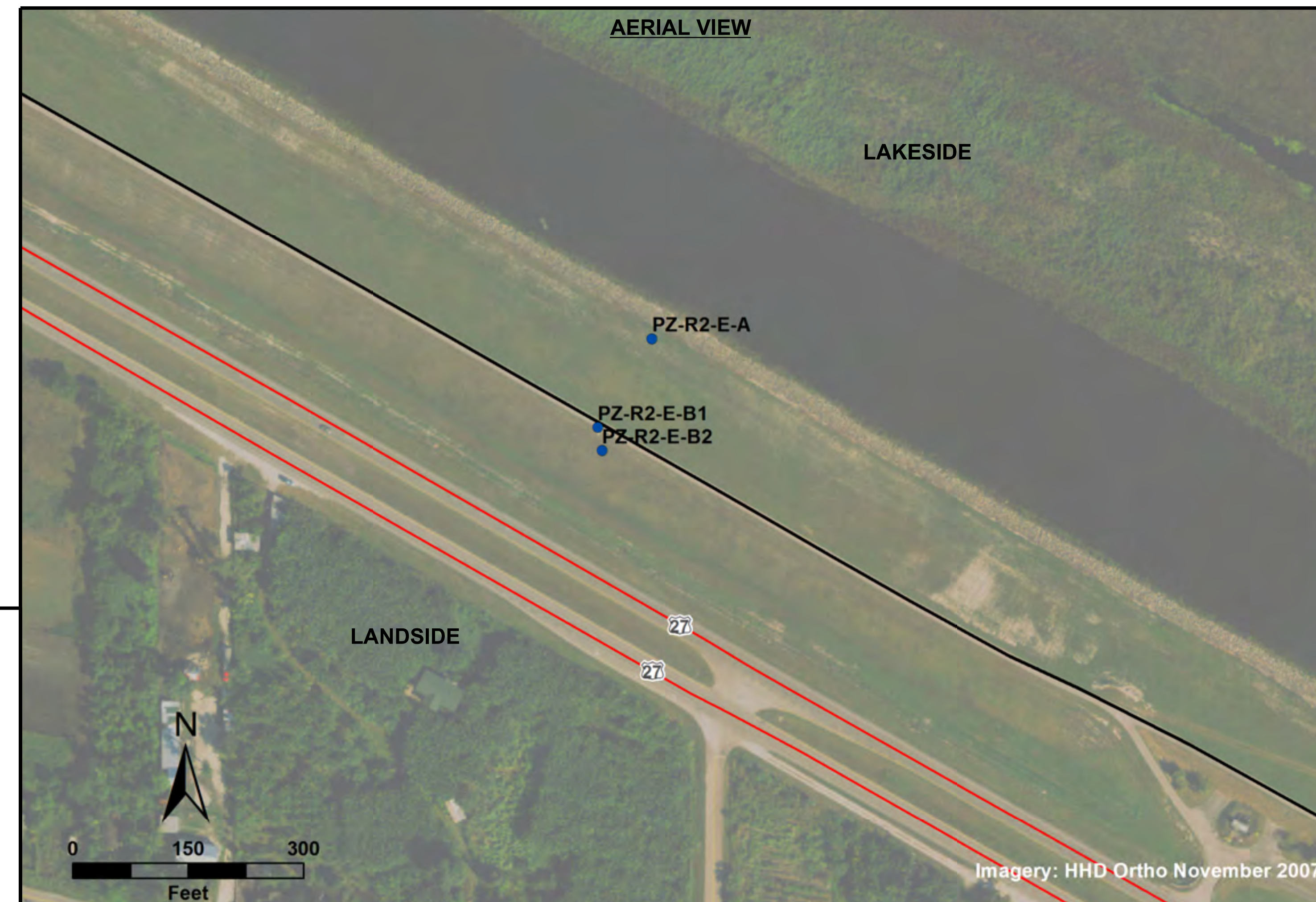
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CB-HHDR201-8A AND 8C ARE LOCATED APPROXIMATELY 875' NW OF PZ LINE.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL
LIMESTONE
(SS) SANDSTONE
(SM) SILTY SAND
(SP) POORLY GRADED SAND
(SP-SM) POORLY GRADED SILTY SAND
(OL) ORGANIC SILT
(OH) ORGANIC CLAY
(PT) PEAT
(SH) SHELL
(SC) CLAYEY SAND
(GP) POORLY GRADED GRAVEL
(ML) SILT
(CH) FAT CLAY
(CL) LEAN CLAY
(MH) ELASTIC SILT

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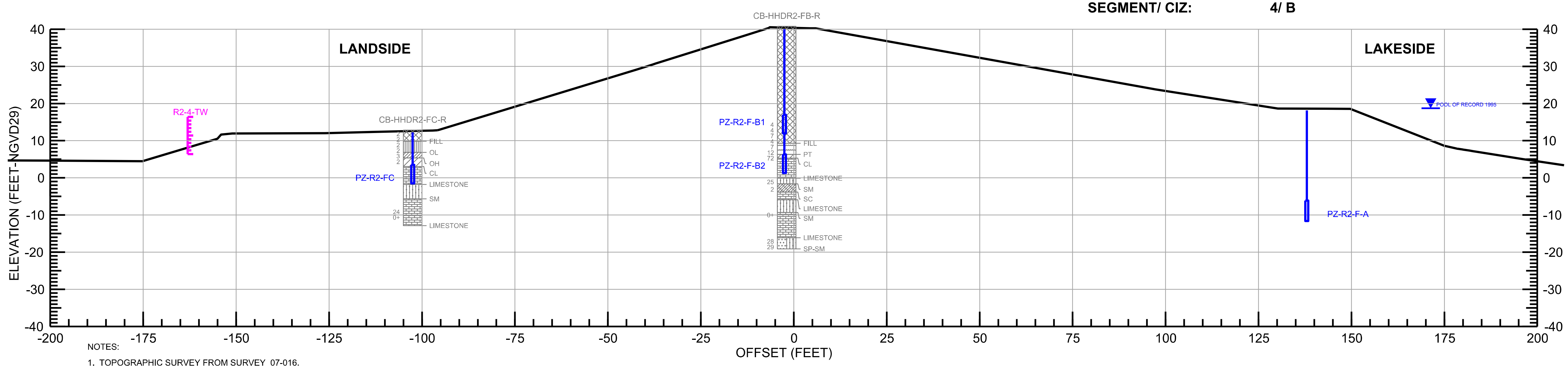
PIEZOMETER LINE CROSS SECTION

R2-3

PIEZOMETER LINE DETAILS

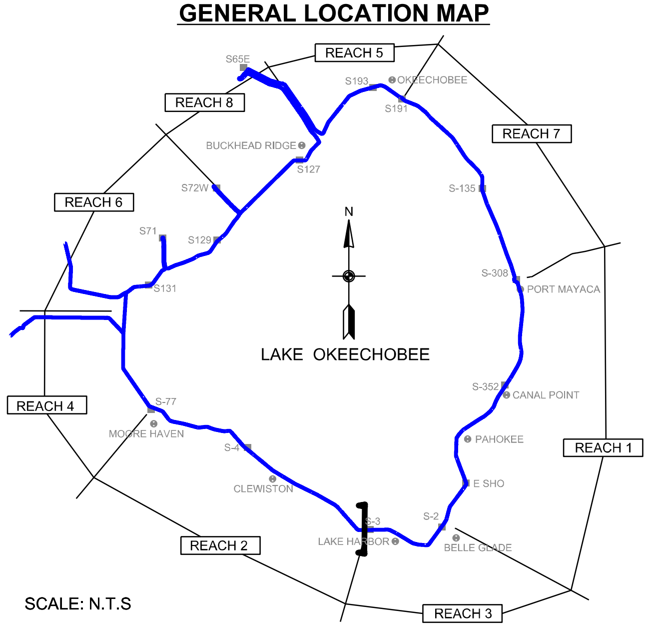
PIEZOMETER LINE:	R2-4
HHD STATION:	HHD 2936+00
LEVEE DESIGNATION:	L-D2 424+00
REACH:	2
SEGMENT/ CIZ:	4/ B



NOTES:

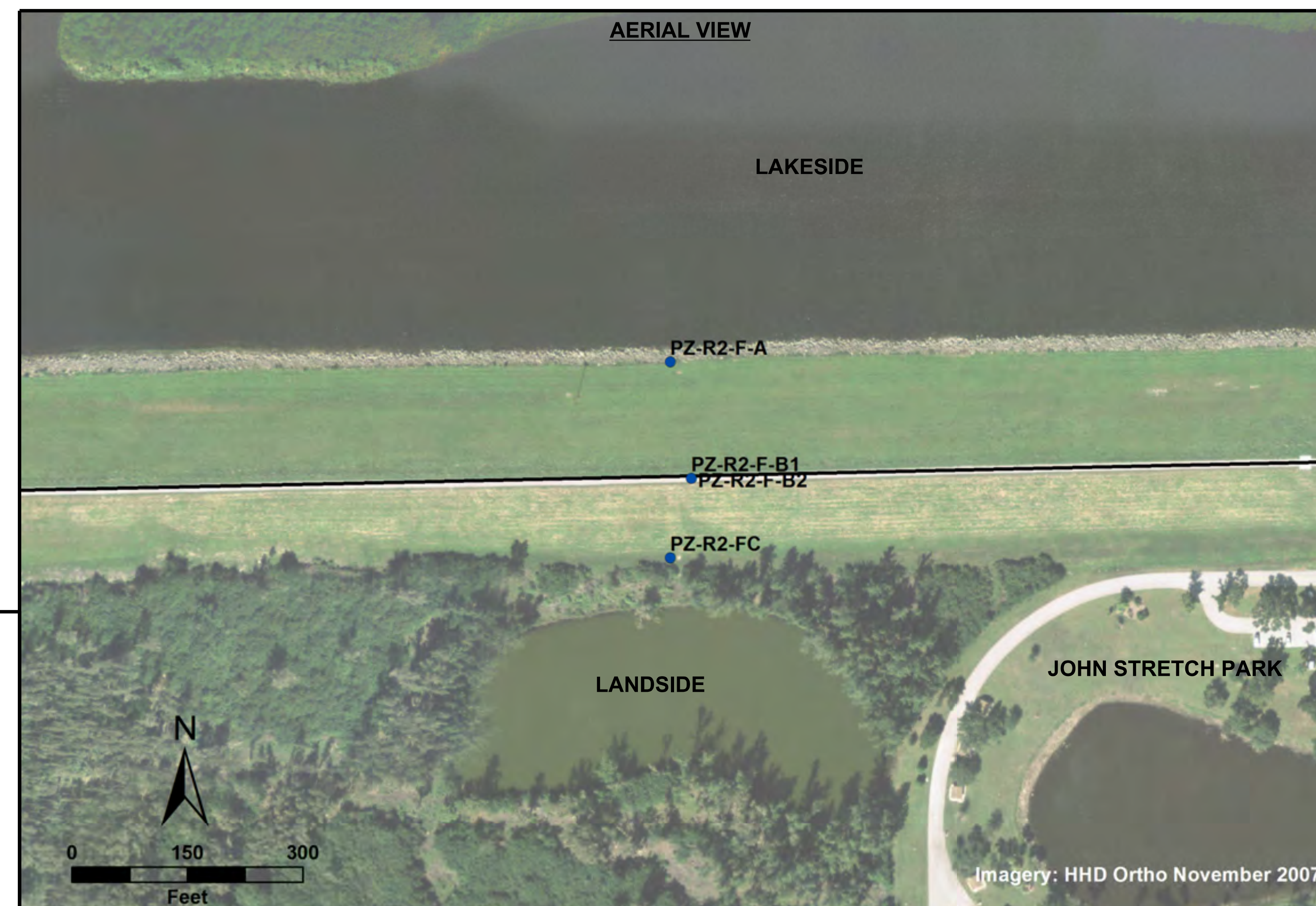
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. BORINGS CB-LD2-31-R AND 32-R ARE 300 FT WEST OF PZ LINE.
4. BORROW PIT AT JOHN STRETCH PARK CONTINUES APPROXIMATELY 500 FT PARALLEL TO EMBANKMENT

GENERAL LOCATION MAP

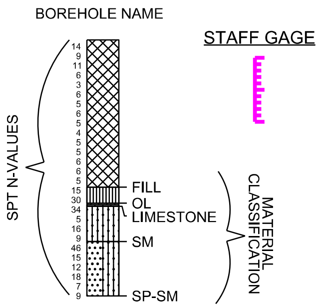


SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
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- (CL) LEAN CLAY
- (MH) ELASTIC SILT

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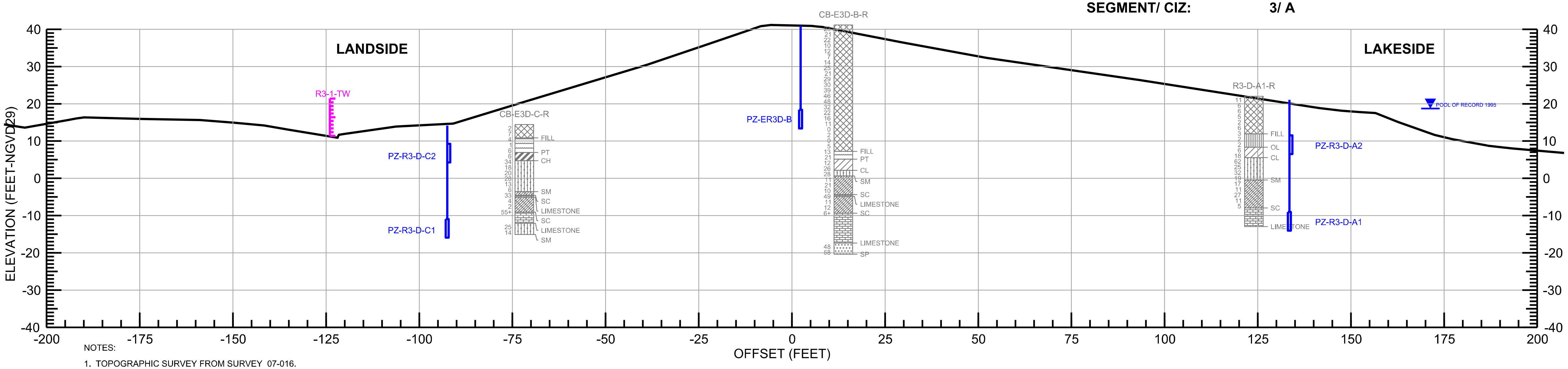
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R2-4

PIEZOMETER LINE DETAILS

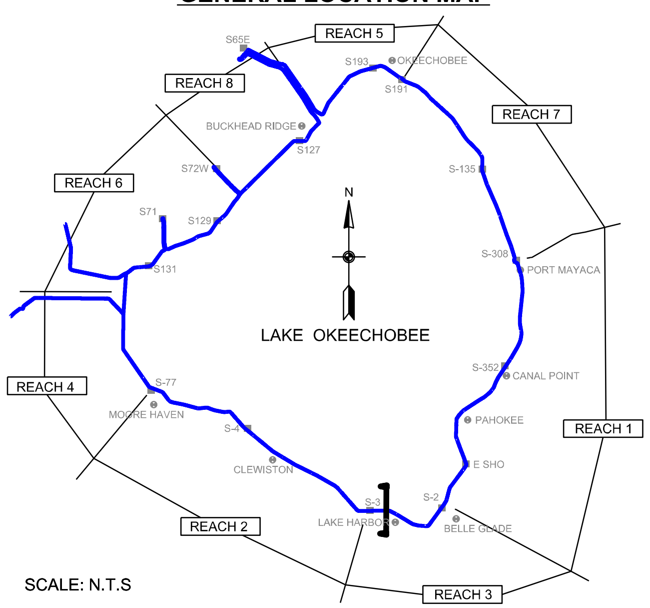
PIEZOMETER LINE:	R3-1
HHD STATION:	HHD 2865+50
LEVEE DESIGNATION:	L-D2 494+00
REACH:	3
SEGMENT/ CIZ:	3/ A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. HHD08-RS-CB-5C IS LOCATED APPROXIMATELY 200 FT WEST OF PIEZOMETER LINE.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
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- (SP-SM) POORLY GRADED SILTY SAND
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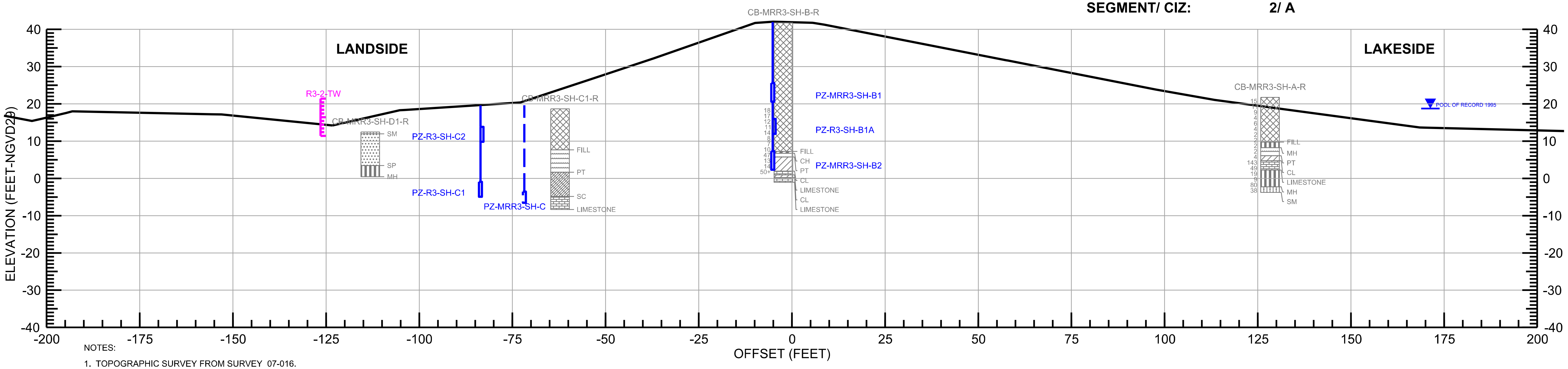
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R3-1

PIEZOMETER LINE DETAILS

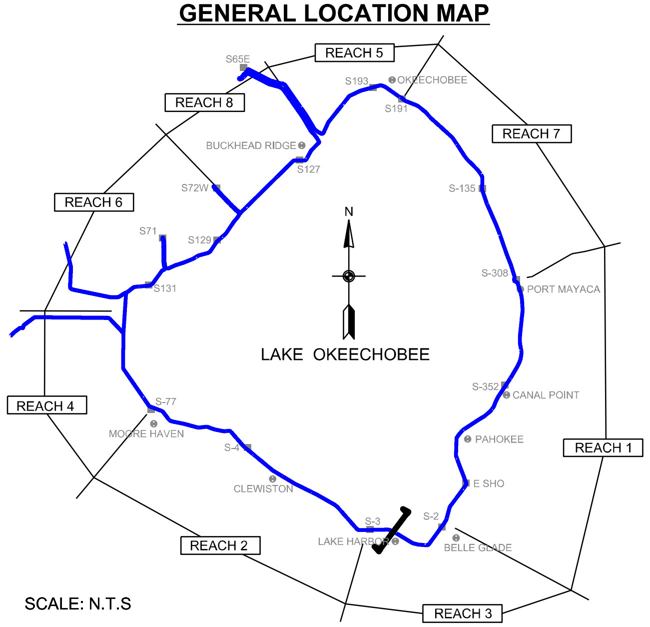
PIEZOMETER LINE:	R3-2
HHD STATION:	HHD 2812+00
LEVEE DESIGNATION:	L-D2 572+00
REACH:	3
SEGMENT/ CIZ:	2/ A



NOTES:

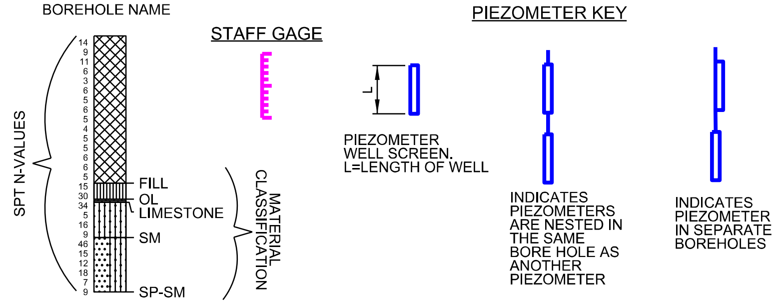
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. LD2 BORINGS ARE APPROXIMATELY 600 FT WEST OF PZ LINE.
4. PZ-MRR3-SH-C DESTROYED SHORTLY AFTER IT WAS INSTALLED IN 1995. IT WAS REPLACED BY PZ-R3-SH-C1 AND PZ-R3-SH-C2 IN AUGUST 1999.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
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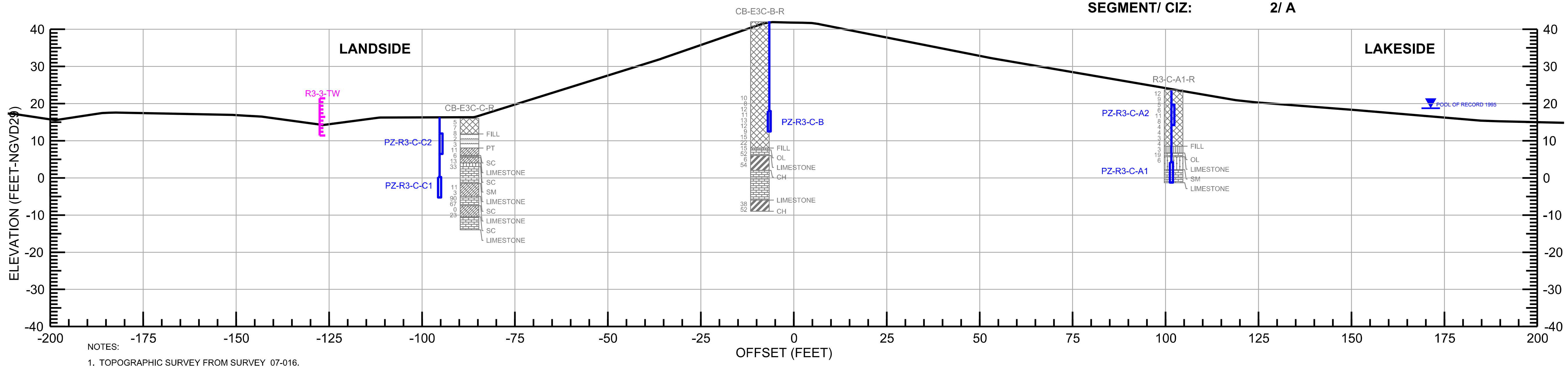
PIEZOMETER LINE CROSS SECTION

R3-2

PIEZOMETER LINE DETAILS

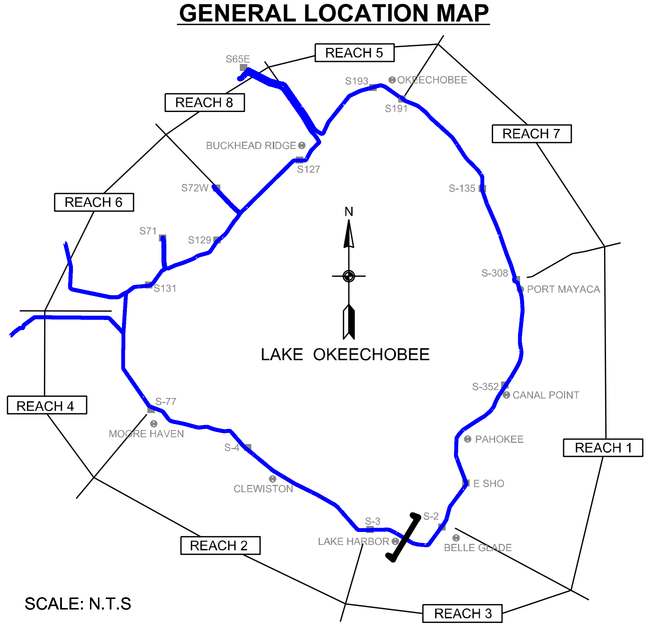
PIEZOMETER LINE:	R3-3
HHD STATION:	HHD 2764+00
LEVEE DESIGNATION:	L-D2 620+00
REACH:	3
SEGMENT/ CIZ:	2/ A



NOTES:

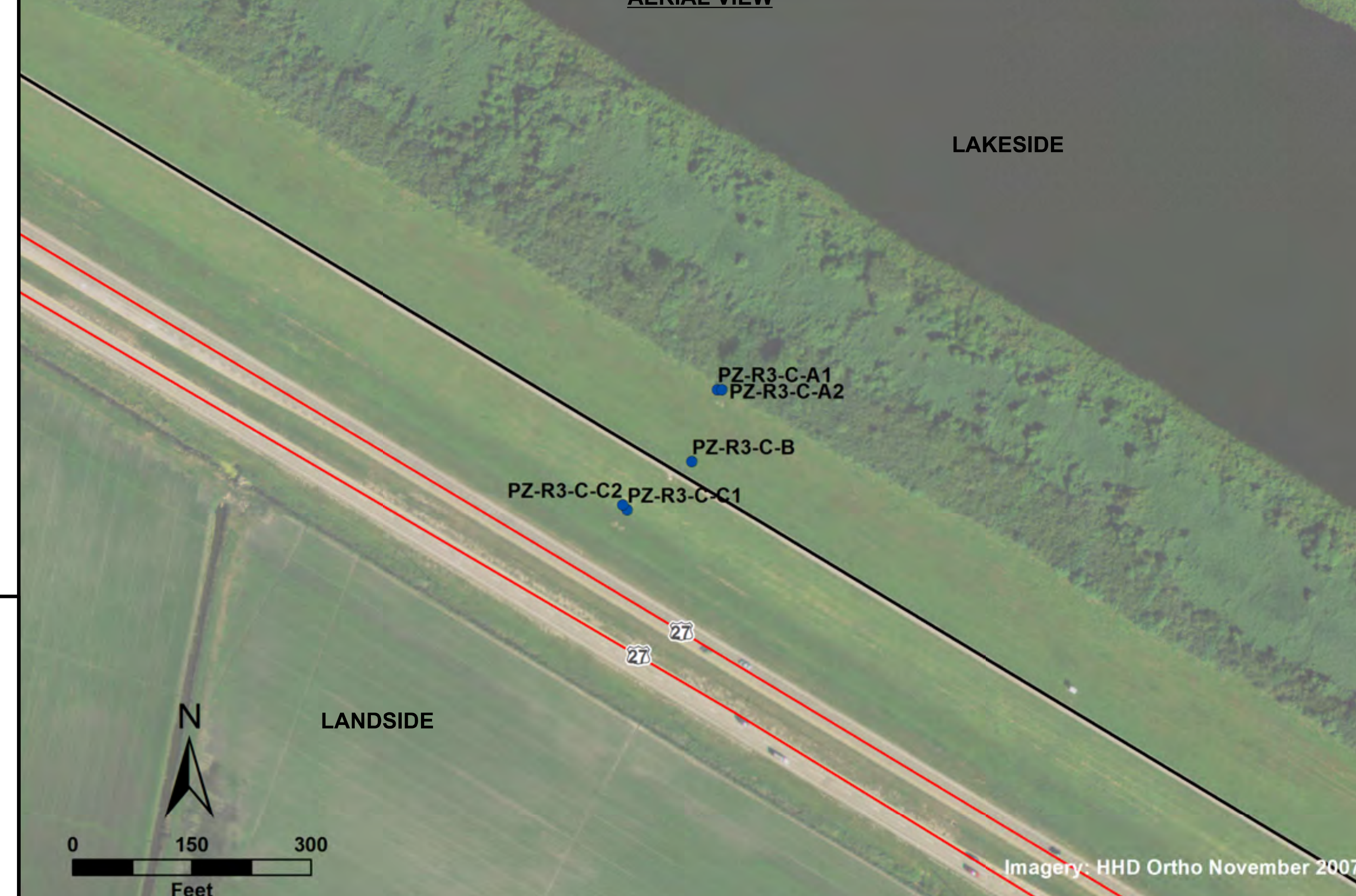
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.

GENERAL LOCATION MAP

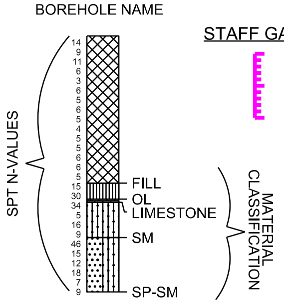


SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

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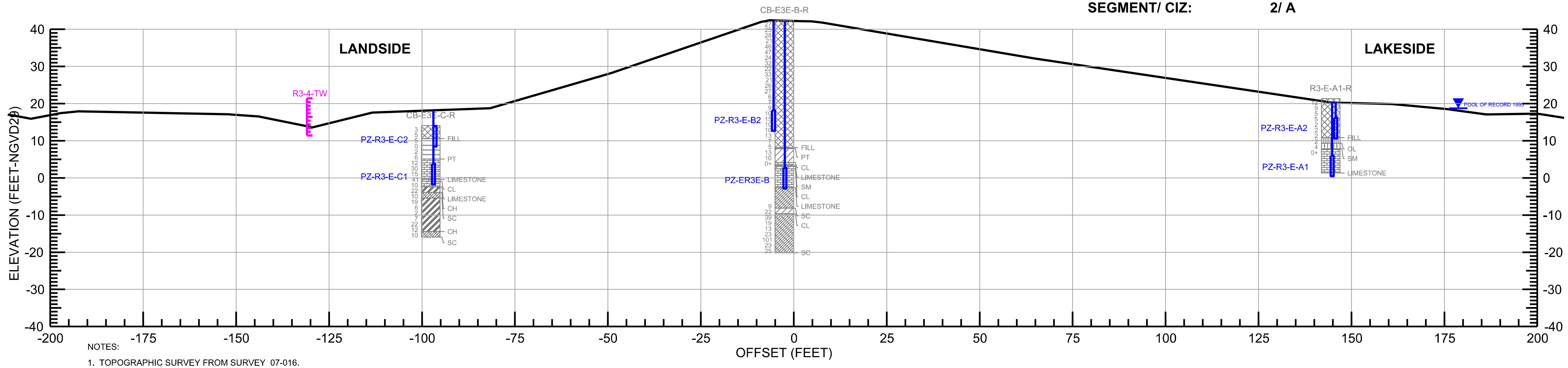
PIEZOMETER LINE CROSS SECTION

R3-3

PIEZOMETER LINE DETAILS

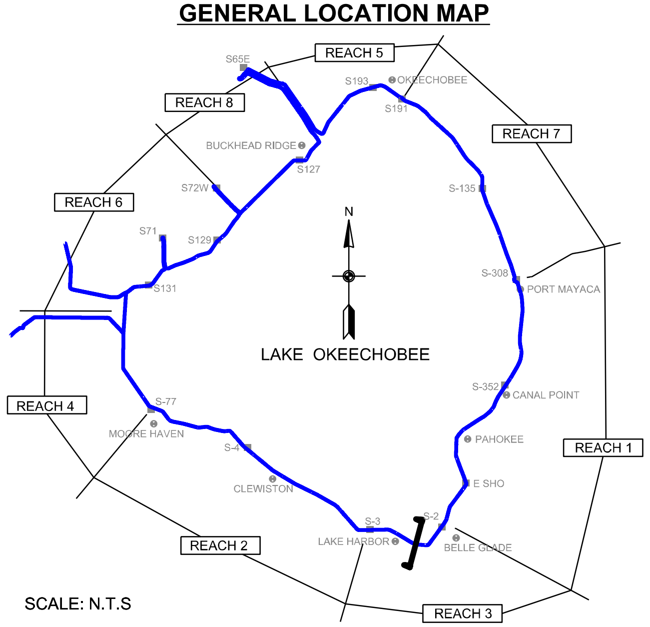
PIEZOMETER LINE:	R3-4
HHD STATION:	HHD 2722+00
LEVEE DESIGNATION:	L-D2 662+00
REACH:	3
SEGMENT/ CIZ:	2/ A



NOTES:

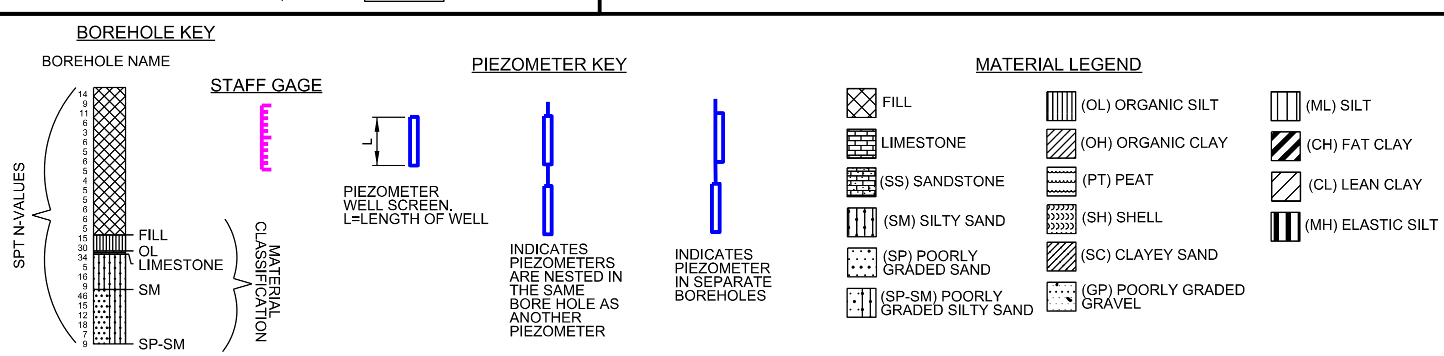
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



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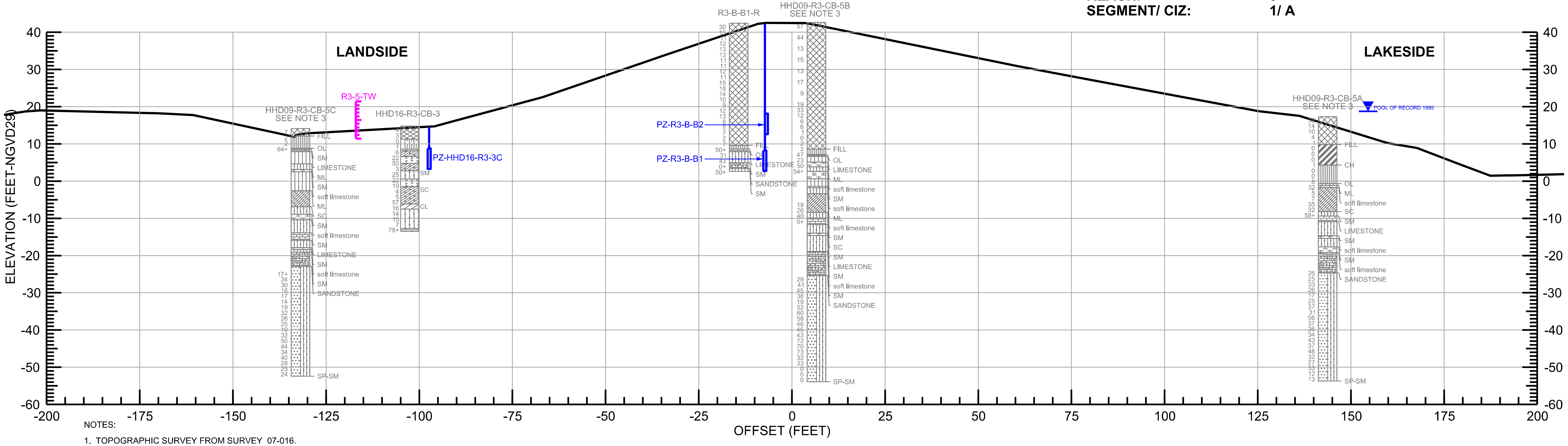
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R3-4

PIEZOMETER LINE DETAILS

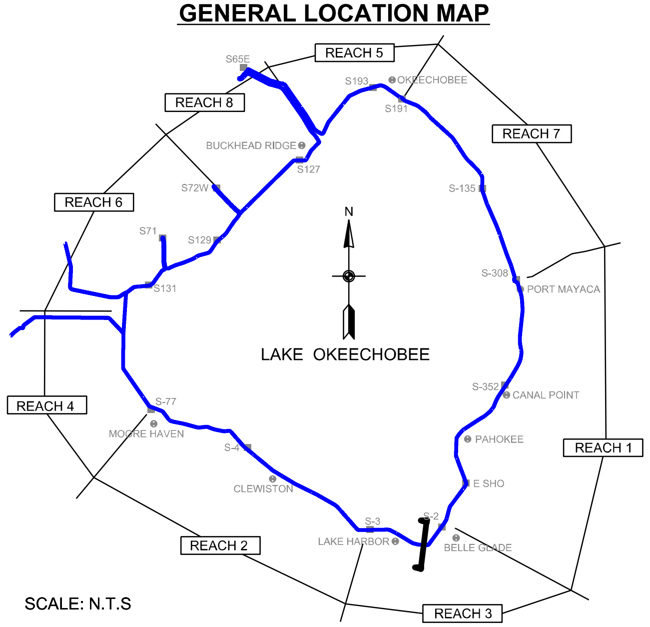
PIEZOMETER LINE:	R3-5
HHD STATION:	HHD 2670+00
LEVEE DESIGNATION:	L-D2 715+00
REACH:	3
SEGMENT/ CIZ:	1/ A



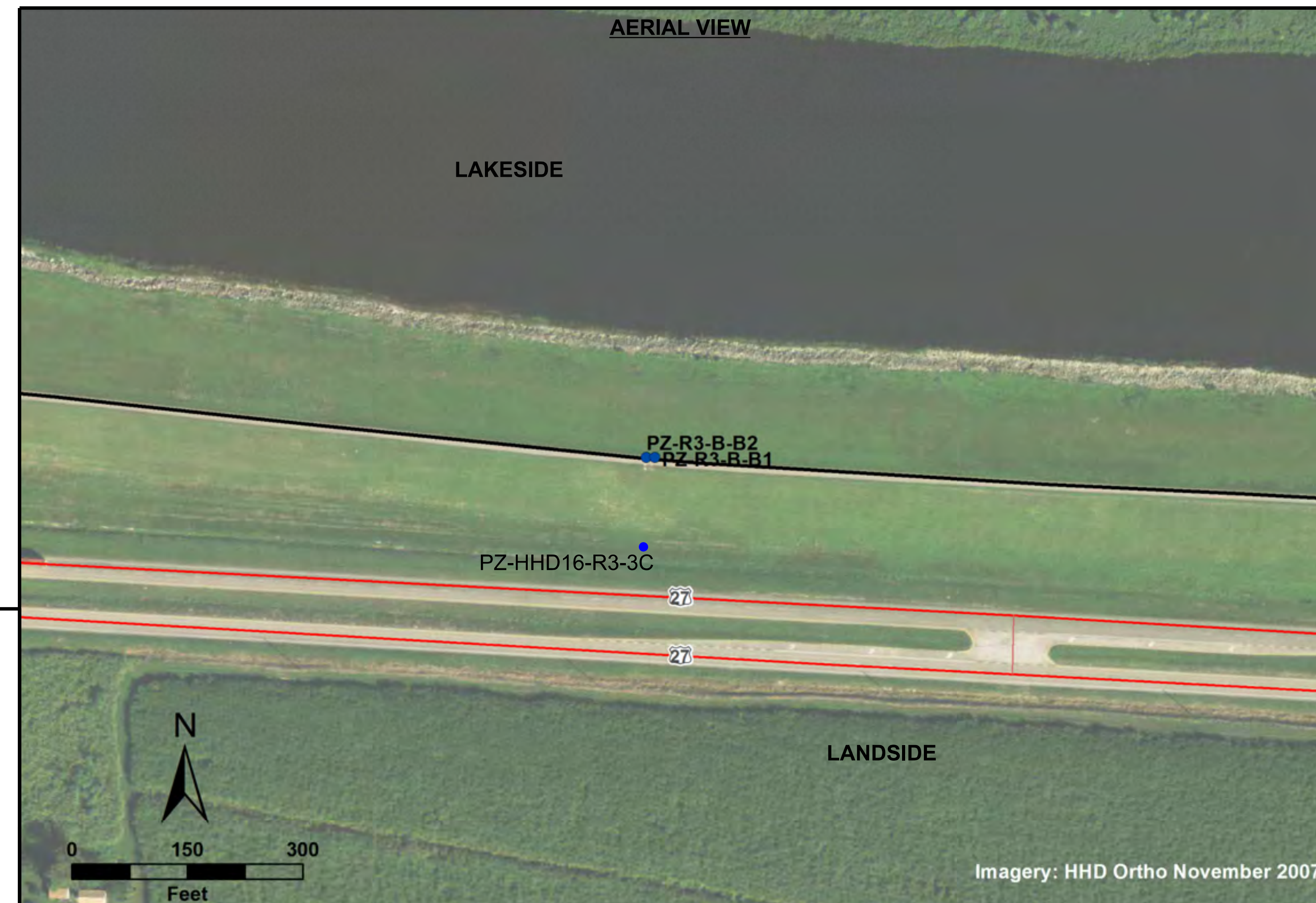
NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. ONLY ONE BORING (R3-B-B1-R) WAS AVAILABLE AT THIS PIEZOMETER LINE; THEREFORE, BORINGS FROM STA 2677+00 (APPROXIMATELY 700 FEET UPSTATION) WERE INCLUDED ON THE CROSS SECTION.

GENERAL LOCATION MAP



AERIAL VIEW



BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL	(OL) ORGANIC SILT	(ML) SILT
LIMESTONE	(OH) ORGANIC CLAY	(CH) FAT CLAY
(SS) SANDSTONE	(PT) PEAT	(CL) LEAN CLAY
(SM) SILTY SAND	(SH) SHELL	(MH) ELASTIC SILT
(SP) POORLY GRADED SAND	(SC) CLAYEY SAND	
(SP-SM) POORLY GRADED SILTY SAND	(GP) POORLY GRADED GRAVEL	

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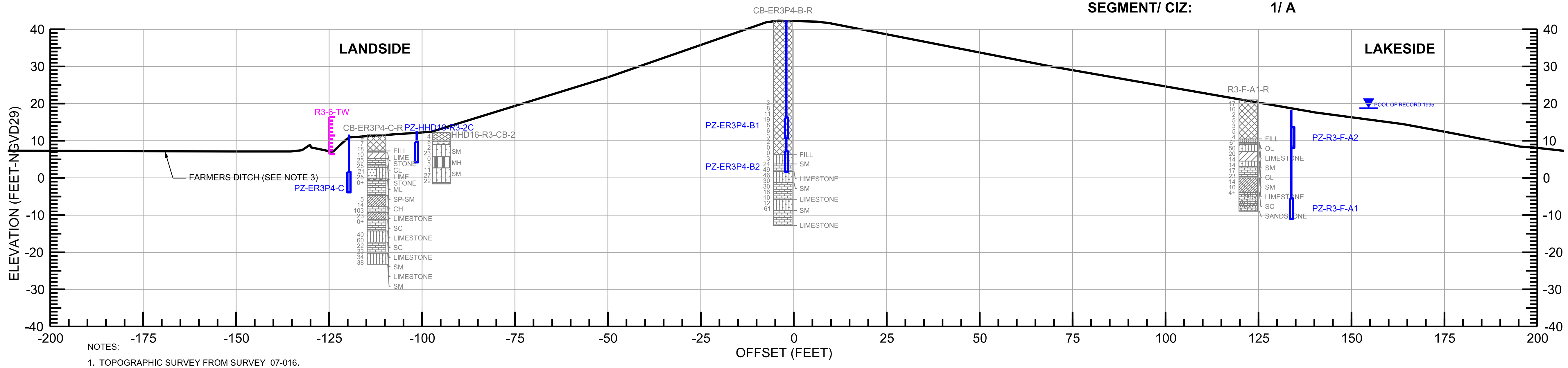
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R3-5

PIEZOMETER LINE DETAILS

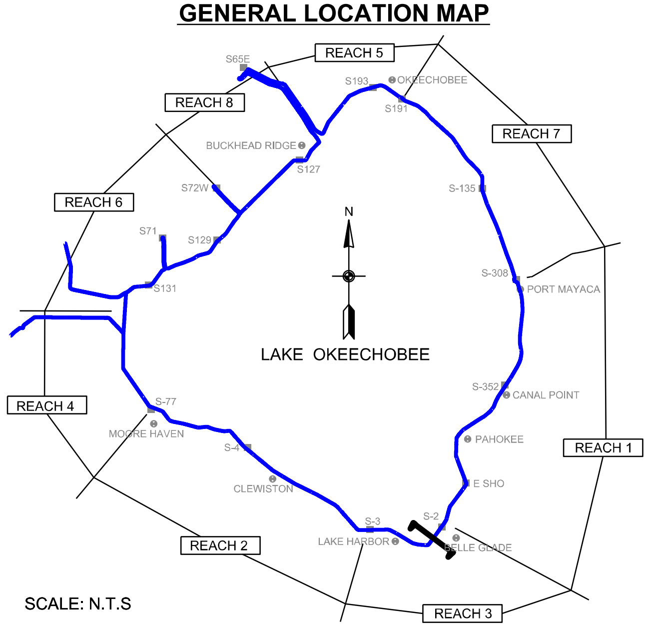
PIEZOMETER LINE:	R3-6
HHD STATION:	HHD 2610+00
LEVEE DESIGNATION:	L-D2 776+00
REACH:	3
SEGMENT/ CIZ:	1/ A



NOTES:

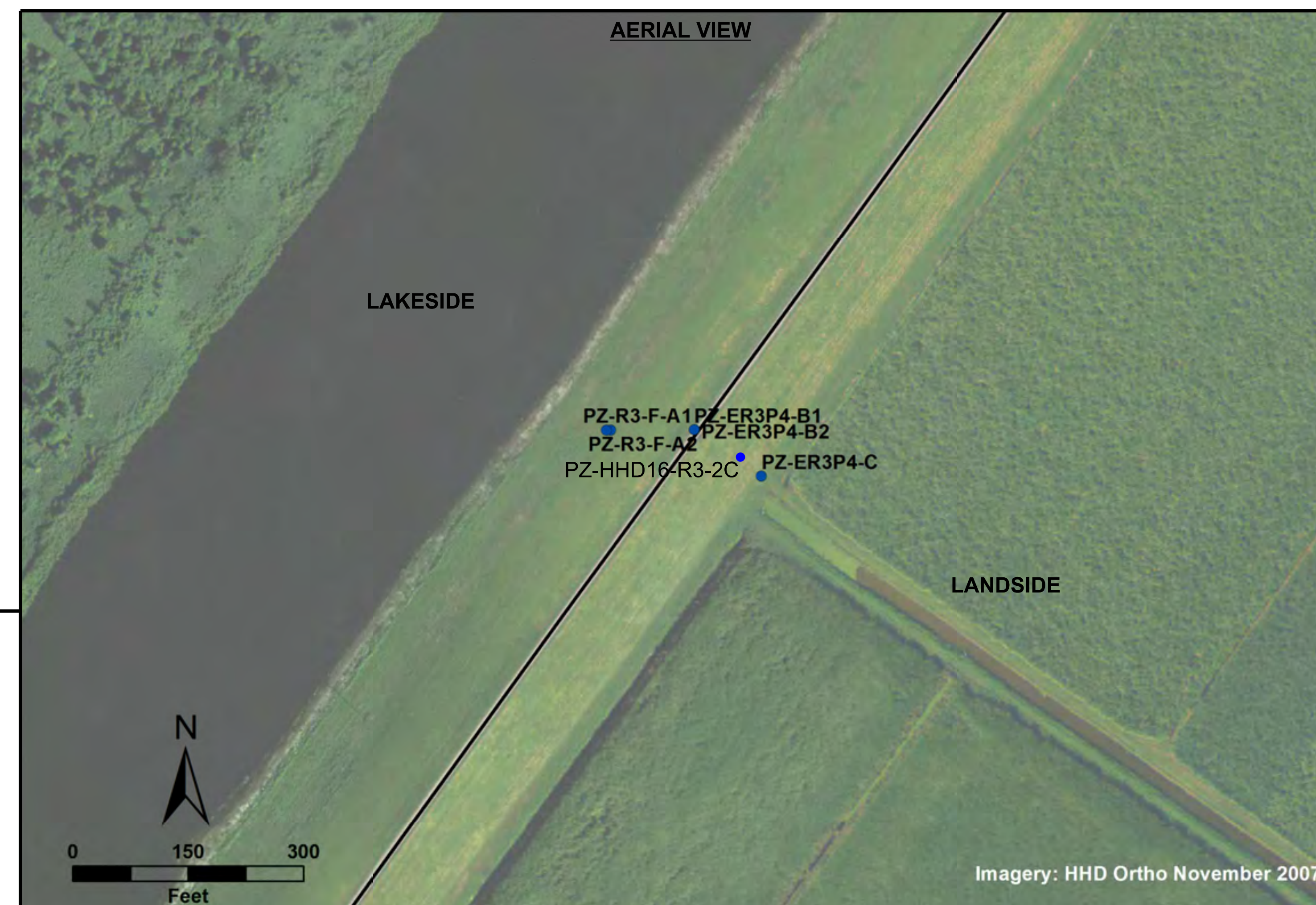
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM 09-127.
3. AT THIS CROSS SECTION, A FARMERS DITCH IS PERPENDICULAR TO HHD ALIGNMENT.

GENERAL LOCATION MAP

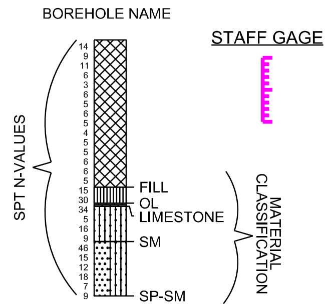


SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

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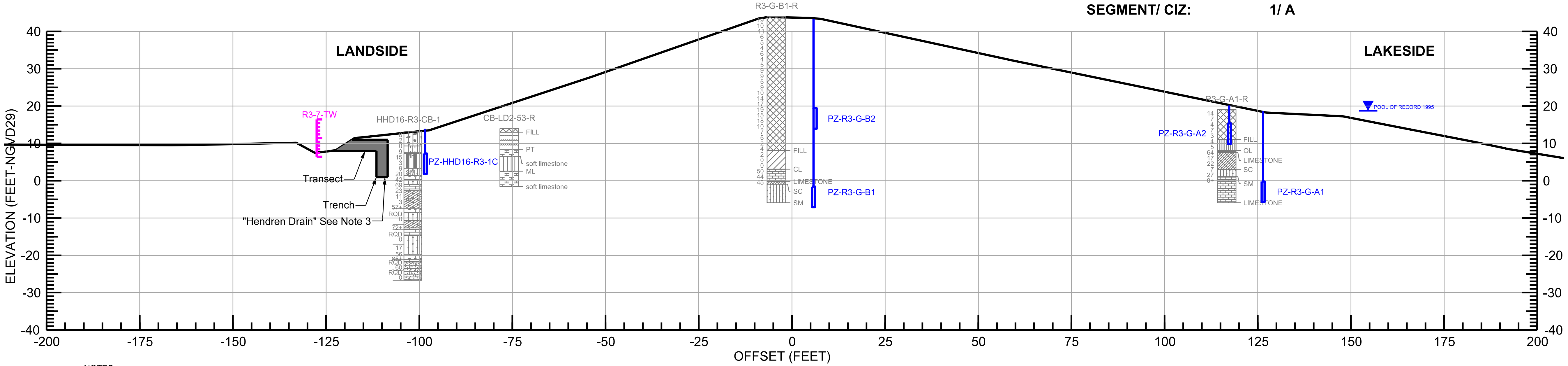
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R3-6

PIEZOMETER LINE DETAILS

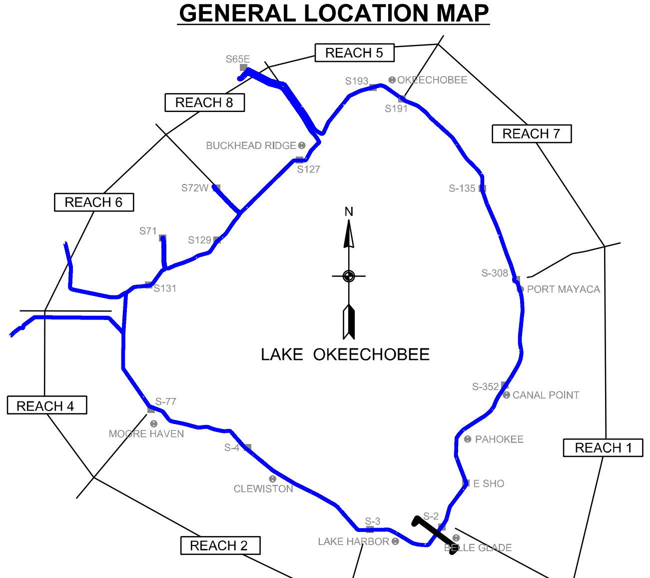
PIEZOMETER LINE:	R3-7
HHD STATION:	HHD 2586+00
LEVEE DESIGNATION:	L-D2 800+00
REACH:	3
SEGMENT/ CIZ:	1/ A



NOTES:

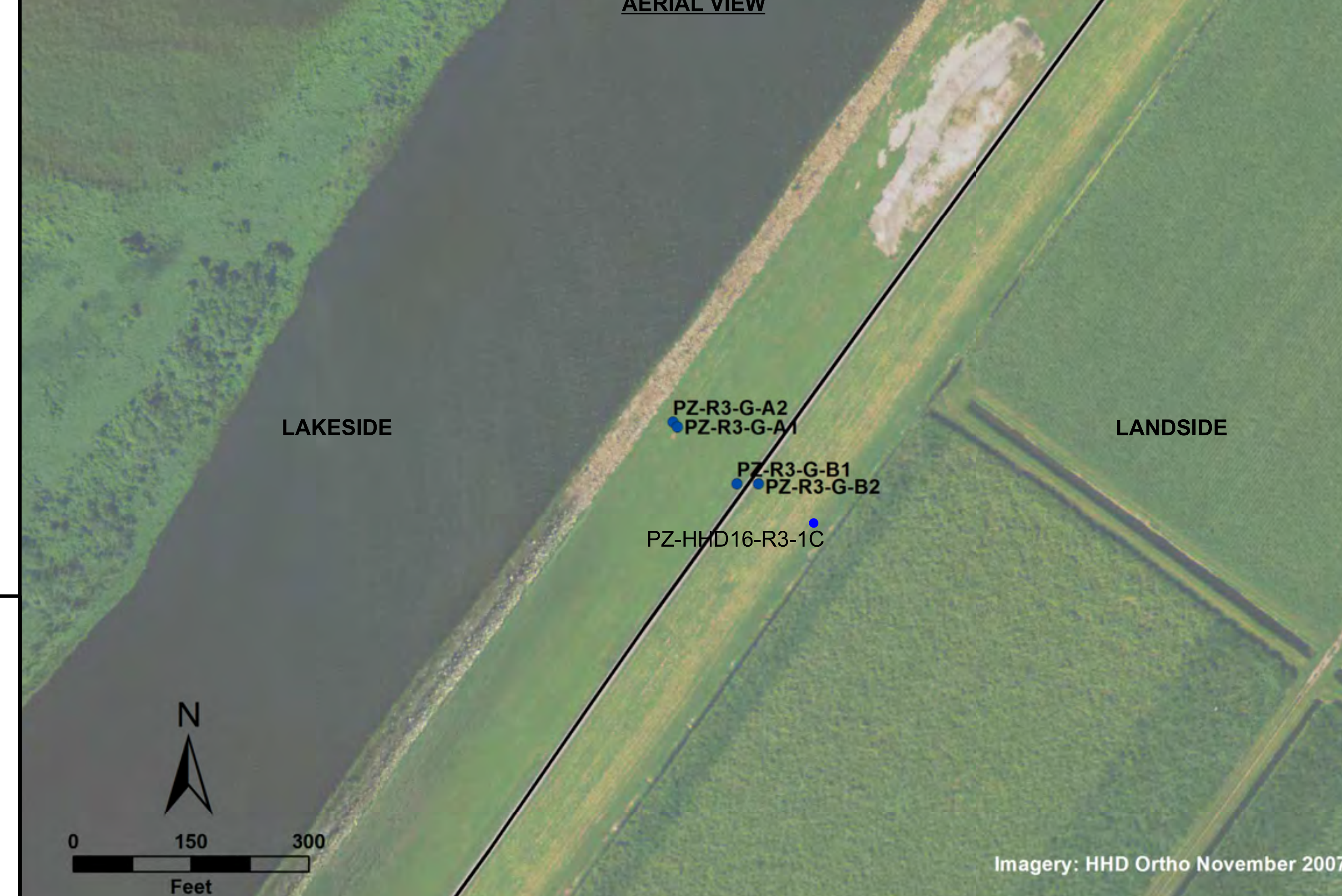
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM 09-127.
3. THE HENDREN DRAIN IS AN EMERGENCY DRAINAGE SYSTEM THAT WAS CONSTRUCTED IN SEGMENT 1 FROM STA. 2584+00 TO STA. 2621+00. THE DRAIN INCLUDES A CONTINUOUS TRENCH AND TRANSECT DRAINS THAT CONSIST OF NO. 57 STONE WRAPPED IN GEOTEXTILE. TRENCH AND TRANSECTS ARE 3' WIDE. TRANSECTS OUTFALL EVERY 75'.

GENERAL LOCATION MAP

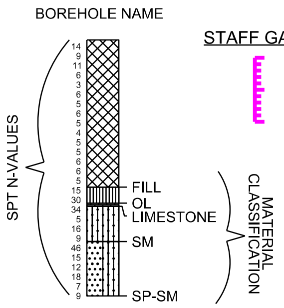


SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

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- (SP-SM) POORLY GRADED SILTY SAND
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- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
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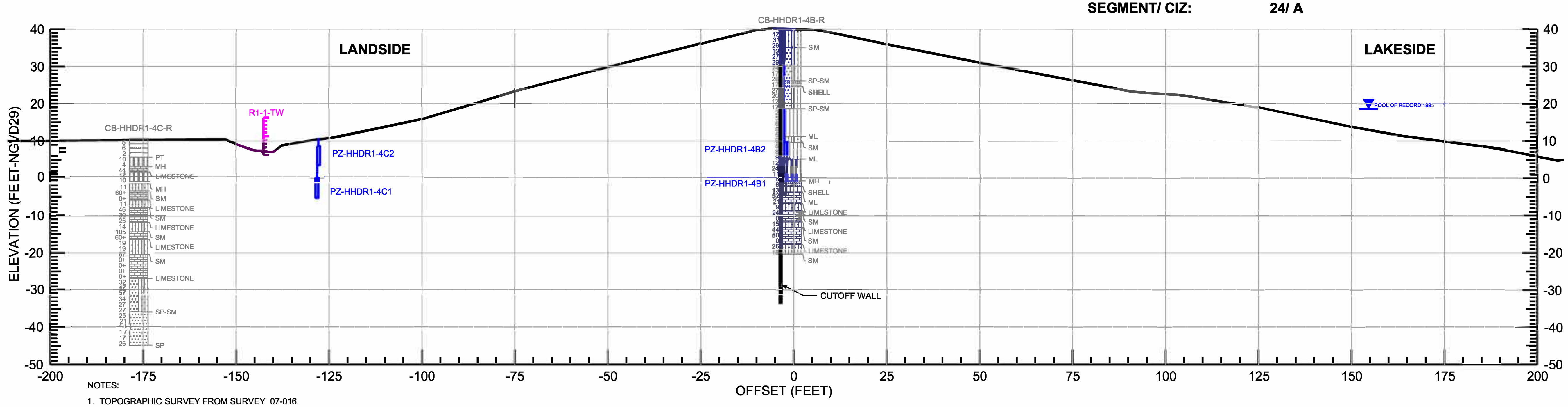
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R3-7

PIEZOMETER LINE DETAILS

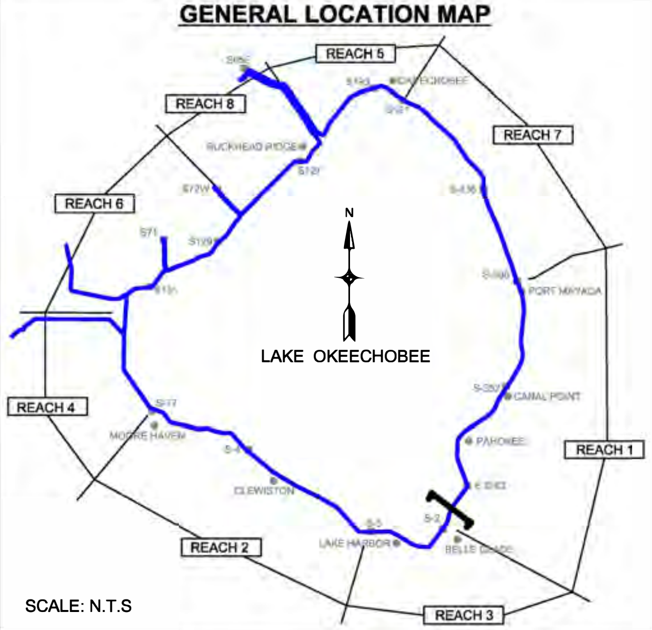
PIEZOMETER LINE:	R1-1
HHD STATION:	HHD 2438+00
LEVEE DESIGNATION:	L-D2 948+00
REACH:	1D
SEGMENT/ CIZ:	24/ A



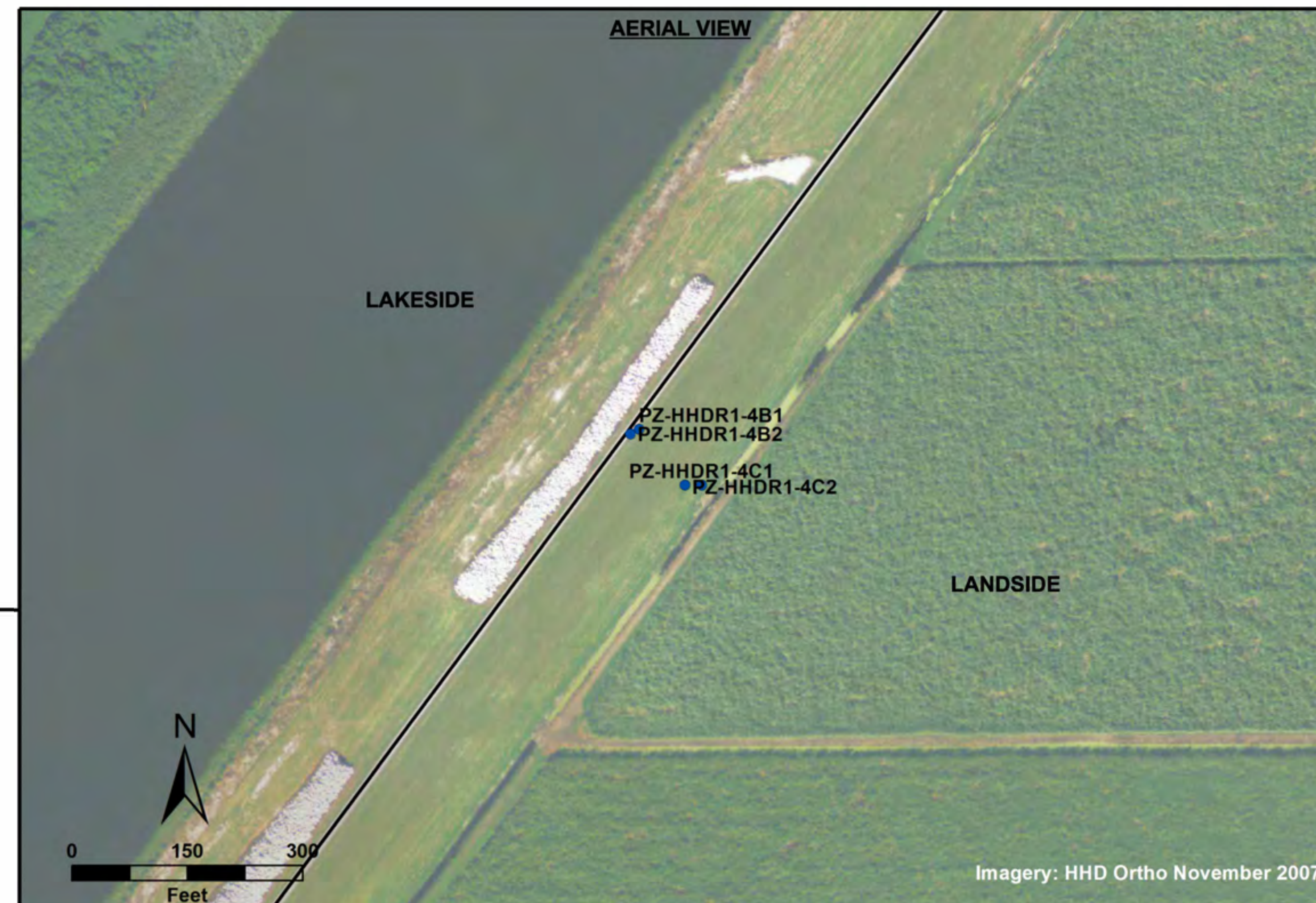
NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. BORING CB-HHDR1-4C-R IS 450 FEET SOUTH OF PROFILE LINE. BORINGS CB-HHDR1-4B-R IS 160 FEET NORT OF PROFILE LINE.
4. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) NOVEMBER 2009

GENERAL LOCATION MAP



AERIAL VIEW



BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN. L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL	(OL) ORGANIC SILT	(ML) SILT
LIMESTONE	(OH) ORGANIC CLAY	(CH) FAT CLAY
(SS) SANDSTONE	(PT) PEAT	(CL) LEAN CLAY
(SM) SILTY SAND	(SH) SHELL	(MH) ELASTIC SILT
(SP) POORLY GRADED SAND	(SC) CLAYEY SAND	
(SP-SM) POORLY GRADED SILTY SAND	(GP) POORLY GRADED GRAVEL	

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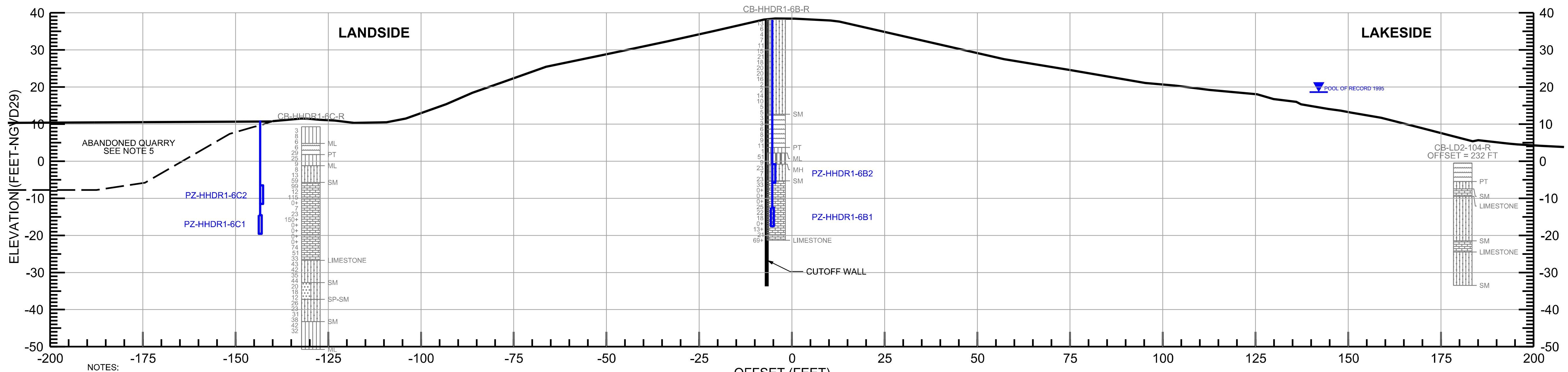
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-1

PIEZOMETER LINE DETAILS

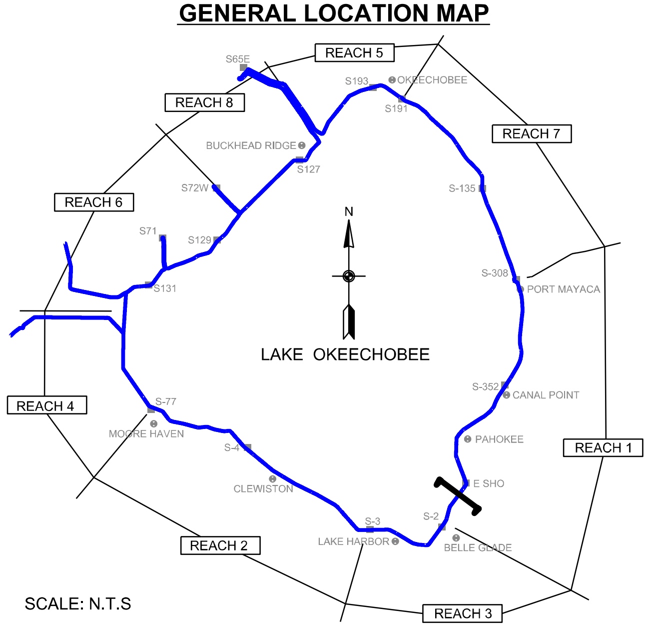
PIEZOMETER LINE:	R1-2
HHD STATION:	HHD 2380+50
LEVEE DESIGNATION:	L-D2 1006+00
REACH:	1D
SEGMENT/ CIZ:	24/A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. BORINGS CB-HHDR1-6D-R, CB-LD2-105-R AND 104-R ARE APPROXIMATELY 450 FT. NORTH OF PZ LINE.
4. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) APRIL 2010.
5. ABANDONED QUARRY BACKFILLED TO GRADE 2010/2011.

GENERAL LOCATION MAP



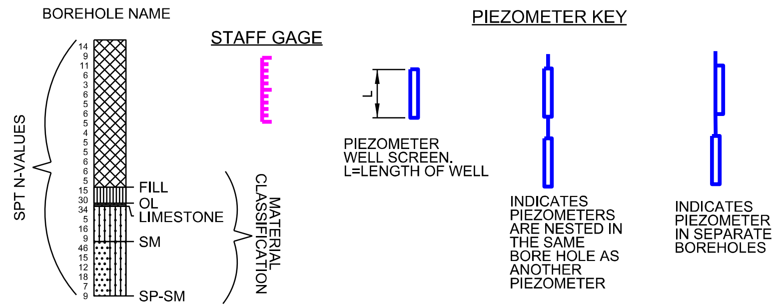
SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

STAFF GAGE

PIEZOMETER KEY



MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
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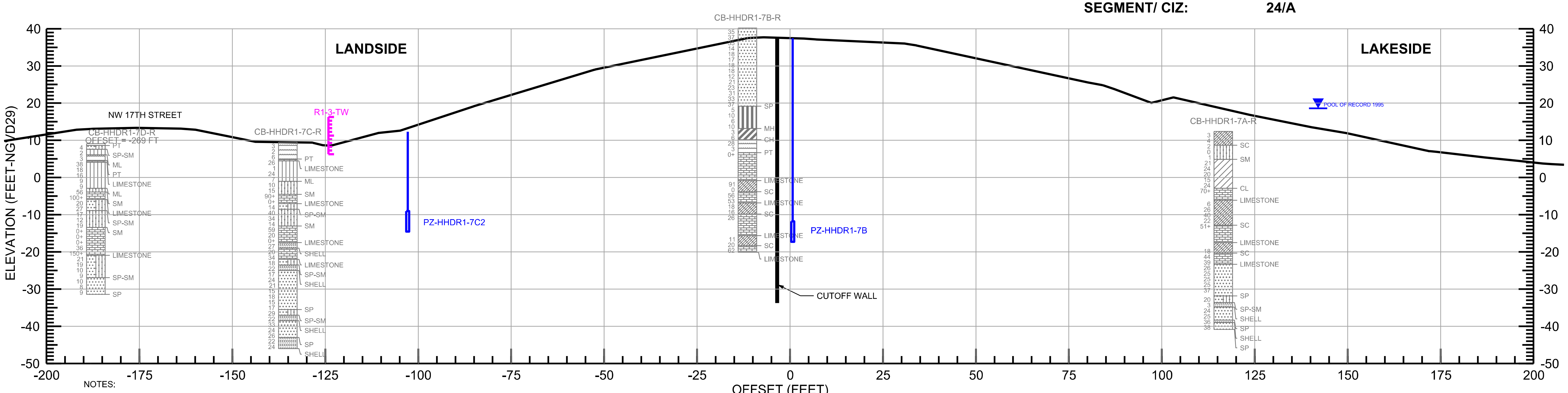
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-2

PIEZOMETER LINE DETAILS

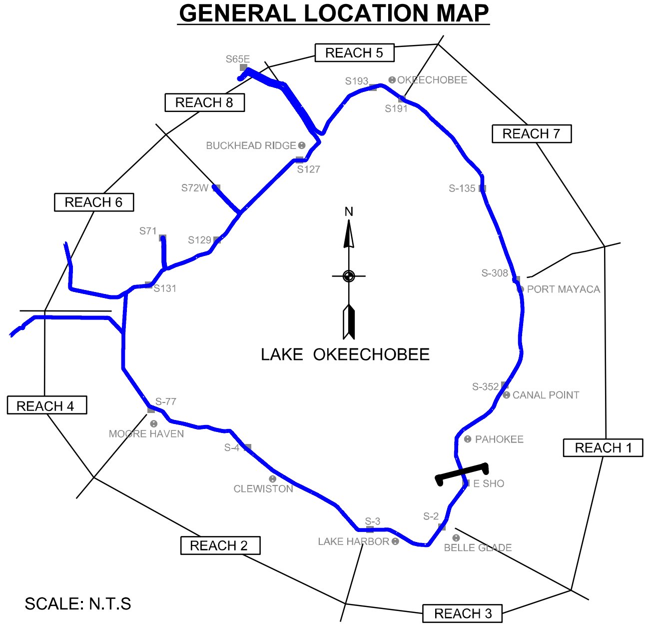
PIEZOMETER LINE:	R1-3
HHD STATION:	HHD 2318+00
LEVEE DESIGNATION:	L-D2 1070+00
REACH:	1D
SEGMENT/ CIZ:	24/A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) AUGUST 2011

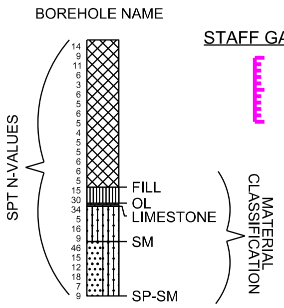
GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
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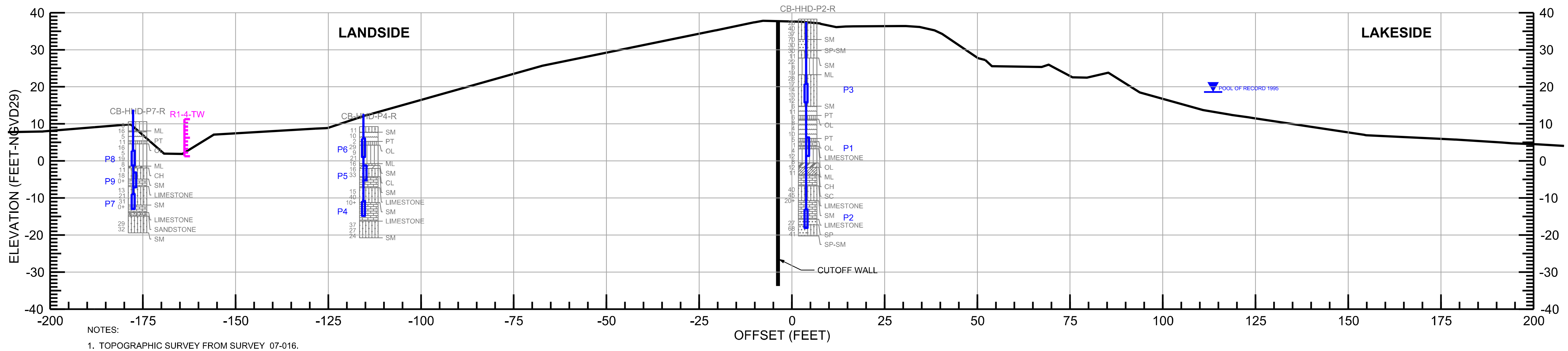
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-3

PIEZOMETER LINE DETAILS

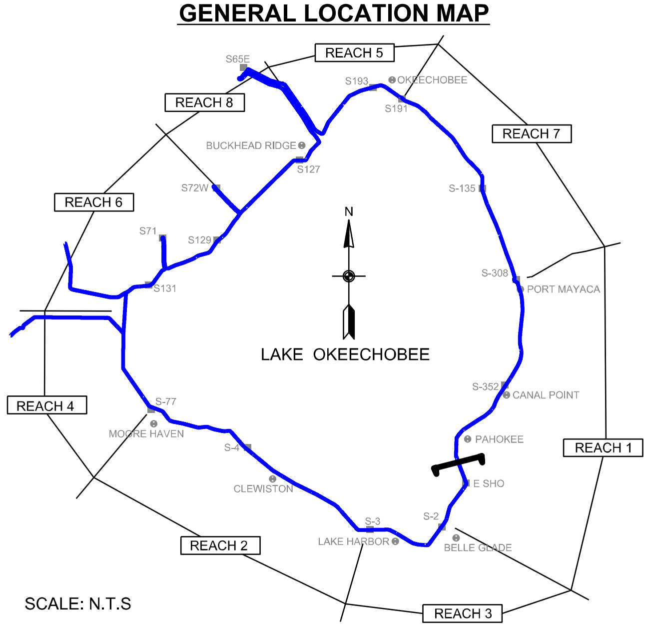
PIEZOMETER LINE:	R1-4
HHD STATION:	HHD 2264+00
LEVEE DESIGNATION:	L-D2 1124+00
REACH:	1D
SEGMENT/CIZ:	24/A



NOTES:

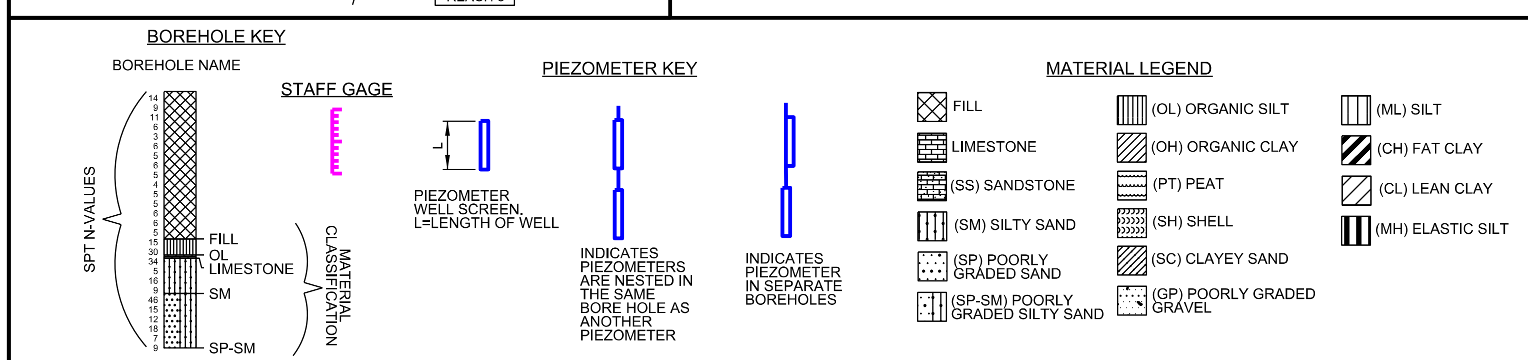
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) AUGUST 2009.
4. BORING LOG CB-HHD-P2-R NOTES A "CAVITY" WITHIN THE SCREENED ZONE OF P1.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



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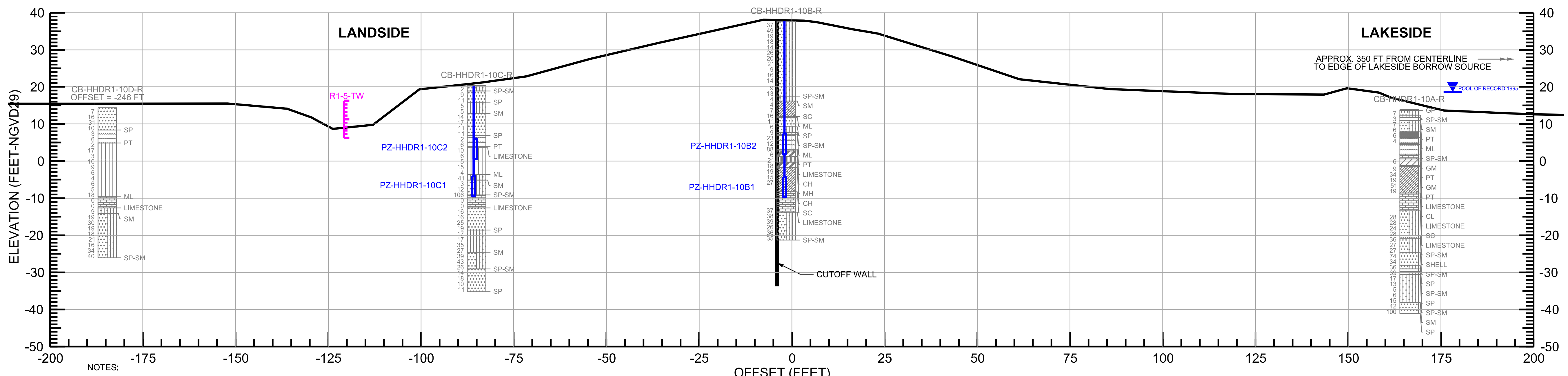
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-4

PIEZOMETER LINE DETAILS

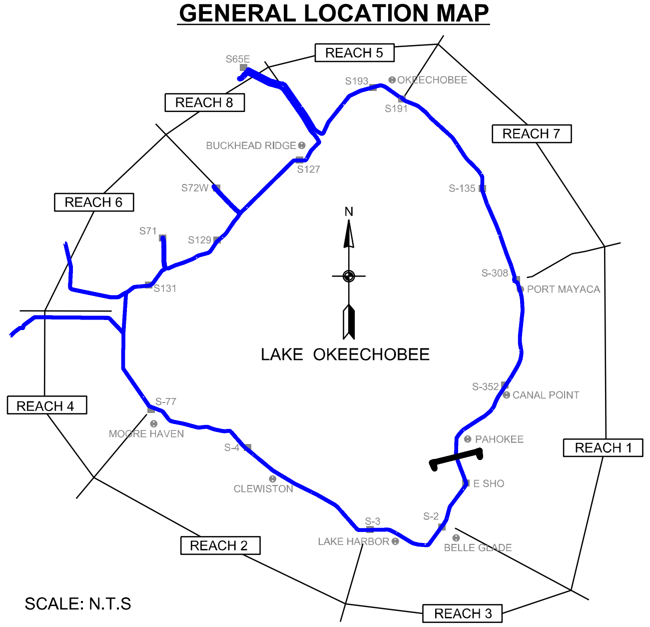
PIEZOMETER LINE:	R1-5
HHD STATION:	HHD 2228+00
LEVEE DESIGNATION:	L-D2 1160+00
REACH:	1D
SEGMENT/ CIZ:	24/A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) MAY 2009.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL

OL

LIMESTONE

SM

SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
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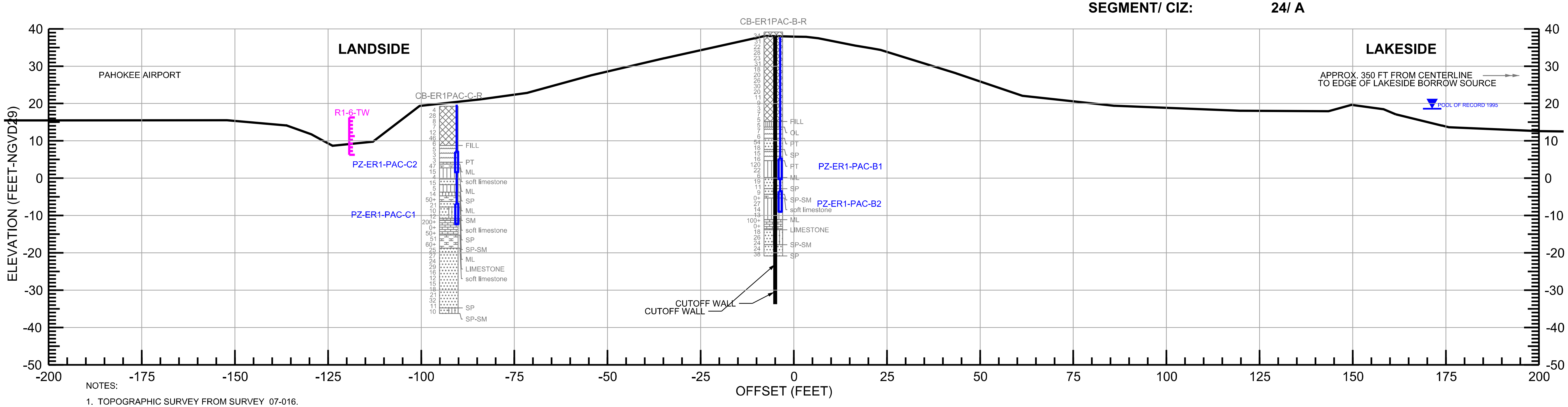
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-5

PIEZOMETER LINE DETAILS

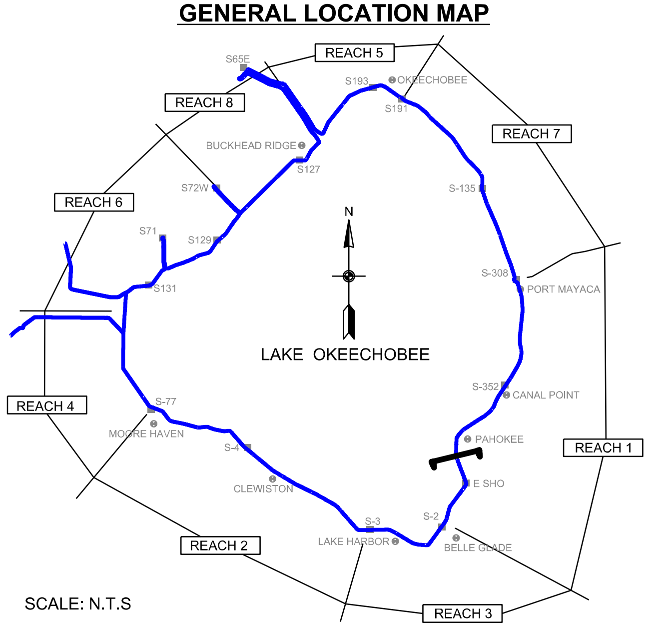
PIEZOMETER LINE:	R1-6
HHD STATION:	HHD 2222+00
LEVEE DESIGNATION:	L-D2 1166+00
REACH:	1D
SEGMENT/ CIZ:	24/ A



NOTES:

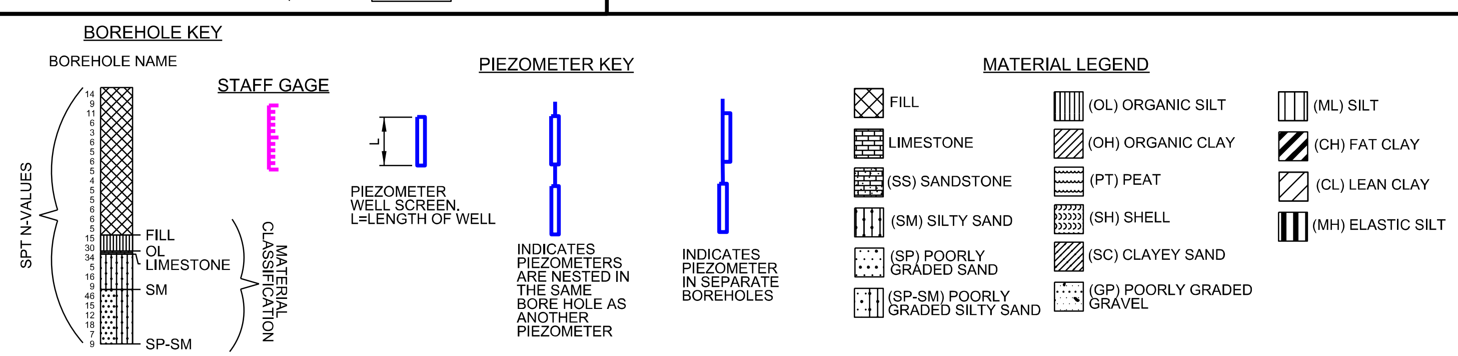
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) MAY 2009.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



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INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-6

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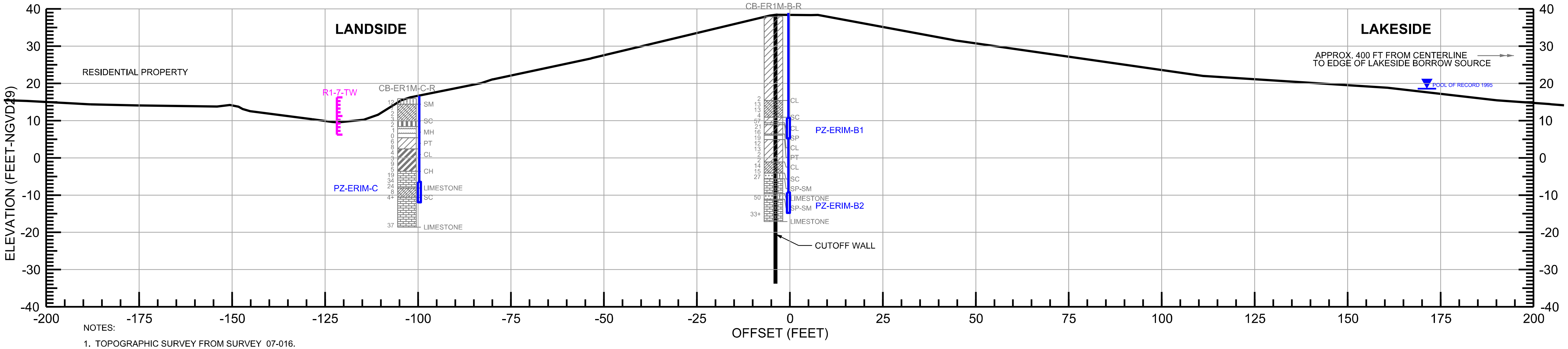
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-7

PIEZOMETER LINE DETAILS

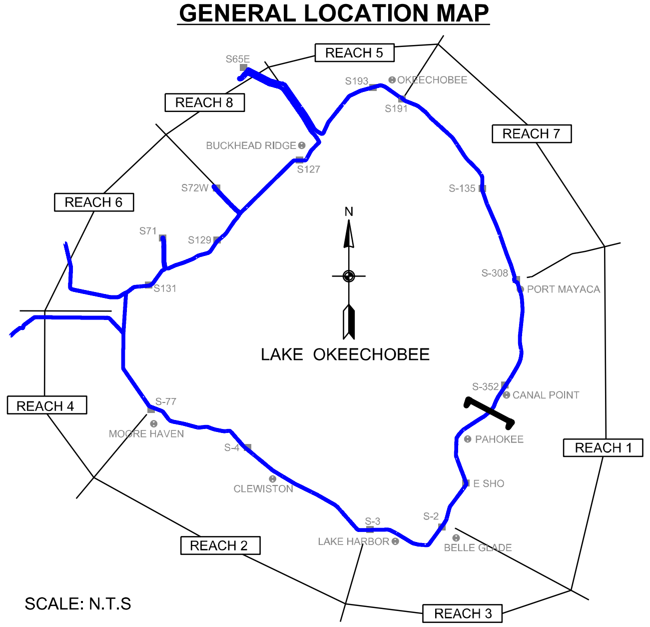
PIEZOMETER LINE:	R1-7
HHD STATION:	HHD 1968+00
LEVEE DESIGNATION:	L-D9 199+00
REACH:	1C
SEGMENT/ CIZ:	24/A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -35 (NAVD88) NOVEMBER 2011.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

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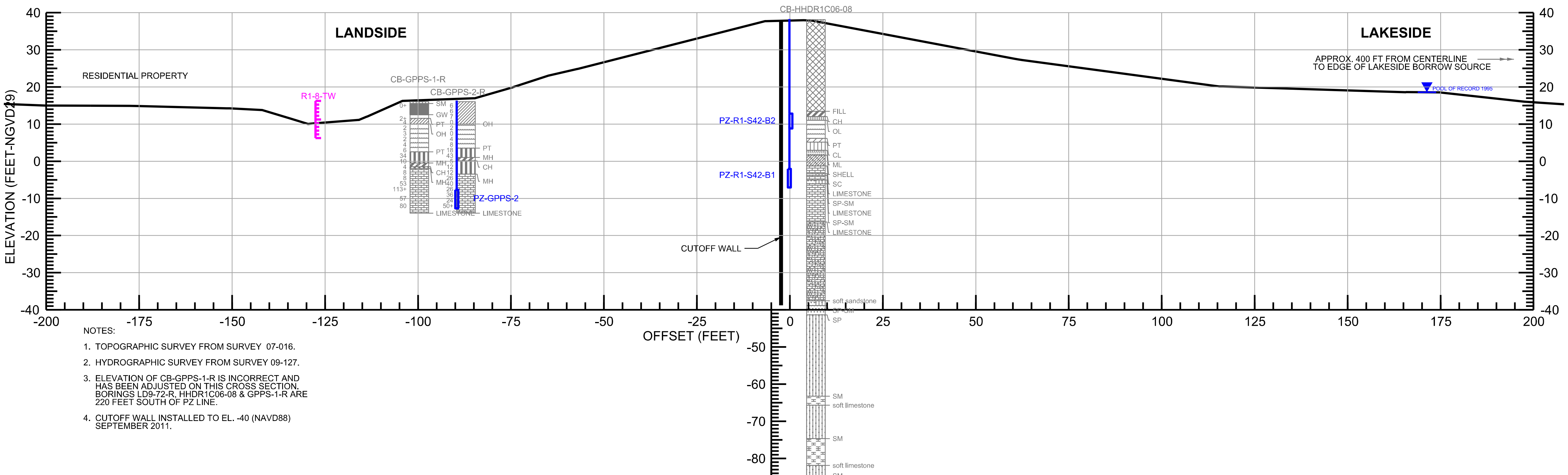
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

PIEZOMETER LINE DETAILS

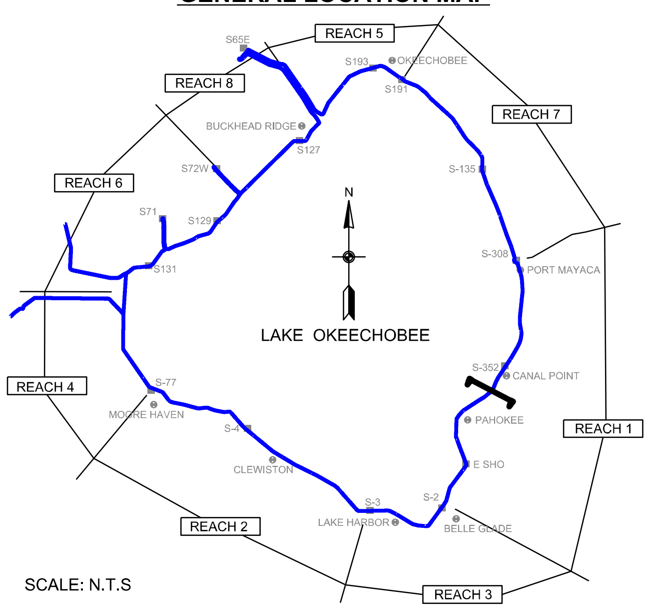
PIEZOMETER LINE:	R1-8
HHD STATION:	HHD 1936+00
LEVEE DESIGNATION:	L-D9 231+00
REACH:	1C
SEGMENT/ CIZ:	24/ A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. ELEVATION OF CB-GPPS-1-R IS INCORRECT AND HAS BEEN ADJUSTED ON THIS CROSS SECTION. BORINGS LD9-72-R, HHDR1C06-08 & GPPS-1-R ARE 220 FEET SOUTH OF PZ LINE.
4. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) SEPTEMBER 2011.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL, OL, LIMESTONE, SM, SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

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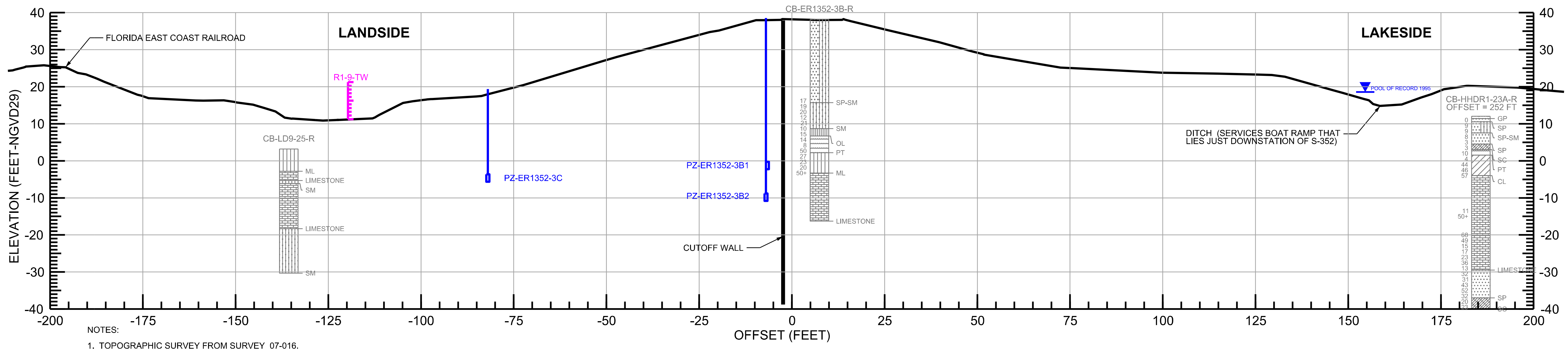
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-8

PIEZOMETER LINE DETAILS

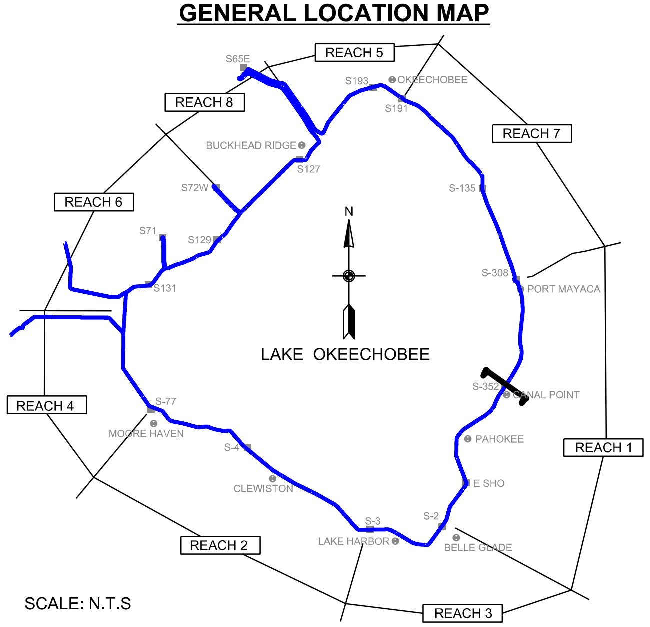
PIEZOMETER LINE:	R1-9
HHD STATION:	HHD 1837+00
LEVEE DESIGNATION:	L-D9 330+00
REACH:	1B
SEGMENT/ CIZ:	23/ A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. ALL BORINGS EXCEPT CB-ER1352-3B-R ARE 400 FEET SOUTH OF THE PZ LINE.
4. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) AUGUST 2012. THE CUTOFF WALL TERMINATES FOR THE S-352 GAP AT STA 1836+50; THEREFORE, THE CUTOFF WALL TERMINATES APPROXIMATELY 350 FEET BEYOND THIS PIEZOMETER LINE.

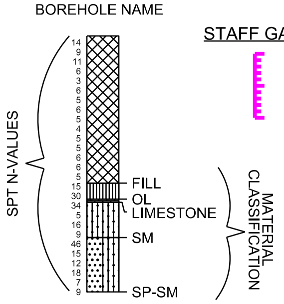
GENERAL LOCATION MAP



SCALE: N.T.S

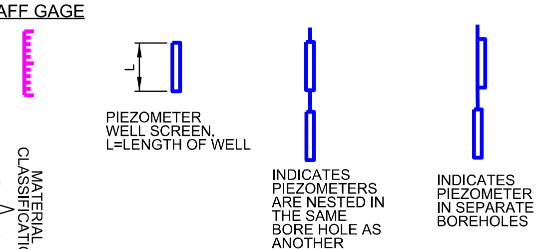
AERIAL VIEW

BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY



MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

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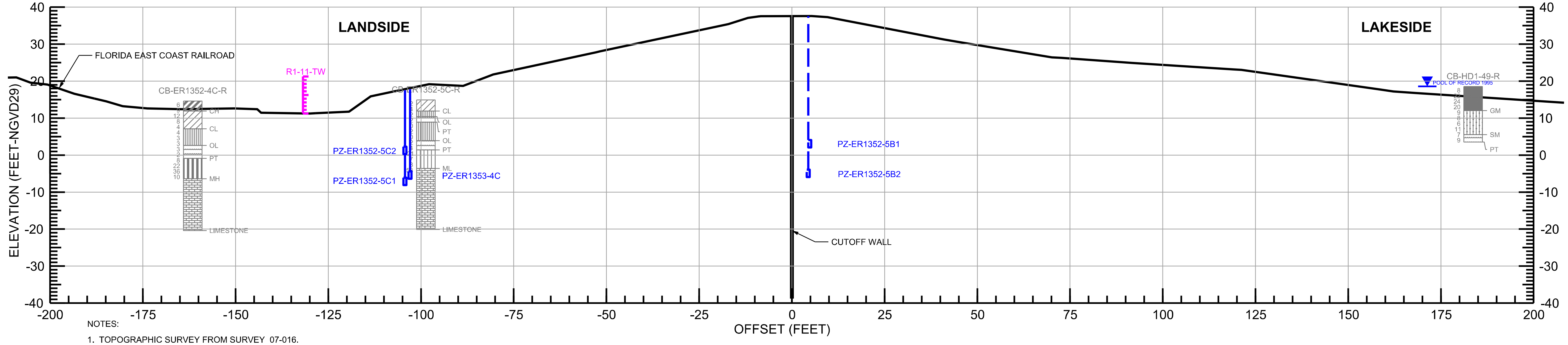
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-9

PIEZOMETER LINE DETAILS

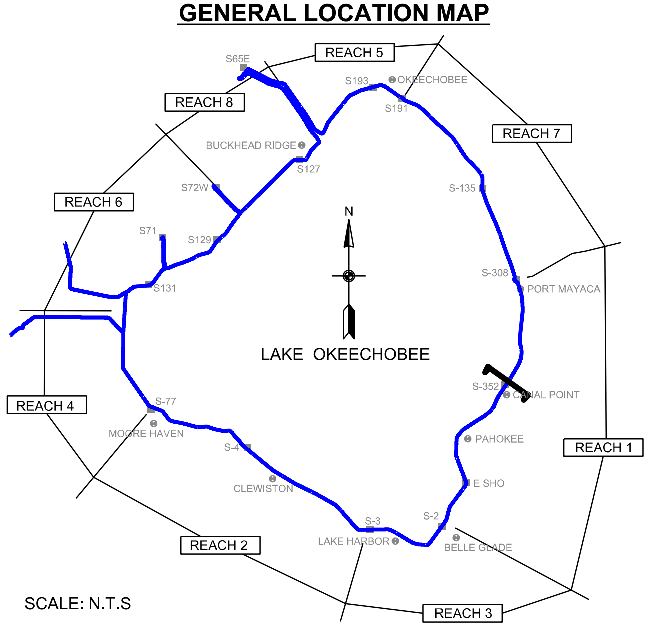
PIEZOMETER LINE: R1-11
HHD STATION: HHD 1818+00
LEVEE DESIGNATION: L-D9 349+00
REACH: 1B
SEGMENT/ CIZ: 23/ A



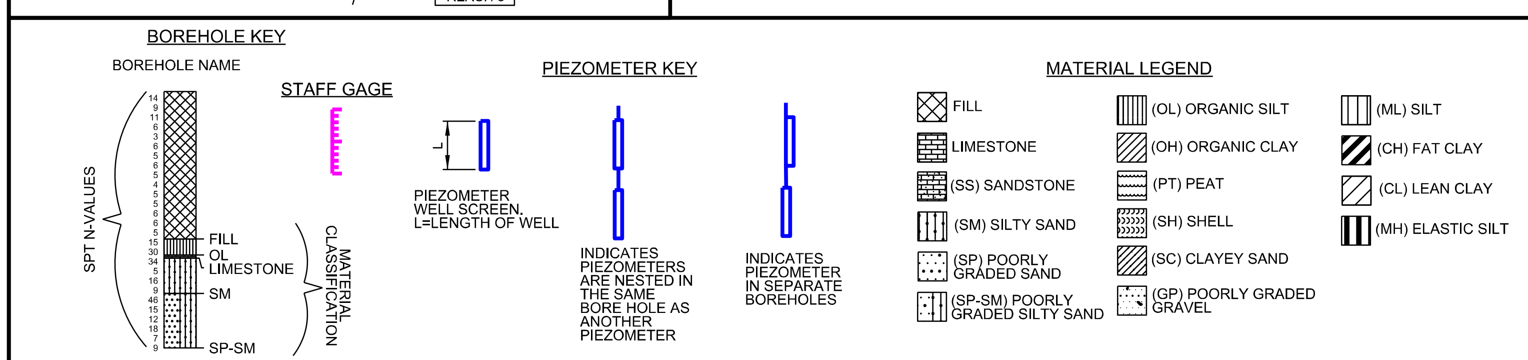
NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. PZ-ER1352-5B1 & PZ-ER1352-5B2 WERE REMOVED DURING CUTOFF WALL INSTALLATION.
4. PZ-ER1353-4C IS APPROXIMATELY 550 FT SW OF PZ LINE.
5. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) JUNE 2012.
6. PIEZOMETERS PZ-ER1352-5B1 and PZER1352-5B2 were decommissioned on 12/7/2011

GENERAL LOCATION MAP



SCALE: N.T.S



AERIAL VIEW

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INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-11

PIEZOMETER LINE DETAILS

PIEZOMETER LINE:	R1-11A
HHD STATION:	HHD 1808+00
LEVEE DESIGNATION:	L-D9 359+00
REACH:	1B
SEGMENT/ CIZ:	23/ A

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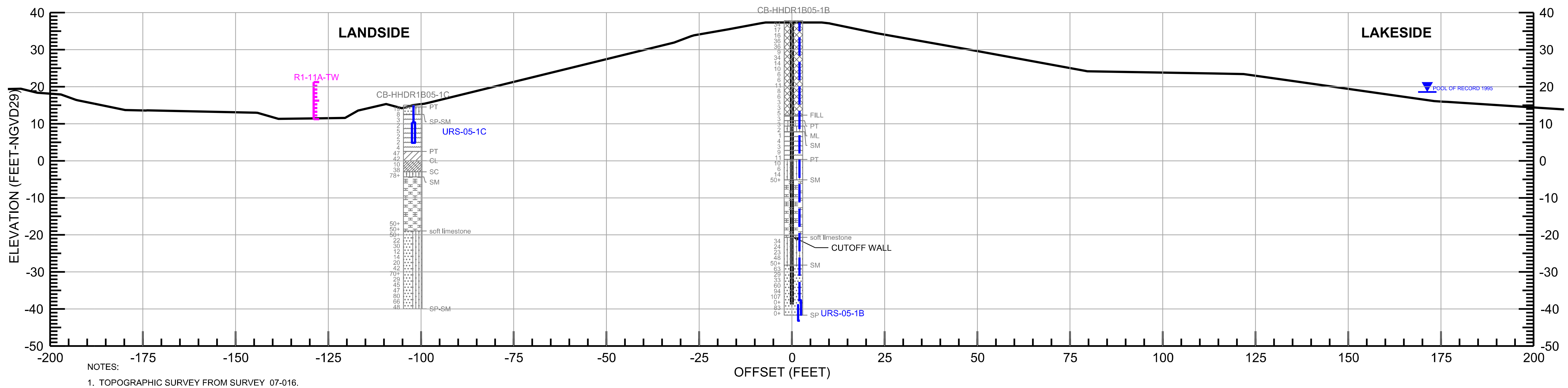
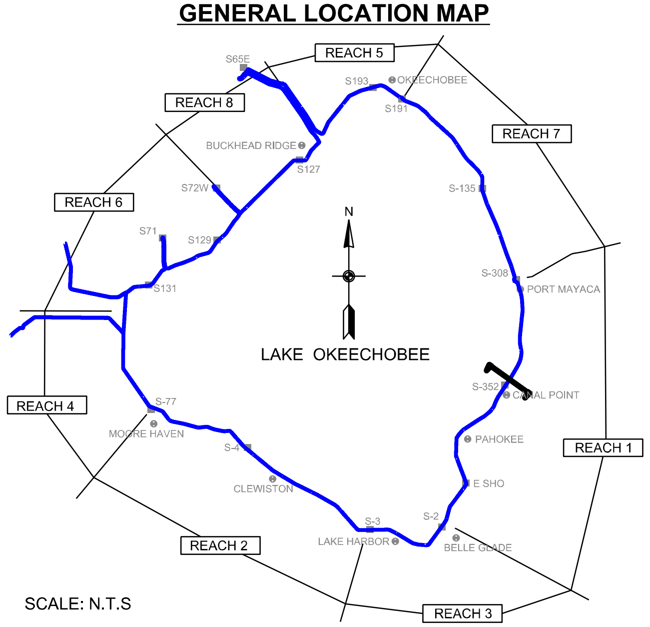


NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. PZ-URS-05-1B WAS REMOVED DURING CUTOFF WALL INSTALLATION.
4. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) APRIL 2012.5.
5. PIEZOMETER URS-05-1B was decommissioned on 12/07/2011

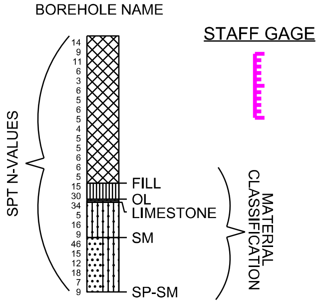
GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
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- (CL) LEAN CLAY
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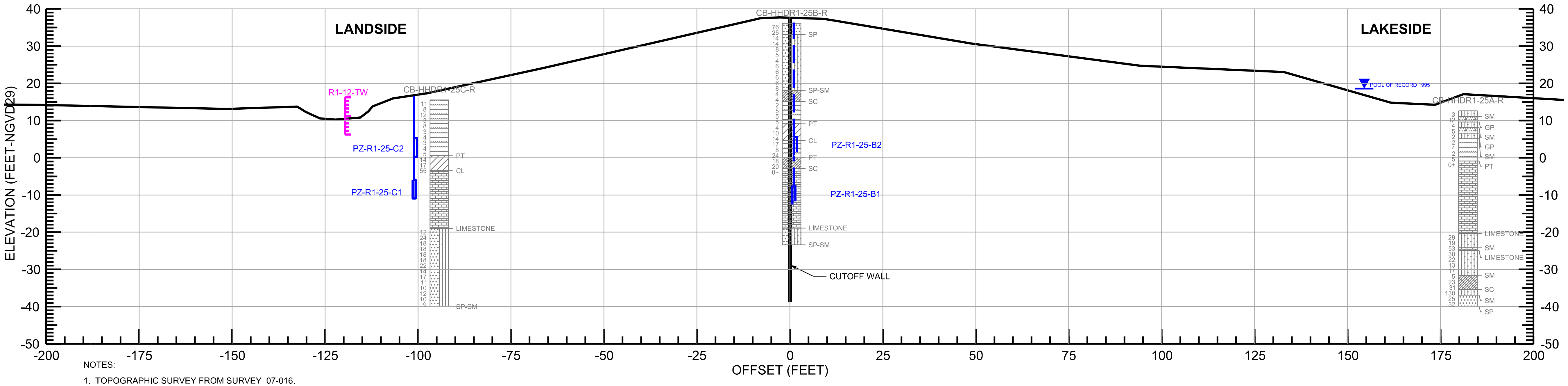
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-11A

PIEZOMETER LINE DETAILS

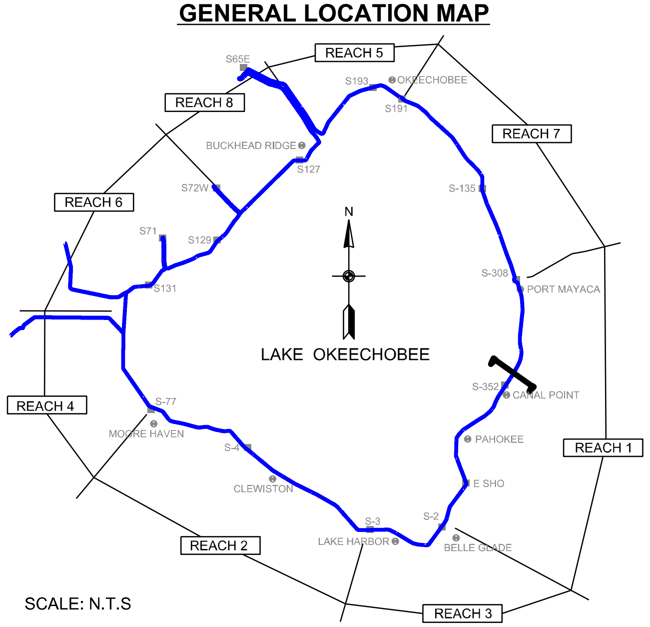
PIEZOMETER LINE:	R1-12
HHD STATION:	HHD 1718+00
LEVEE DESIGNATION:	L-D9 389+00
REACH:	1B
SEGMENT/ CIZ:	23/A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. PZ-R1-25-B1 & PZ-R1-25-B2 WERE REMOVED DURING CUTOFF WALL INSTALLATION
4. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) DECEMBER 2011.
5. PIEZOMETERS PZ-R1-25-B1 and PZ-R1-25-B2 were decommissioned on 09/16/2011

GENERAL LOCATION MAP

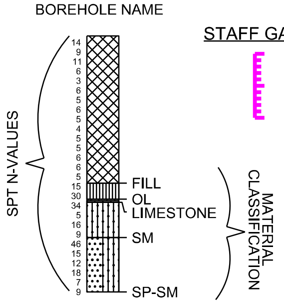


SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL	(OL) ORGANIC SILT	(ML) SILT
LIMESTONE	(OH) ORGANIC CLAY	(CH) FAT CLAY
(SS) SANDSTONE	(PT) PEAT	(CL) LEAN CLAY
(SM) SILTY SAND	(SH) SHELL	(MH) ELASTIC SILT
(SP) POORLY GRADED SAND	(SC) CLAYEY SAND	
(SP-SM) POORLY GRADED SILTY SAND	(GP) POORLY GRADED GRAVEL	

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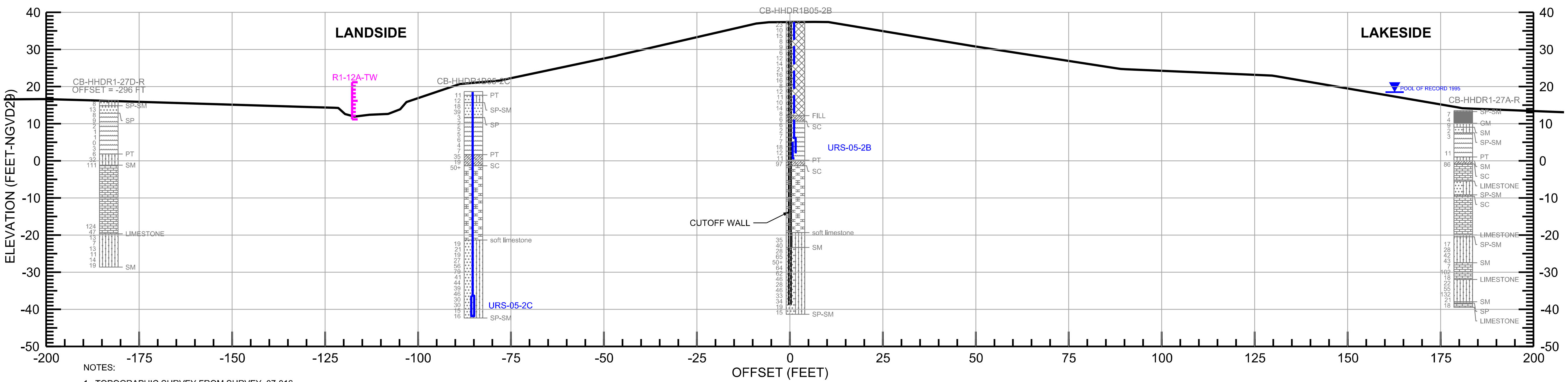
PIEZOMETER LINE CROSS SECTION

R1-12

PIEZOMETER LINE DETAILS

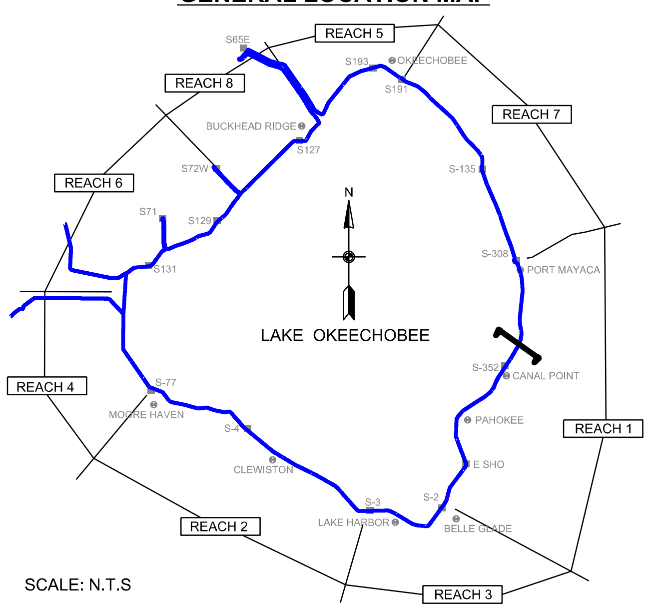
PIEZOMETER LINE:	R1-12A
HHD STATION:	HHD 1778+50
LEVEE DESIGNATION:	L-D9 449+00
REACH:	1B
SEGMENT/ CIZ:	23/ A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. PZ-URS-05-2B WAS REMOVED DURING CUTOFF WALL INSTALLATION.
4. CUTOFF WALL INSTALLED TO EL. -40 (NAVD88) MAY 2011.
5. PIEZOMETER URS-05-2B was decommissioned on 02/16/2011

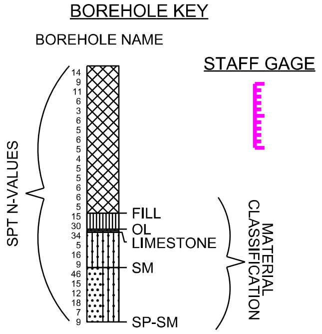
GENERAL LOCATION MAP



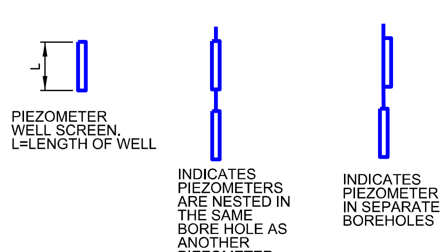
SCALE: N.T.S

AERIAL VIEW

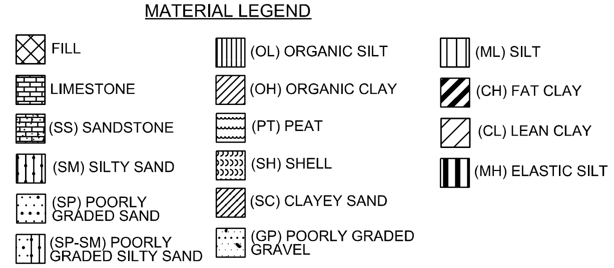
BOREHOLE KEY



PIEZOMETER KEY



MATERIAL LEGEND



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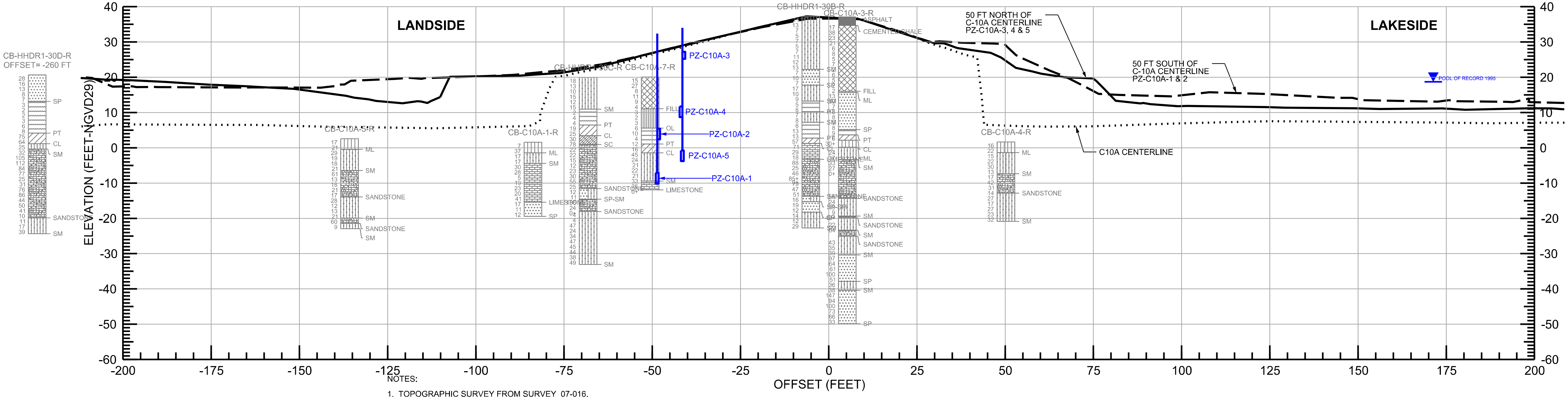
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-12A

PIEZOMETER LINE DETAILS

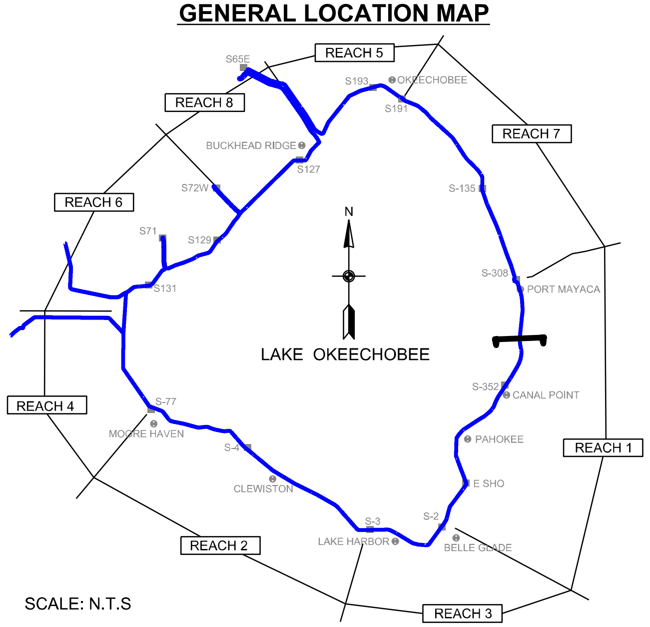
PIEZOMETER LINE:	R1-13
HHD STATION:	HHD 1628+50
LEVEE DESIGNATION:	L-D9 540+00
REACH:	1A/B
SEGMENT/ CIZ:	22-23/ A



NOTES:

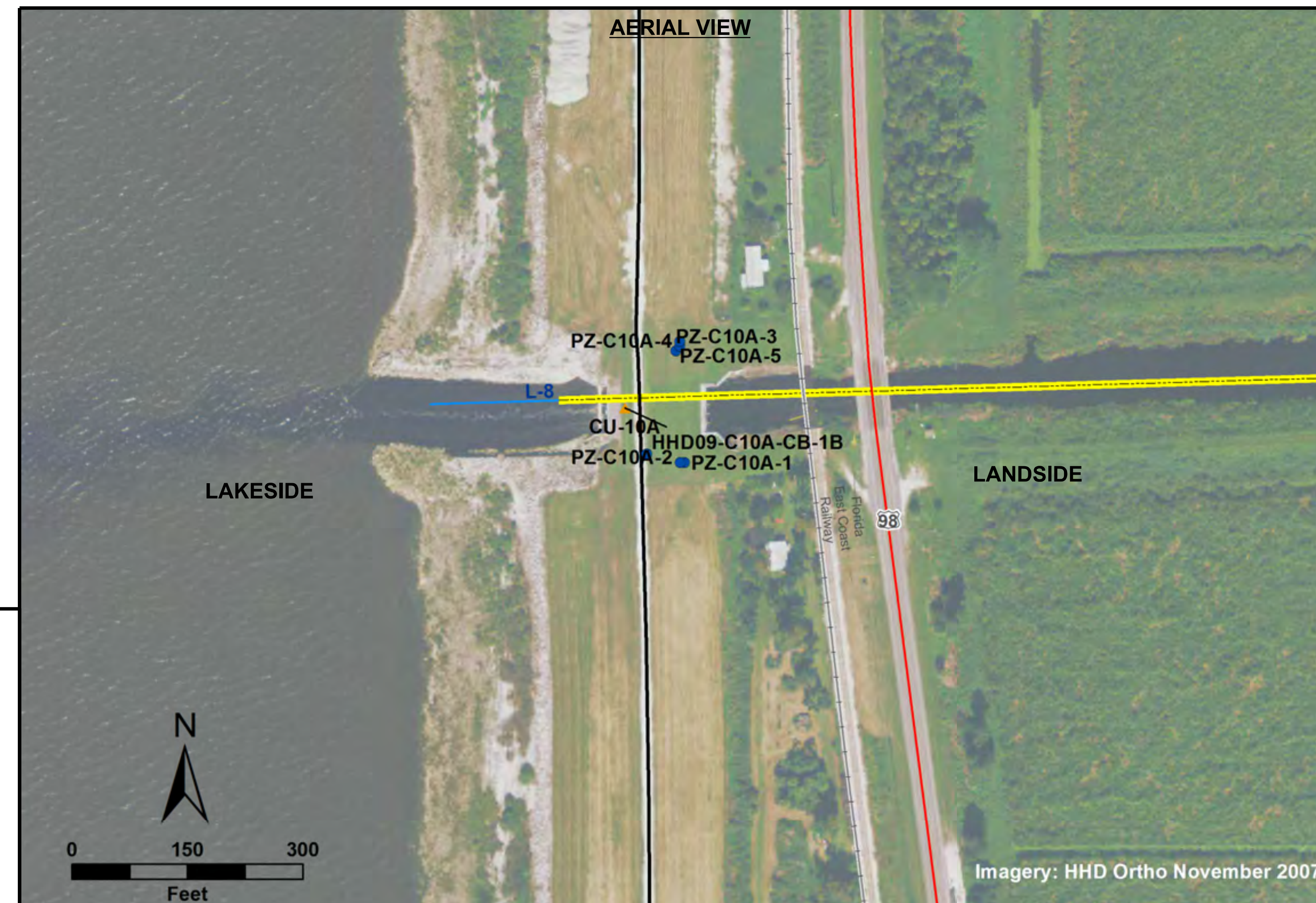
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -30 (NAVD88) AND TERMINATES +/- 500 FEET FROM CENTERLINE OF CULVERT. SOUTH OF CULVERT, CUTOFF WALL INSTALLED XX 20XX. NORTH OF CULVERT, CUTOFF WALL INSTALLED XX 20XX.
4. BORINGS AND PIEZOMETERS ARE PROJECTED TO THE CENTERLINE OF THE CULVERT.

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

FILL
OL
LIMESTONE
SM
SP-SM

MATERIAL CLASSIFICATION

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL	(OL) ORGANIC SILT	(ML) SILT
LIMESTONE	(OH) ORGANIC CLAY	(CH) FAT CLAY
(SS) SANDSTONE	(PT) PEAT	(CL) LEAN CLAY
(SM) SILTY SAND	(SH) SHELL	(MH) ELASTIC SILT
(SP) POORLY GRADED SAND	(SC) CLAYEY SAND	
(SP-SM) POORLY GRADED SILTY SAND	(GP) POORLY GRADED GRAVEL	

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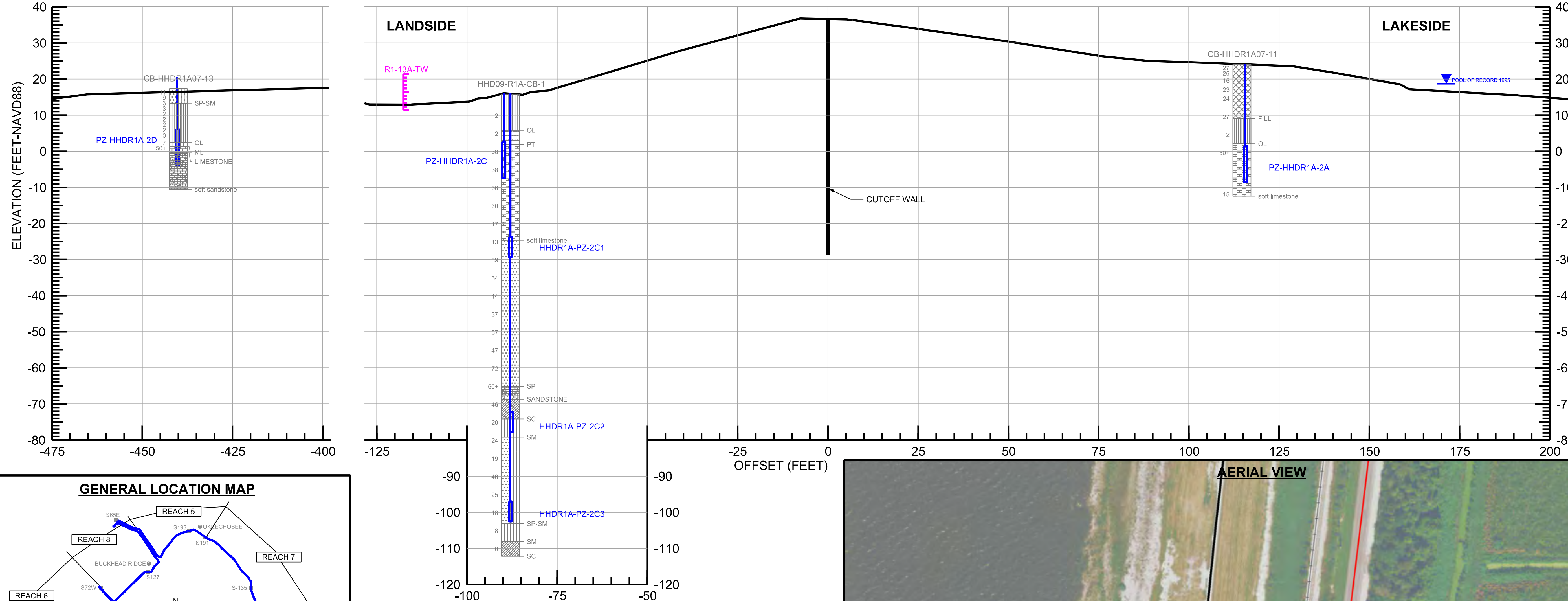
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-13

PIEZOMETER LINE DETAILS

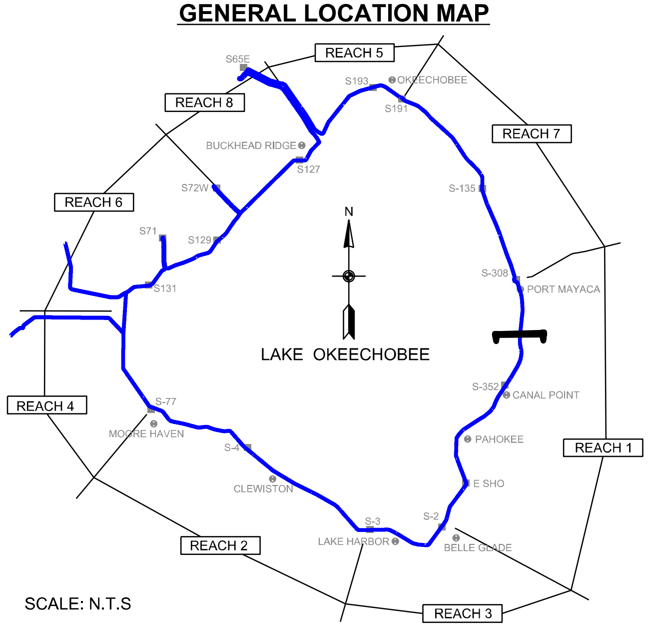
PIEZOMETER LINE:	R1-13A
HHD STATION:	HHD 1612+00
LEVEE DESIGNATION:	L-D9 557+00
REACH:	1A
SEGMENT/ CIZ:	22/ A



NOTES:

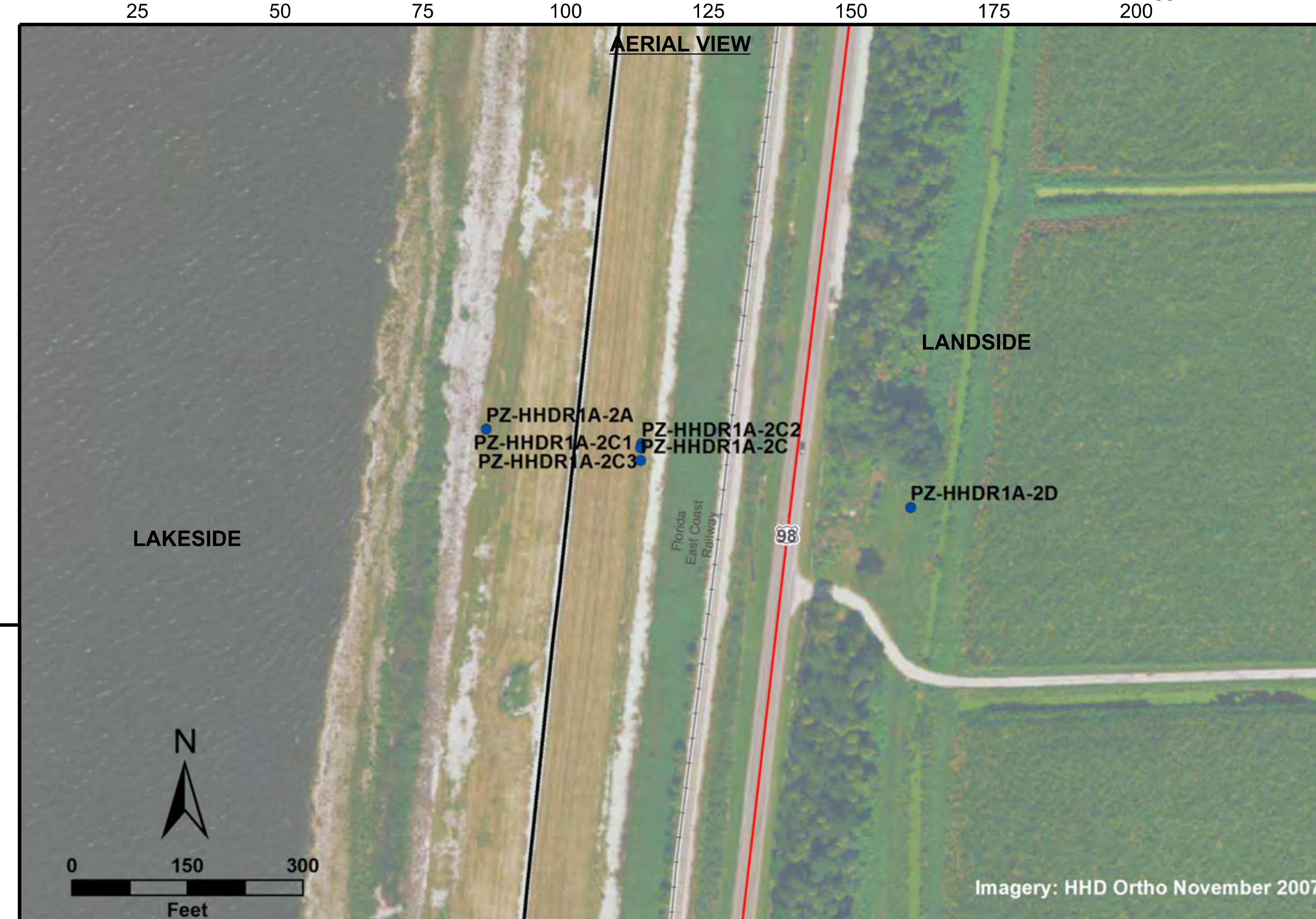
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -30 (NAVD88) AUGUST 2011.
4. PIEZOMETER PZ-HHDR1A-2C was decommissioned on 07/09/2013

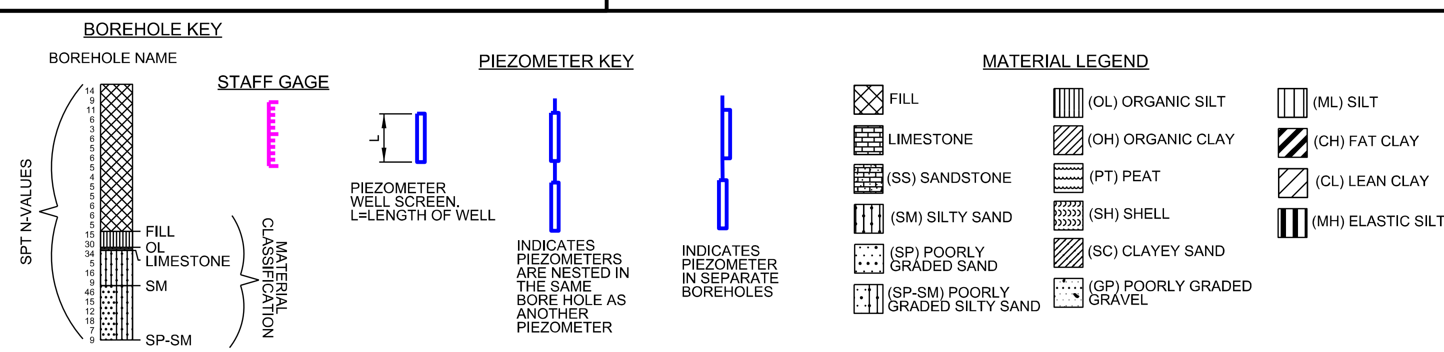
GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW





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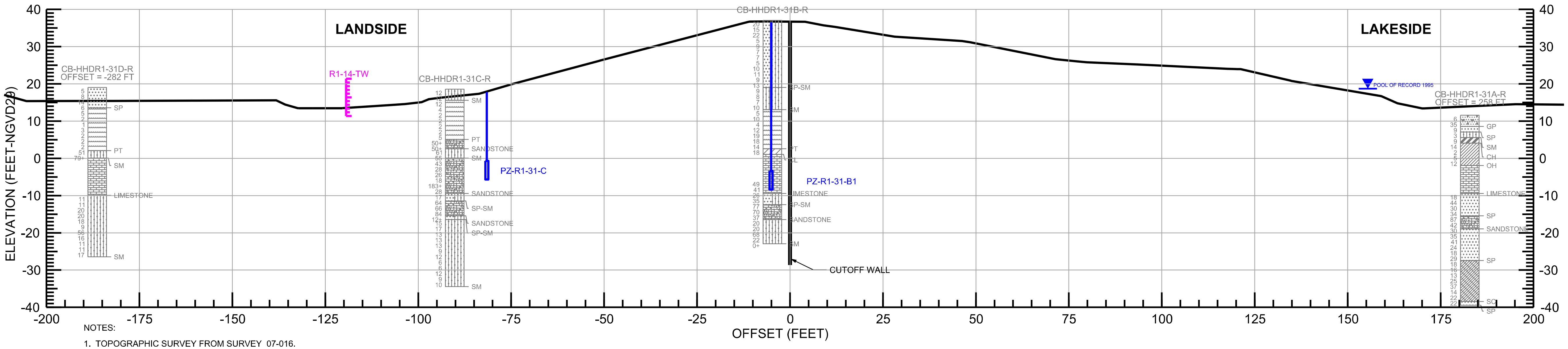
PIEZOMETER LINE CROSS SECTION

R1-13A

PIEZOMETER LINE DETAILS

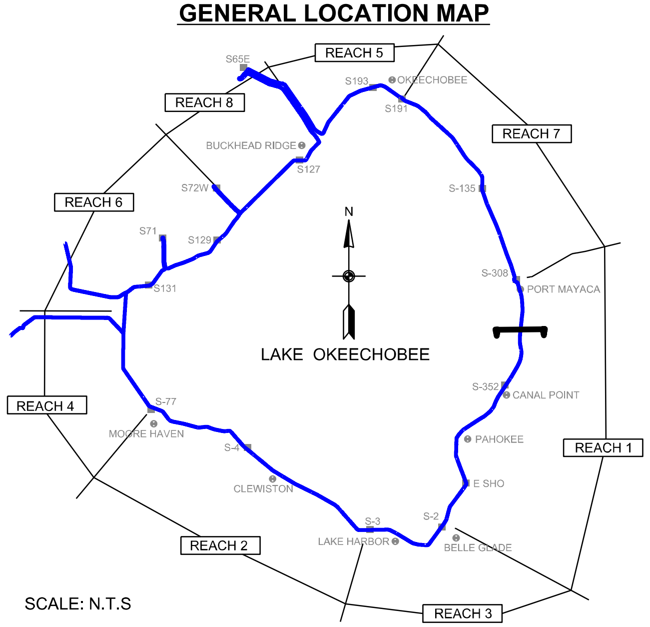
PIEZOMETER LINE: R1-14
HHD STATION: HHD 1598+00
LEVEE DESIGNATION: L-D9 570+00
REACH: 1A
SEGMENT/ CIZ: 22/ A



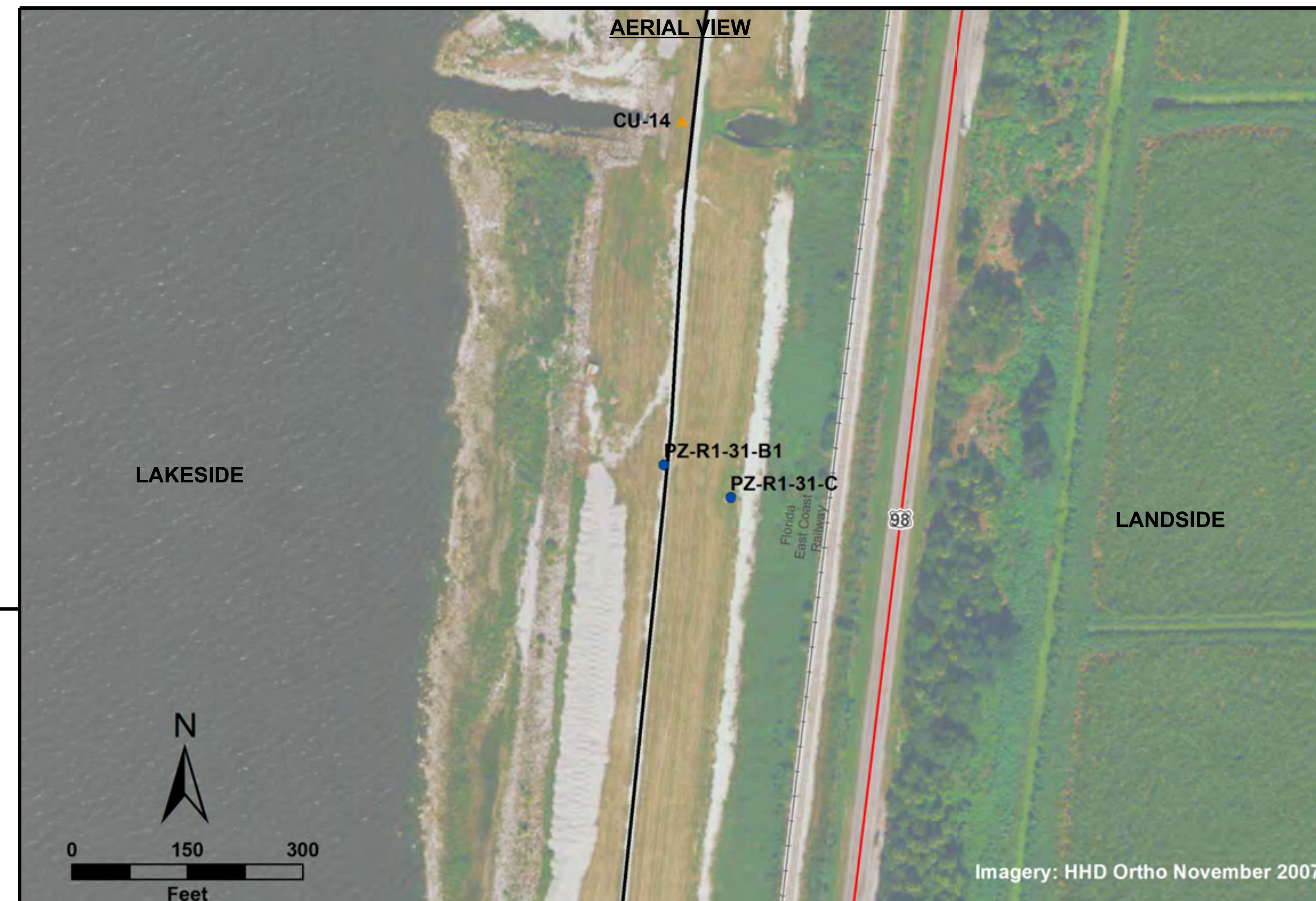
NOTES:

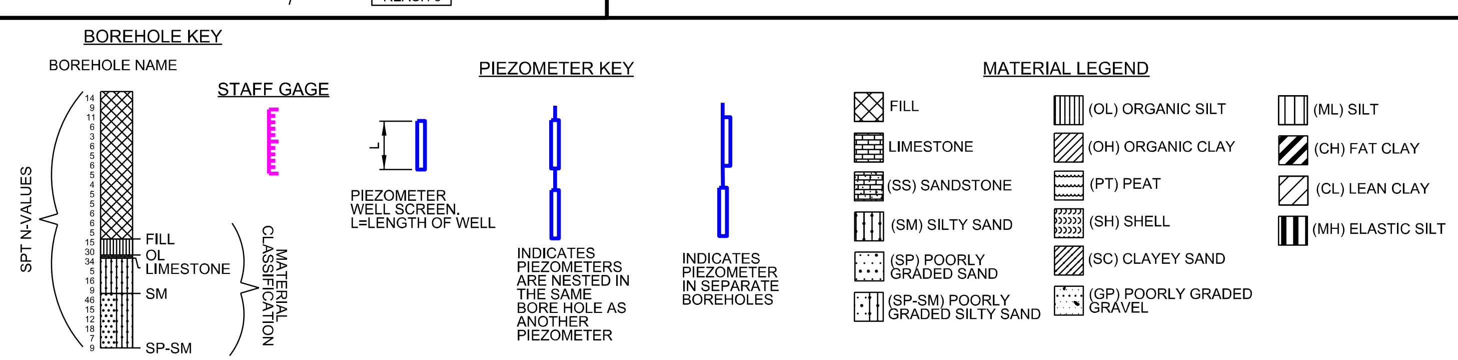
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -30 (NAVD88) APRIL 2010.

GENERAL LOCATION MAP



SCALE: N.T.S





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INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-14

PIEZOMETER LINE DETAILS

PIEZOMETER LINE:	R1-15
HHD STATION:	HHD 1499+00
LEVEE DESIGNATION:	L-D9 669+00
REACH:	1A
SEGMENT/ CIZ:	22/ A

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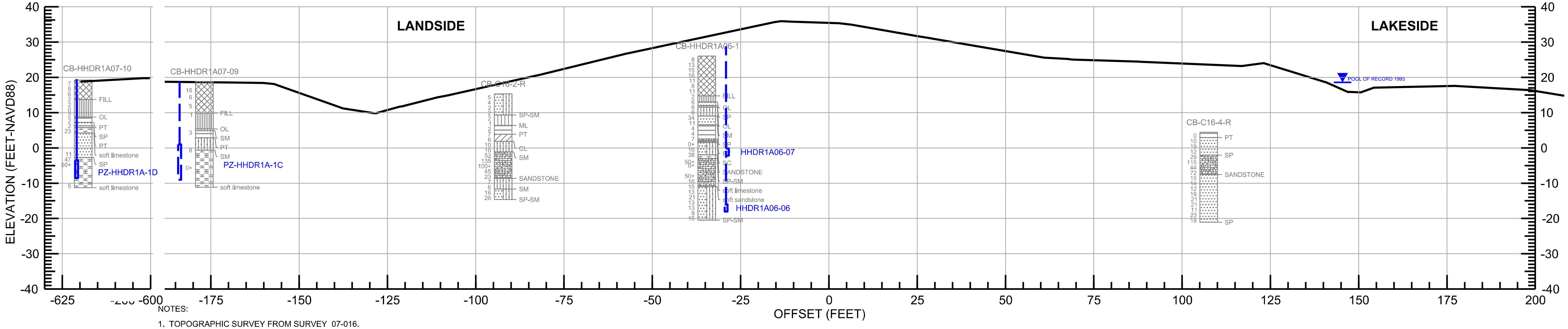
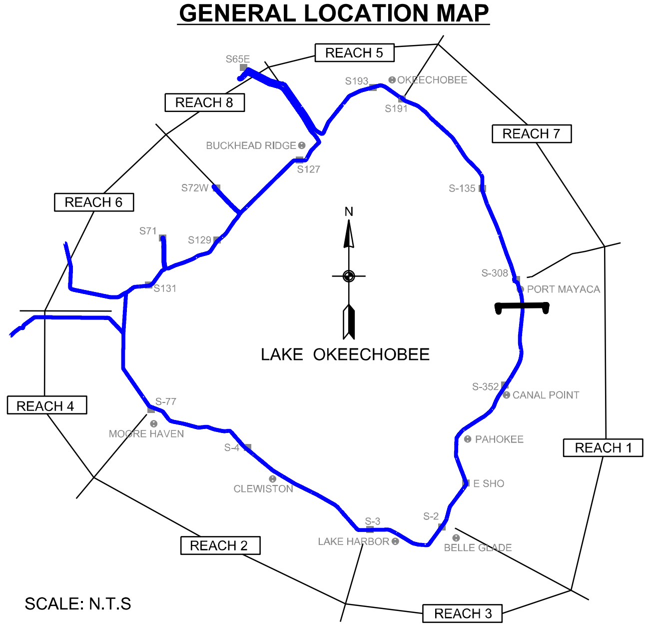


NOTES:

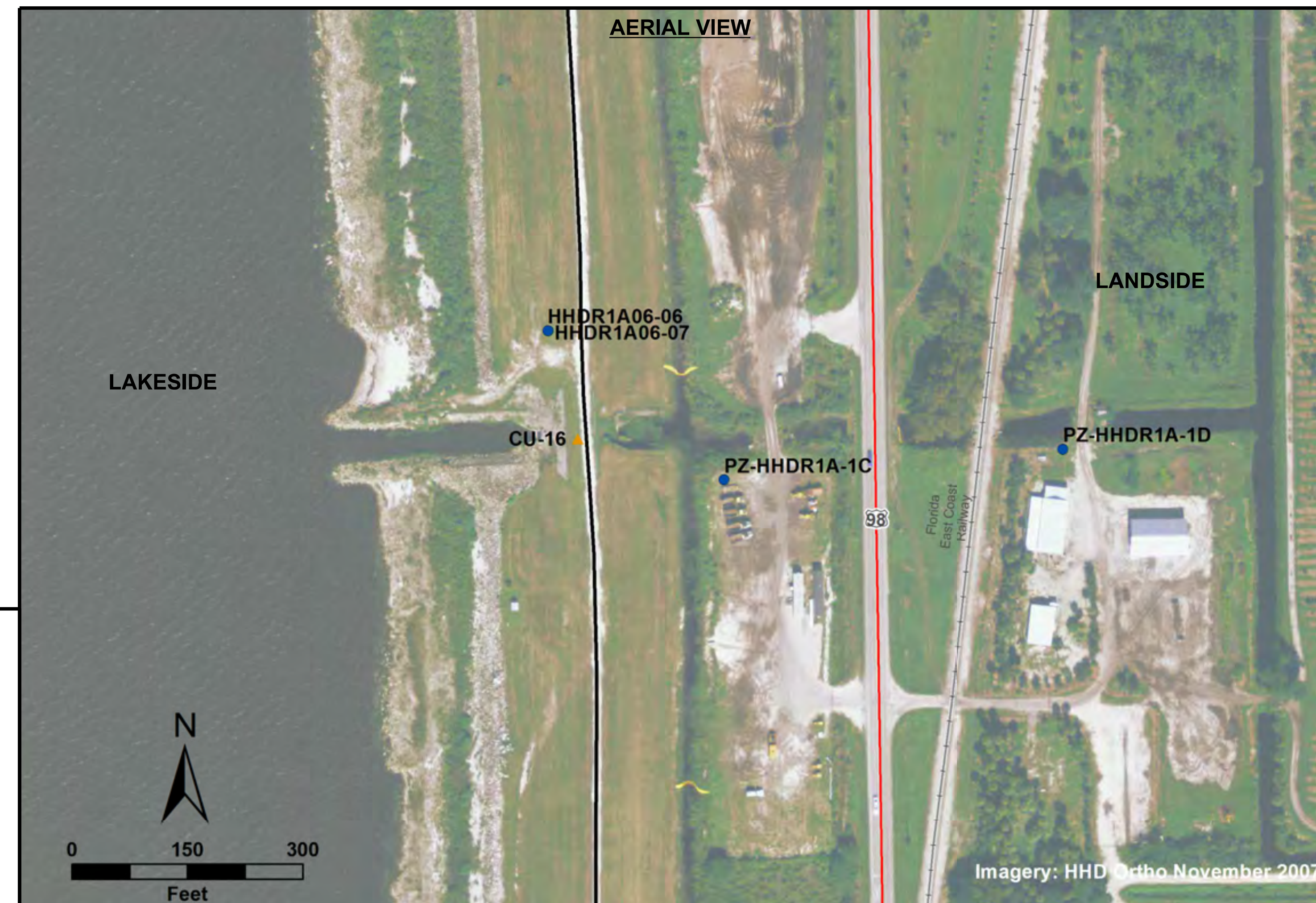
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL TERMINATES 300' AWAY FROM PIEZOMETER GROUP.
4. PIEZOMETERS LOCATED AT C-16.
5. PIEZOMETERS HHDR1A06-06 and HHDR1A06-07 were decommissioned on 06/28/2012.
6. PIEZOMETER PZ-HHDR1A-1C was decommissioned on 07/08/2013.

GENERAL LOCATION MAP

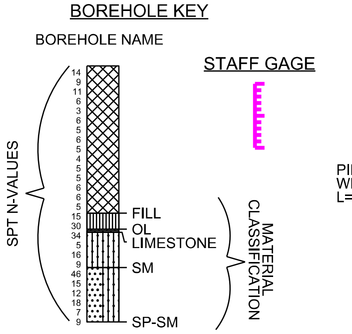


SCALE: N.T.S

AERIAL VIEW



BOREHOLE KEY



PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL	(OL) ORGANIC SILT	(ML) SILT
LIMESTONE	(OH) ORGANIC CLAY	(CH) FAT CLAY
(SS) SANDSTONE	(PT) PEAT	(CL) LEAN CLAY
(SM) SILTY SAND	(SH) SHELL	(MH) ELASTIC SILT
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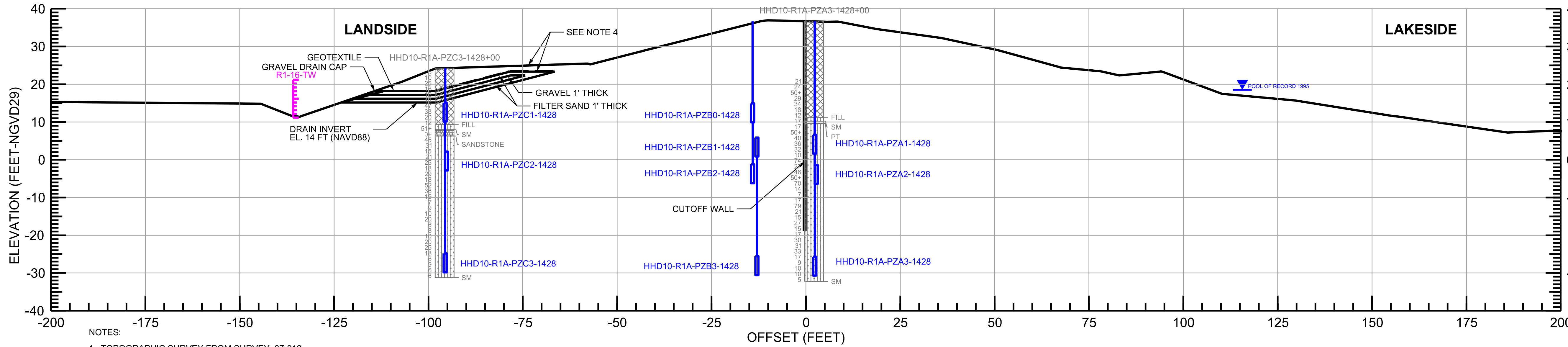
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-15

PIEZOMETER LINE DETAILS

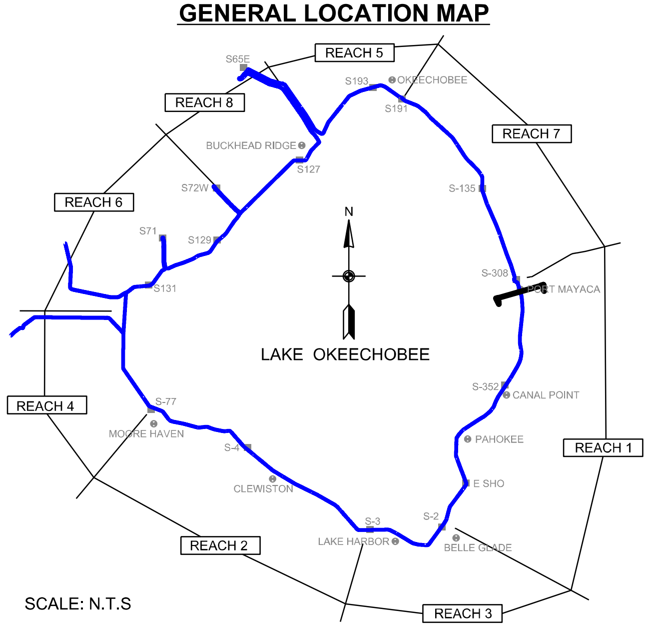
PIEZOMETER LINE:	R1-16
HHD STATION:	HHD 1428+00
LEVEE DESIGNATION:	L-D9 740+00
REACH:	1A
SEGMENT/ CIZ:	22/ A



NOTES:

1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -20 (NAVD88) JUNE 2008.
4. SEEPAGE BERM INSTALLED 2009 (W912EP-07-B-0015).

GENERAL LOCATION MAP



SCALE: N.T.S

AERIAL VIEW

BOREHOLE KEY

BOREHOLE NAME

SPT N-VALUES

MATERIAL CLASSIFICATION

FILL
OL
LIMESTONE
SM
SP-SM

STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

- FILL
- LIMESTONE
- (SS) SANDSTONE
- (SM) SILTY SAND
- (SP) POORLY GRADED SAND
- (SP-SM) POORLY GRADED SILTY SAND
- (OL) ORGANIC SILT
- (OH) ORGANIC CLAY
- (PT) PEAT
- (SH) SHELL
- (SC) CLAYEY SAND
- (GP) POORLY GRADED GRAVEL
- (ML) SILT
- (CH) FAT CLAY
- (CL) LEAN CLAY
- (MH) ELASTIC SILT

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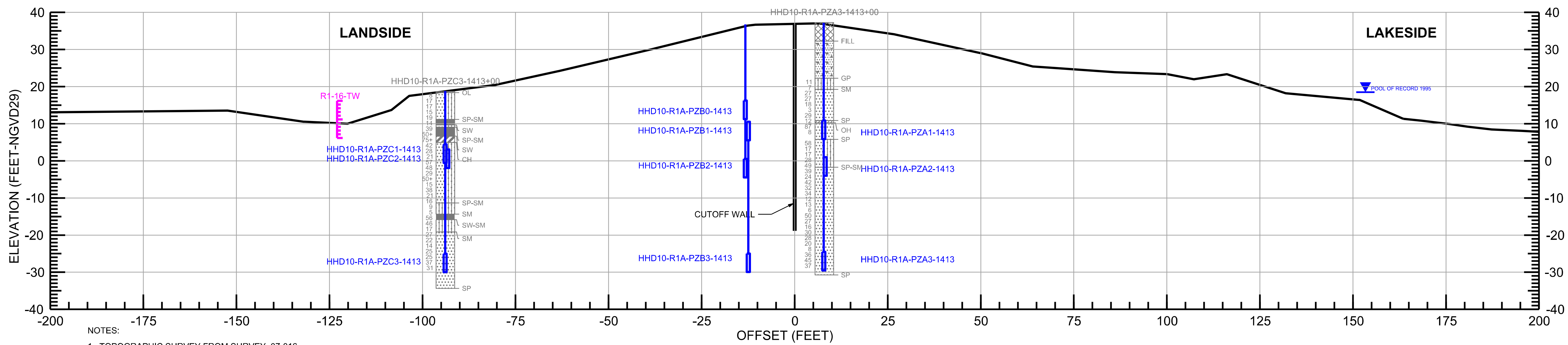
INSTRUMENTATION UPDATE
PIEZOMETER LINE CROSS SECTION

R1-16

PIEZOMETER LINE DETAILS

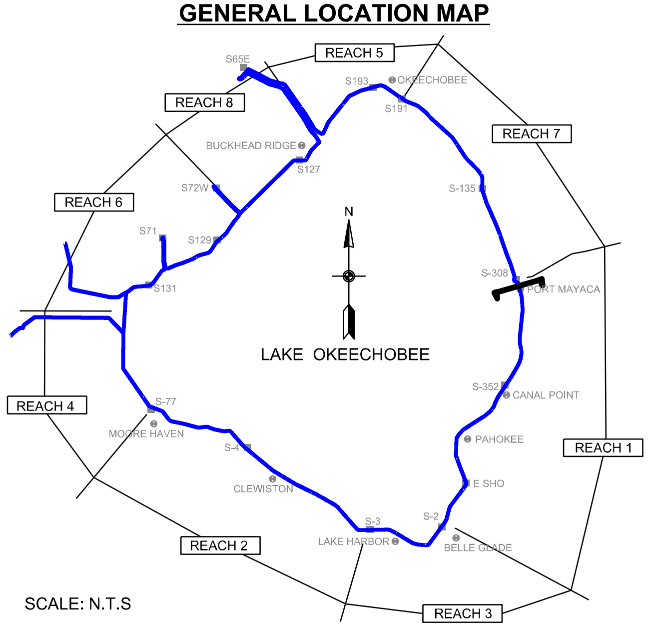
PIEZOMETER LINE:	R1-17
HHD STATION:	HHD 1413+00
LEVEE DESIGNATION:	L-D9 755+00
REACH:	1A
SEGMENT/ CIZ:	22/ A



NOTES:

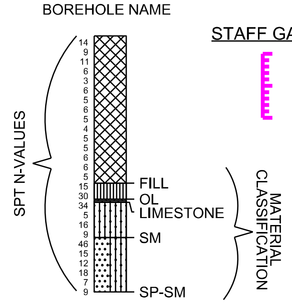
1. TOPOGRAPHIC SURVEY FROM SURVEY 07-016.
2. HYDROGRAPHIC SURVEY FROM SURVEY 09-127.
3. CUTOFF WALL INSTALLED TO EL. -20 (NAVD88) FEBRUARY 2008.
4. CUTOFF WALL PART OF TASK ORDER #1 HAYWARD BAKER DEMONSTRATION PANEL.

GENERAL LOCATION MAP



SCALE: N.T.S

BOREHOLE KEY



STAFF GAGE

PIEZOMETER KEY

PIEZOMETER WELL SCREEN, L=LENGTH OF WELL

INDICATES PIEZOMETERS ARE NESTED IN THE SAME BORE HOLE AS ANOTHER PIEZOMETER

INDICATES PIEZOMETER IN SEPARATE BOREHOLES

MATERIAL LEGEND

FILL
LIMESTONE
(SS) SANDSTONE
(SM) SILTY SAND
(SP) POORLY GRADED SAND
(SP-SM) POORLY GRADED SILTY SAND
(OL) ORGANIC SILT
(OH) ORGANIC CLAY
(PT) PEAT
(SH) SHELL
(SC) CLAYEY SAND
(GP) POORLY GRADED GRAVEL
(ML) SILT
(CH) FAT CLAY
(CL) LEAN CLAY
(MH) ELASTIC SILT

AERIAL VIEW

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PIEZOMETER LINE CROSS SECTION

R1-17

APPENDIX D: PIEZOMETER LINE TIME-HISTORY PLOTS

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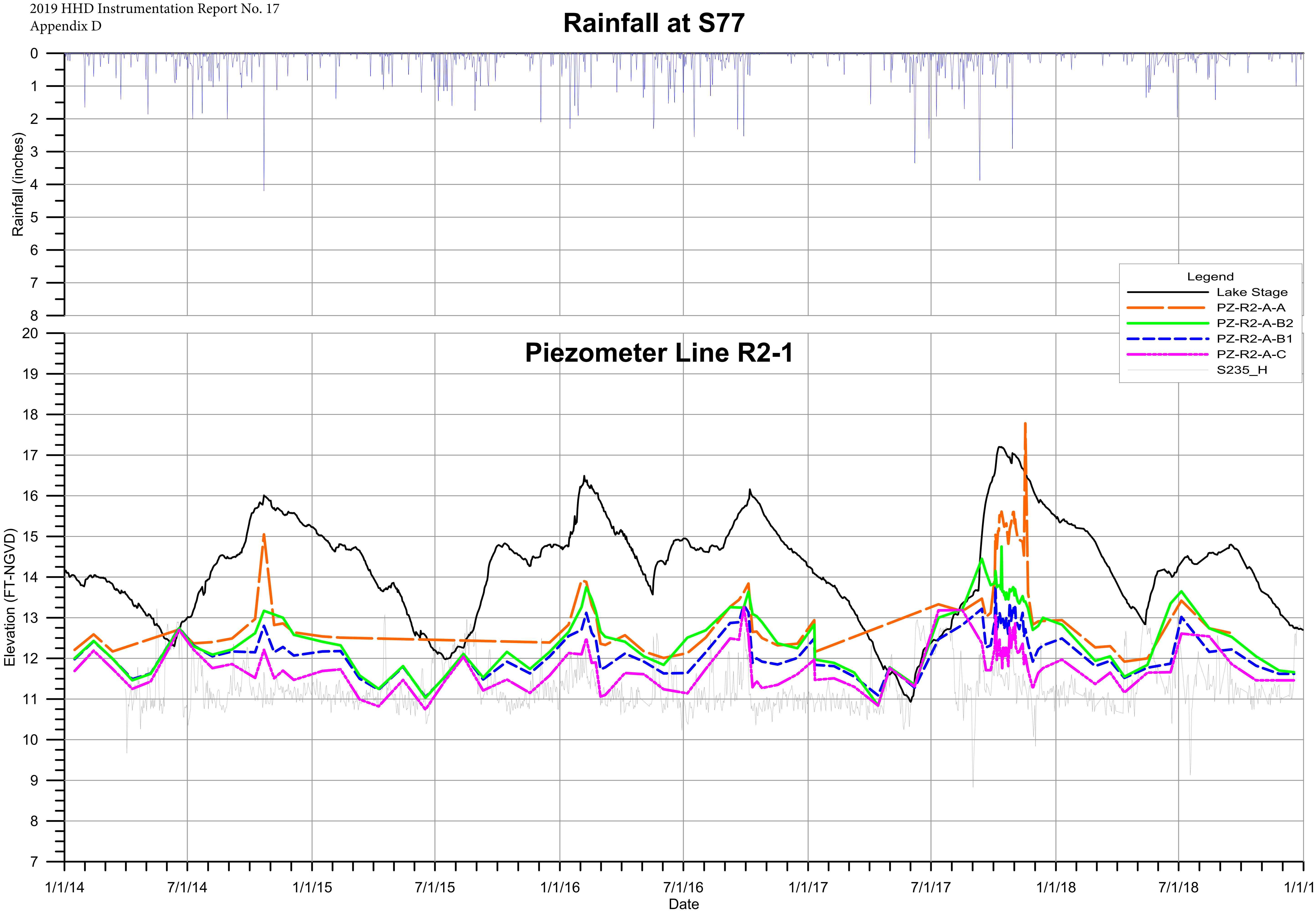

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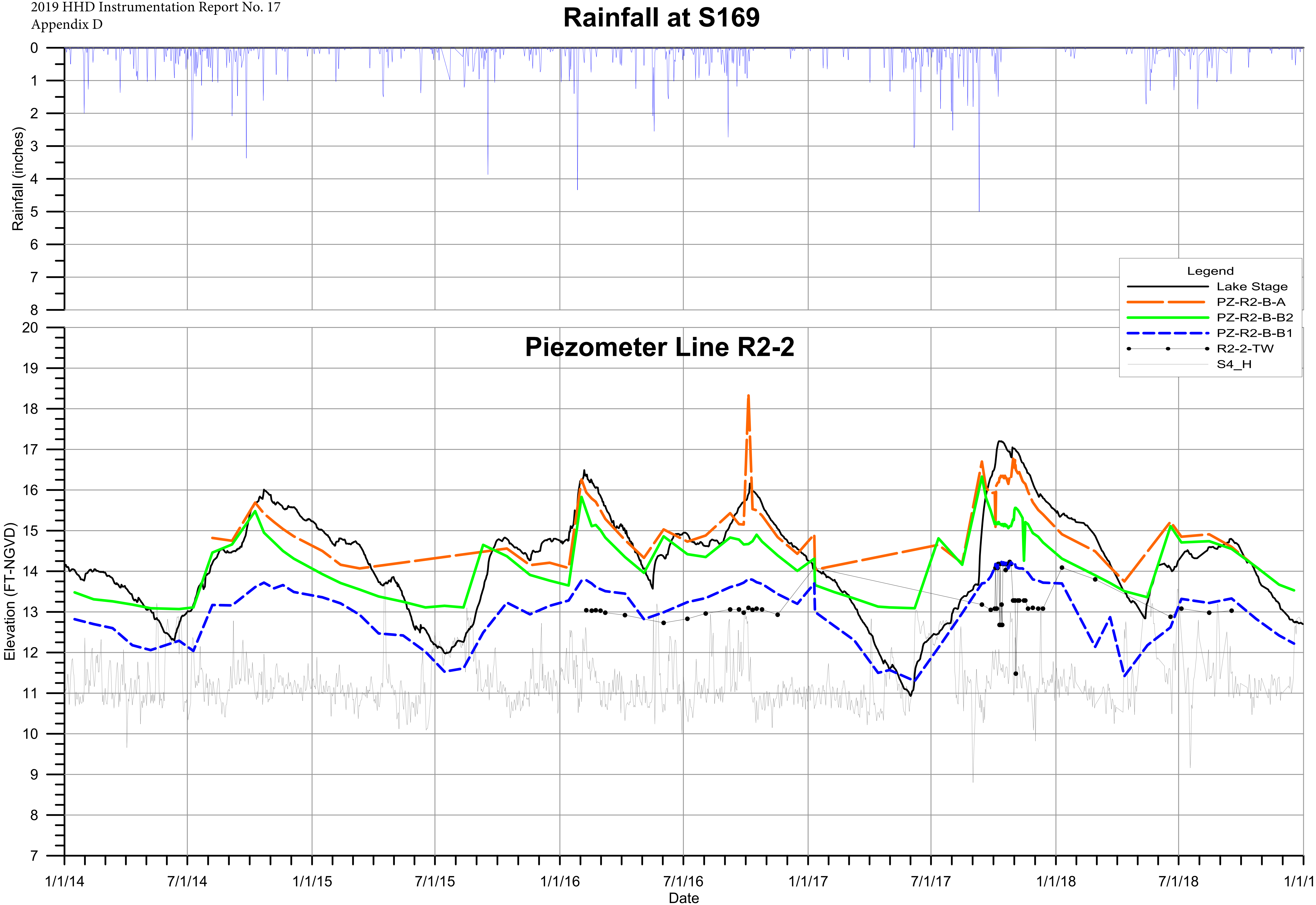
R2-1



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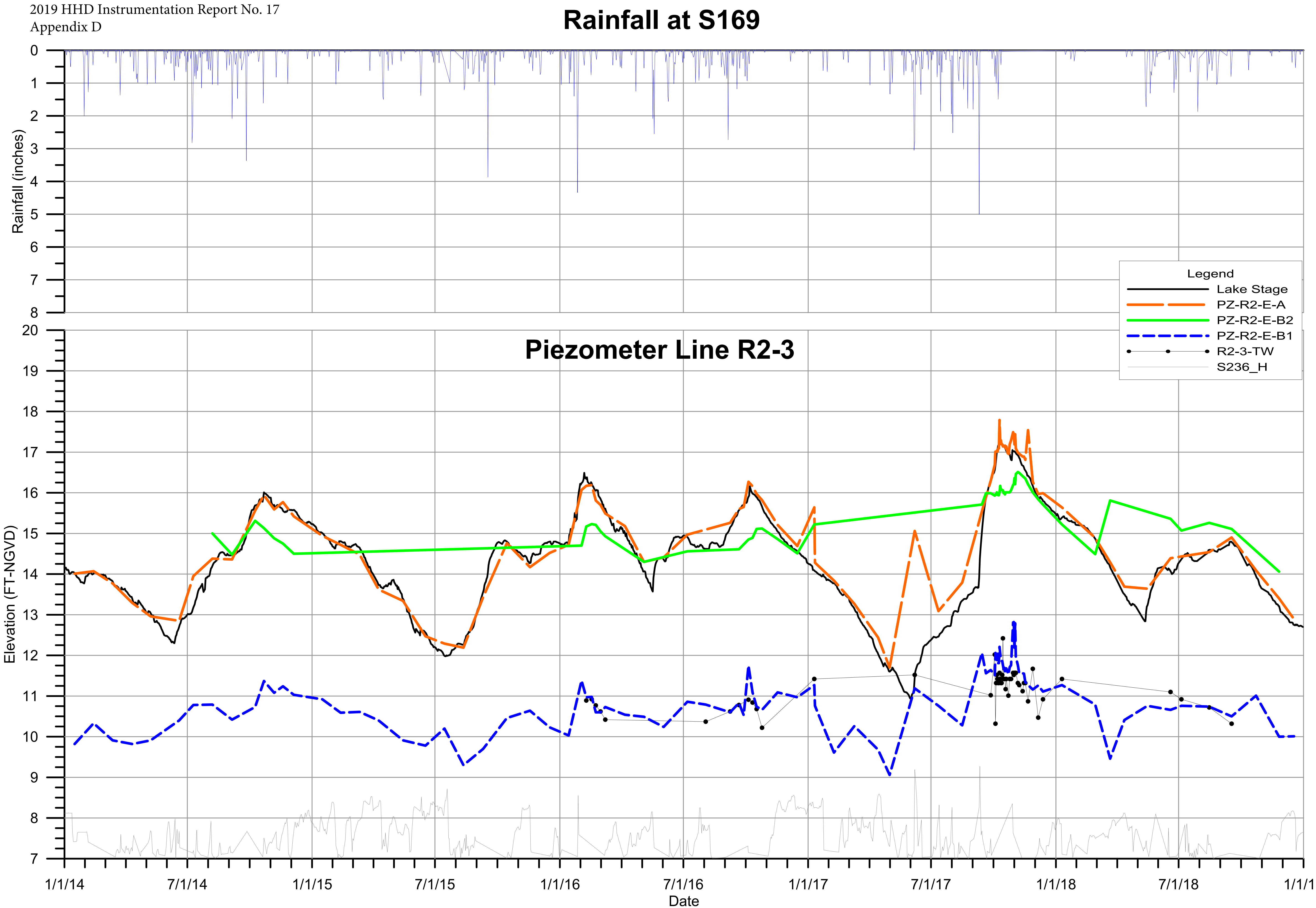
R2-2



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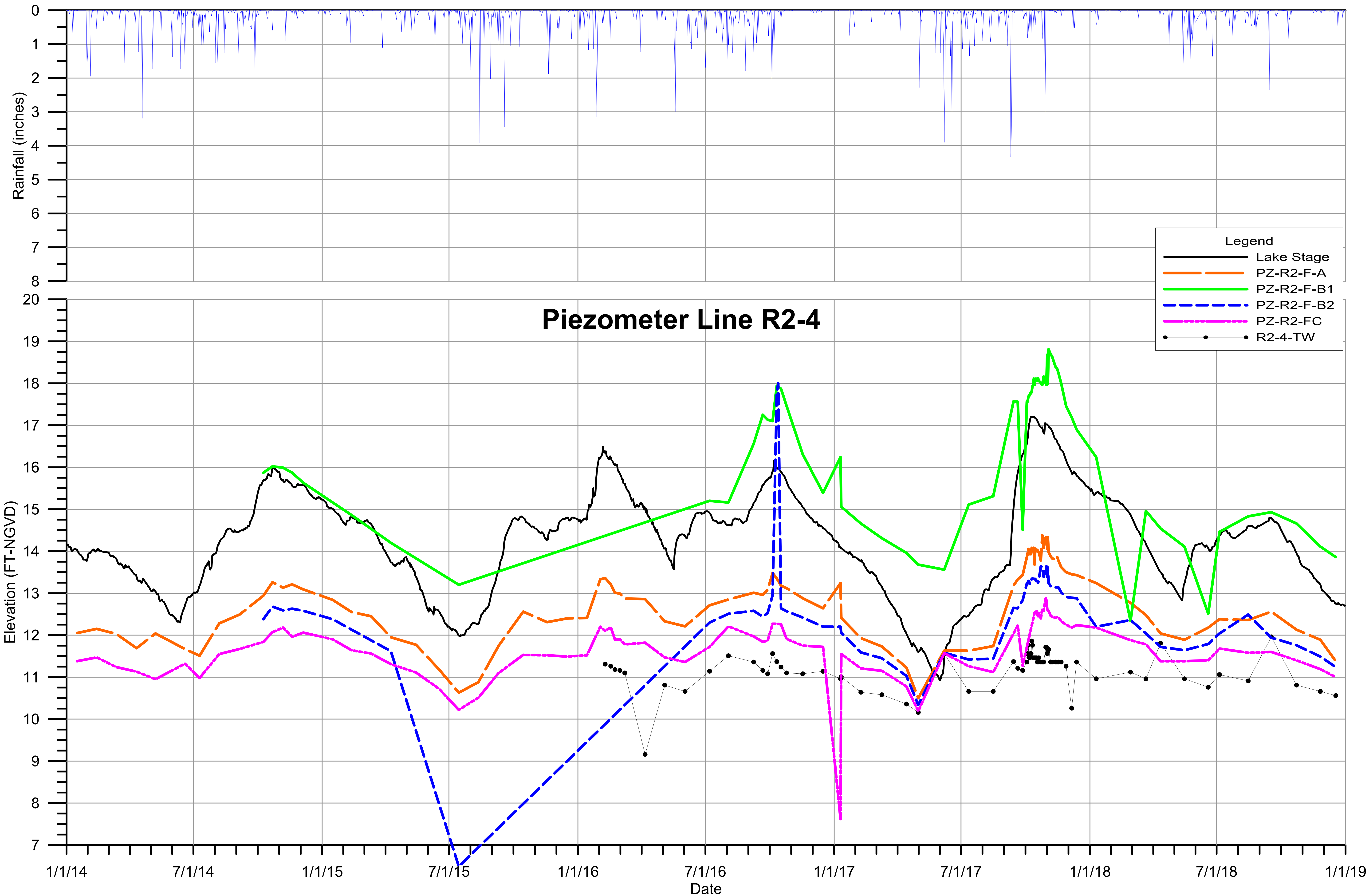
R2-3

Rainfall at S3



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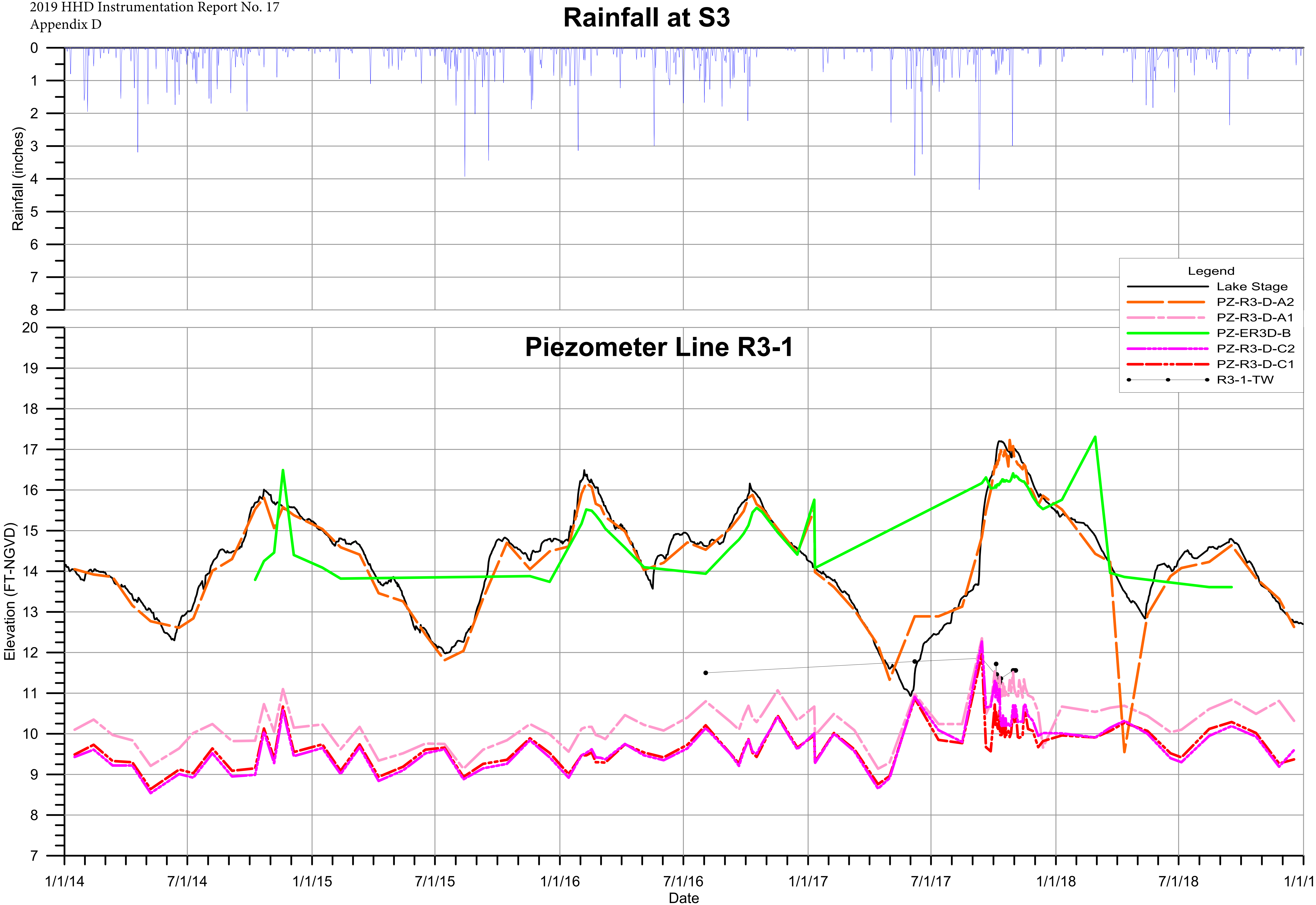
R2-4



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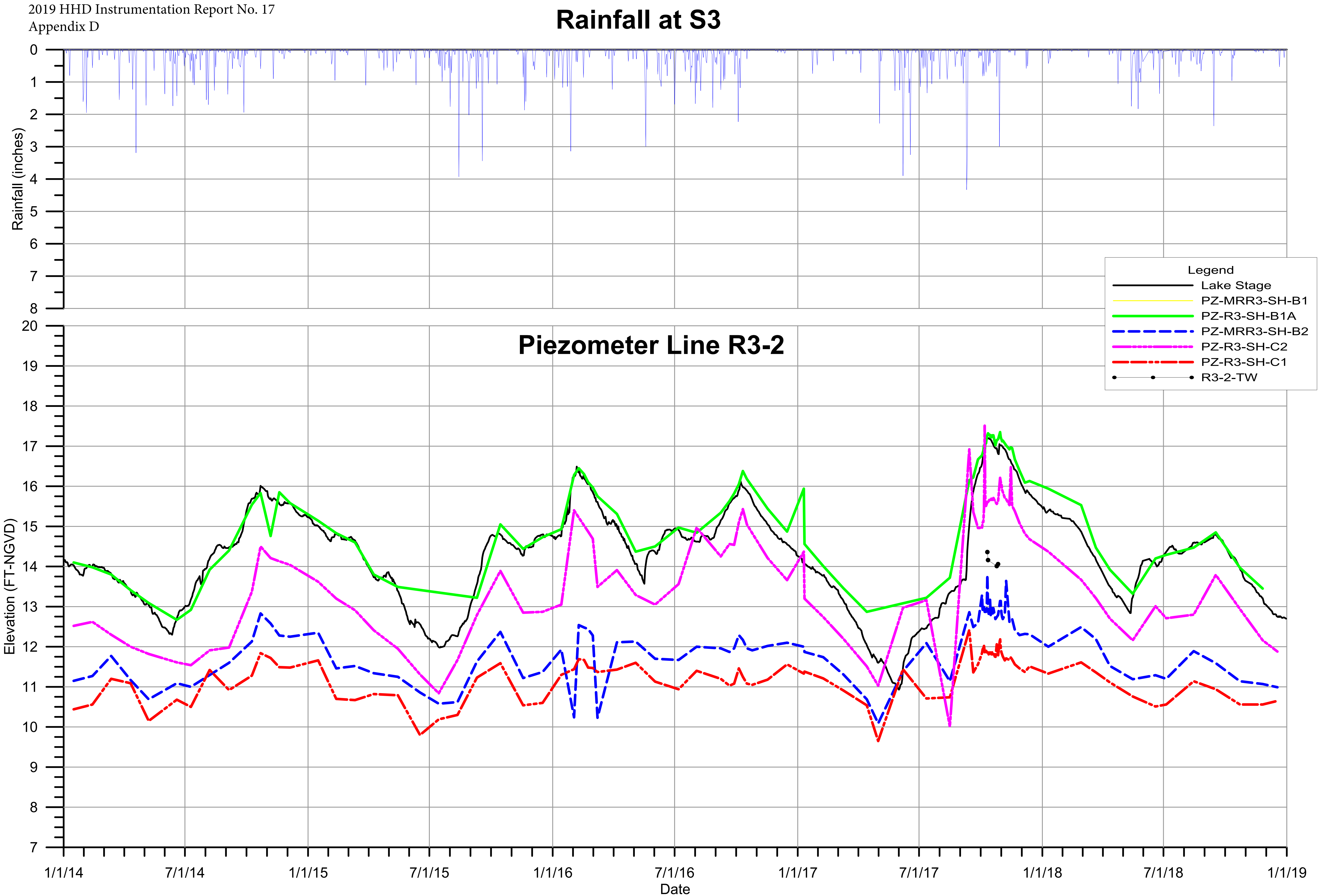
R3-1



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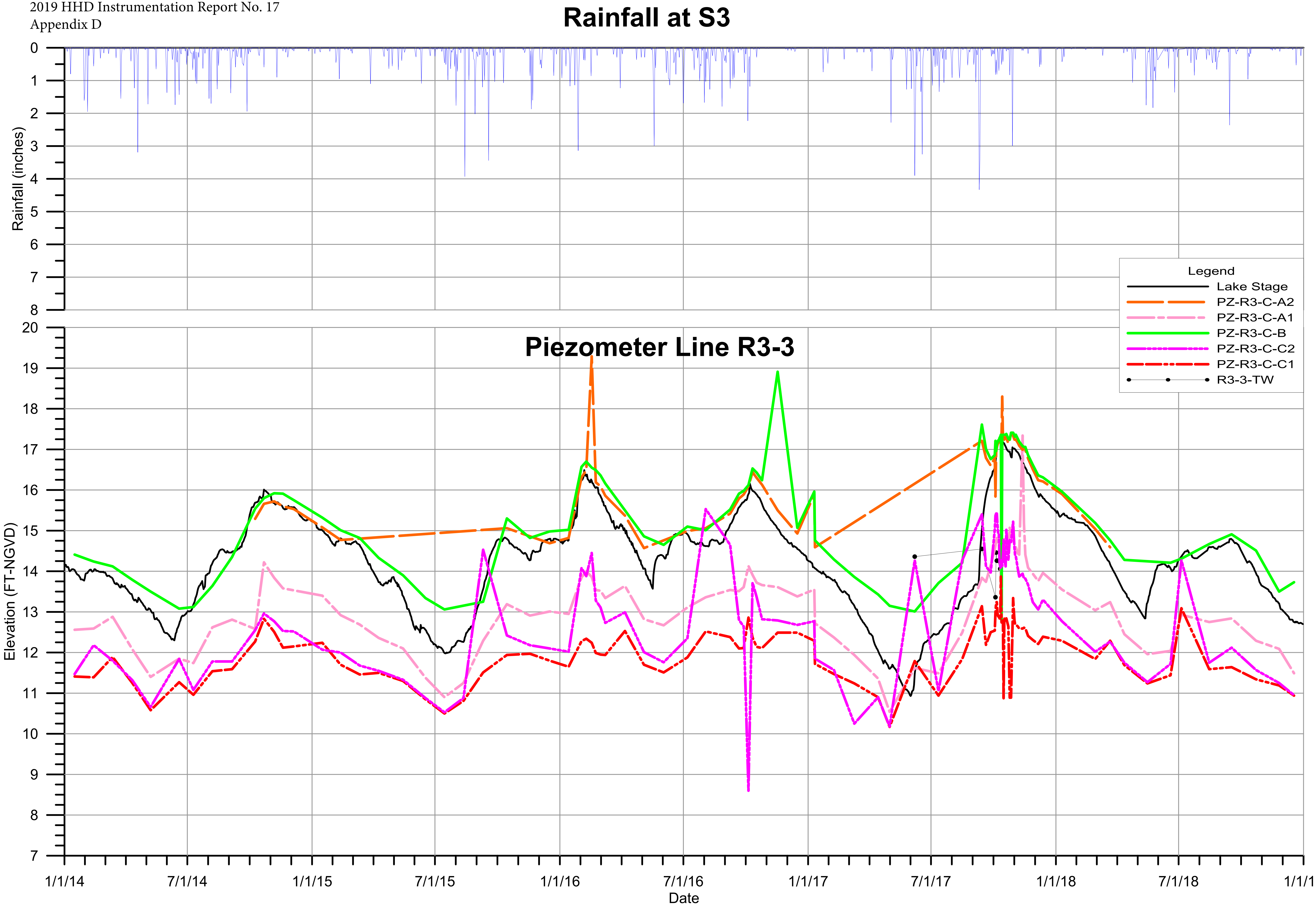
R3-2



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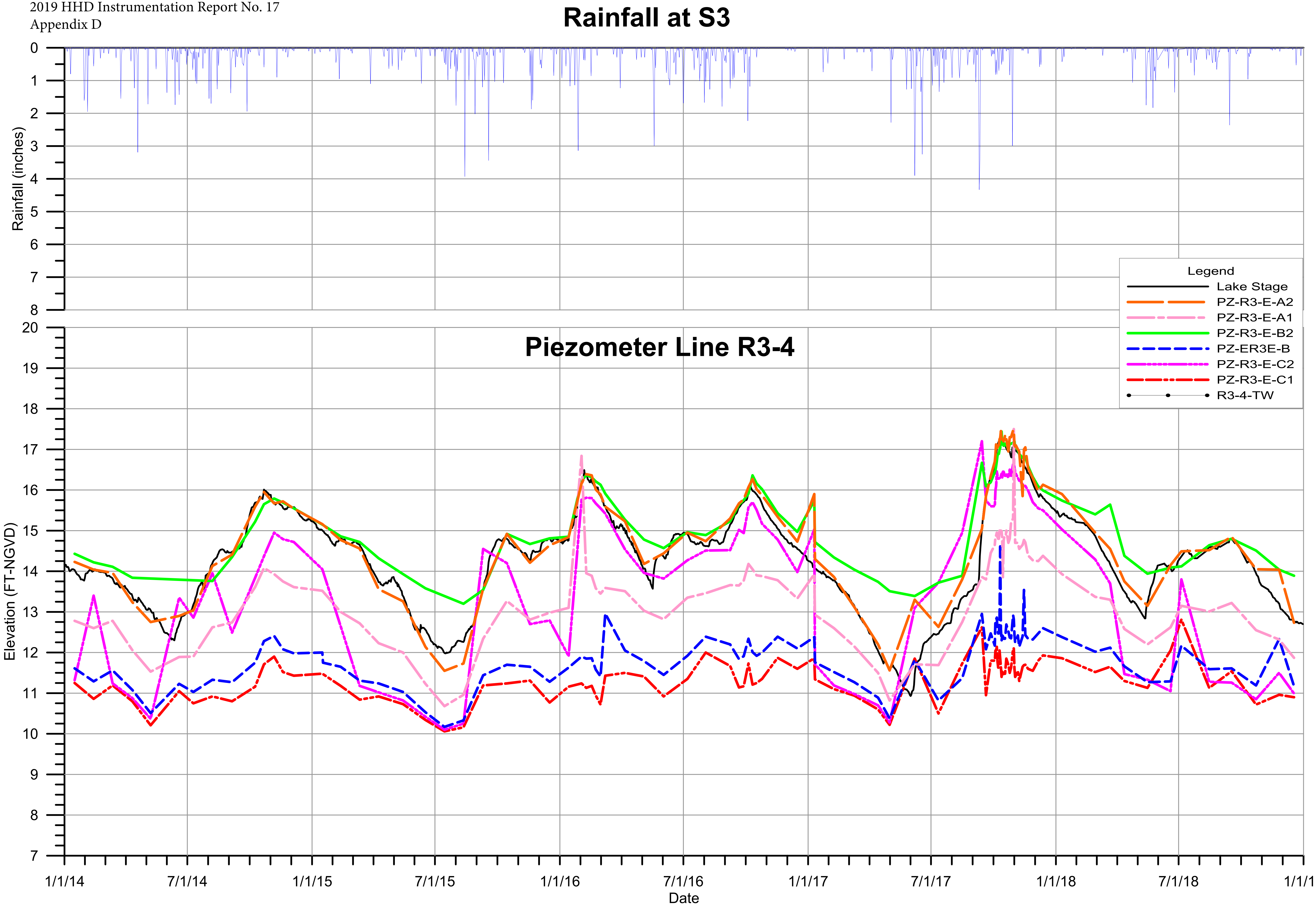
R3-3



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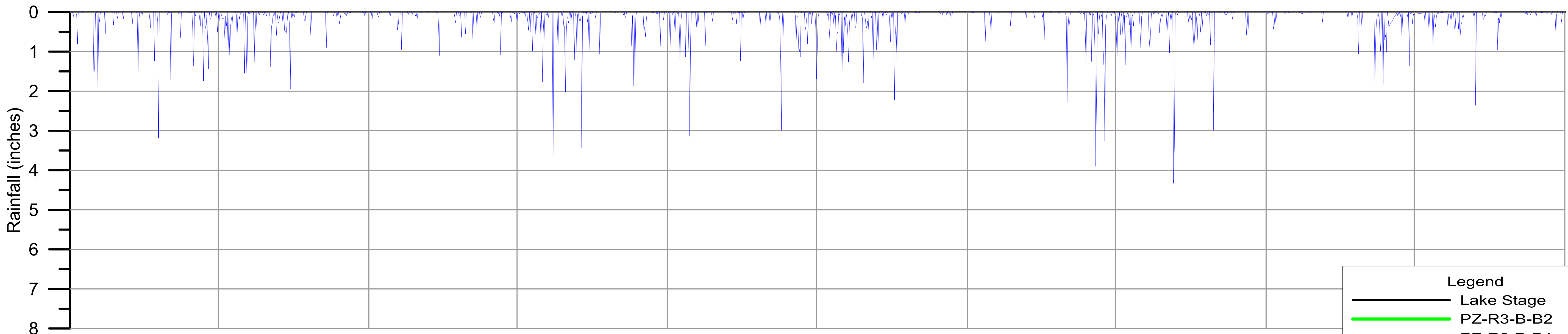
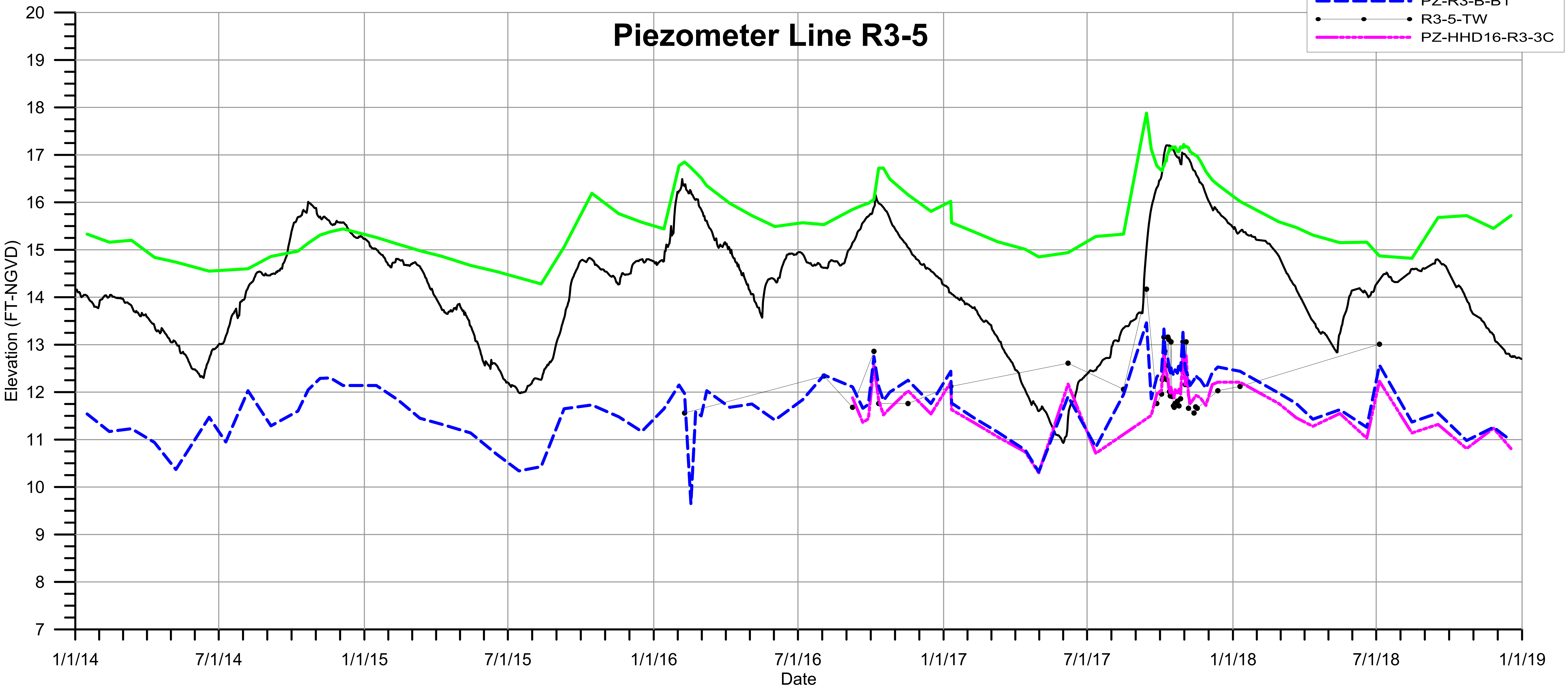
R3-4

Rainfall at S3



Piezometer Line R3-5



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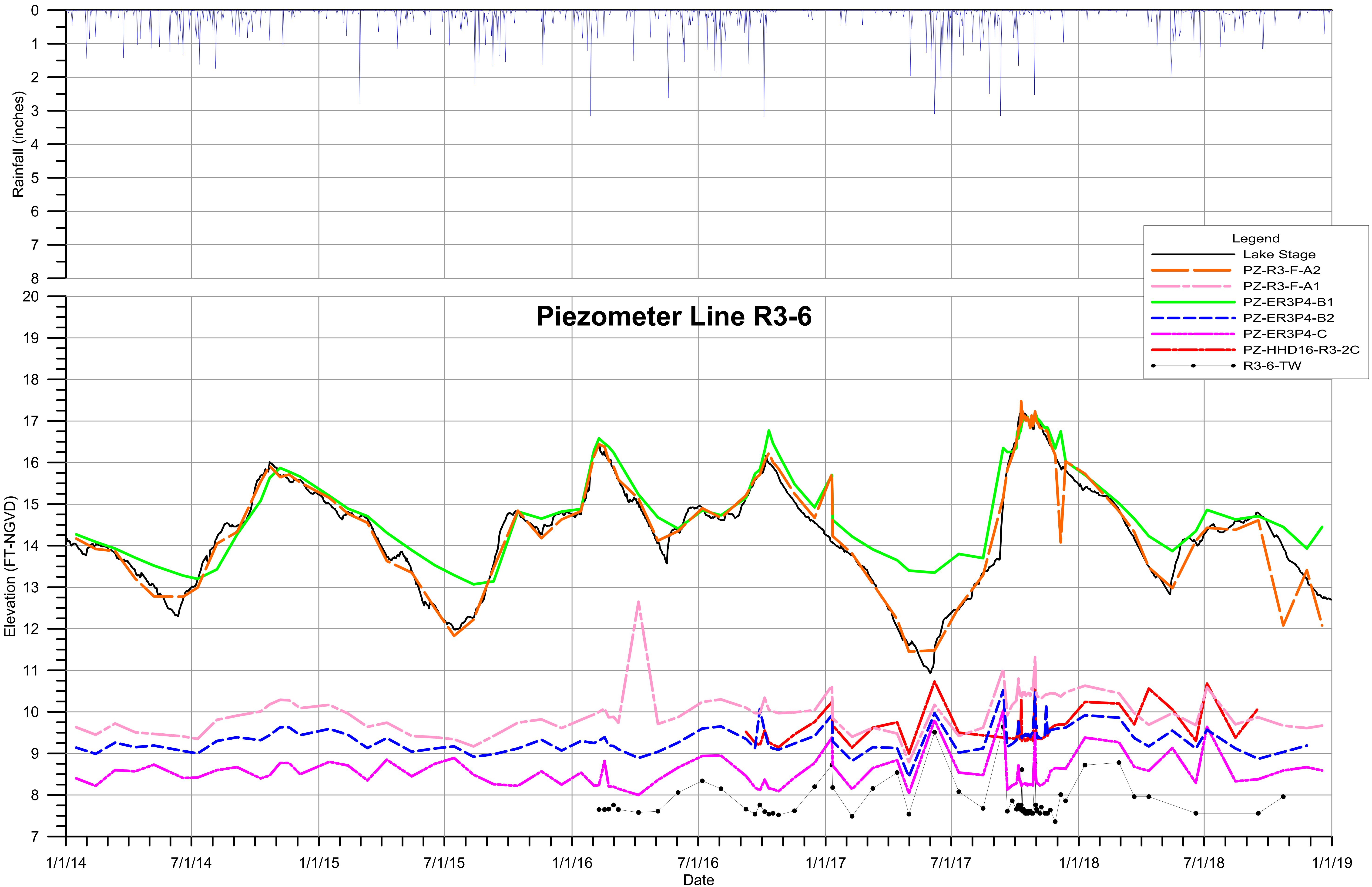
R3-5

Rainfall at S2



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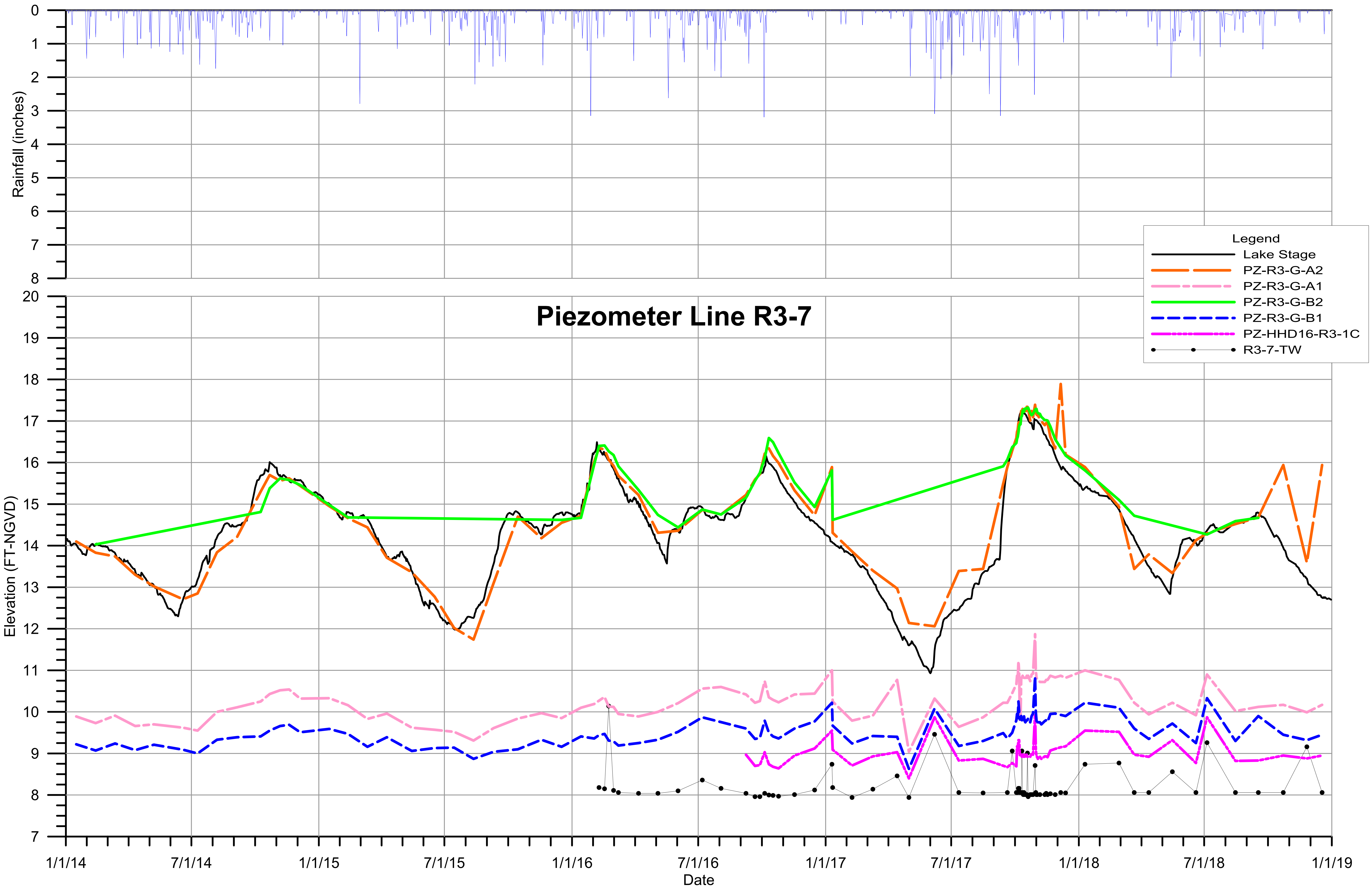
R3-6

Rainfall at S2



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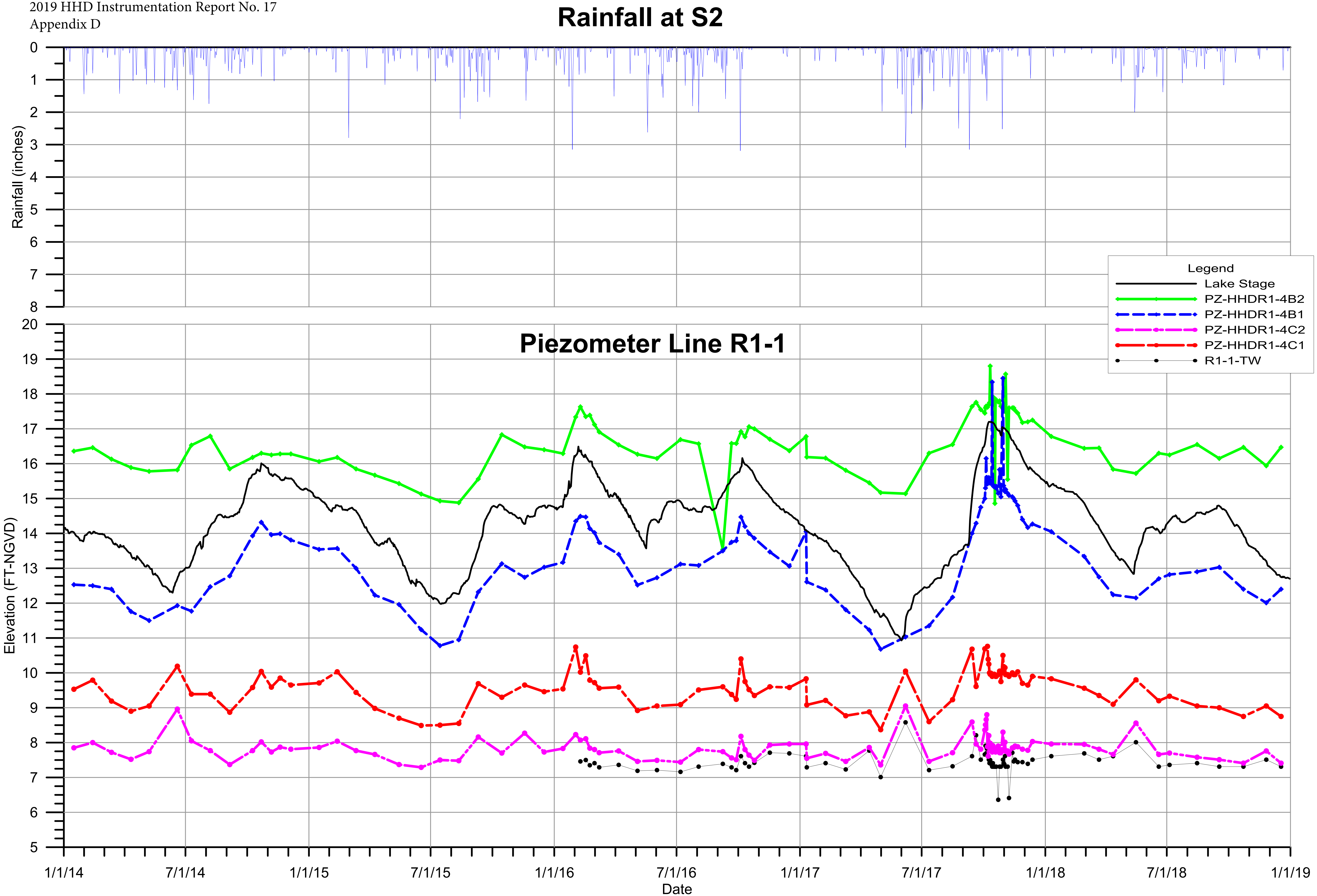
R3-7



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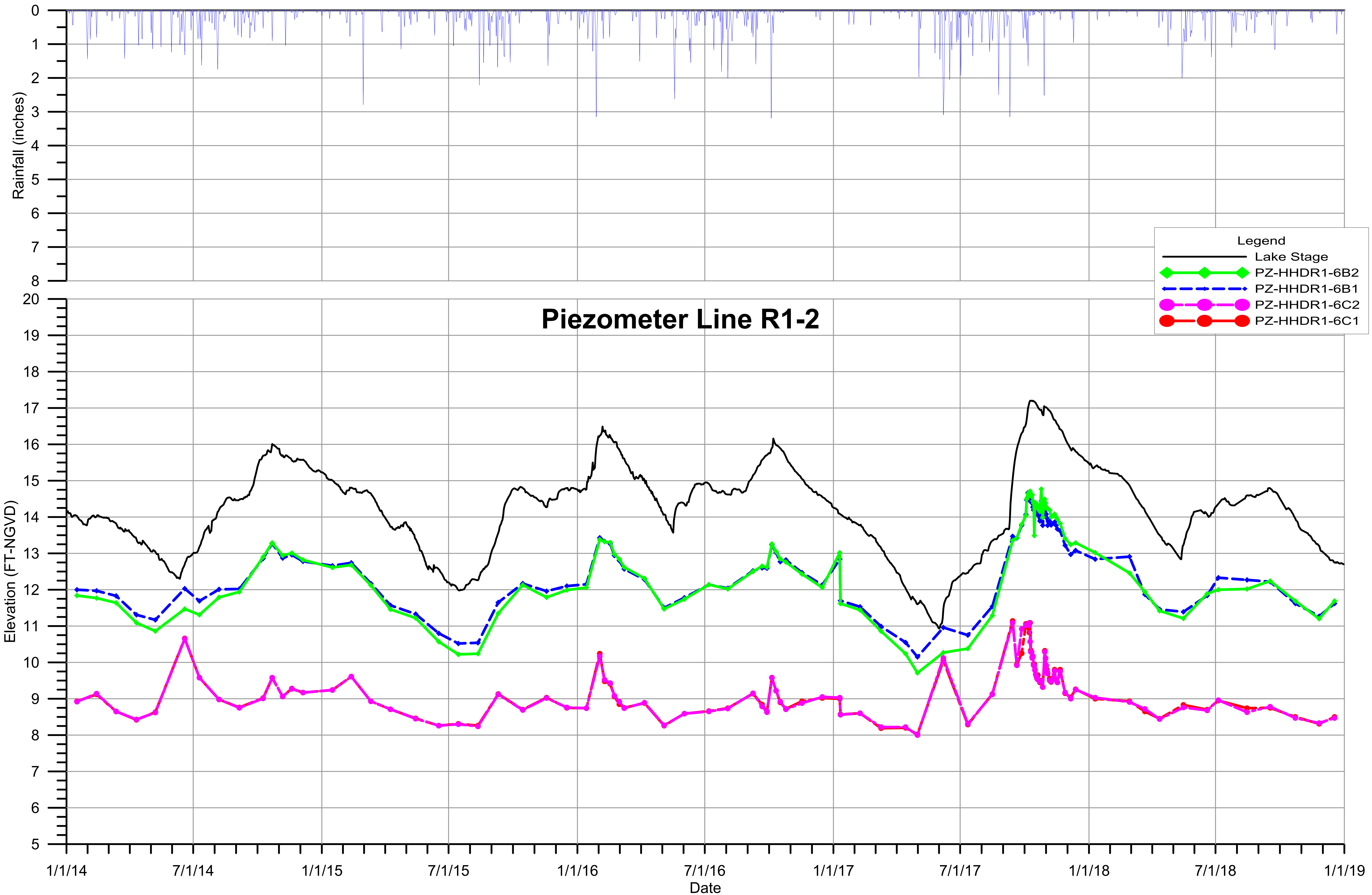
R1-1

Rainfall at S2



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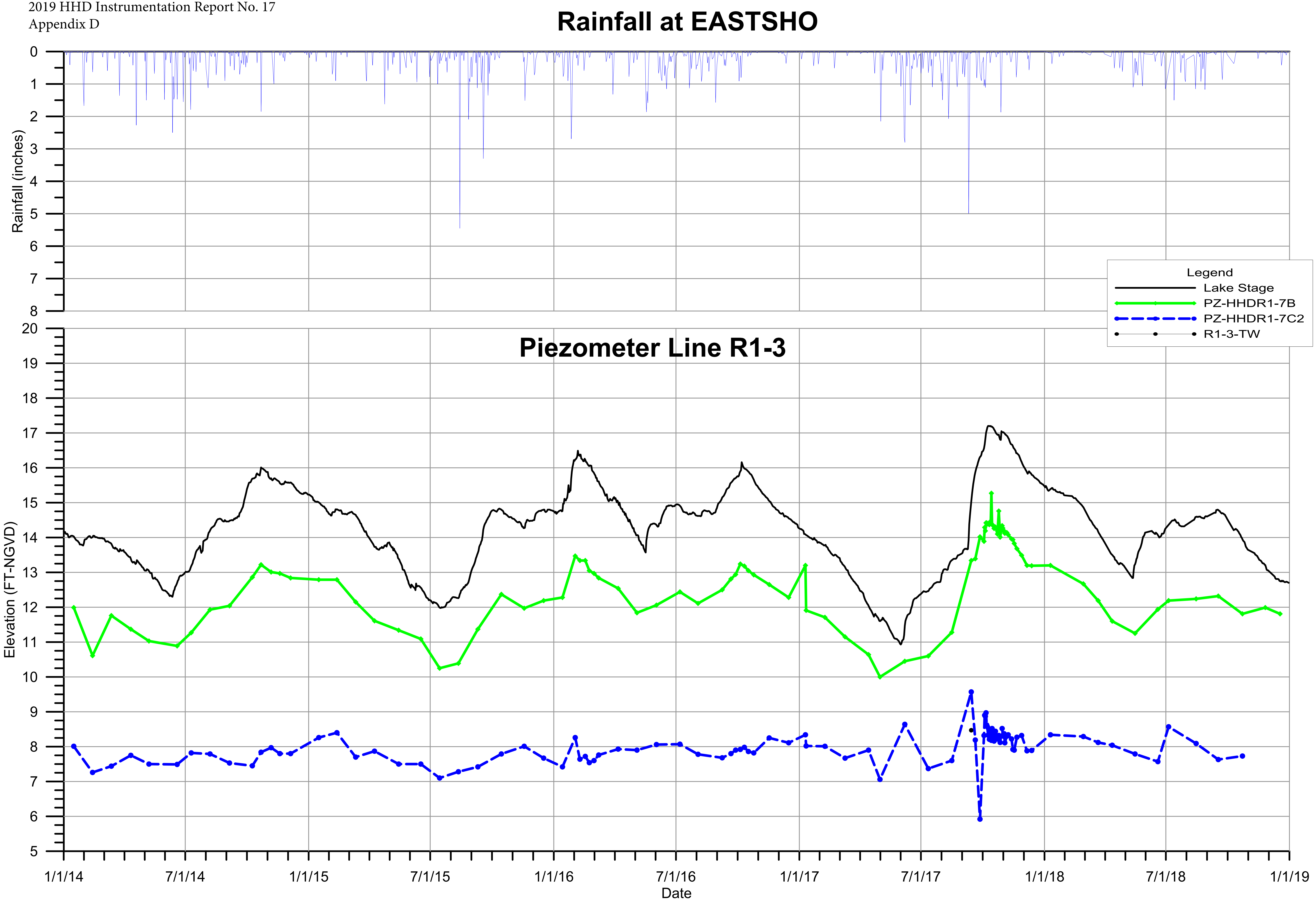
R1-2



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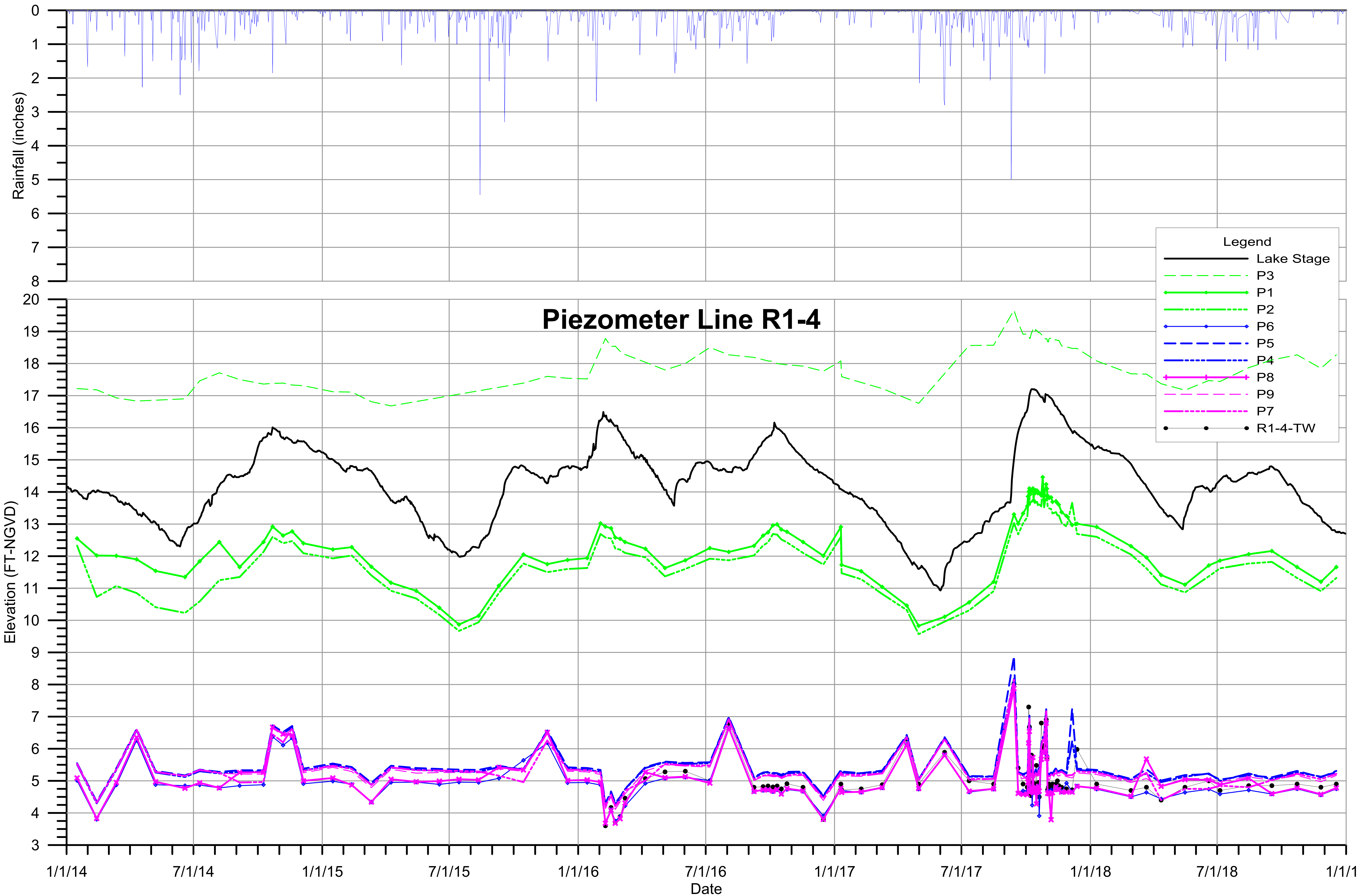
R1-3

Rainfall at EASTSHO



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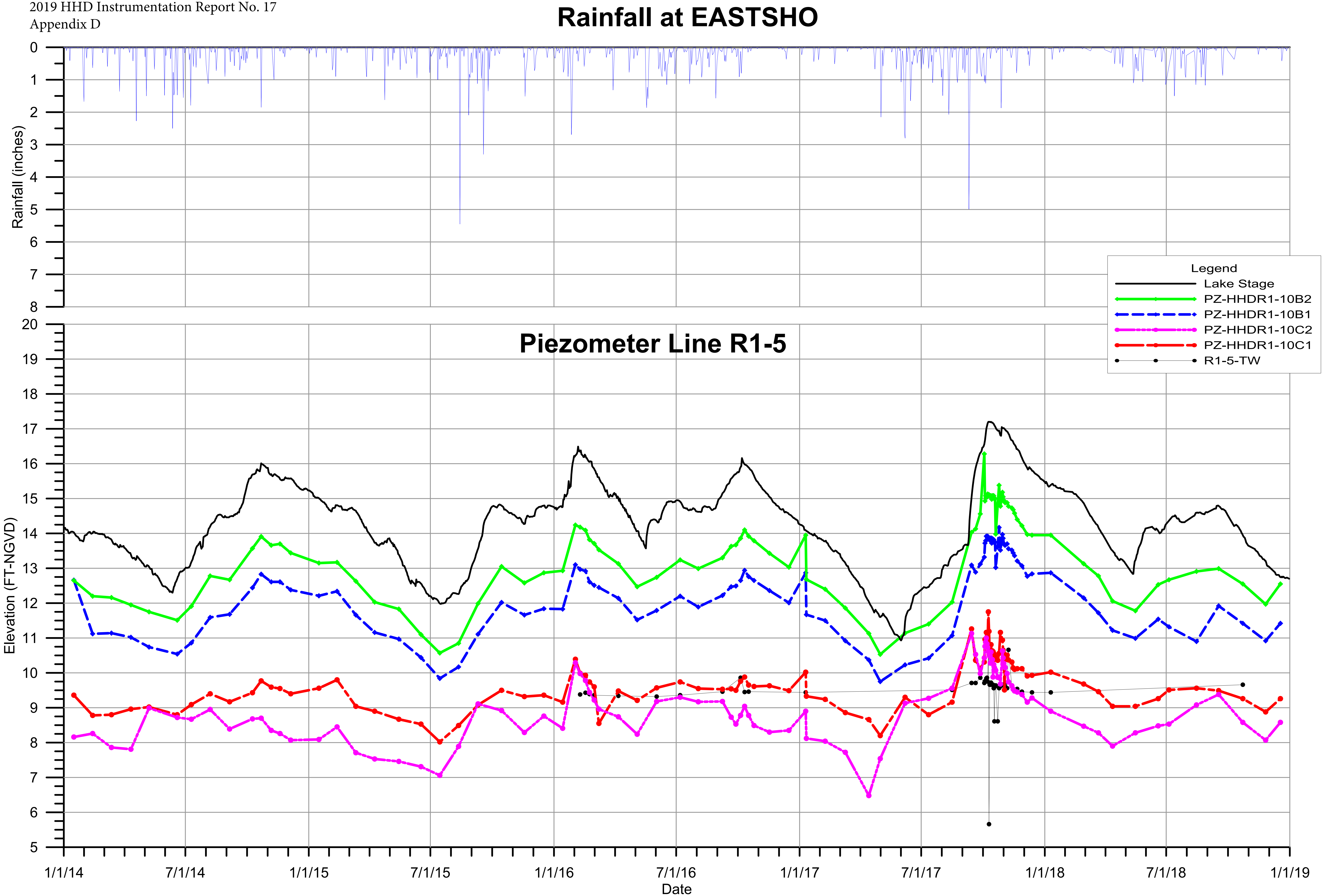
R1-4



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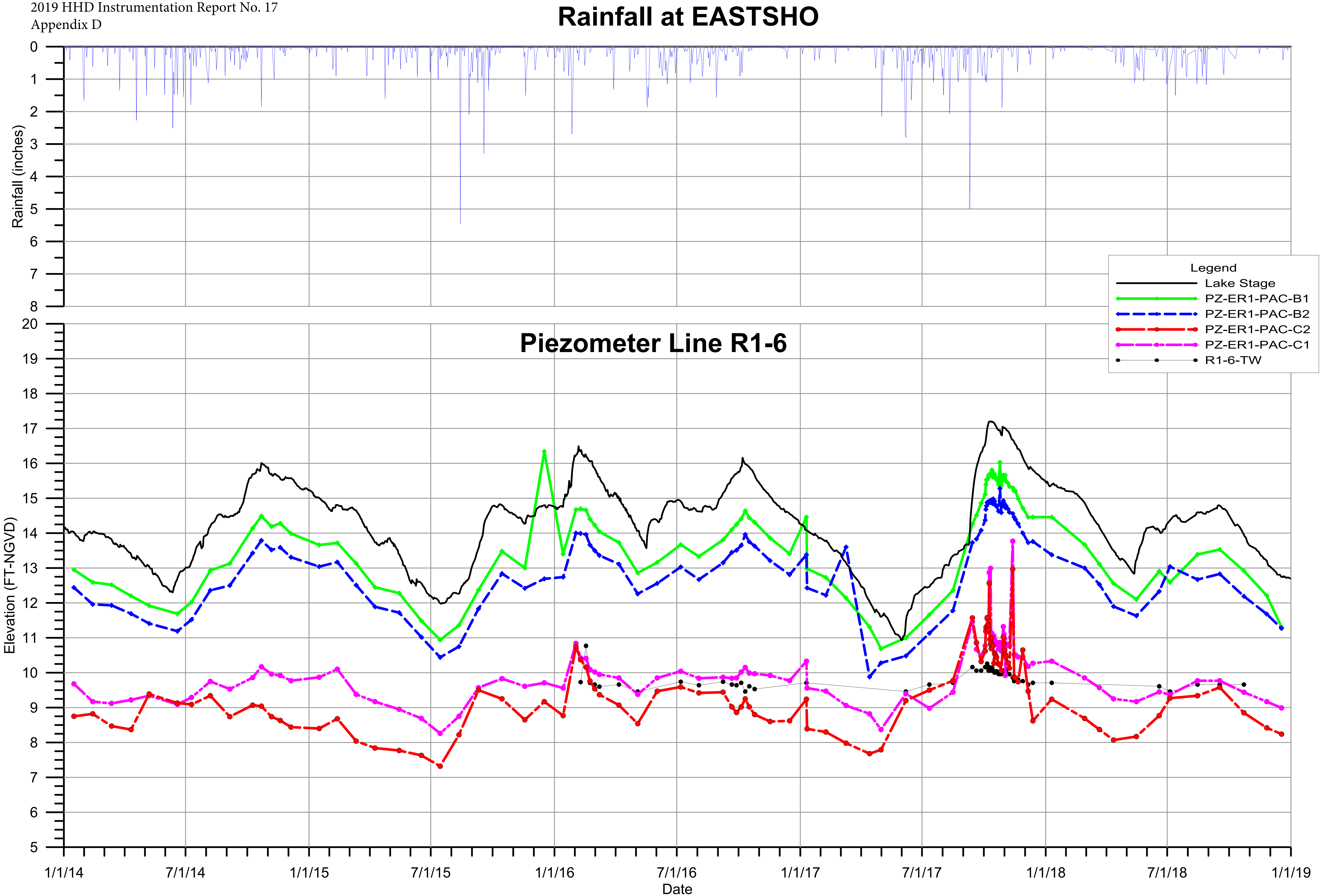
R1-5



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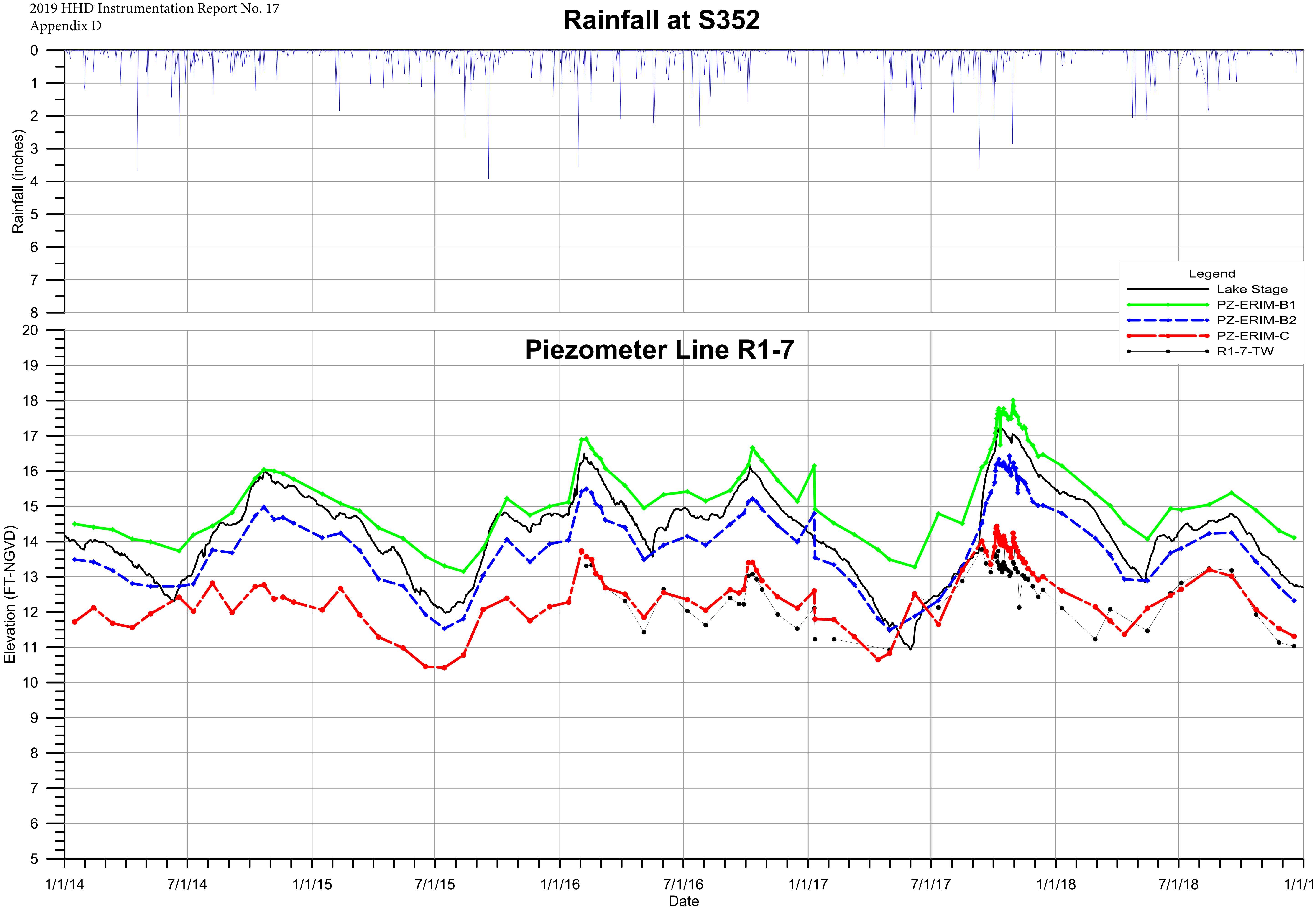
R1-6



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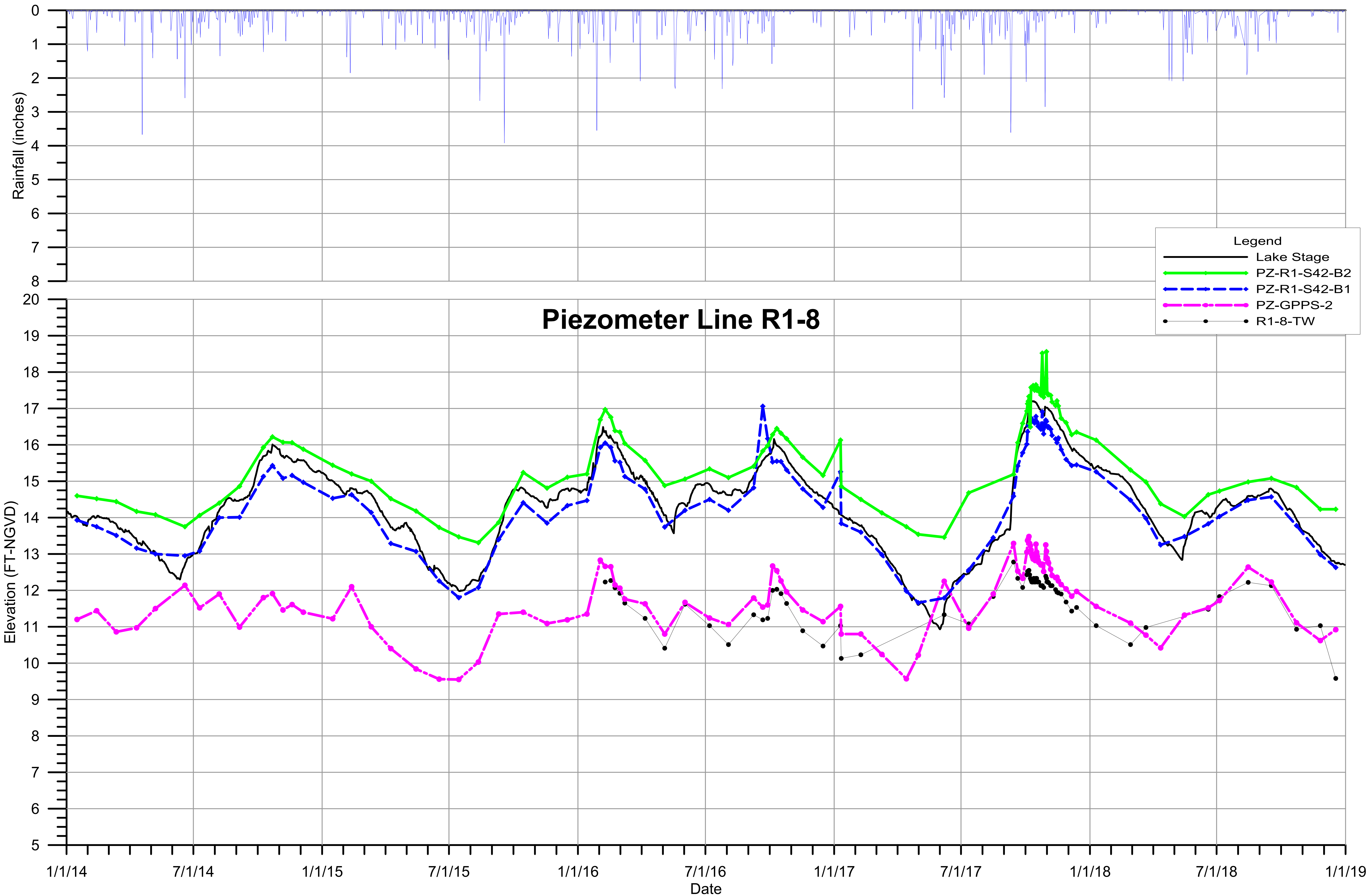
R1-7

Rainfall at S352



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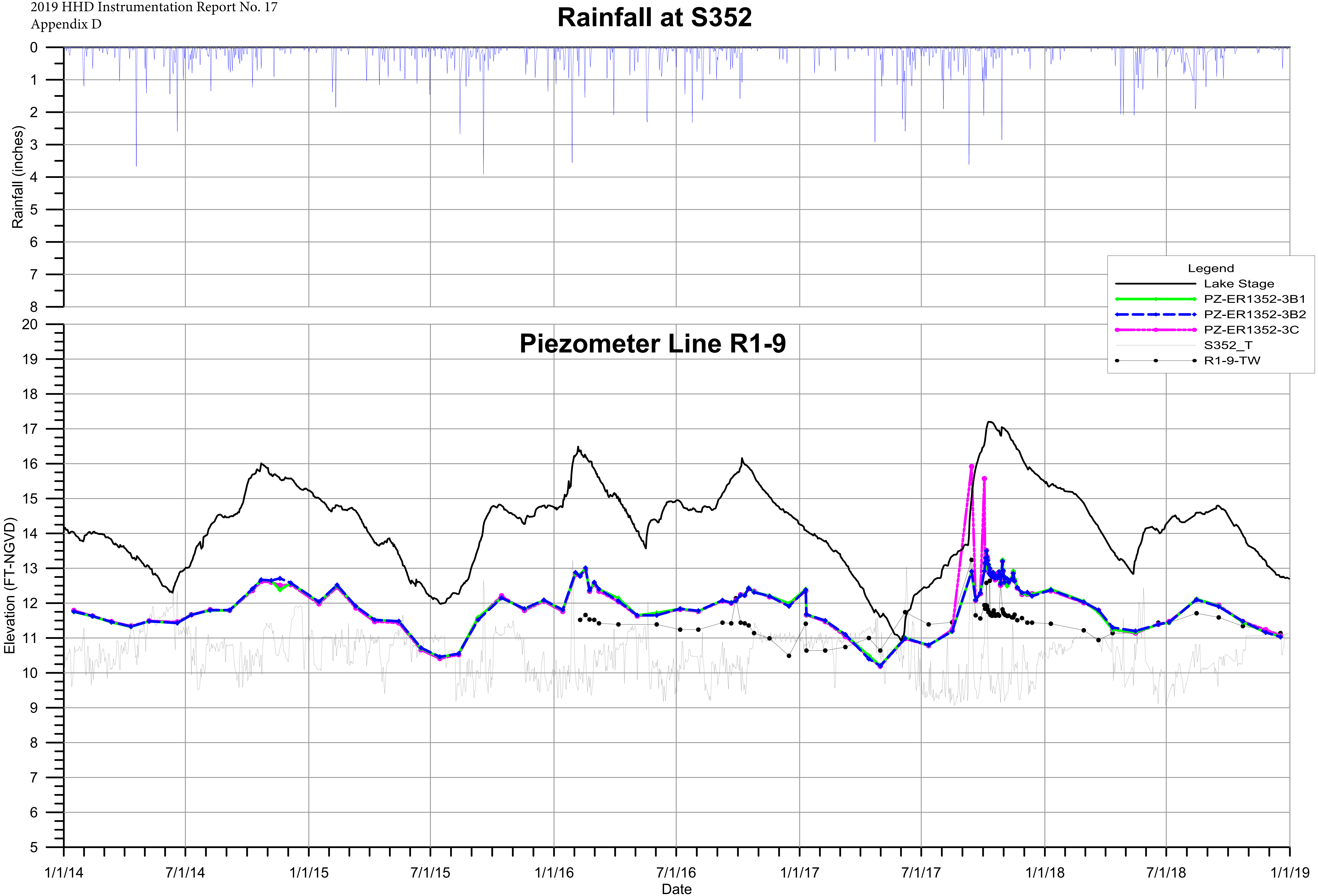
R1-8



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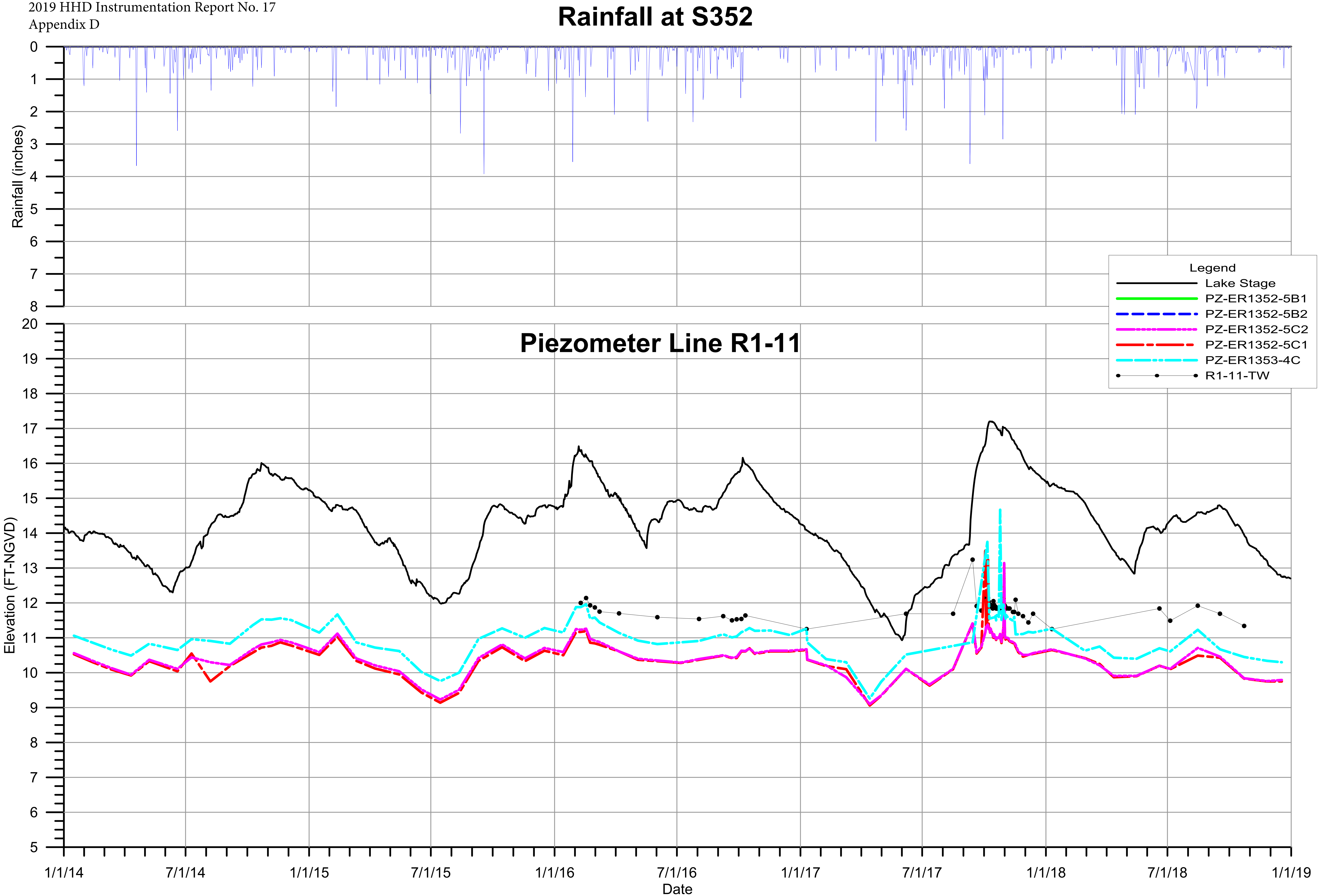
R1-9



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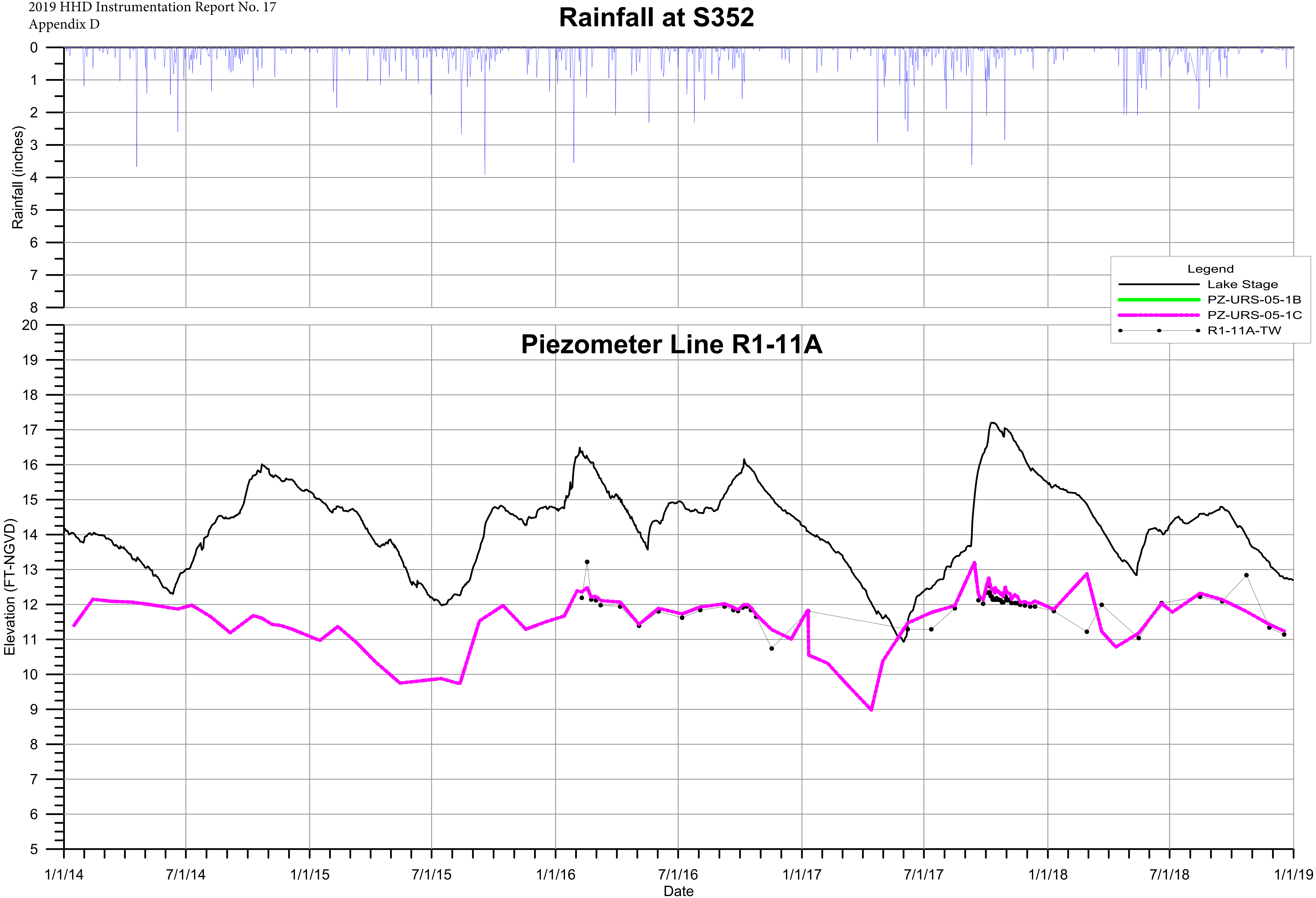
R1-11



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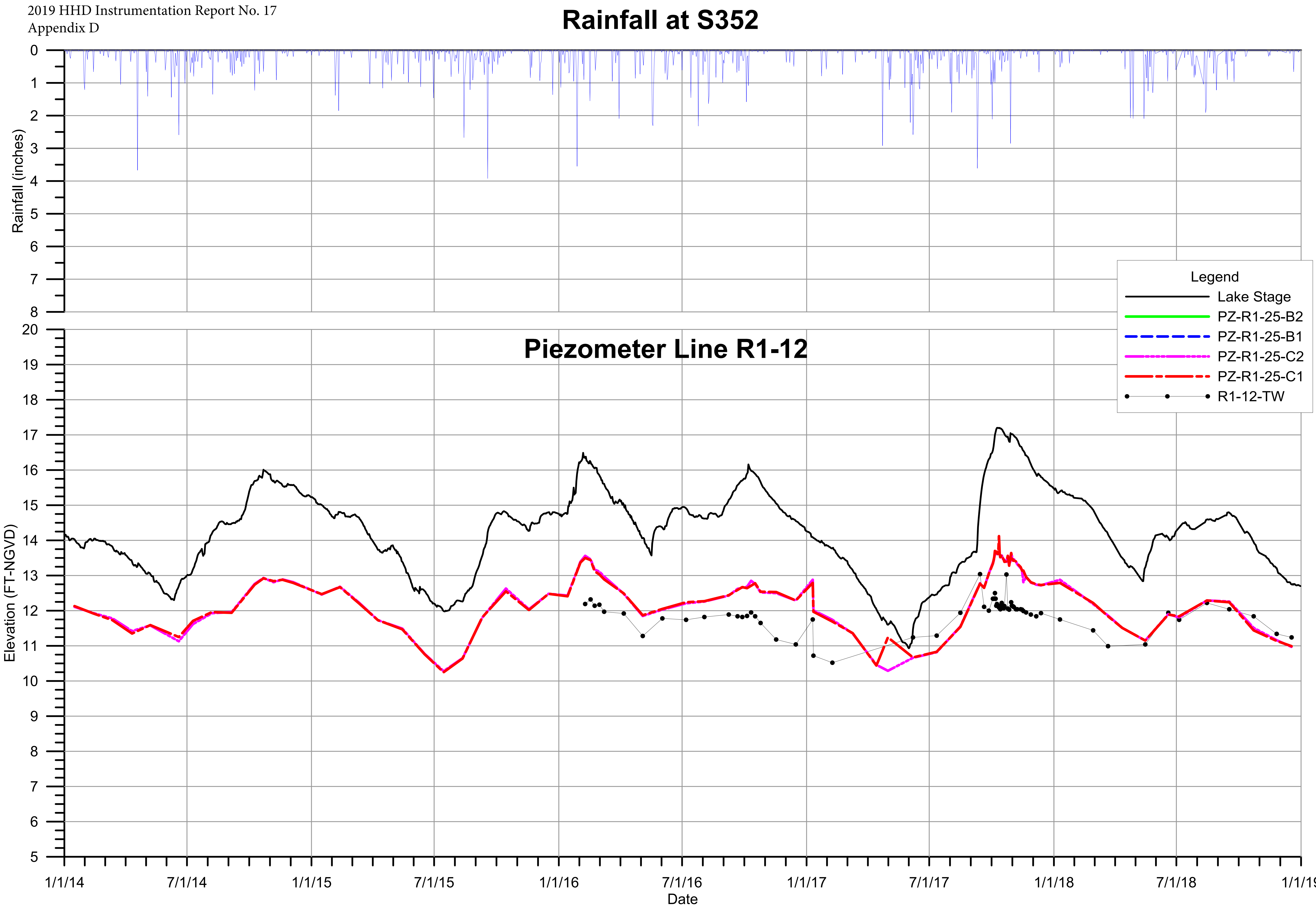
R1-11A



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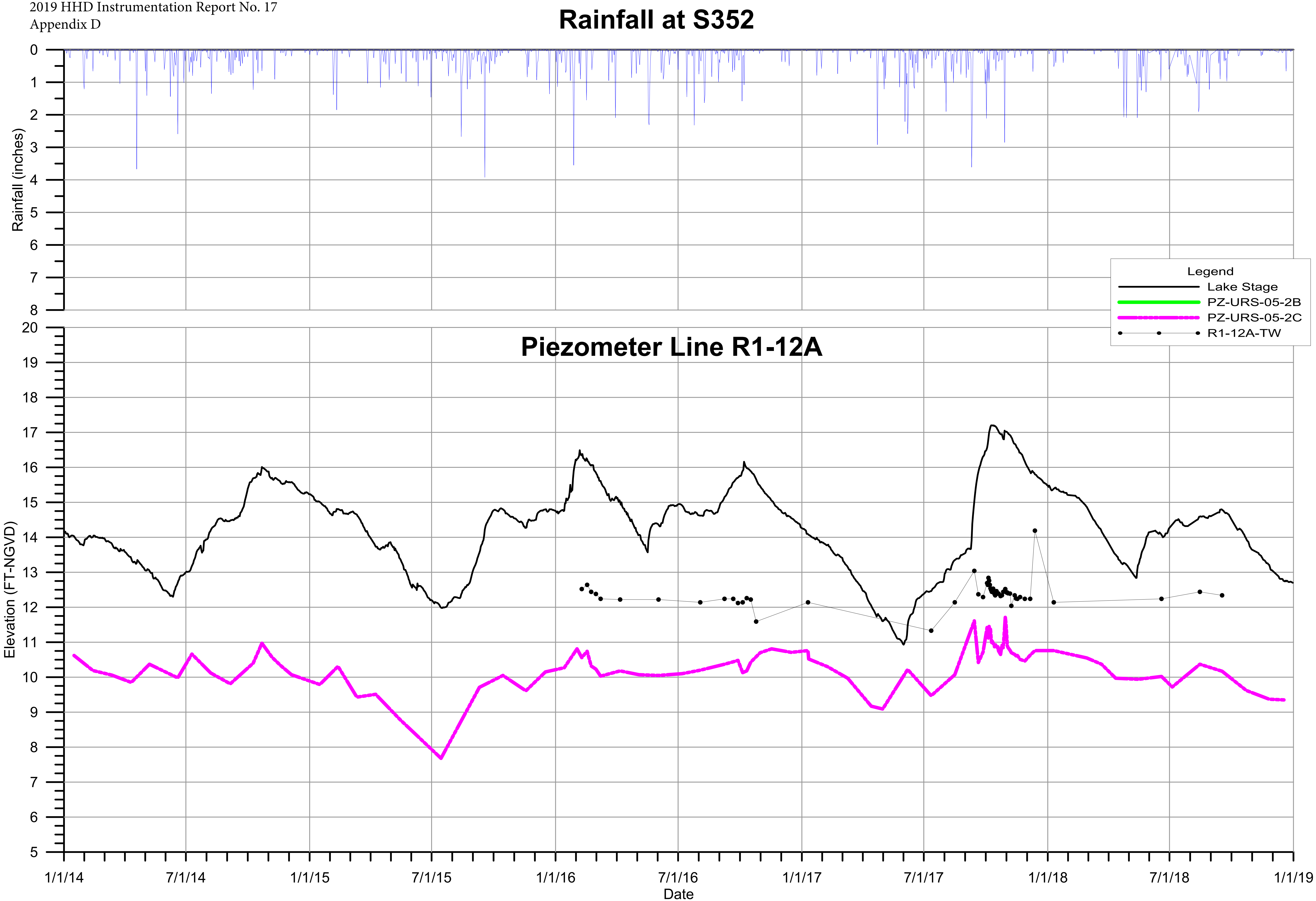
R1-12



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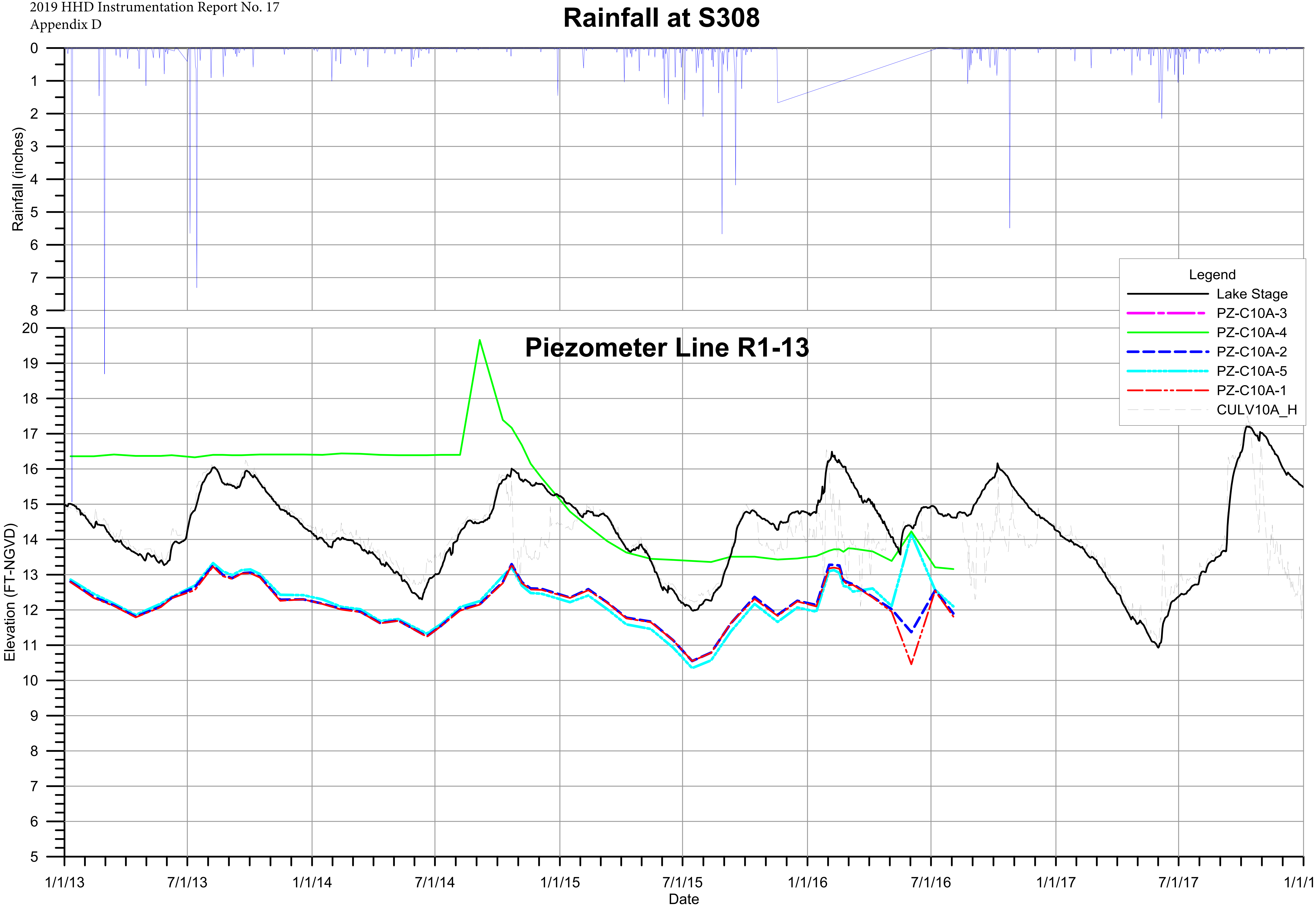
R1-12A



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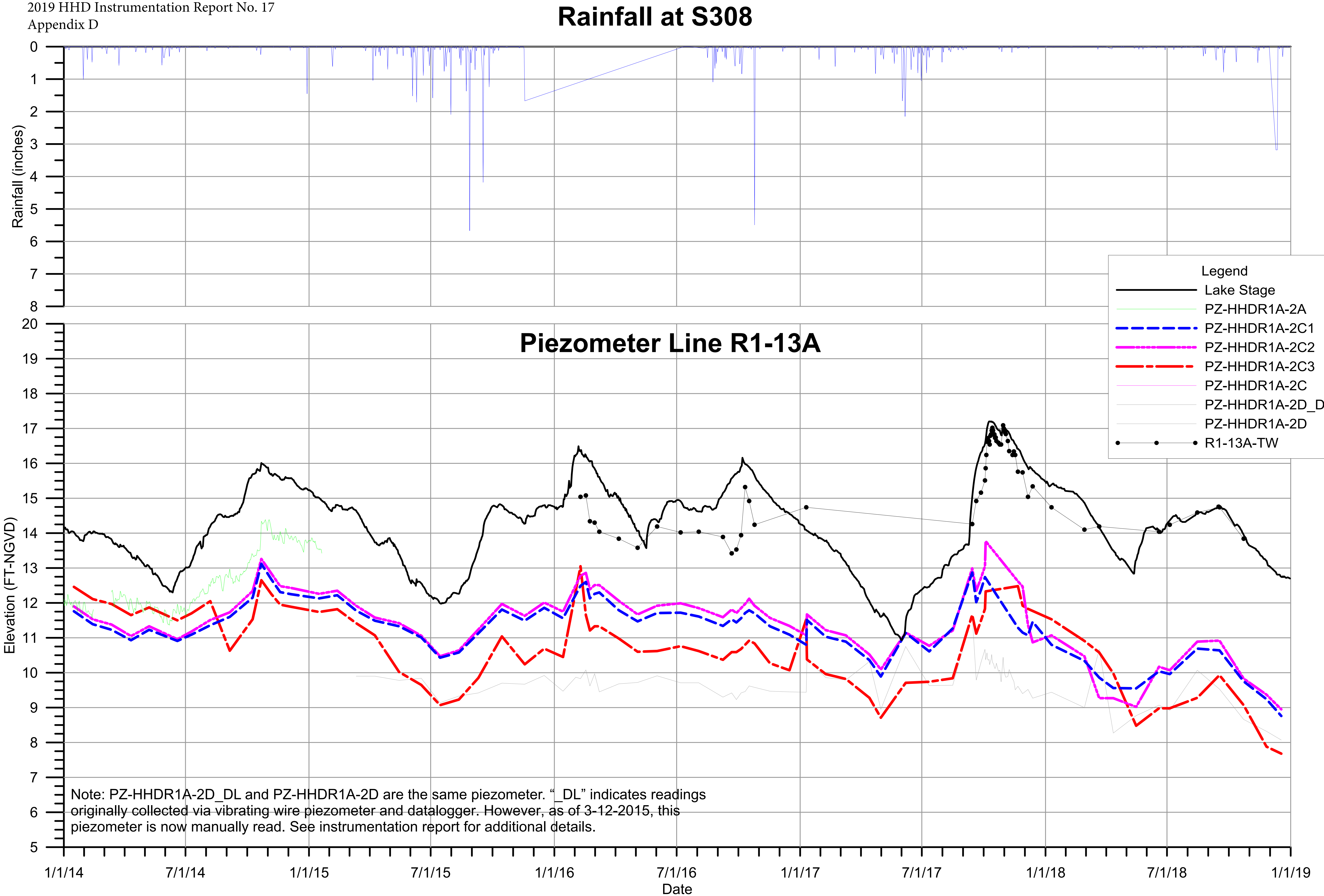
R1-13



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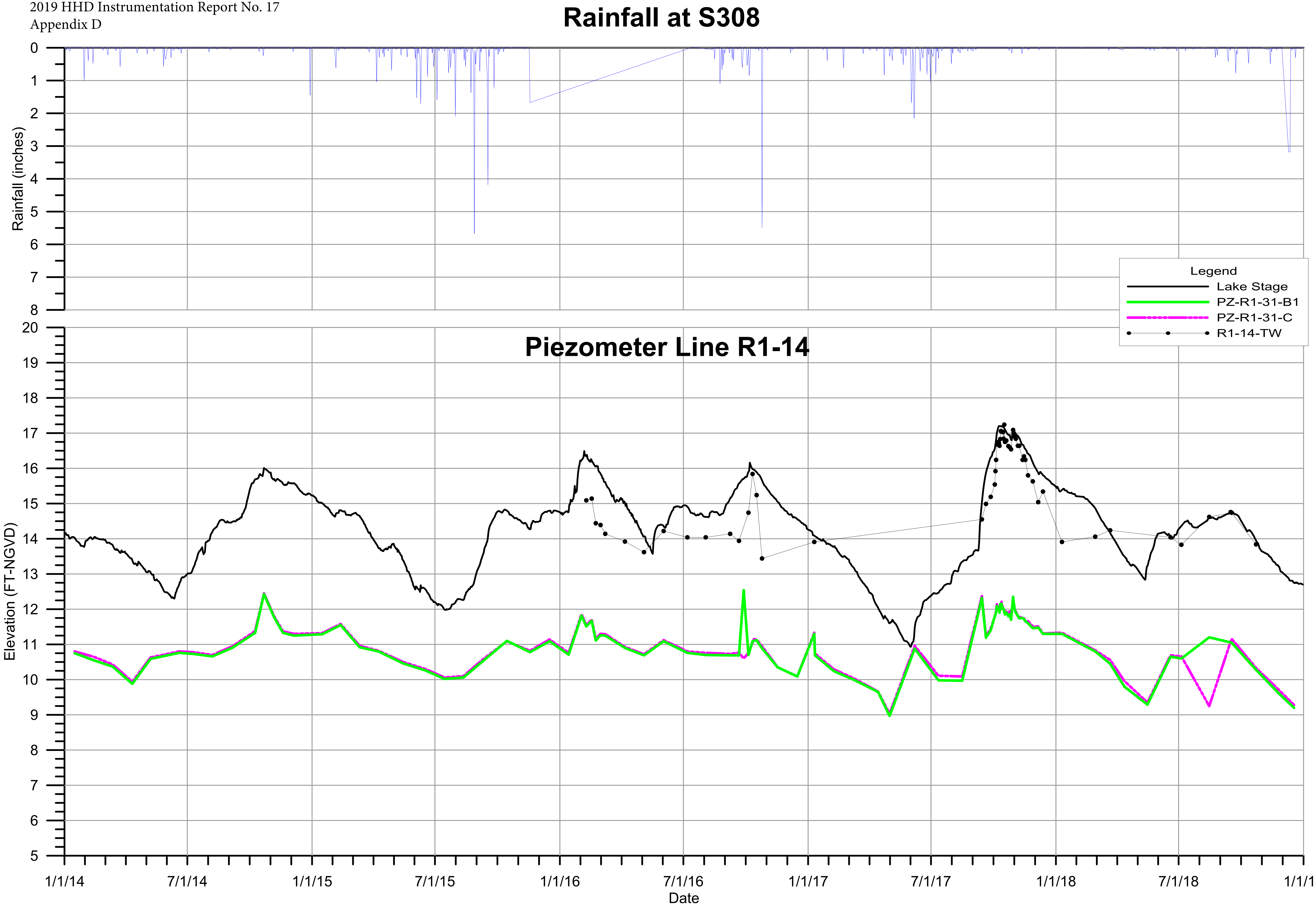
R1-13A



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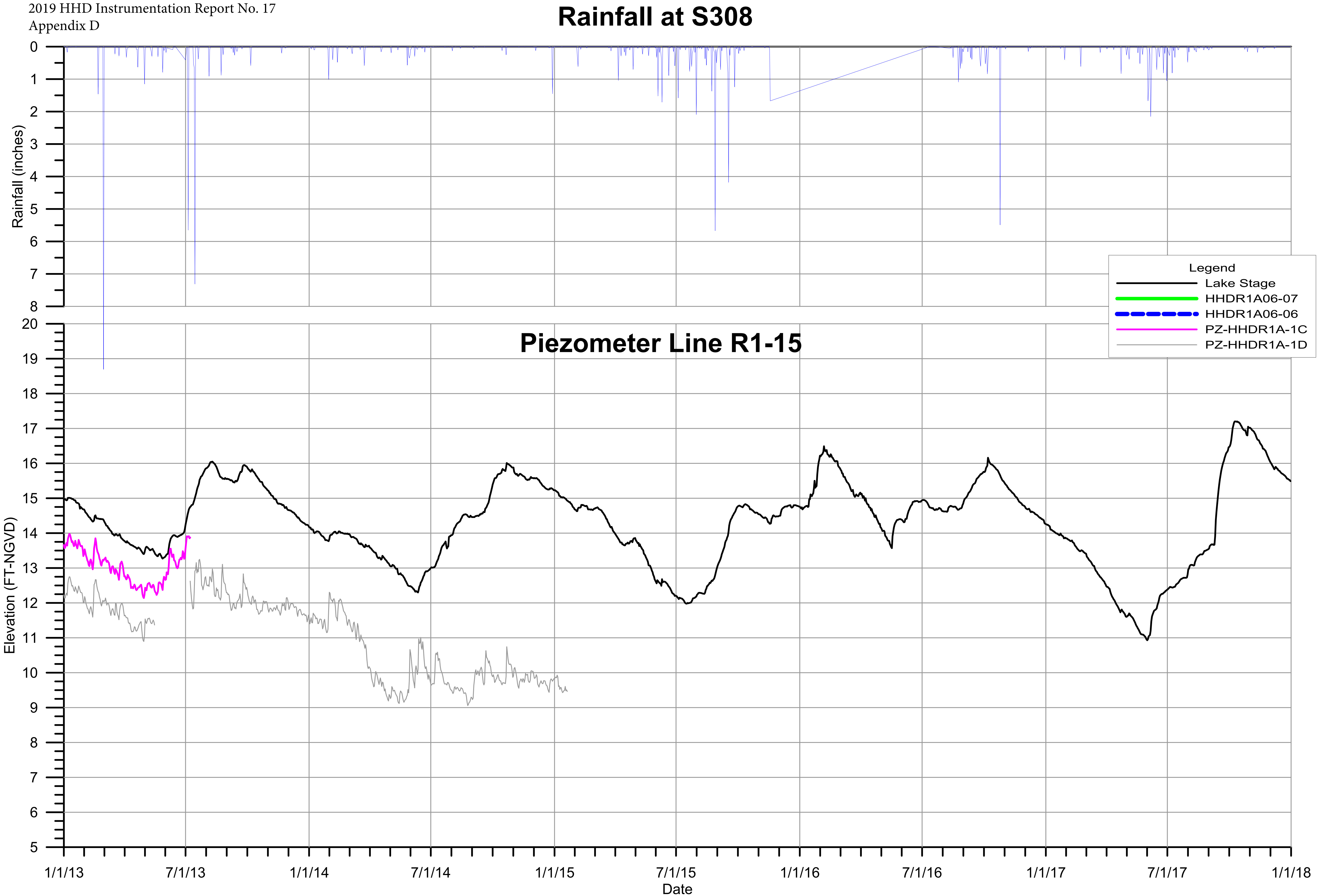
R1-14



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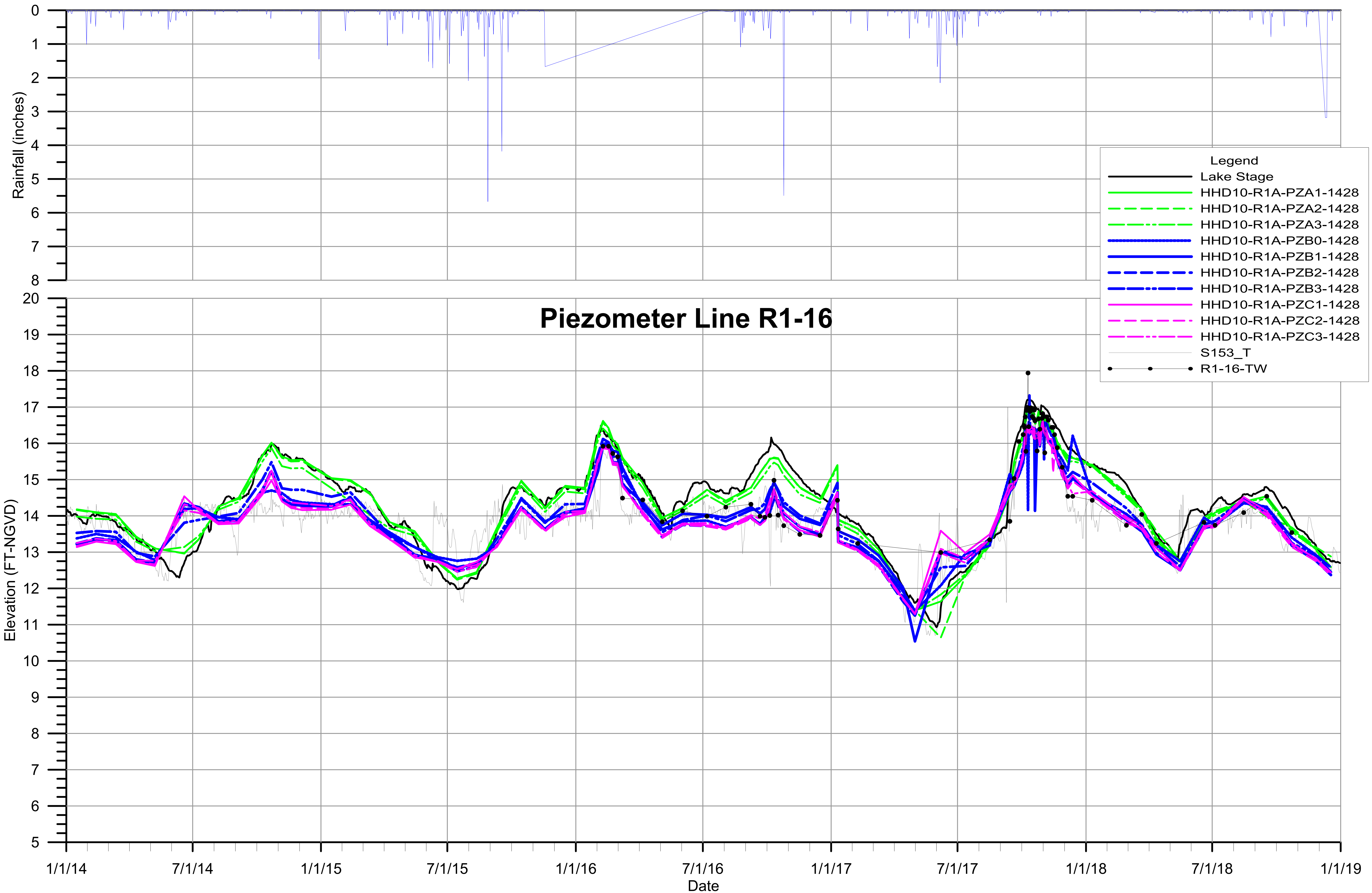
R1-15

Rainfall at S308



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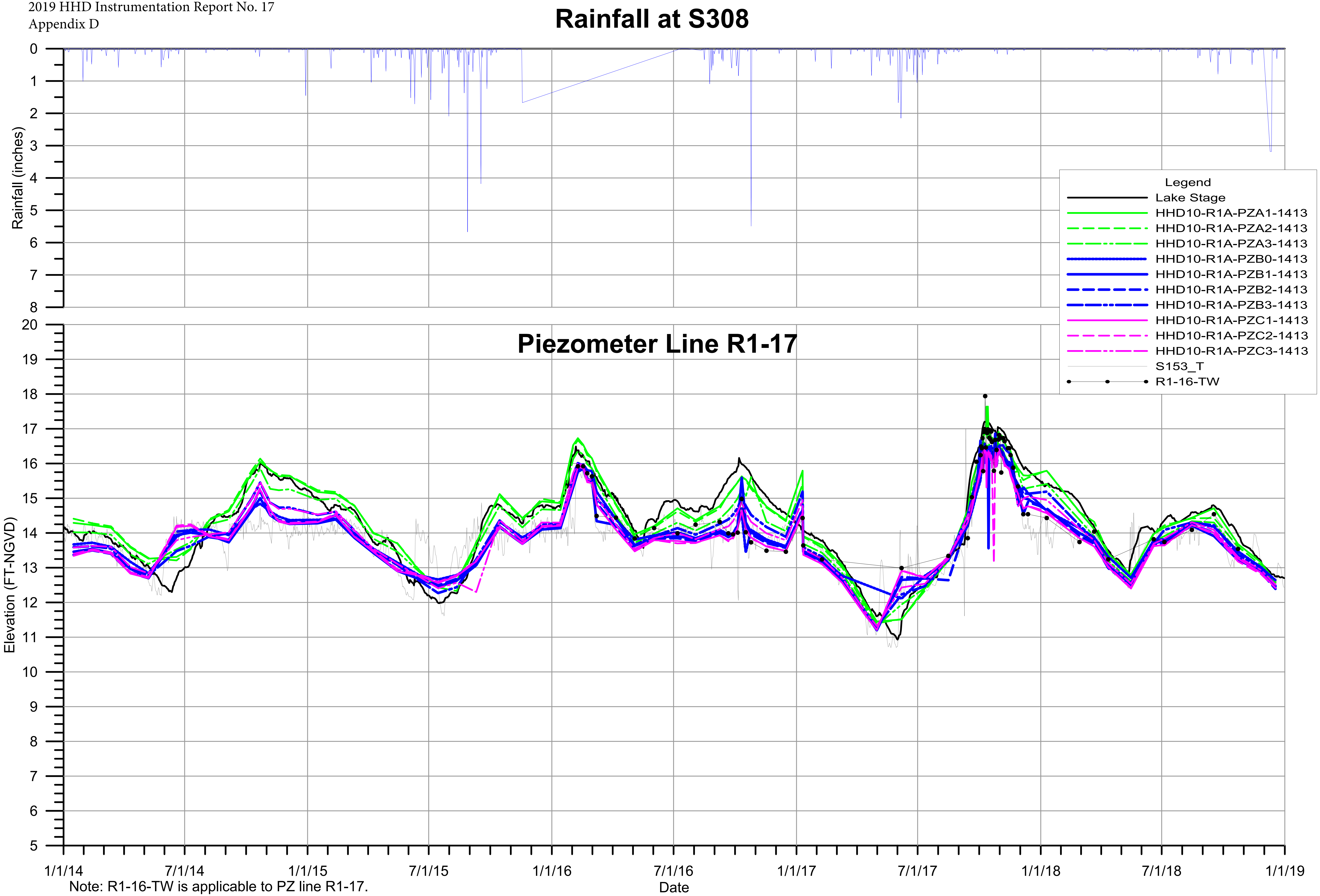
R1-16



Note: R1-16-TW is applicable to PZ line R1-17.

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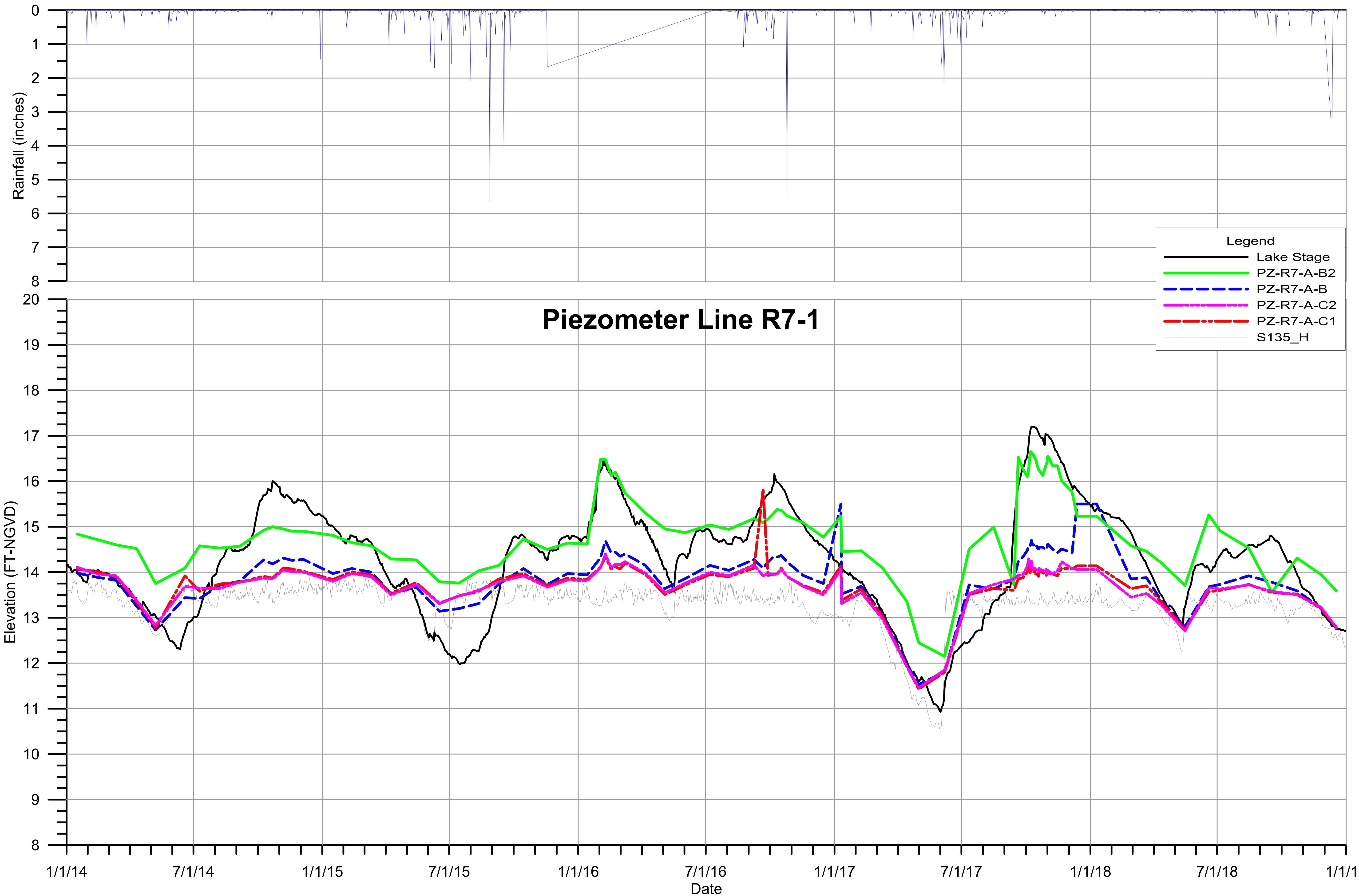
R1-17

Rainfall at S308



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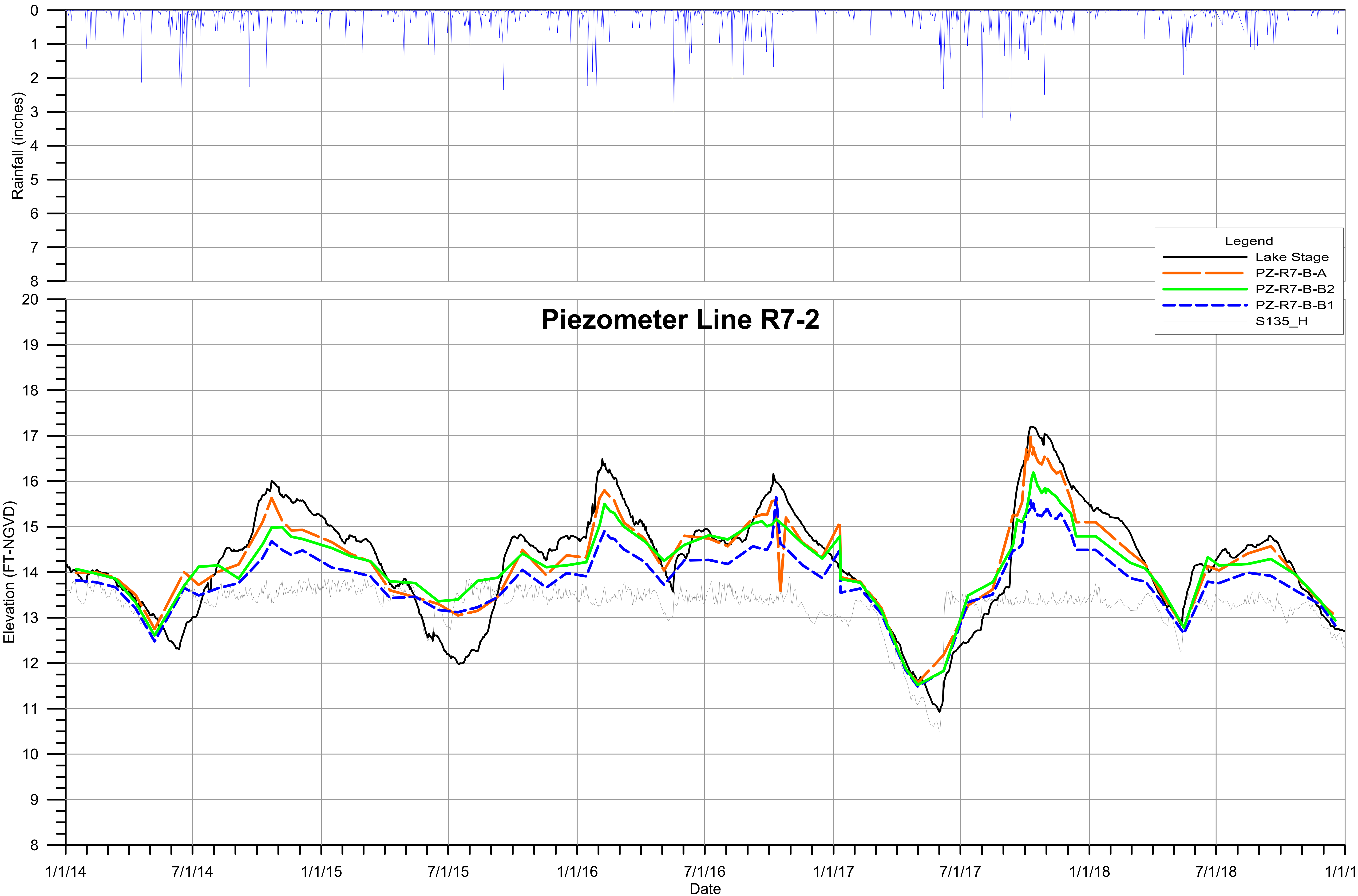
R7-1

Rainfall at S135



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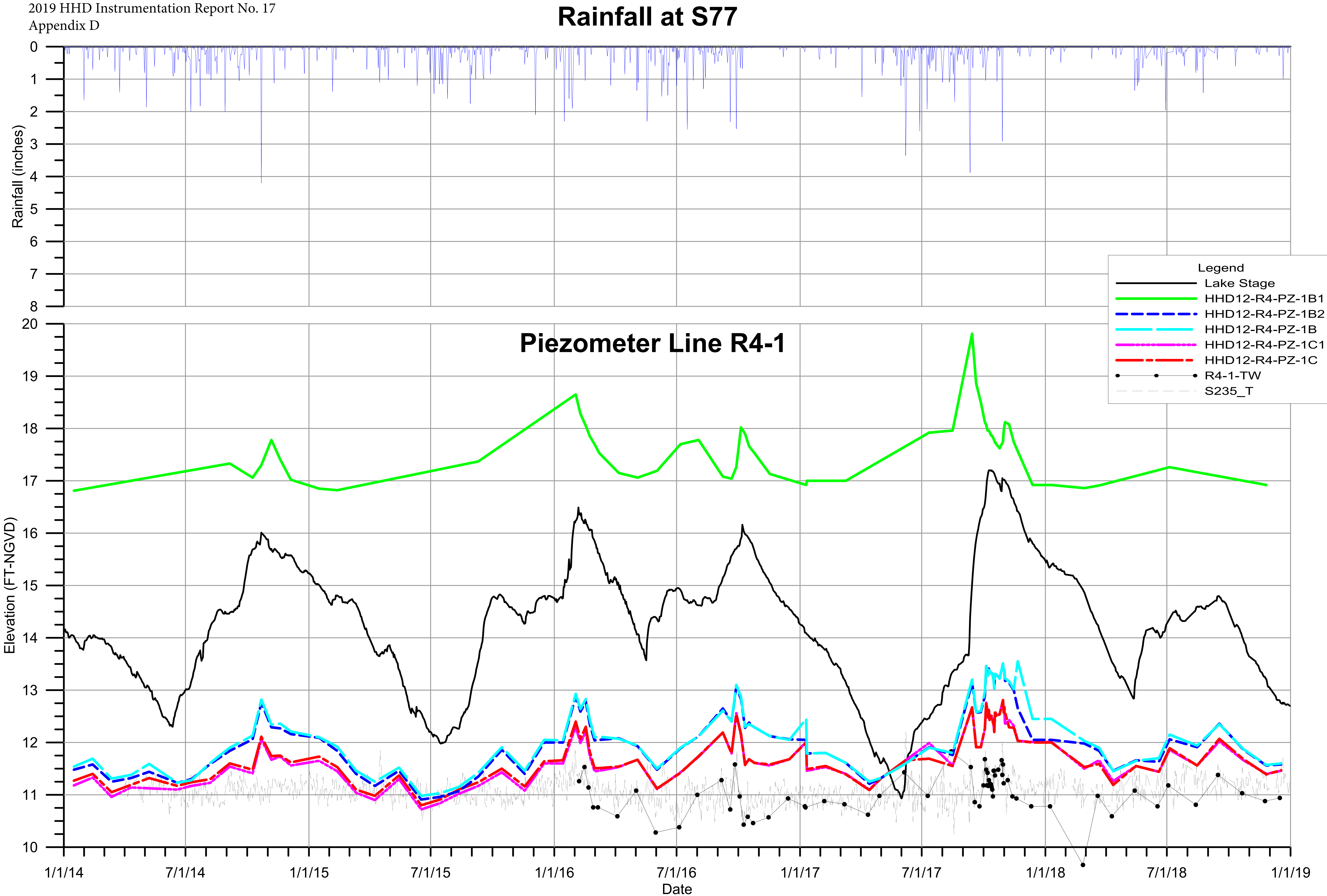
R7-2



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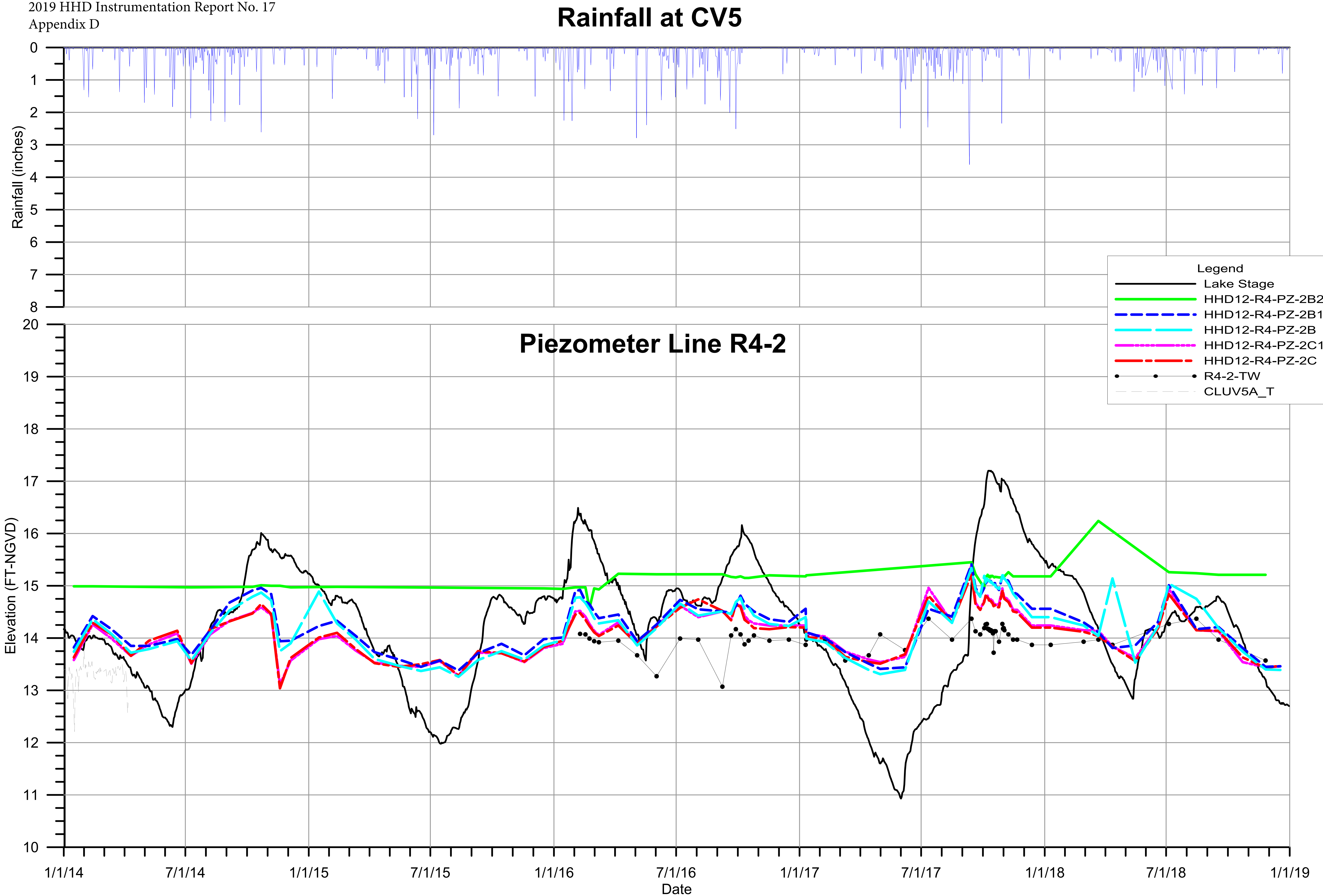
R4-1



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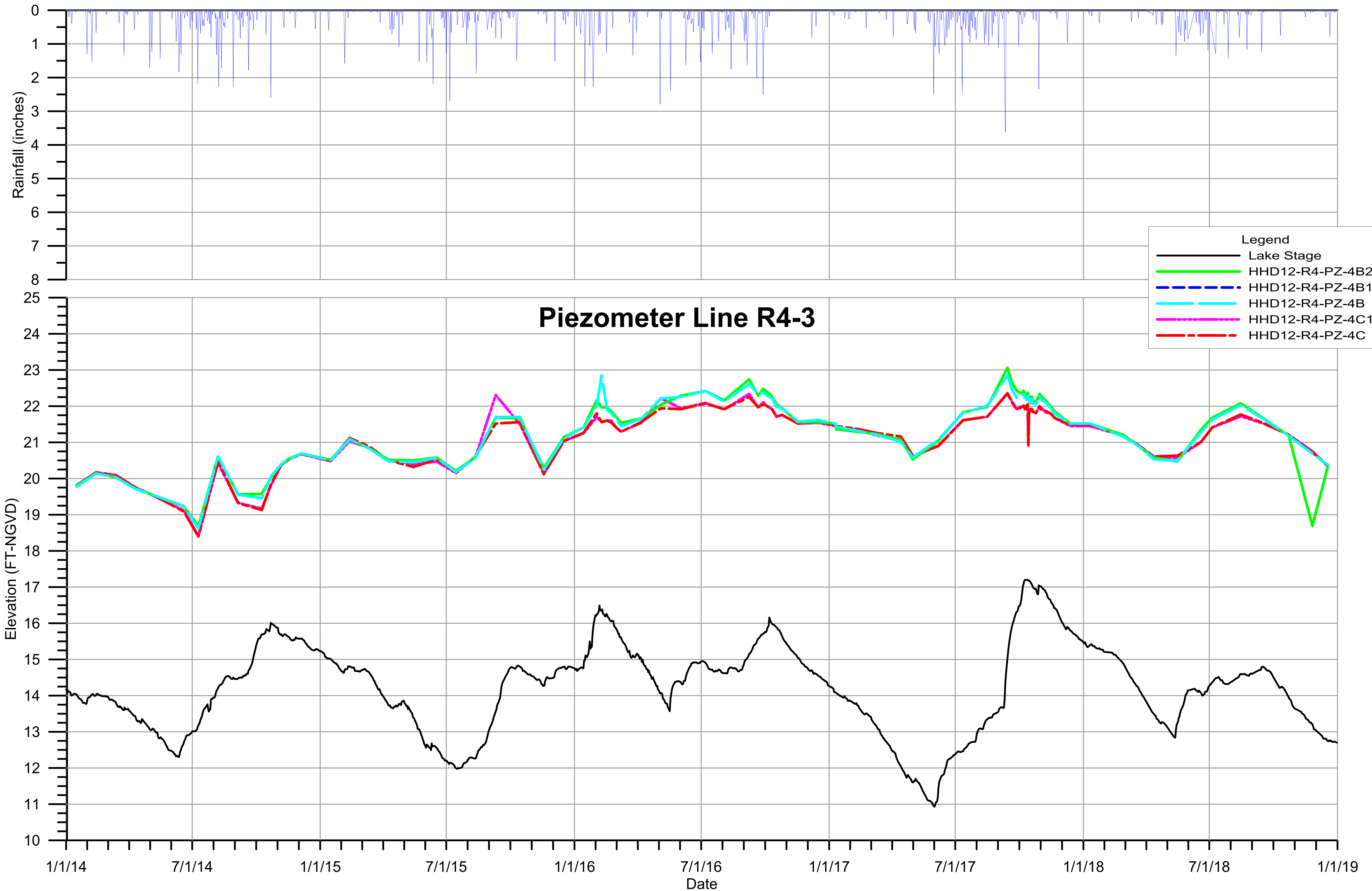
R4-2

Rainfall at CV5



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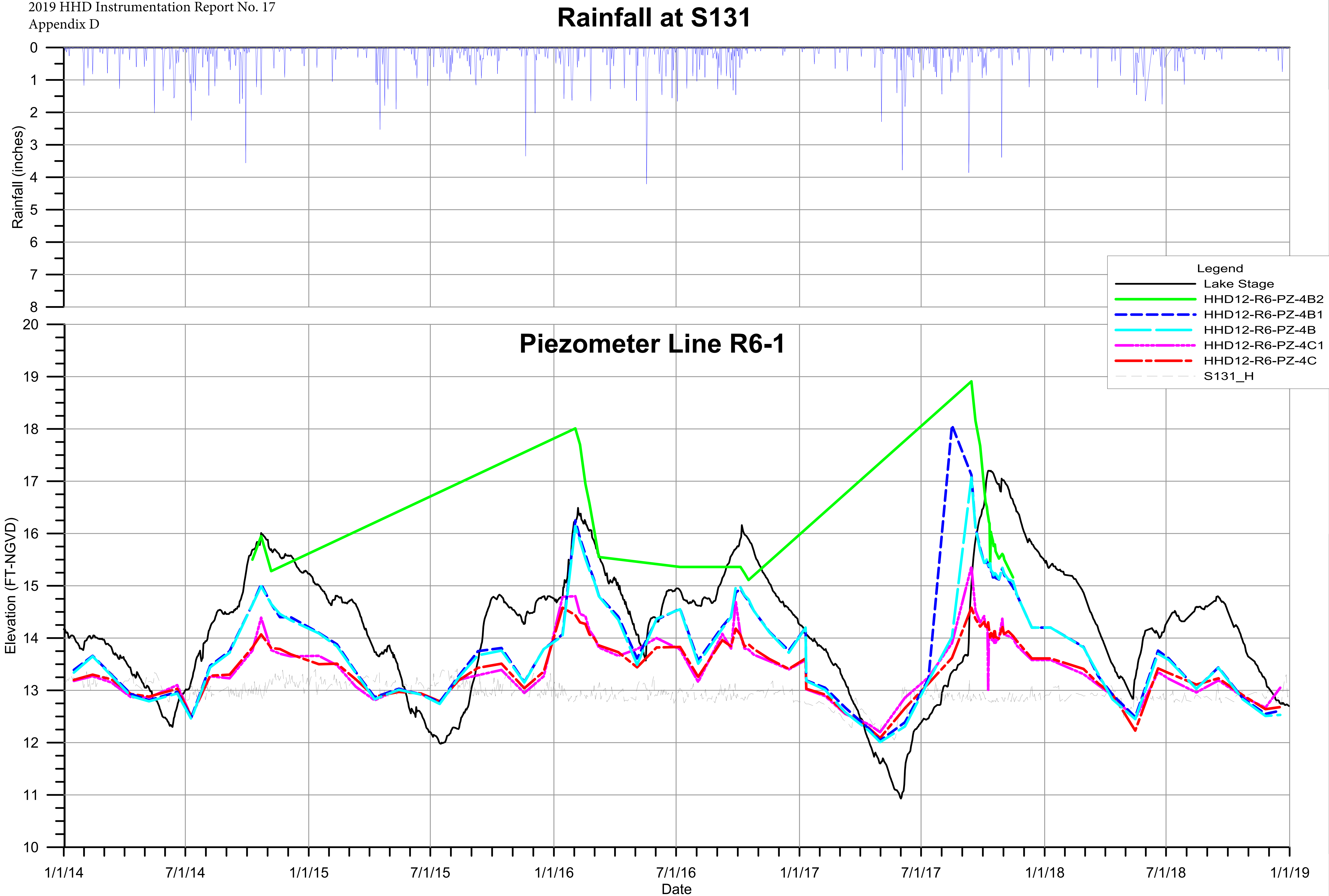
R4-3



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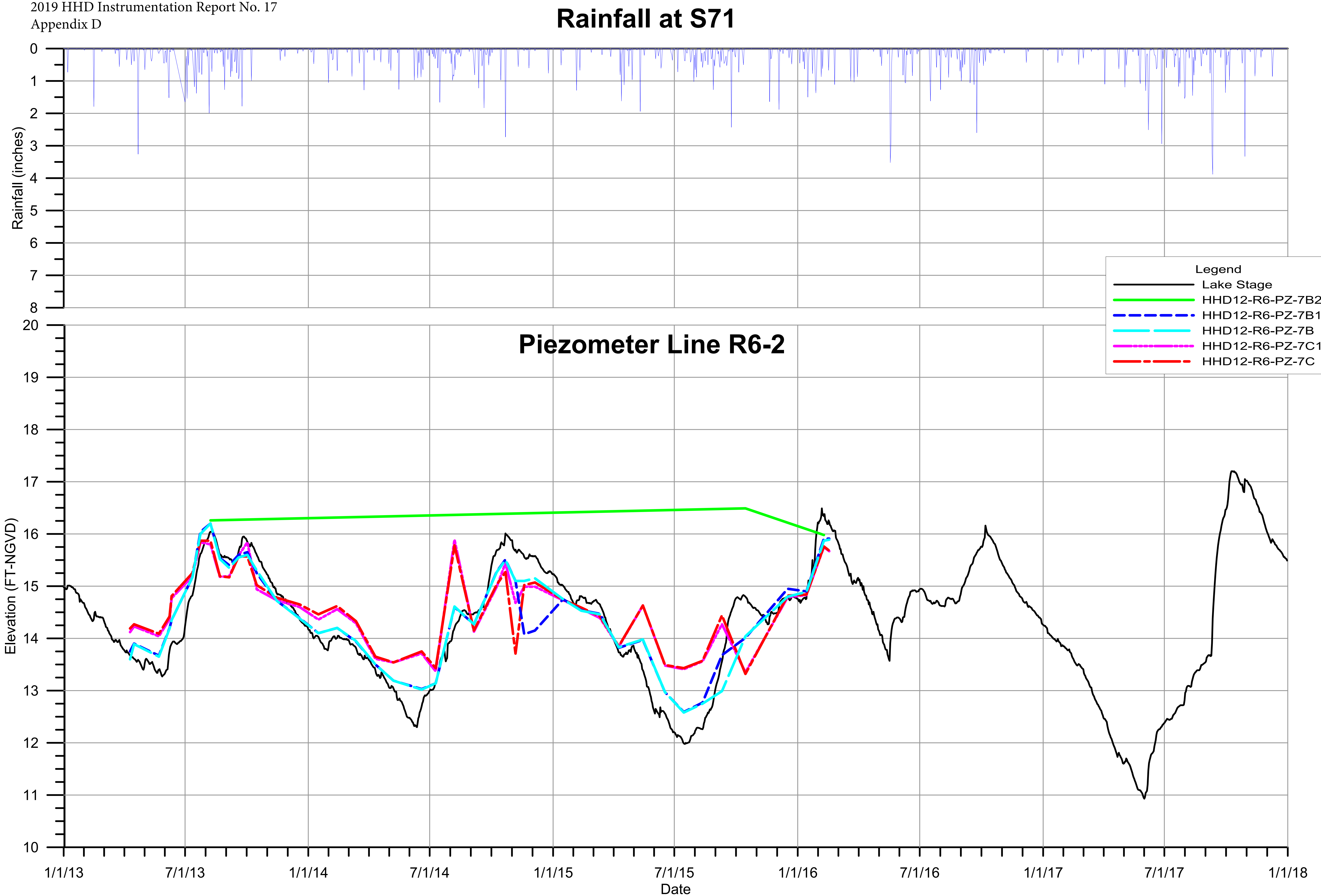
R6-1



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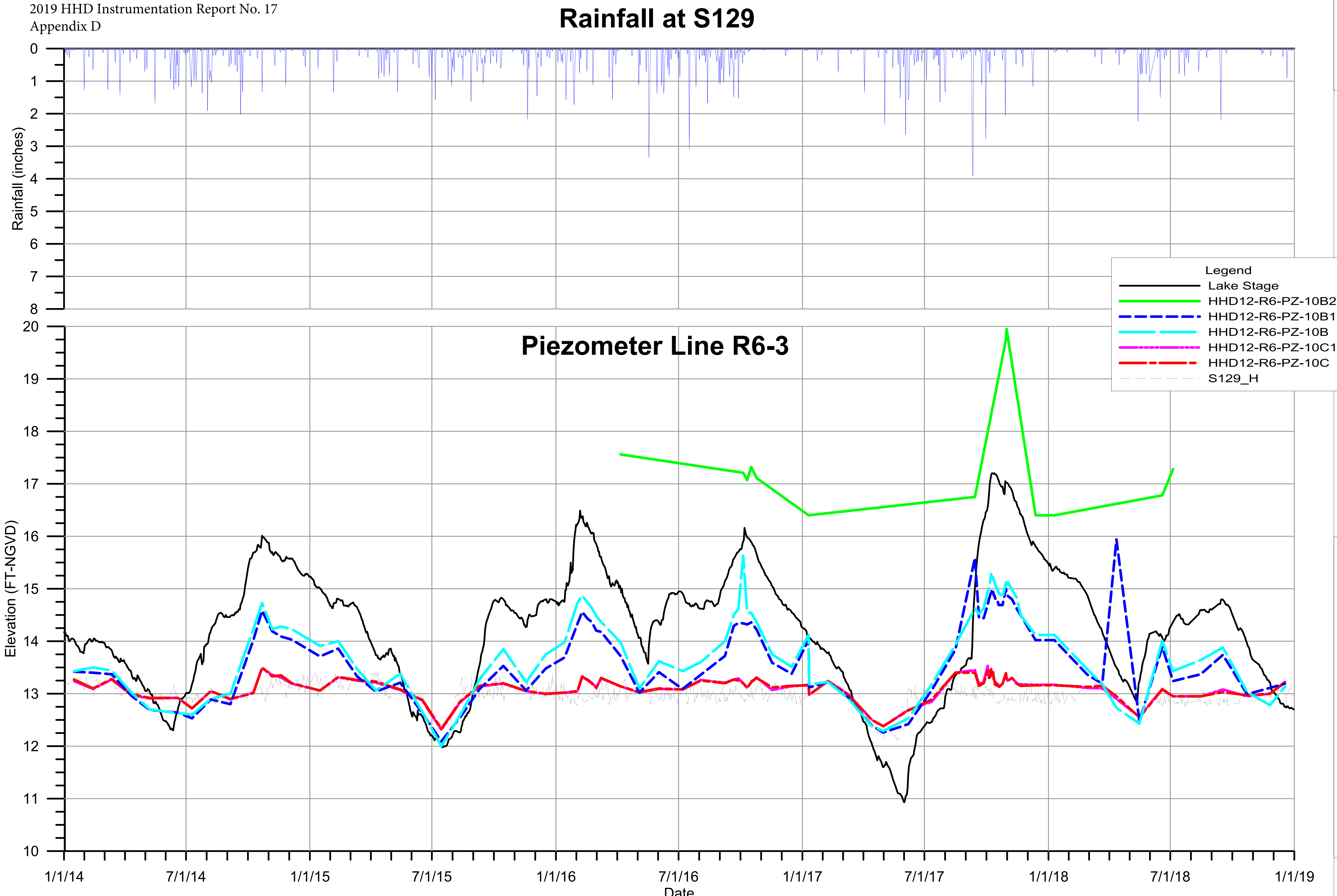
R6-2



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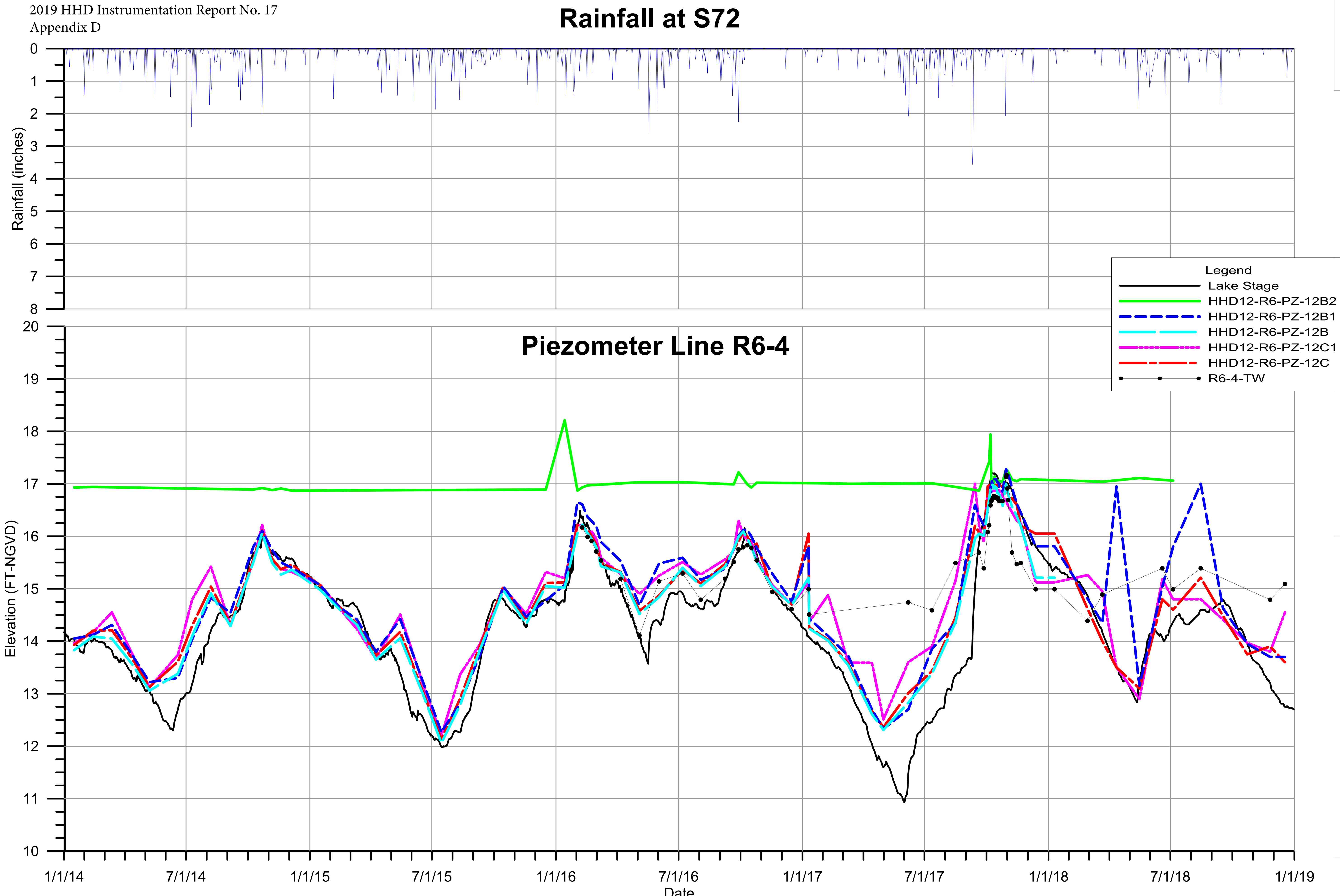
Instrumentation Update

R6-3



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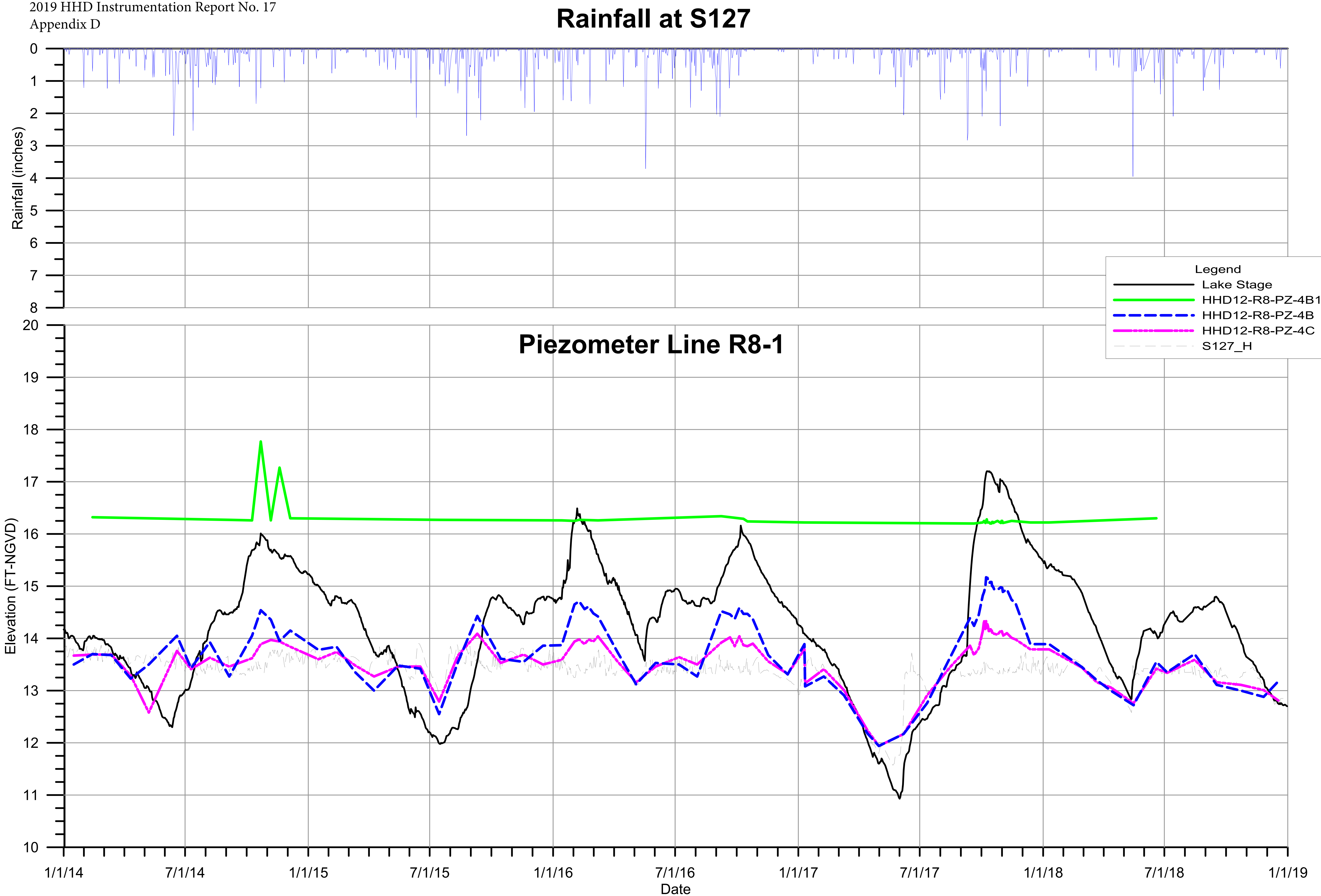
Herbert Hoover Dike
Lake Okeechobee, Florida
Instrumentation Update

R6-4



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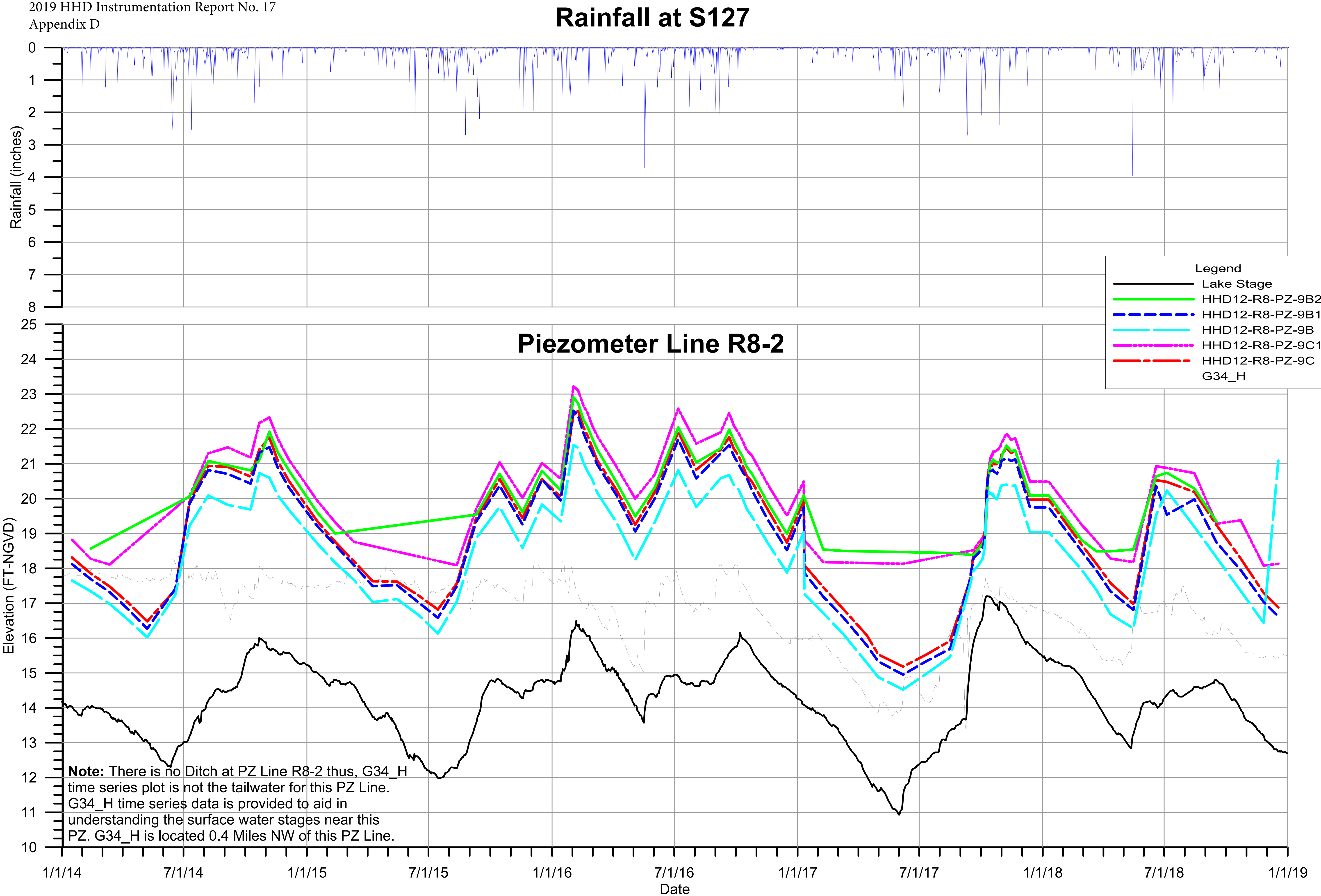
JACKSONVILLE, FLORIDA

Herbert Hoover Dike
Lake Okeechobee, Florida
Instrumentation Update

R8-1



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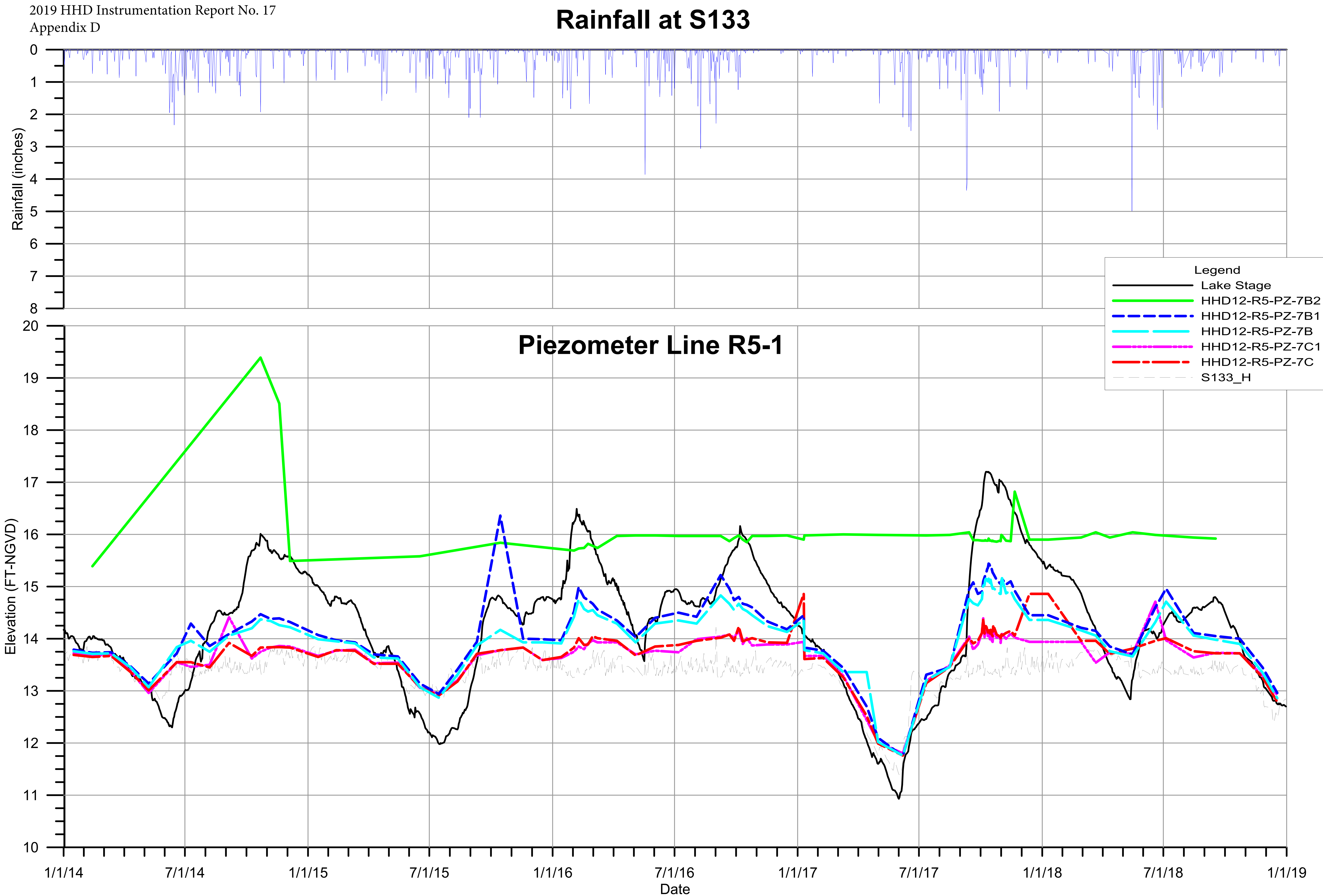
Herbert Hoover Dike
Lake Okeechobee, Florida
Instrumentation Update

R8-2



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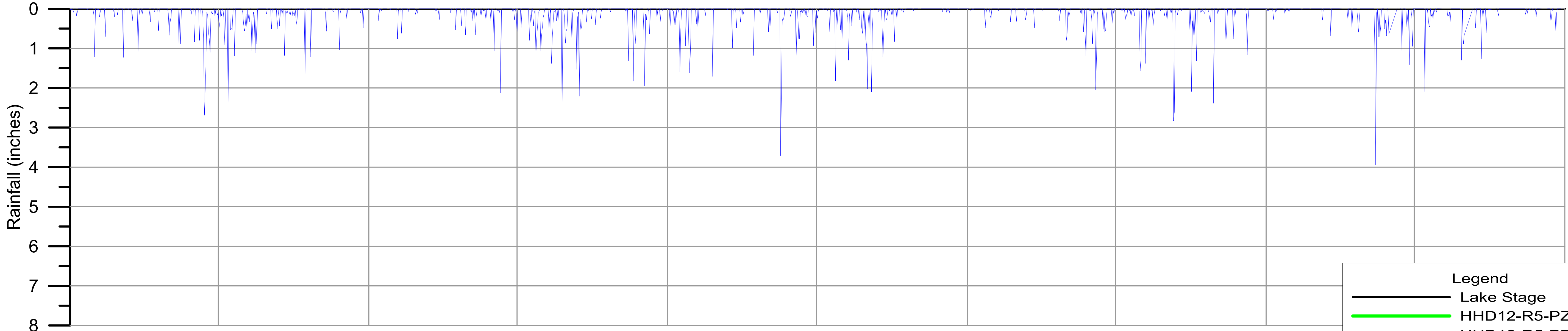
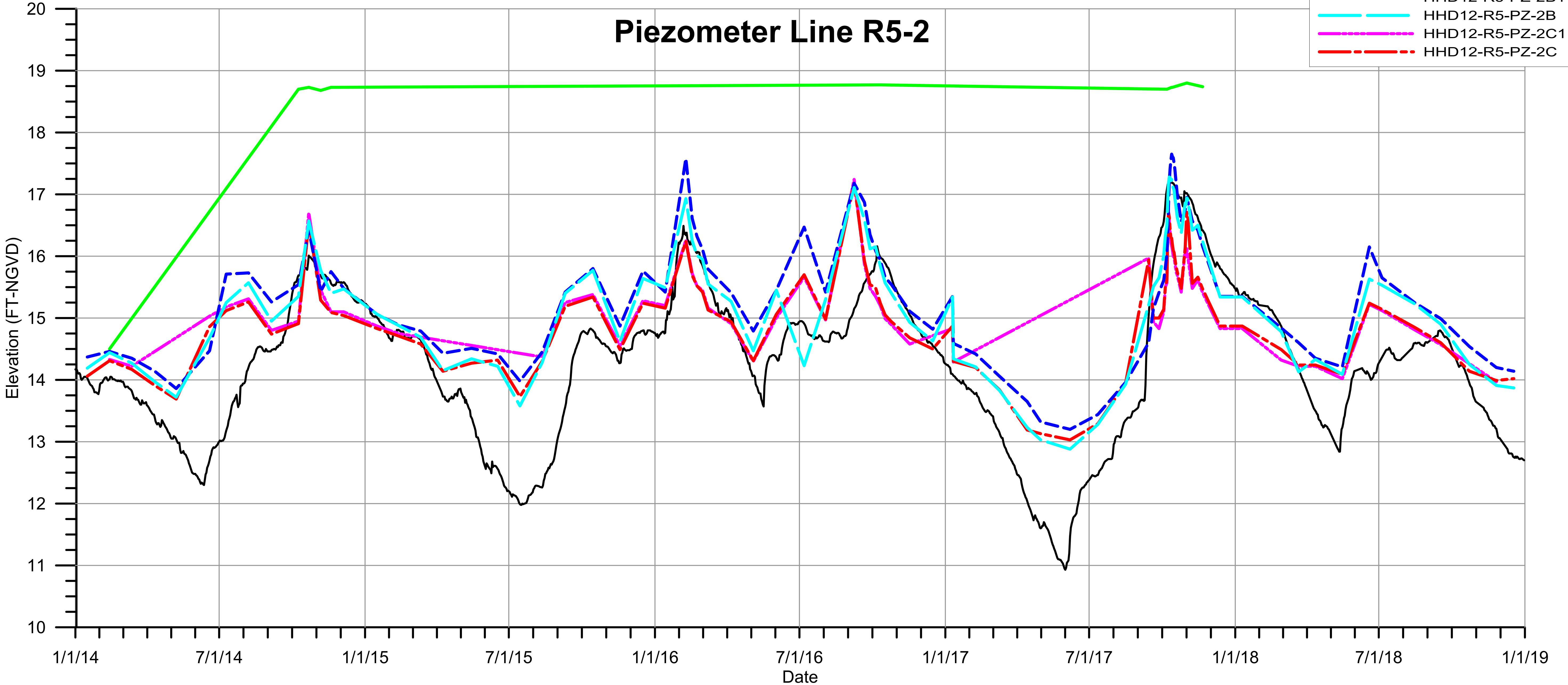
Instrumentation Update

R5-1

Rainfall at S127



Piezometer Line R5-2



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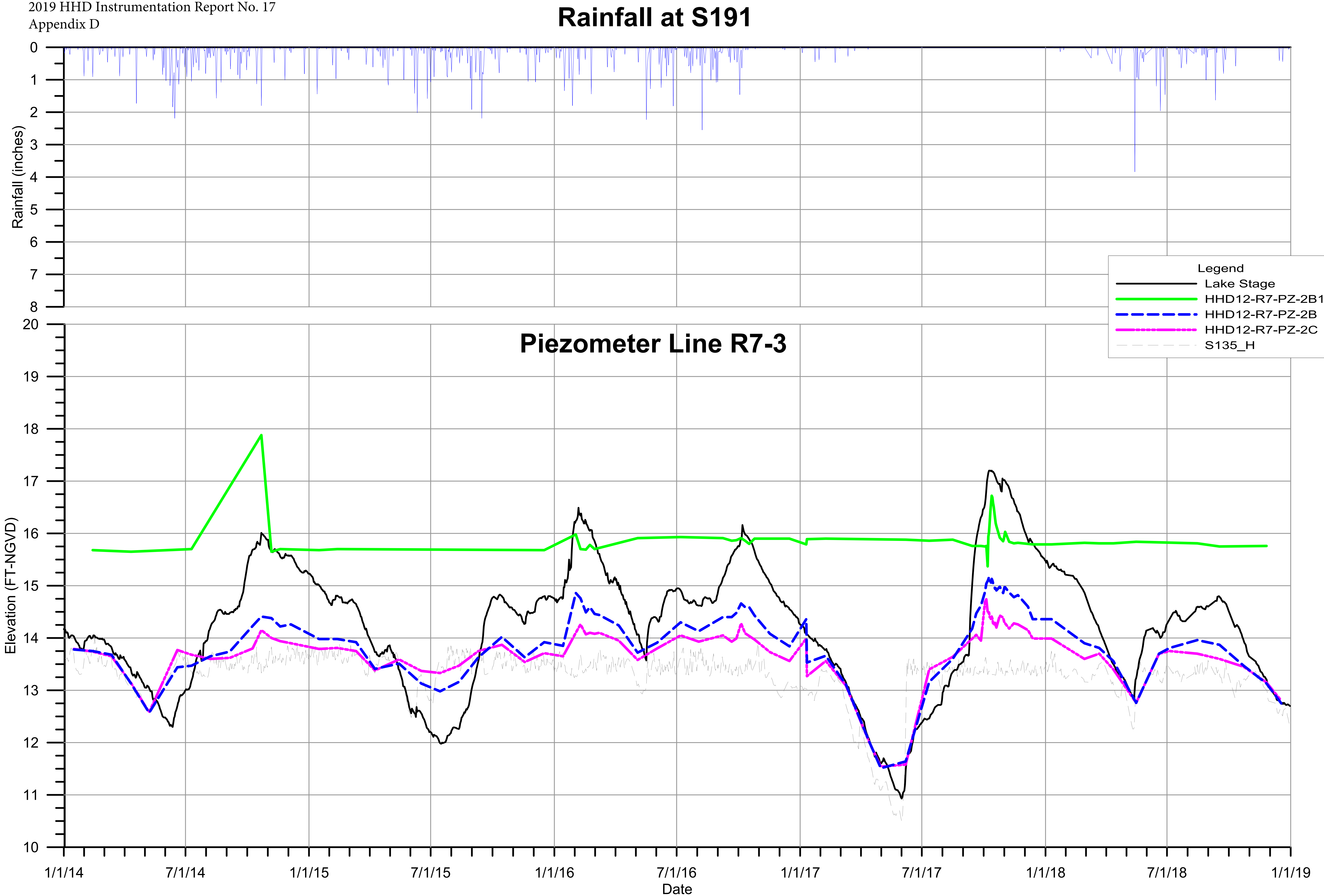
Herbert Hoover Dike
Lake Okeechobee, Florida
Instrumentation Update

R5-2



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Herbert Hoover Dike
Lake Okeechobee, Florida
Instrumentation Update

R7-3

APPENDIX E: PIEZOMETER LINE HYSTERESIS PLOTS

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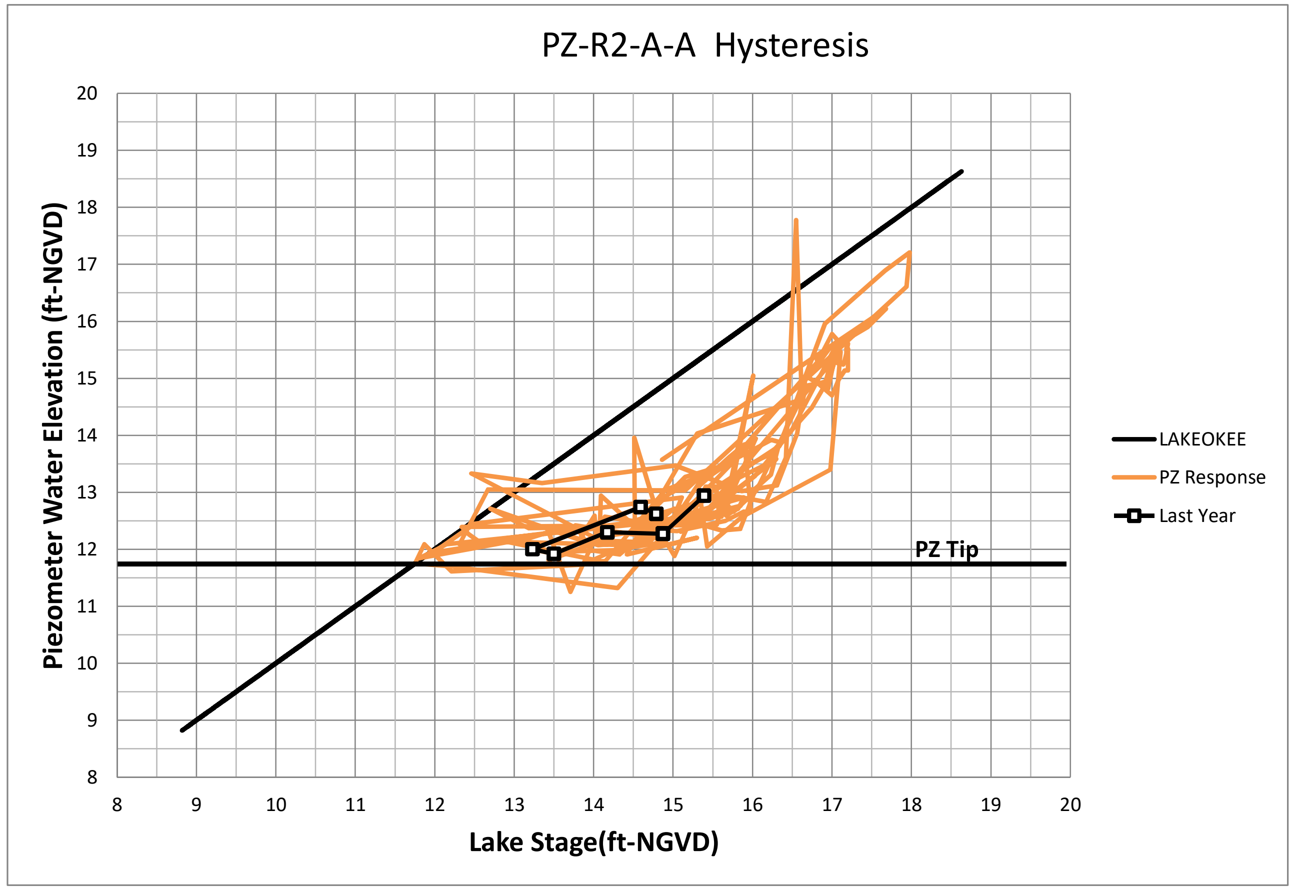
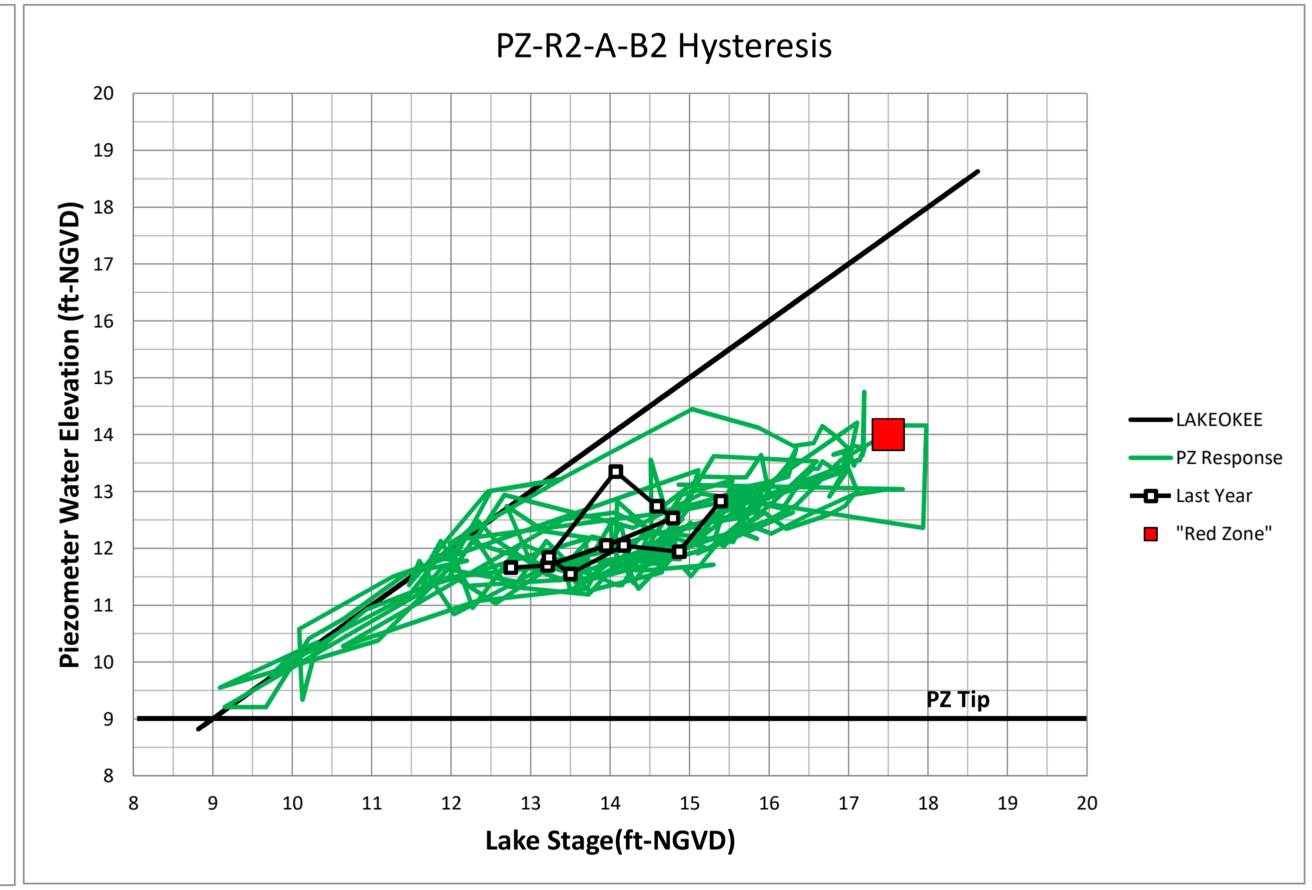
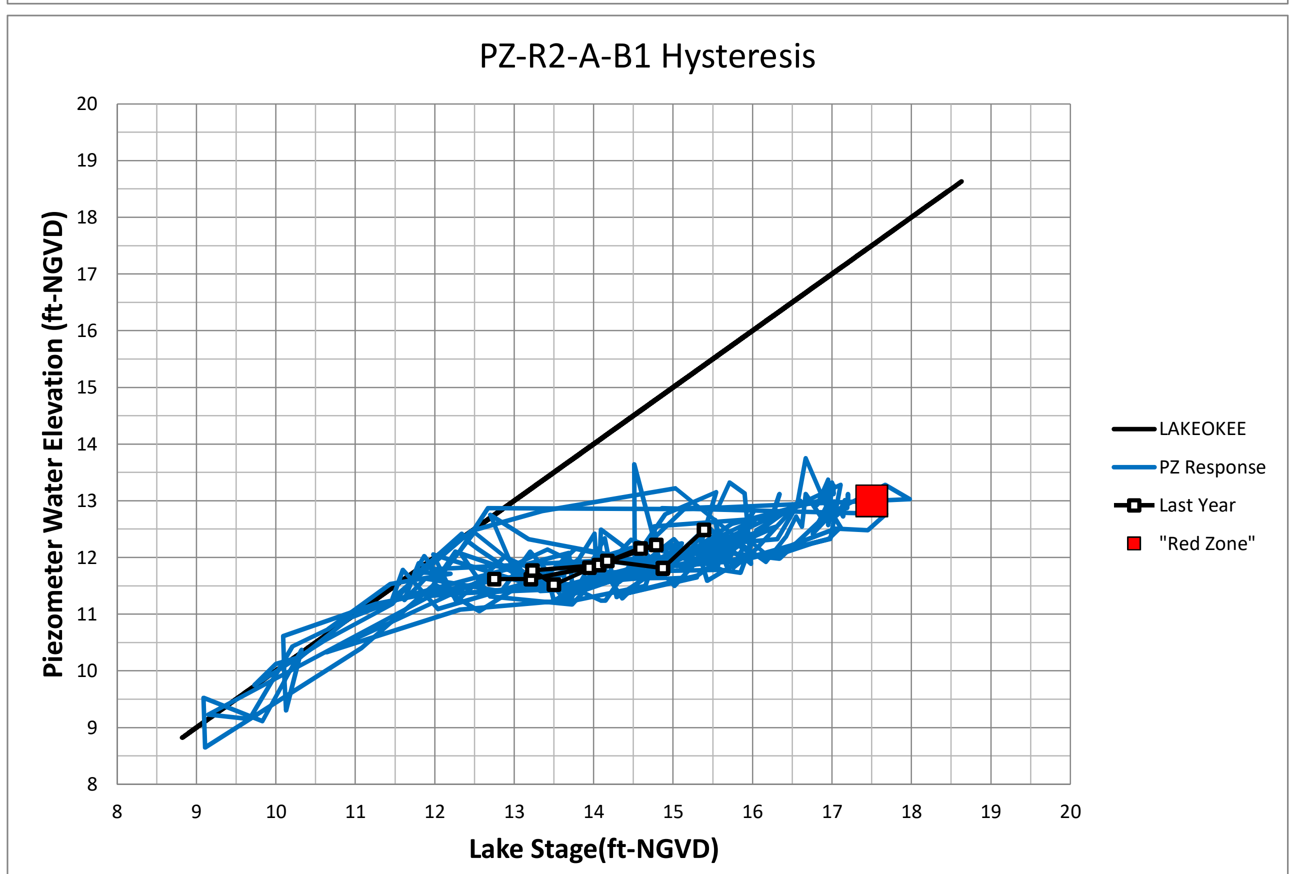
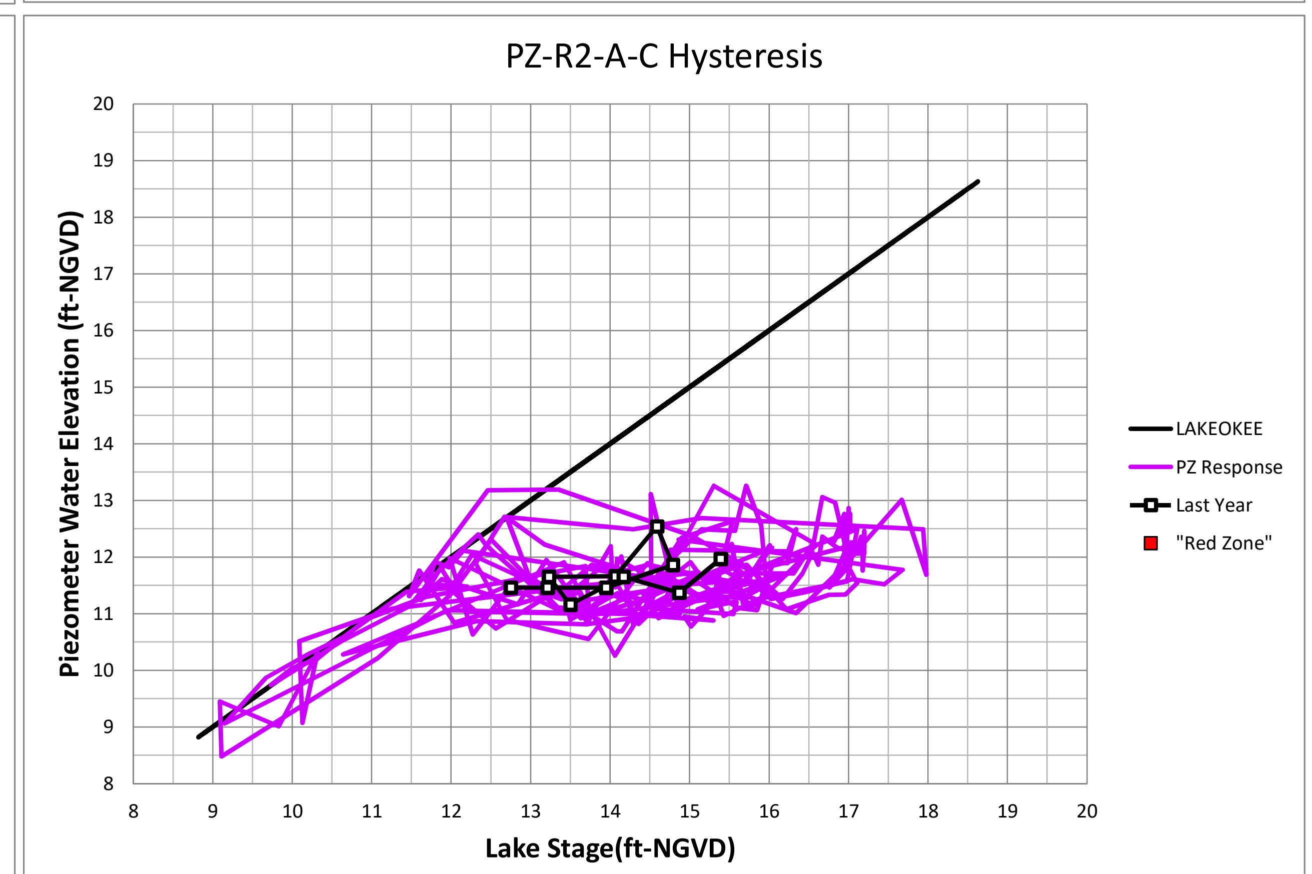
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

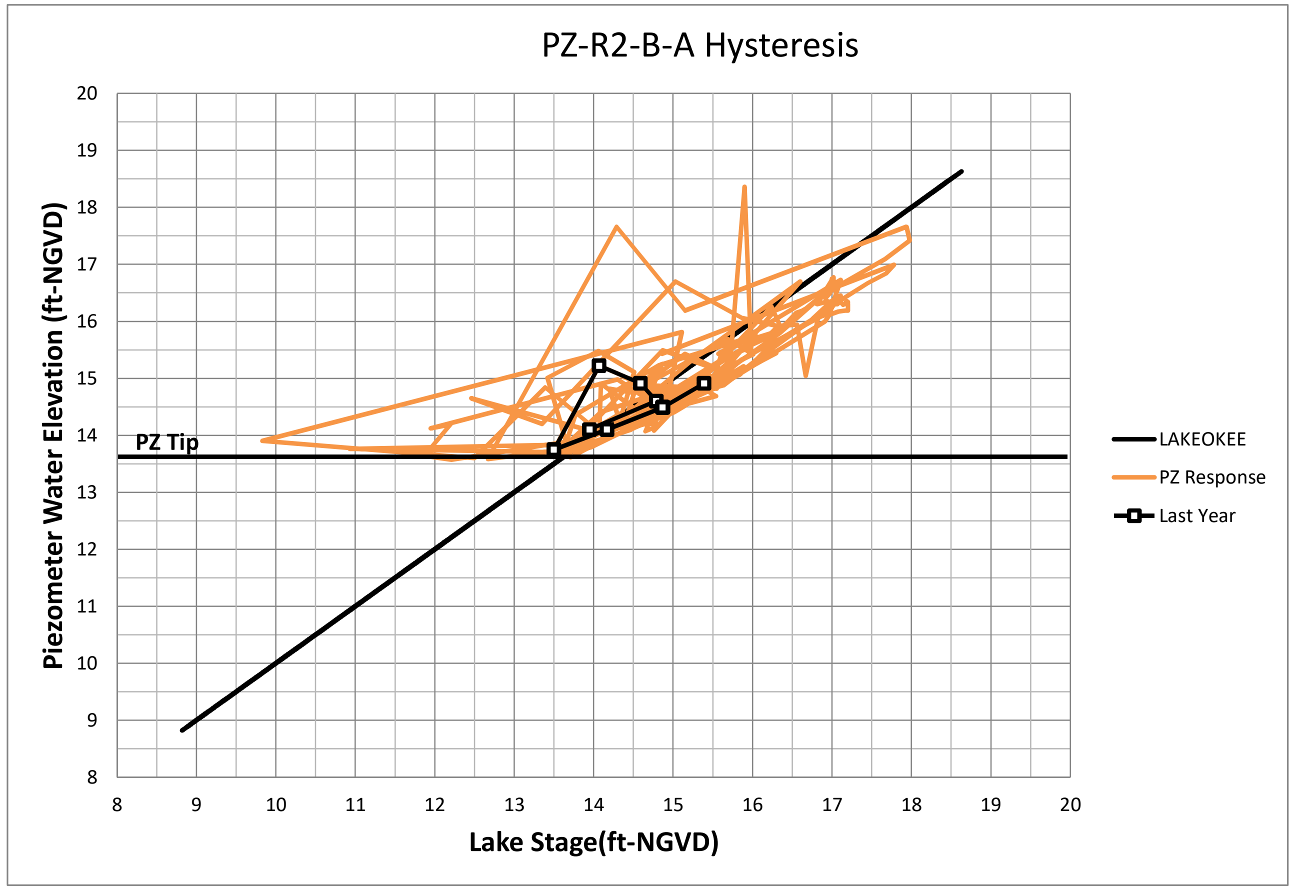


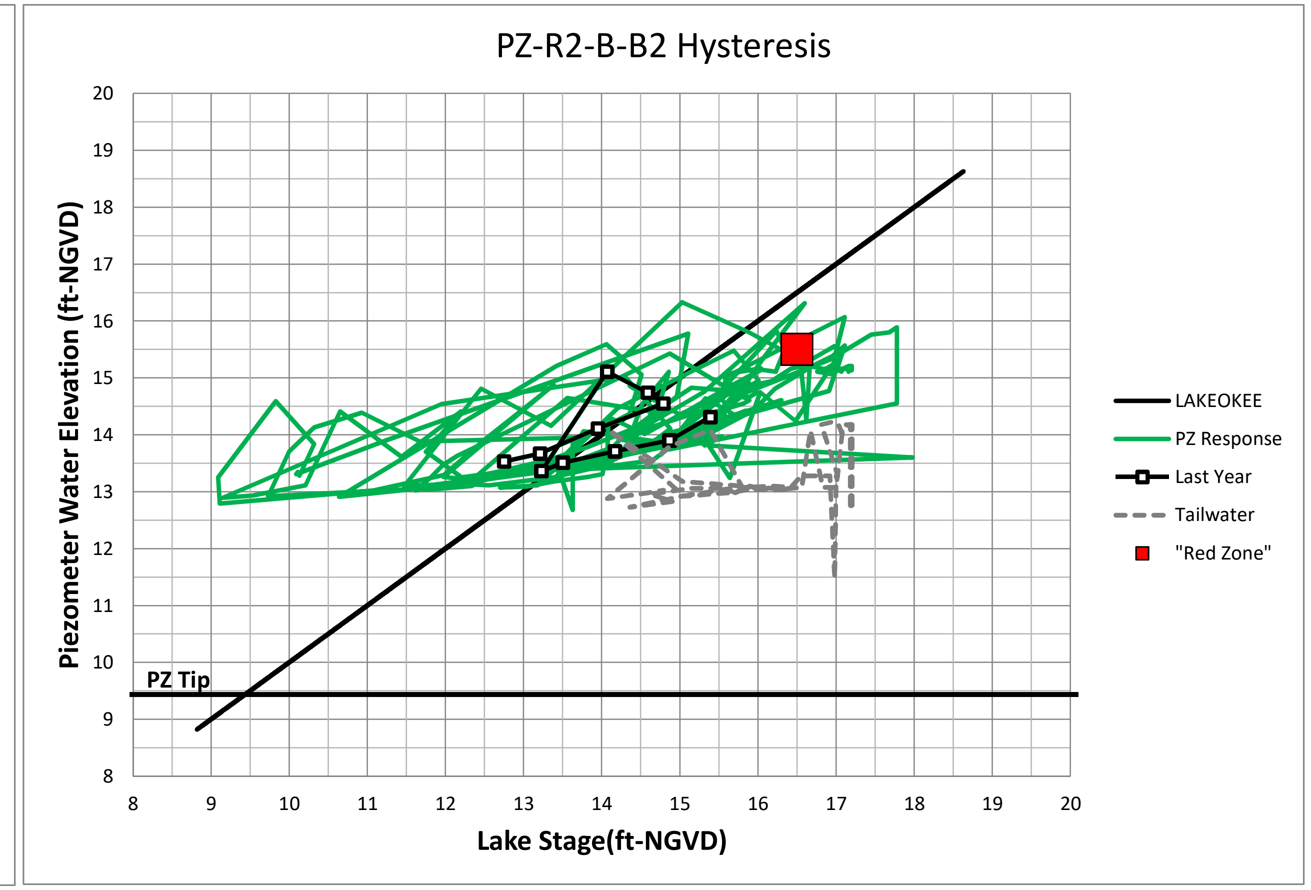


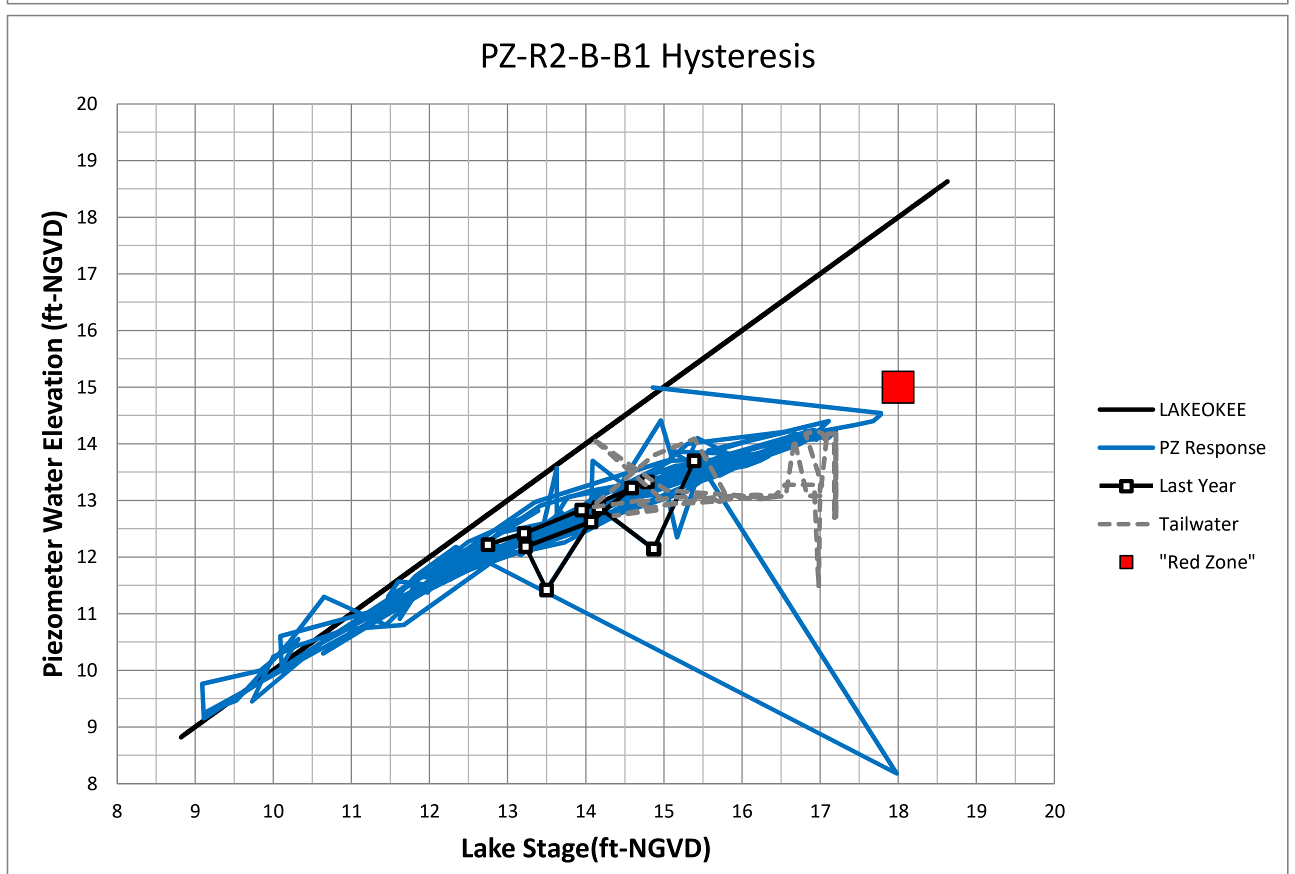




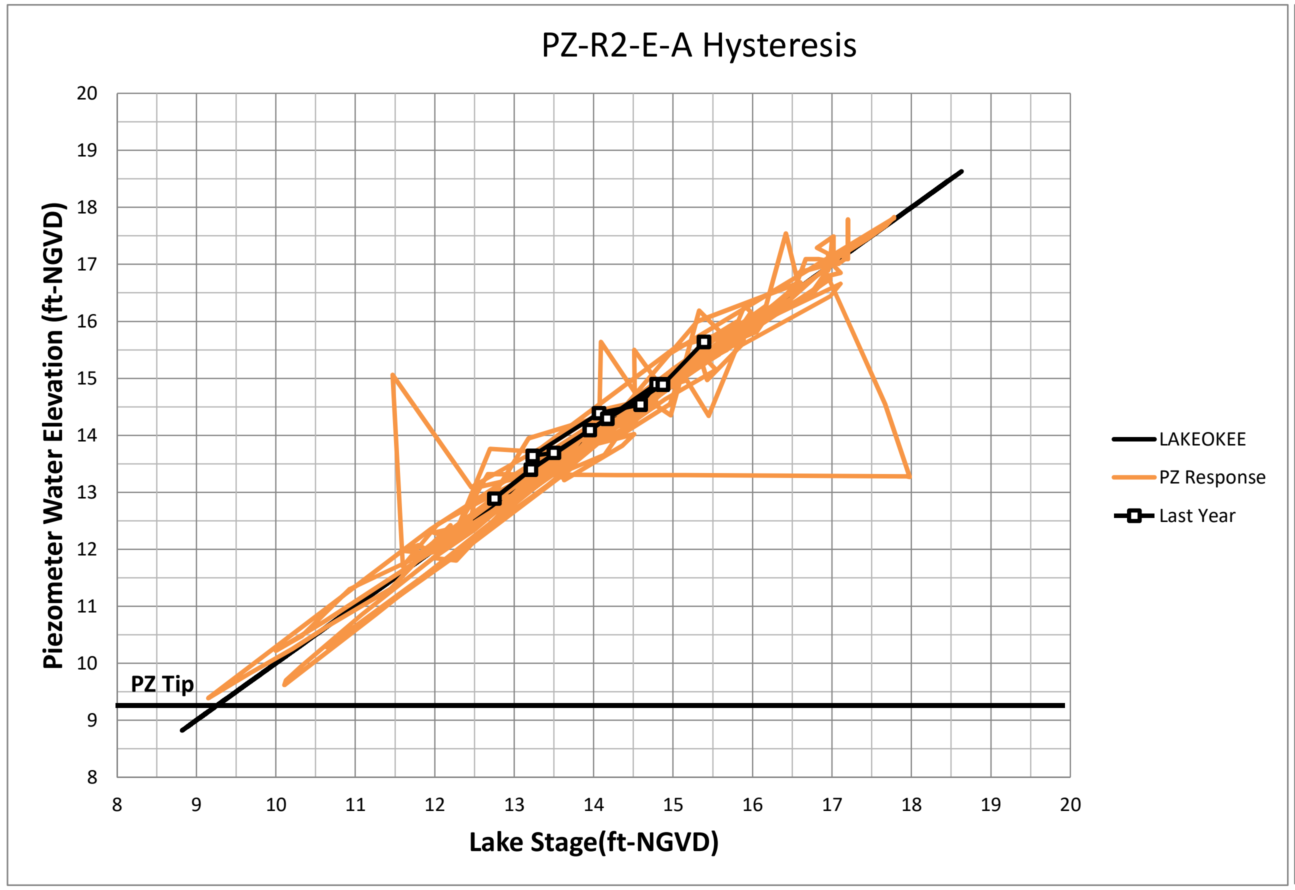
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

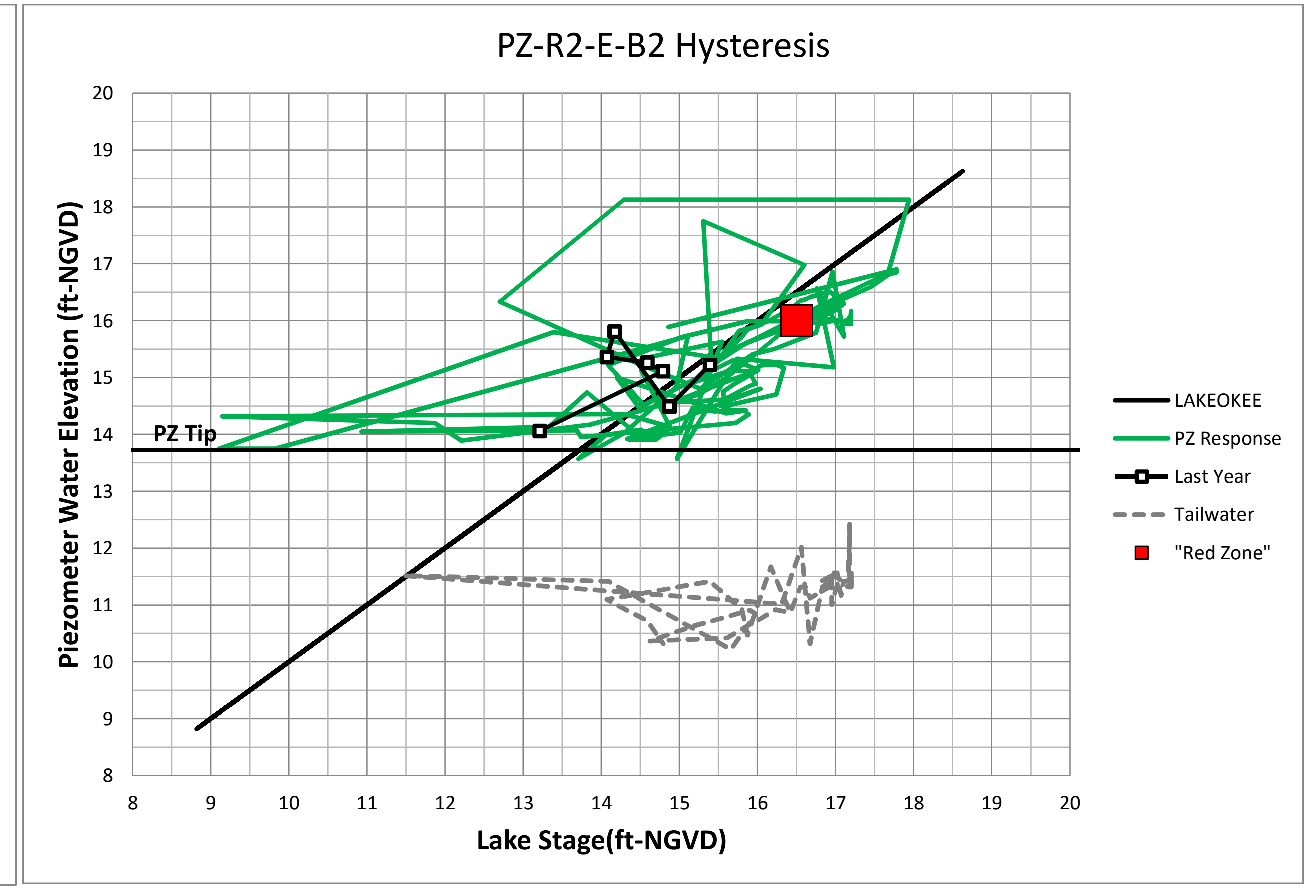


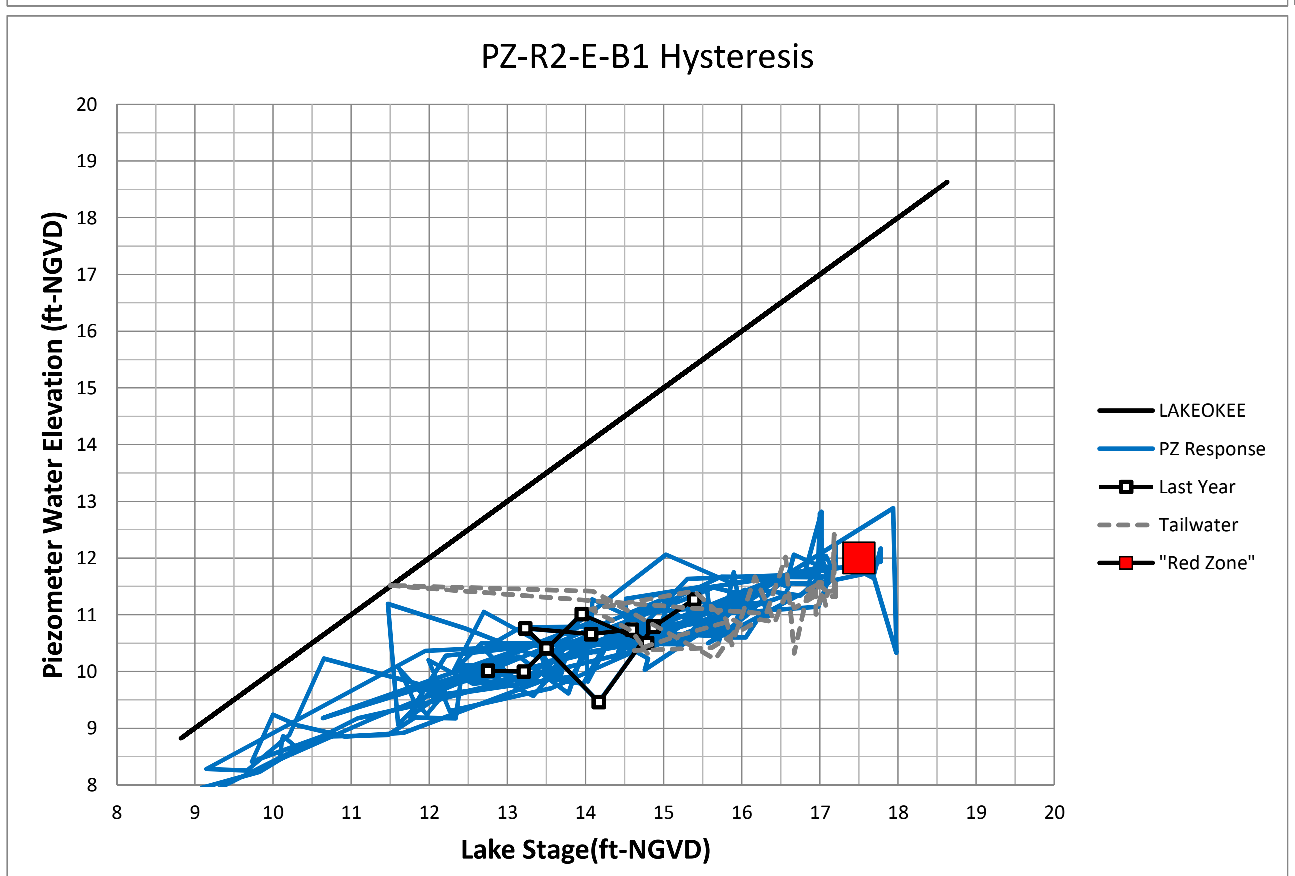




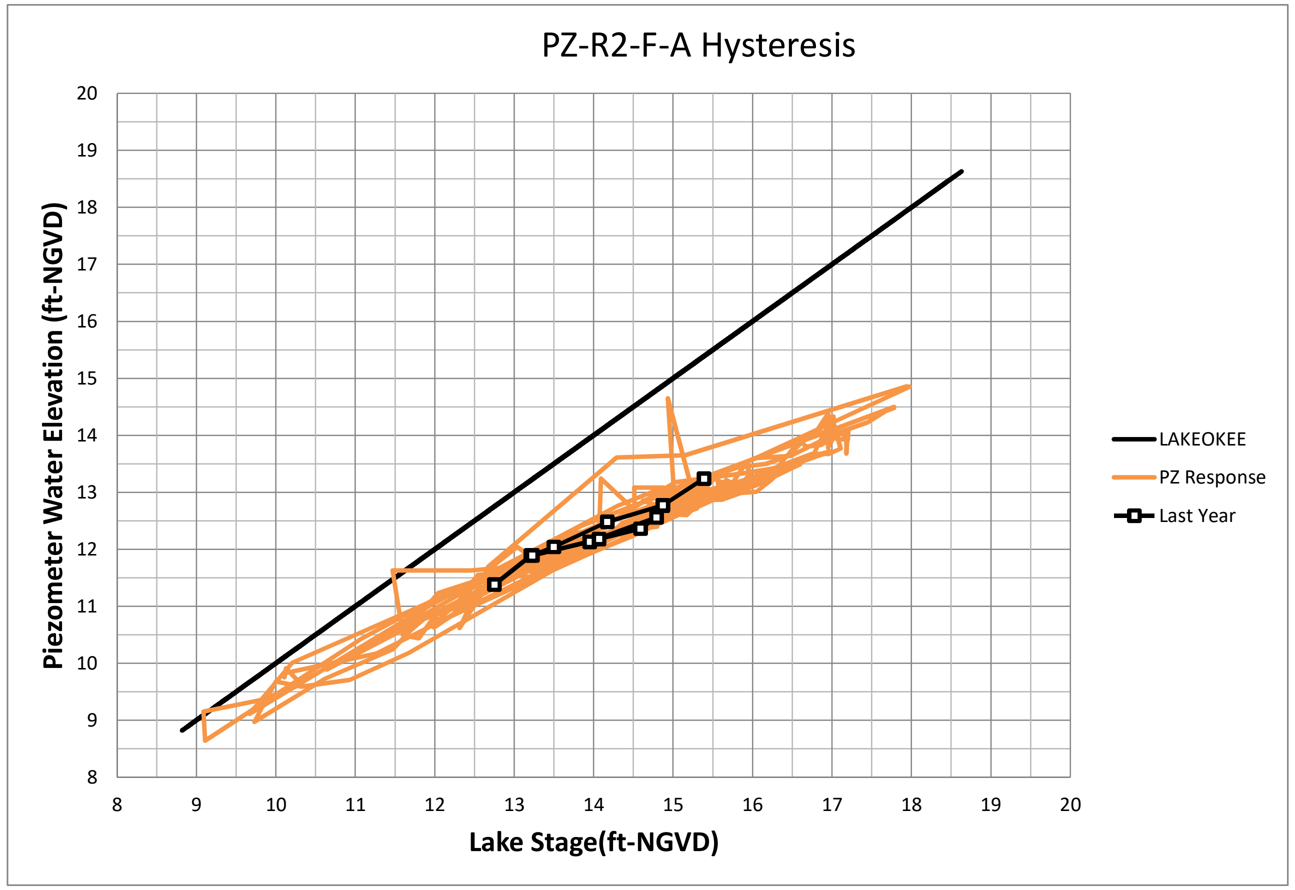
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

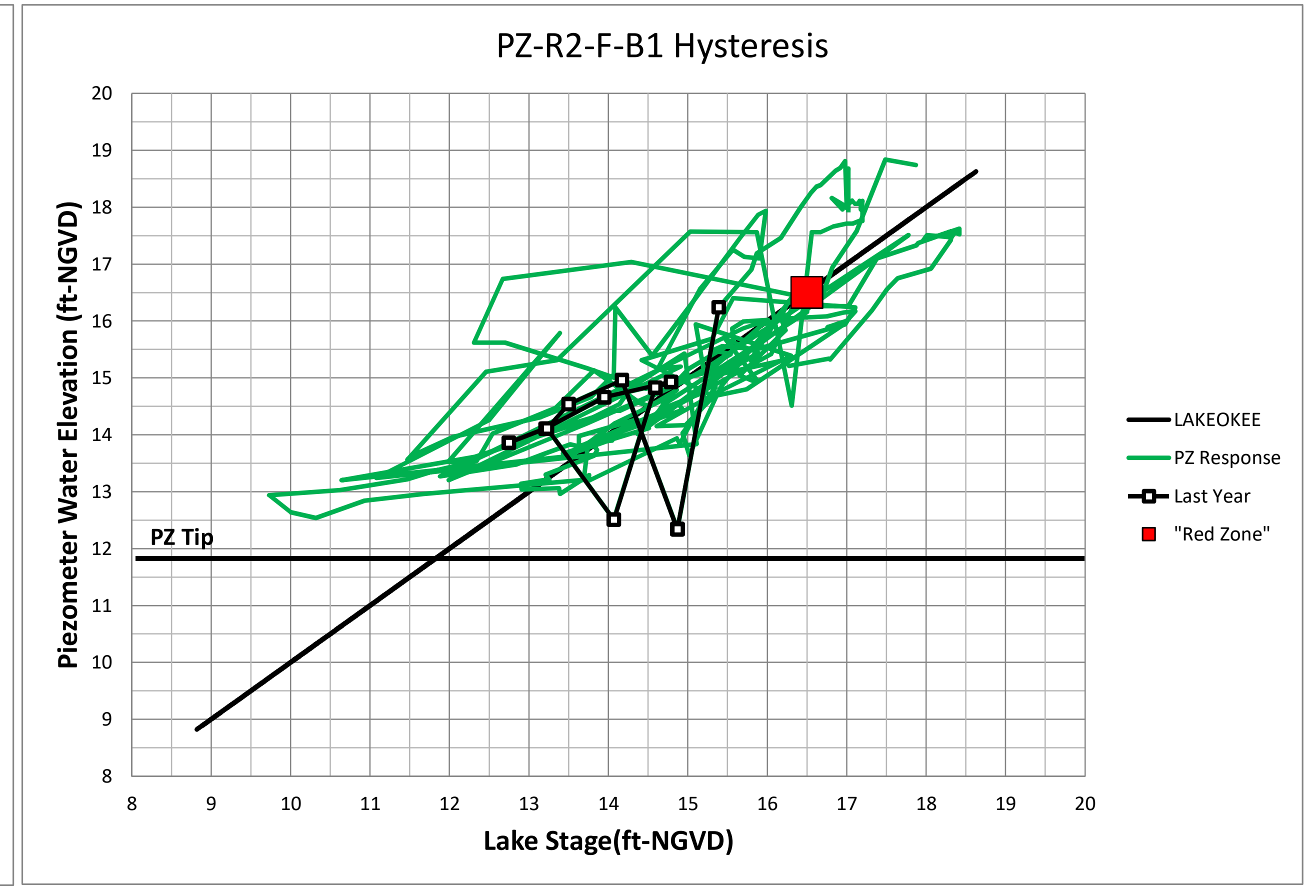


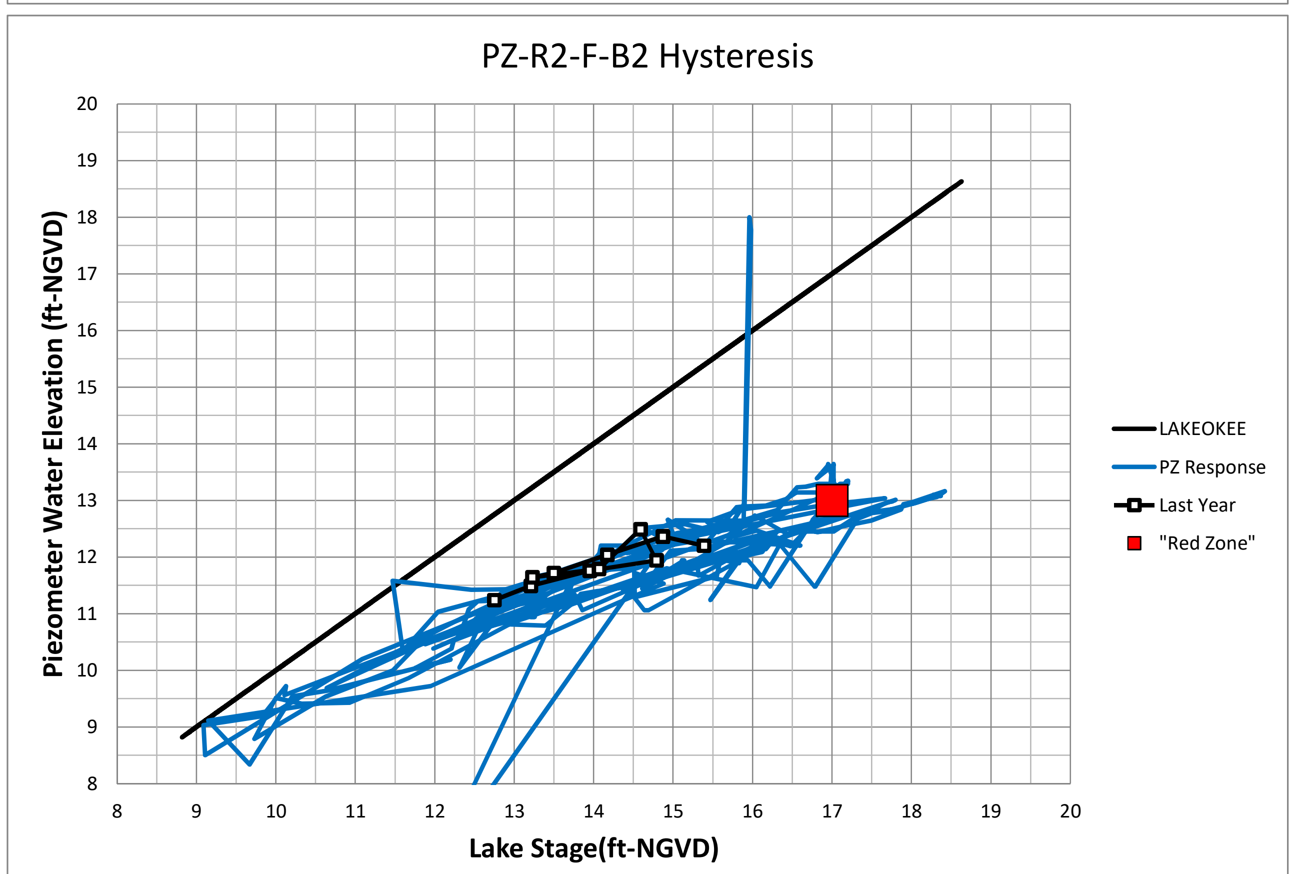


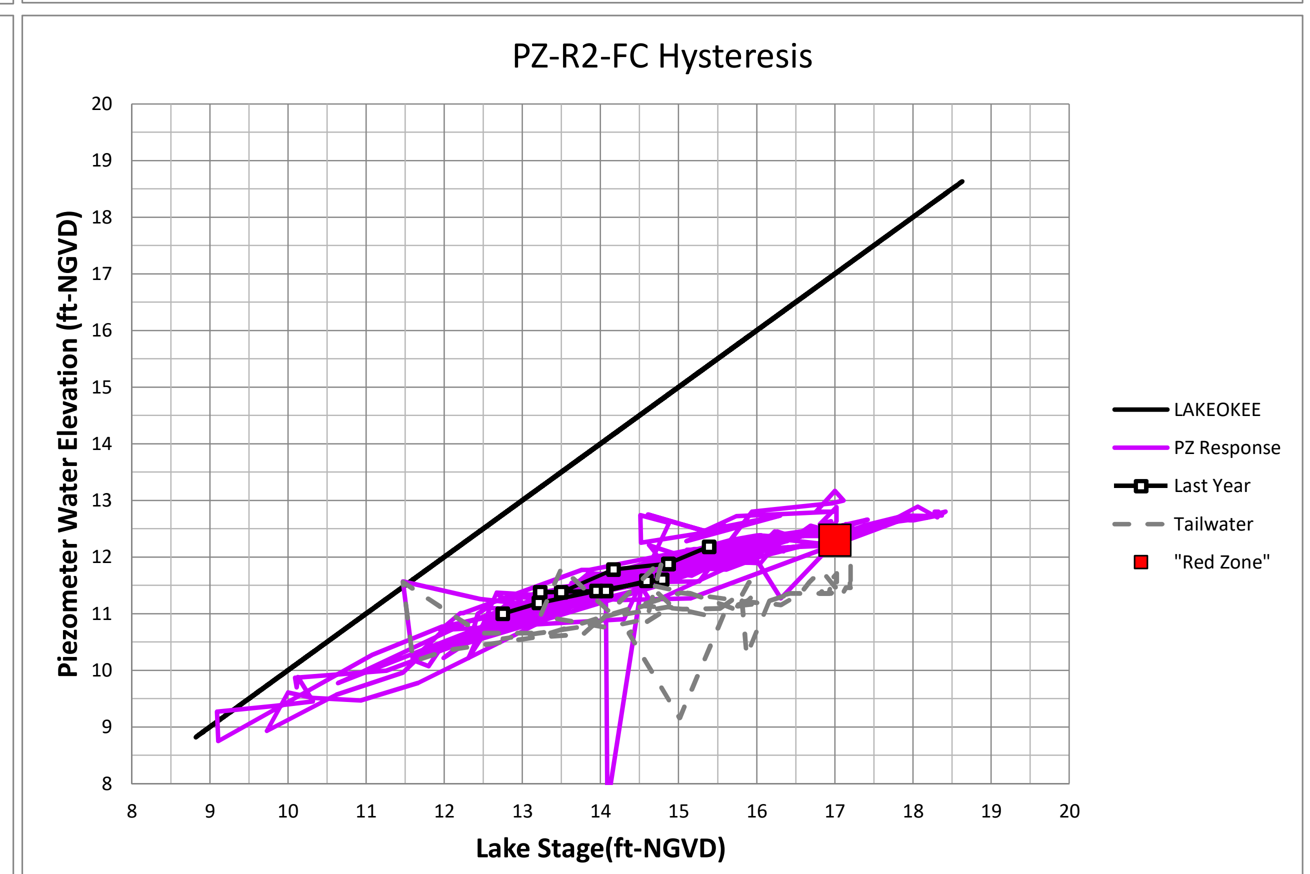


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

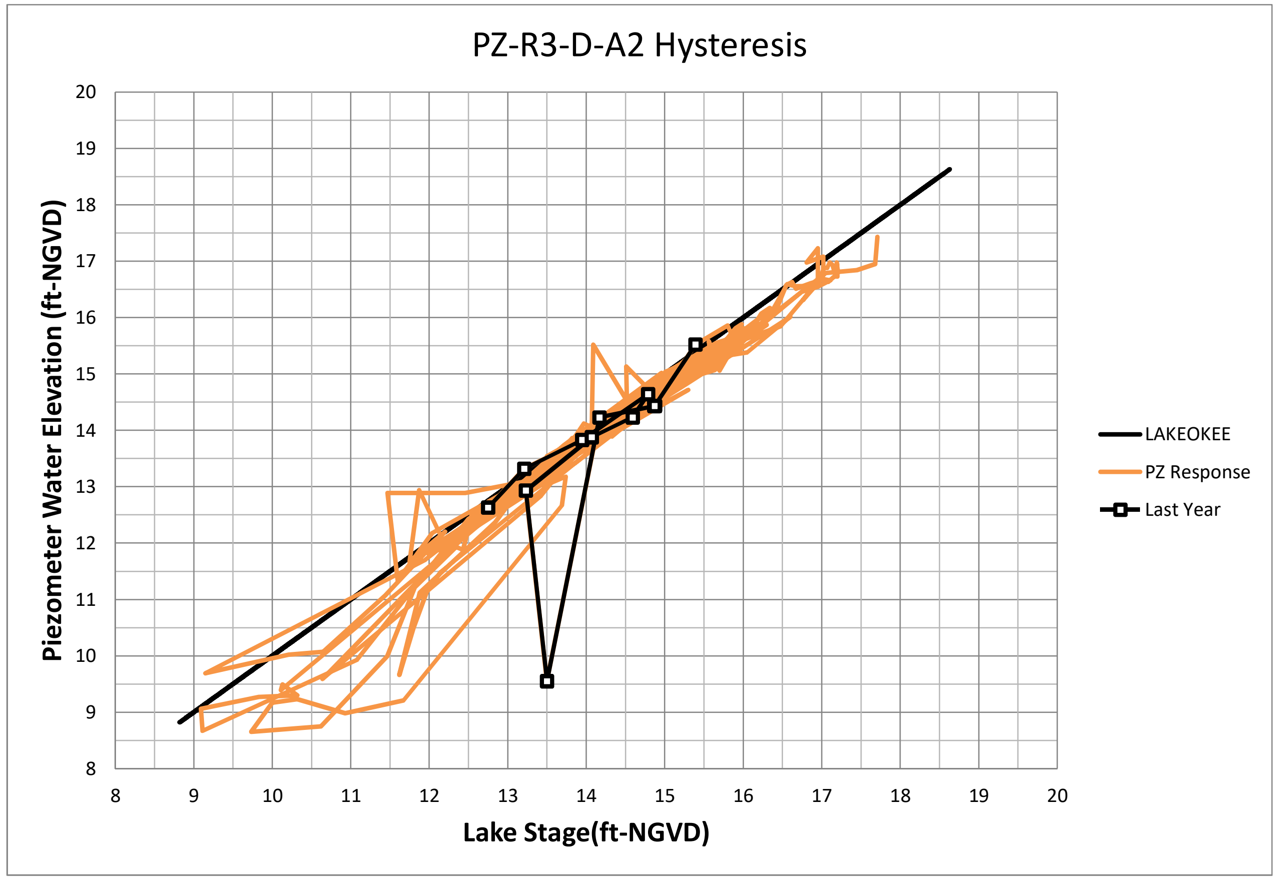


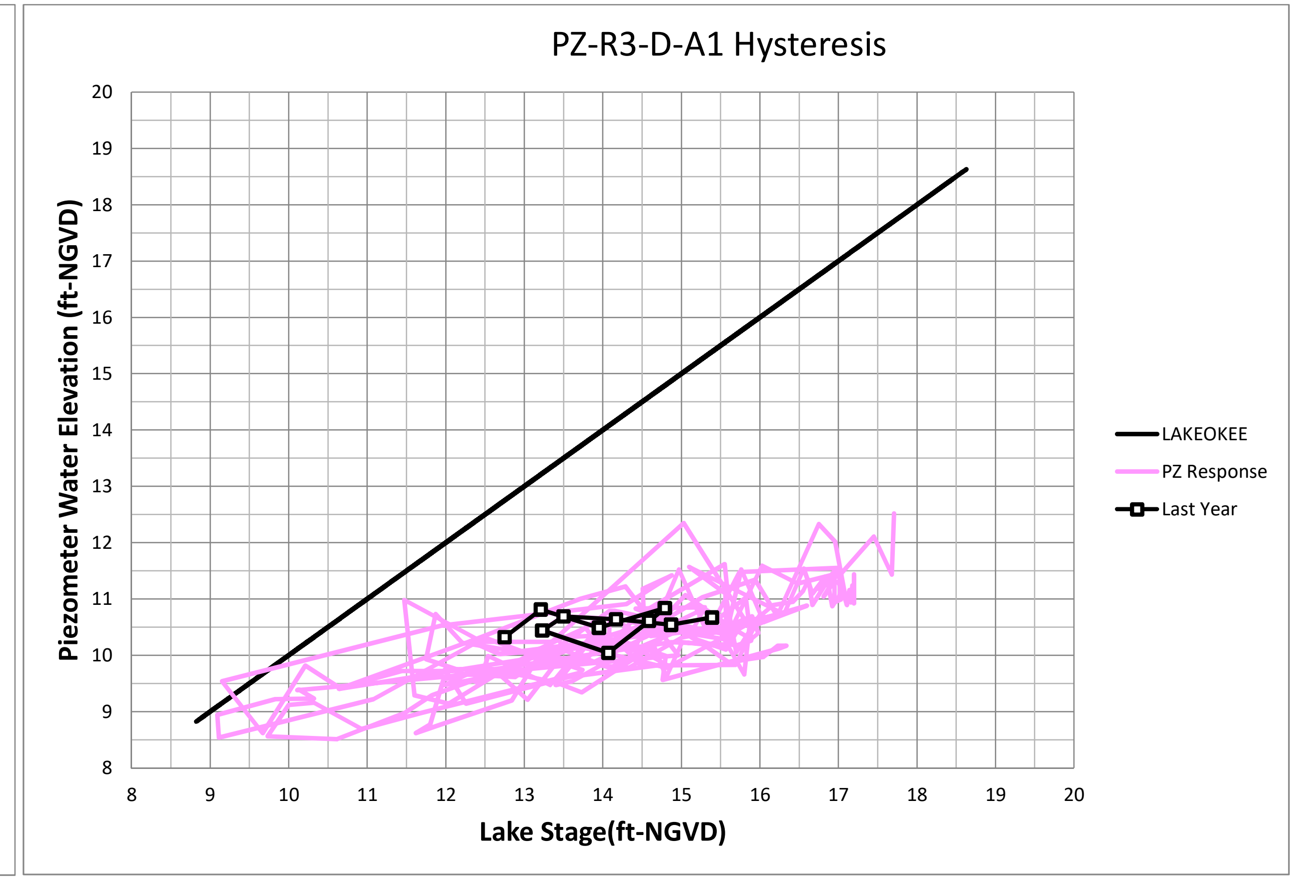


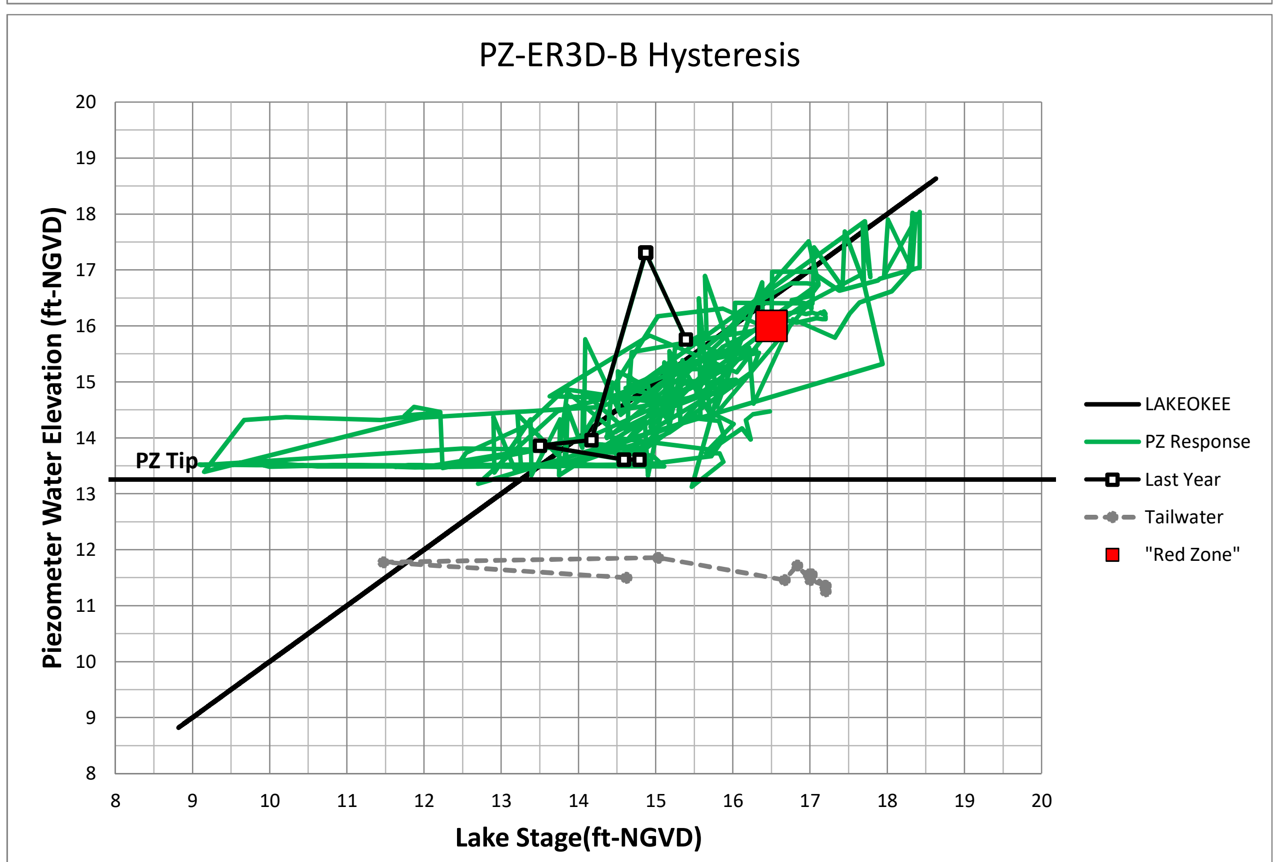


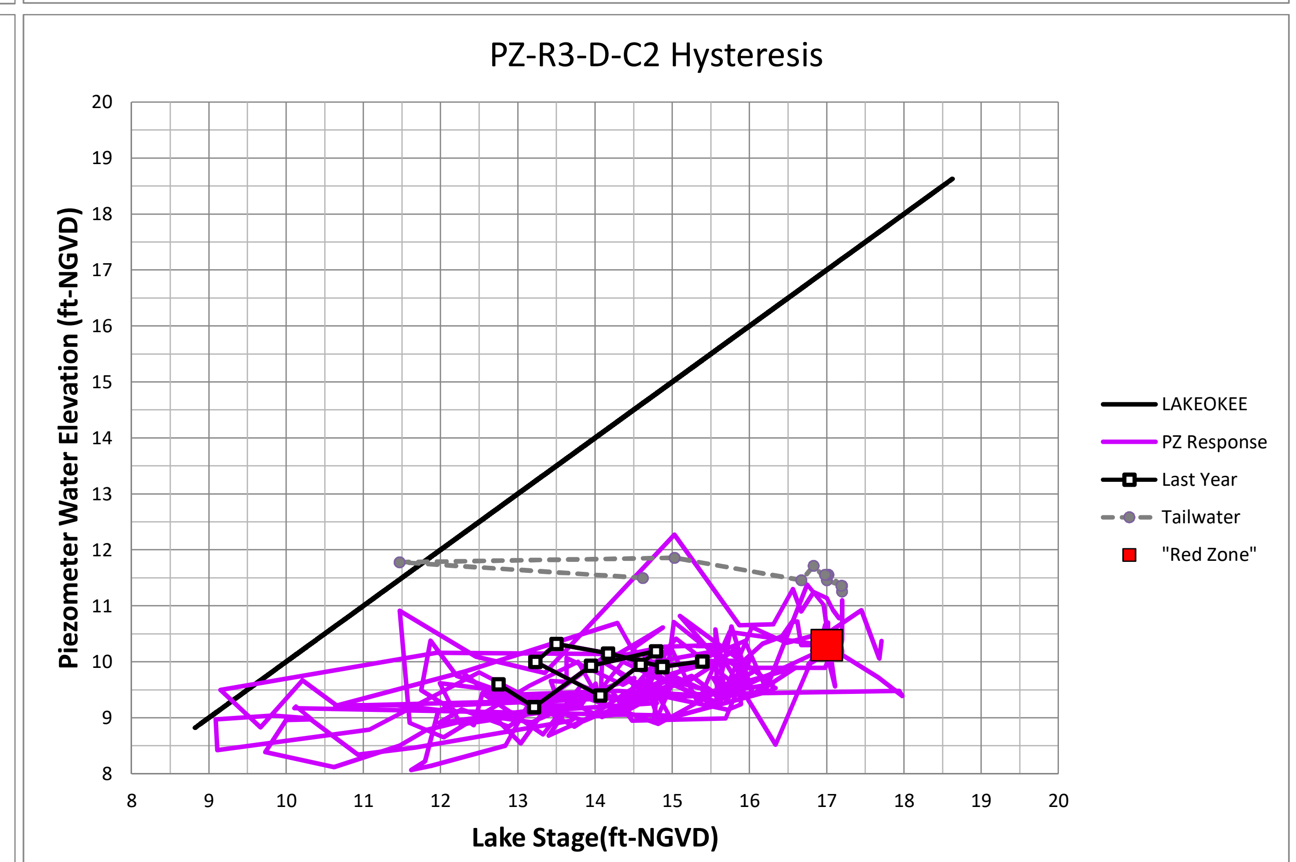


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update









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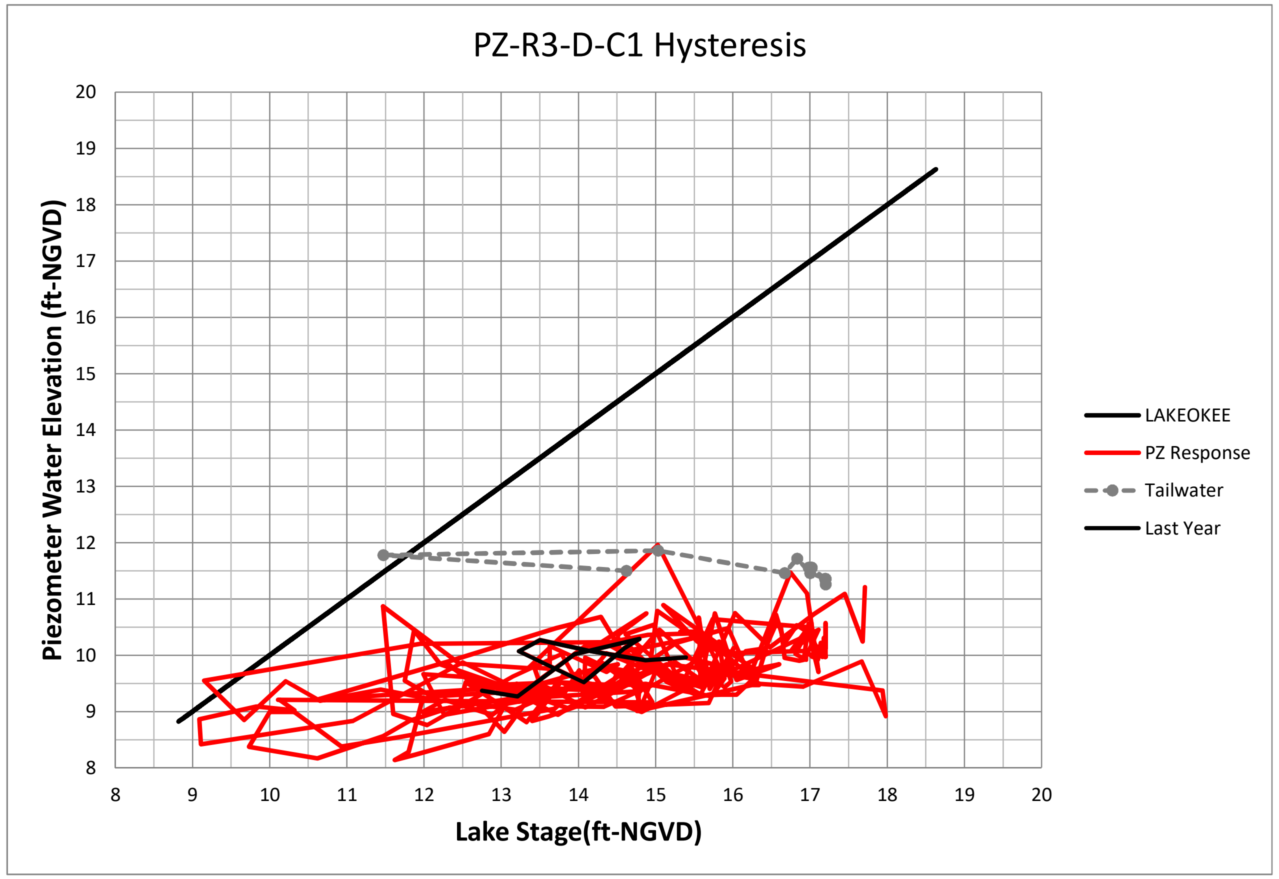
PZ-R3-D-C1 Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
8
9
10
11
12
13
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15
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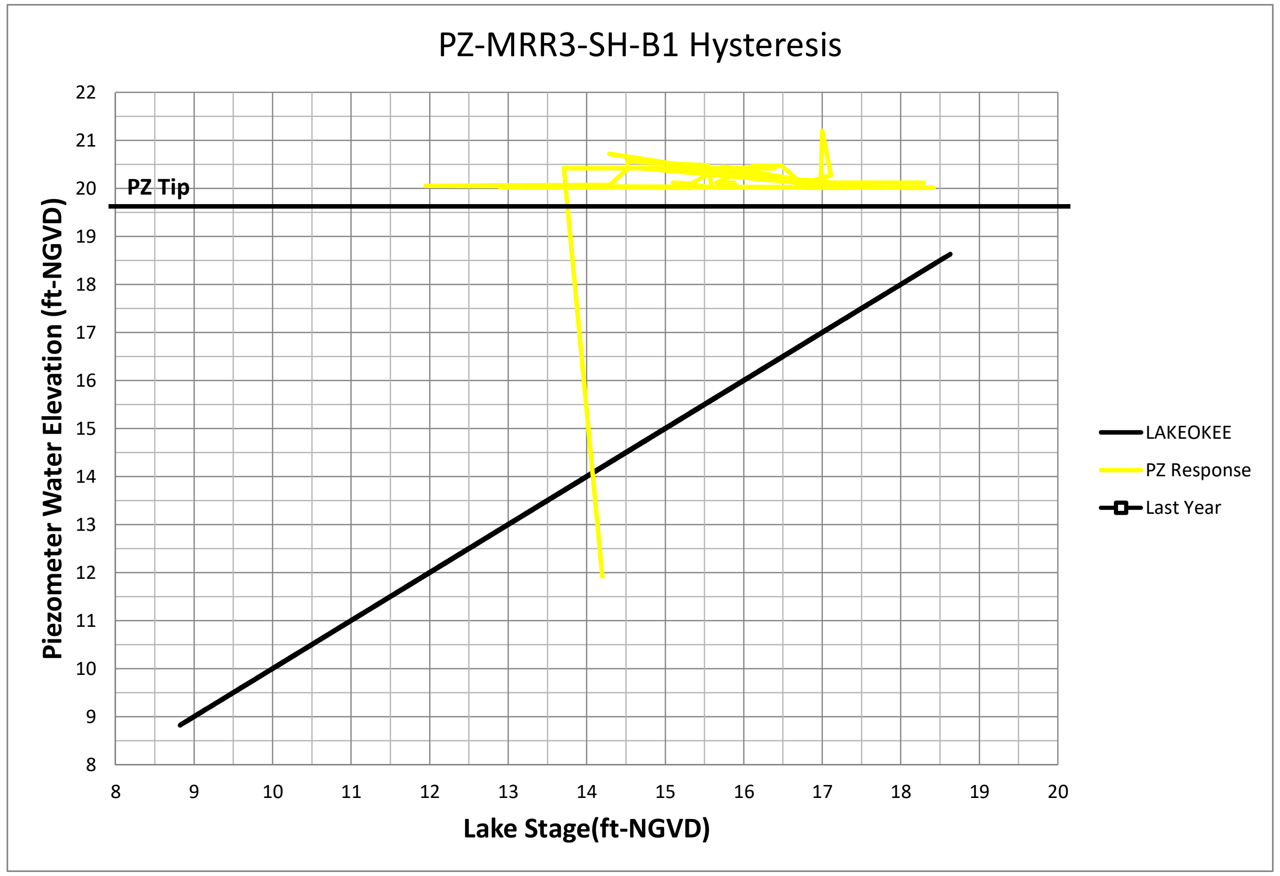
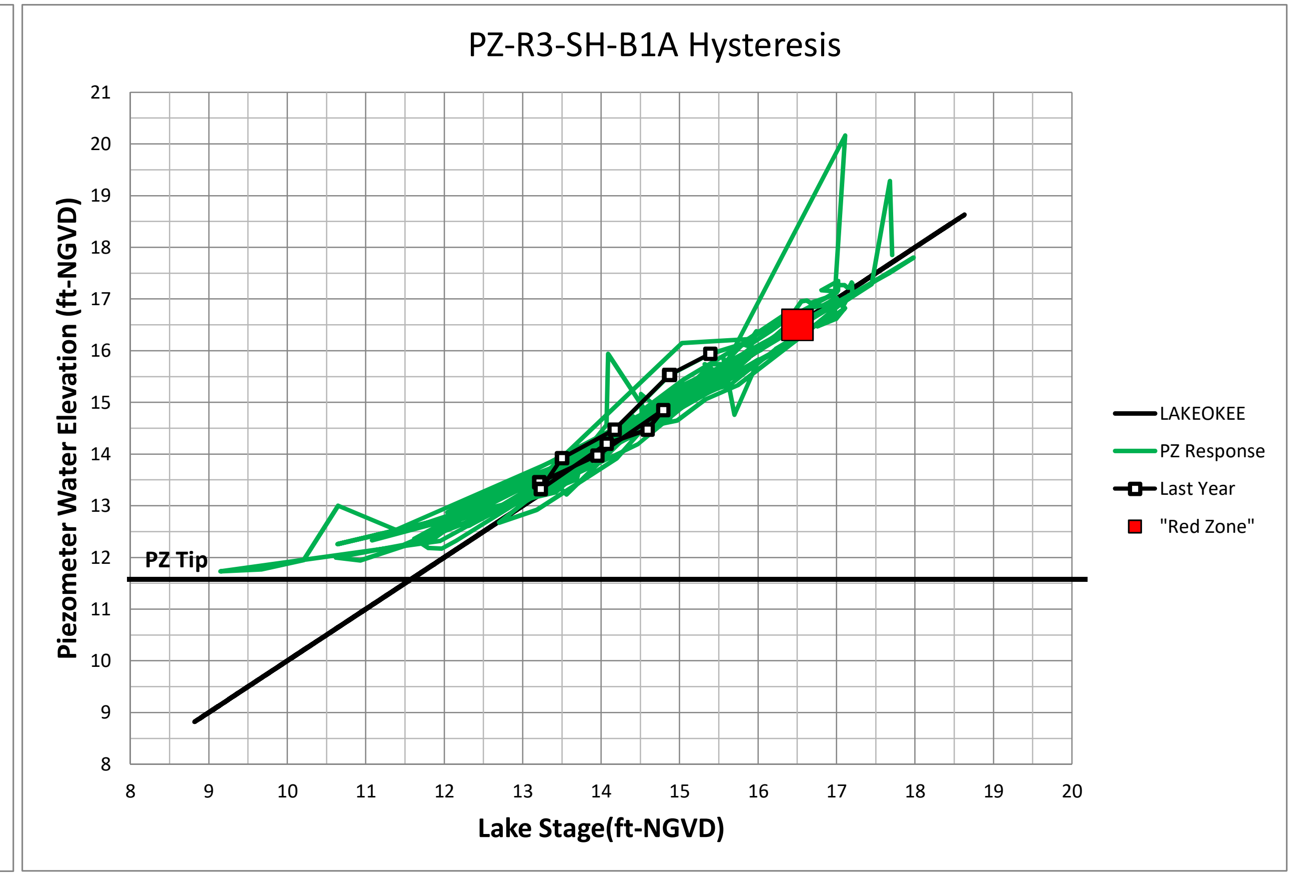
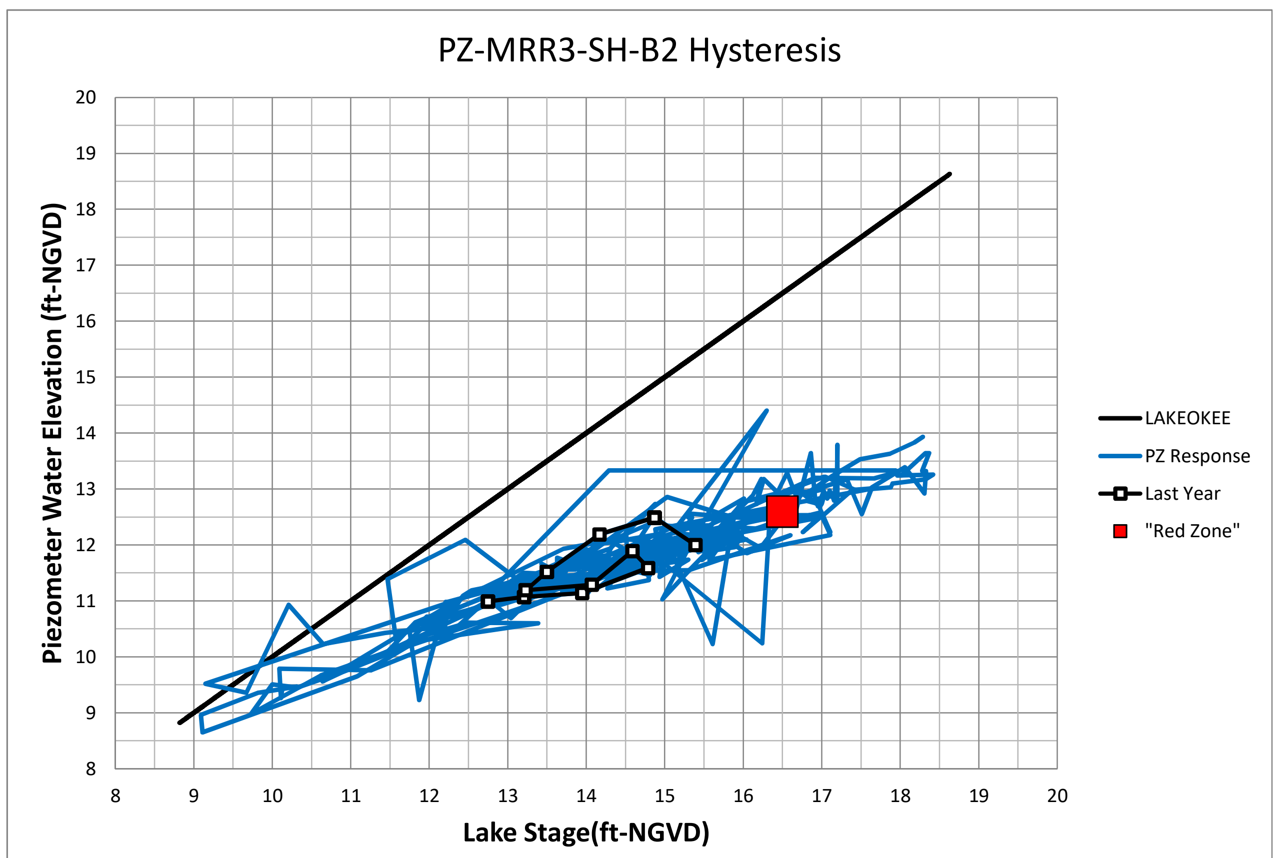
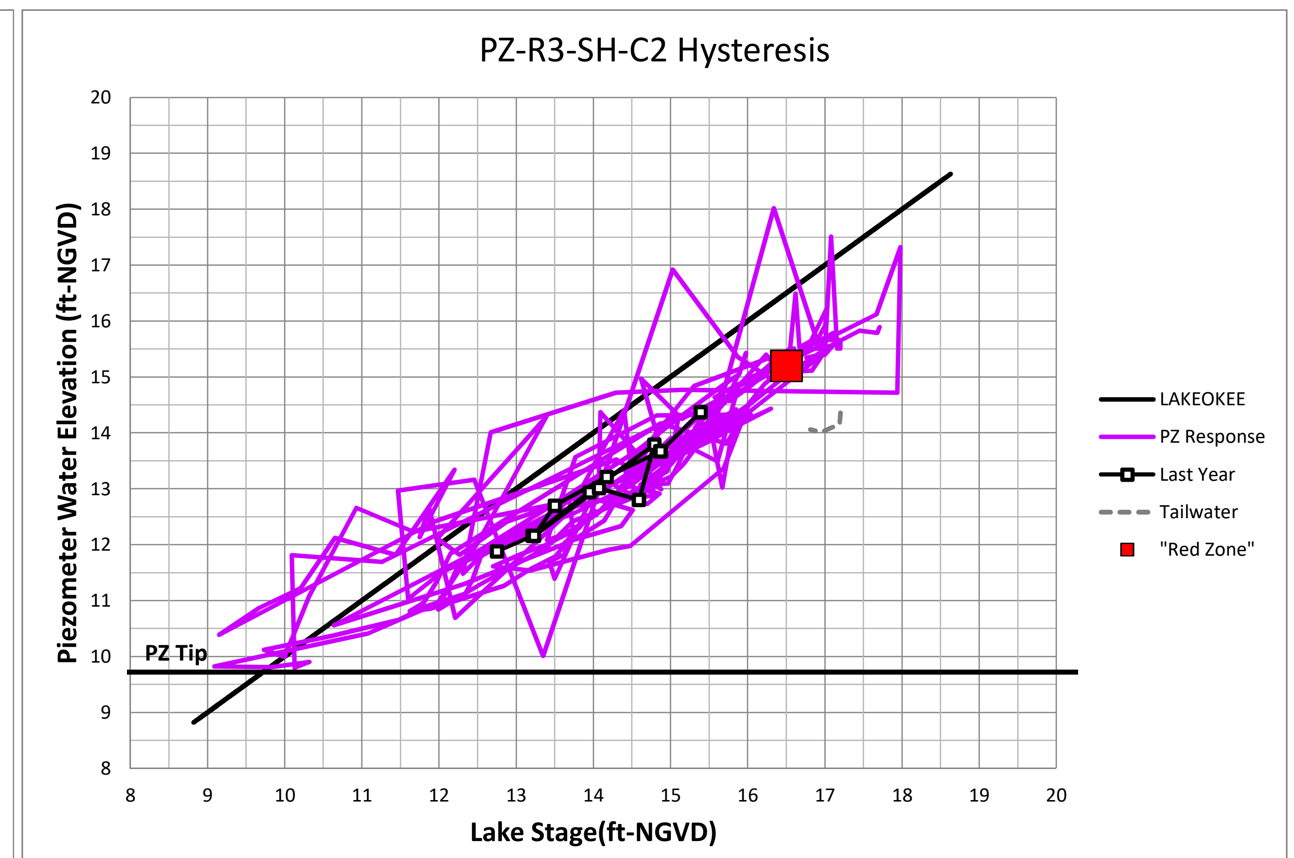
19
20
LAKEOKEE
PZ Response
Tailwater
Last Year

Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

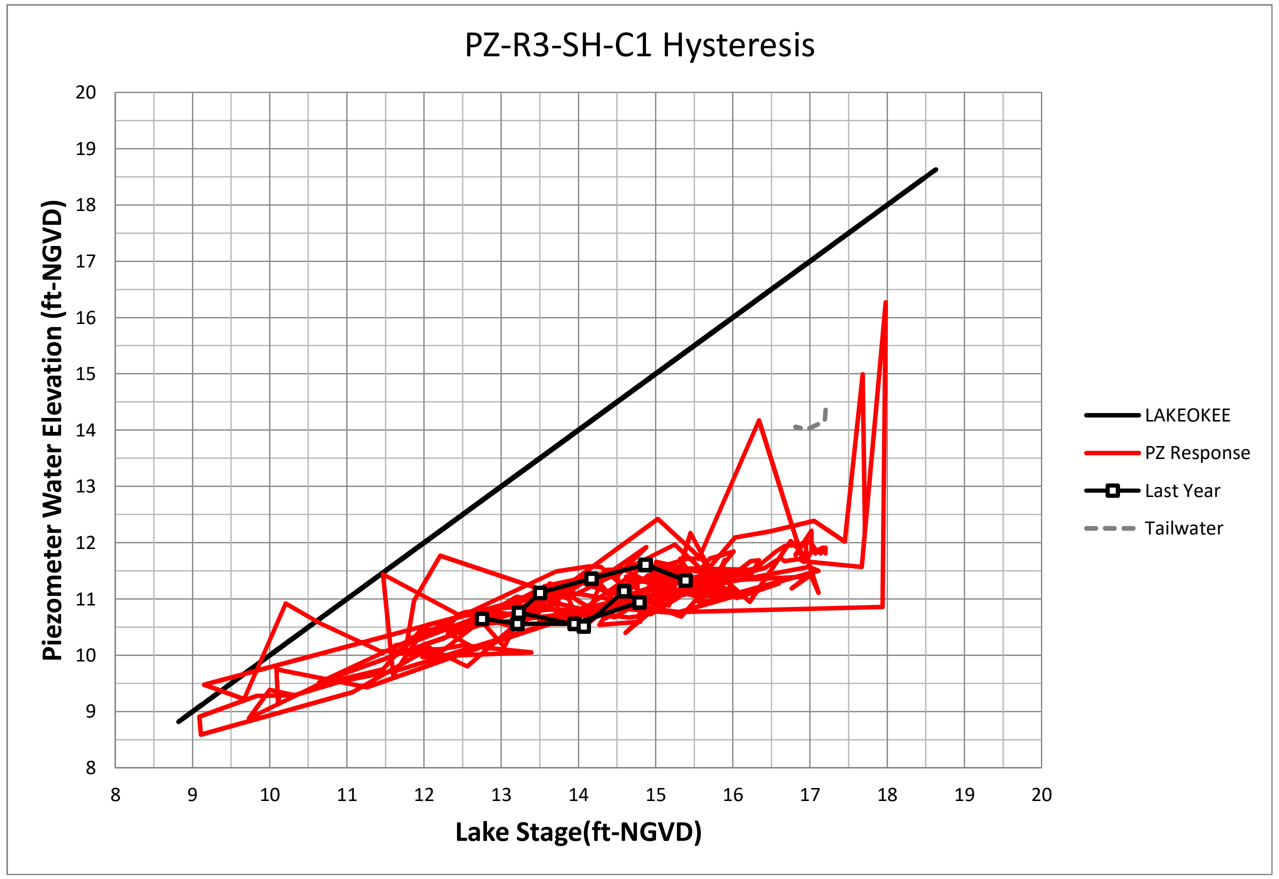




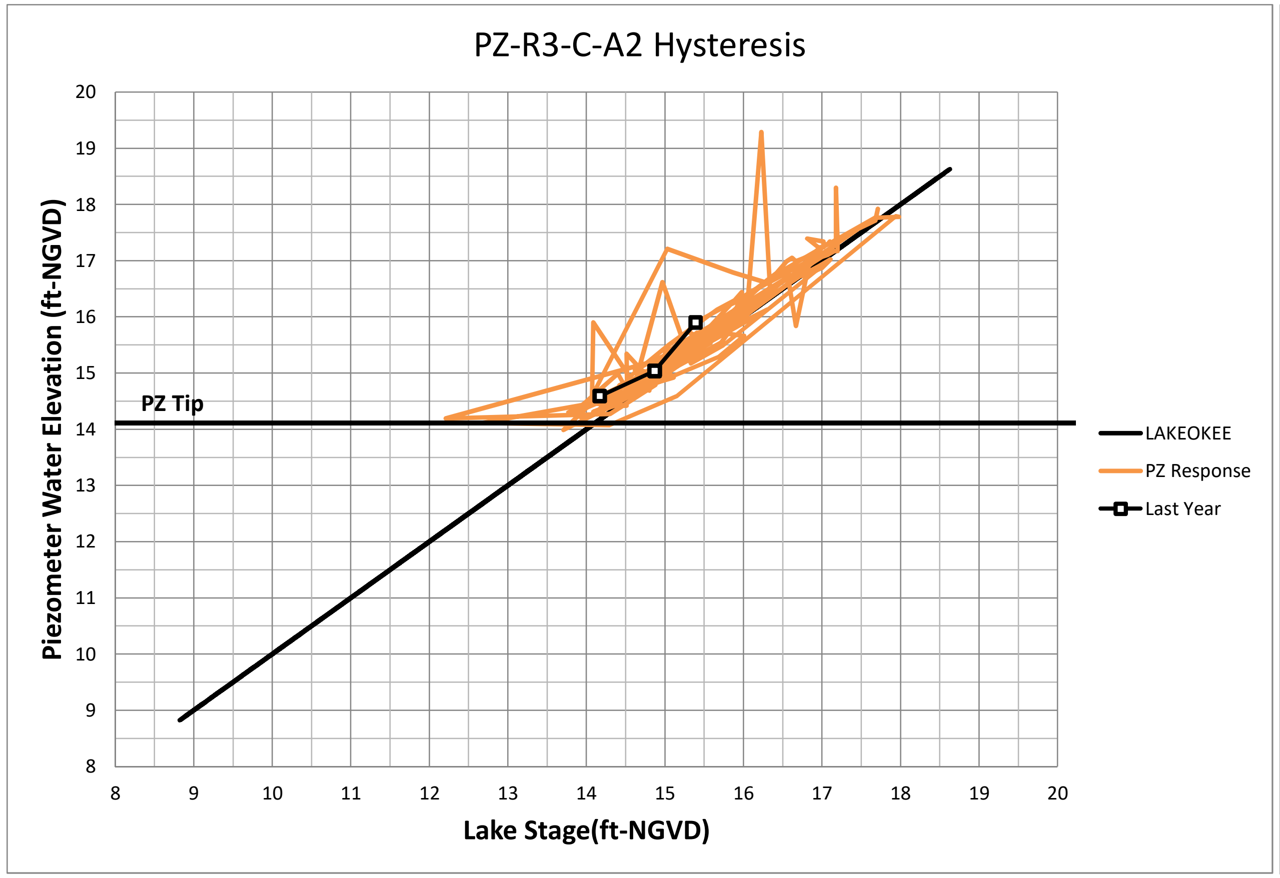


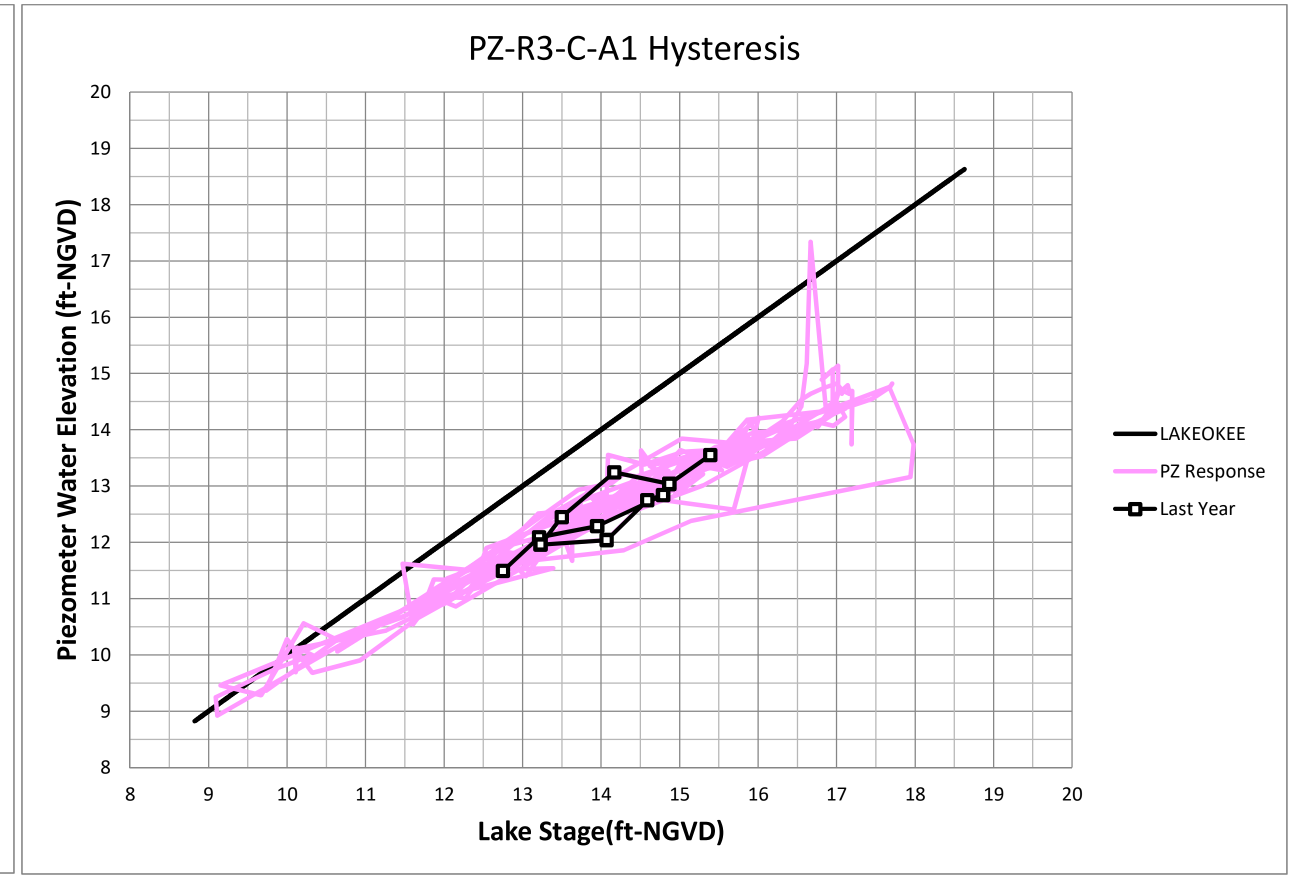


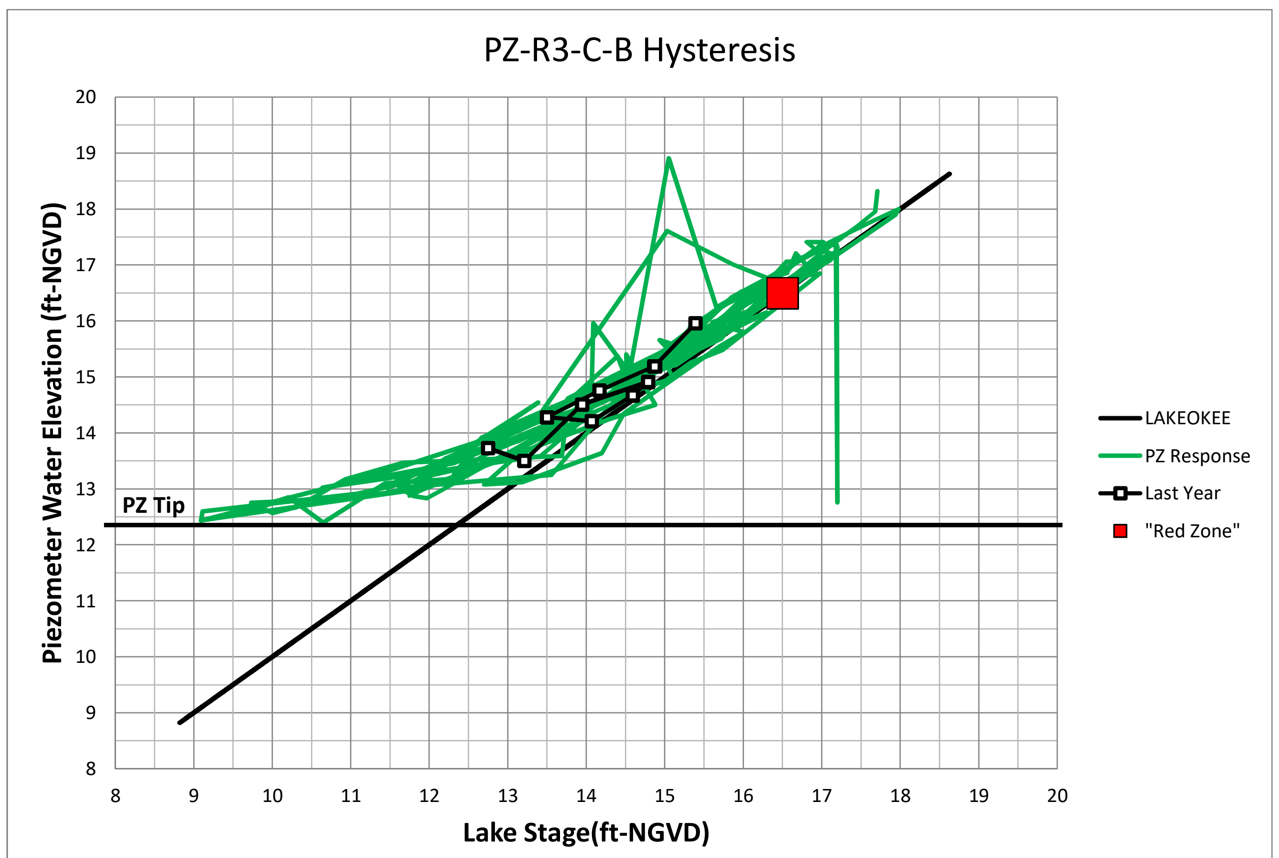
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

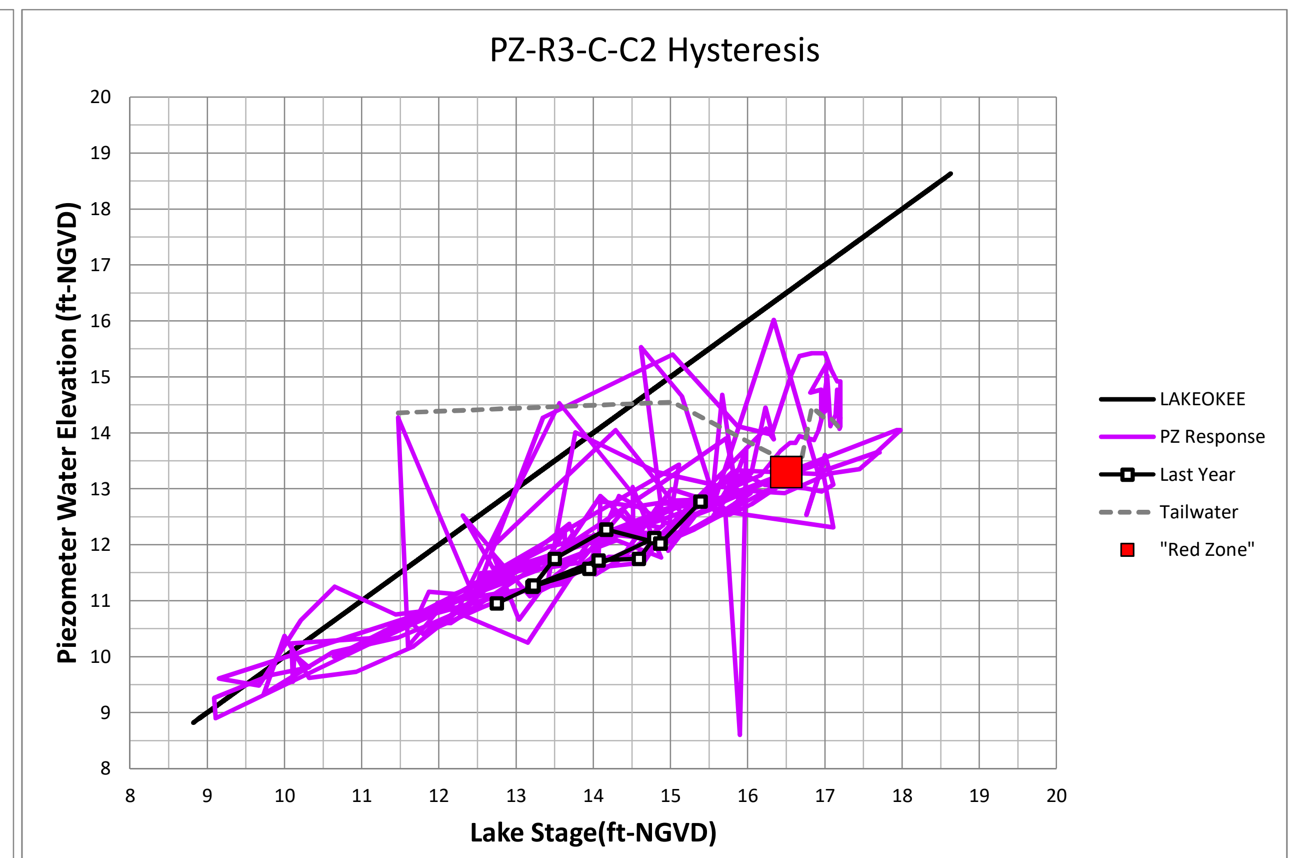


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update









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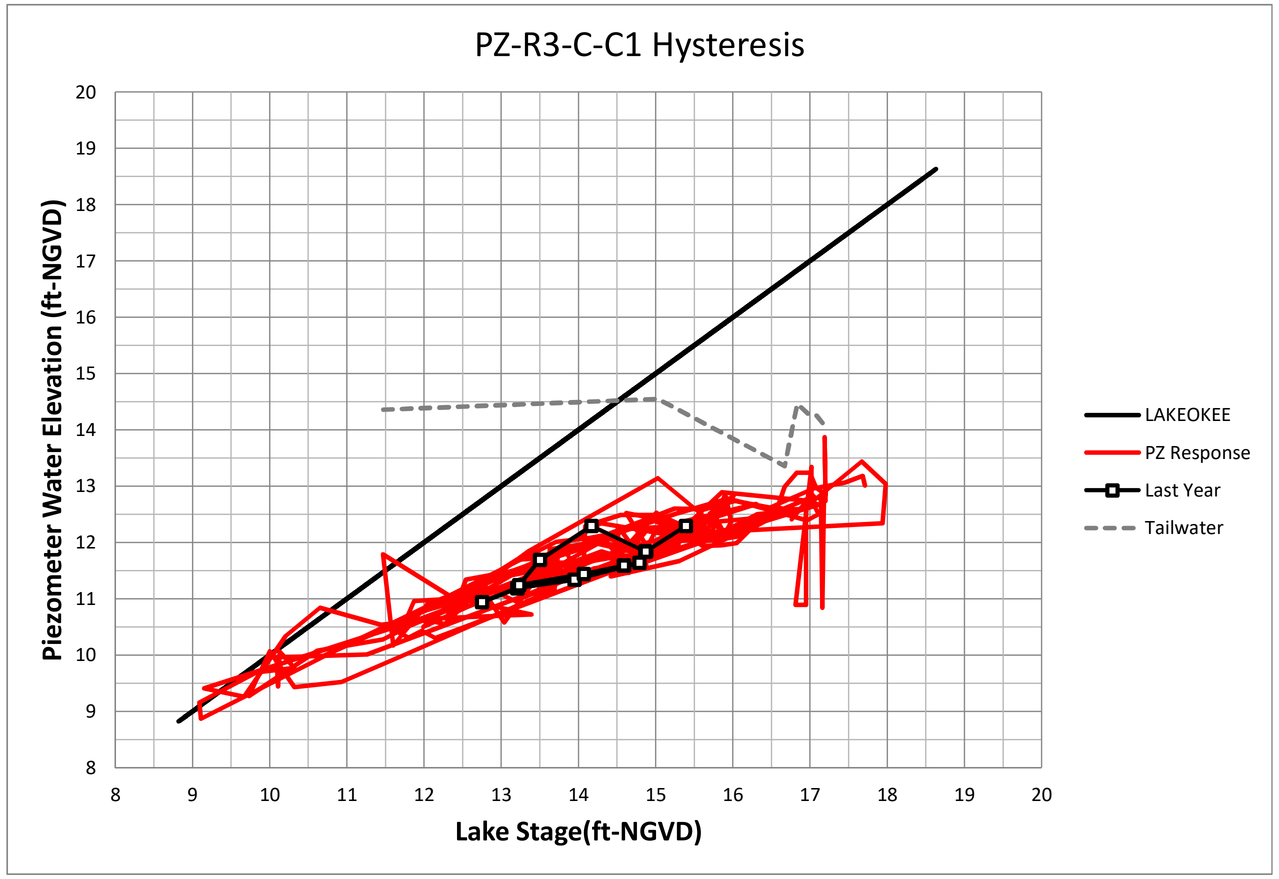
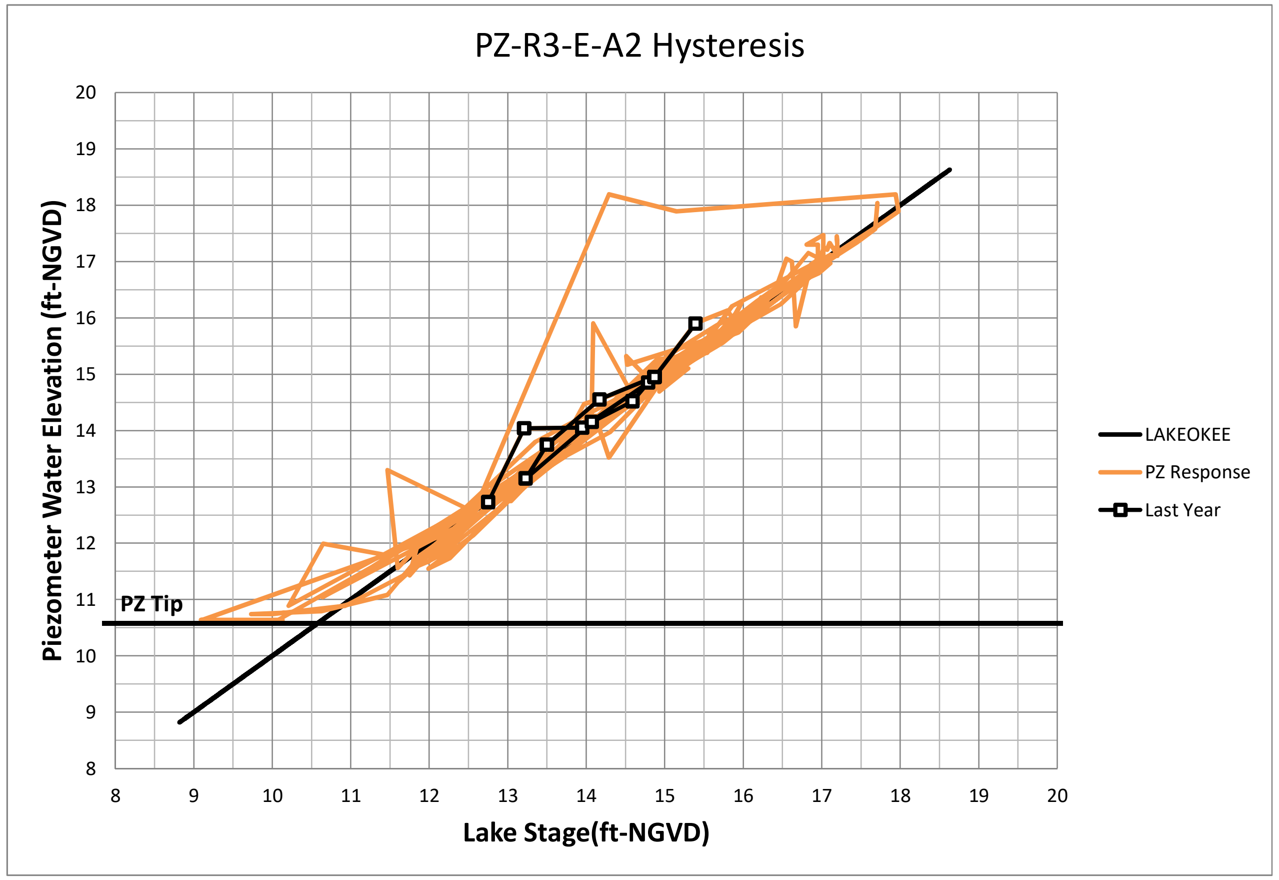
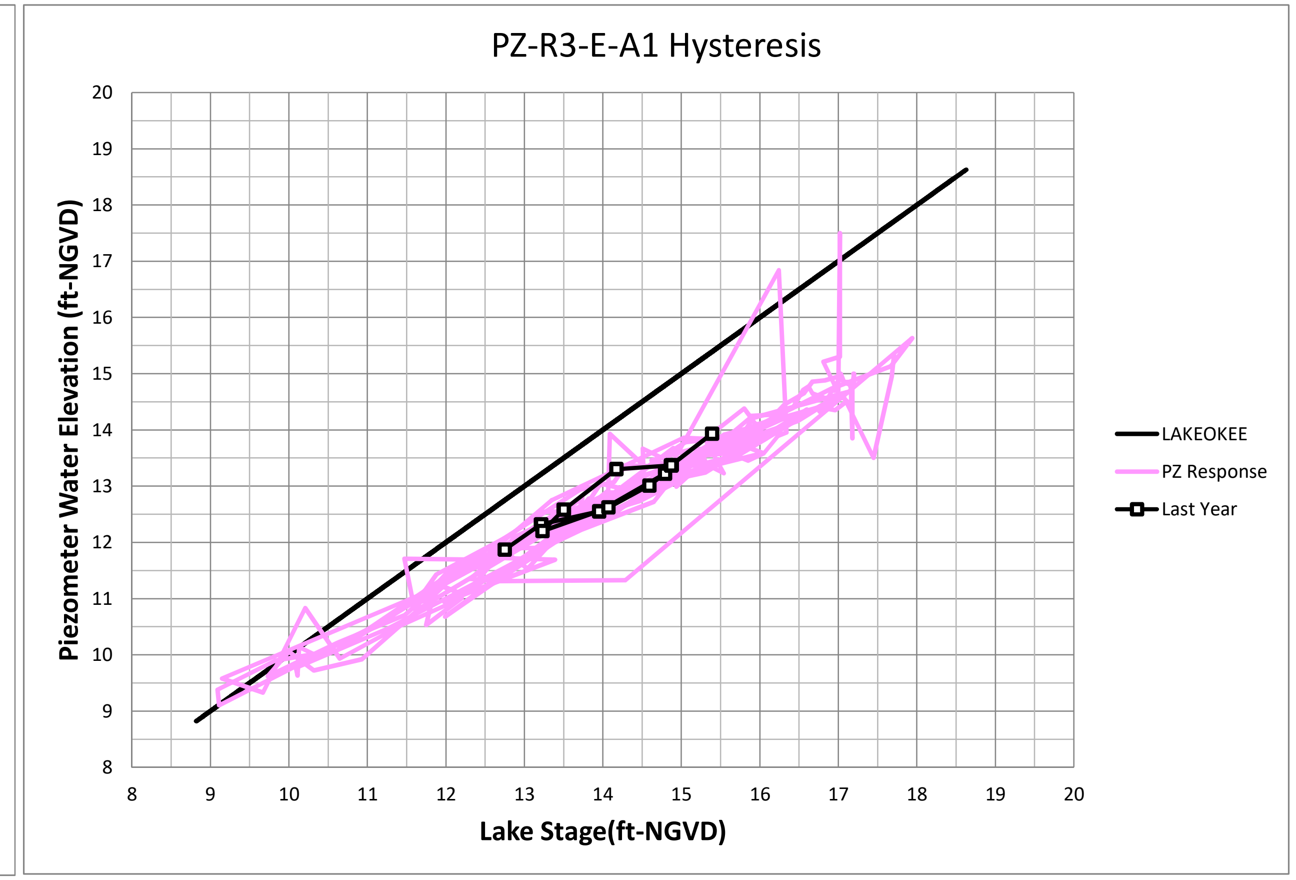
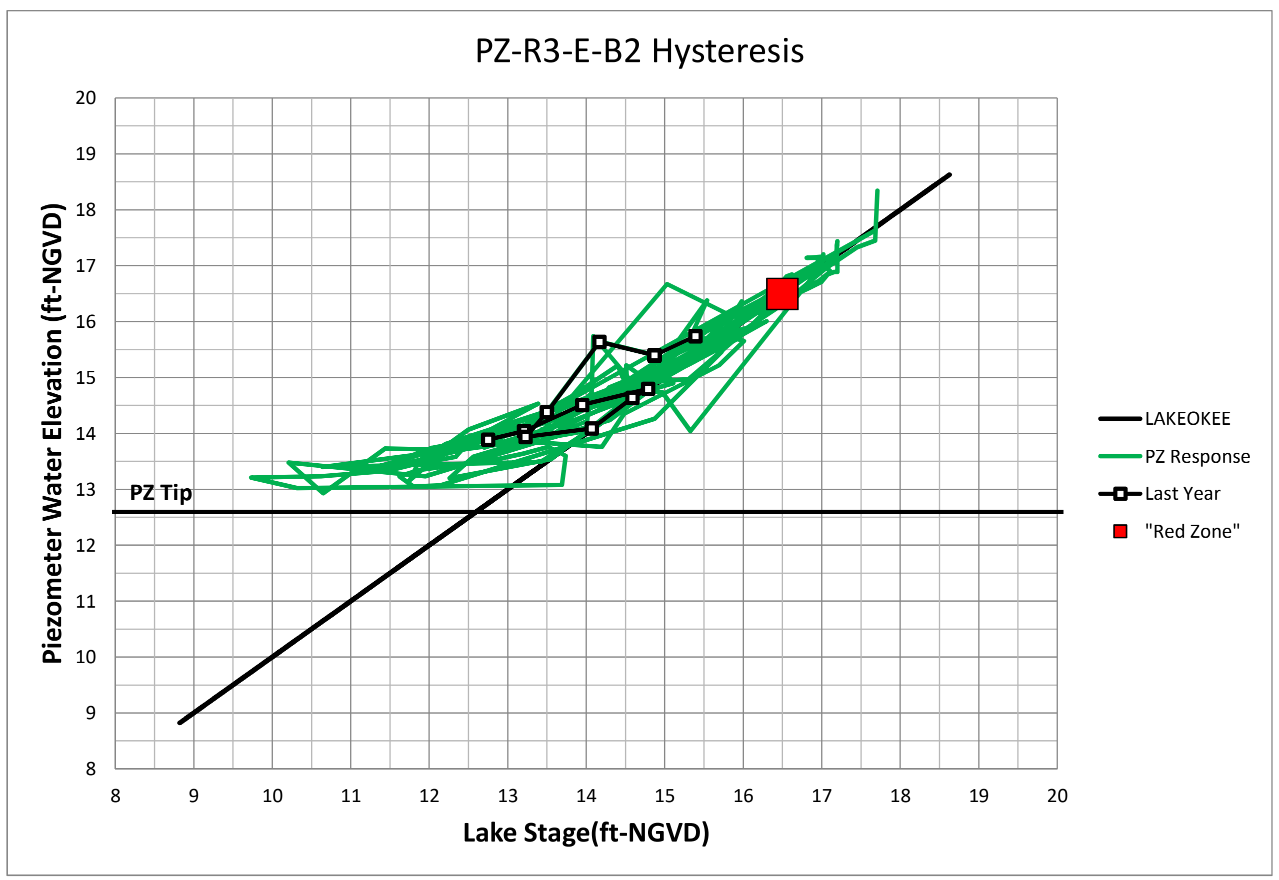
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

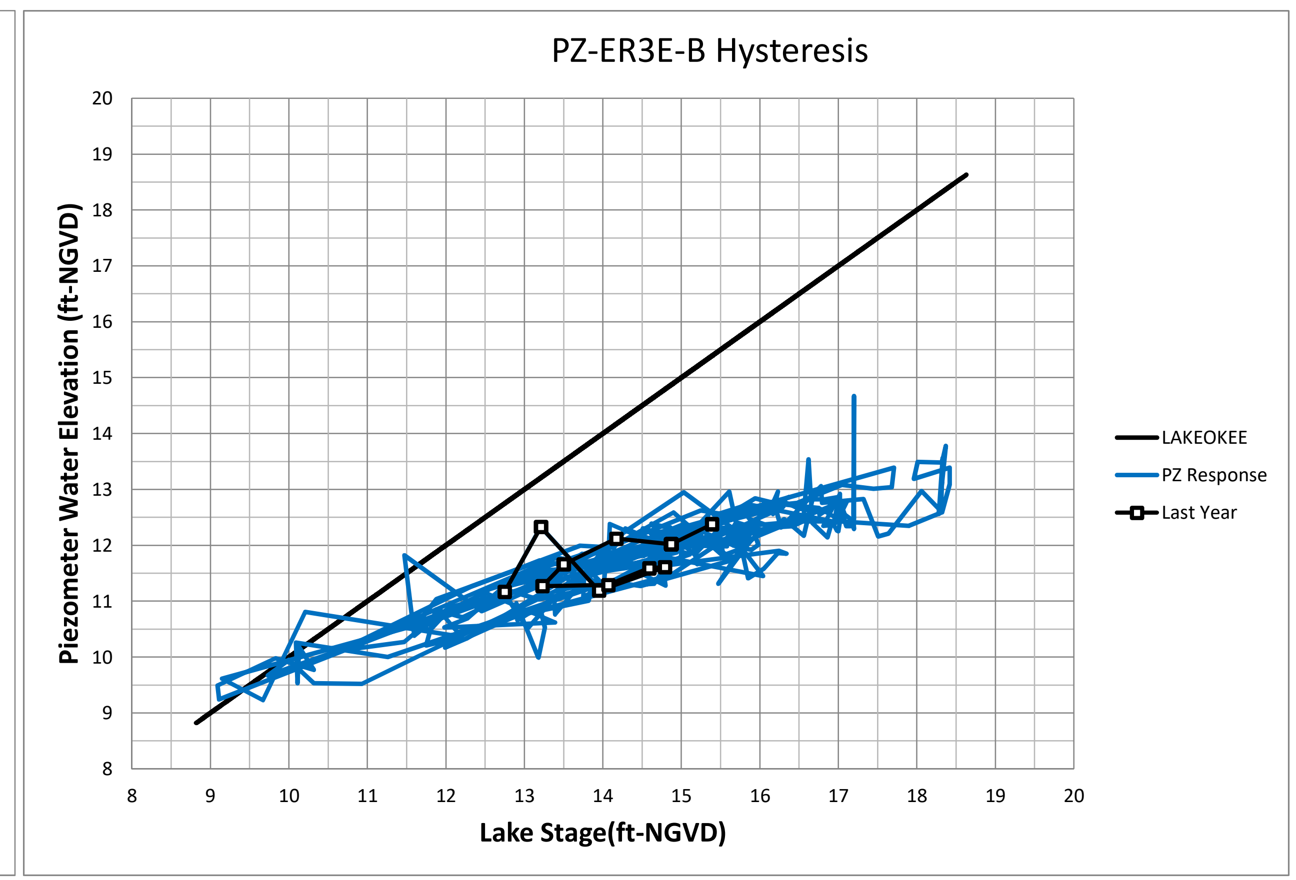


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

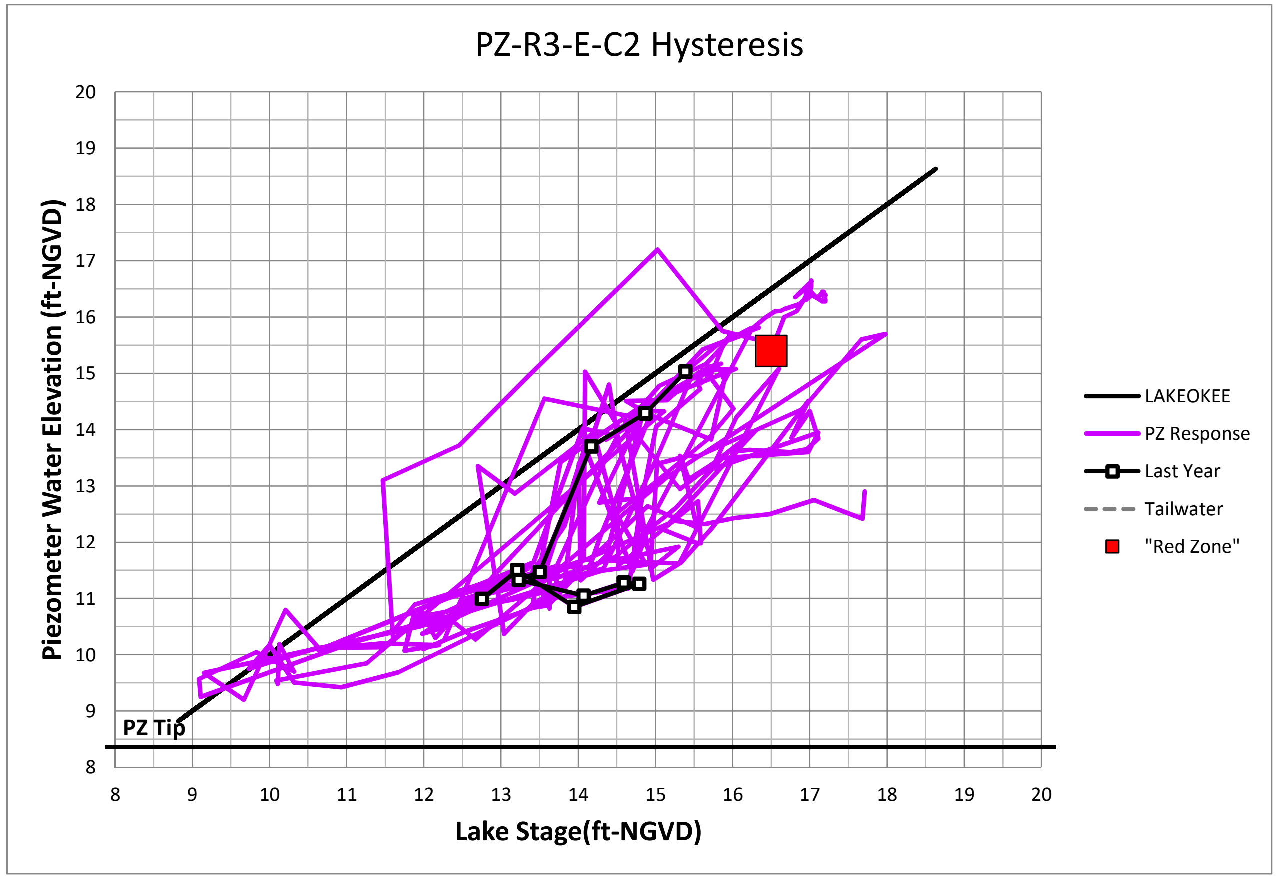


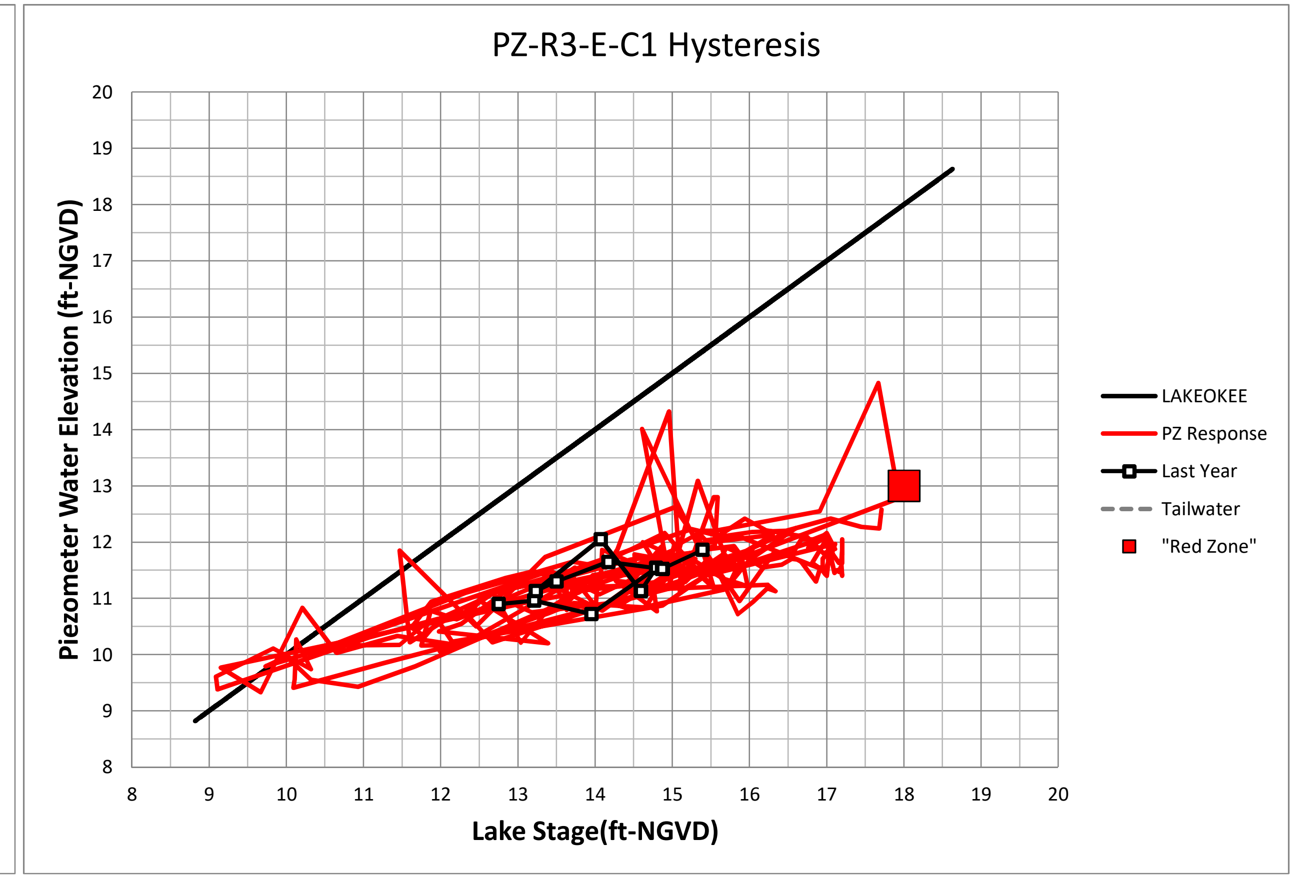




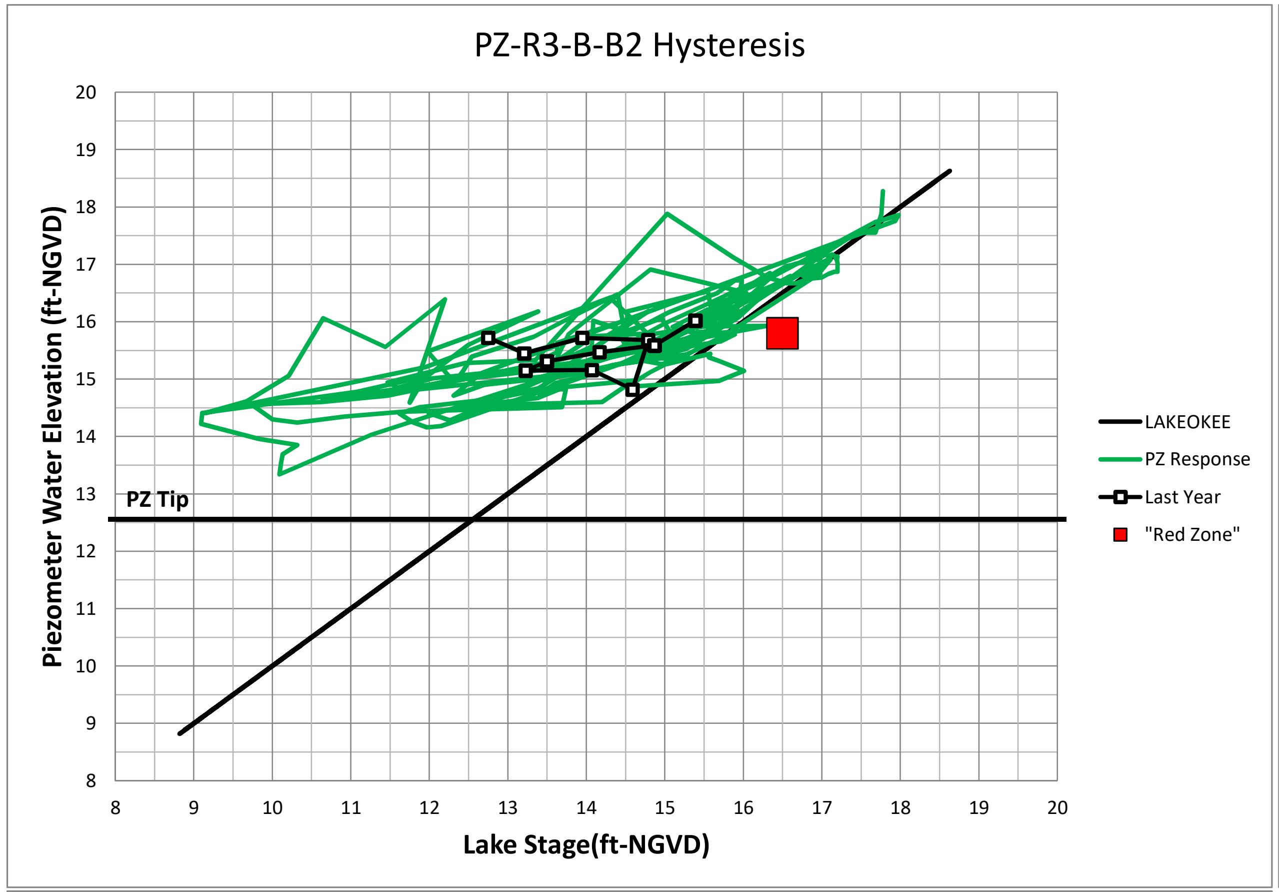


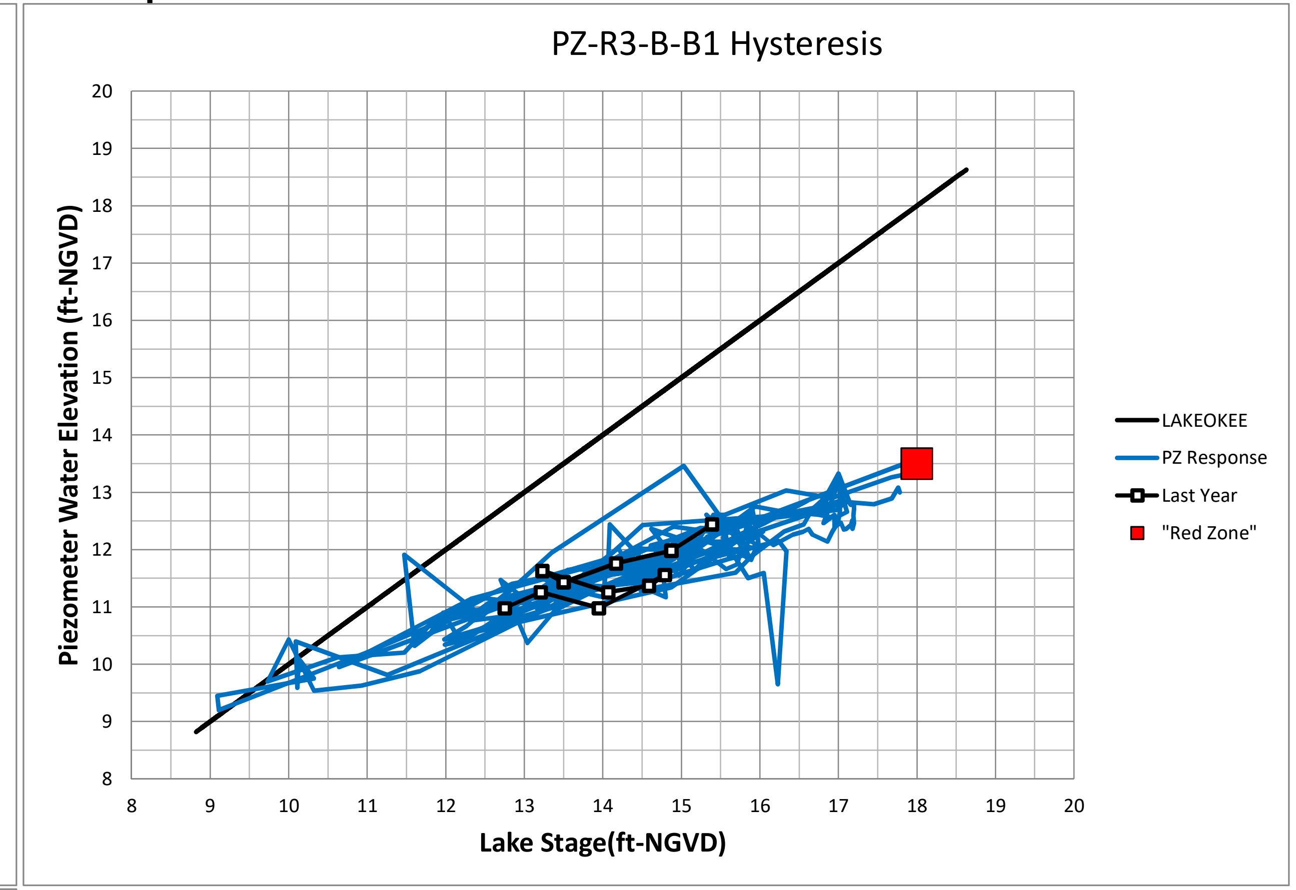
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

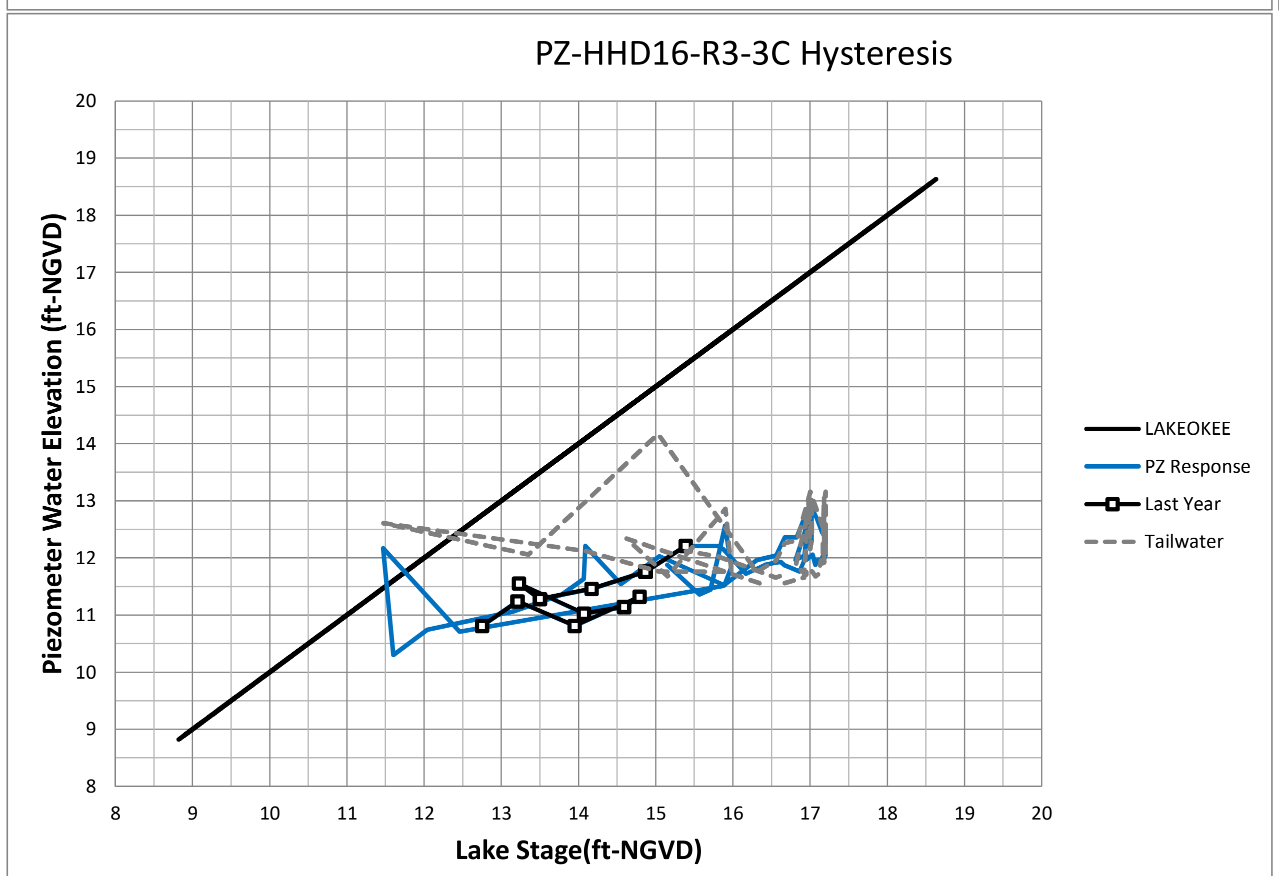




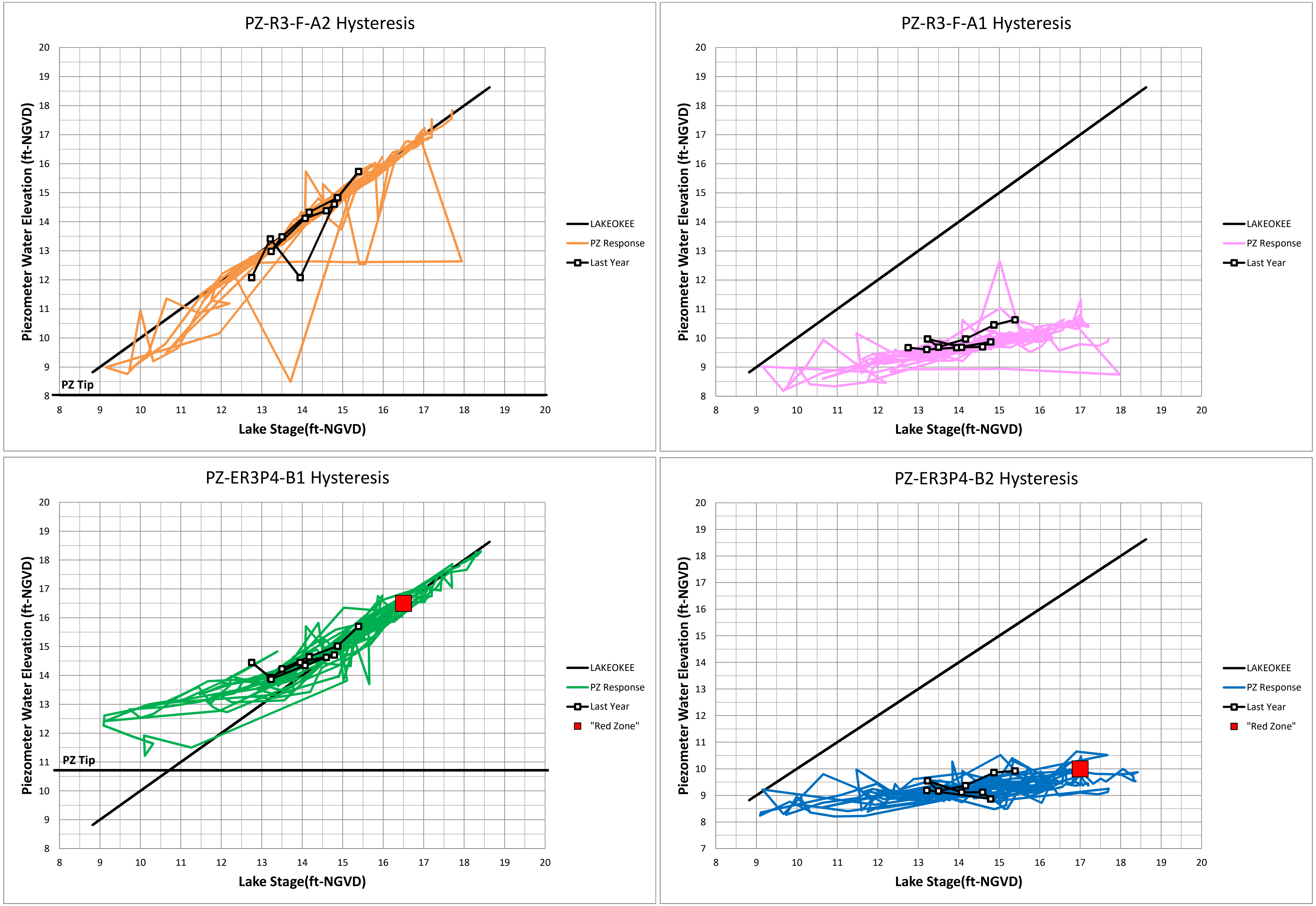
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update



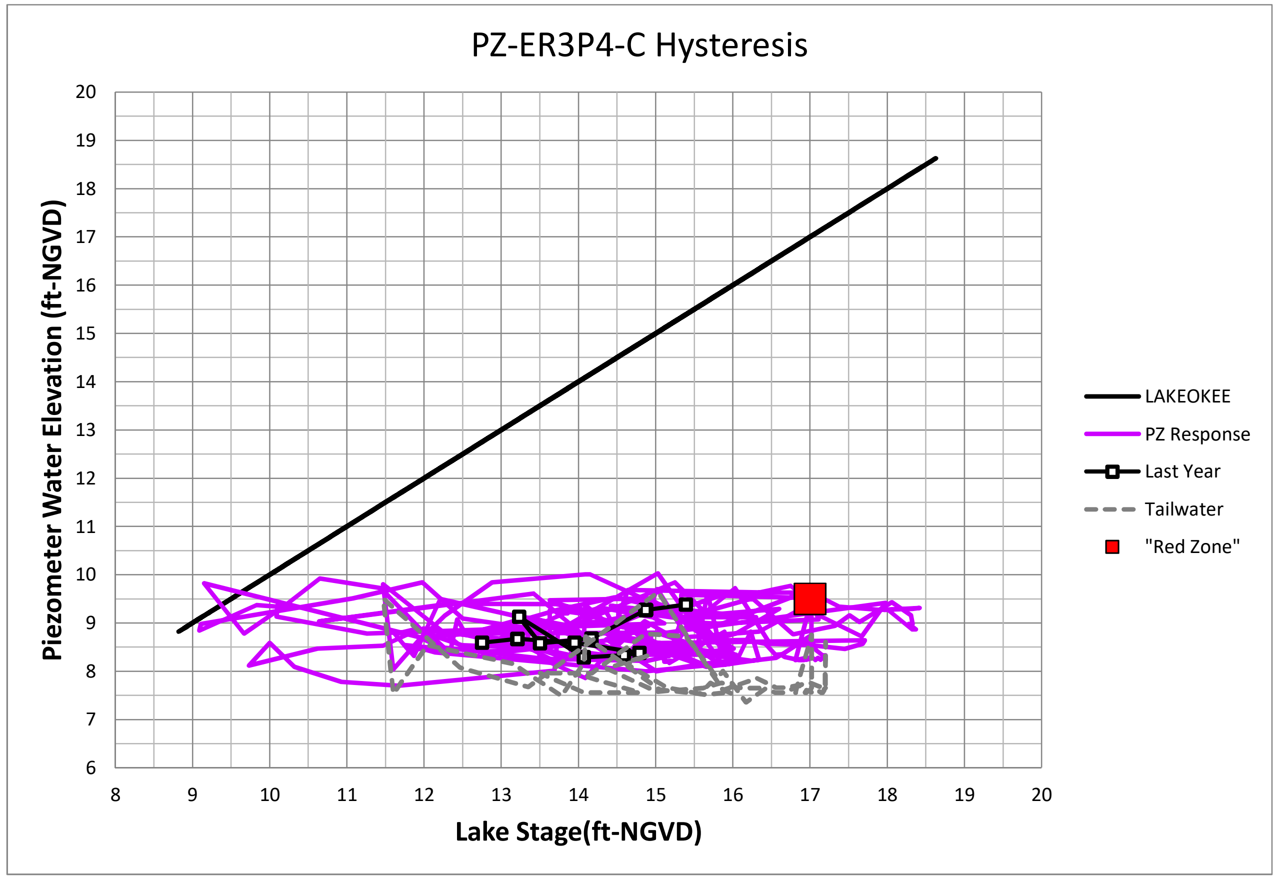


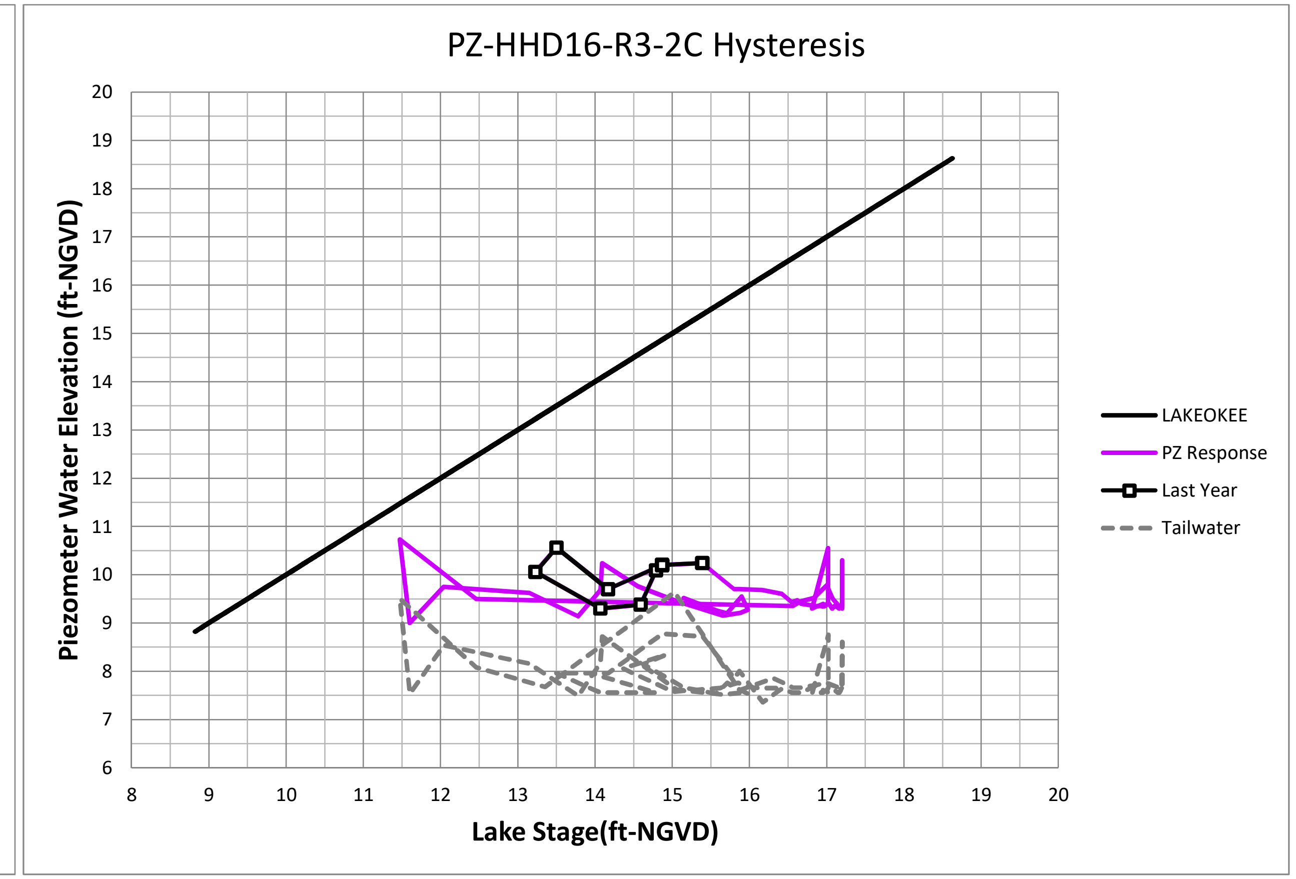


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

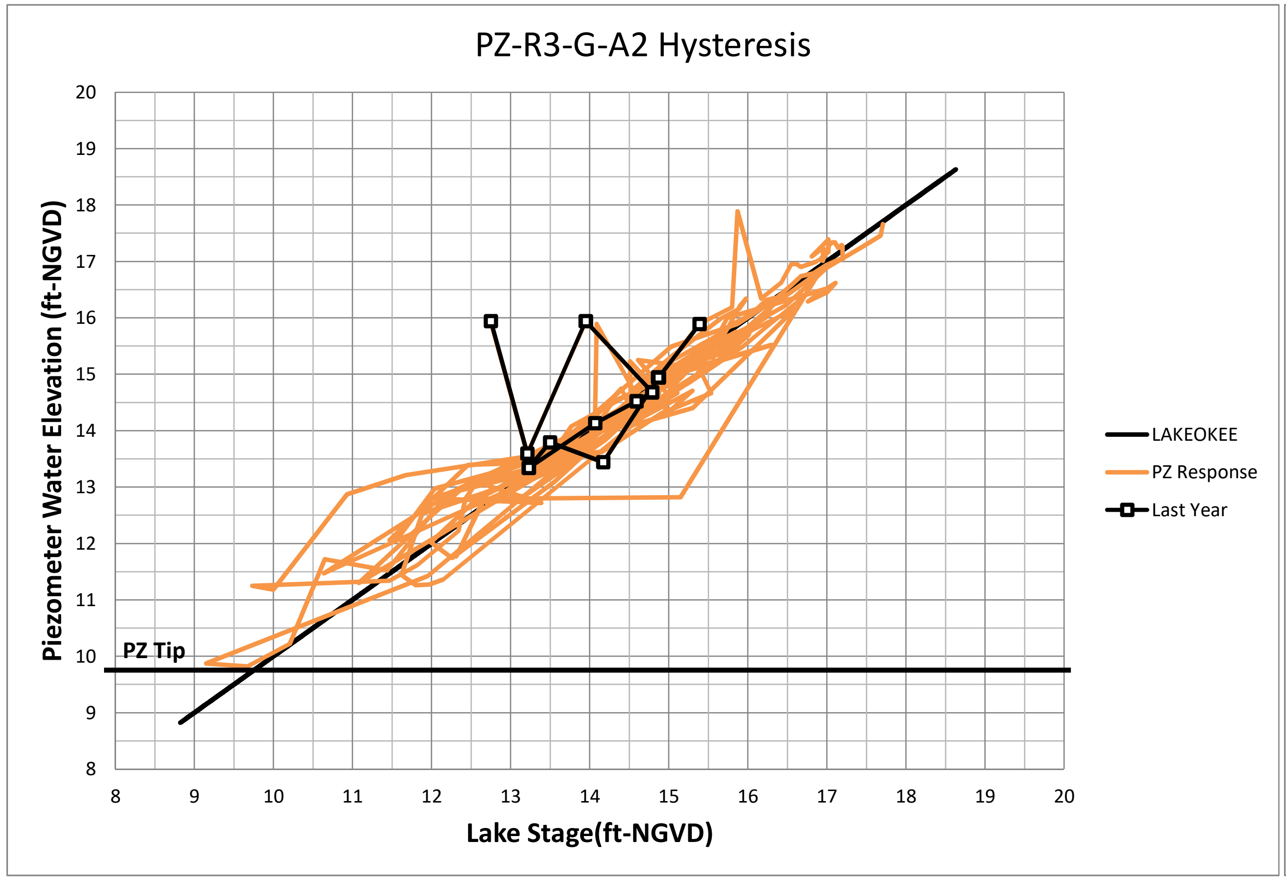


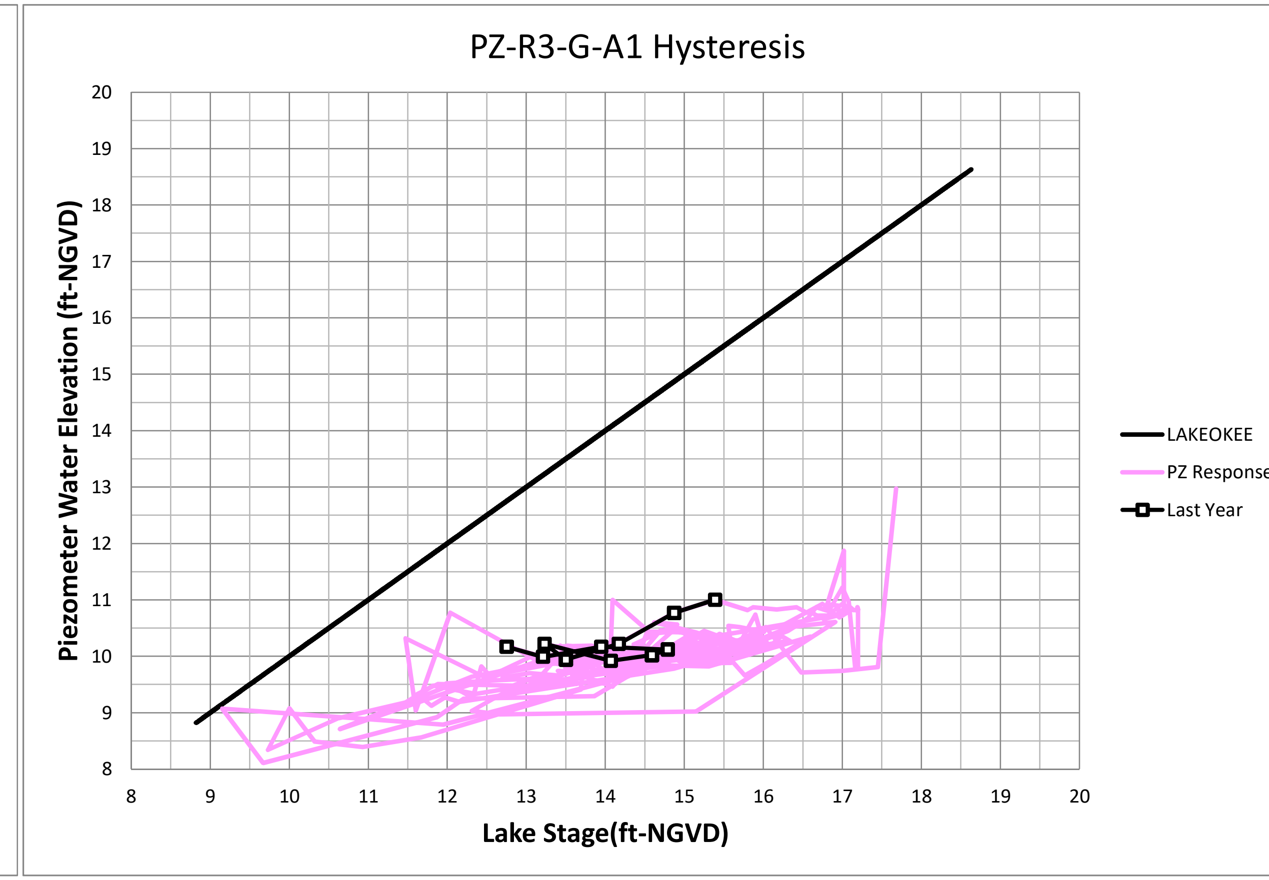
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

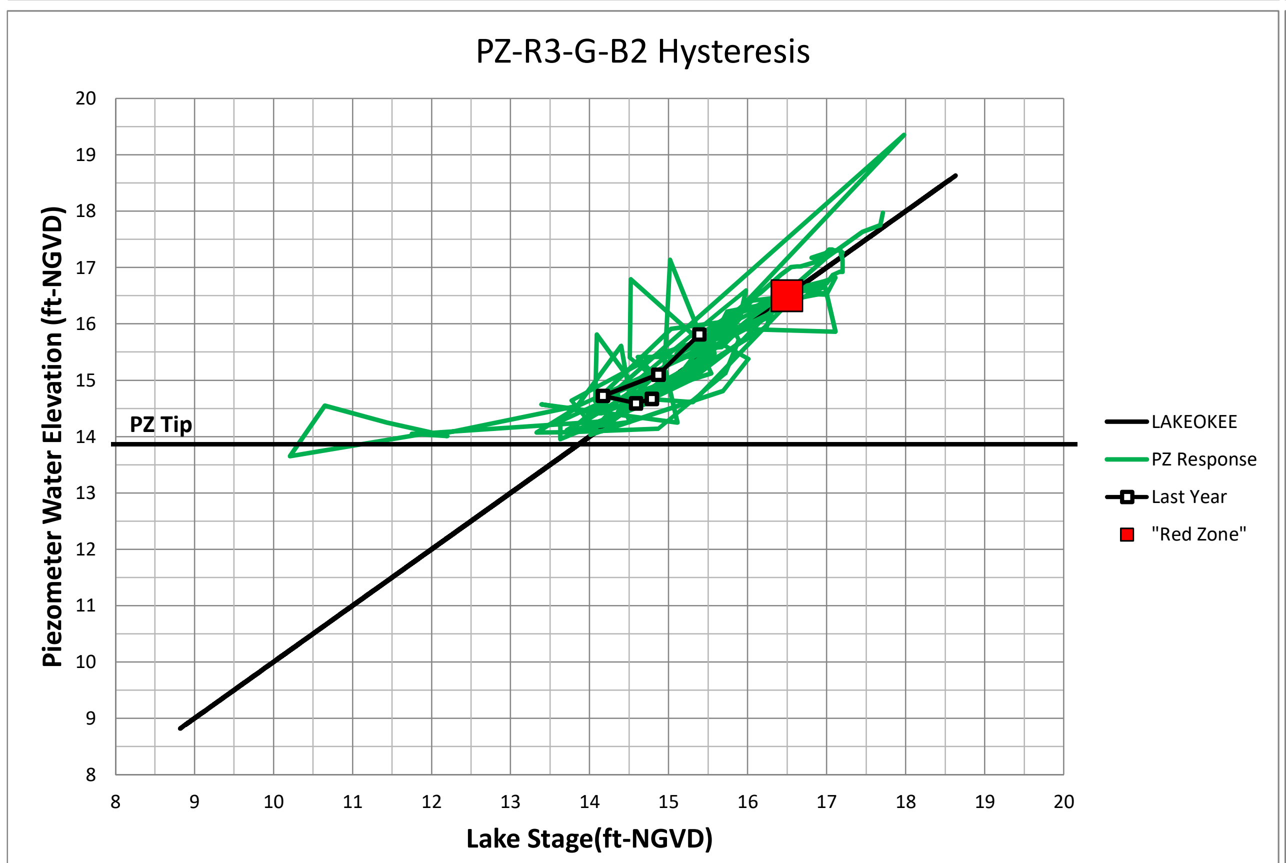


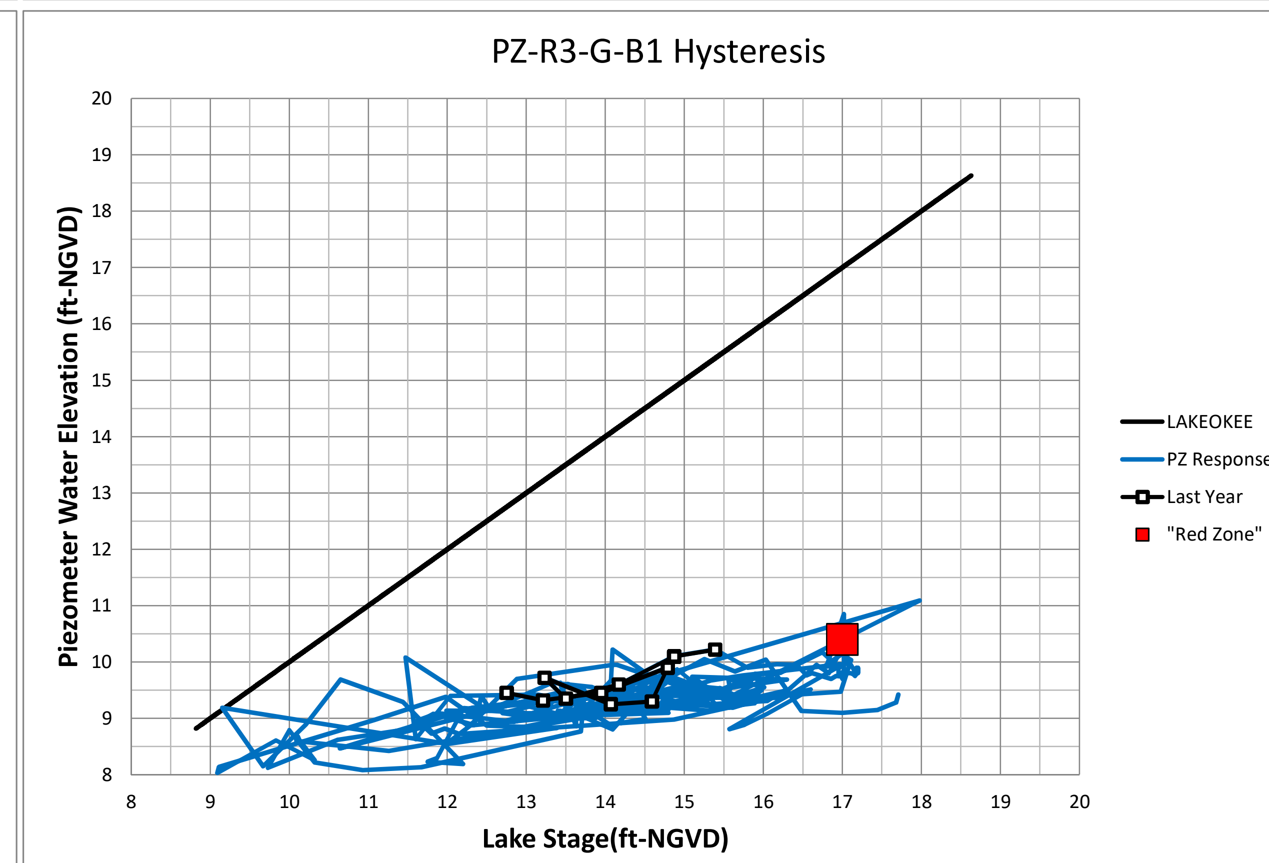


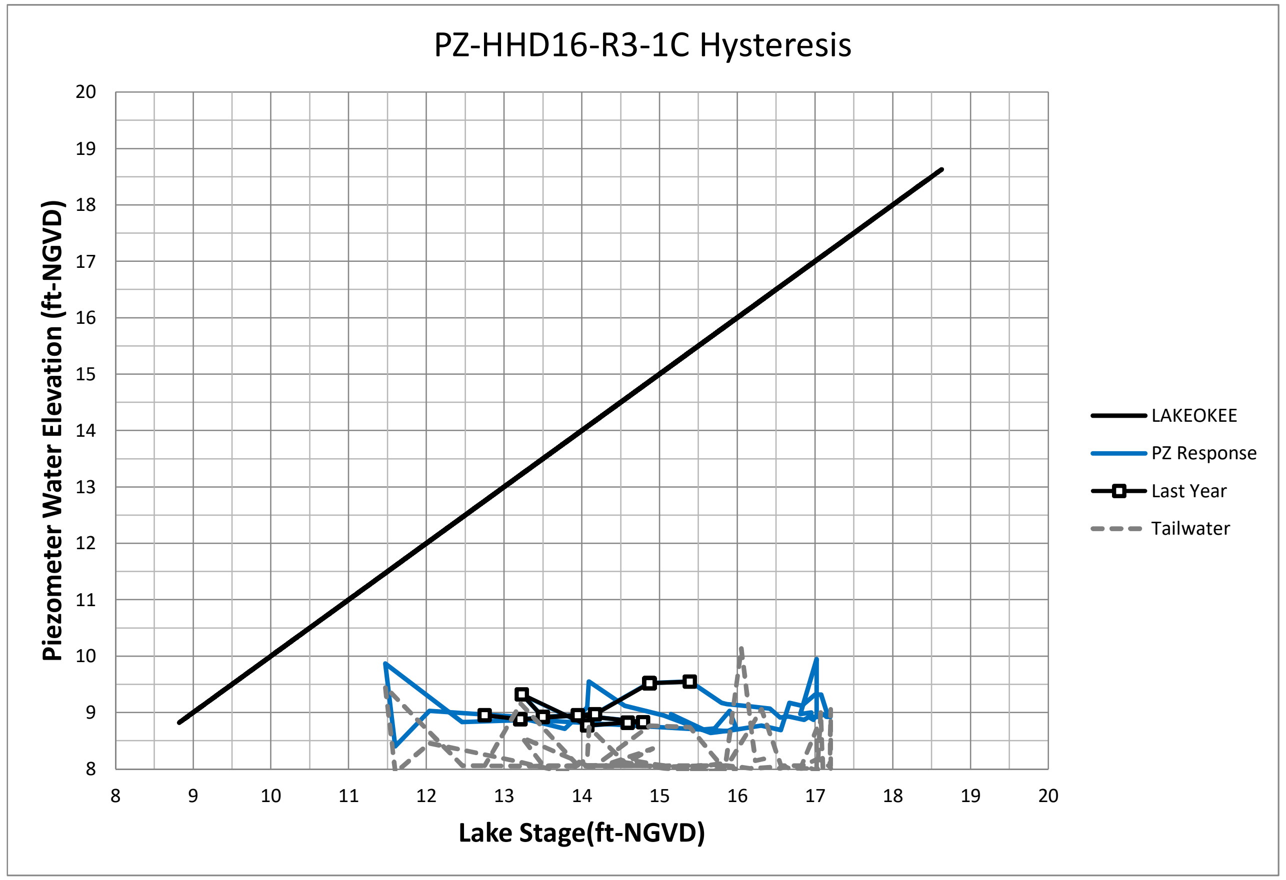
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update



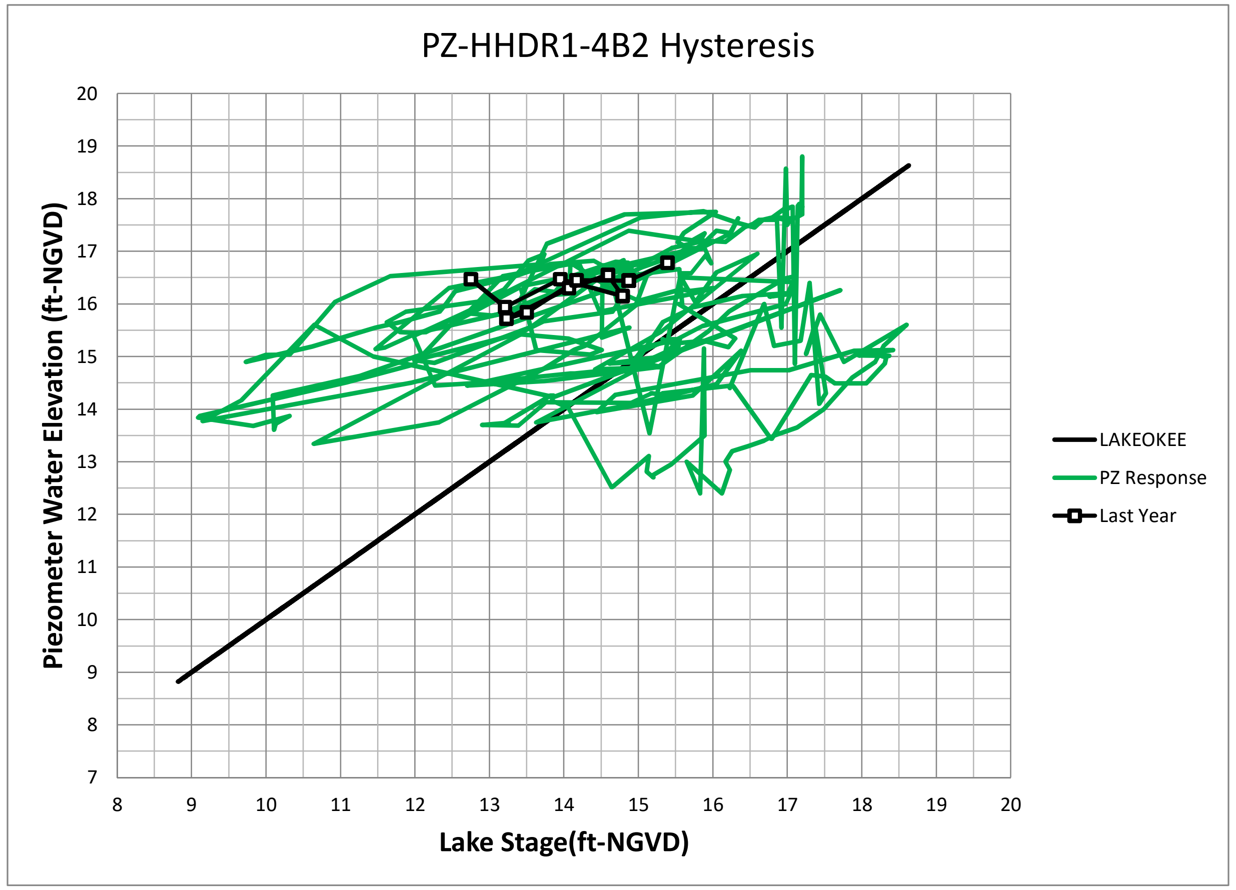


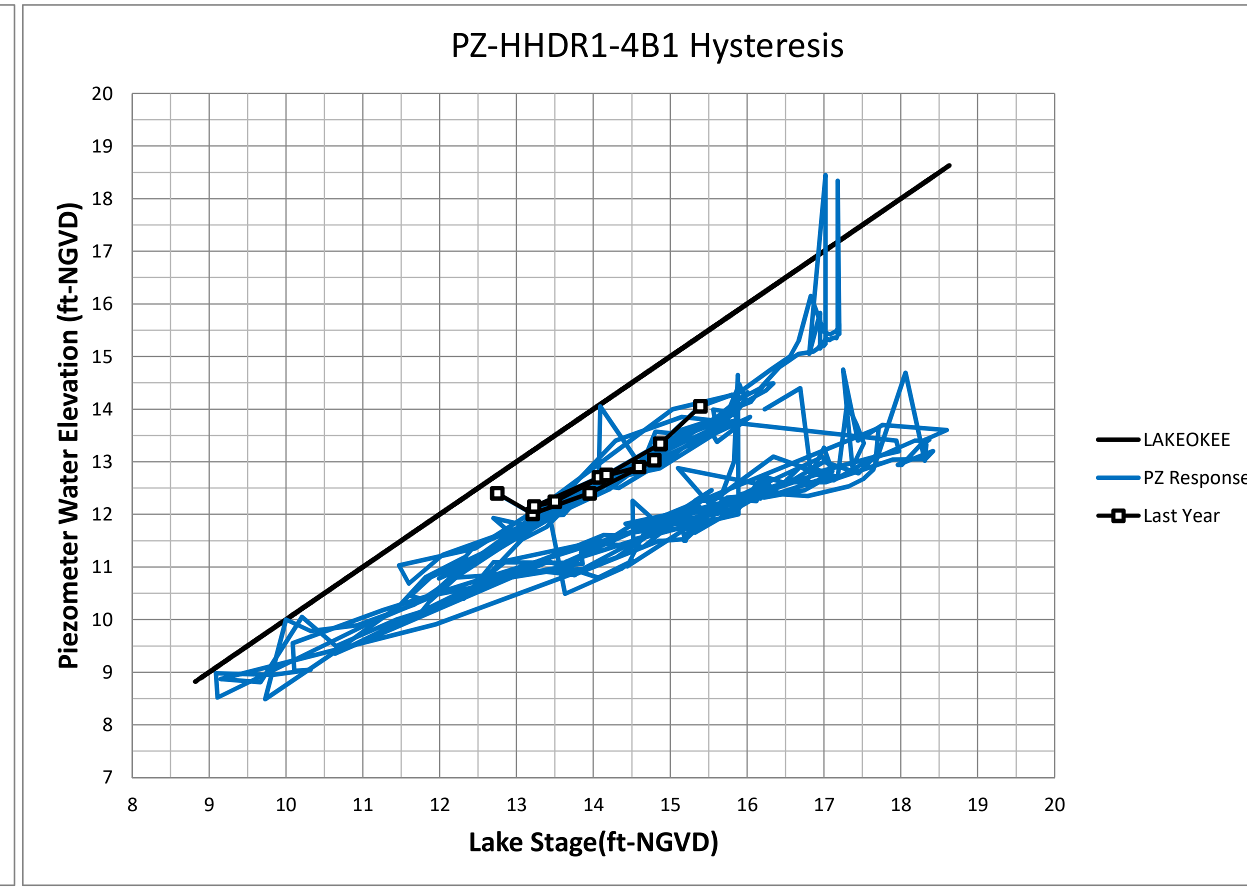


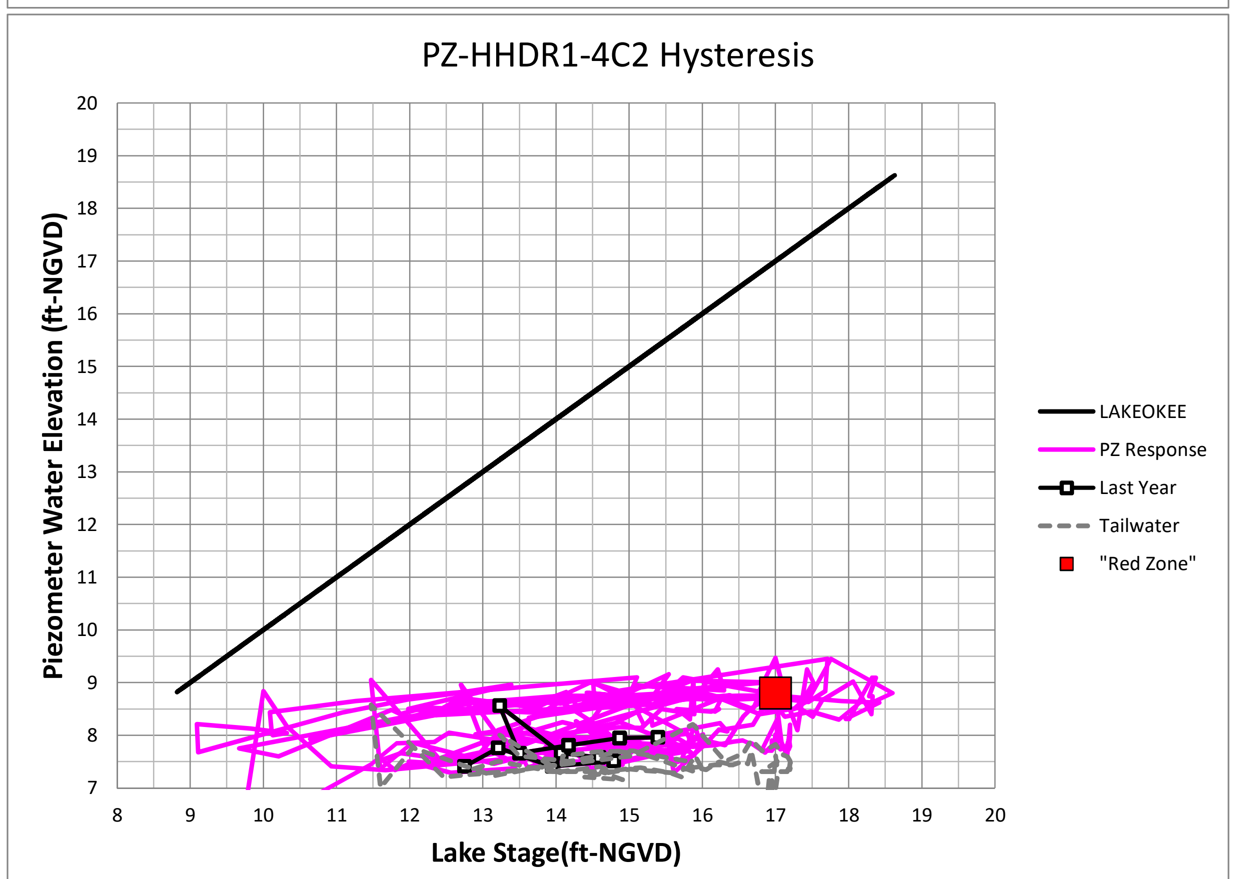


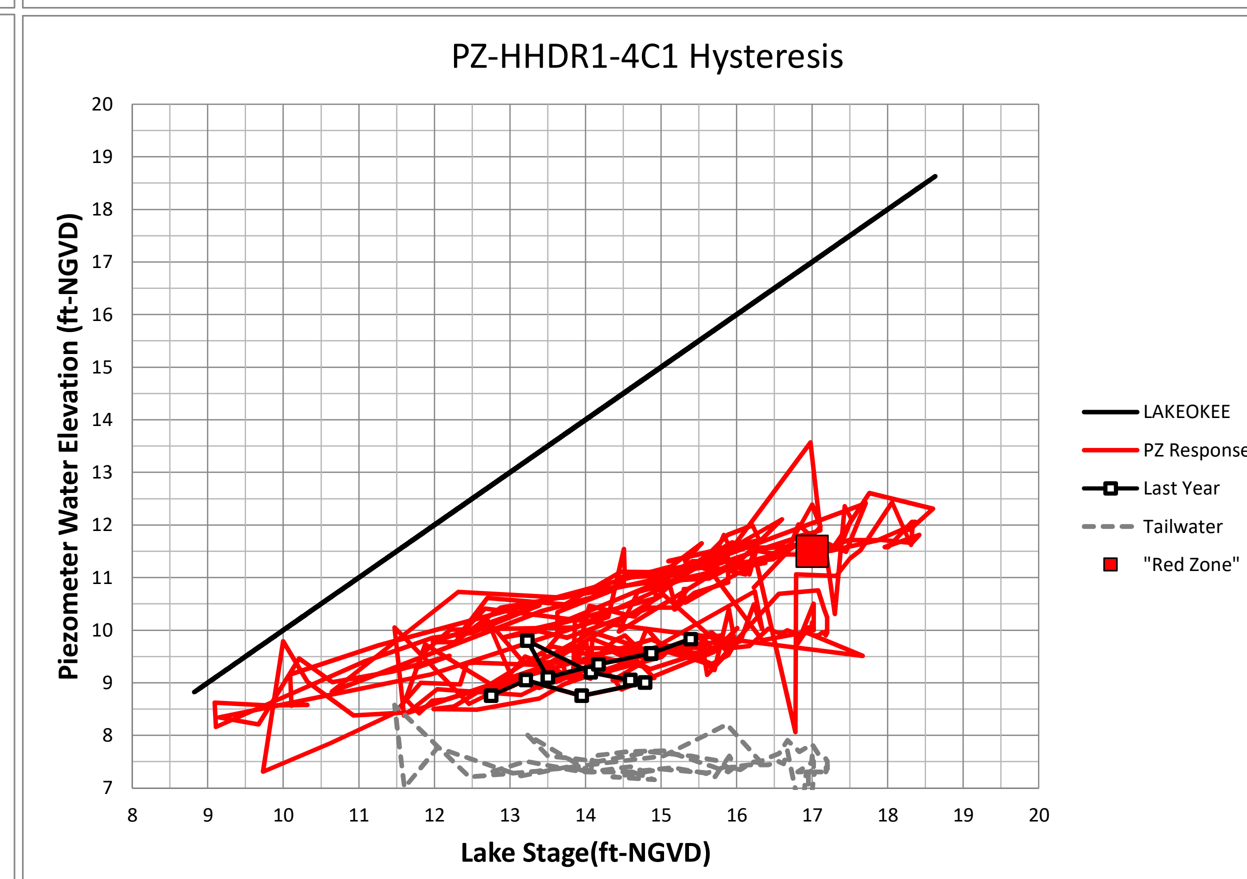

PZ-HHD16-R3-1C Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
LAKEOKEE
PZ Response
Last Year
Tailwater

Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

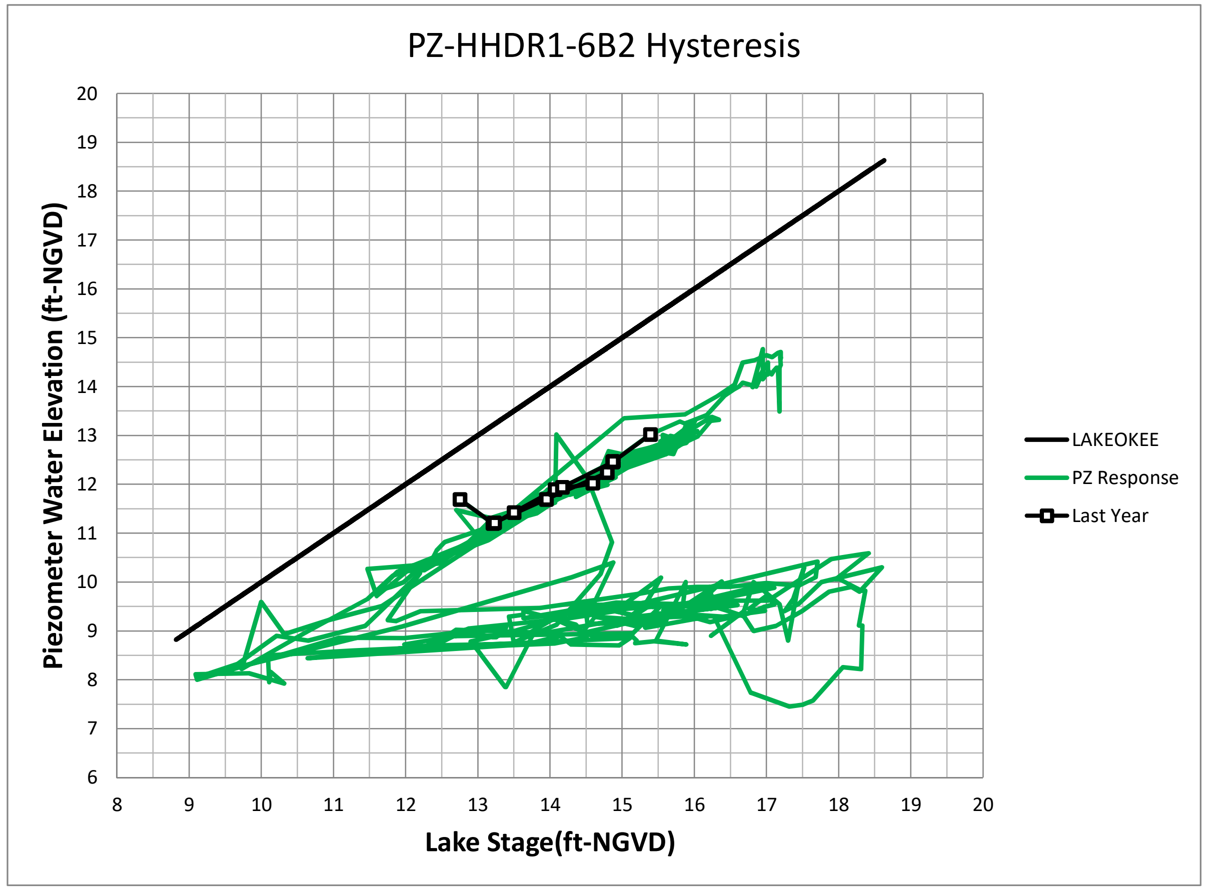


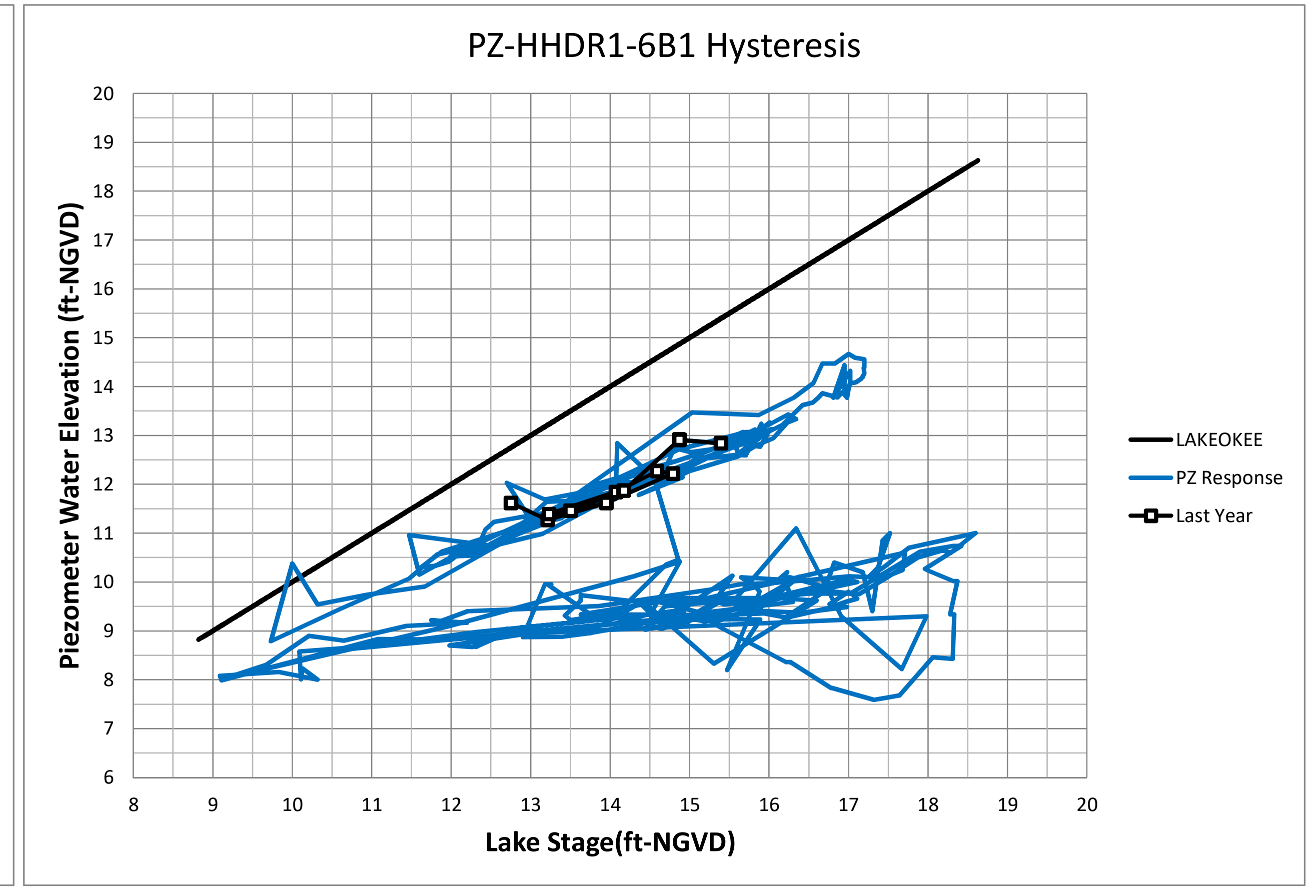


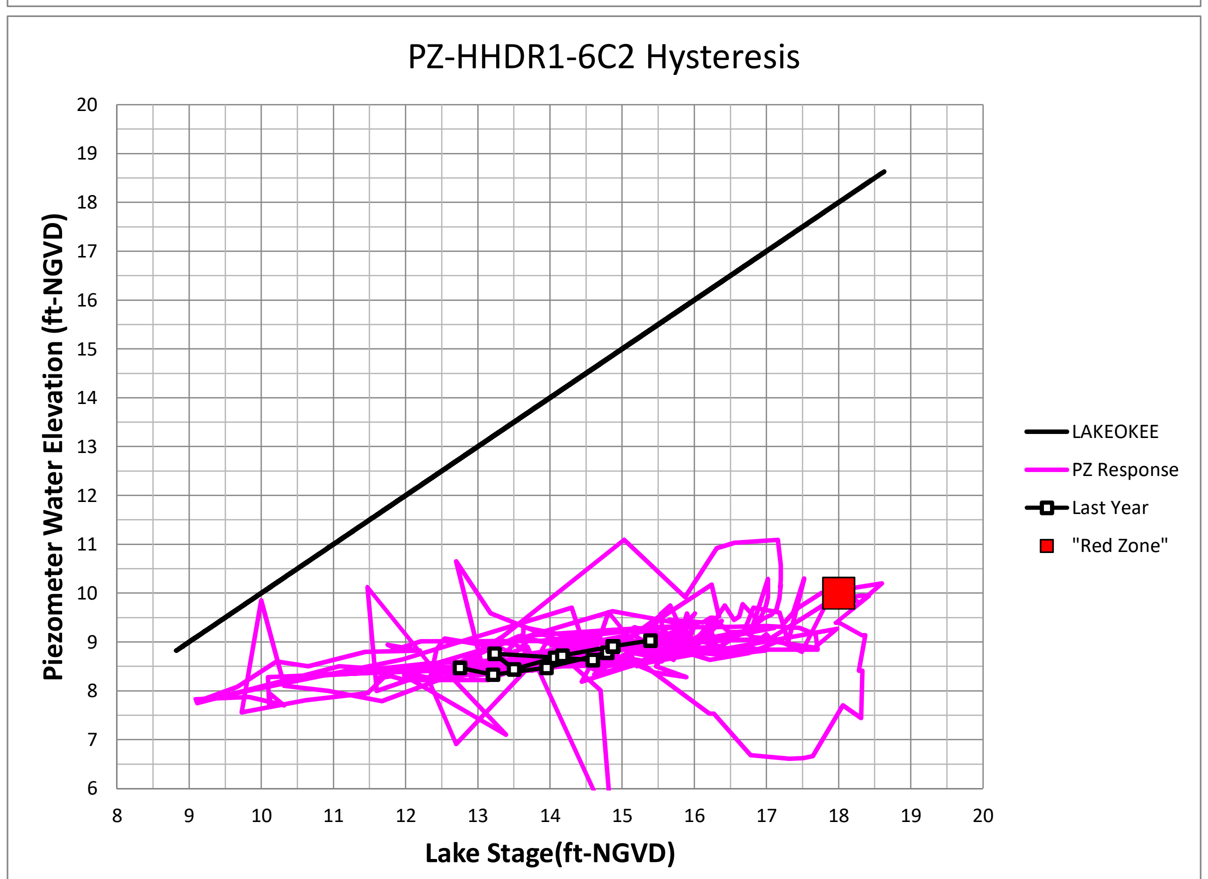


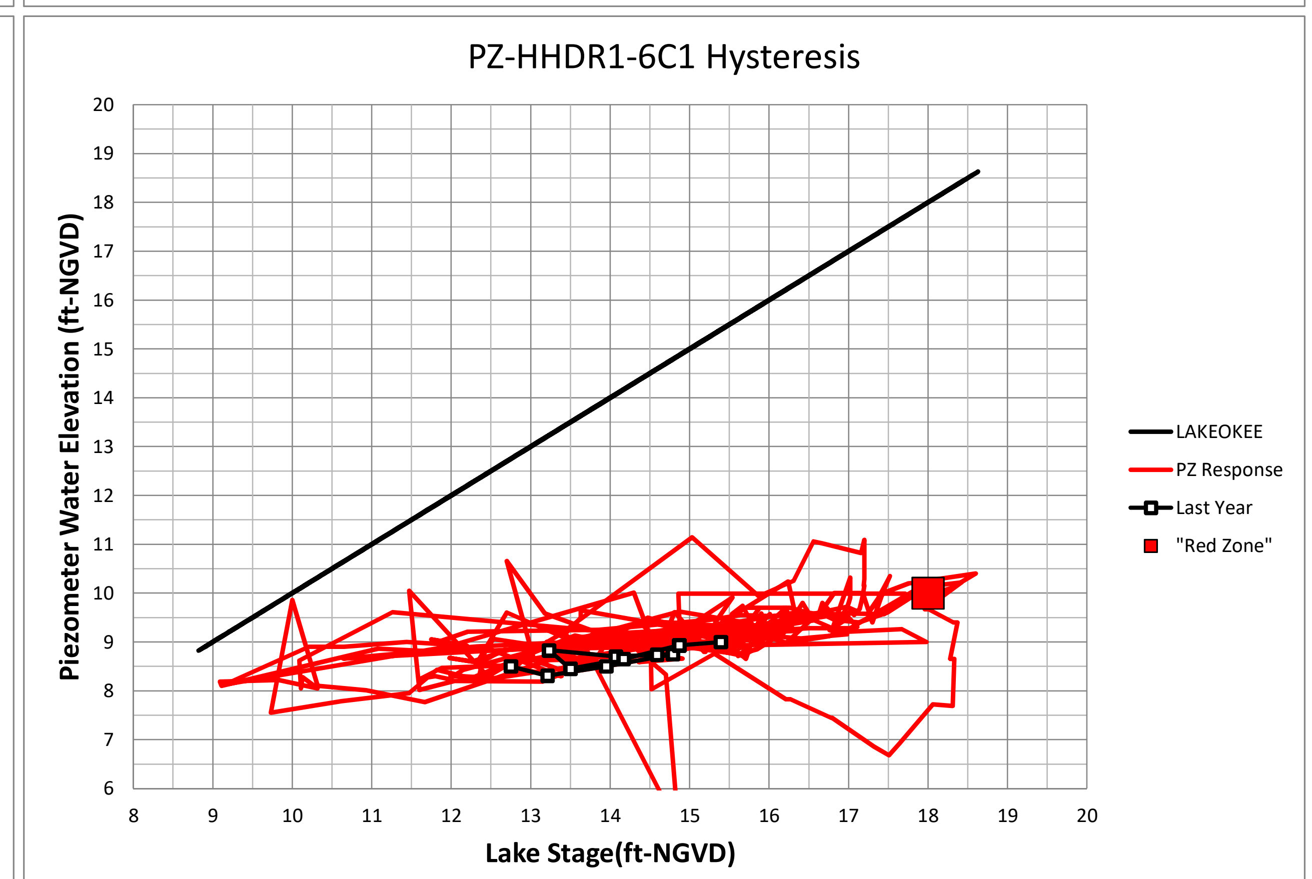


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

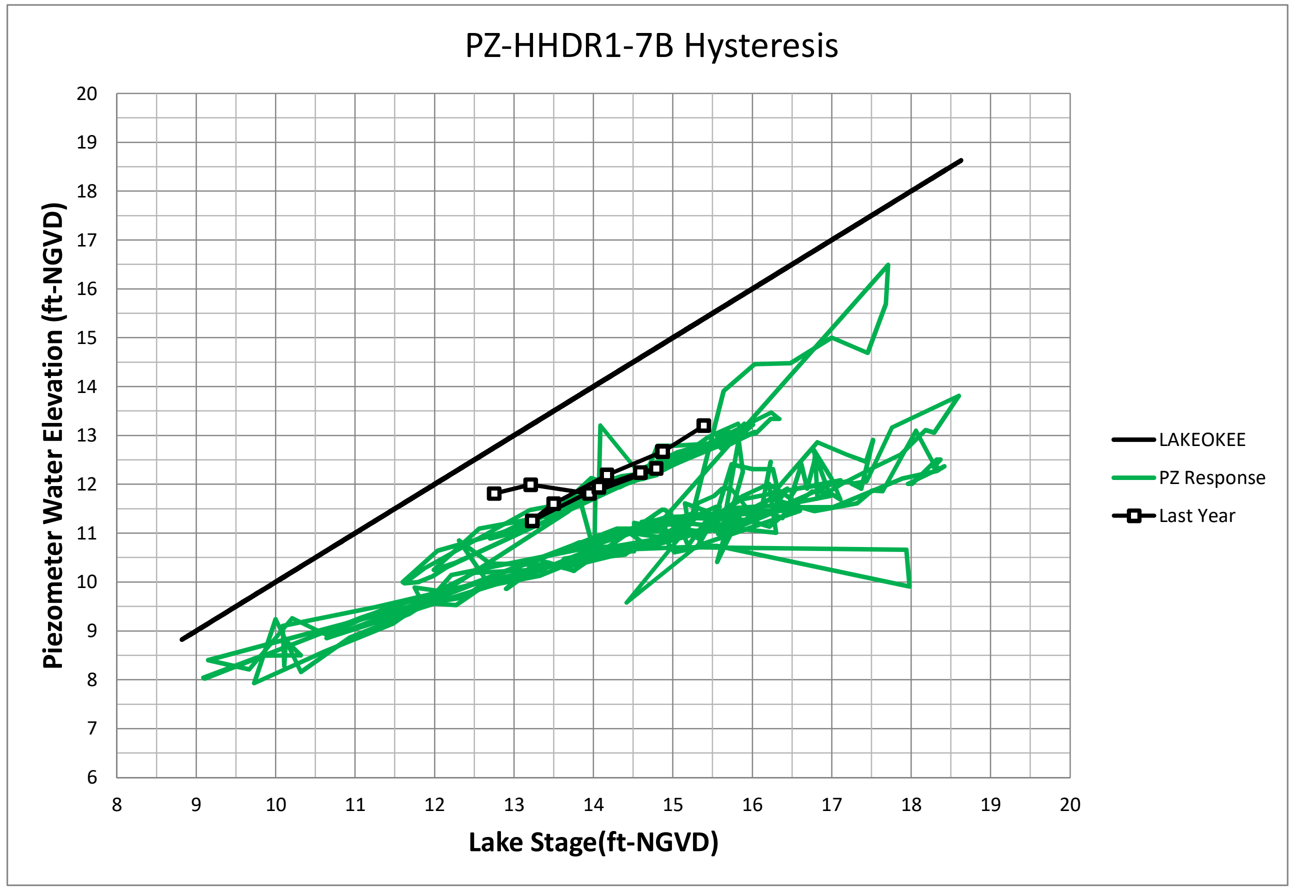


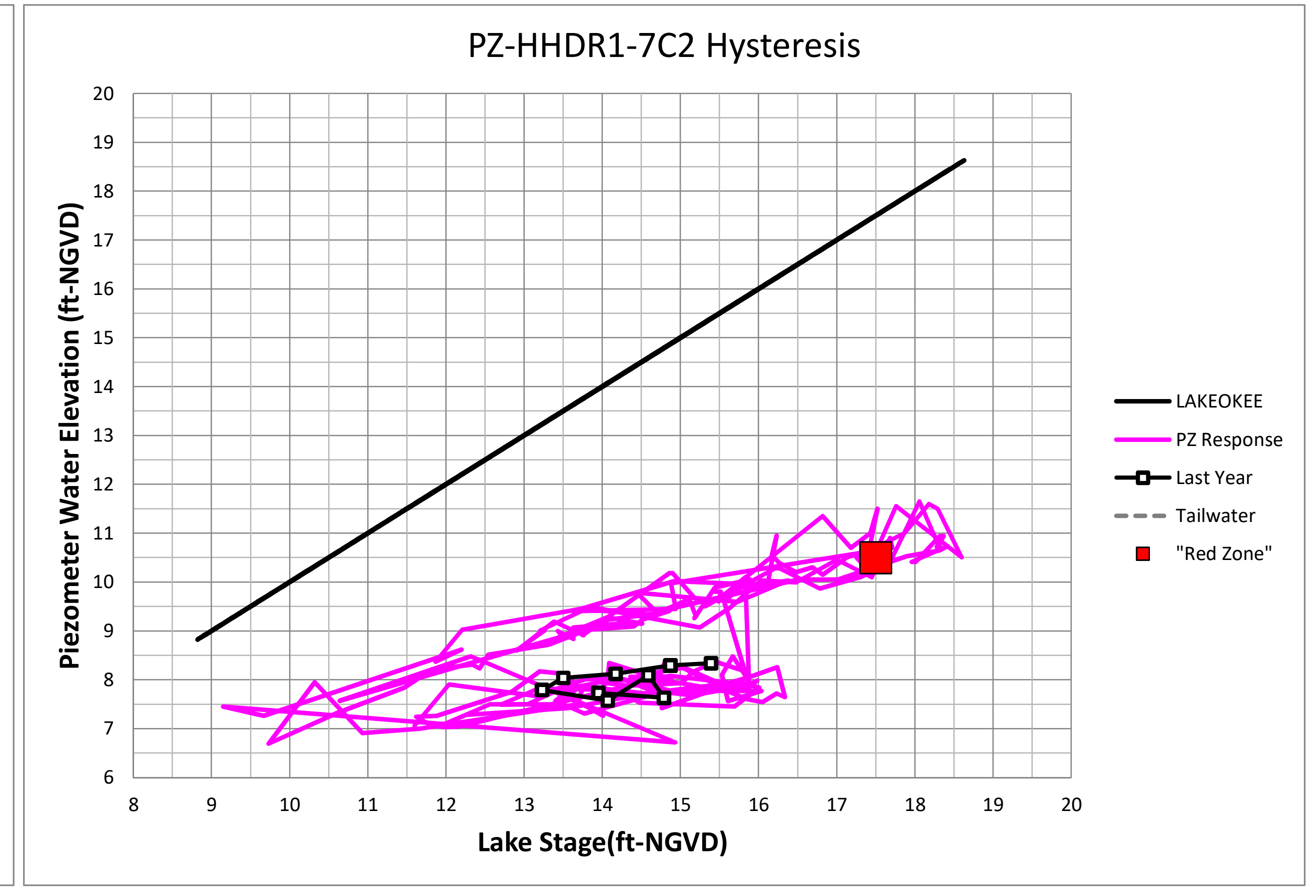






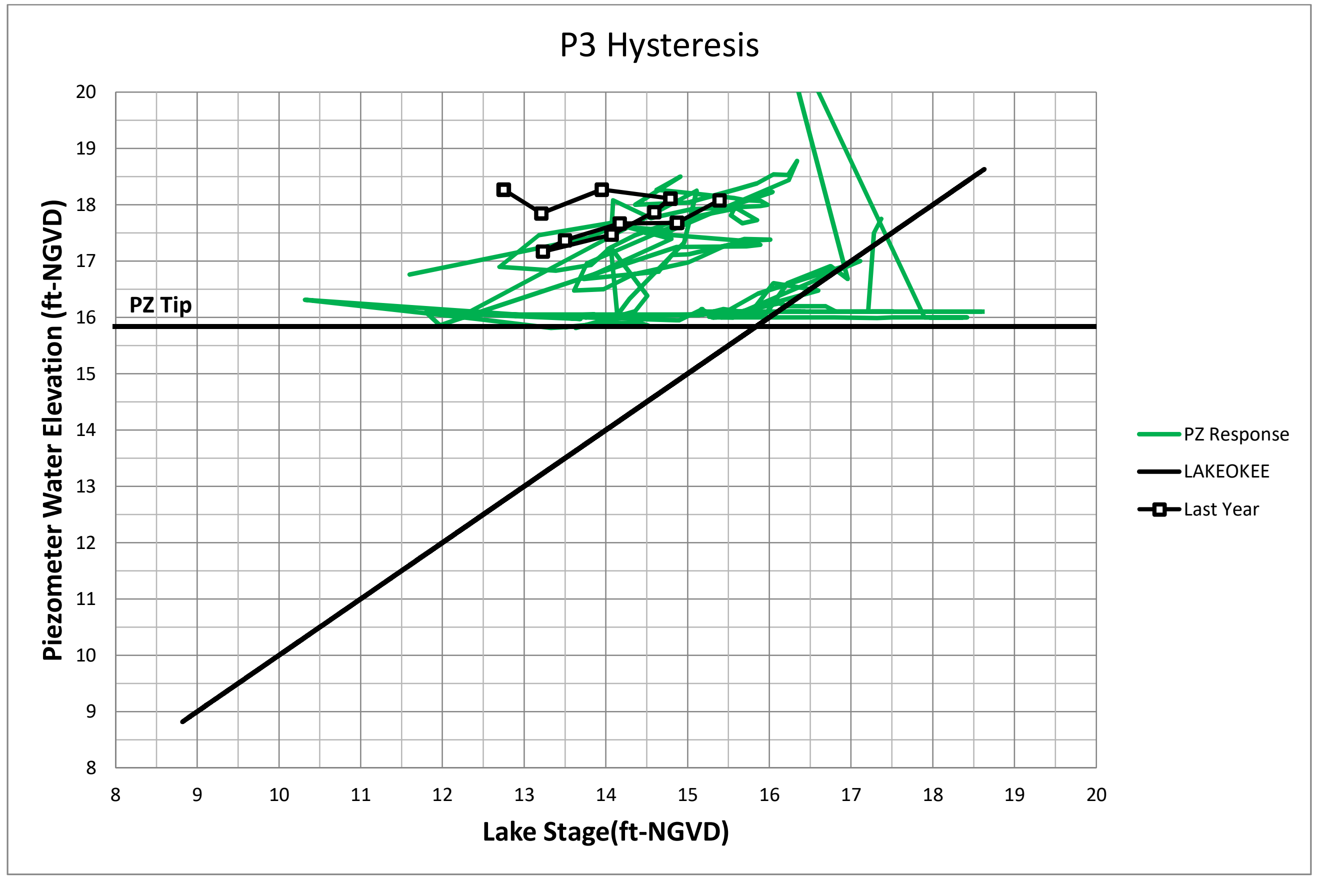
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

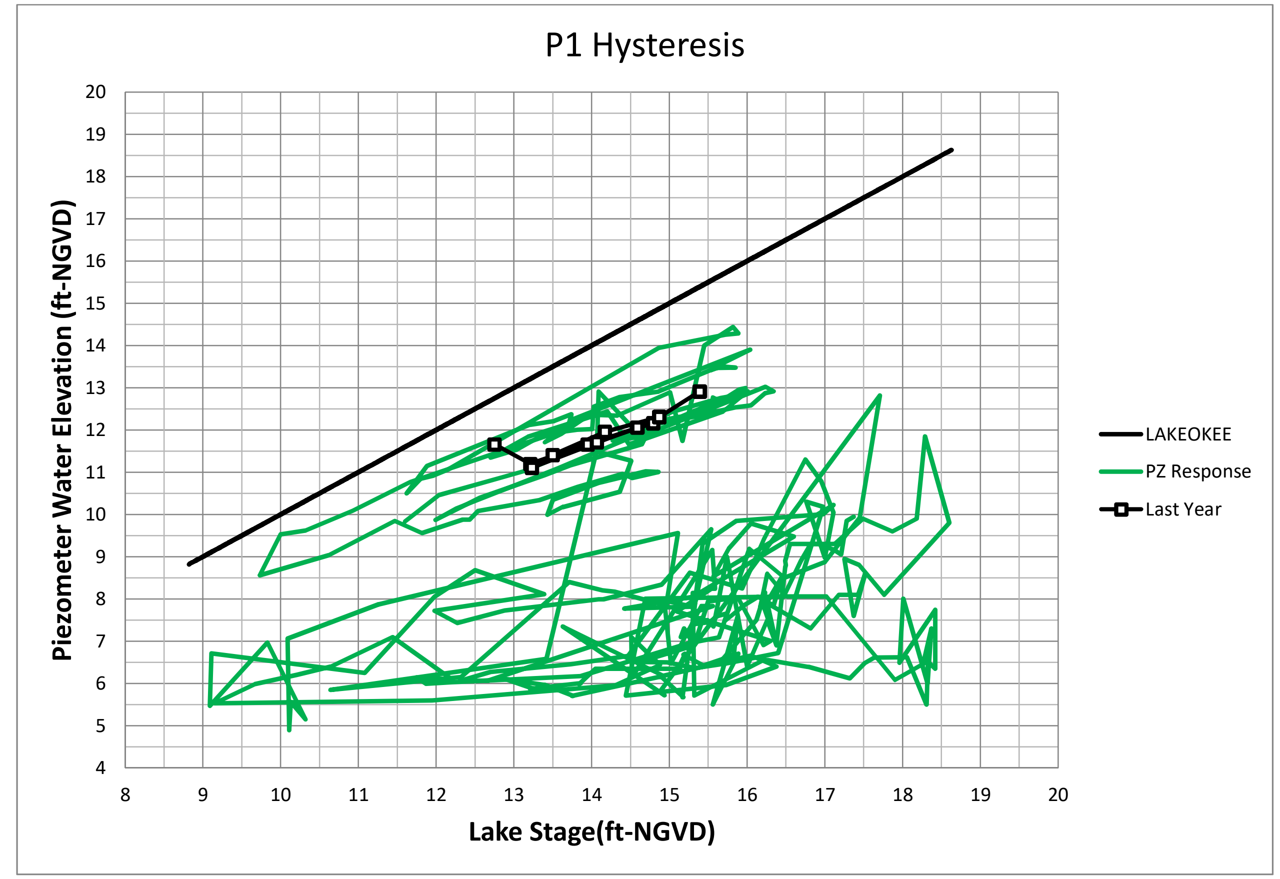


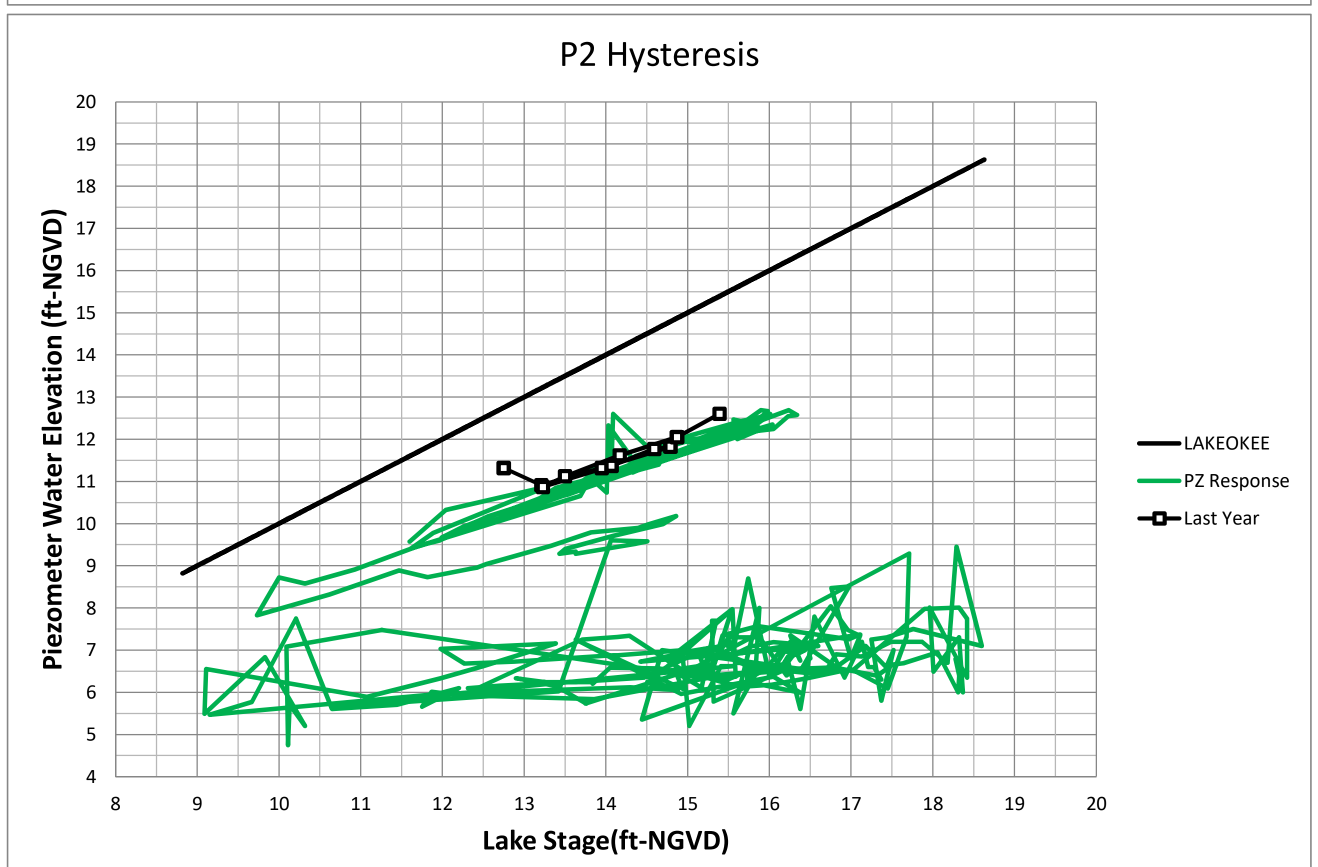


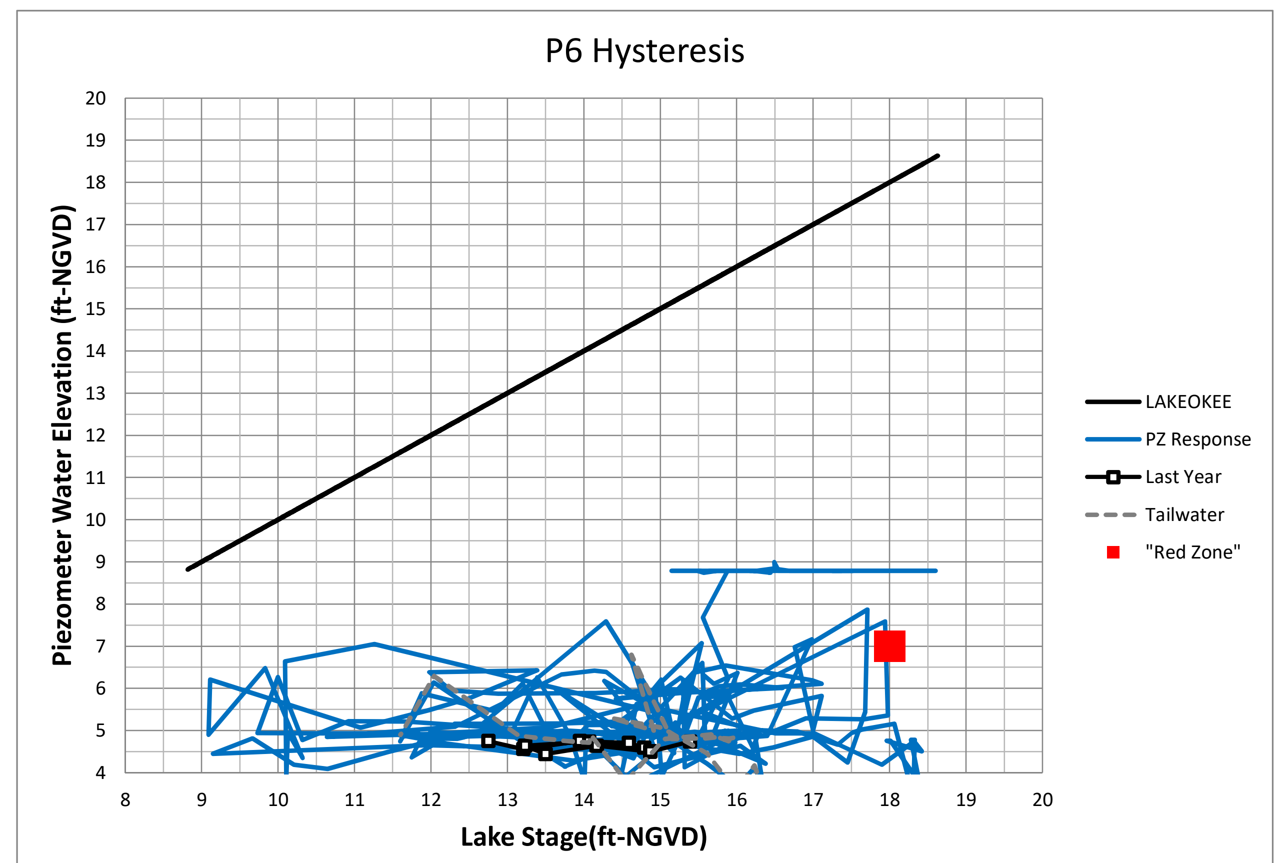
Herbert Hoover Dike- Lake Okeechobee, Florida

Instrumentation Update









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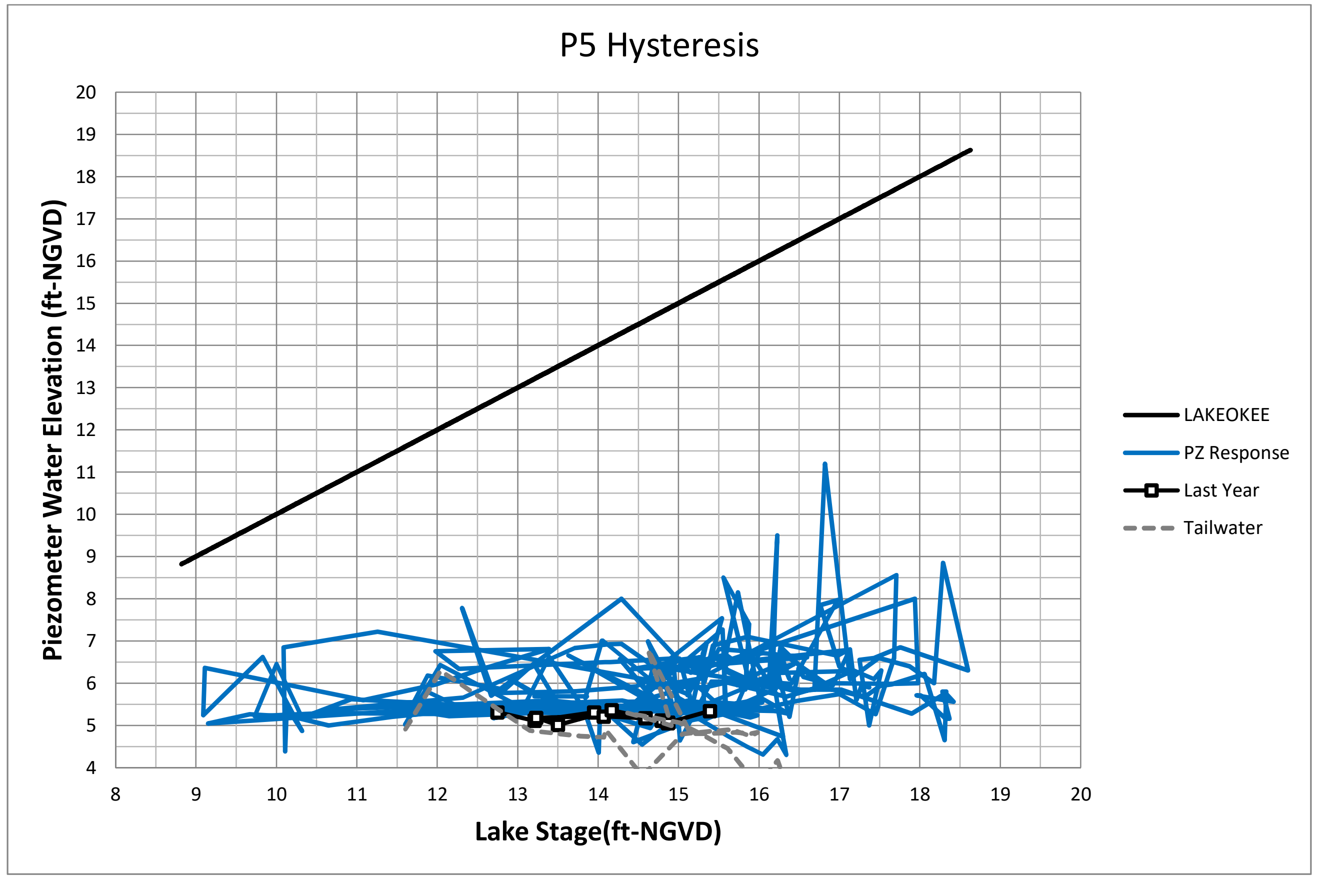
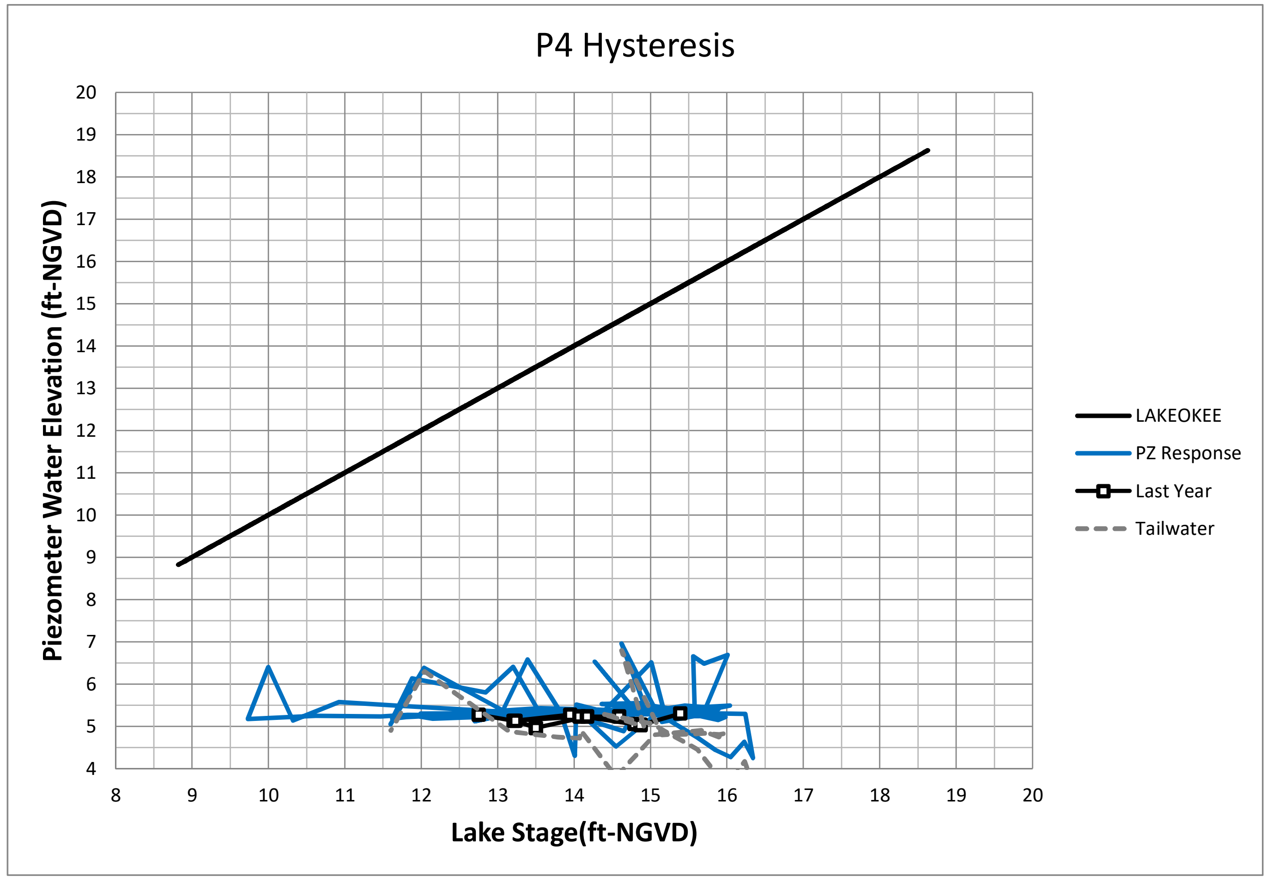
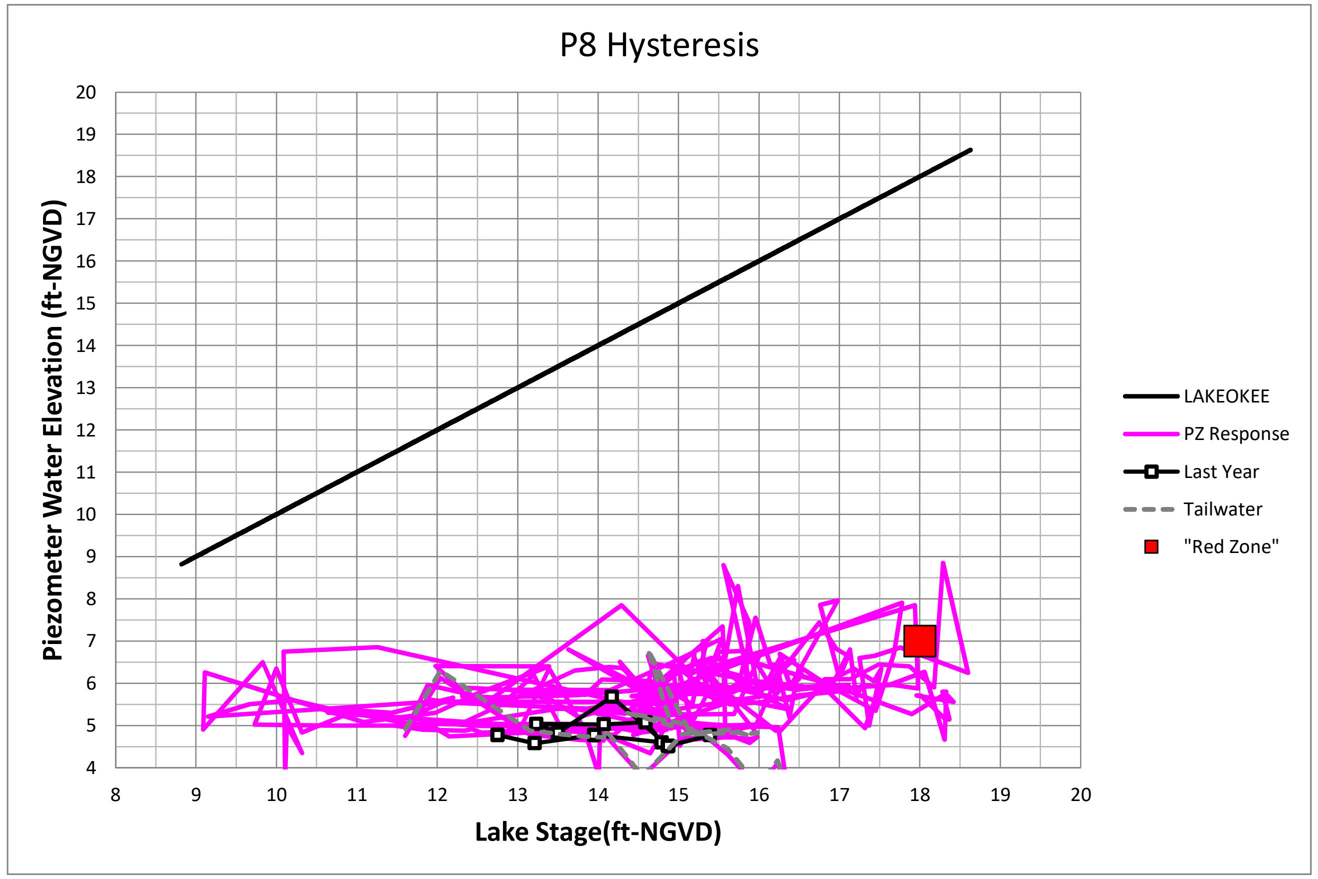
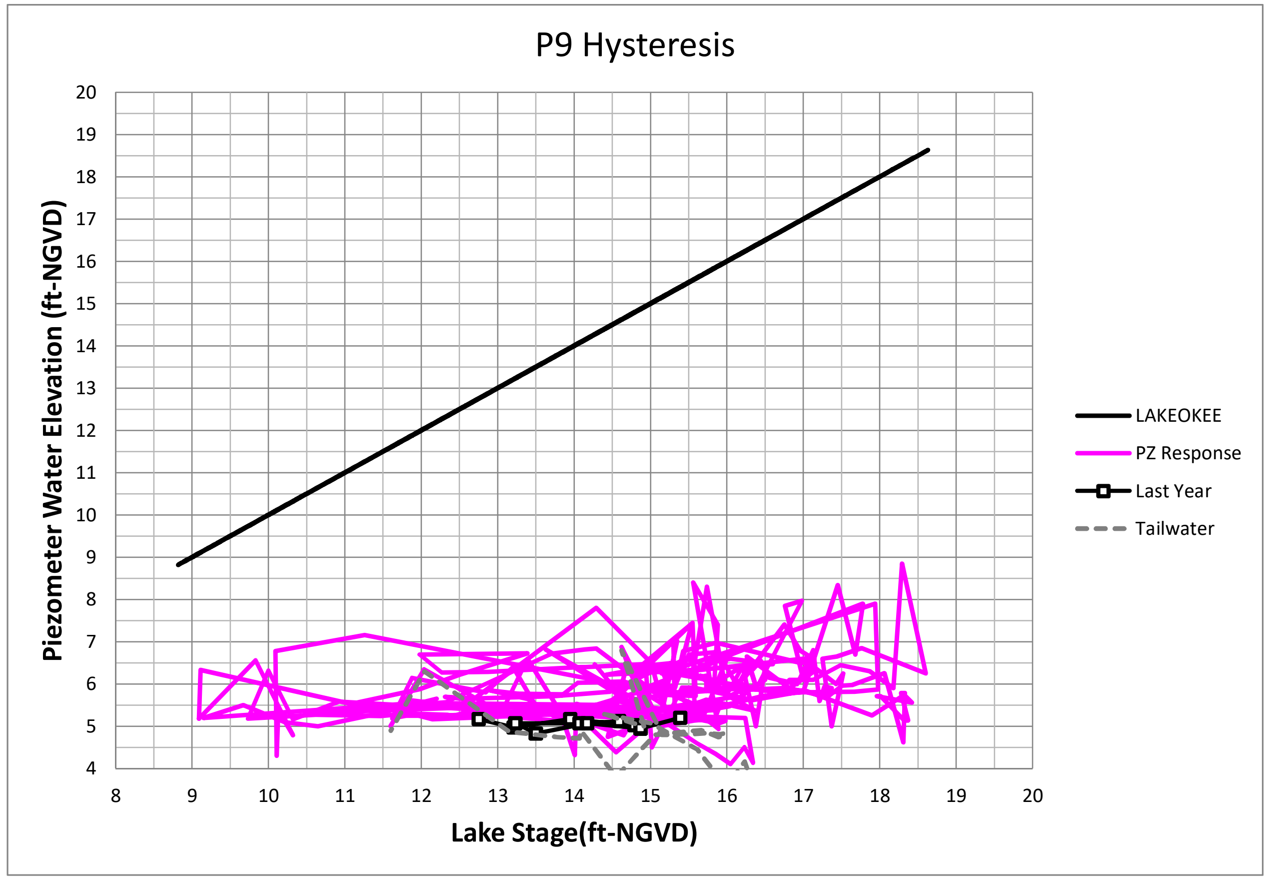
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update









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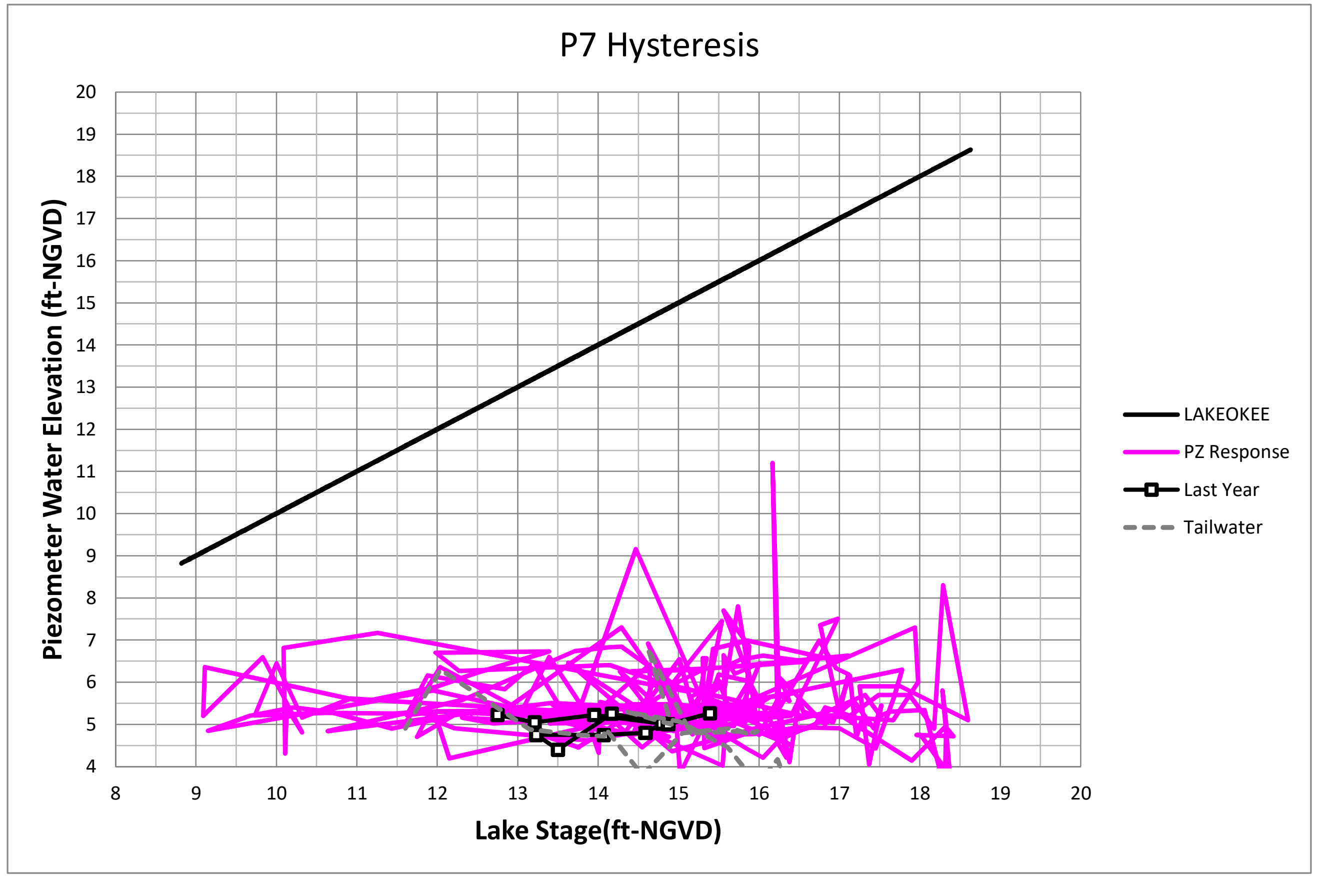
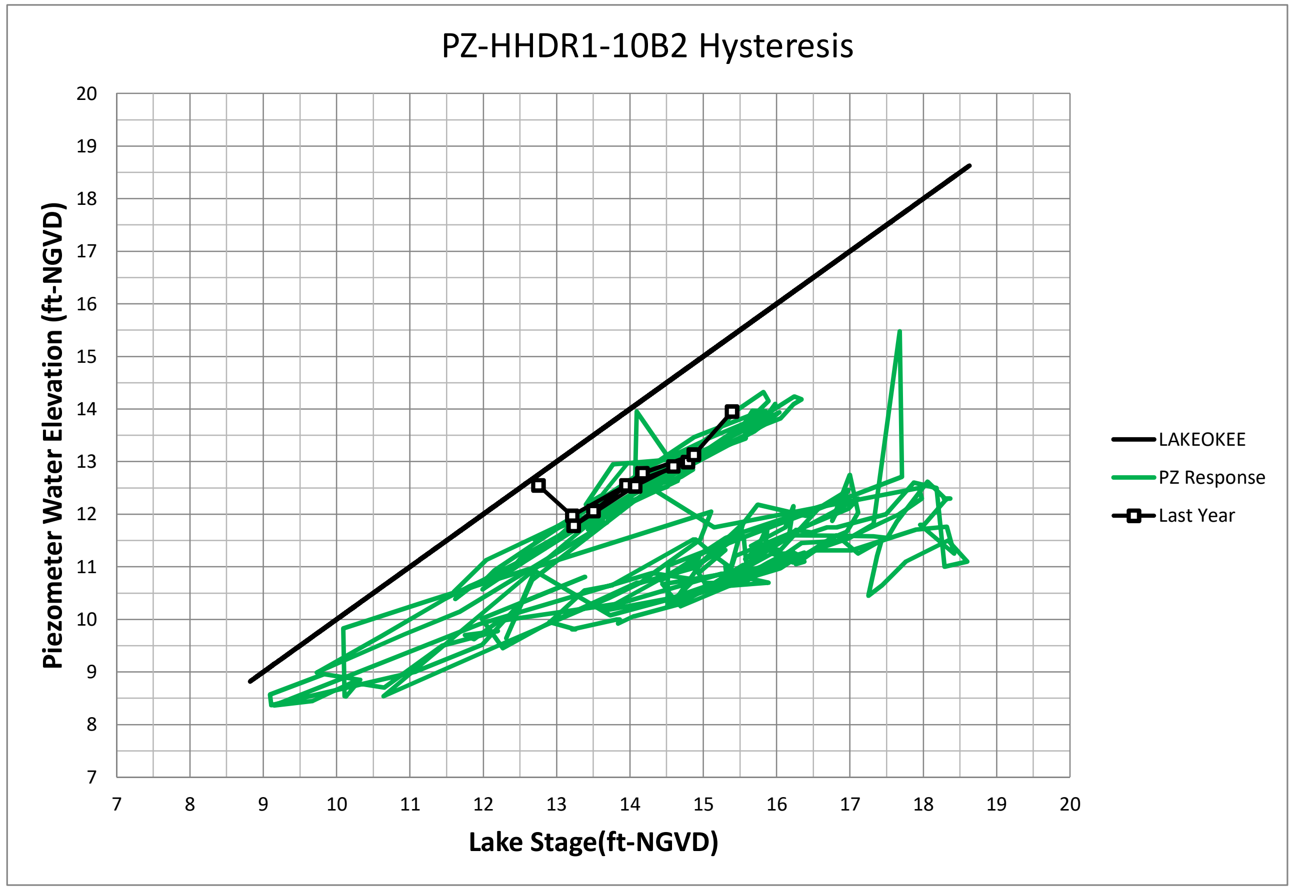
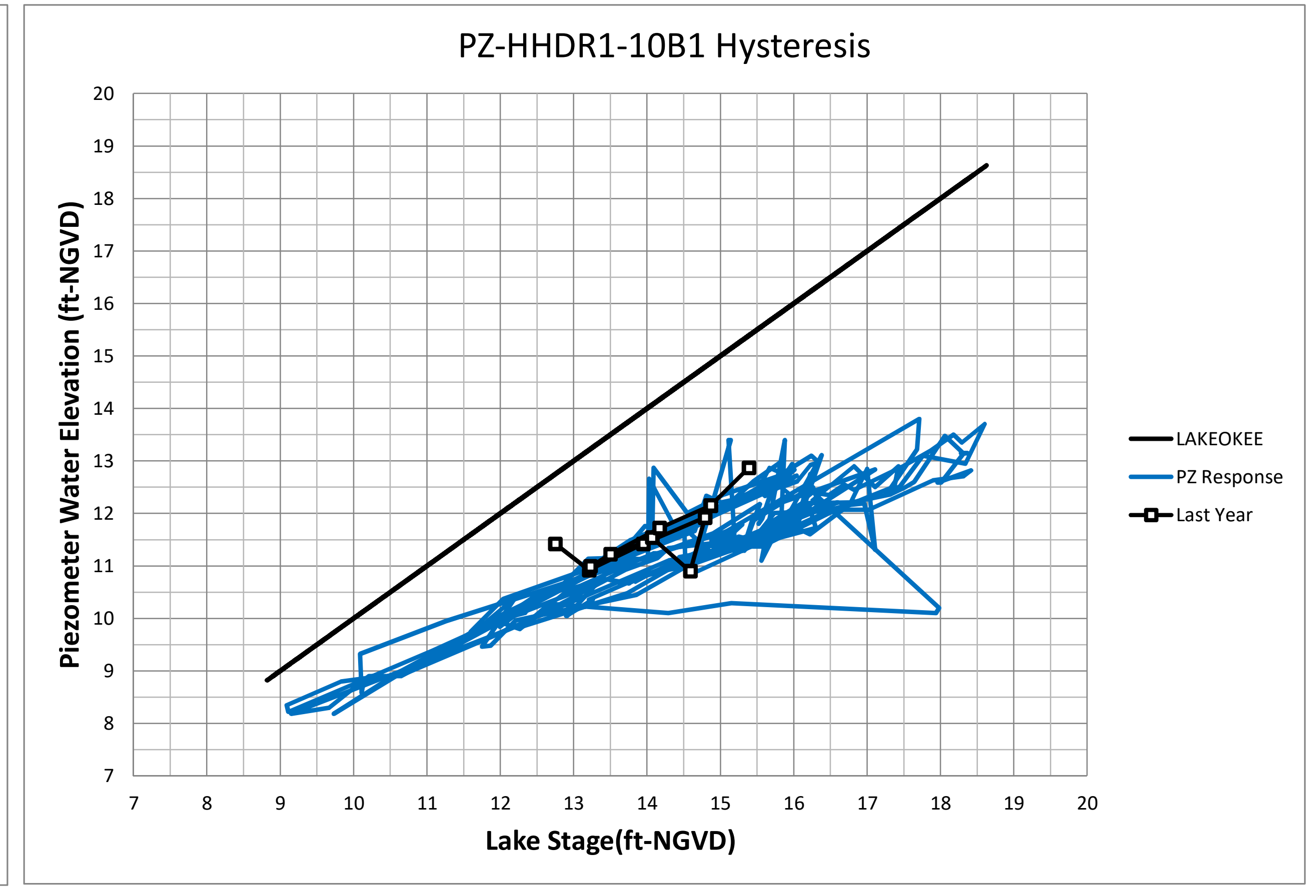
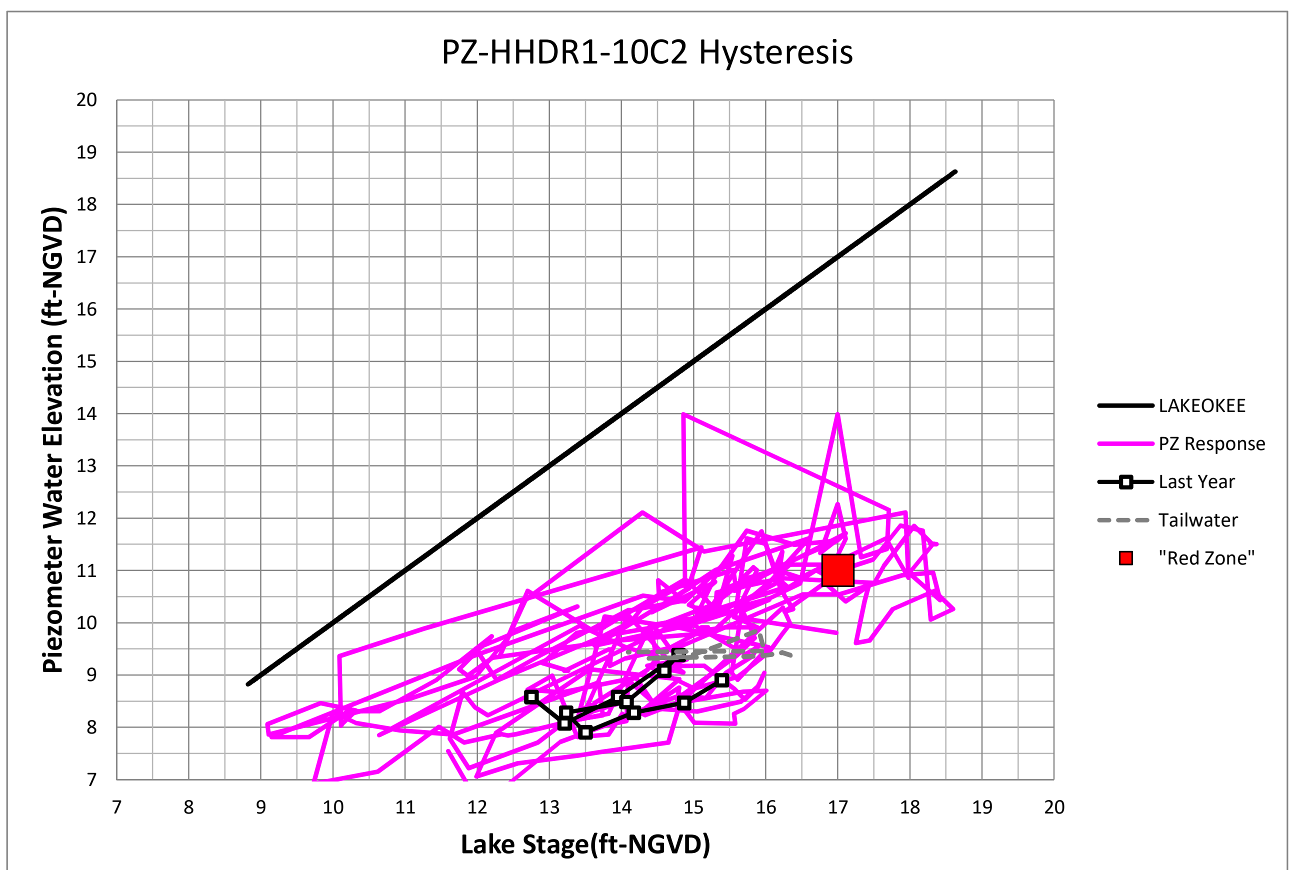
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

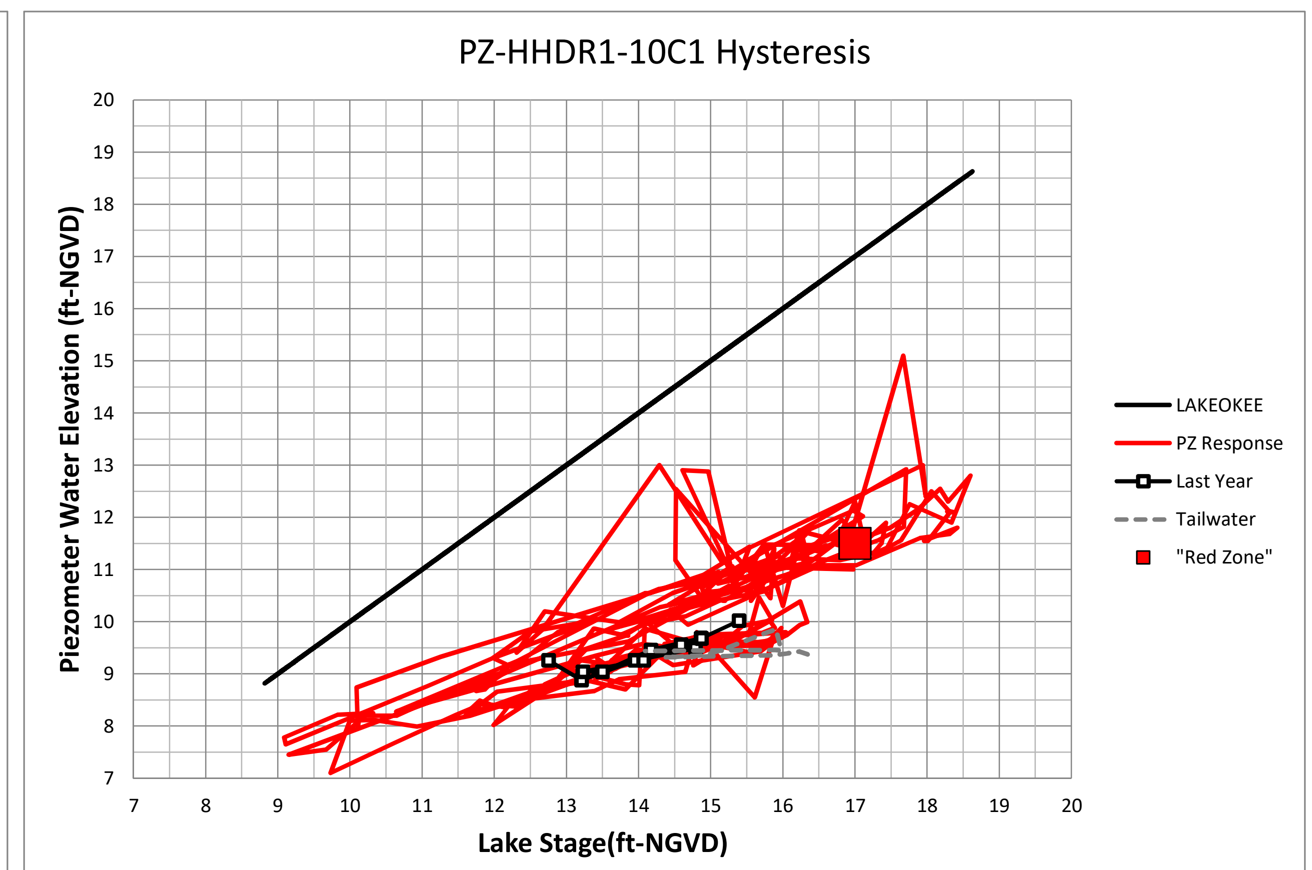


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

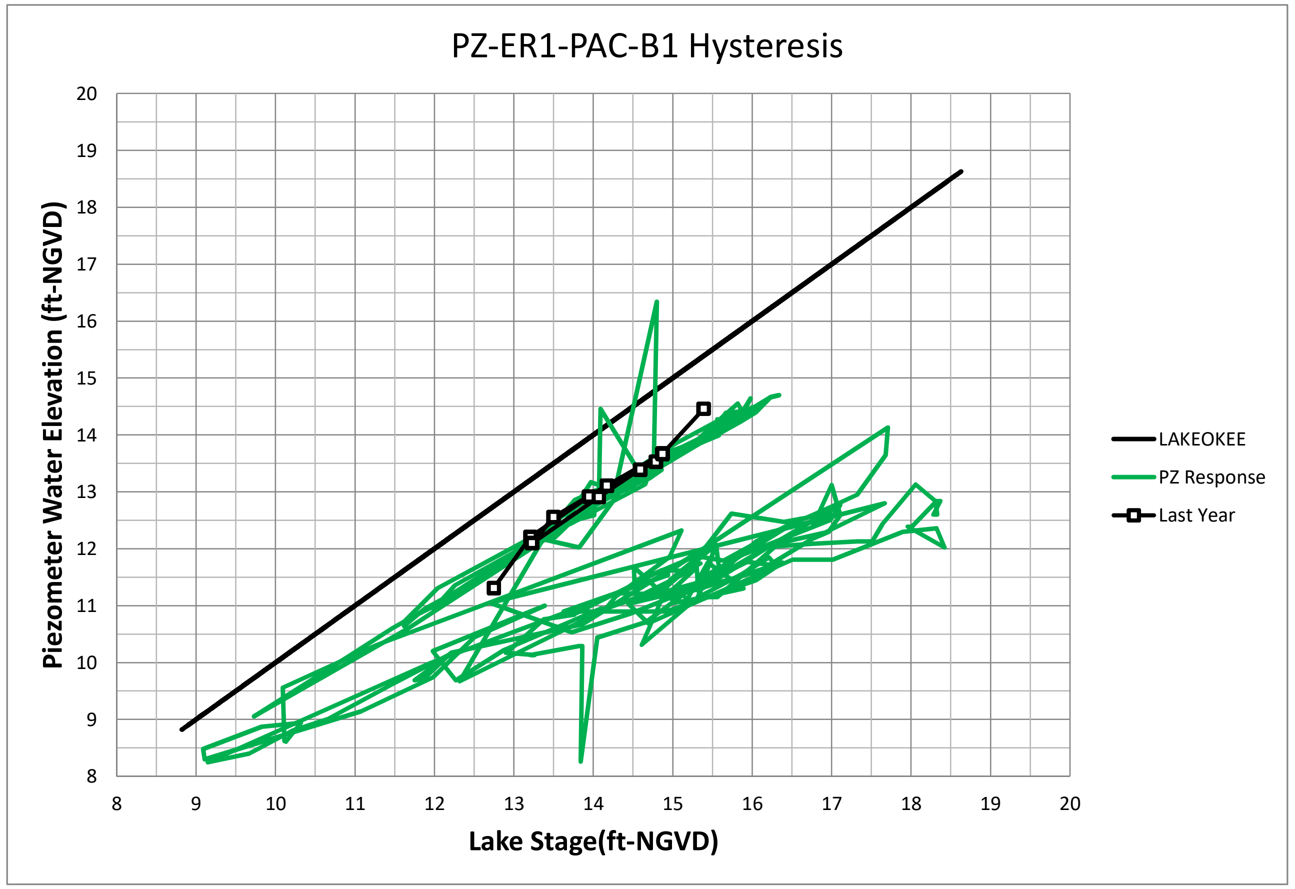


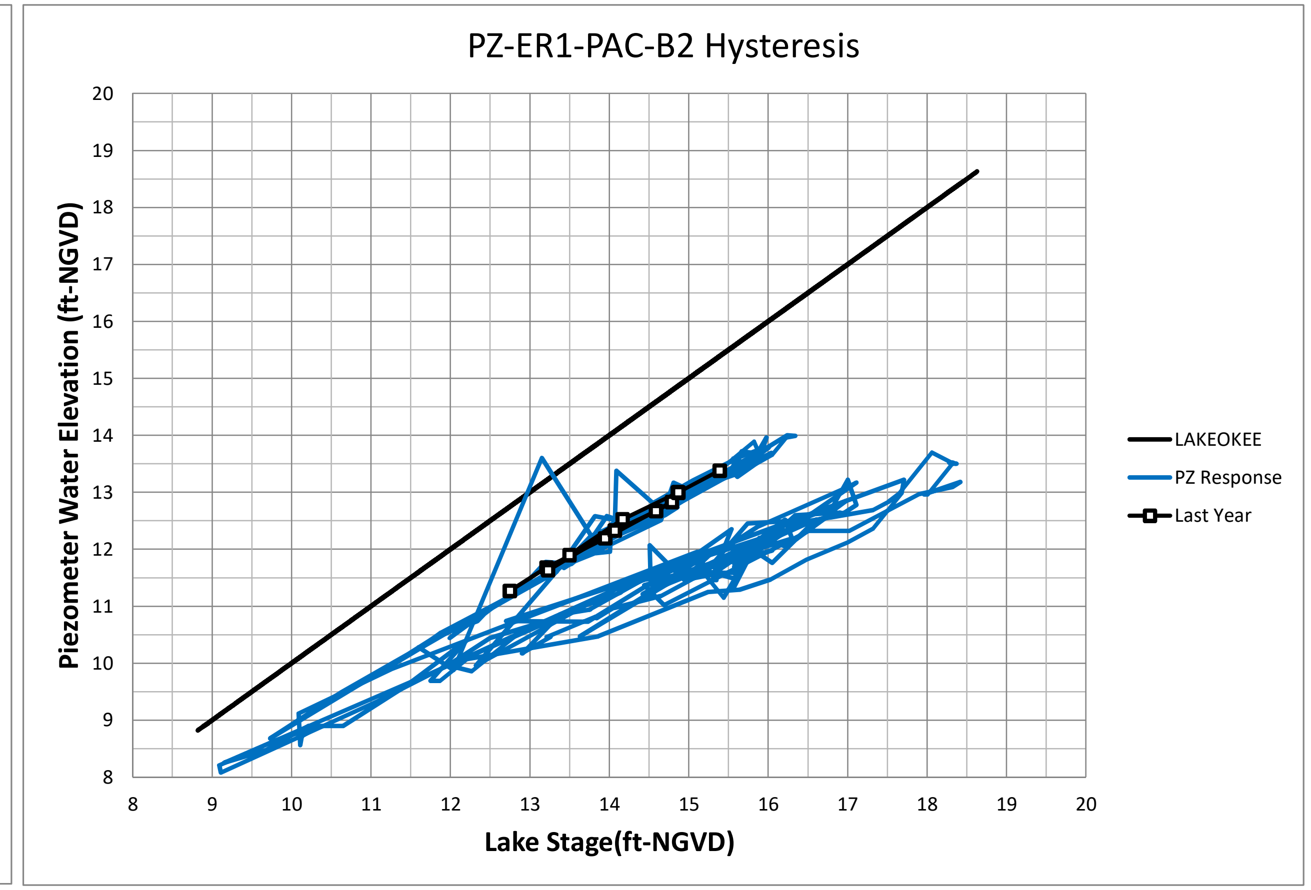


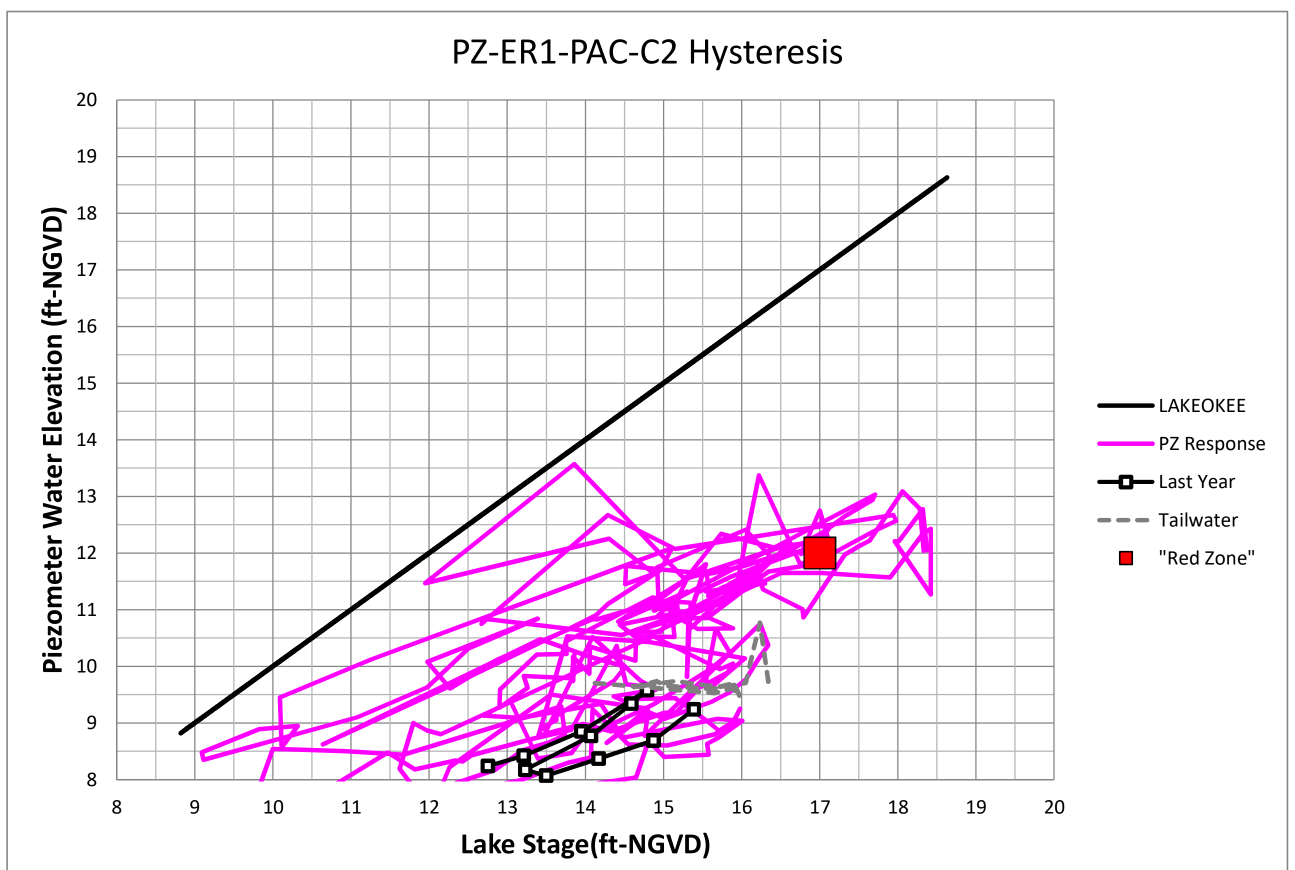


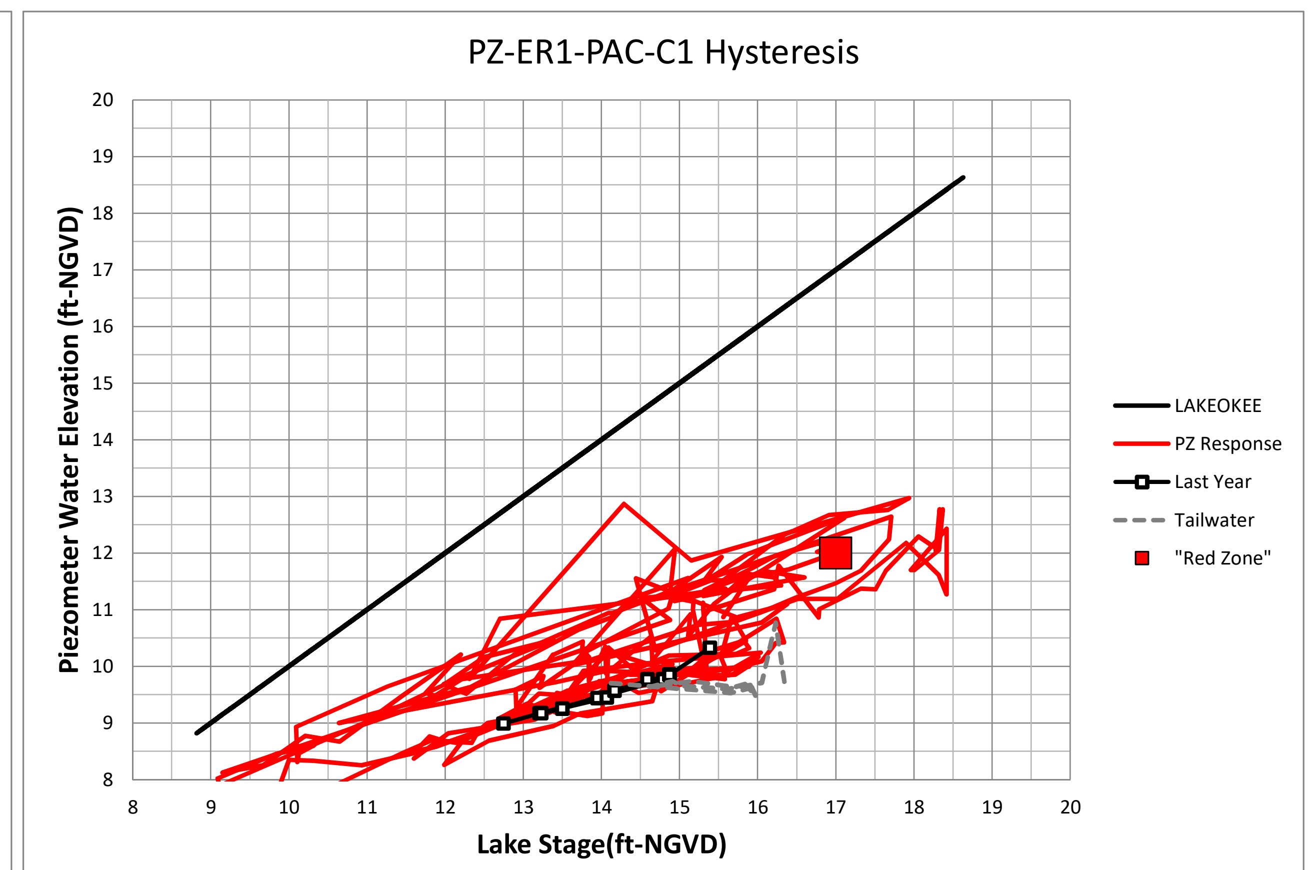


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

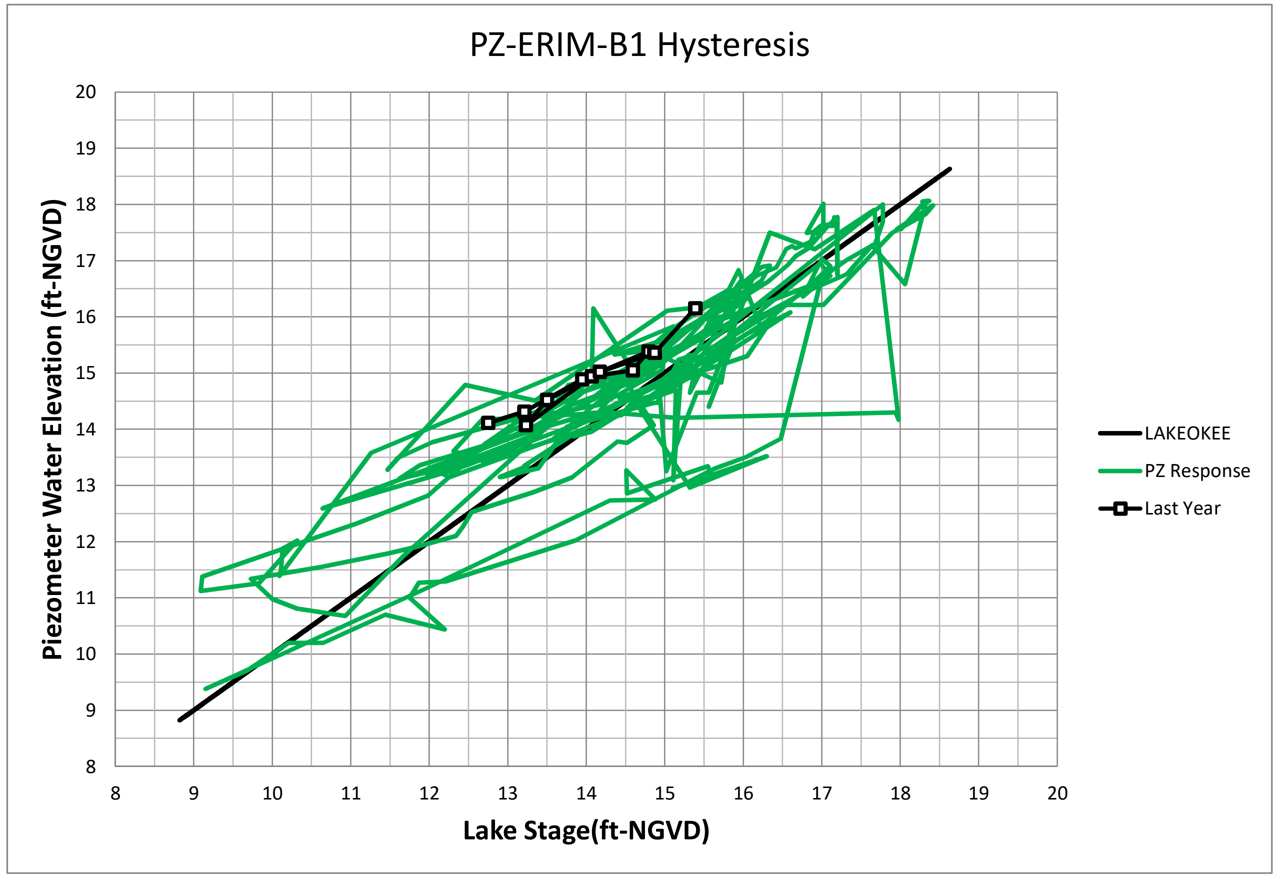


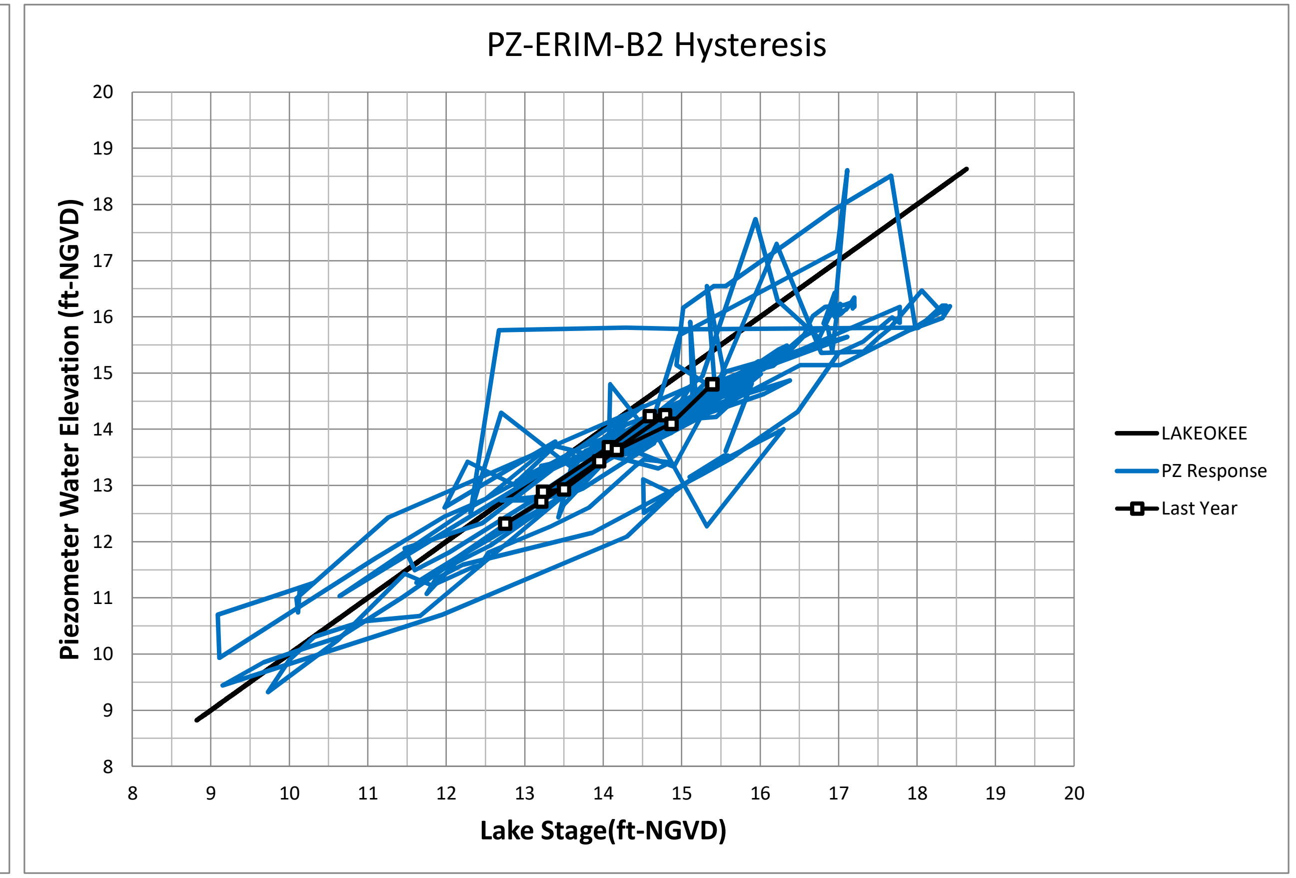


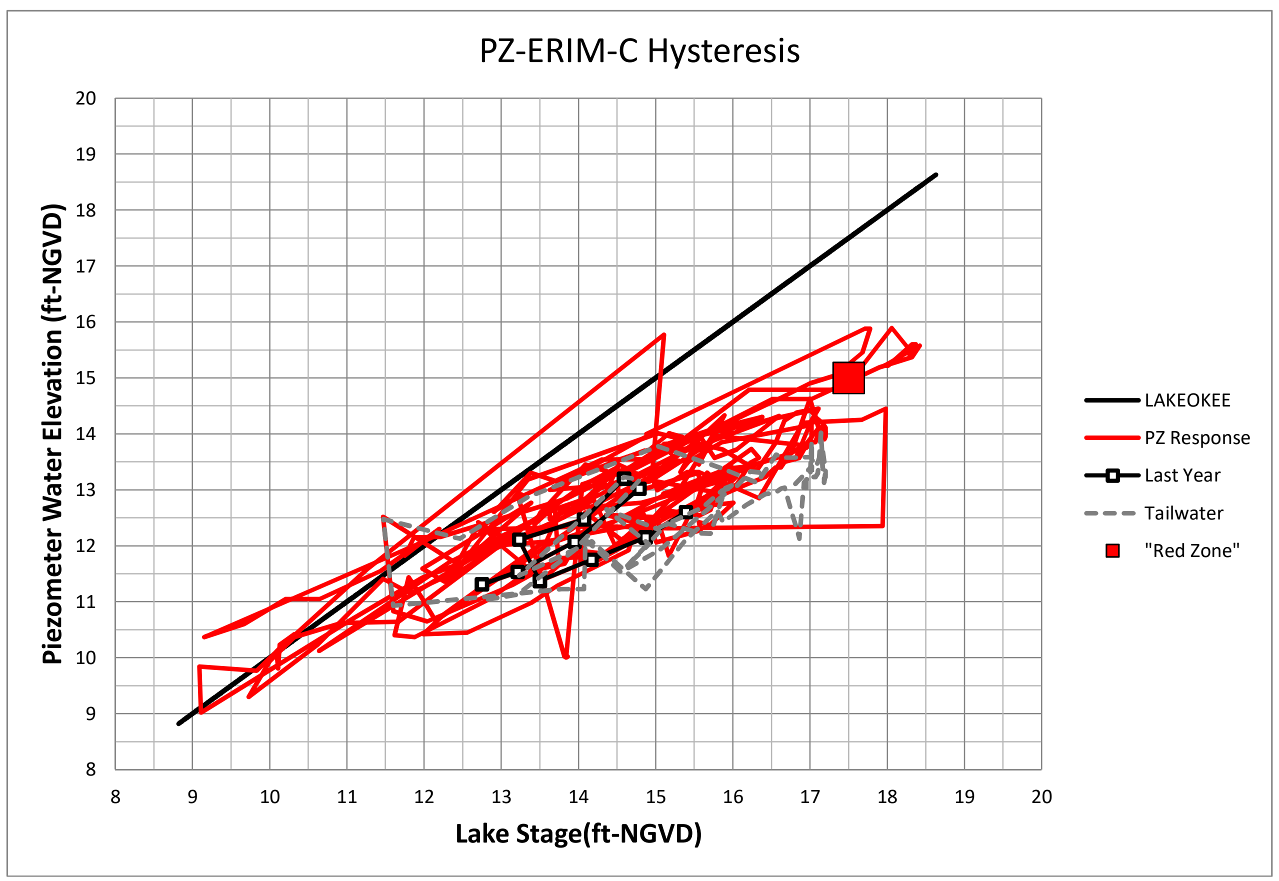




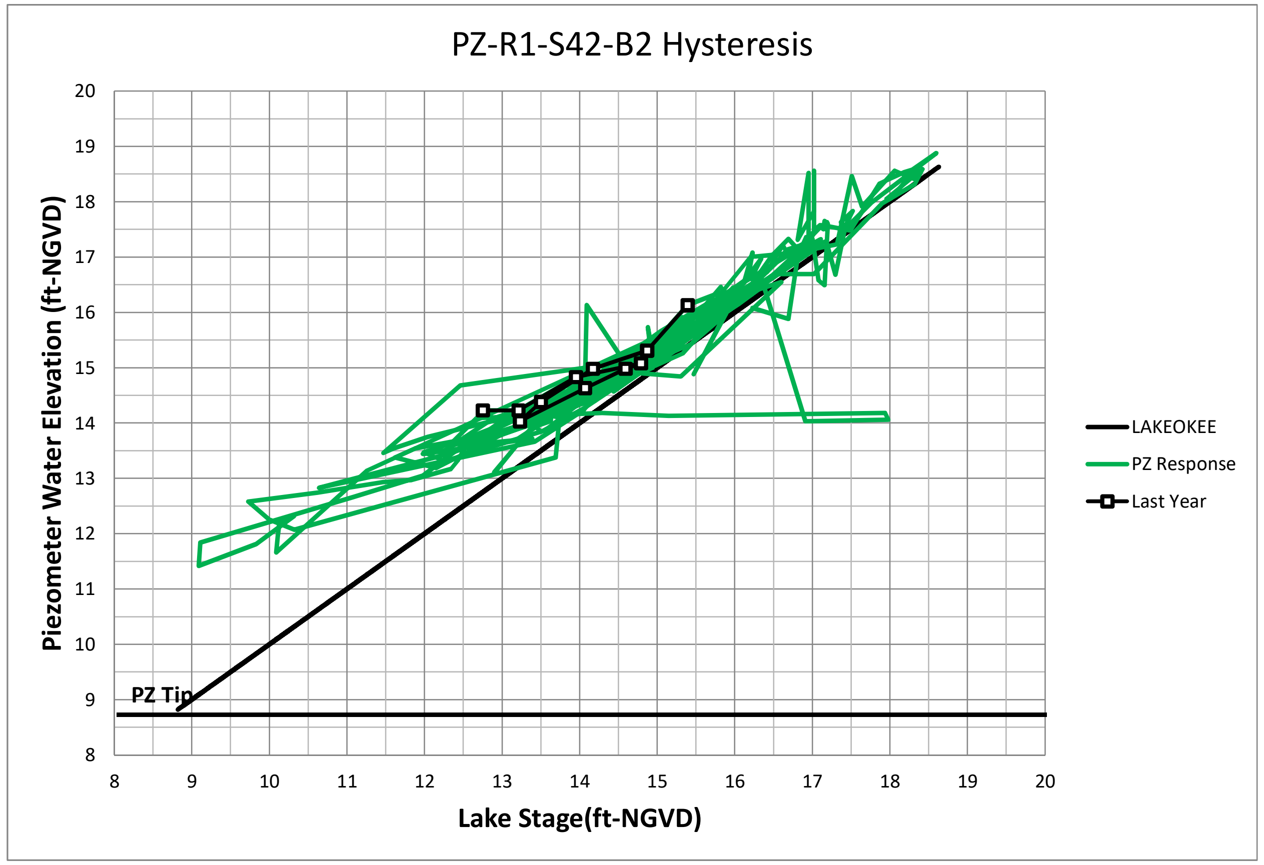
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

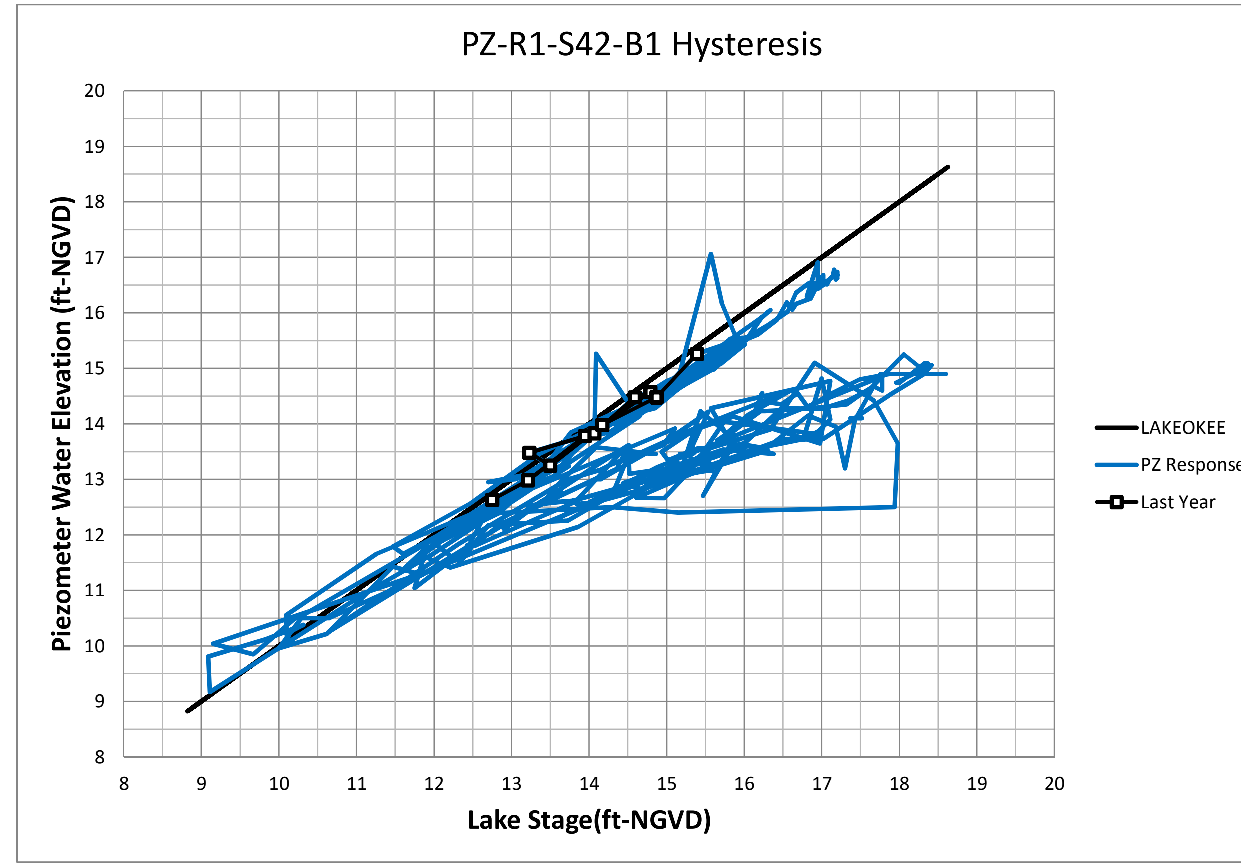


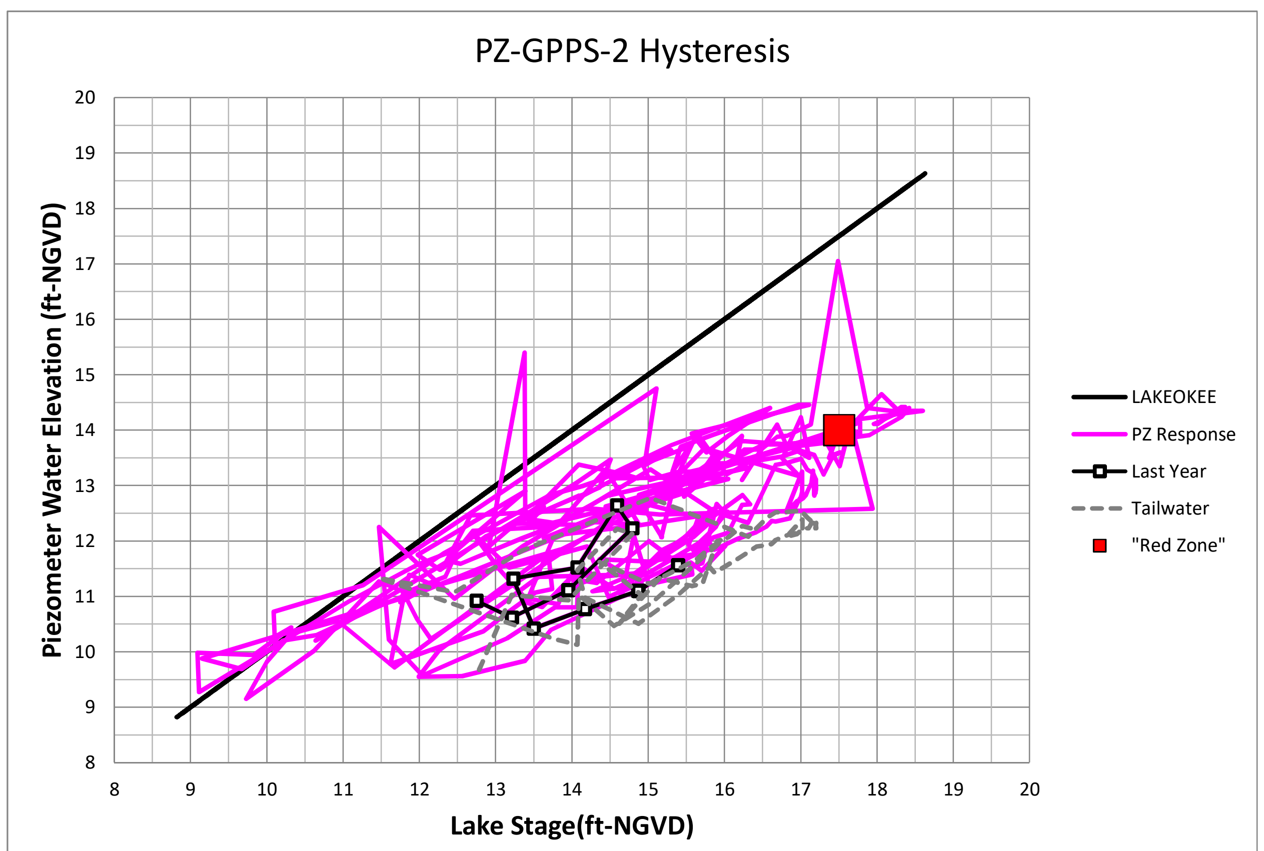




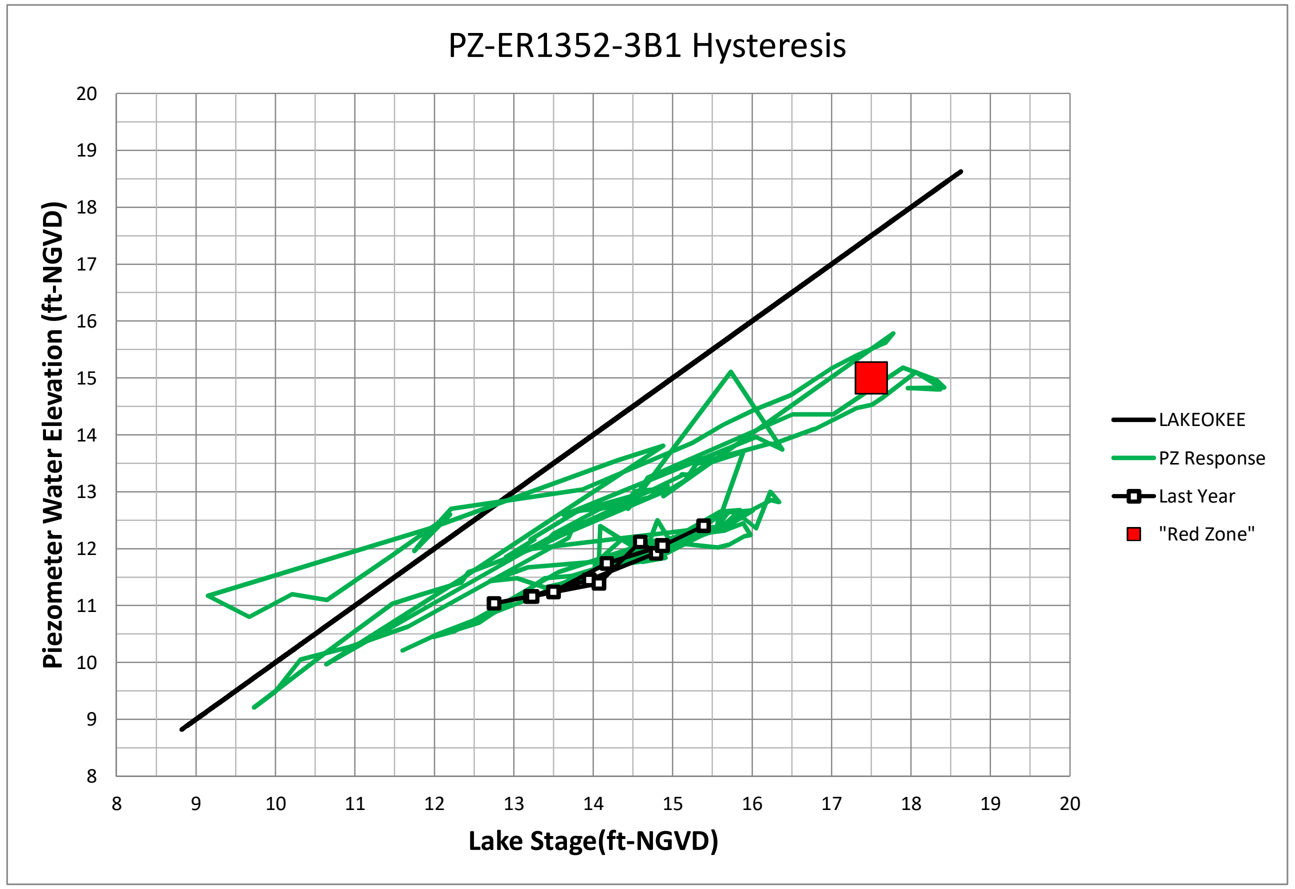
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

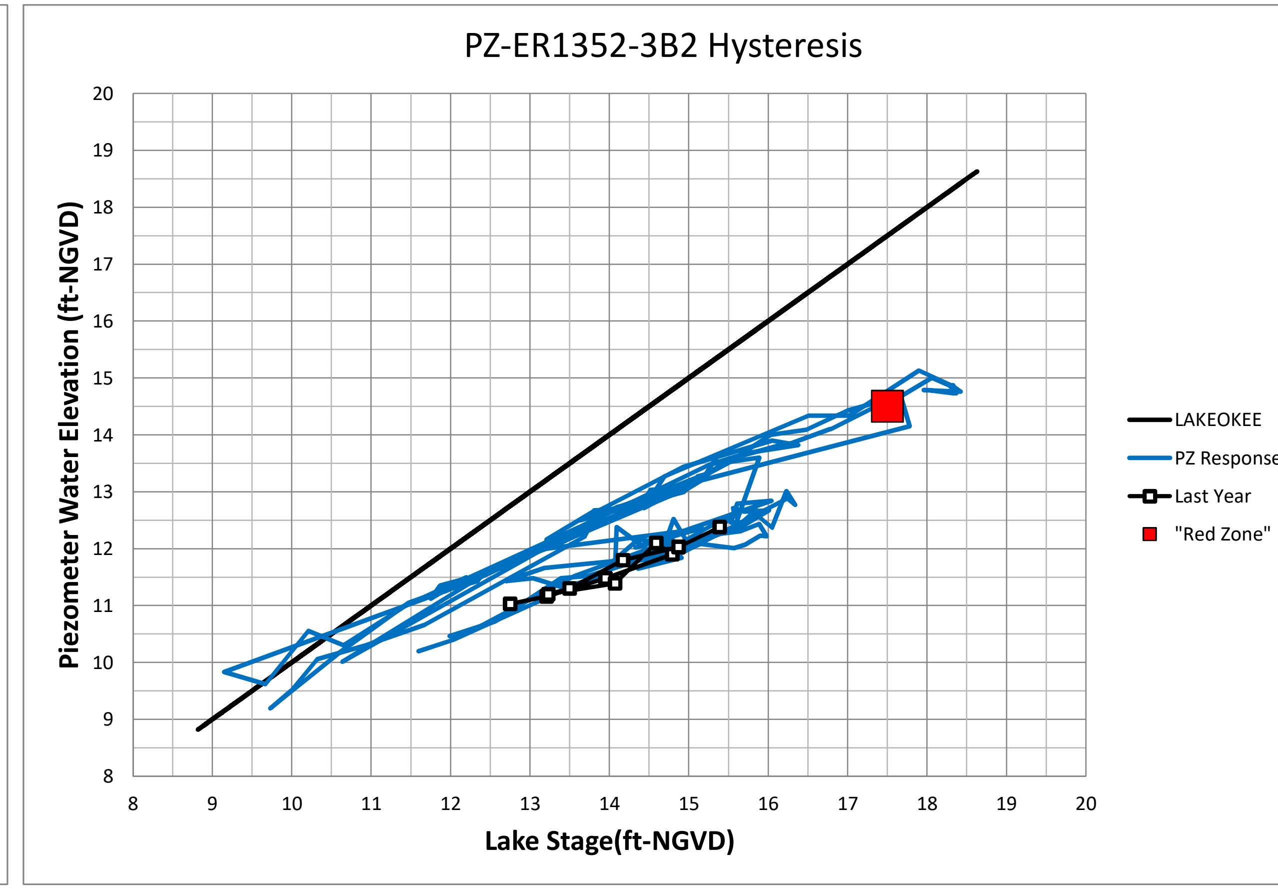


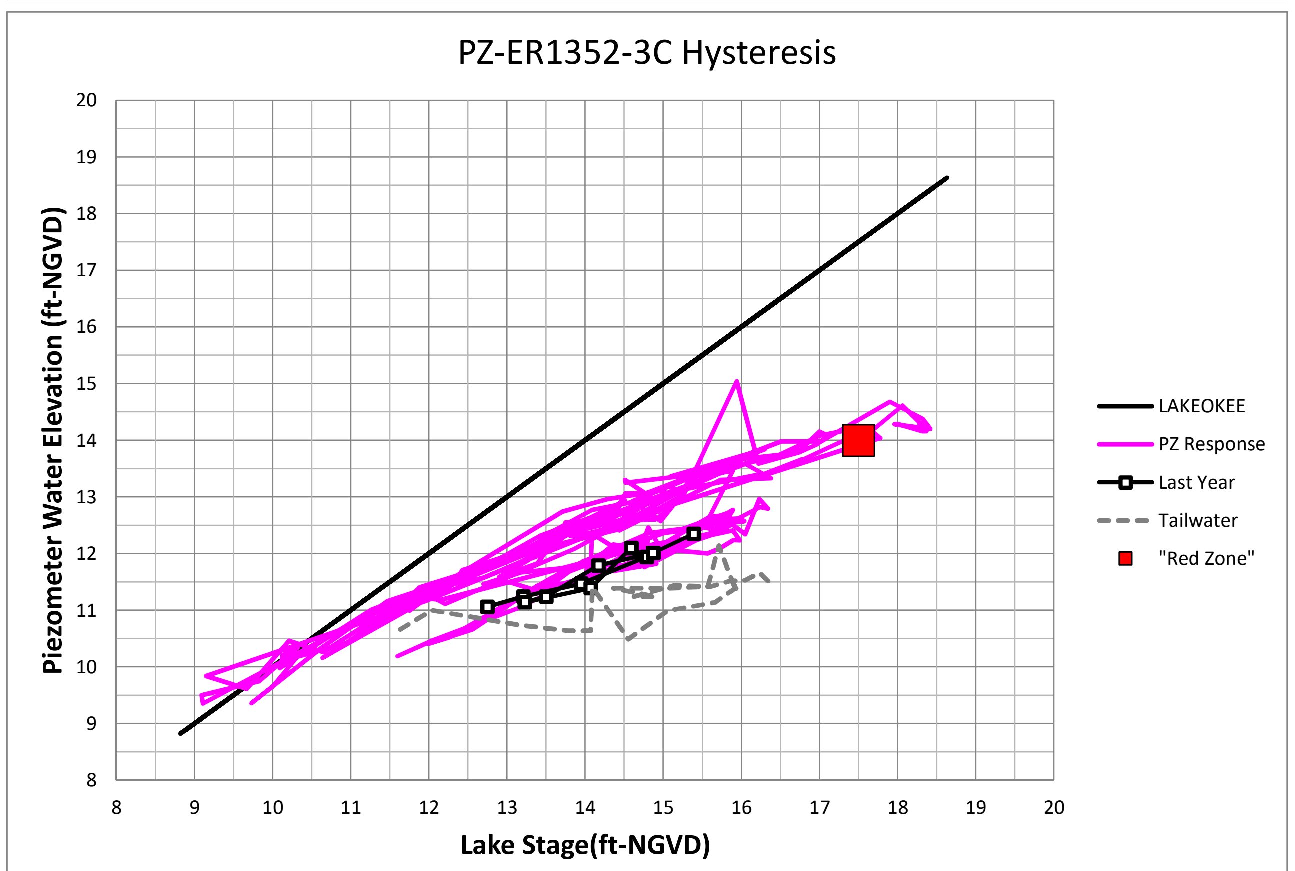




Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update







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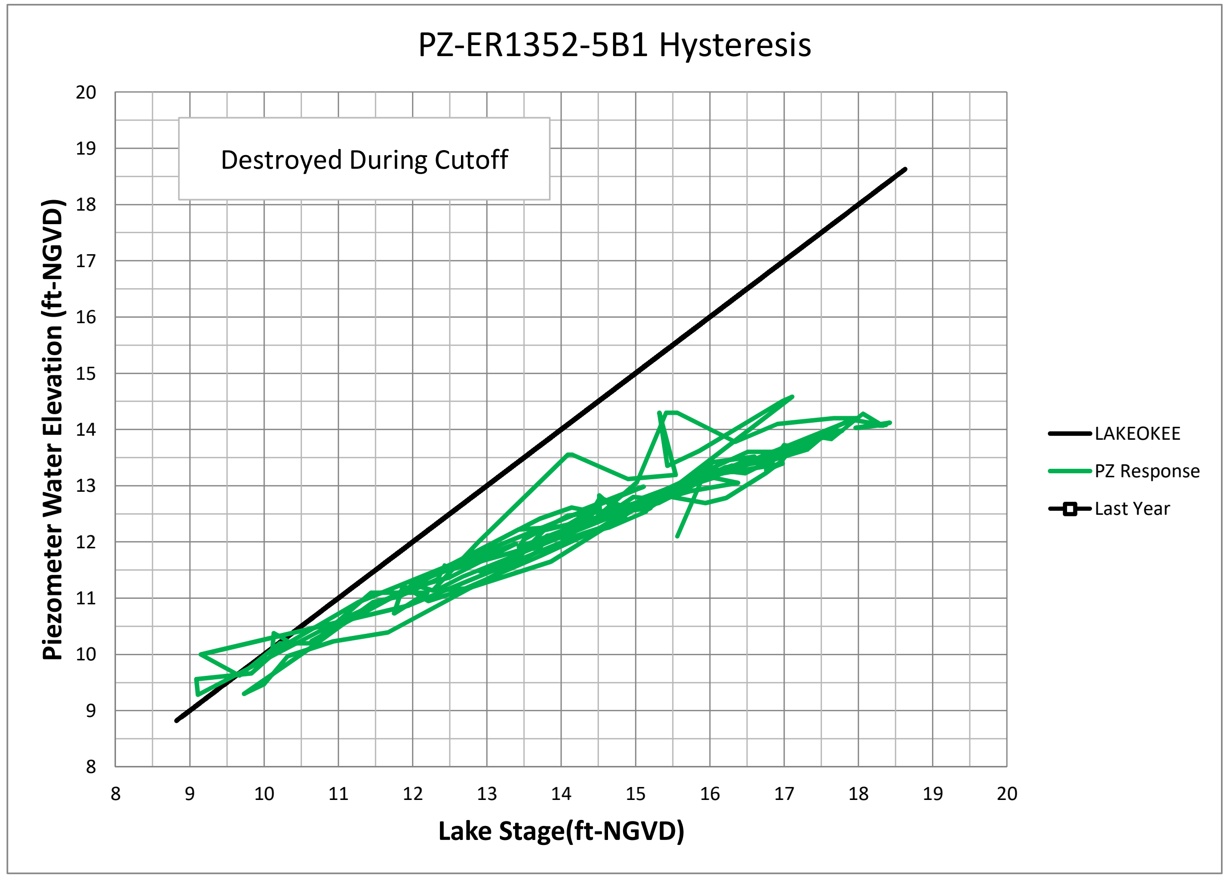
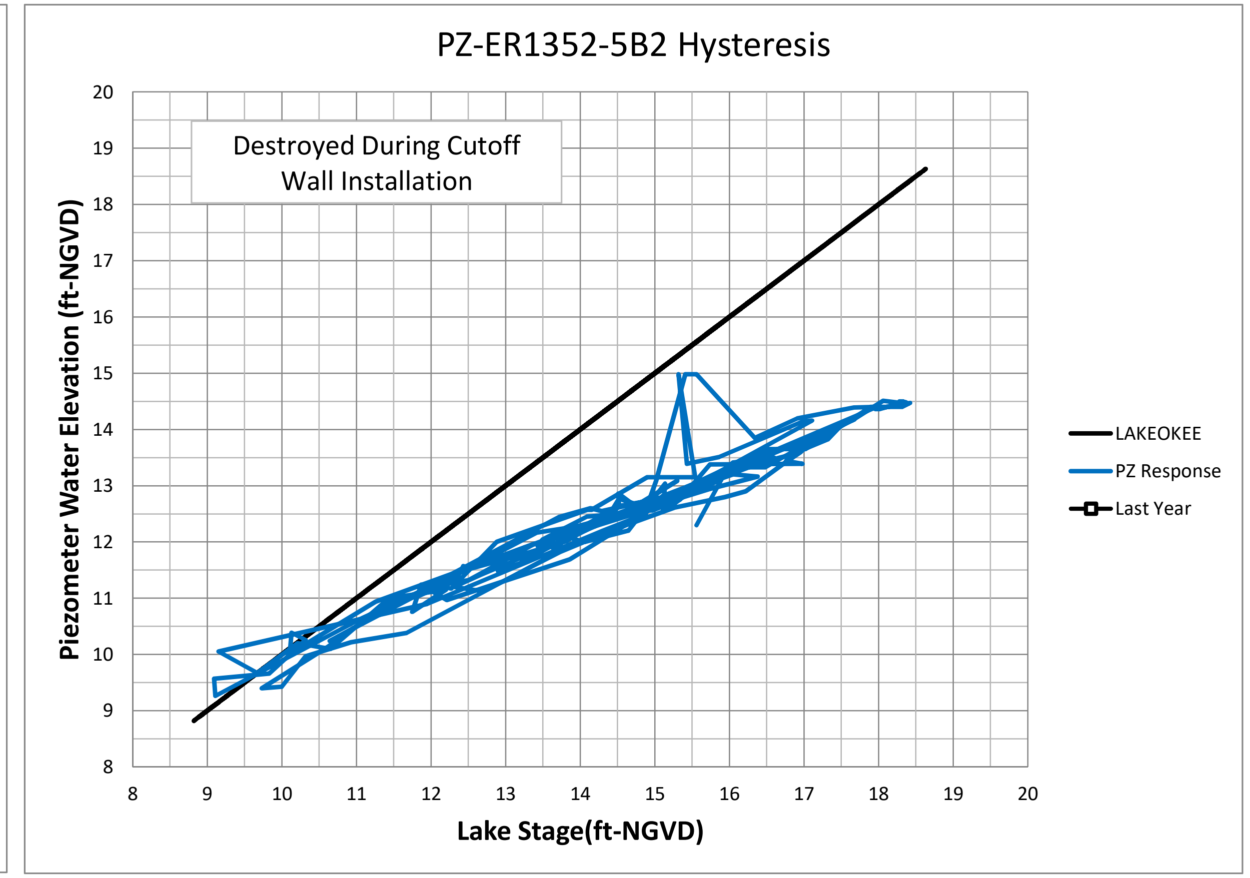
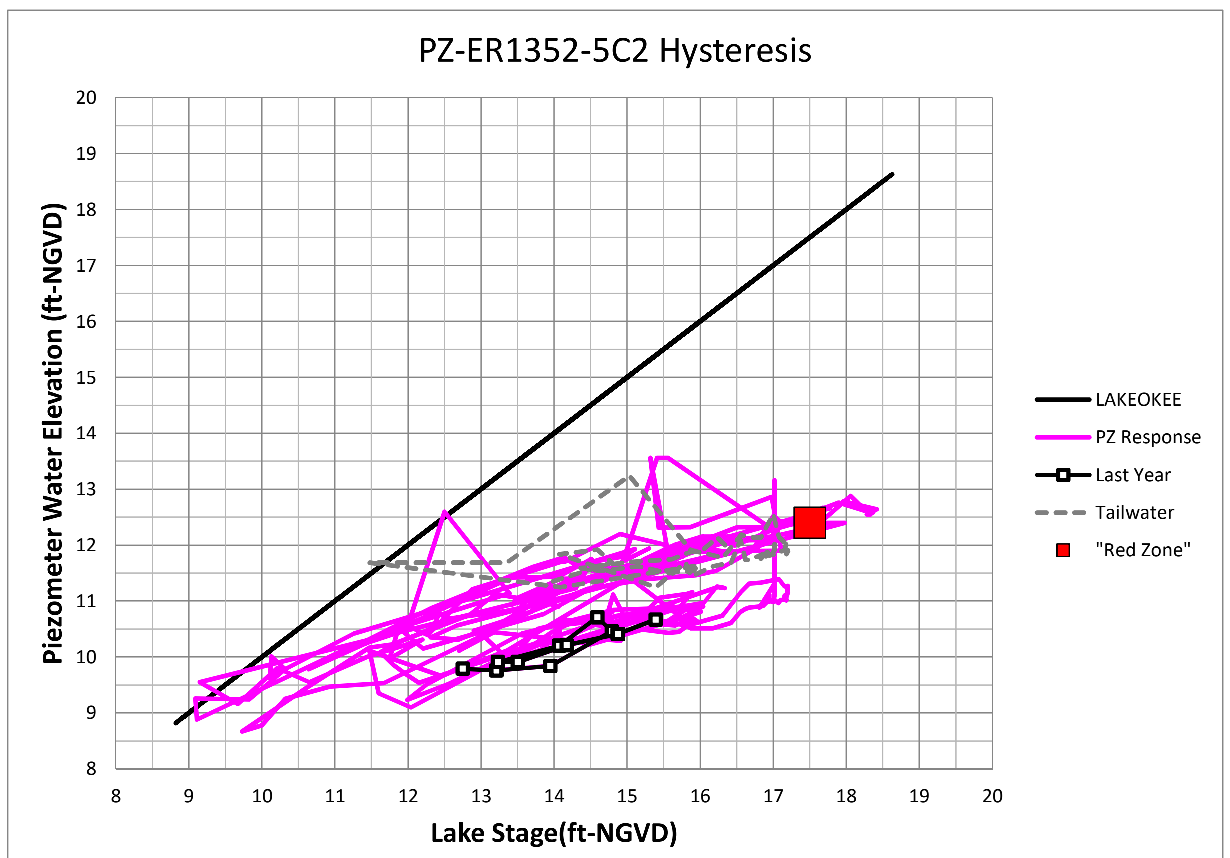
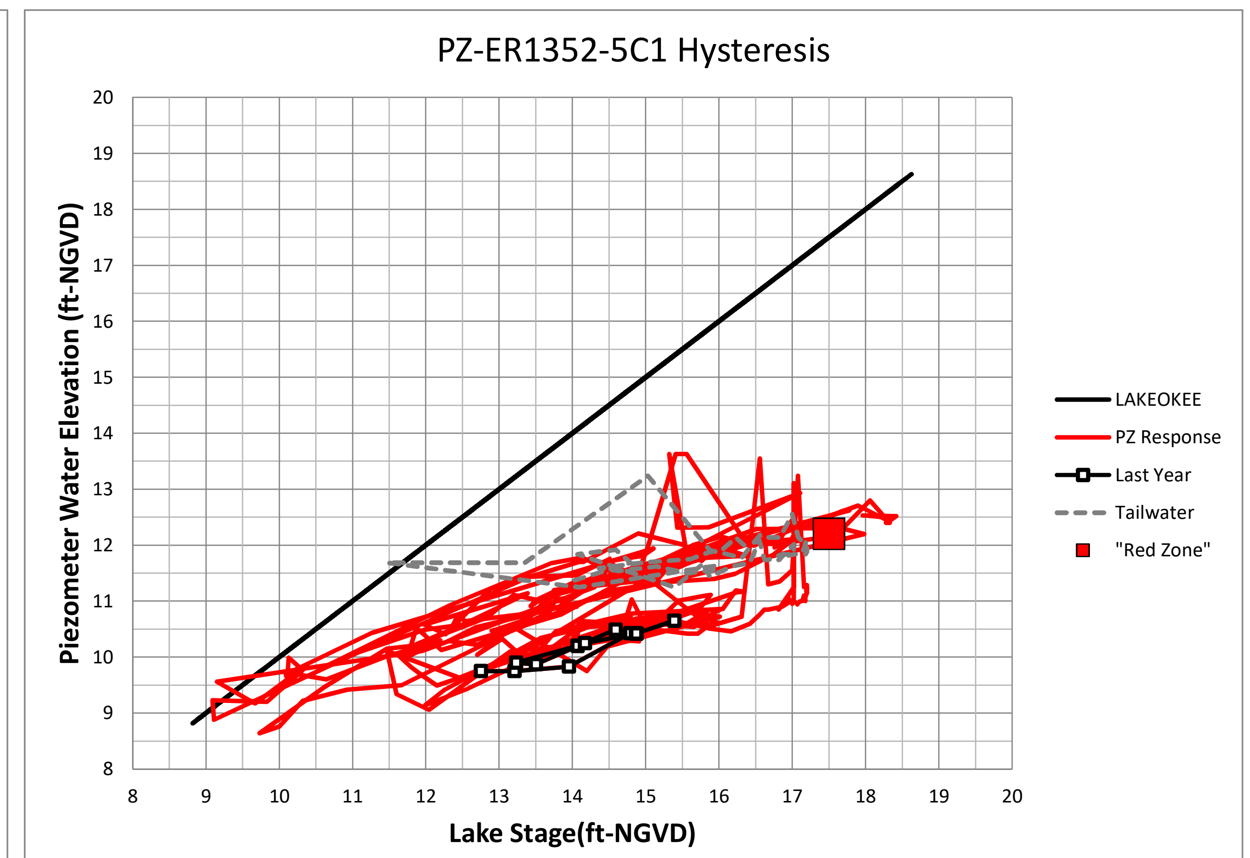
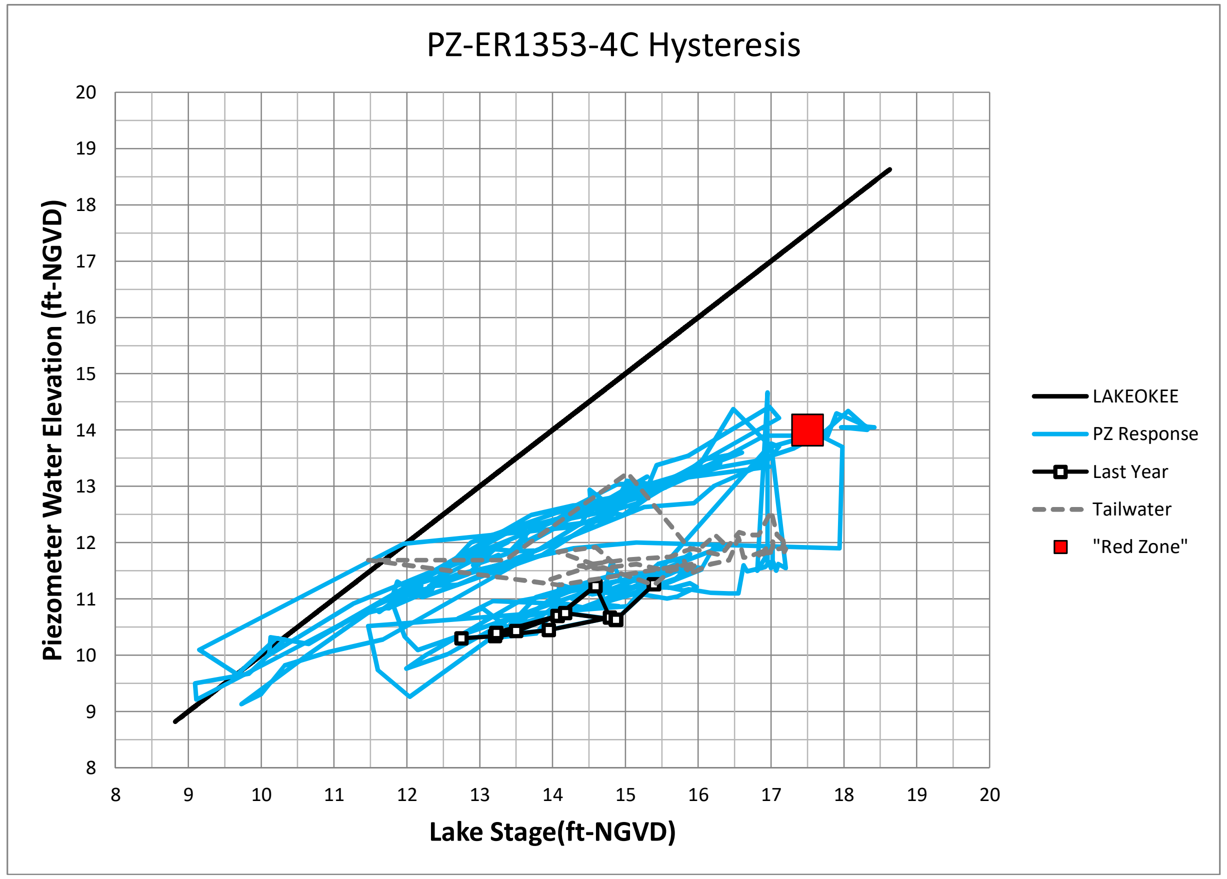
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update










PZ-ER1353-4C Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
20
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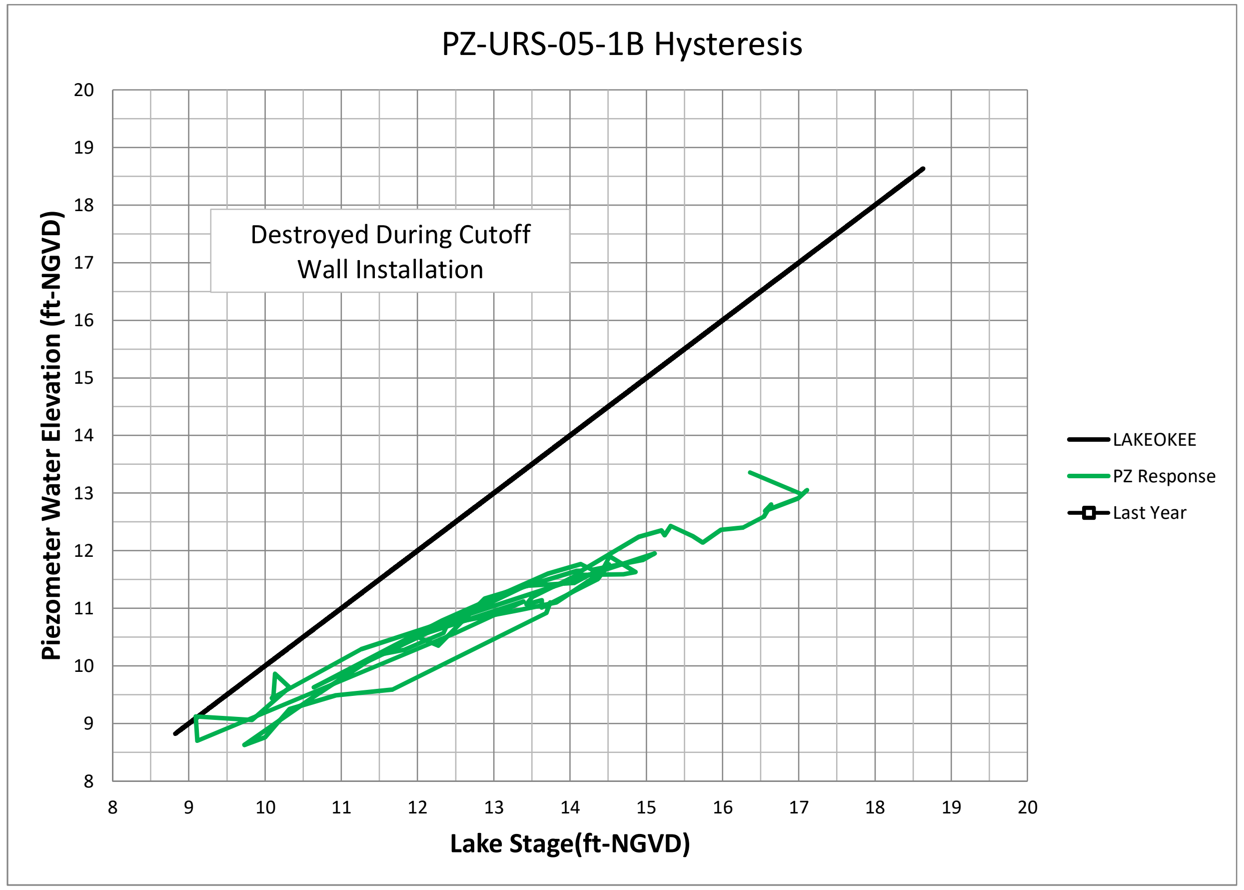
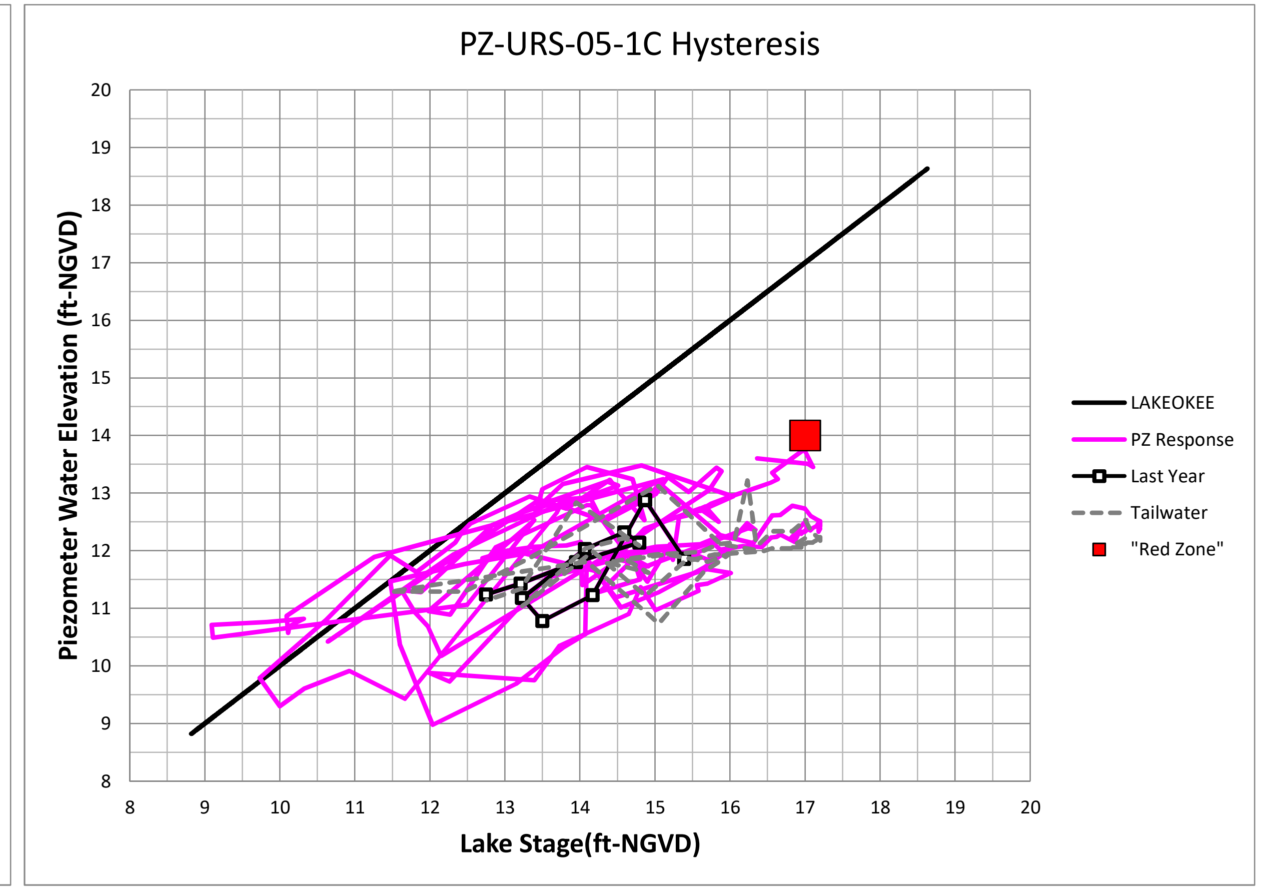
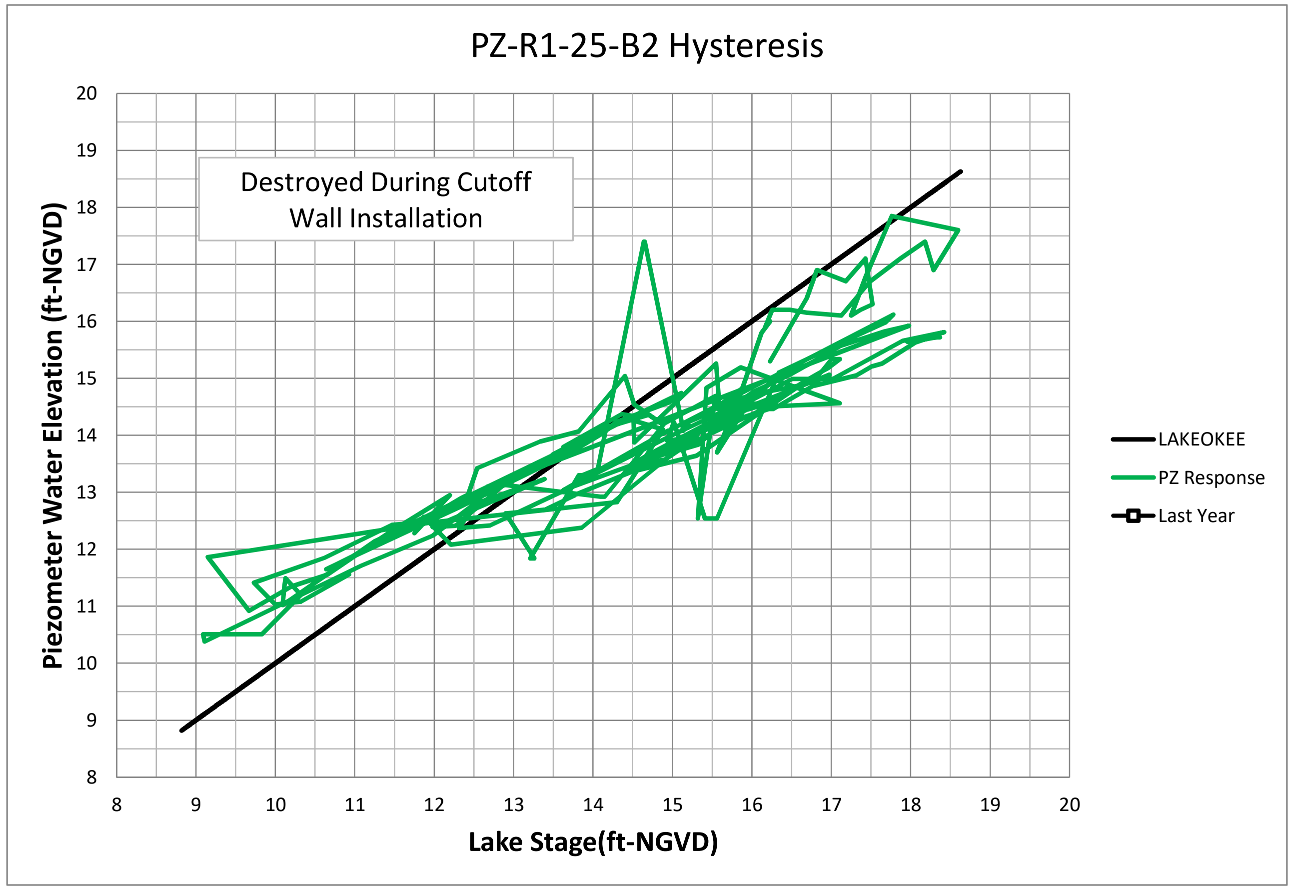
20
LAKEOKEE
PZ Response
Last Year
Tailwater
"Red Zone"

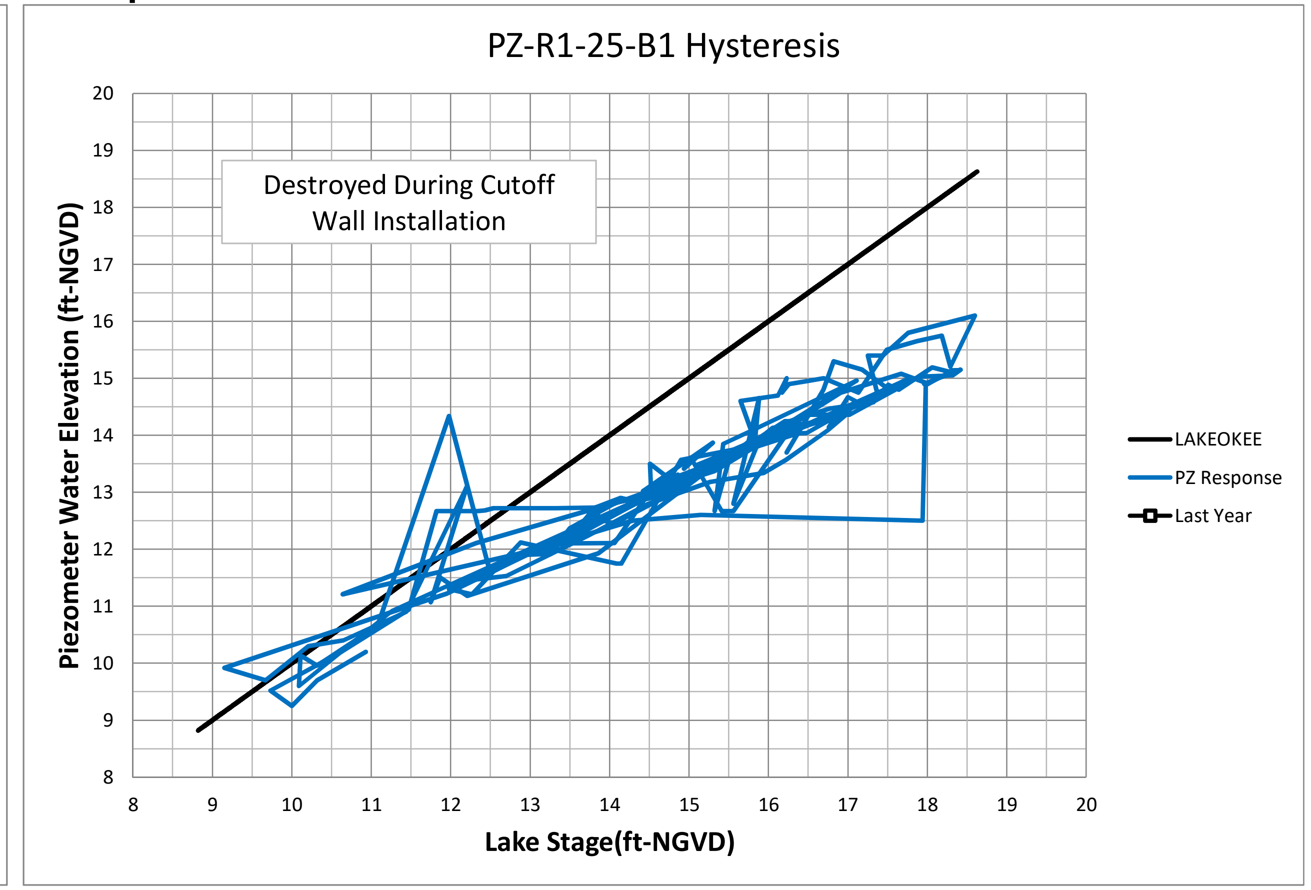
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

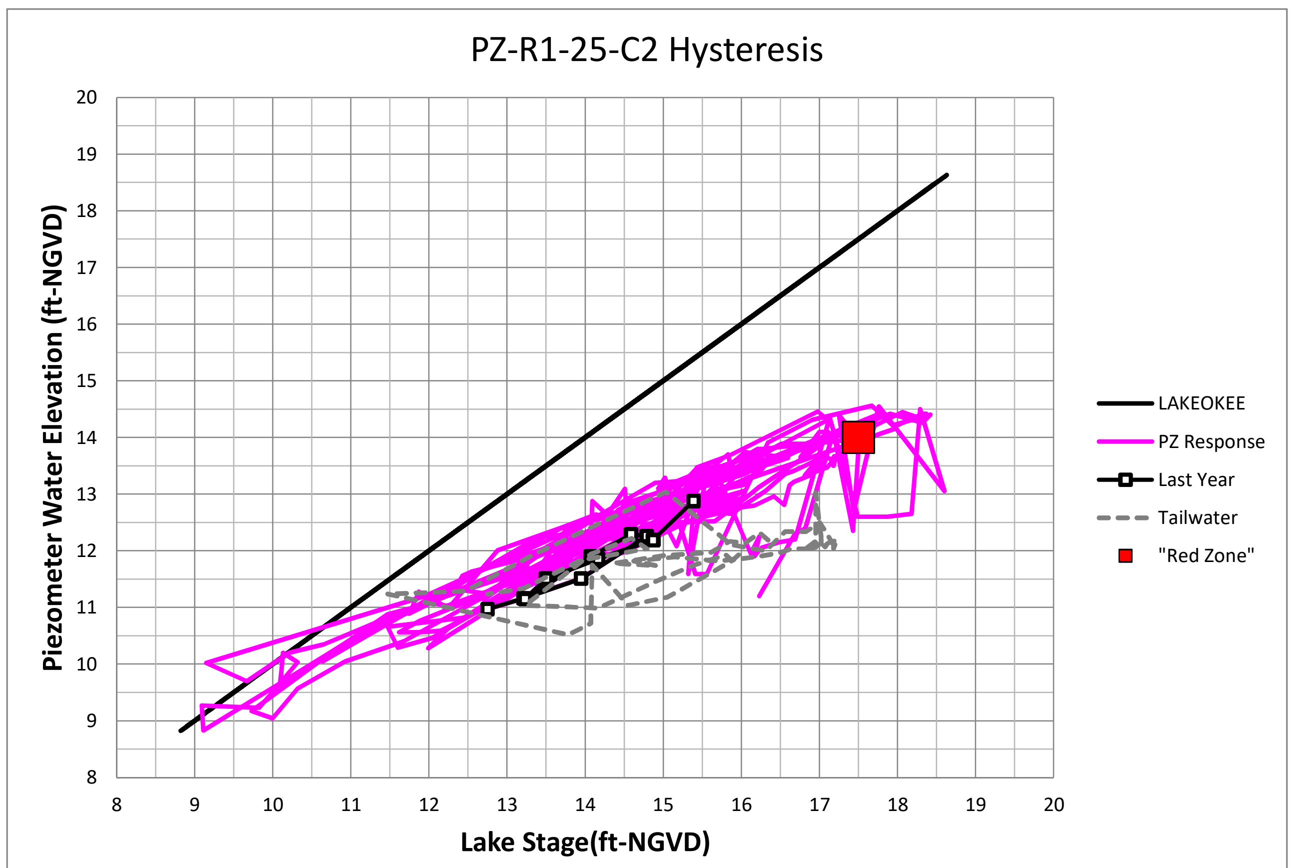


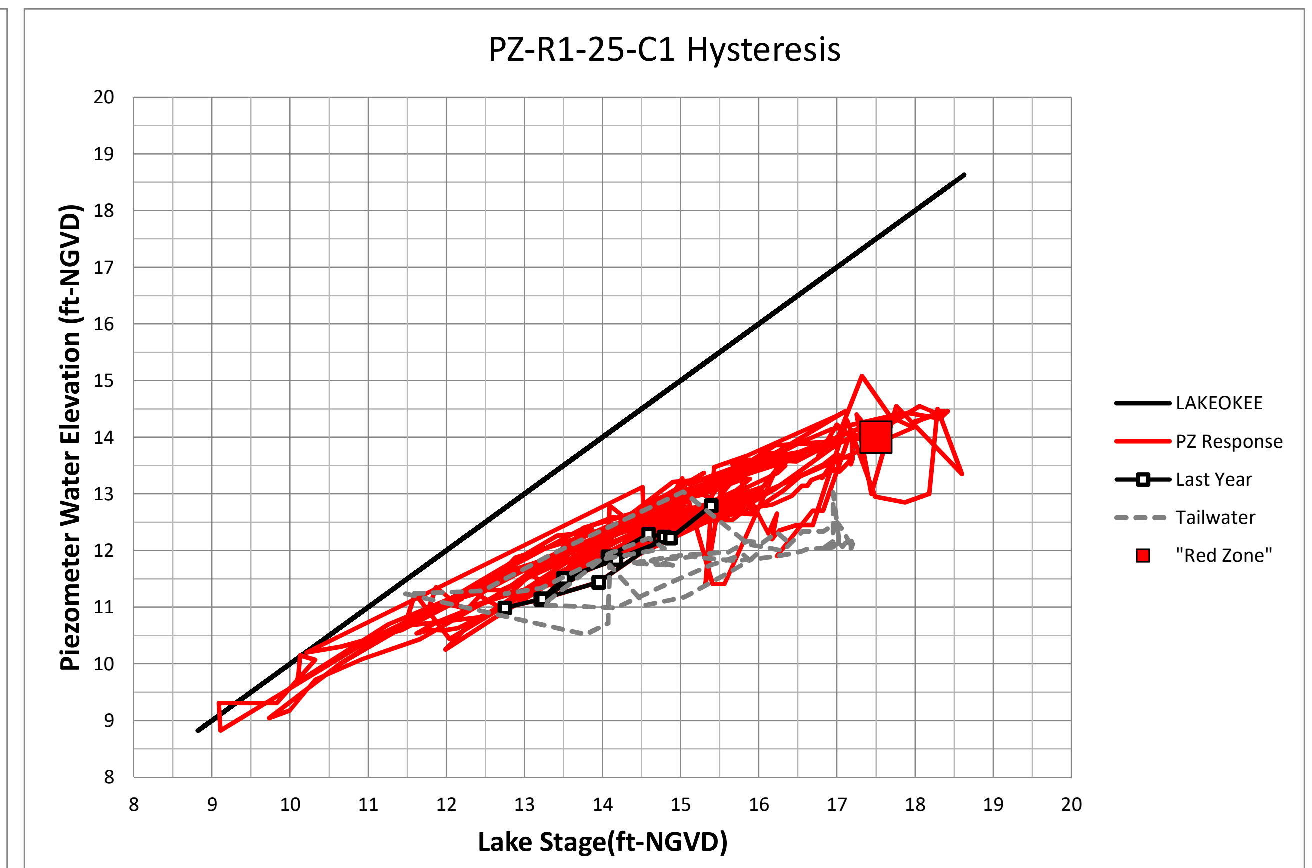


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

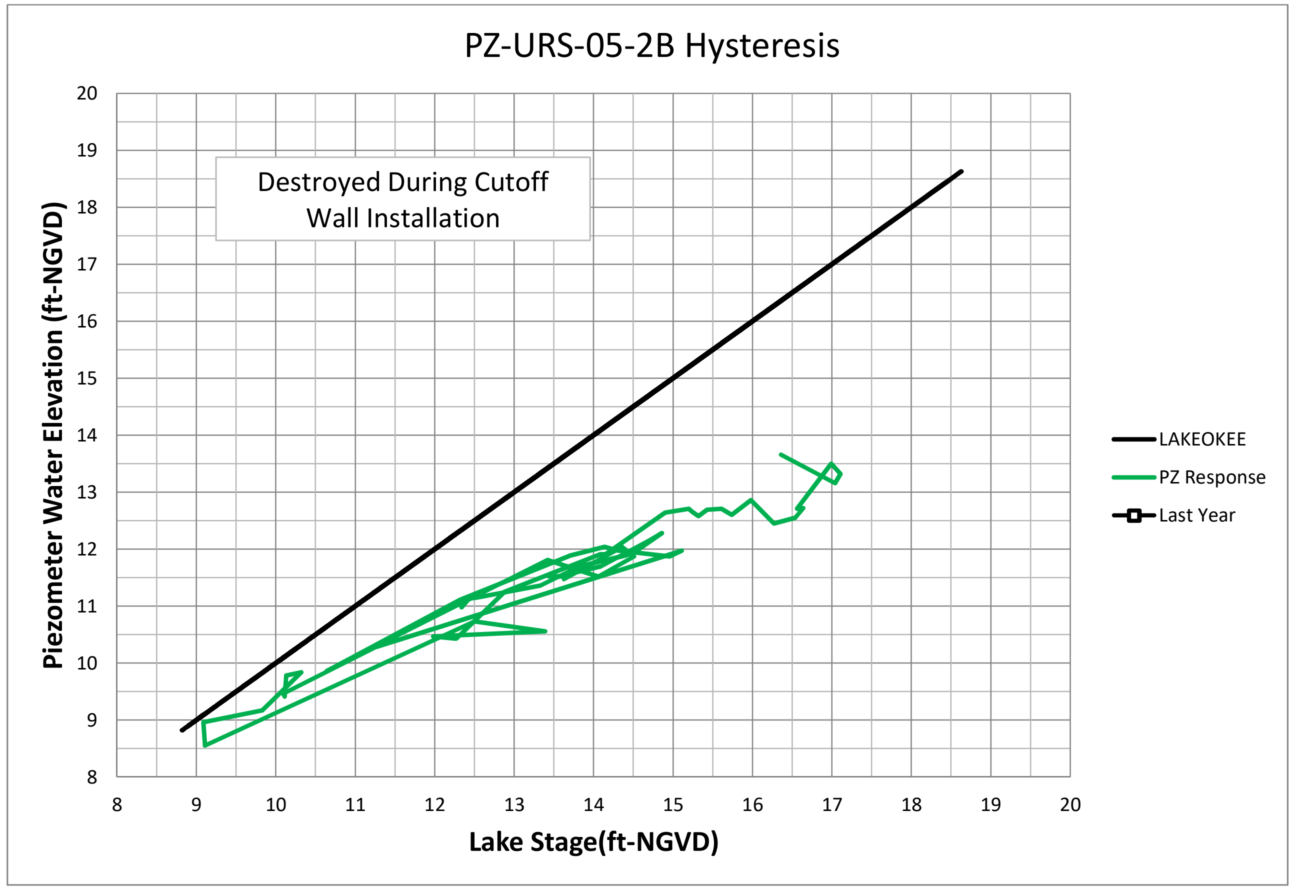


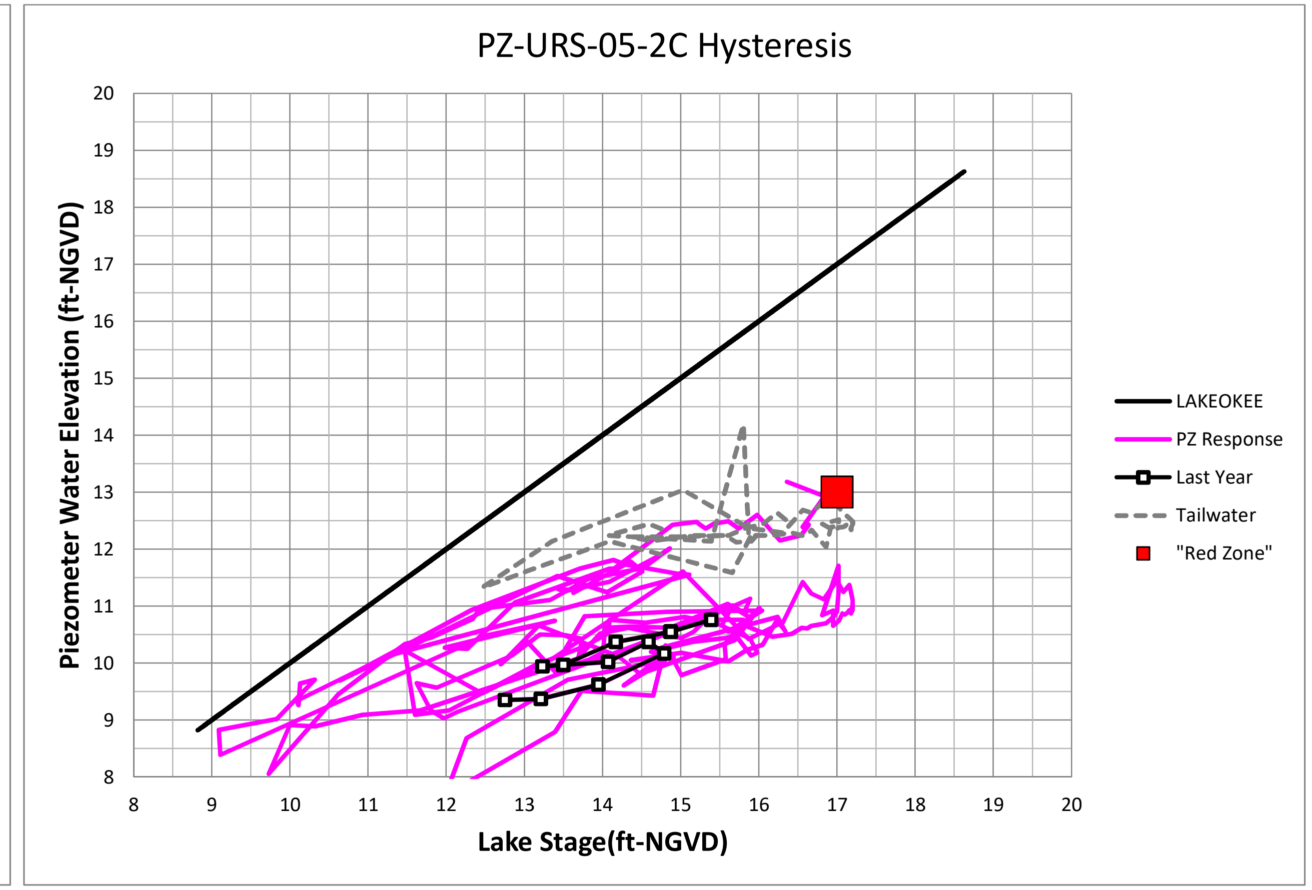




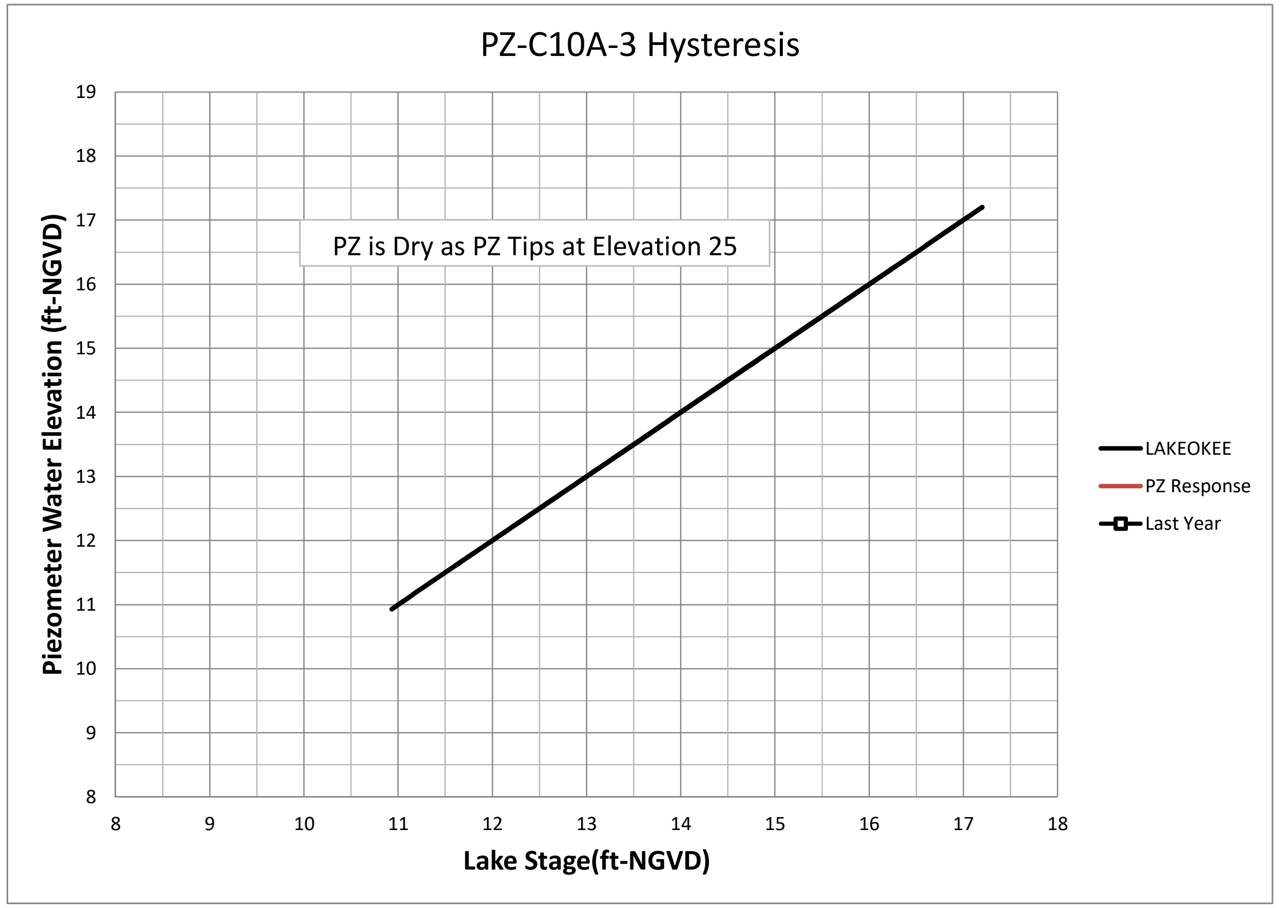


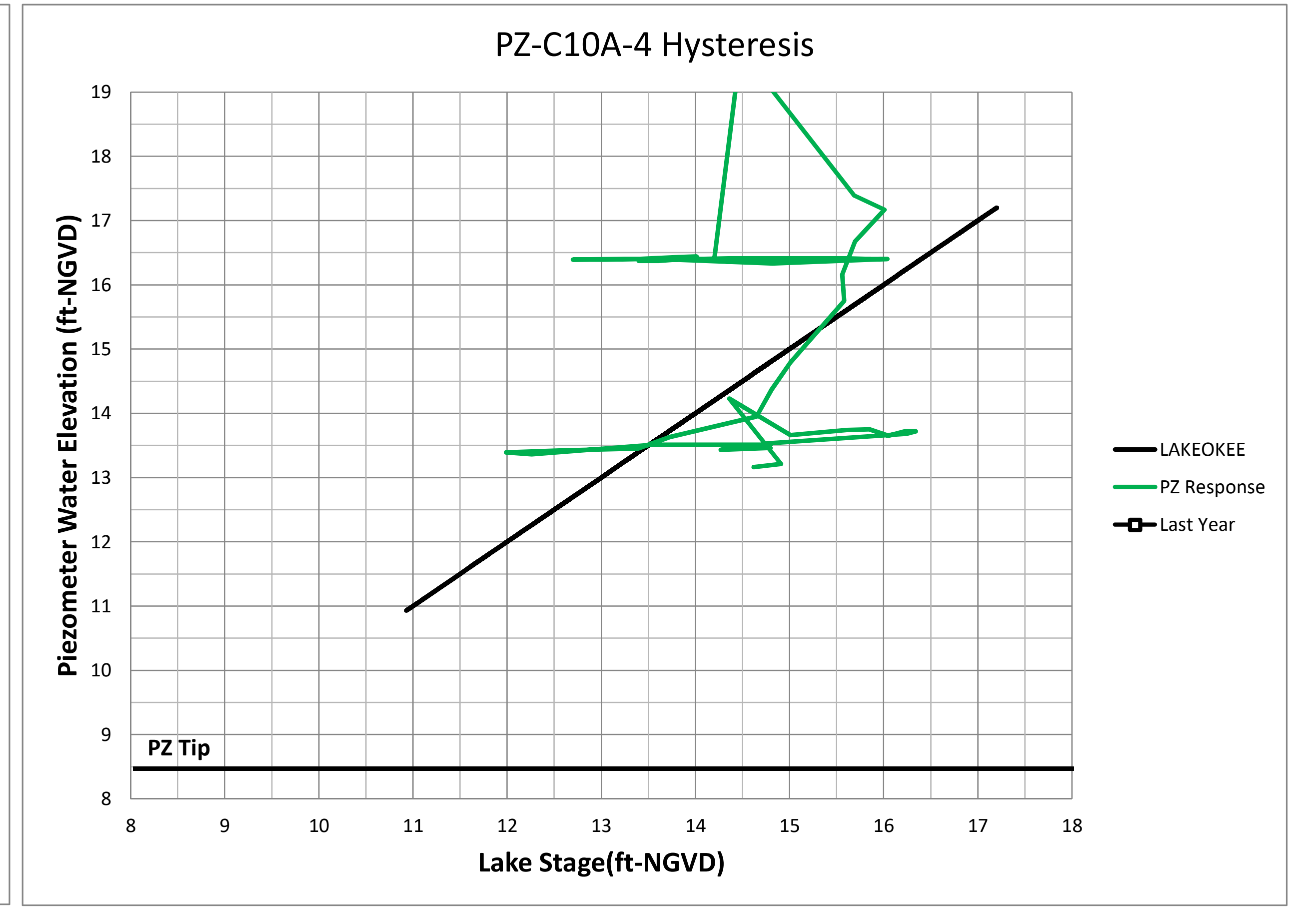
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

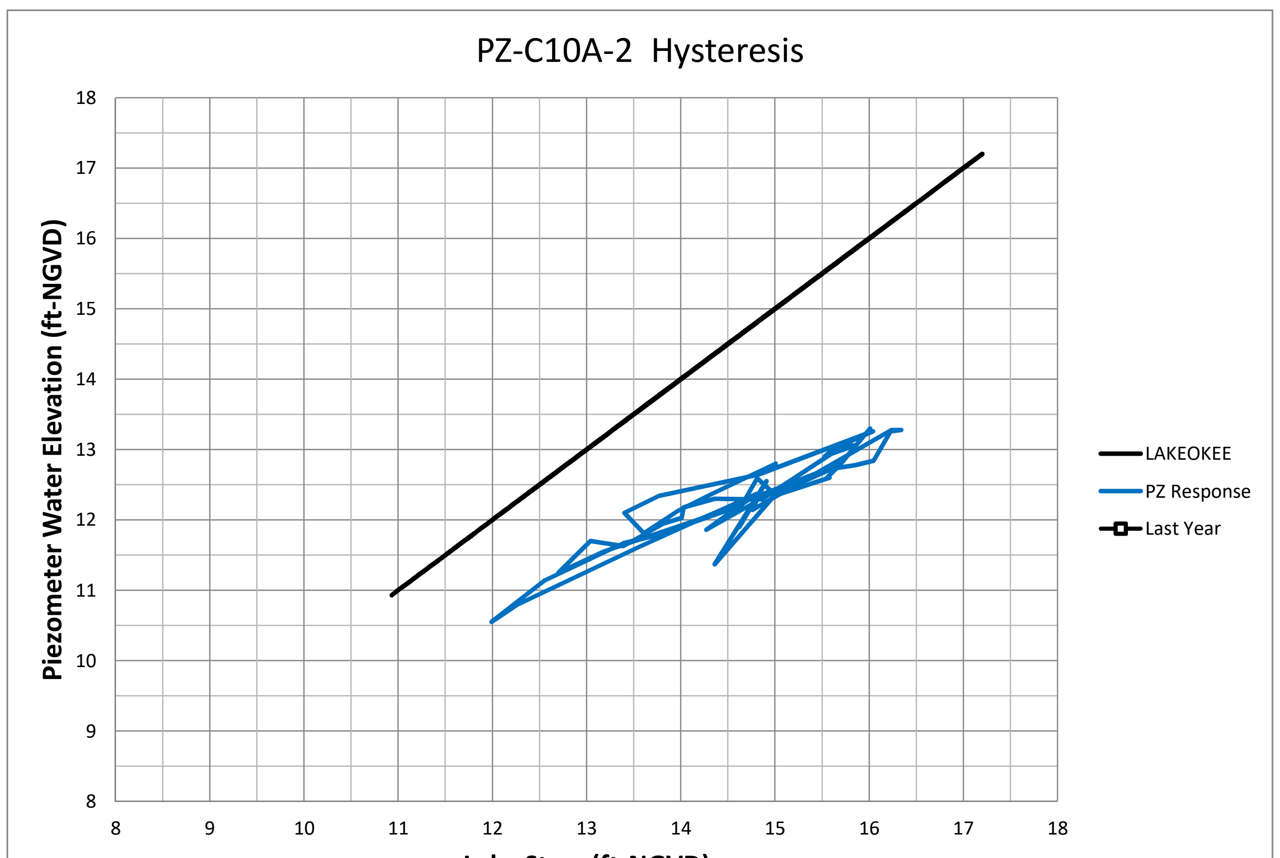


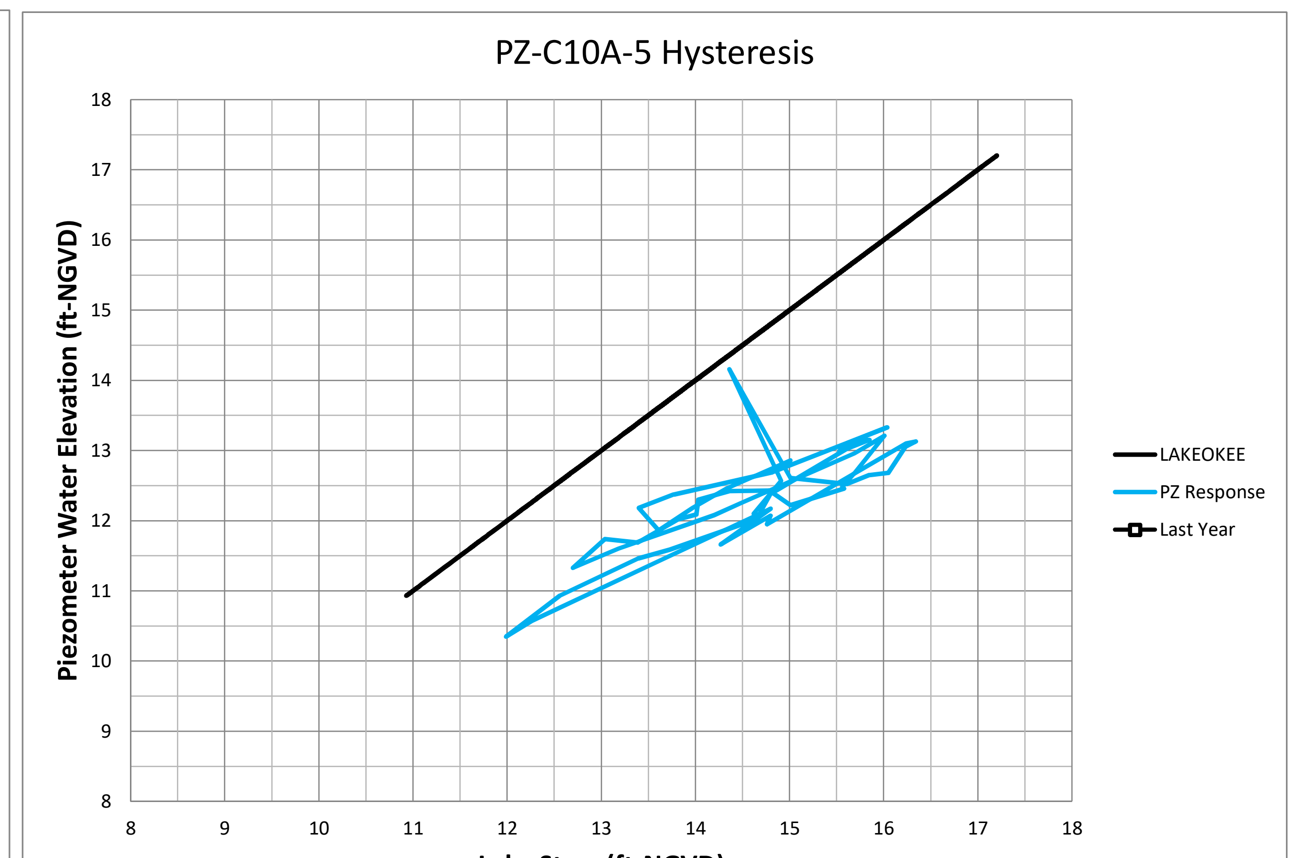


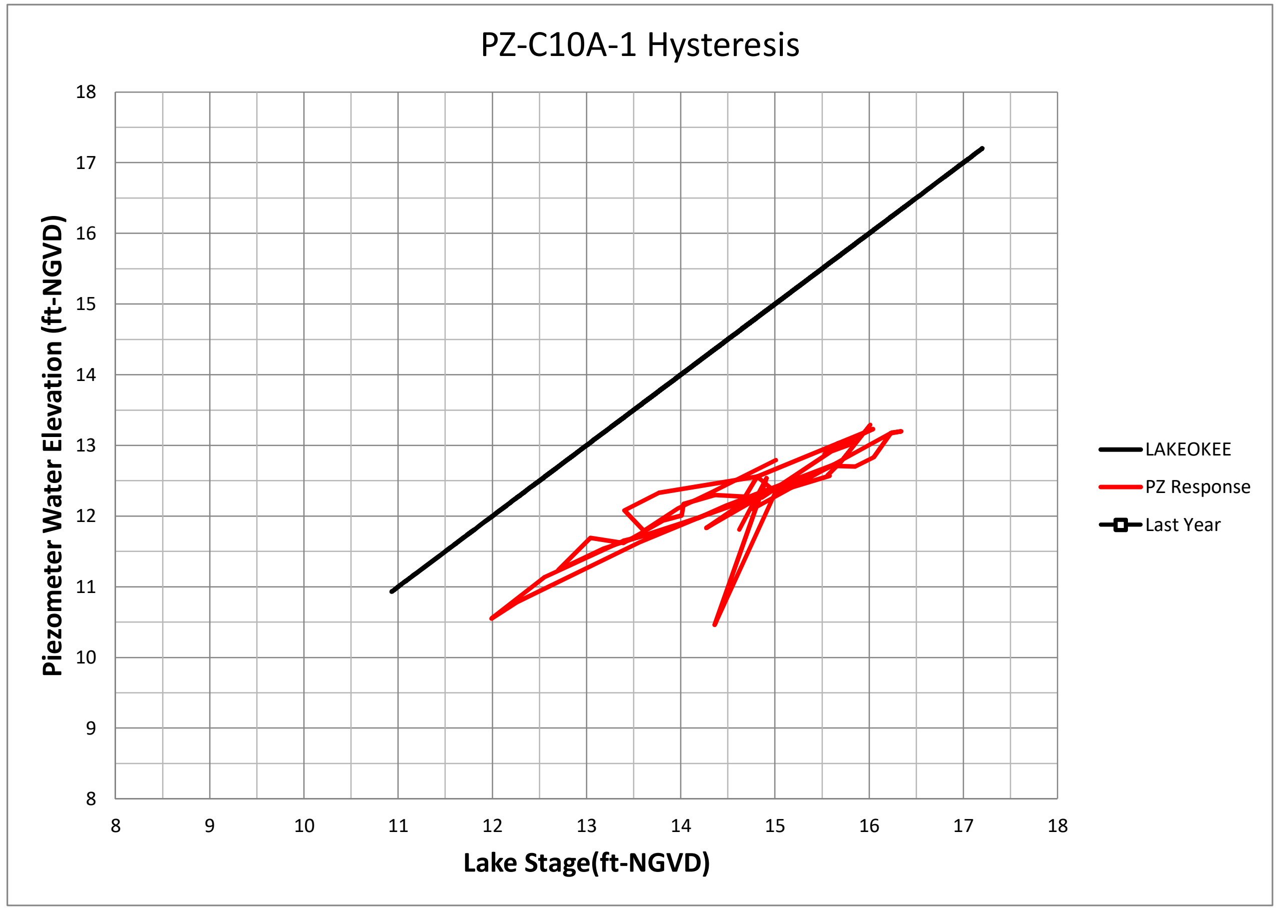
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update










PZ-C10A-1 Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
18
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LAKEOKEE
PZ Response
Last Year

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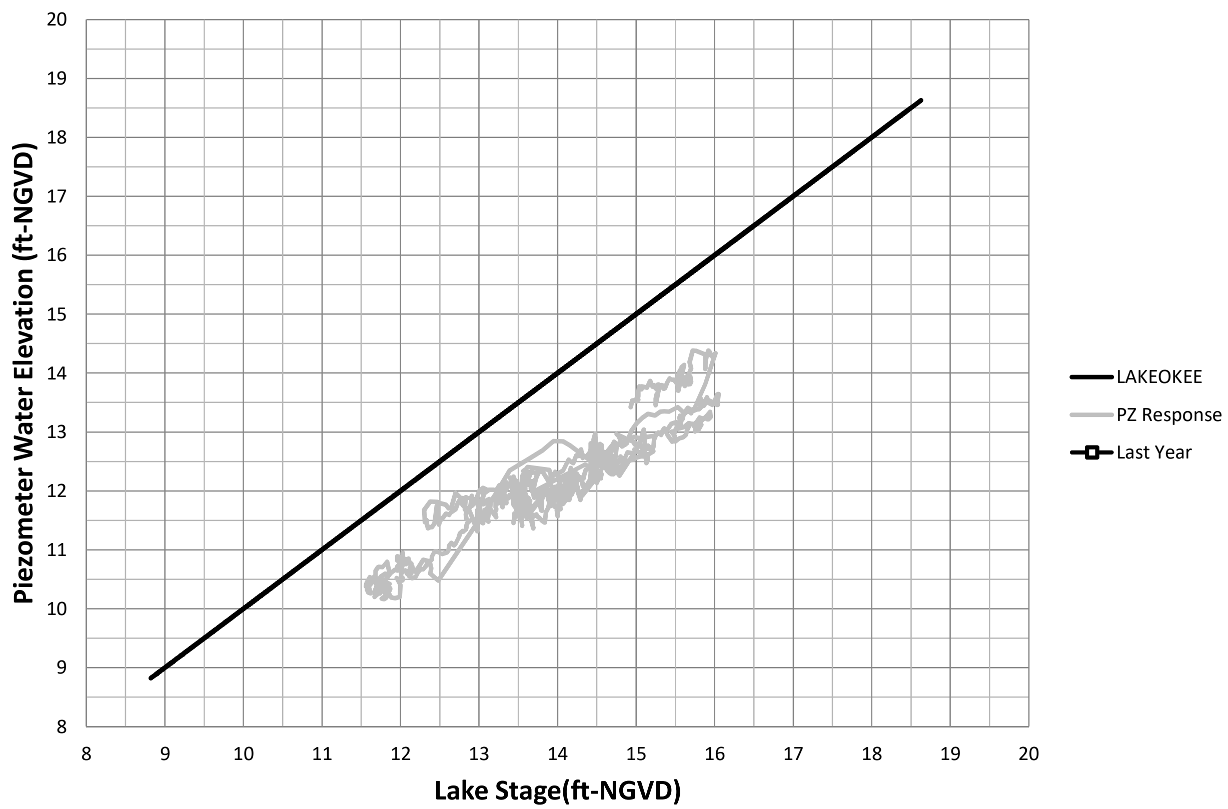
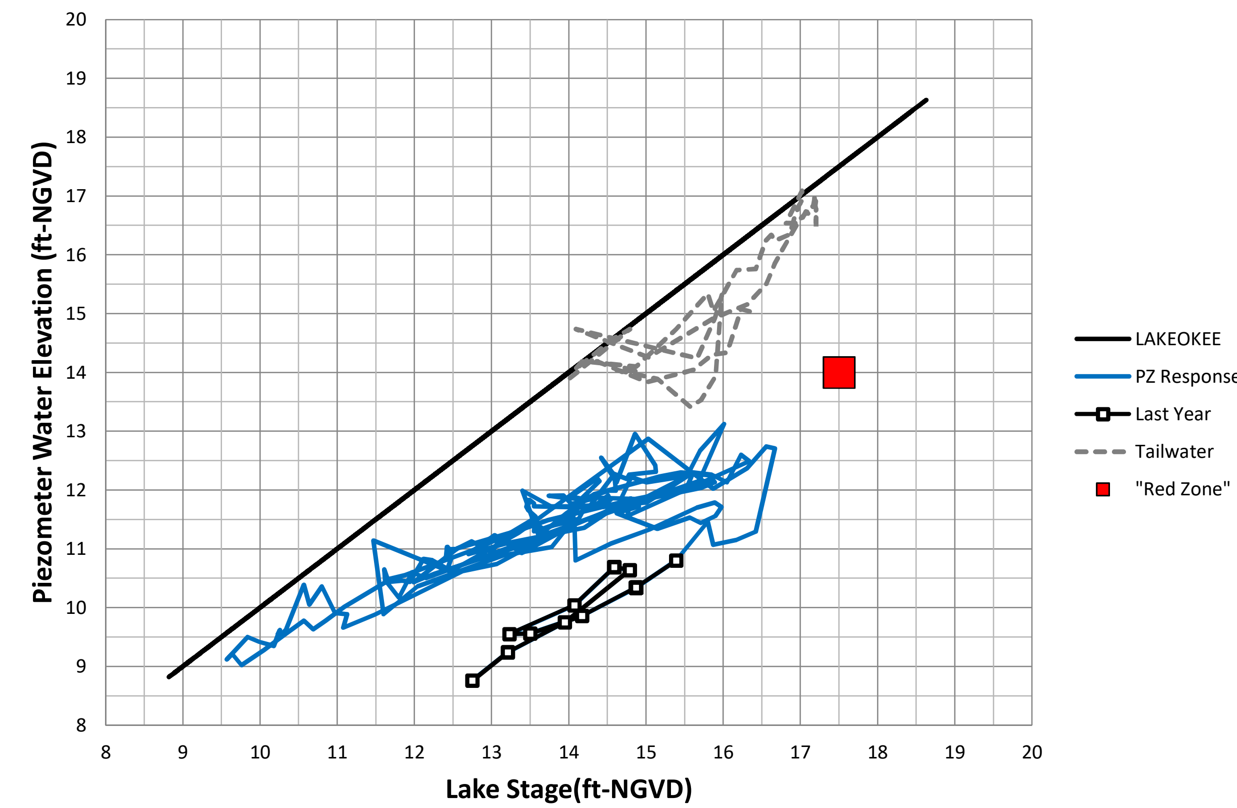
Instrumentation Update

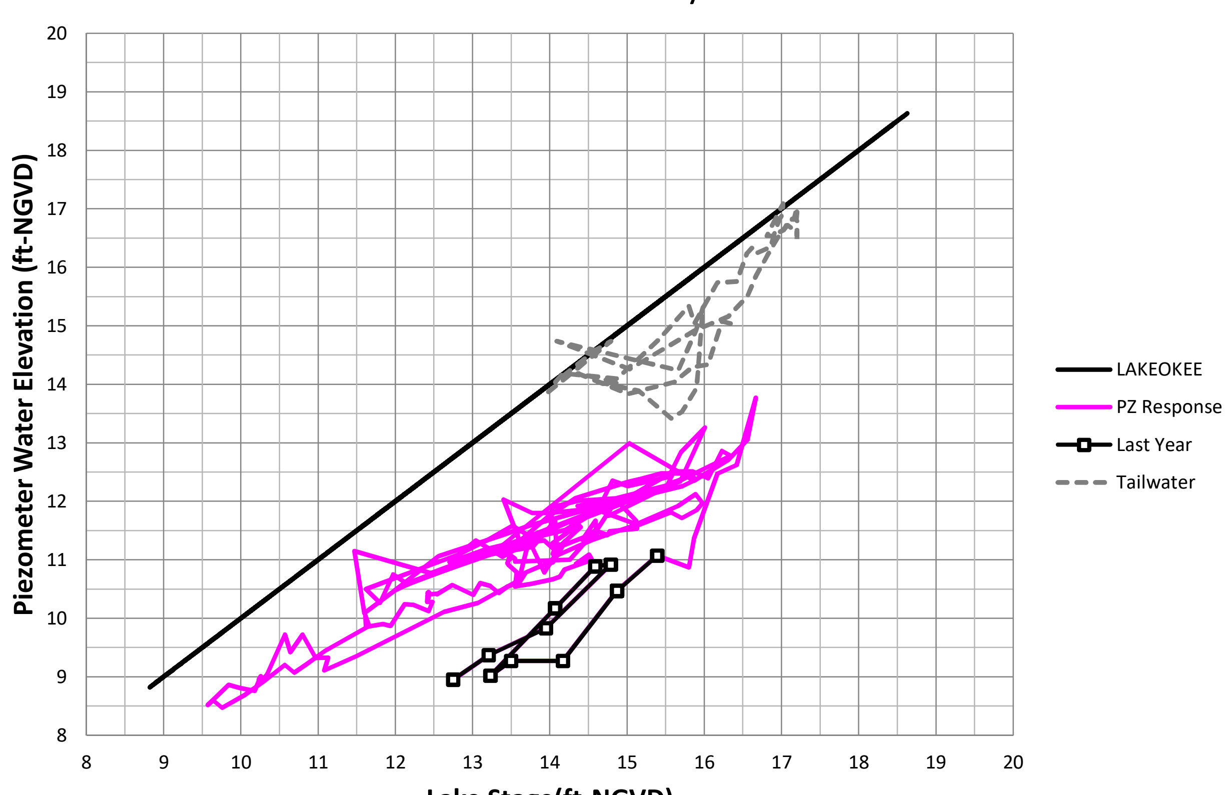
PZ-HHDR1A-2A Hysteresis



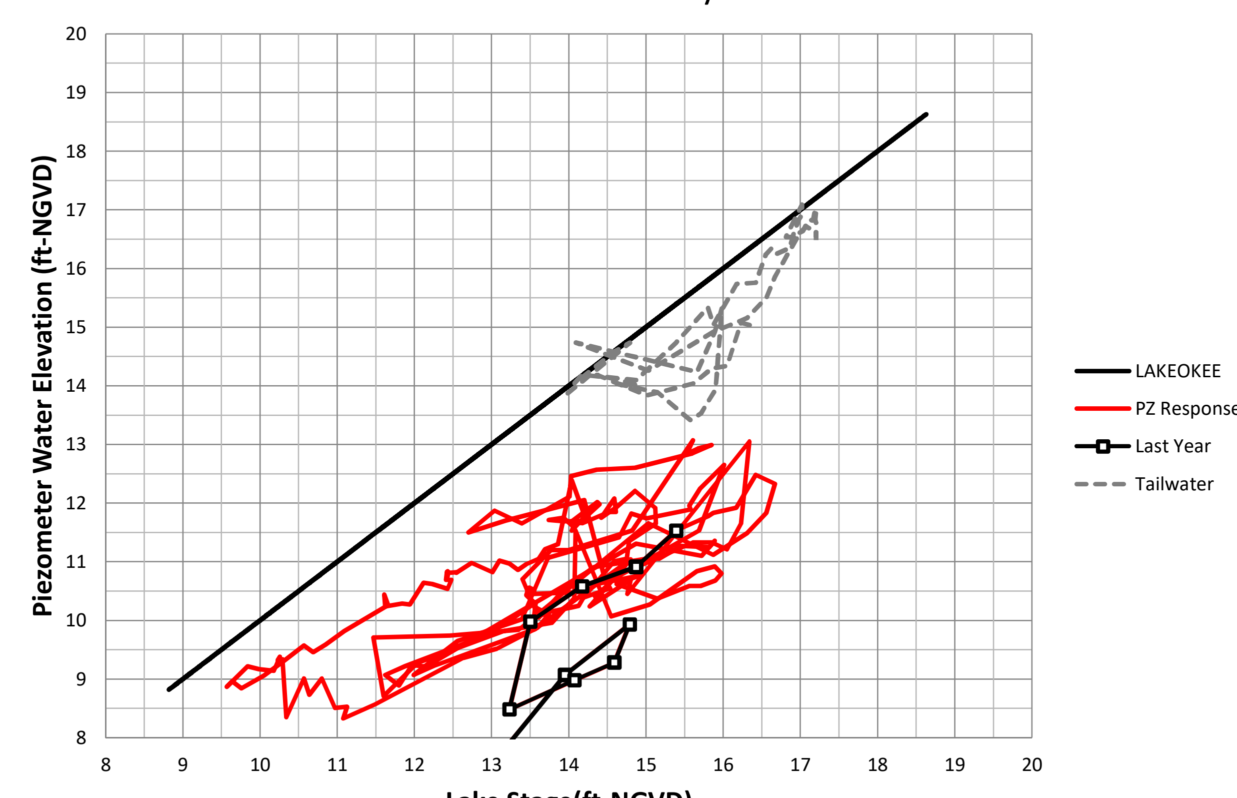
PZ-HHDR1A-2C1 Hysteresis



PZ-HHDR1A-2C2 Hysteresis



PZ-HHDR1A-2C3Hysteresis



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Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

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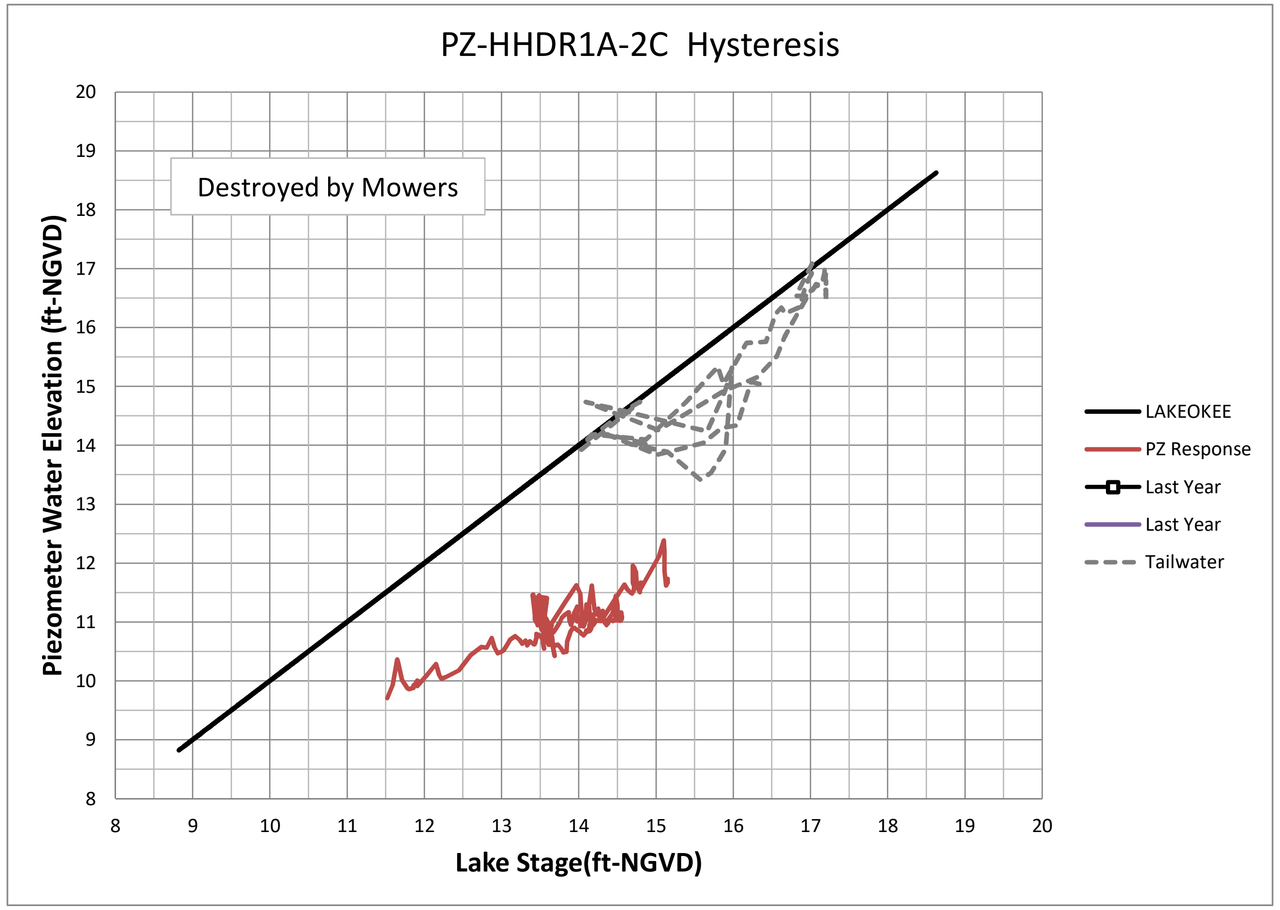
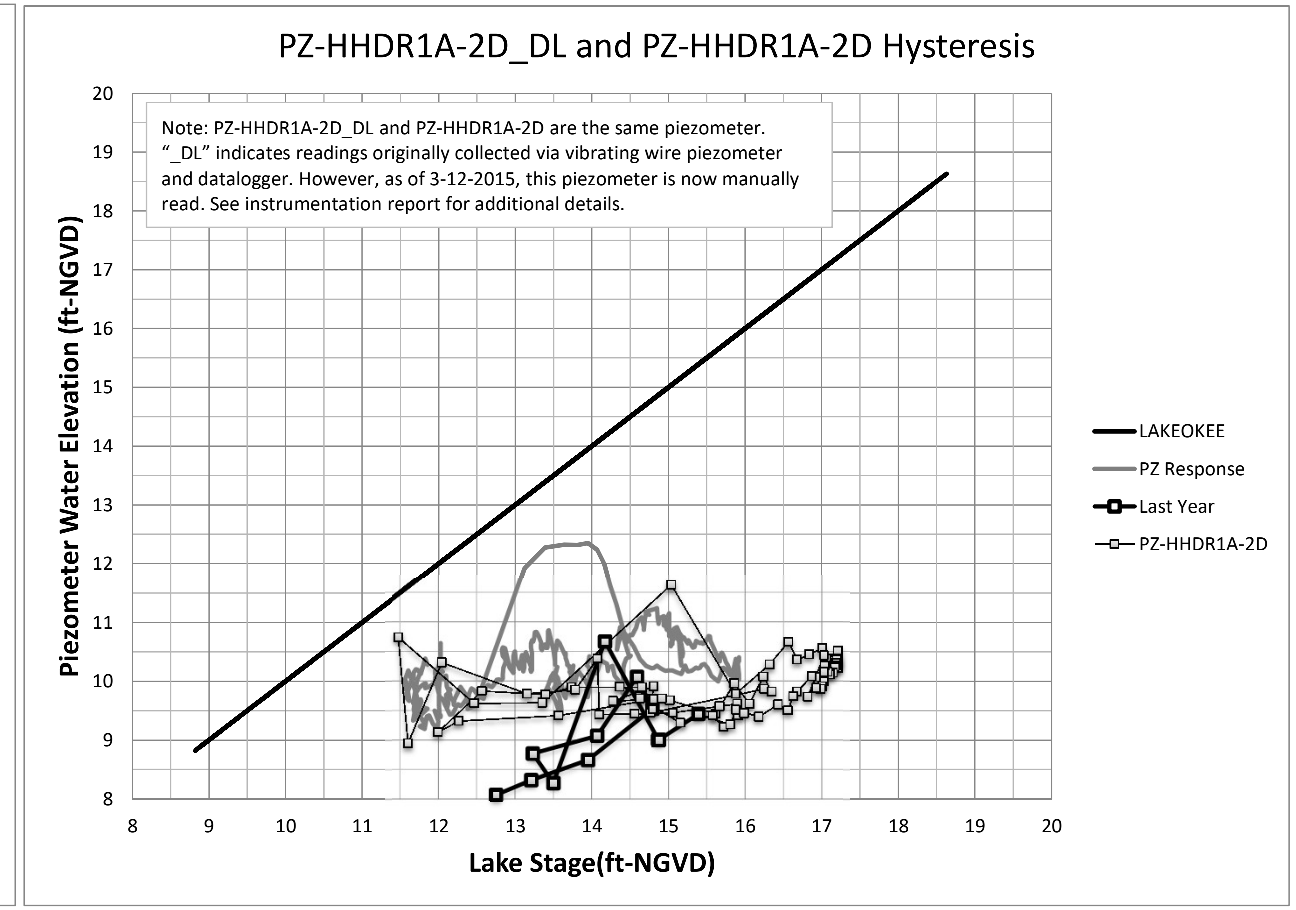
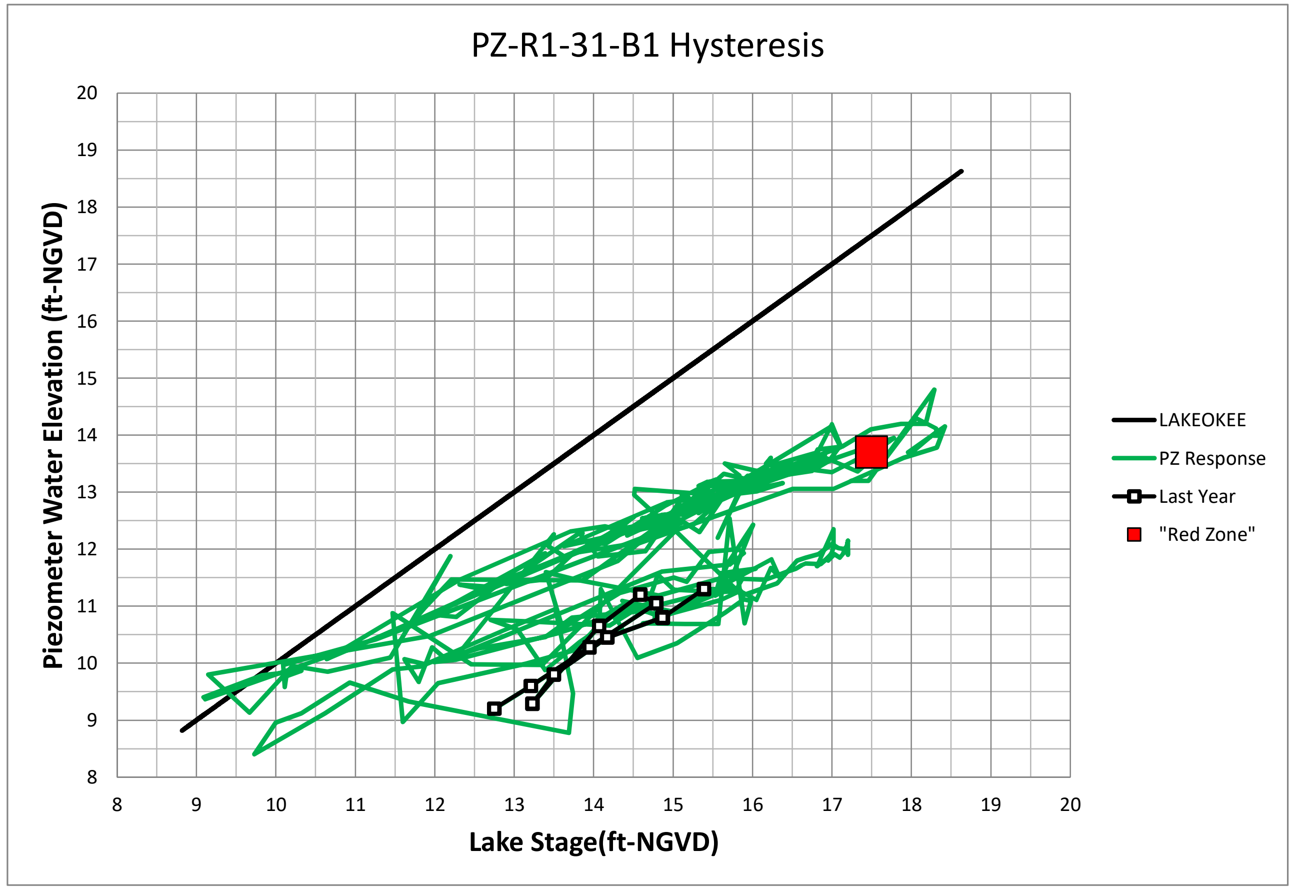
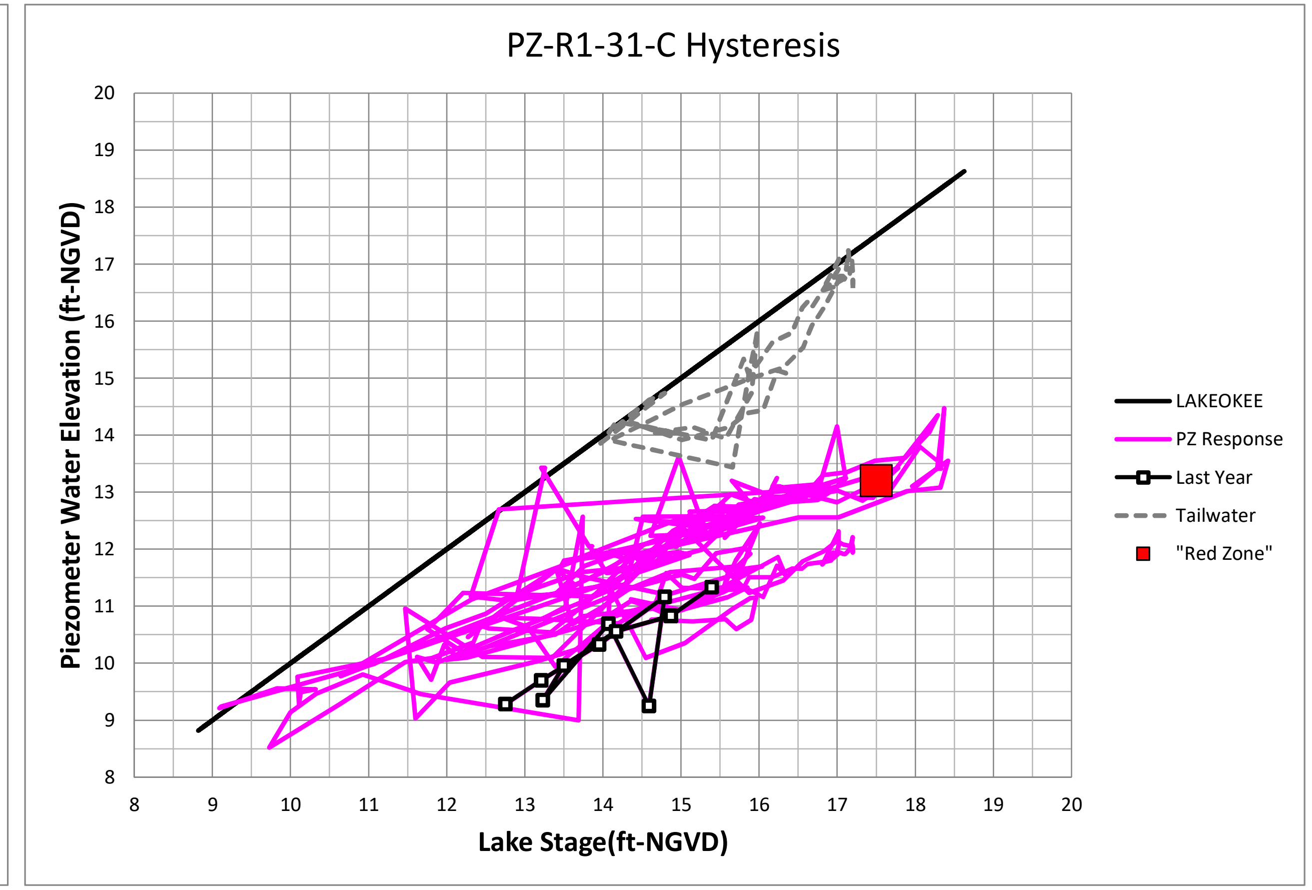
Instrumentation Update



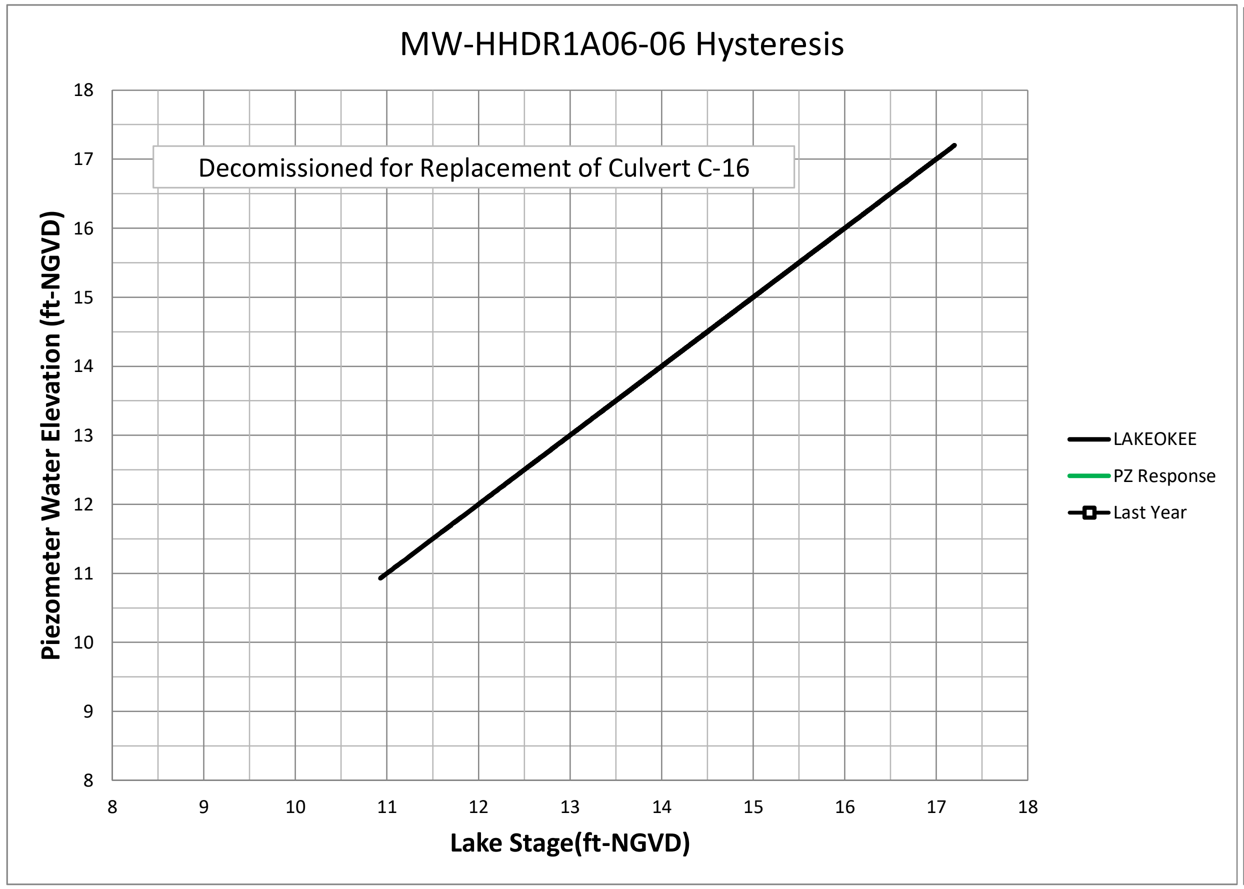


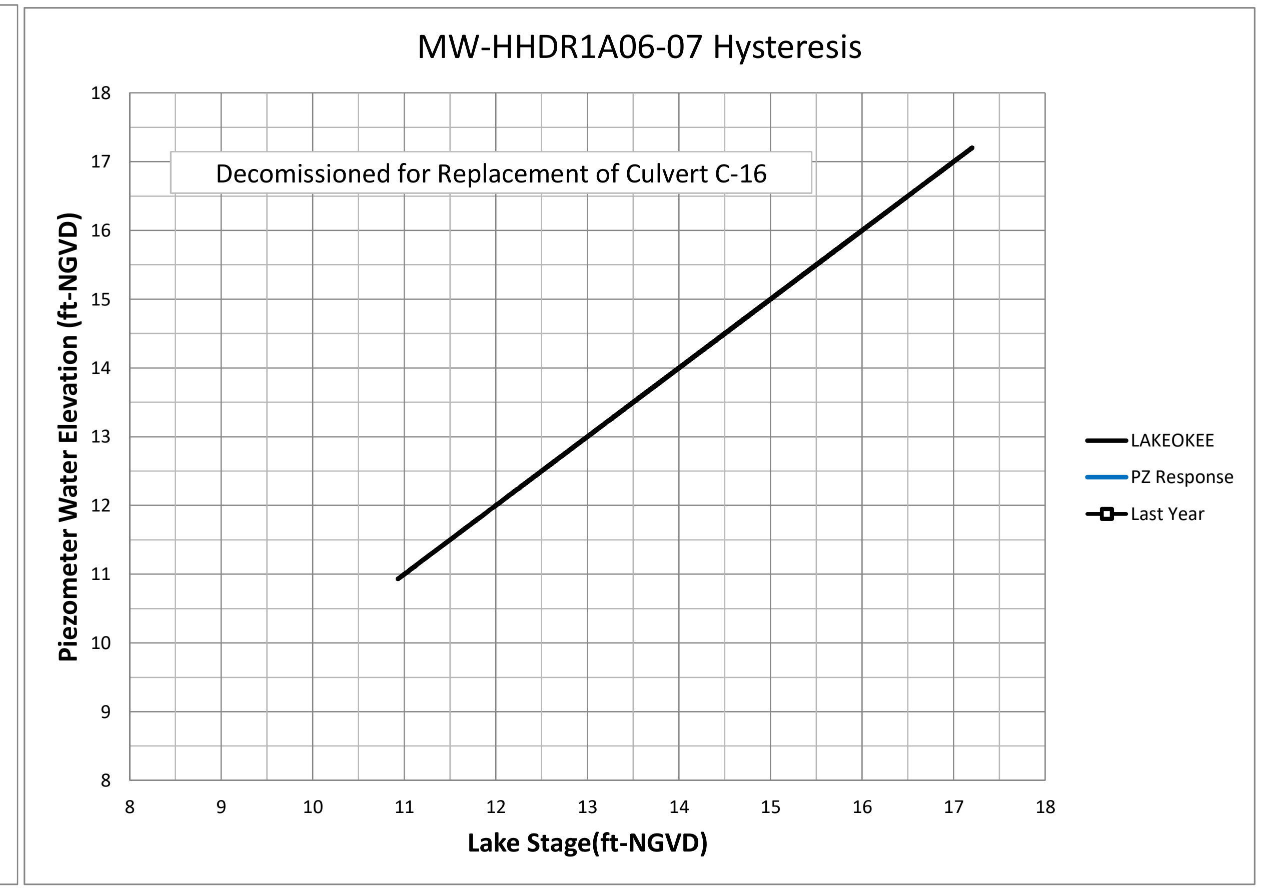
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

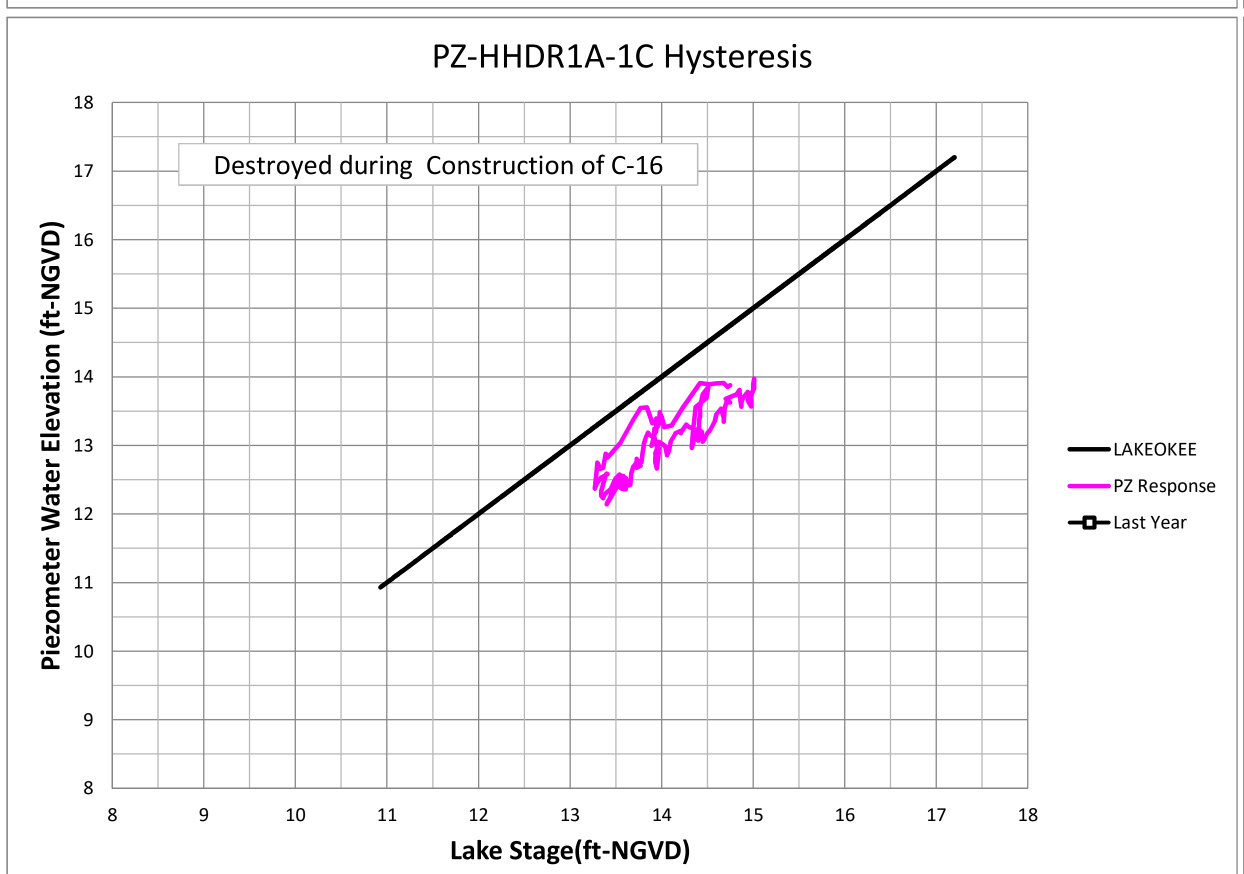


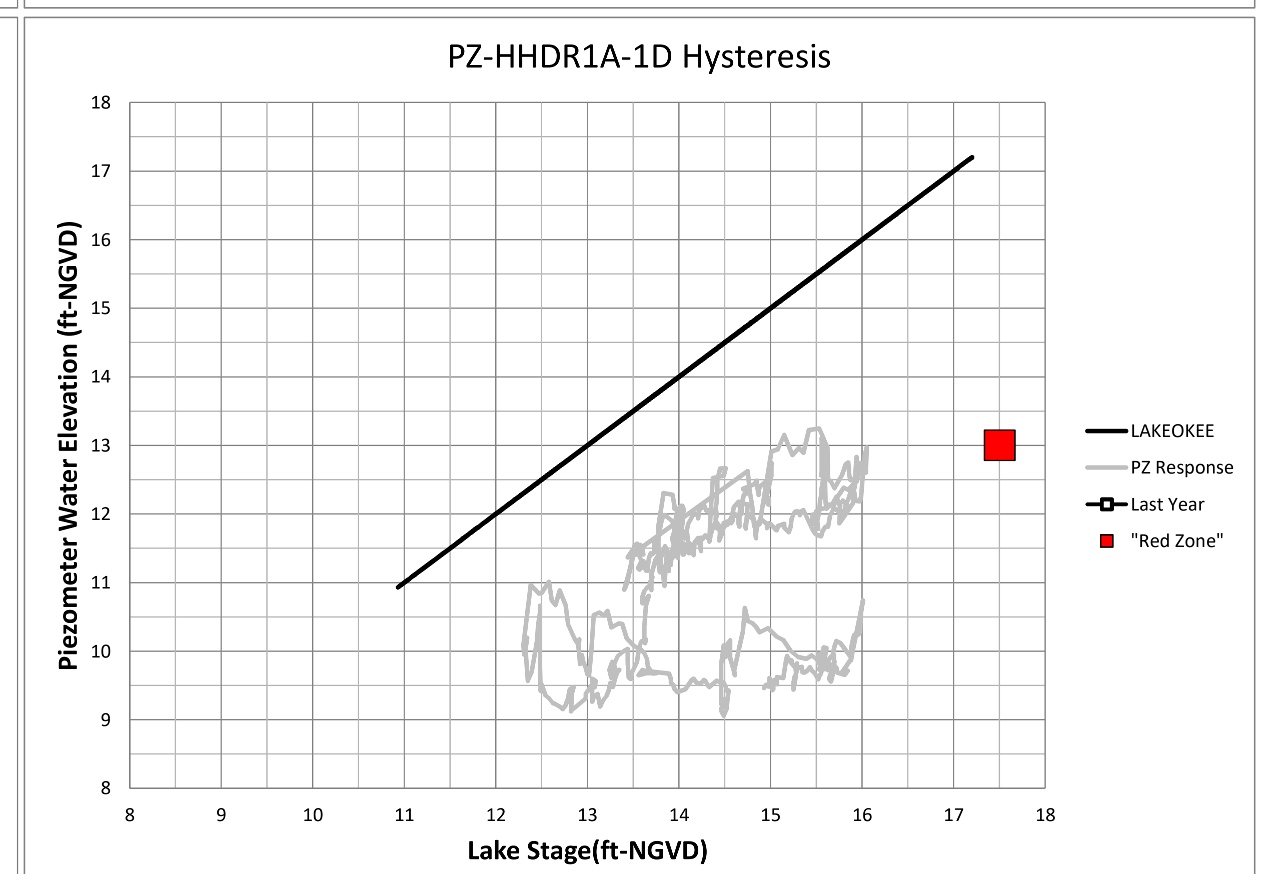


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

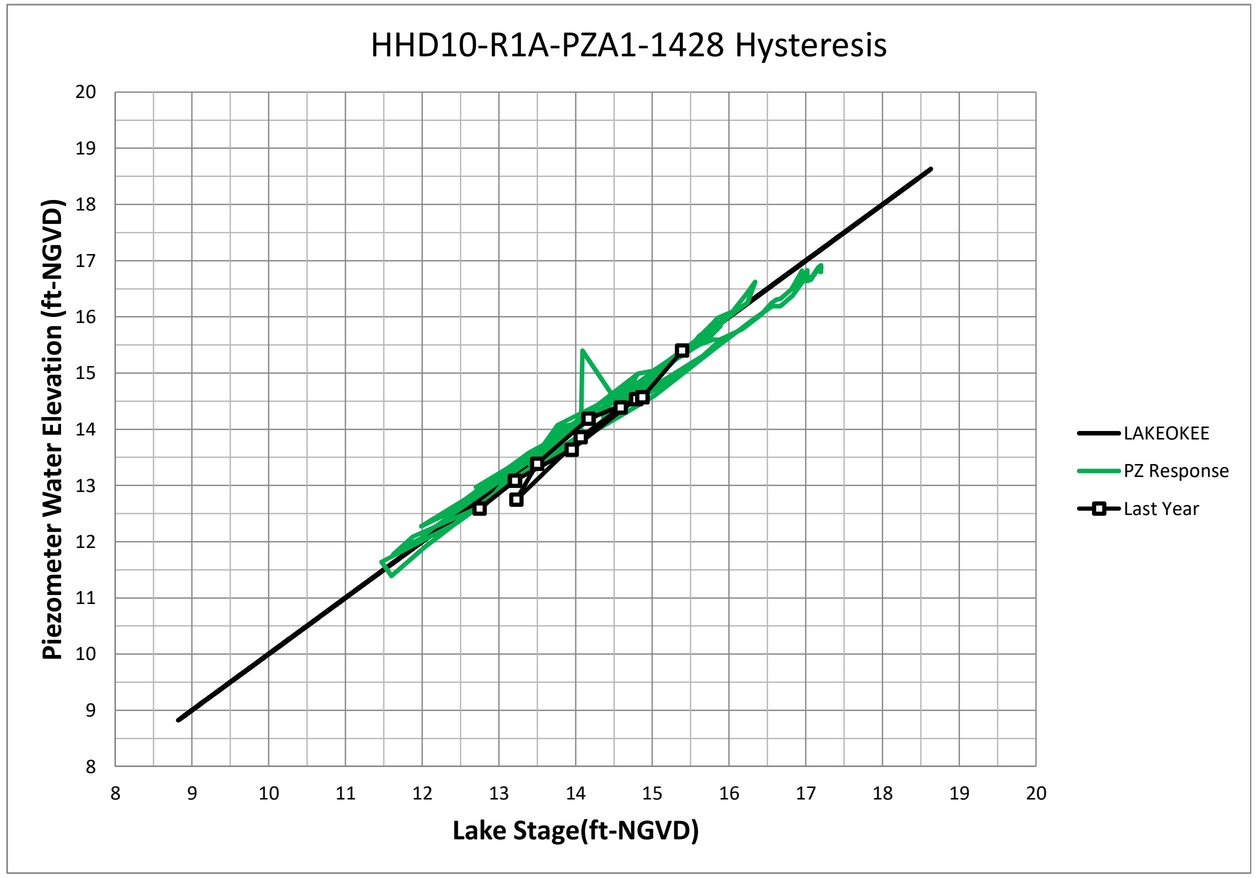


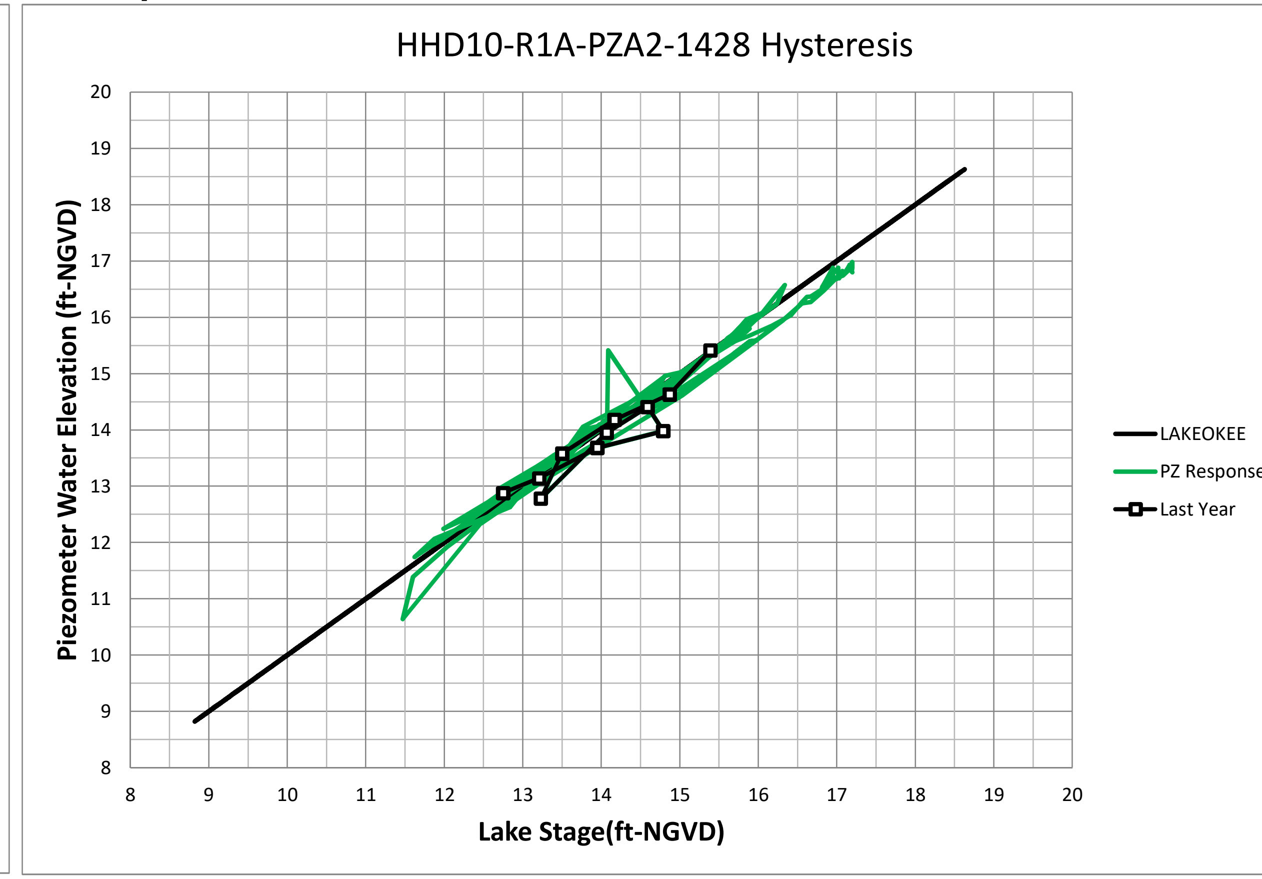


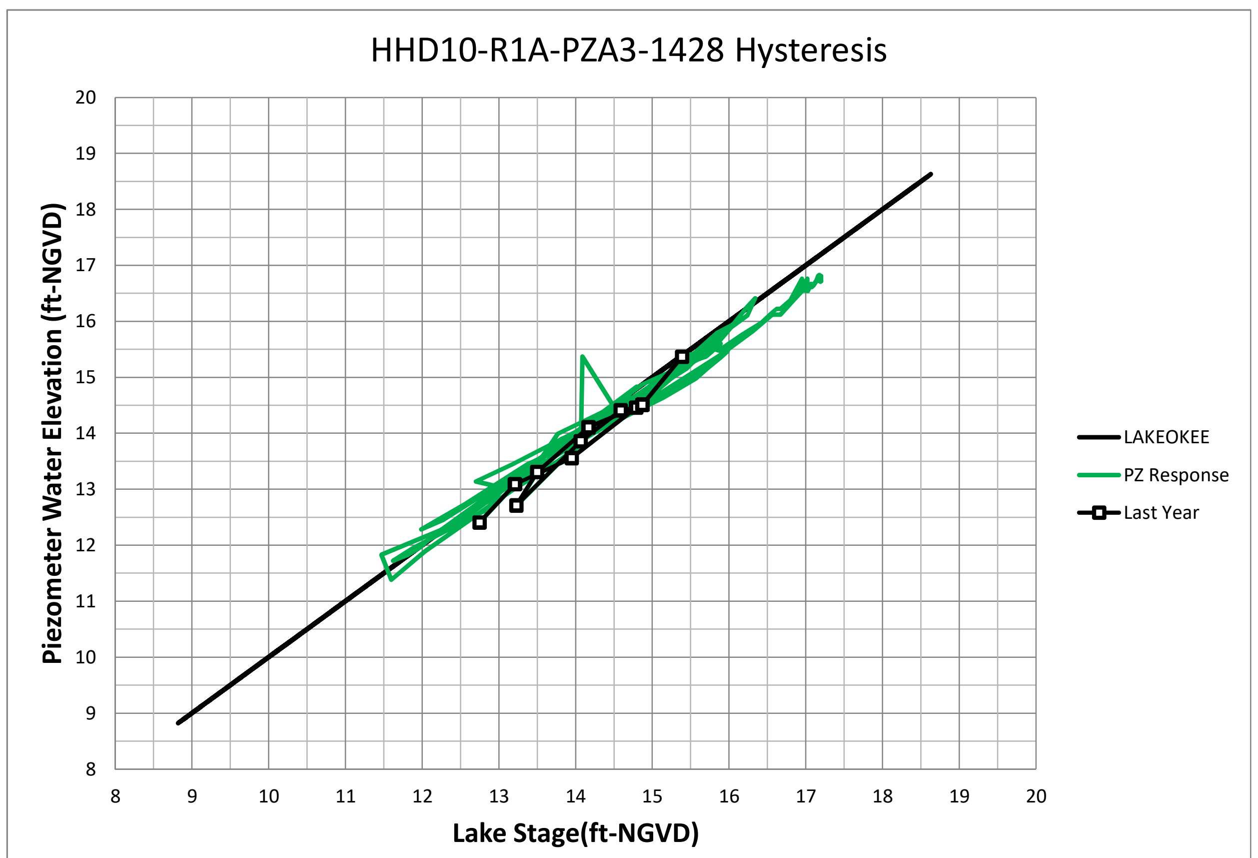


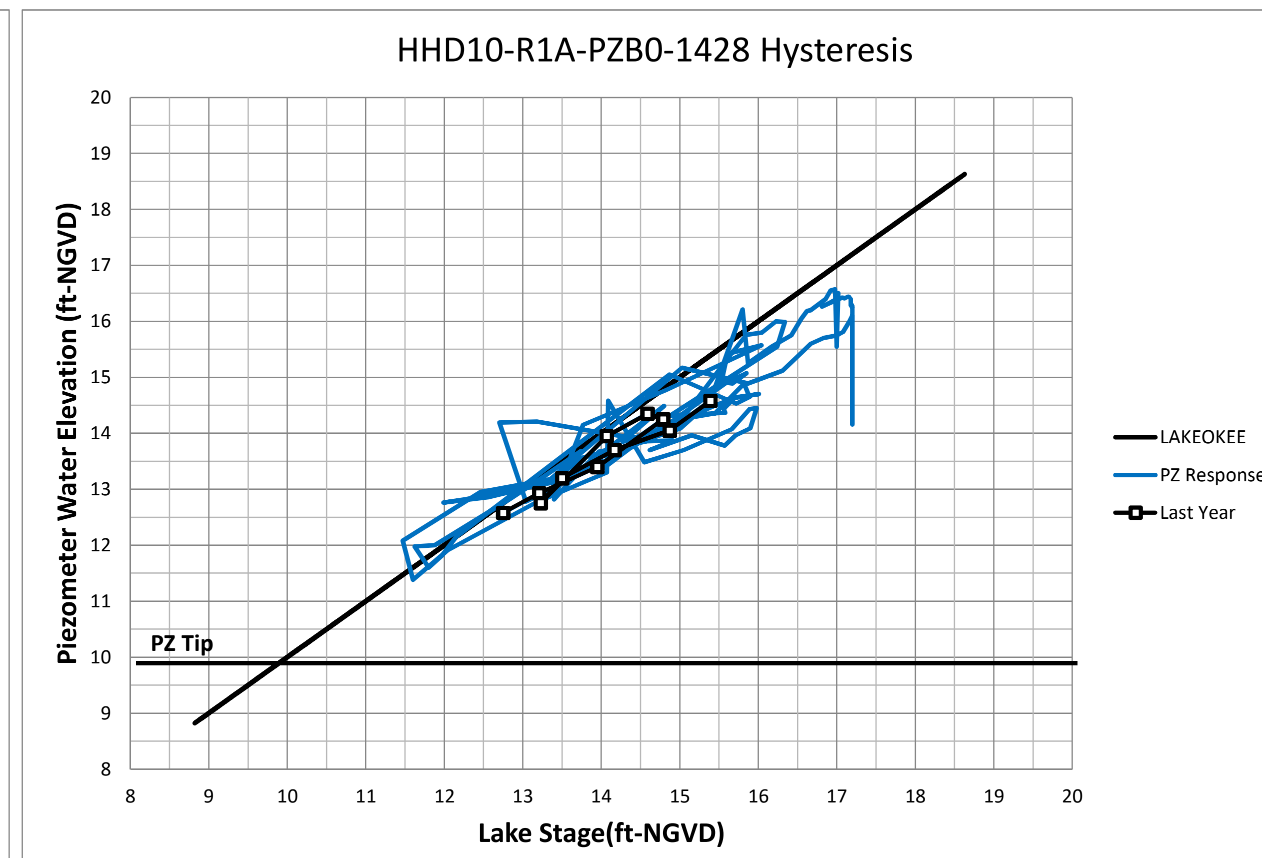


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

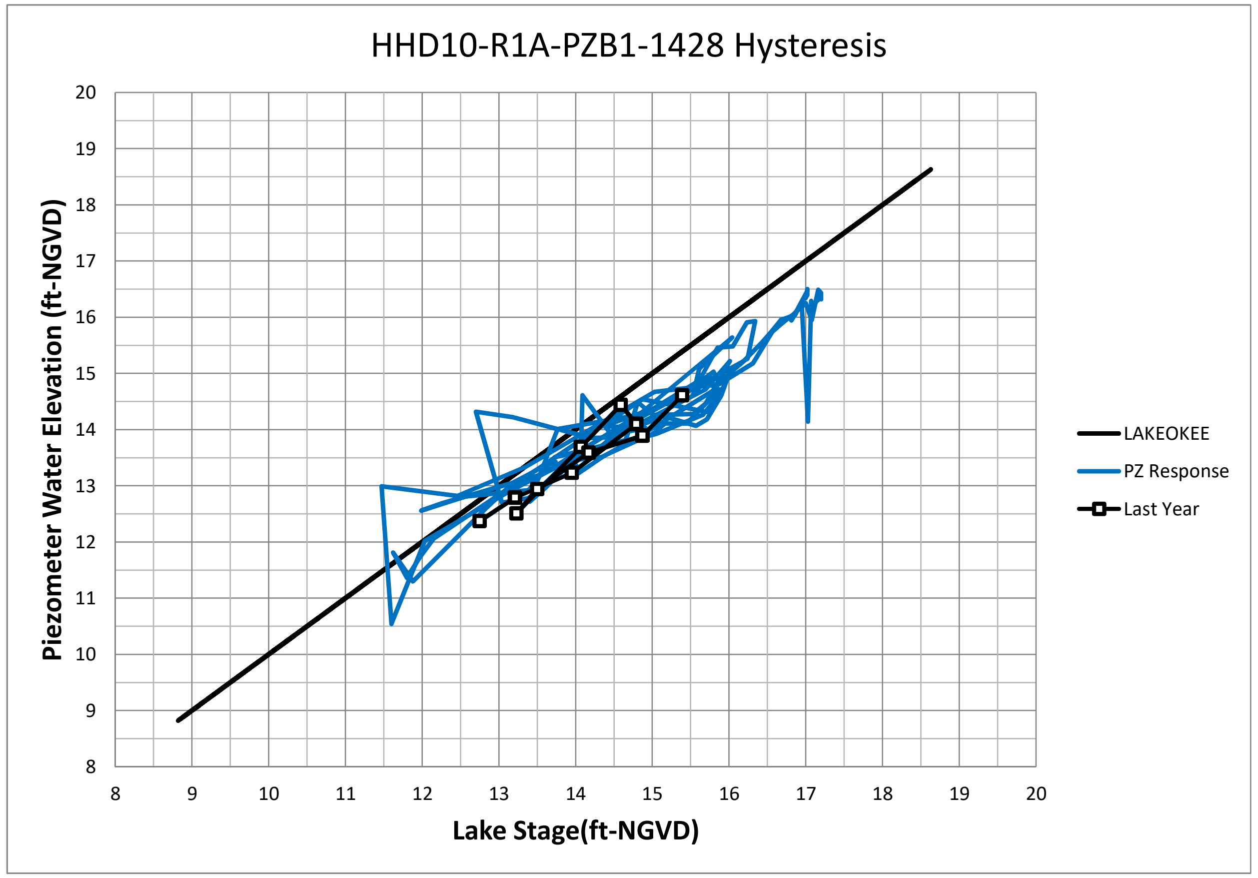


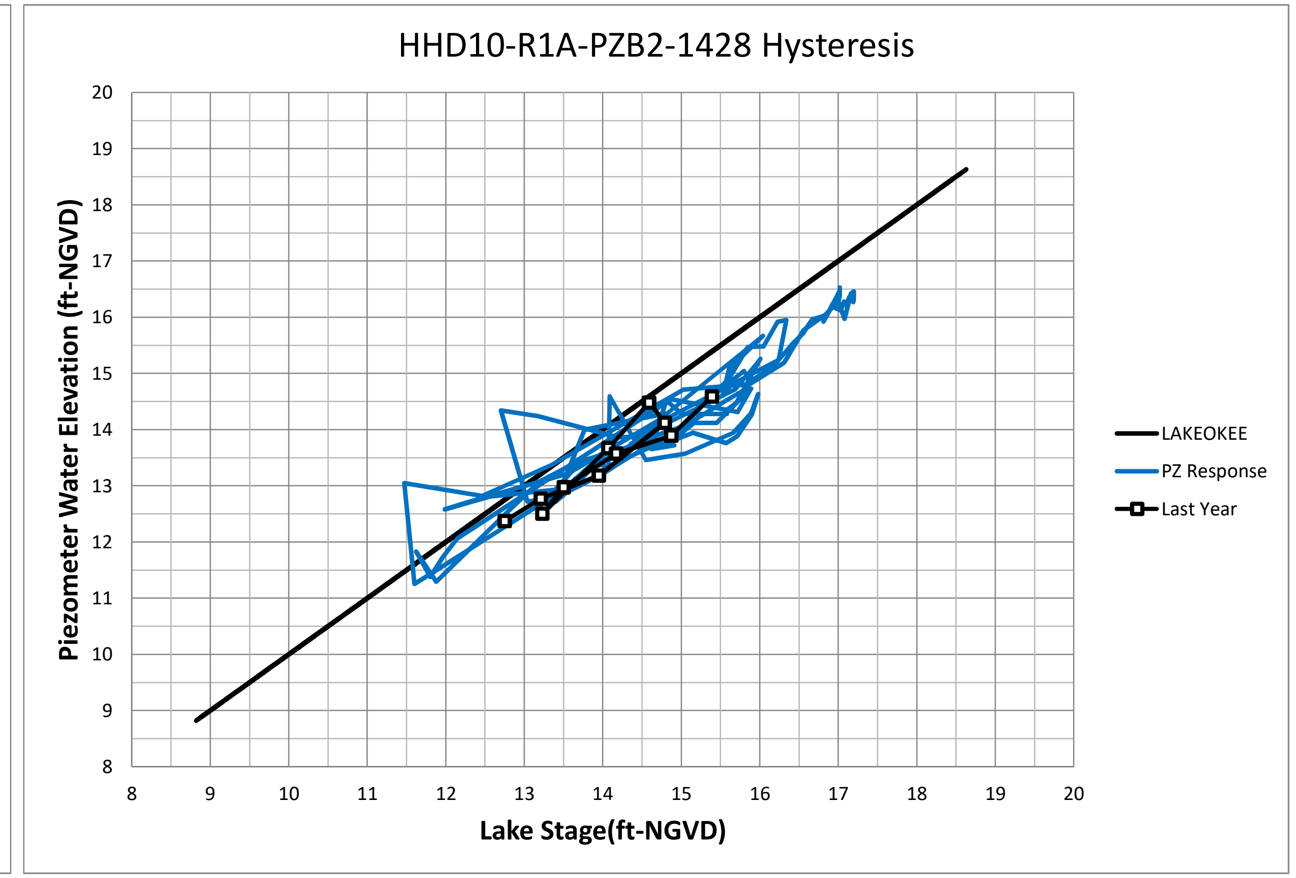


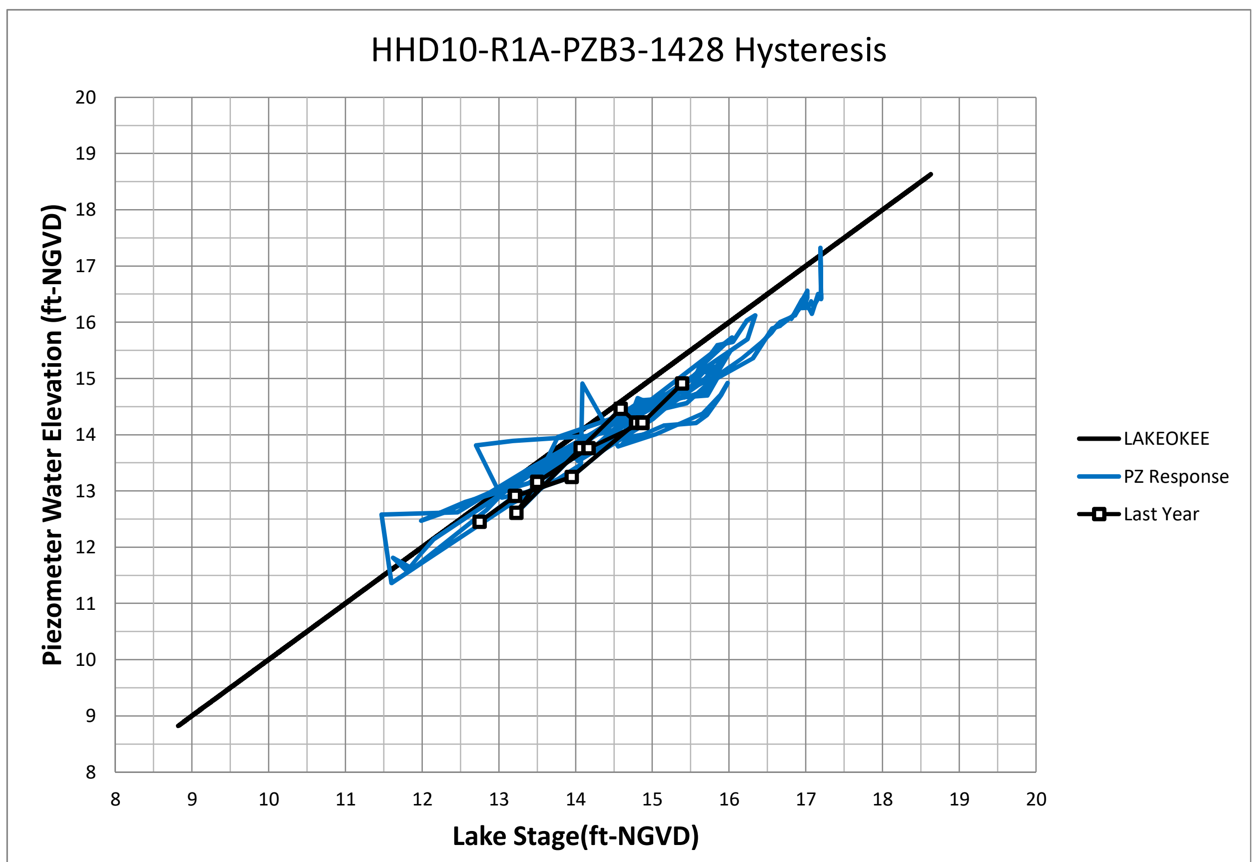


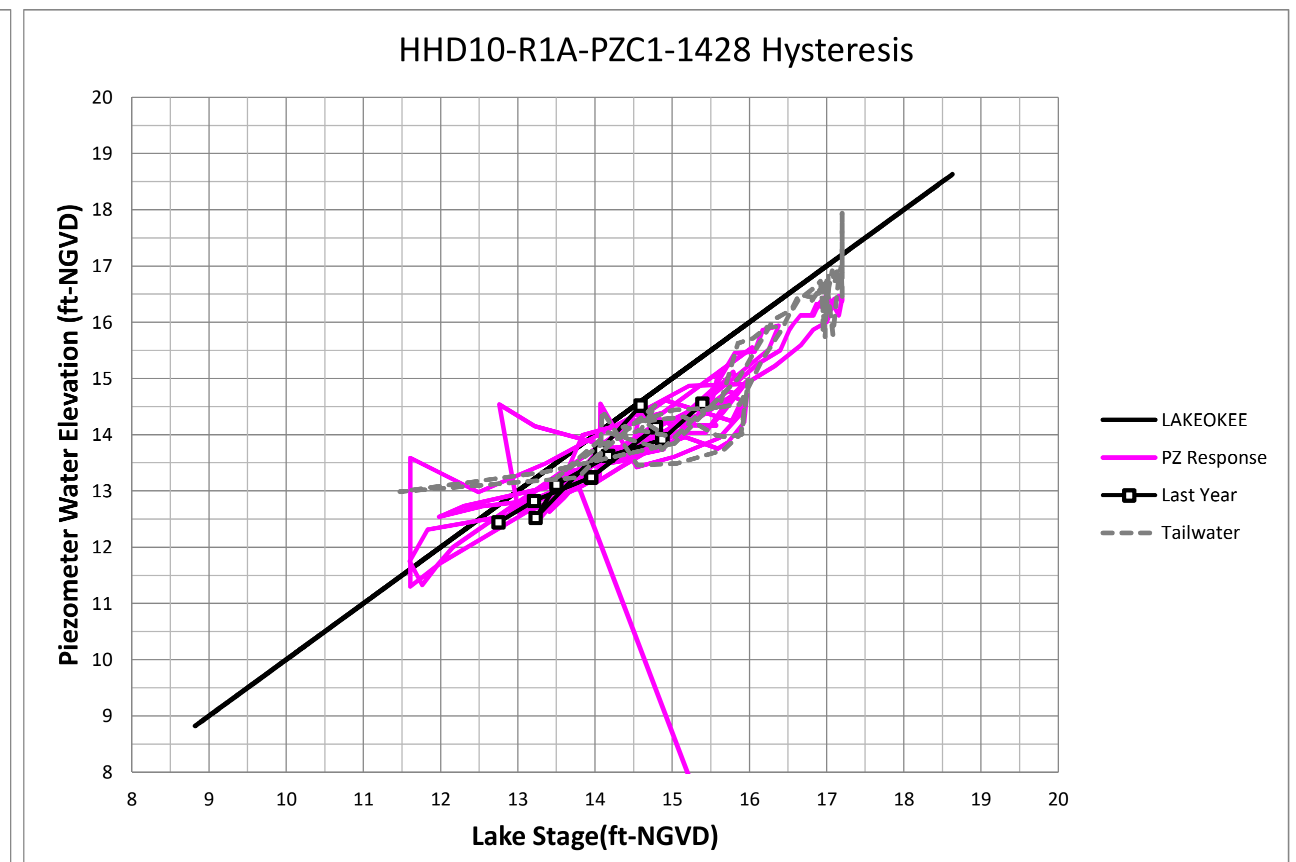


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

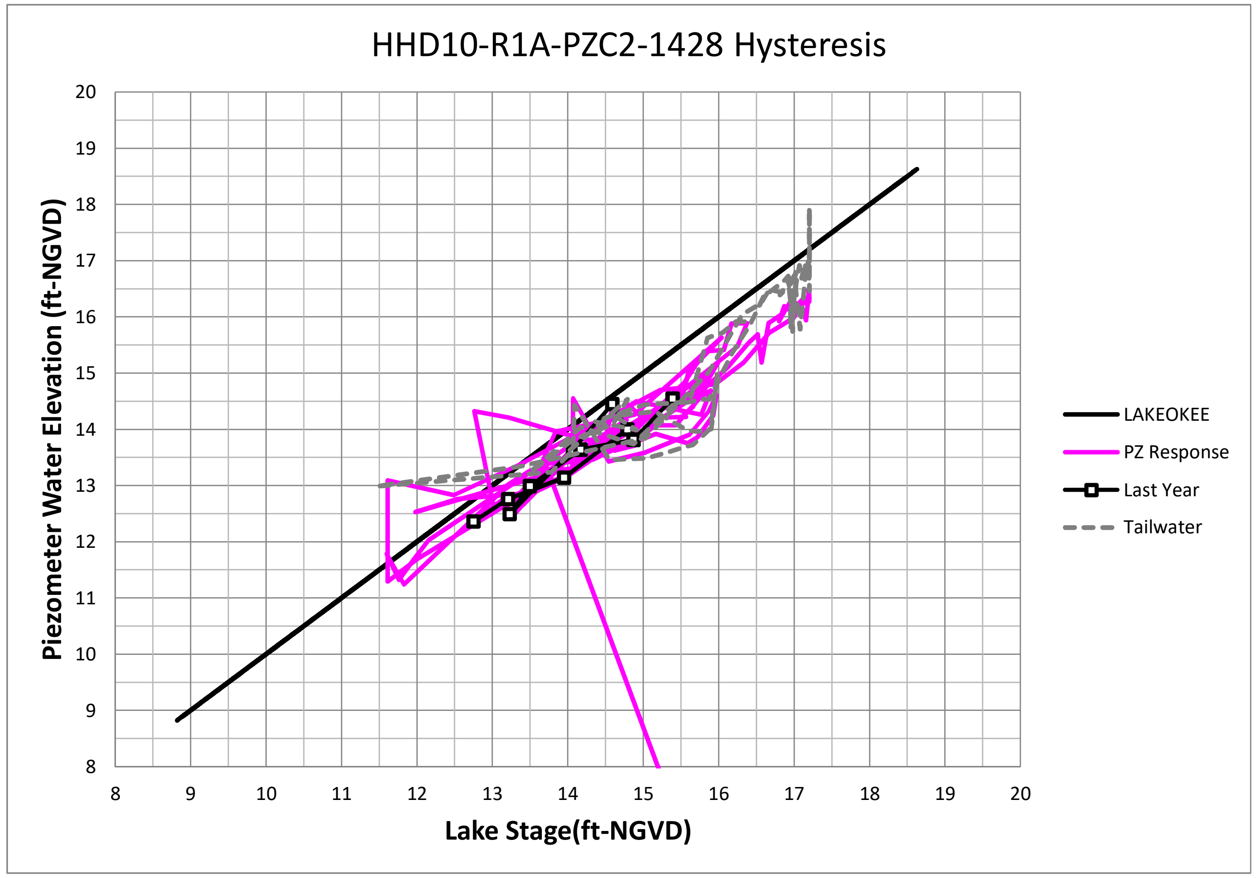


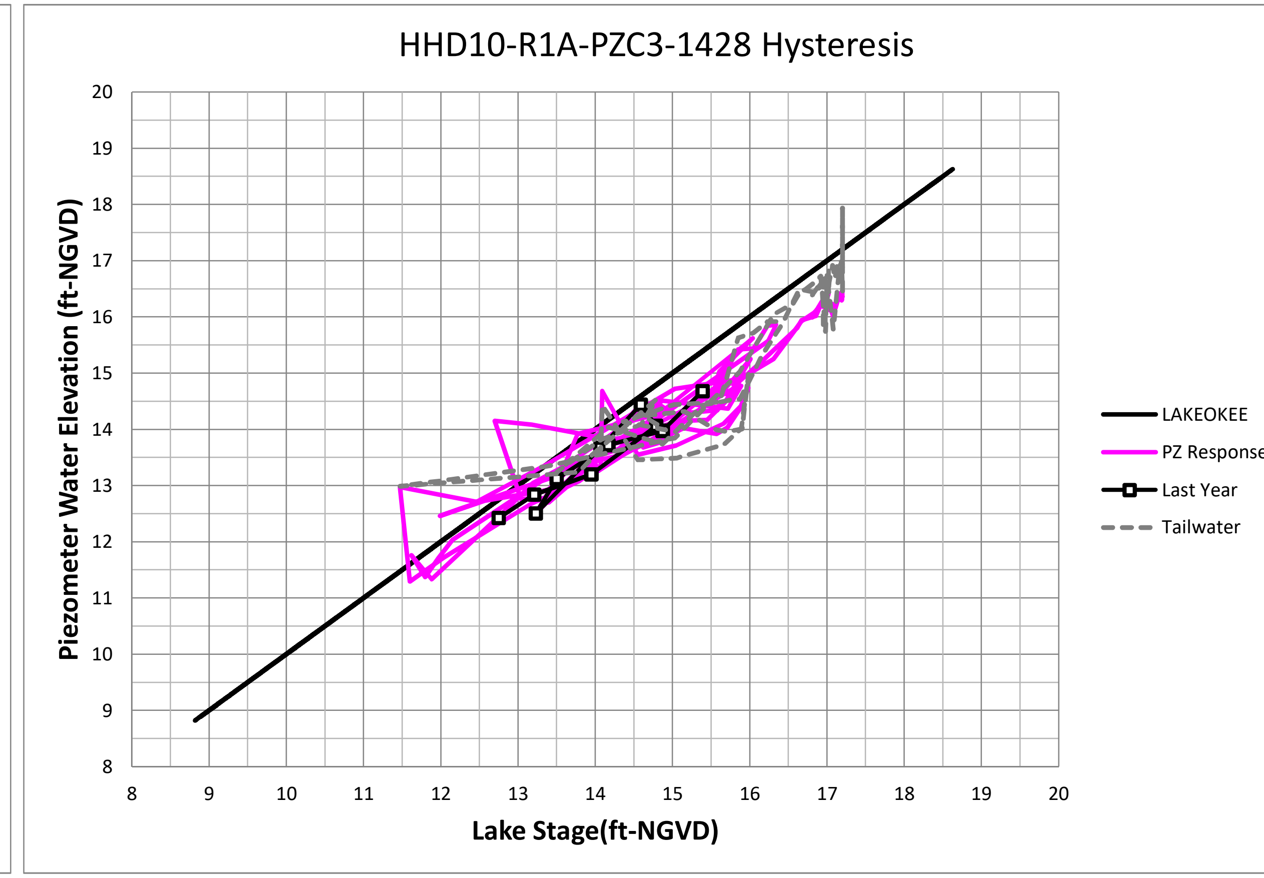




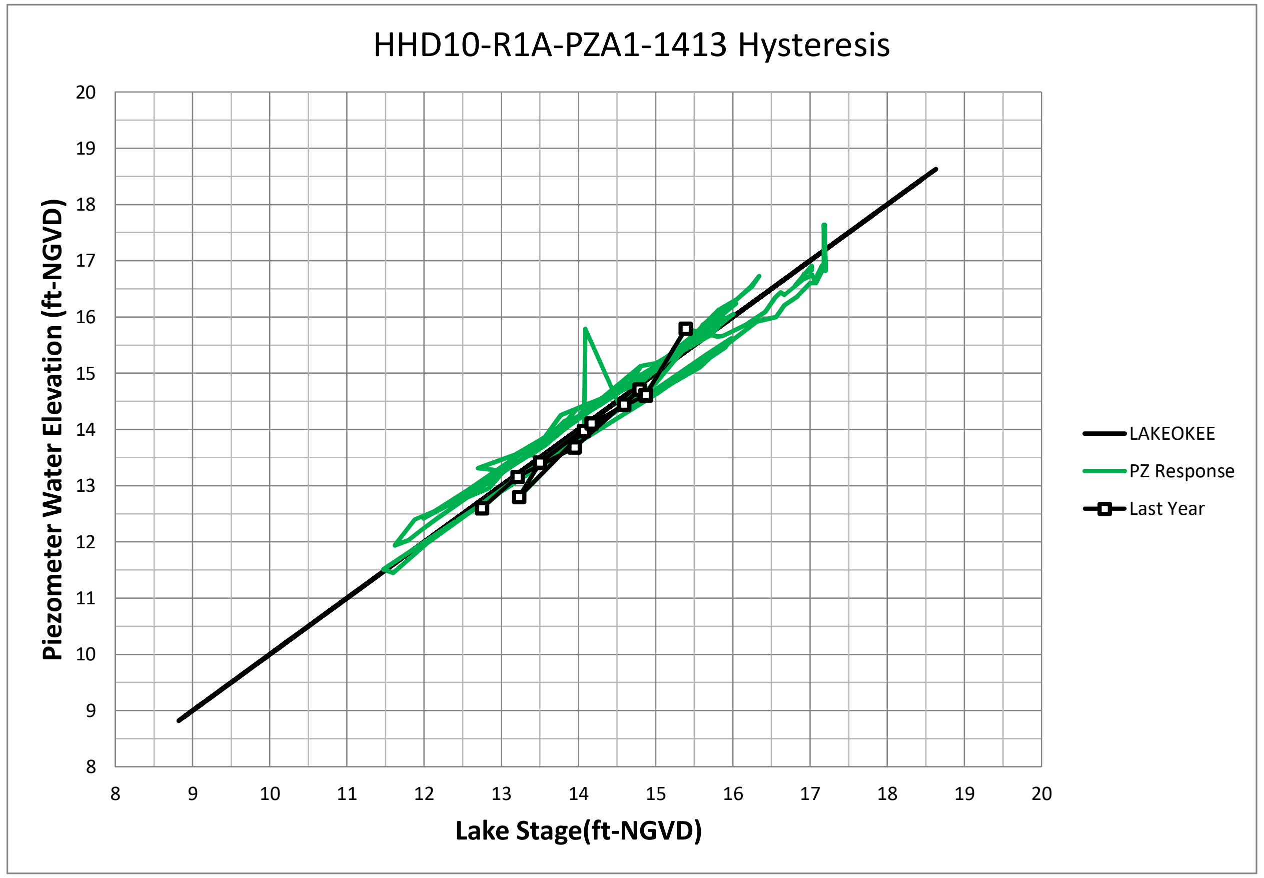


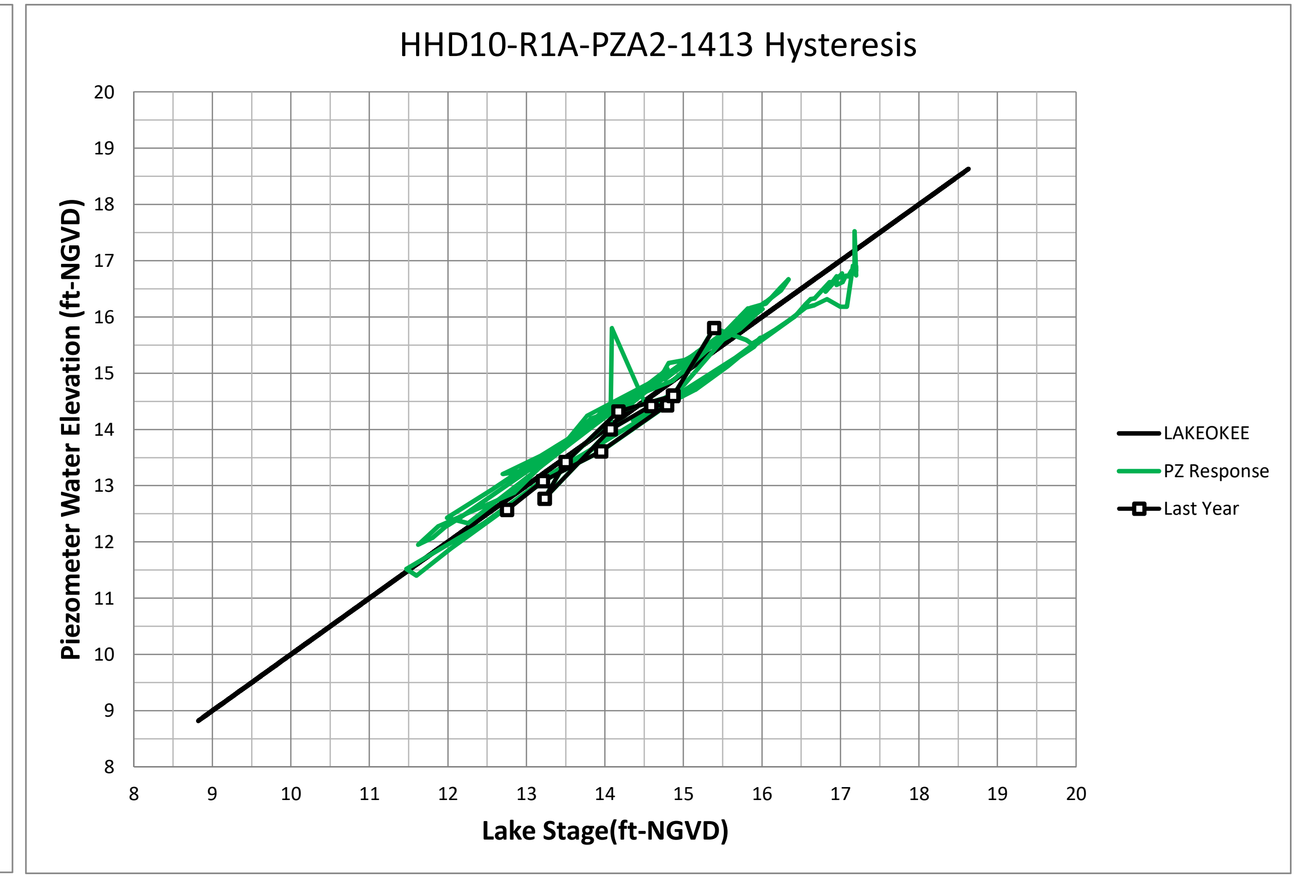
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

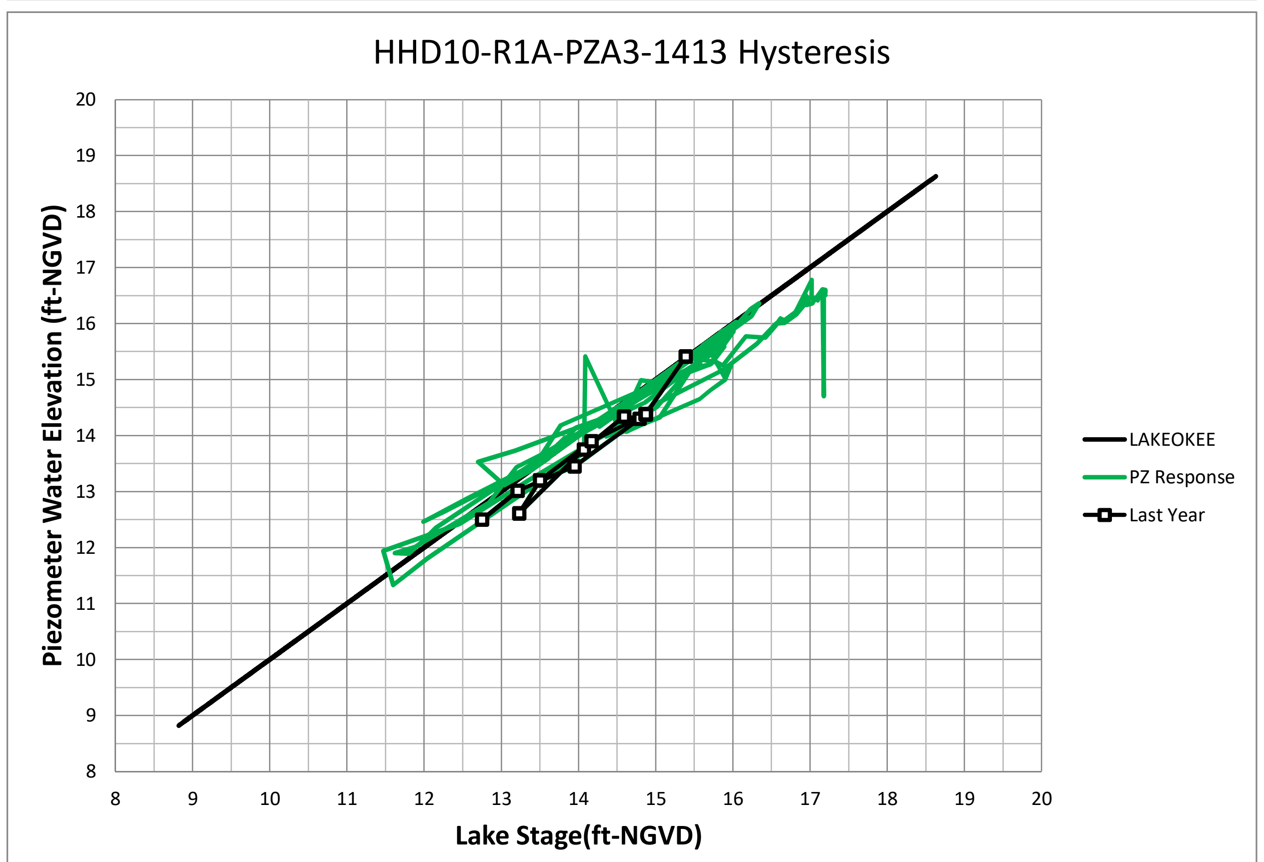


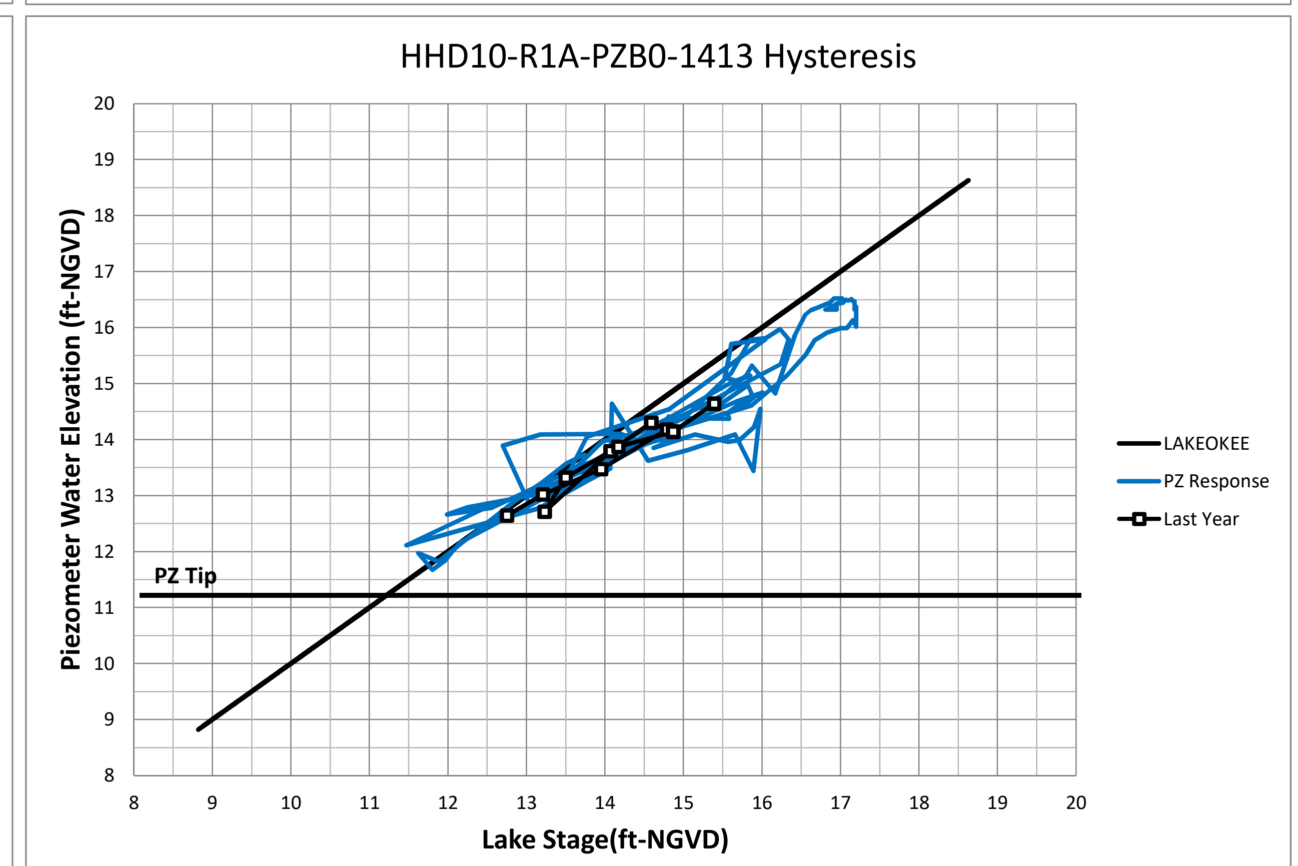


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

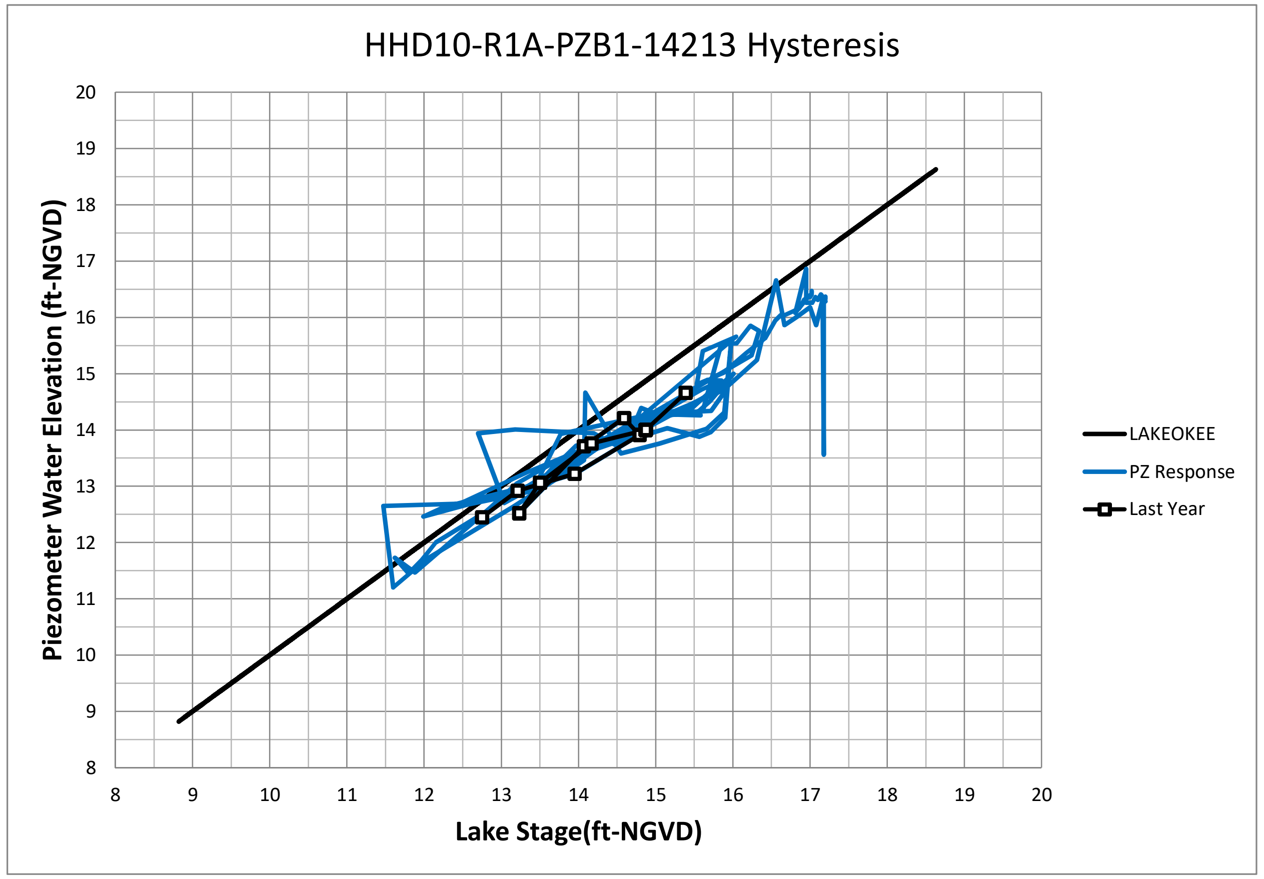


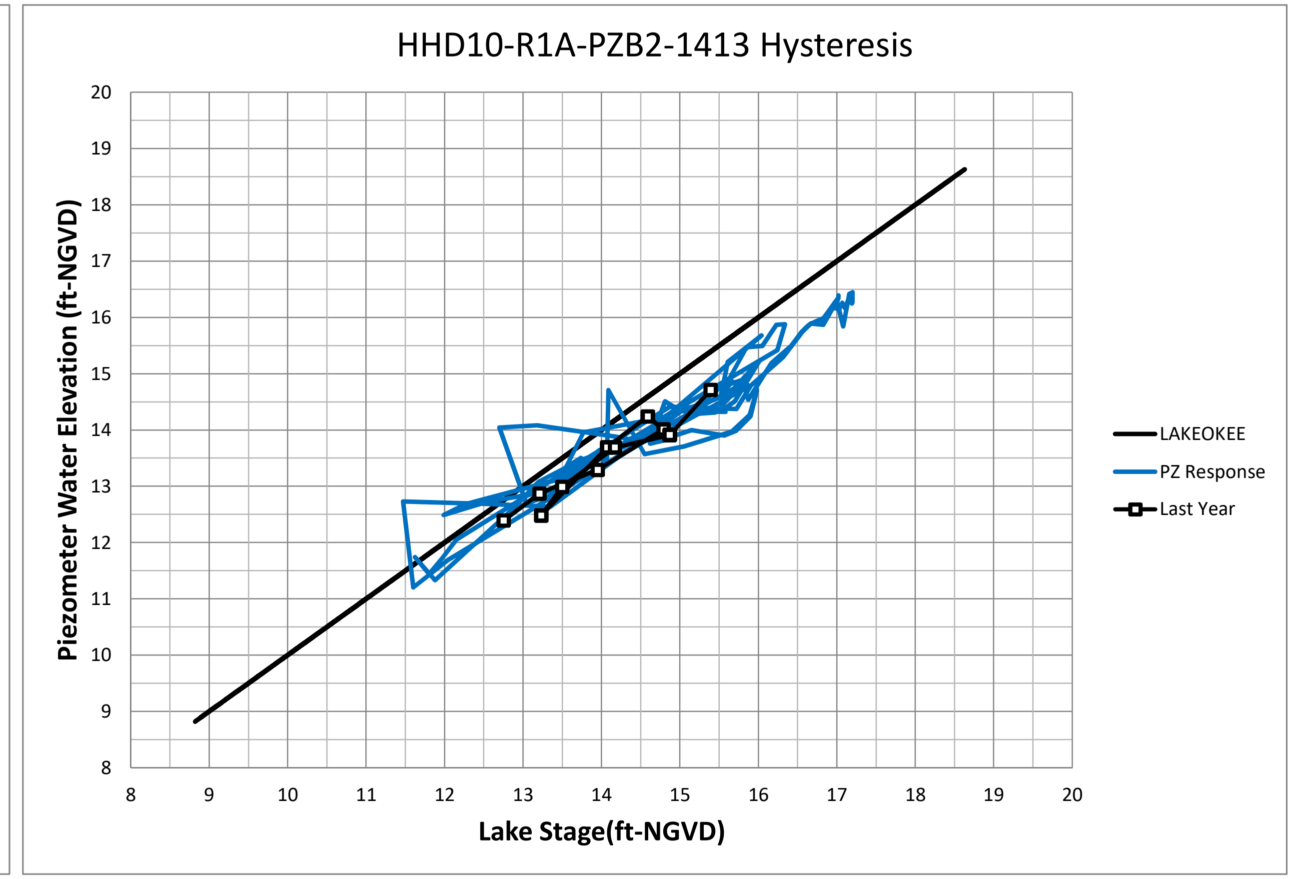


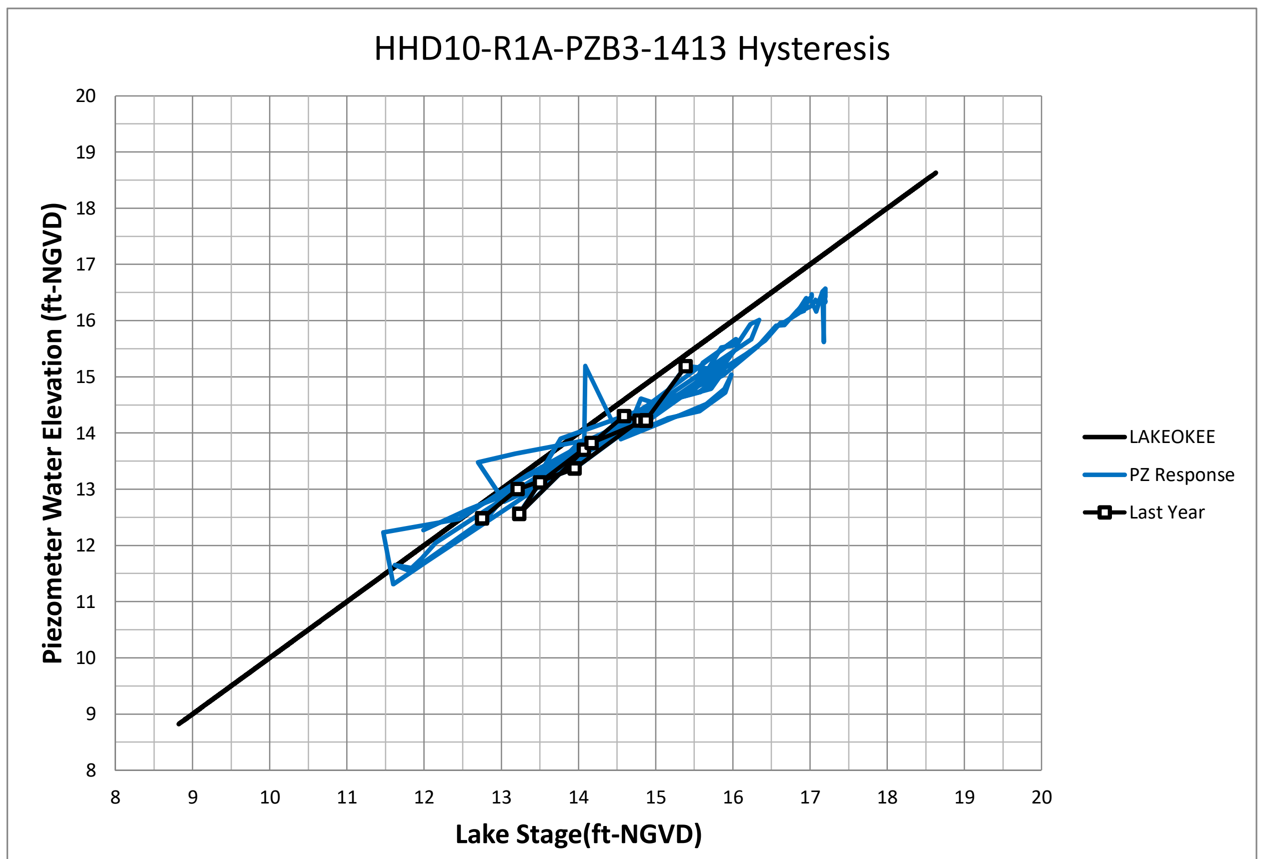


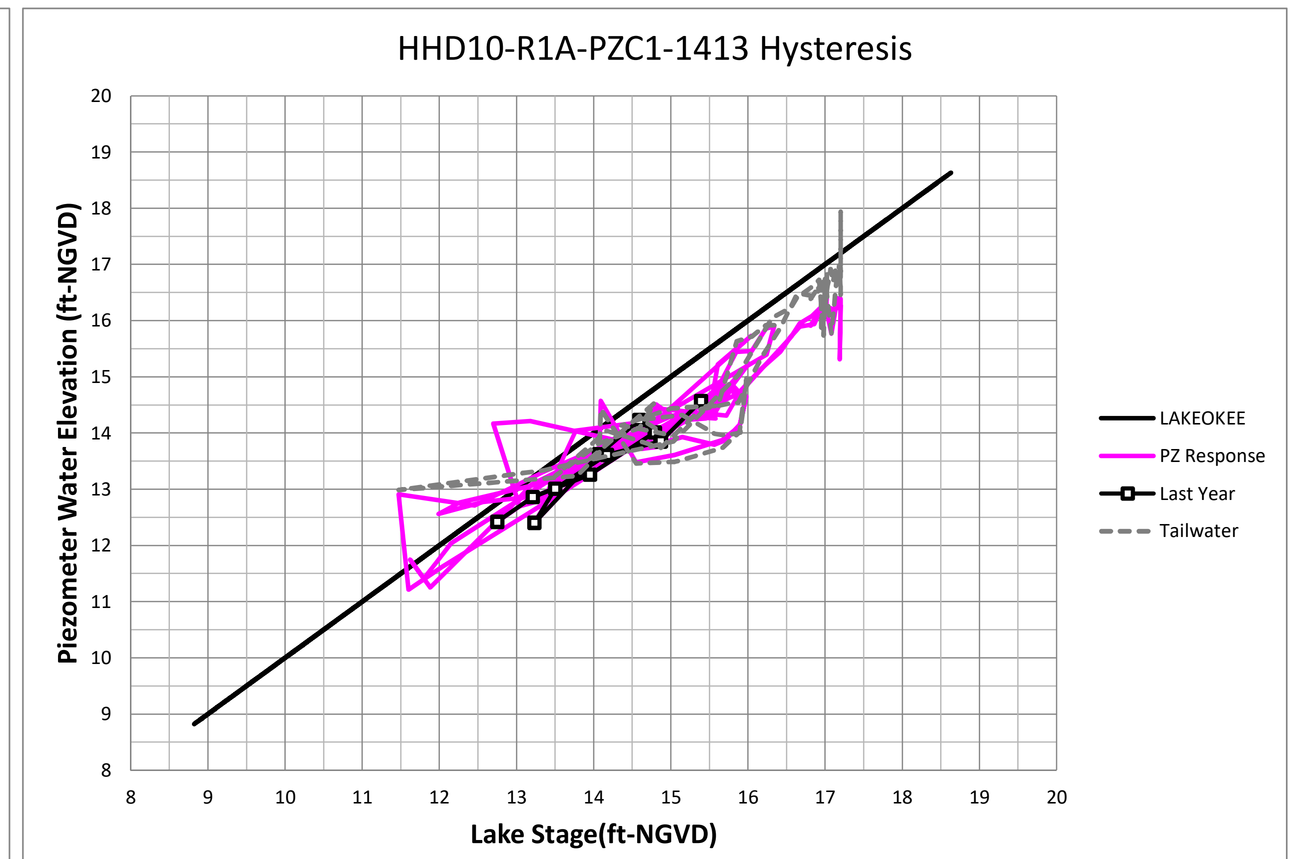


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

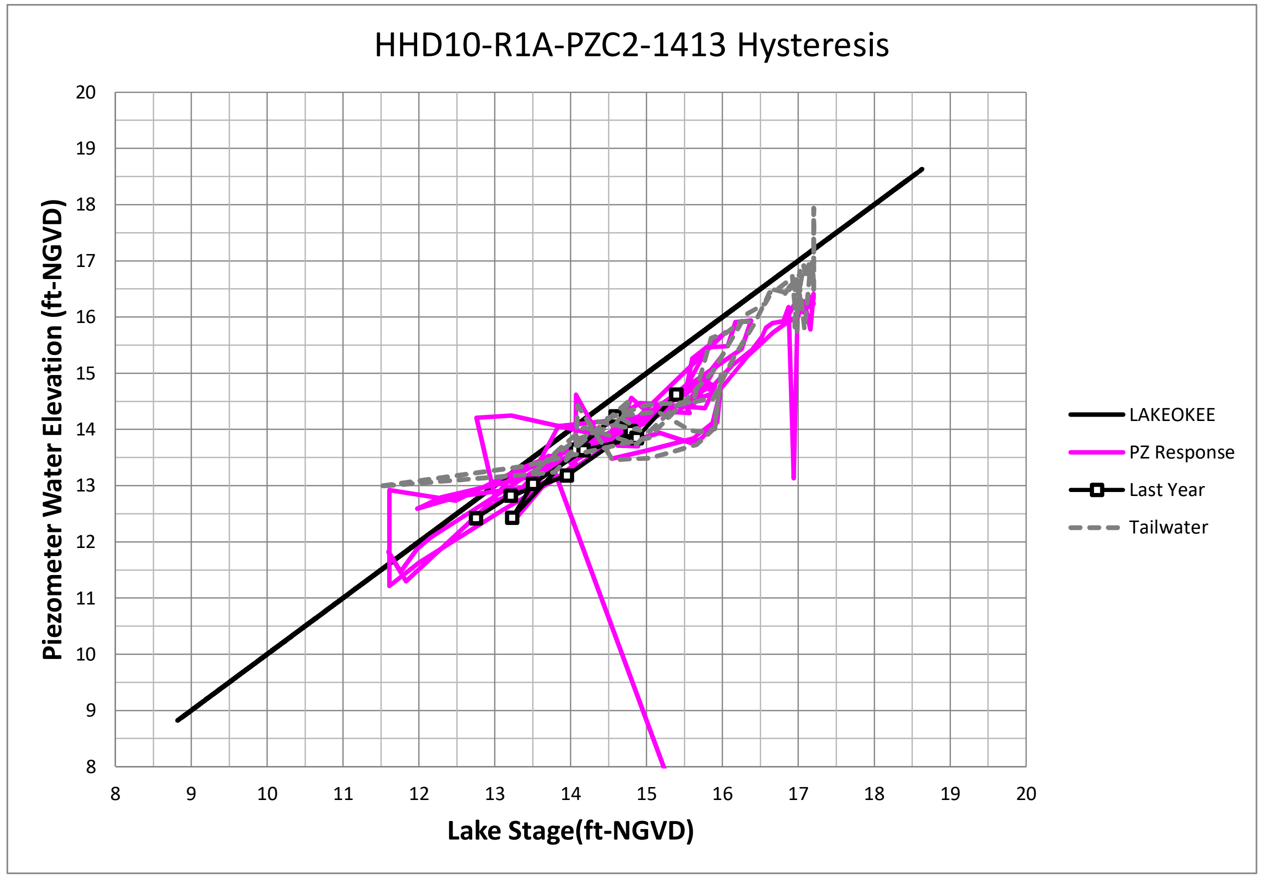


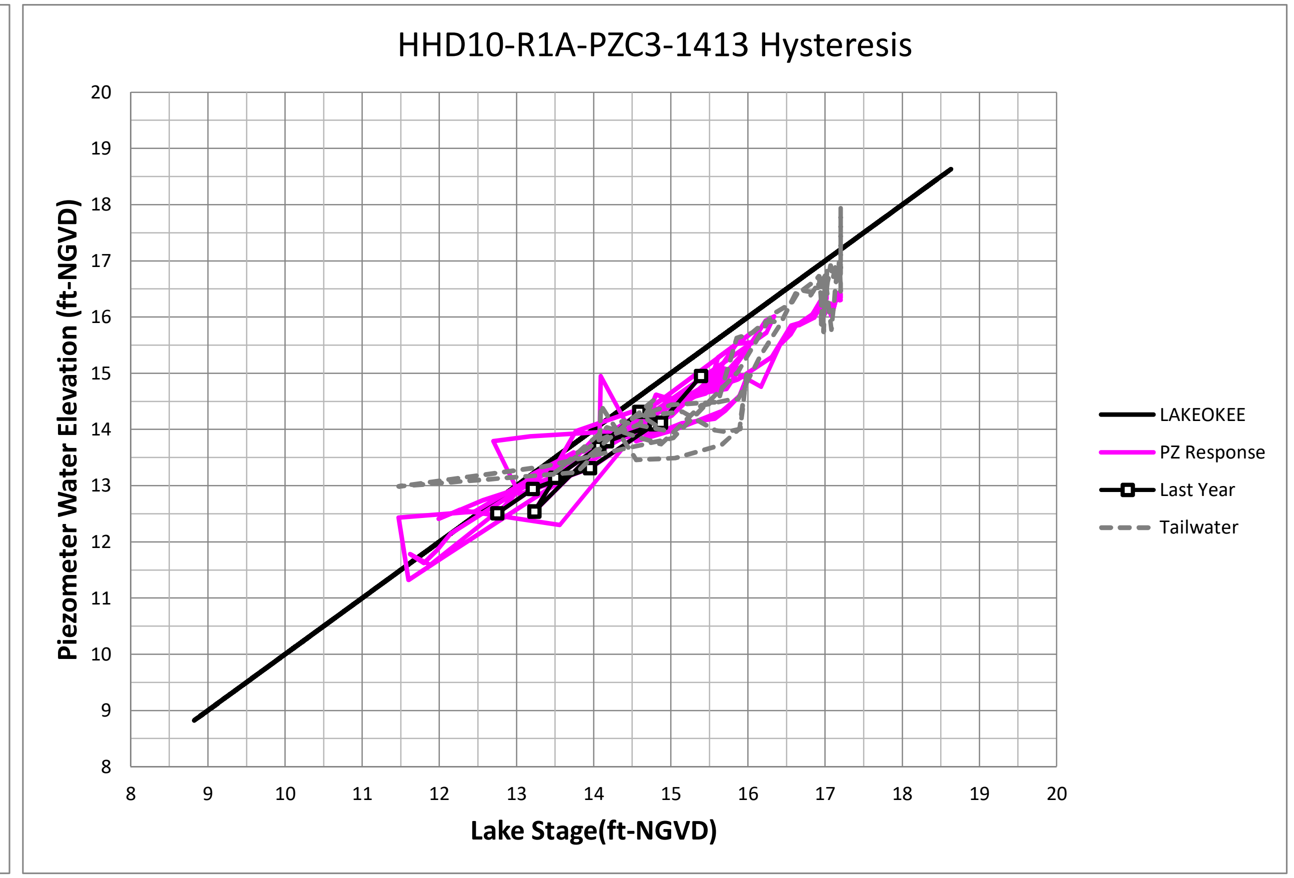






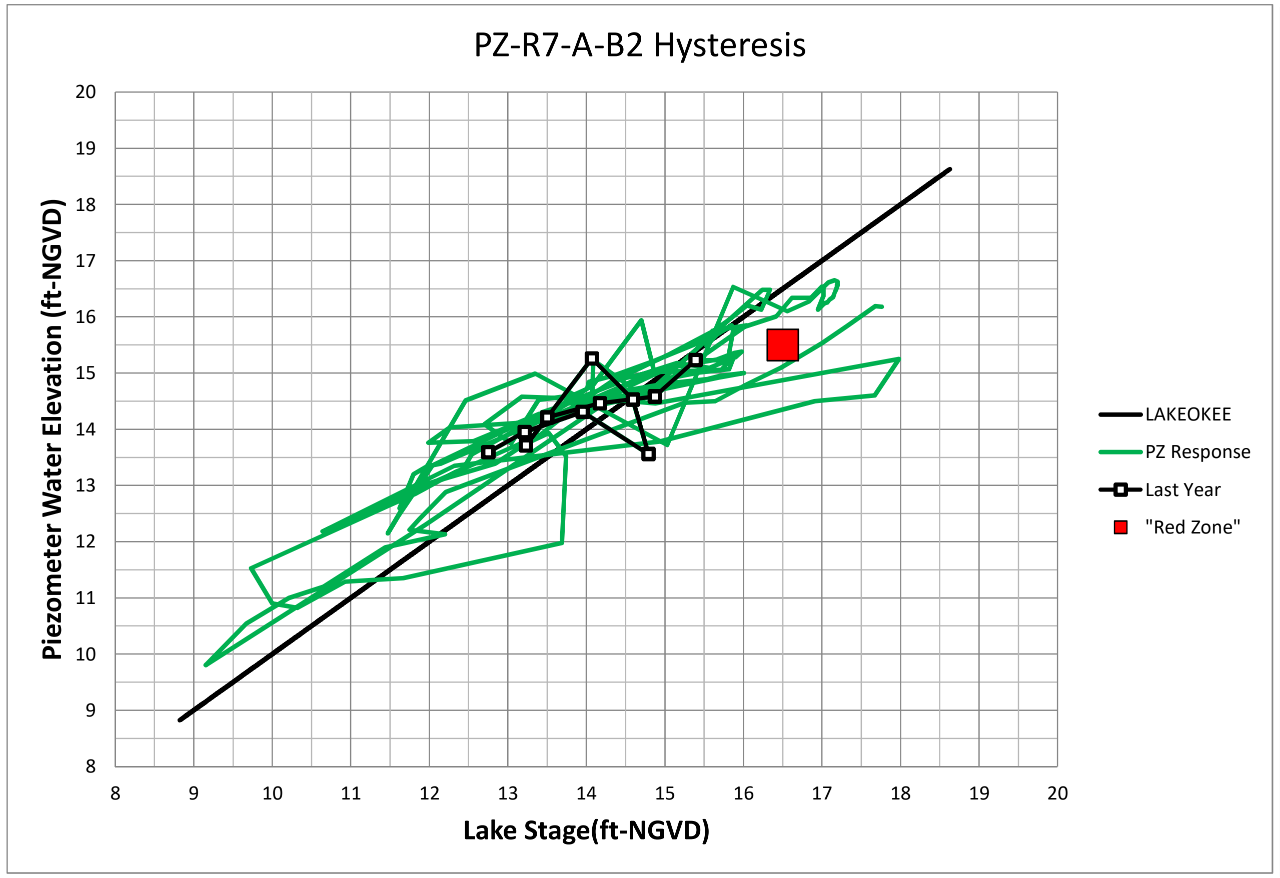
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

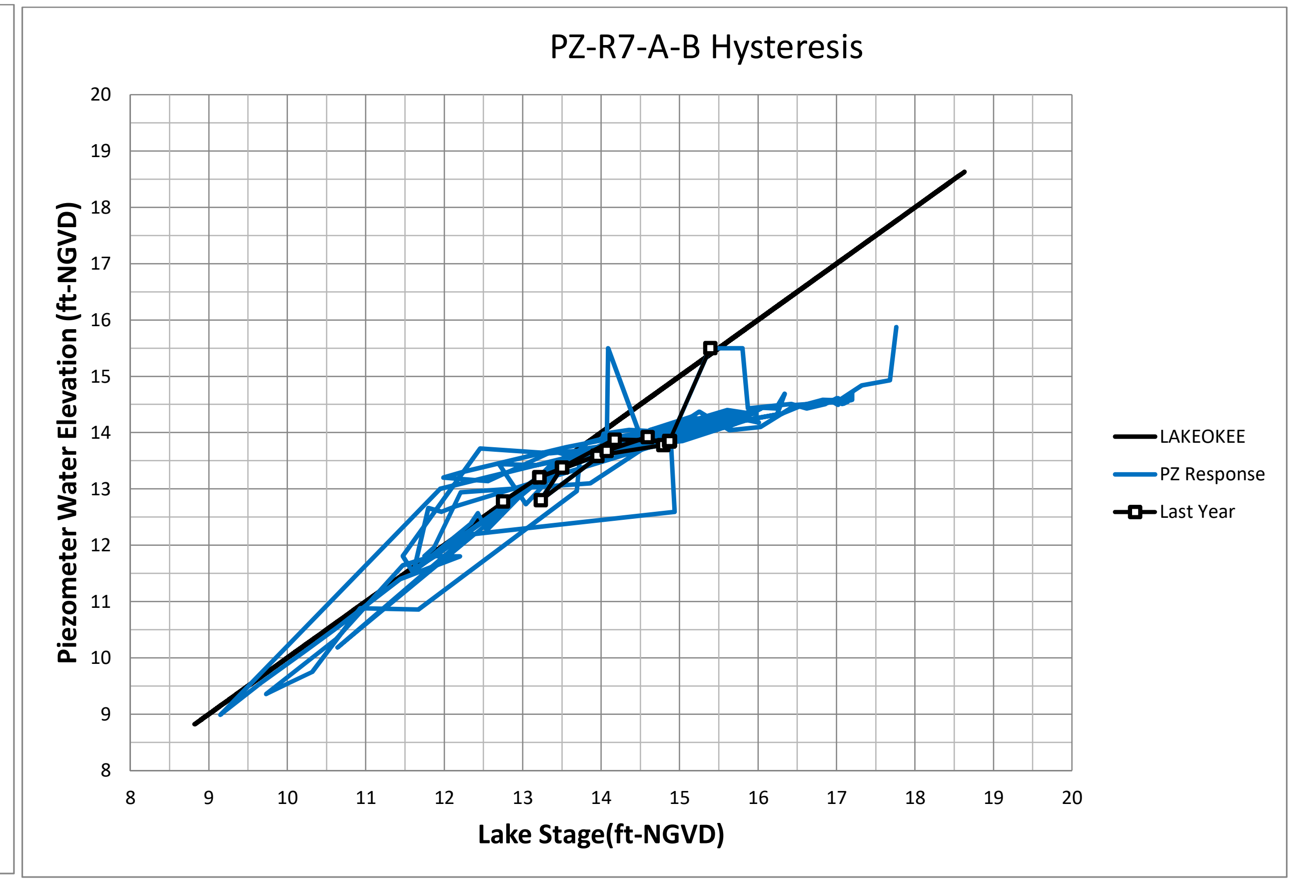


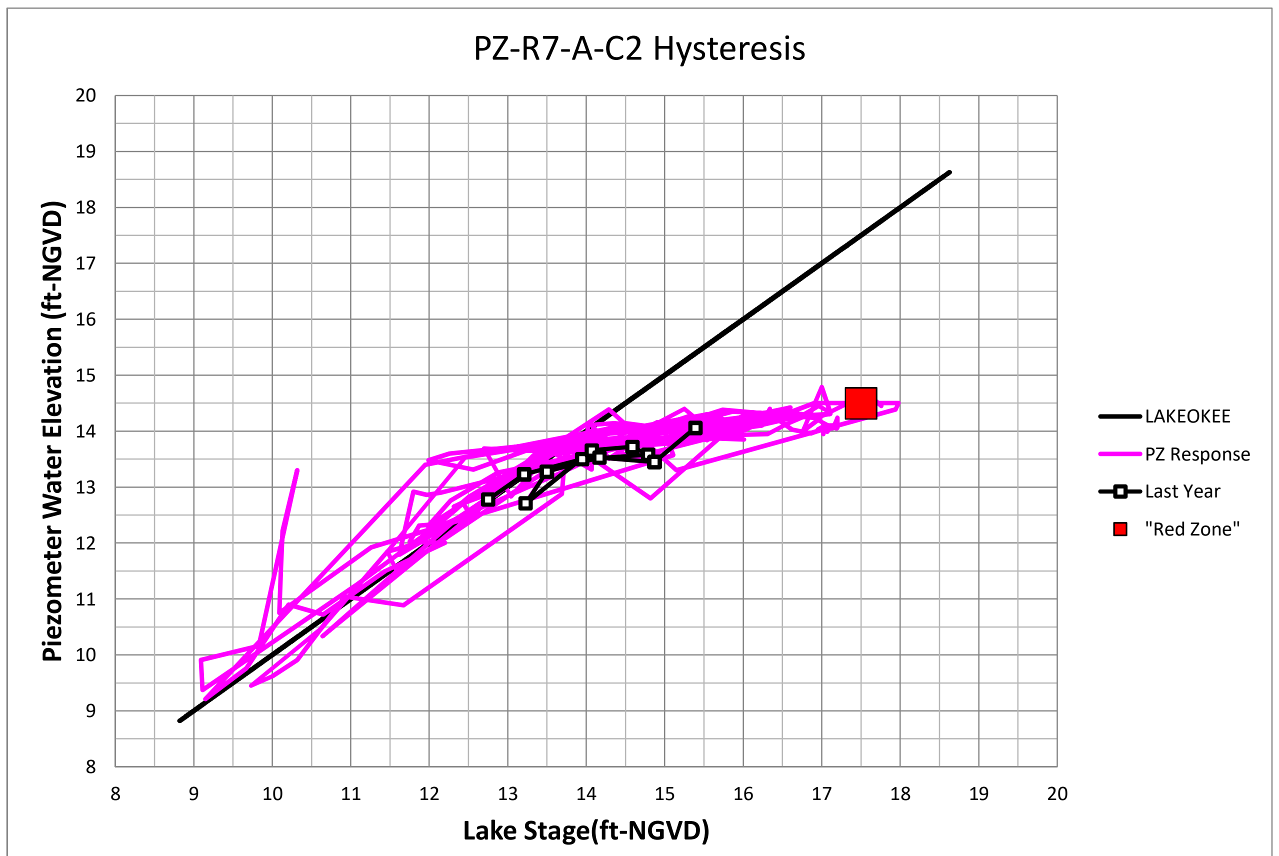


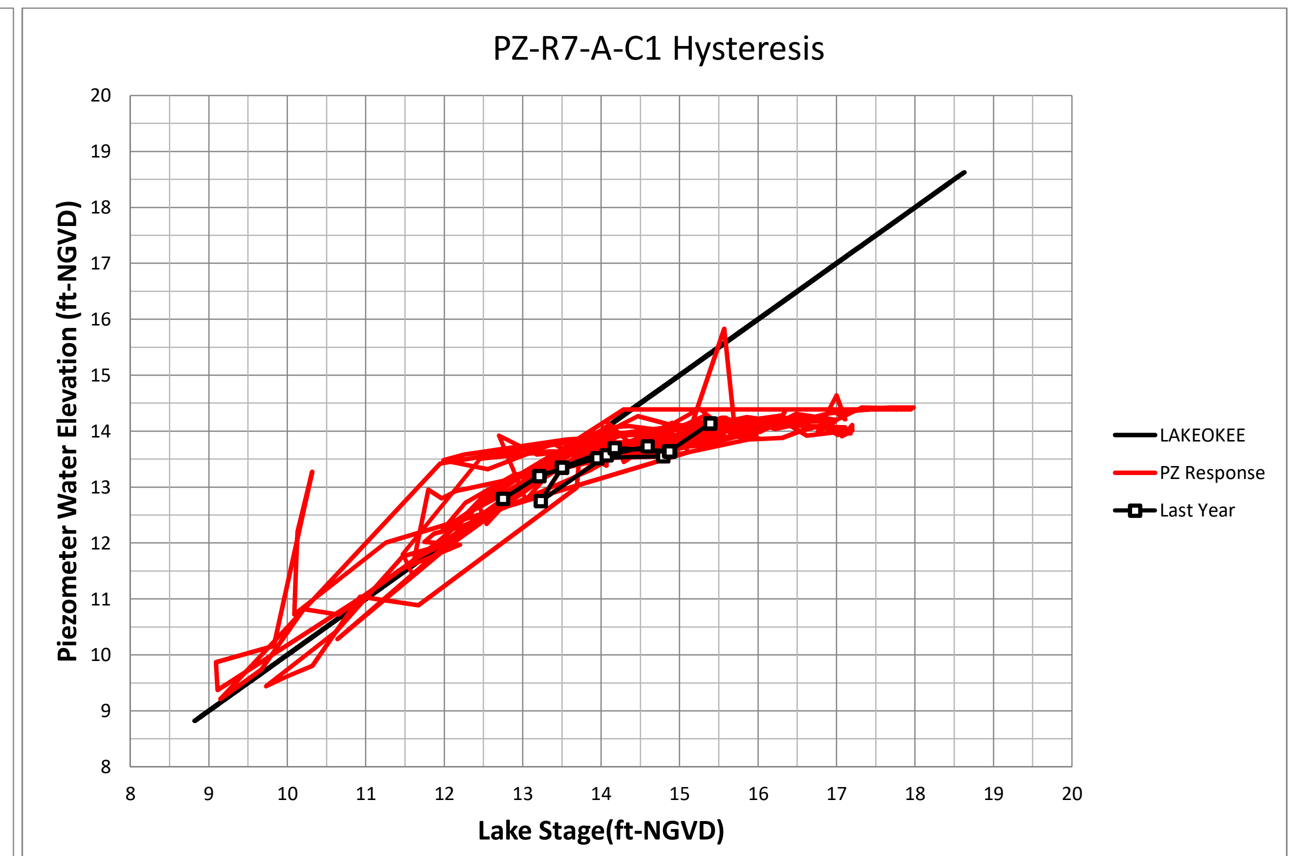
Herbert Hoover Dike- Lake Okeechobee, Florida

Instrumentation Update

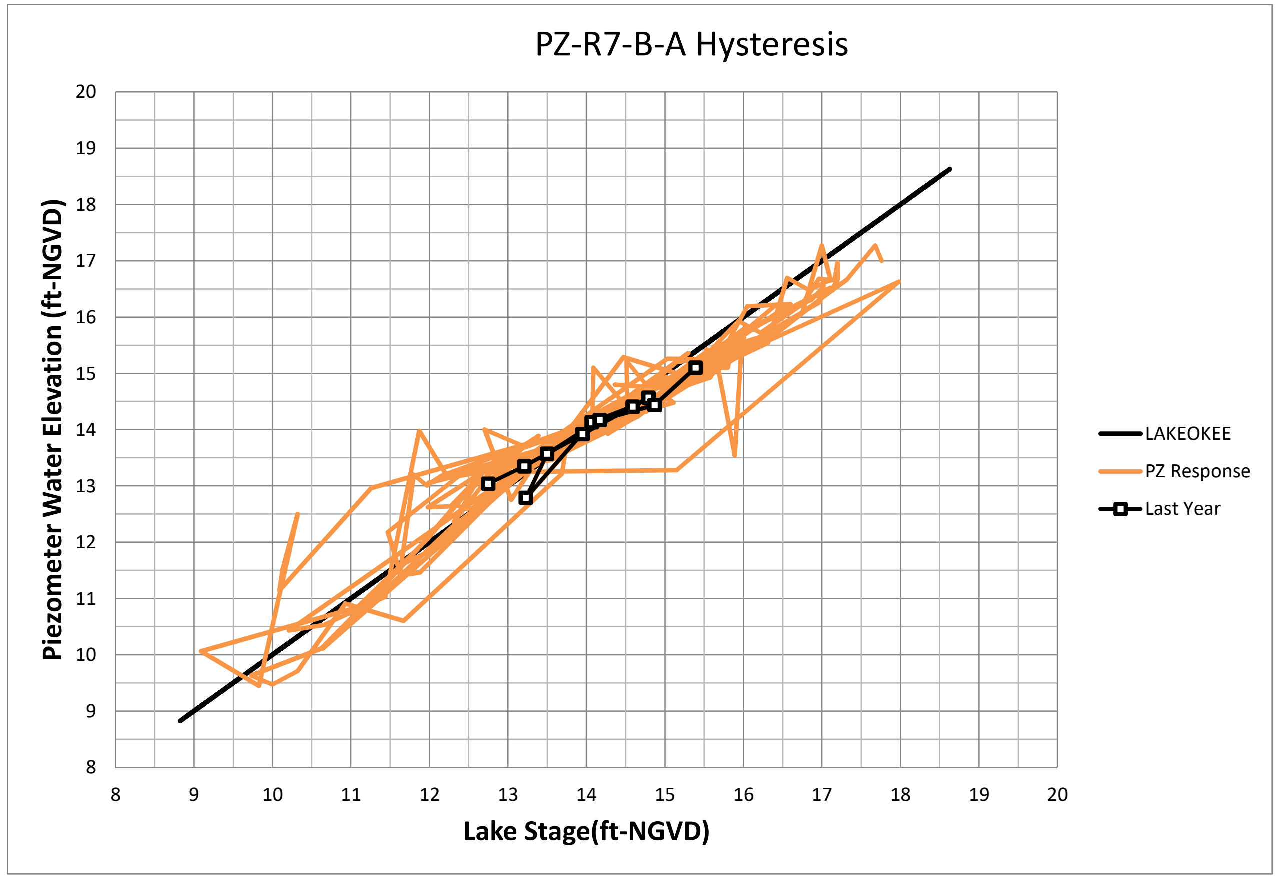


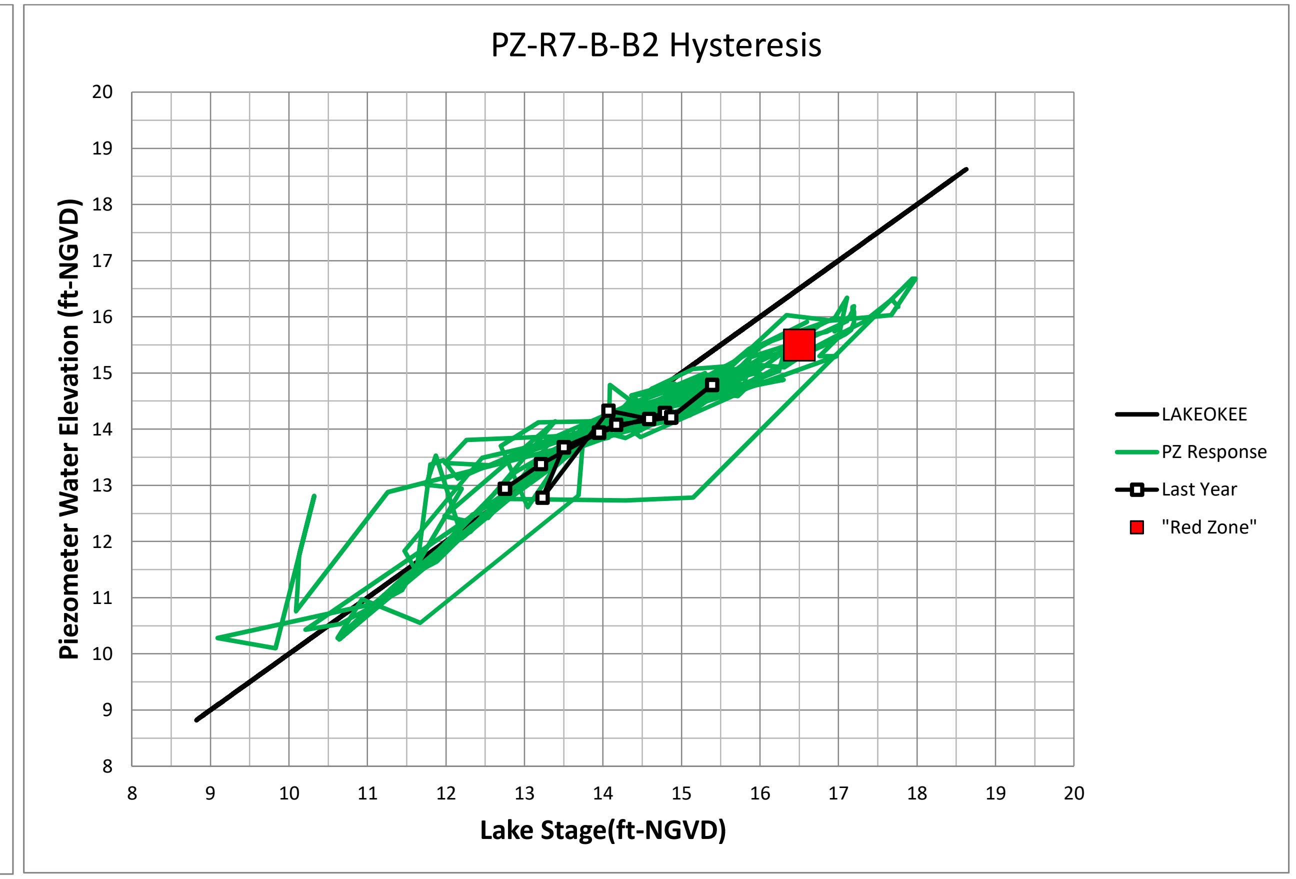


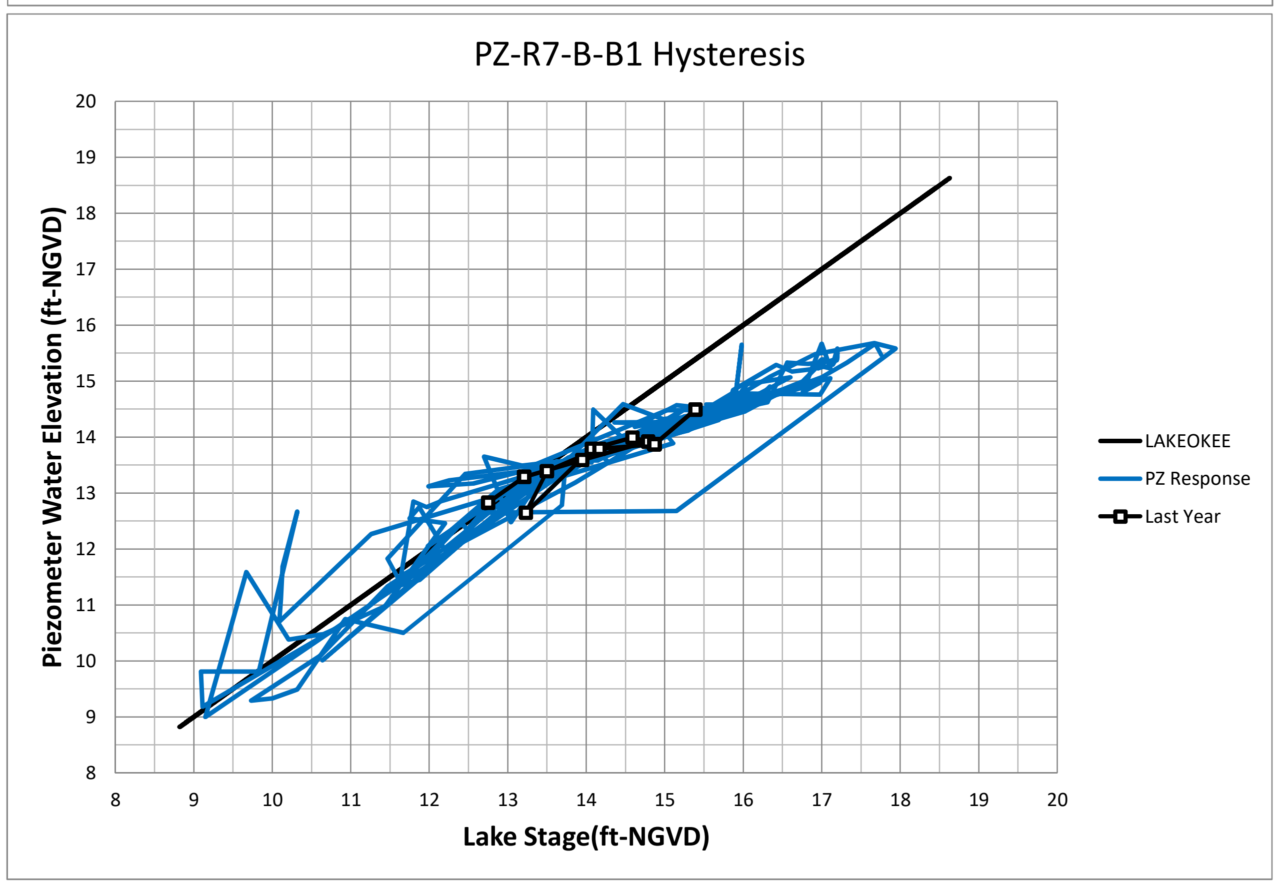




Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

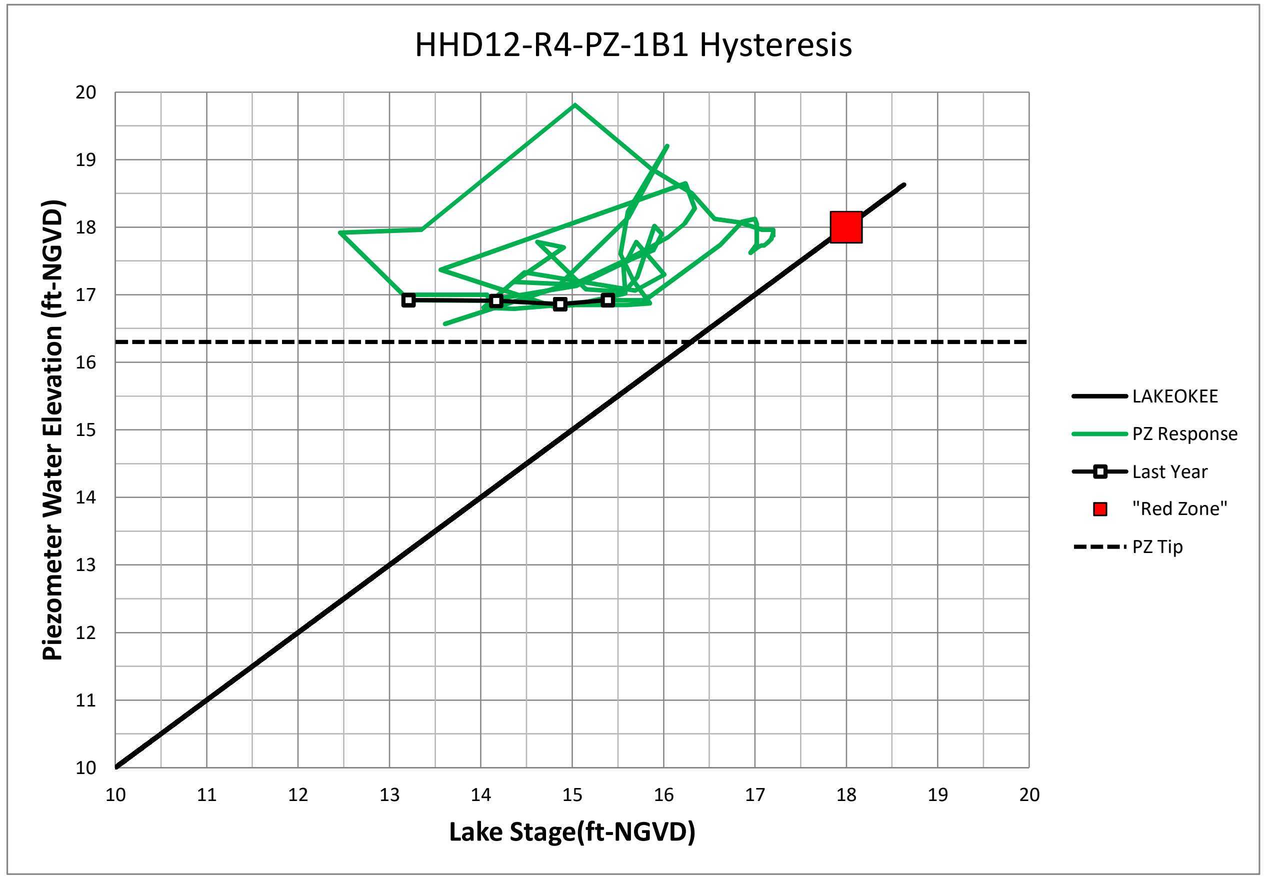


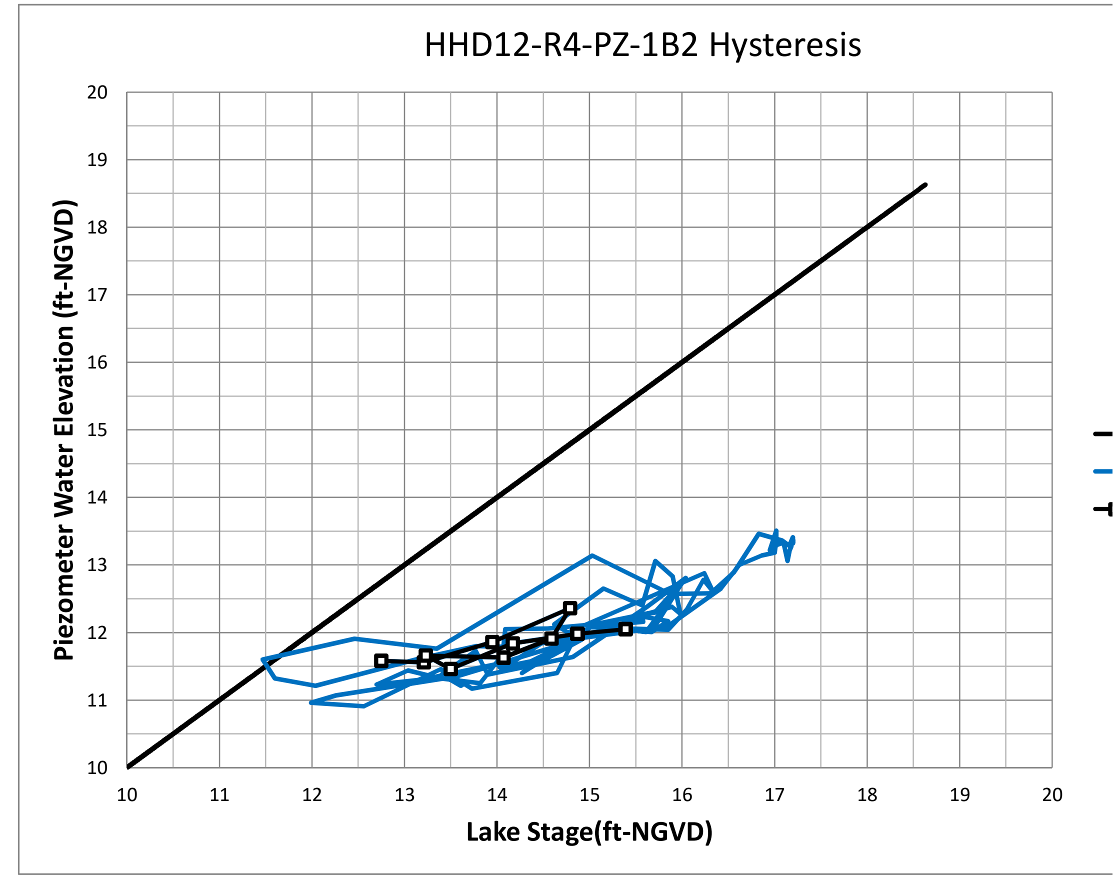


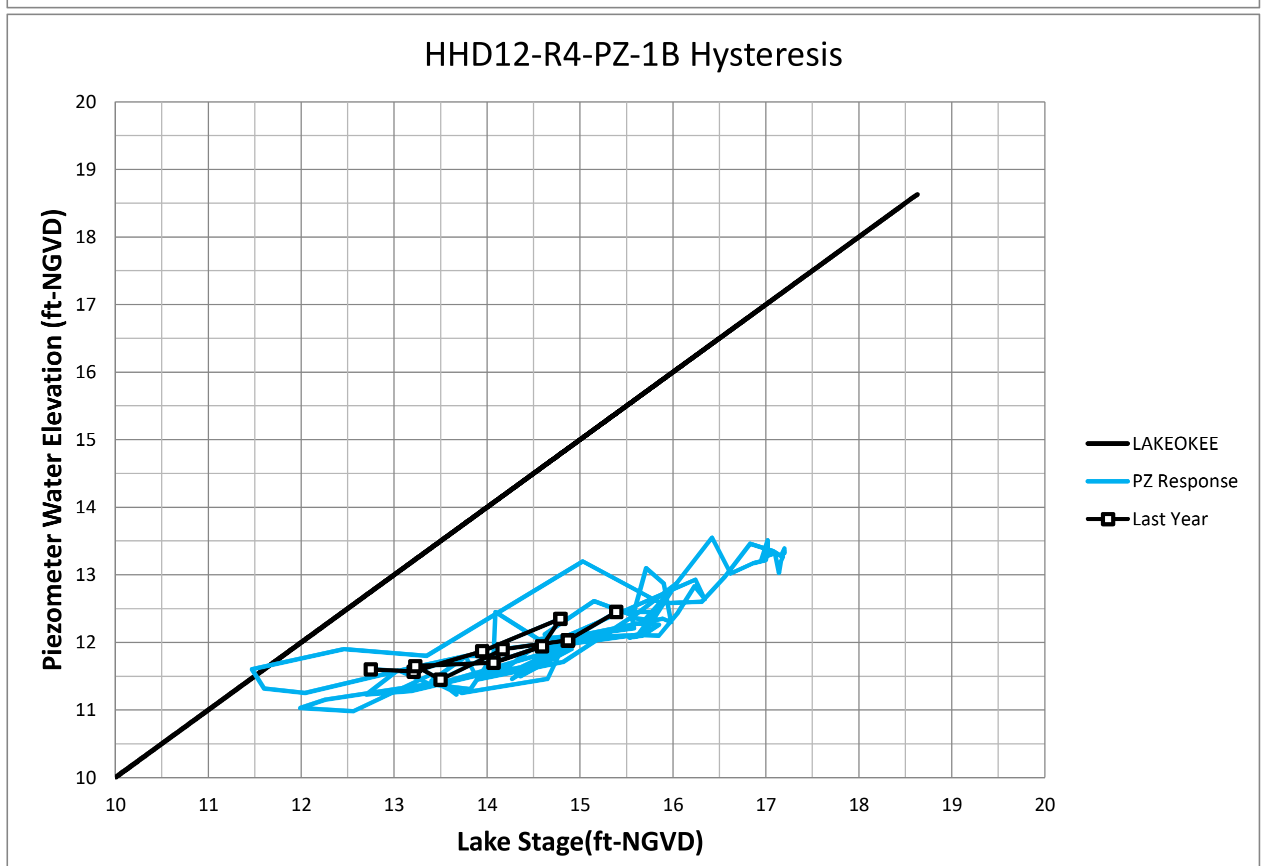


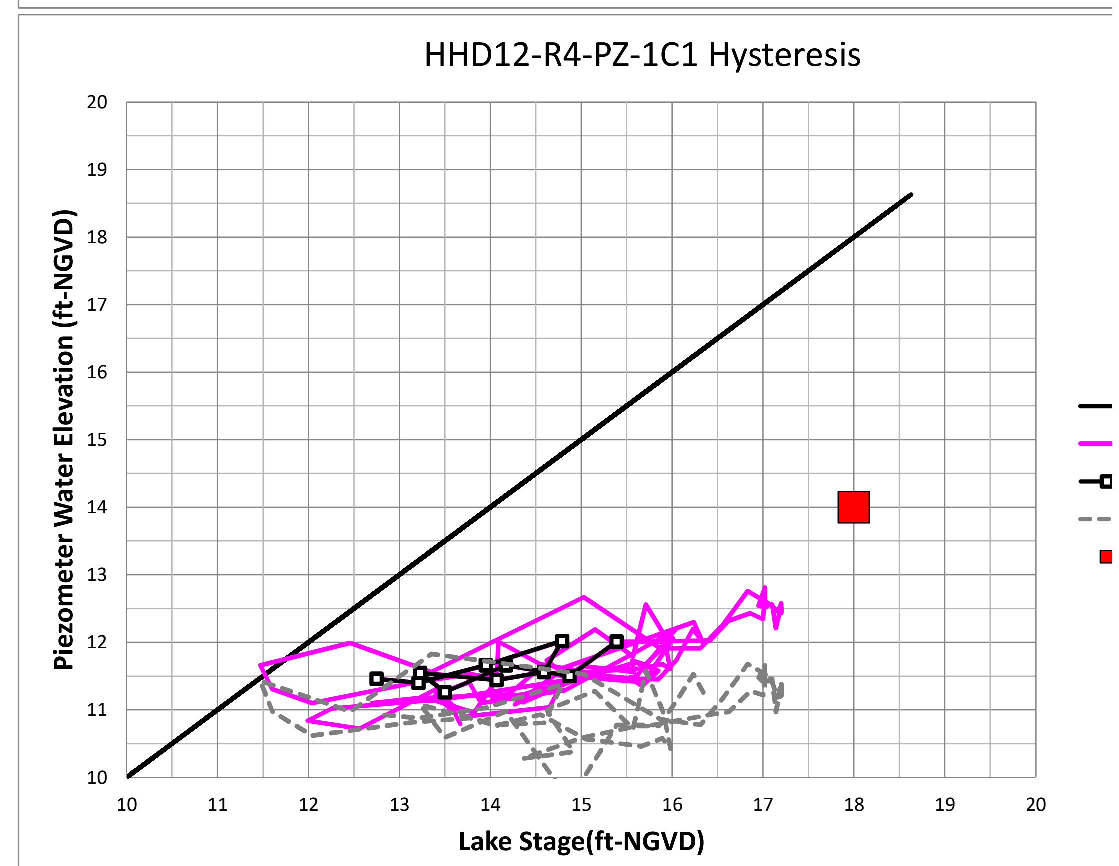
Herbert Hoover Dike- Lake Okeechobee, Florida

Instrumentation Update



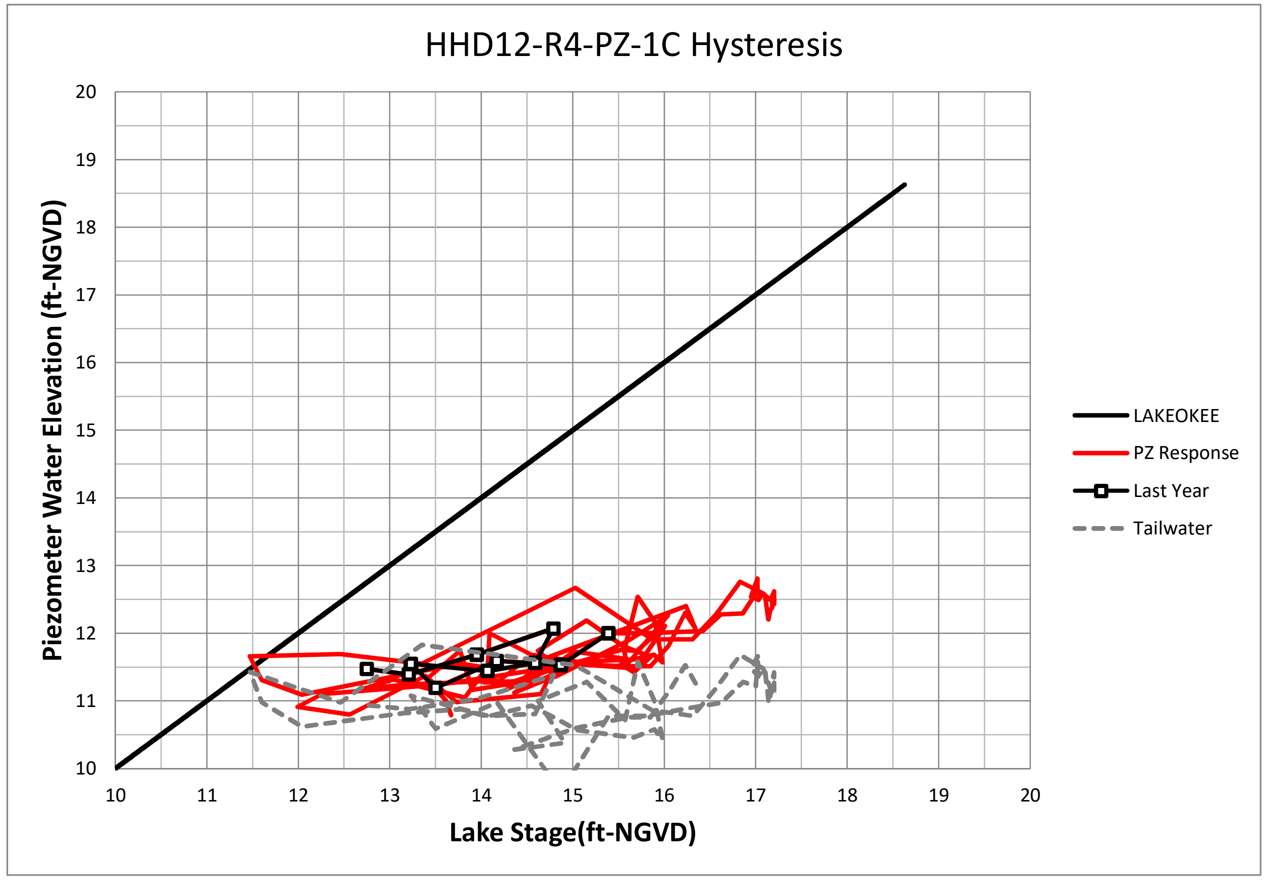




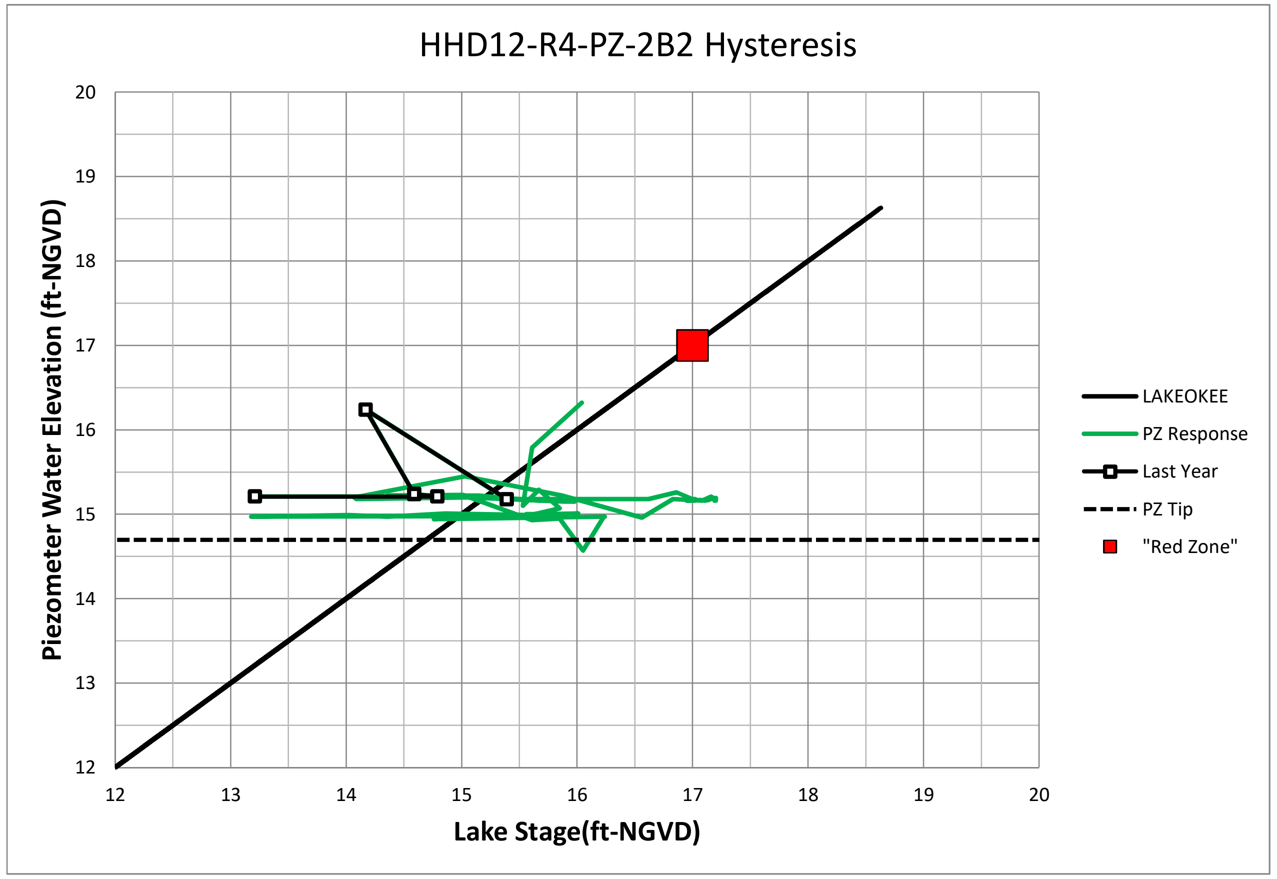


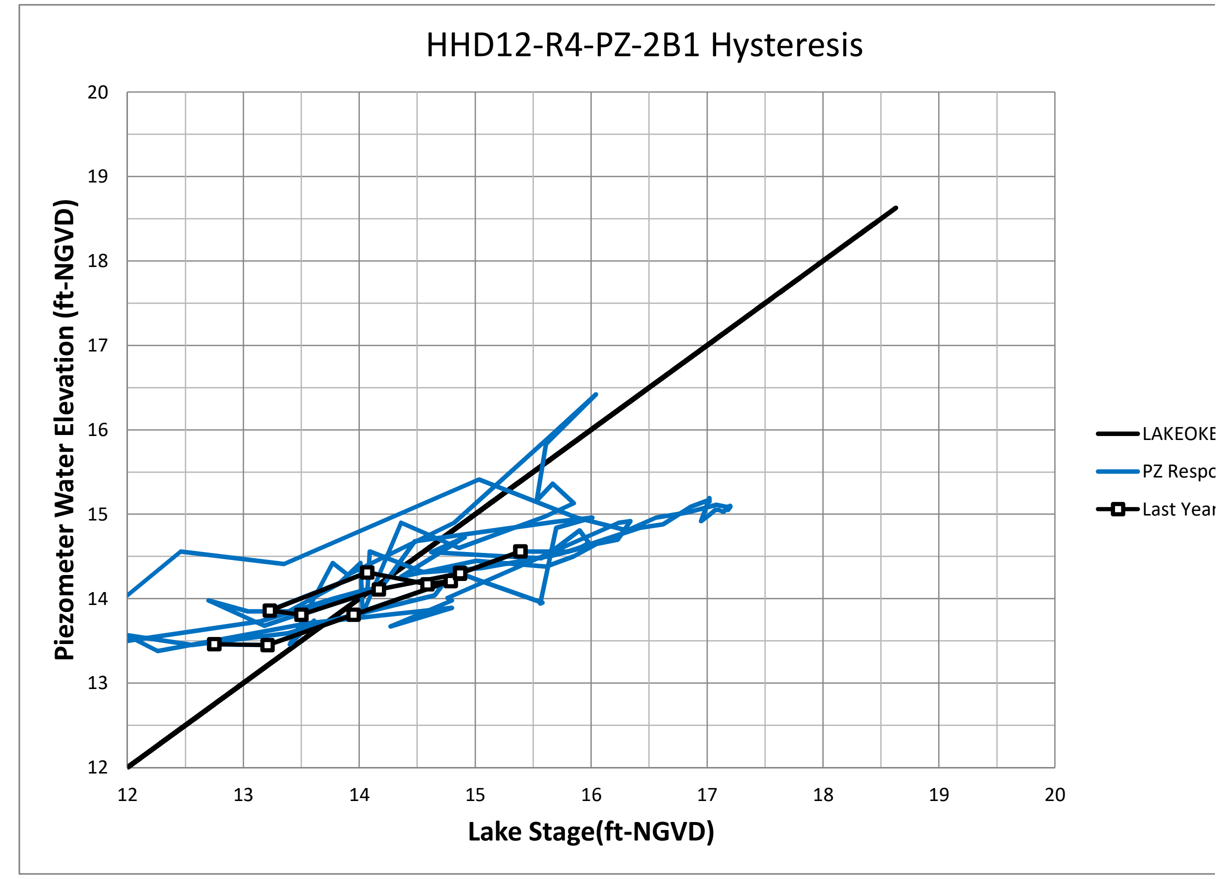
Department of the Army
Jacksonville District, Corps of Engineers
Jacksonville, Florida

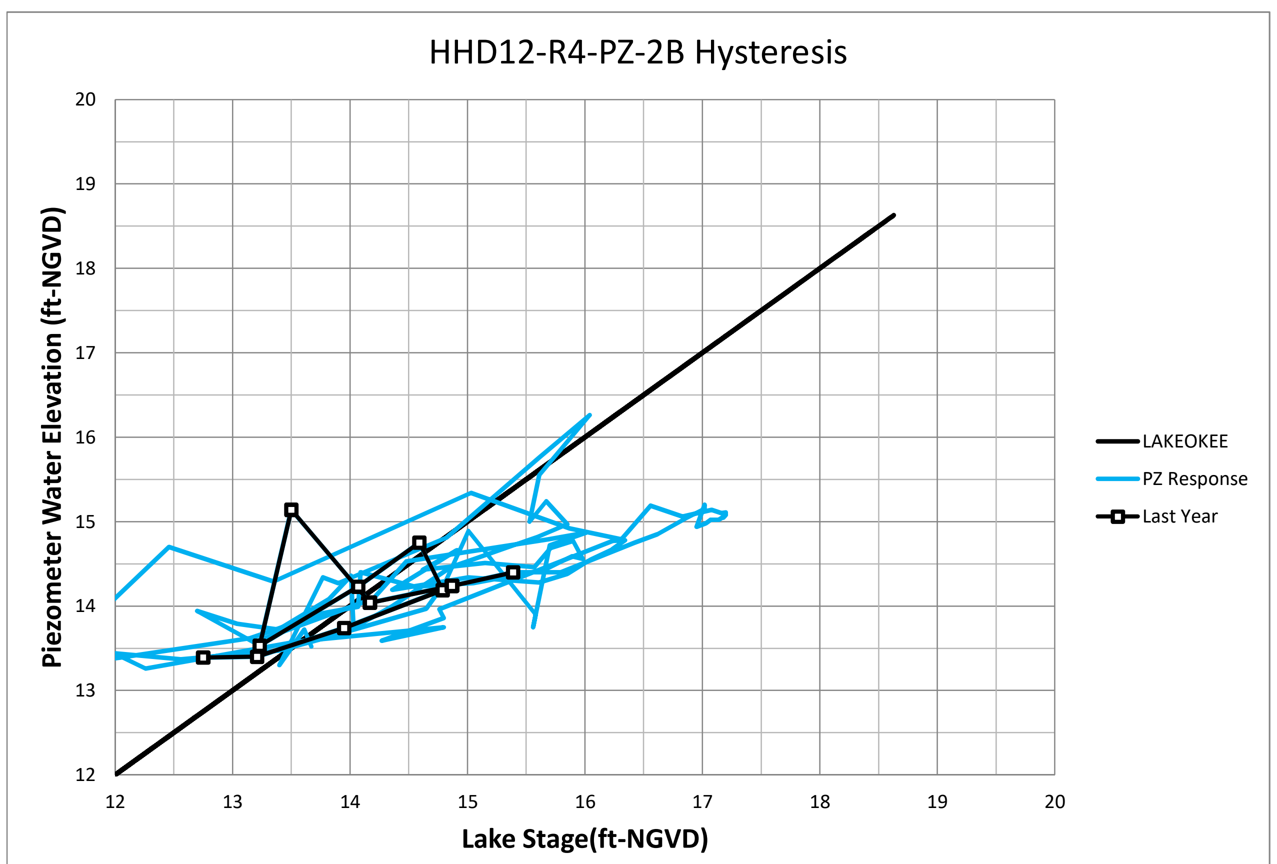
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

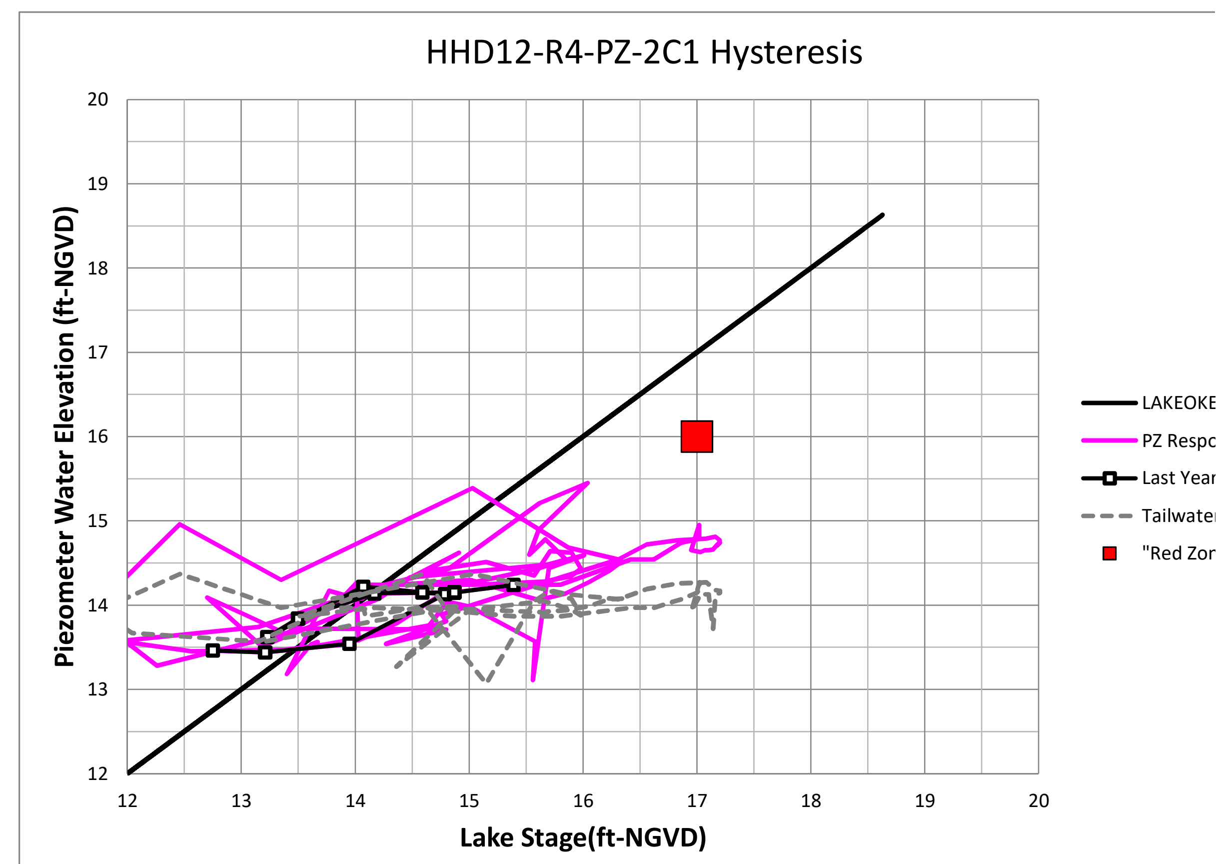


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

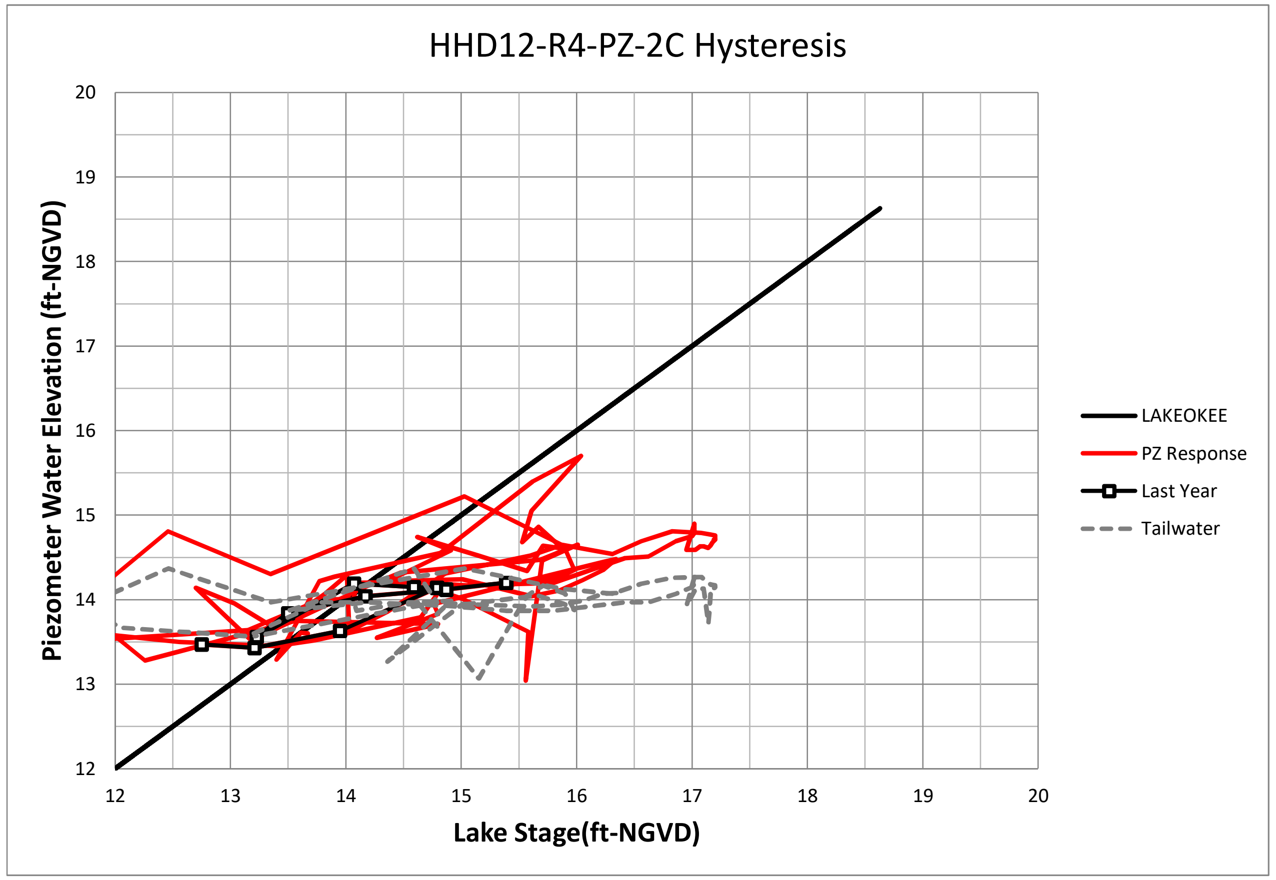






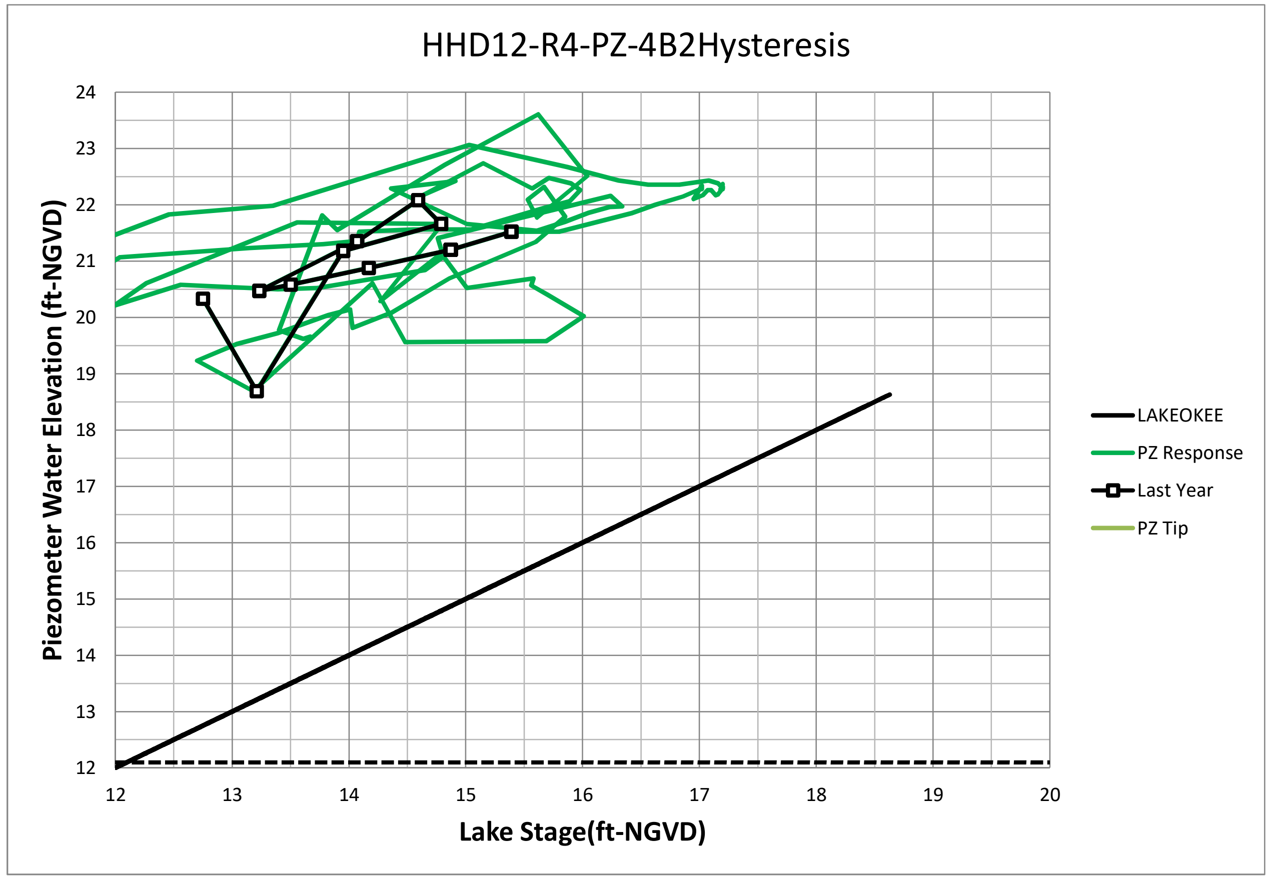


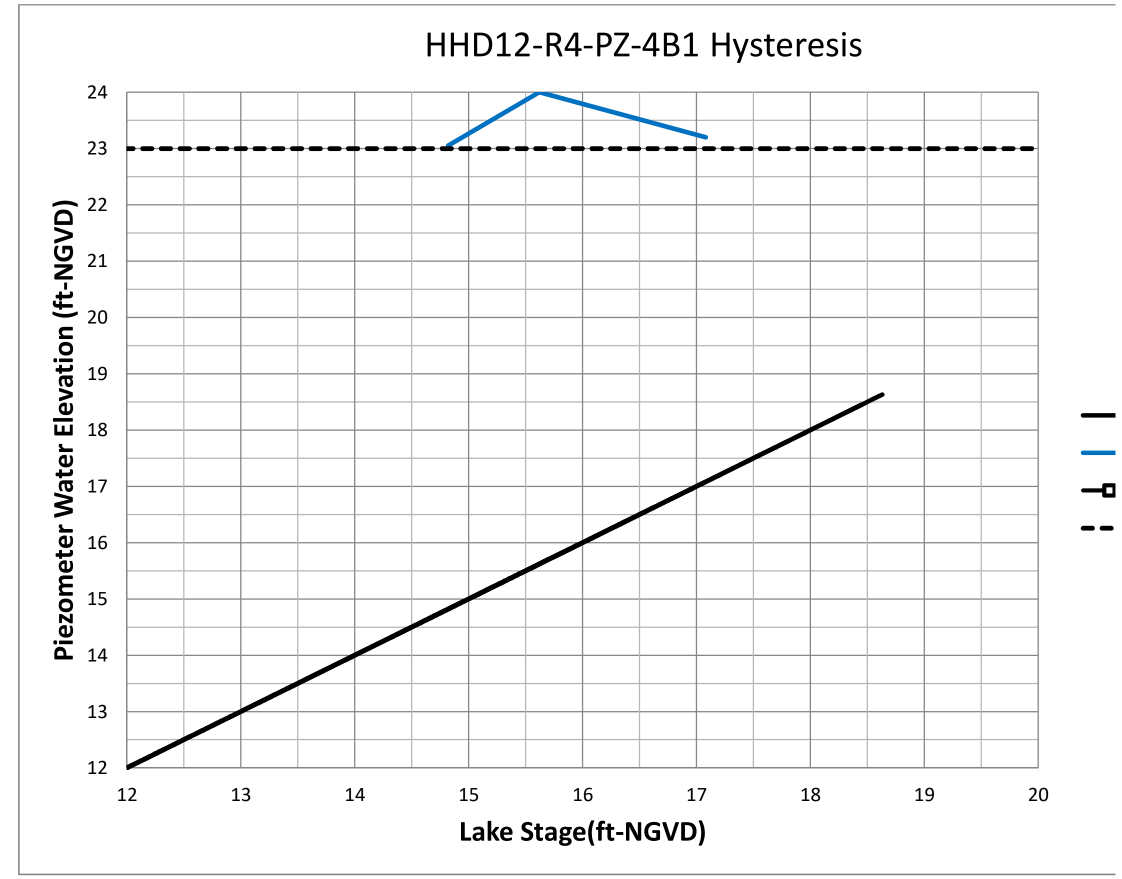
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

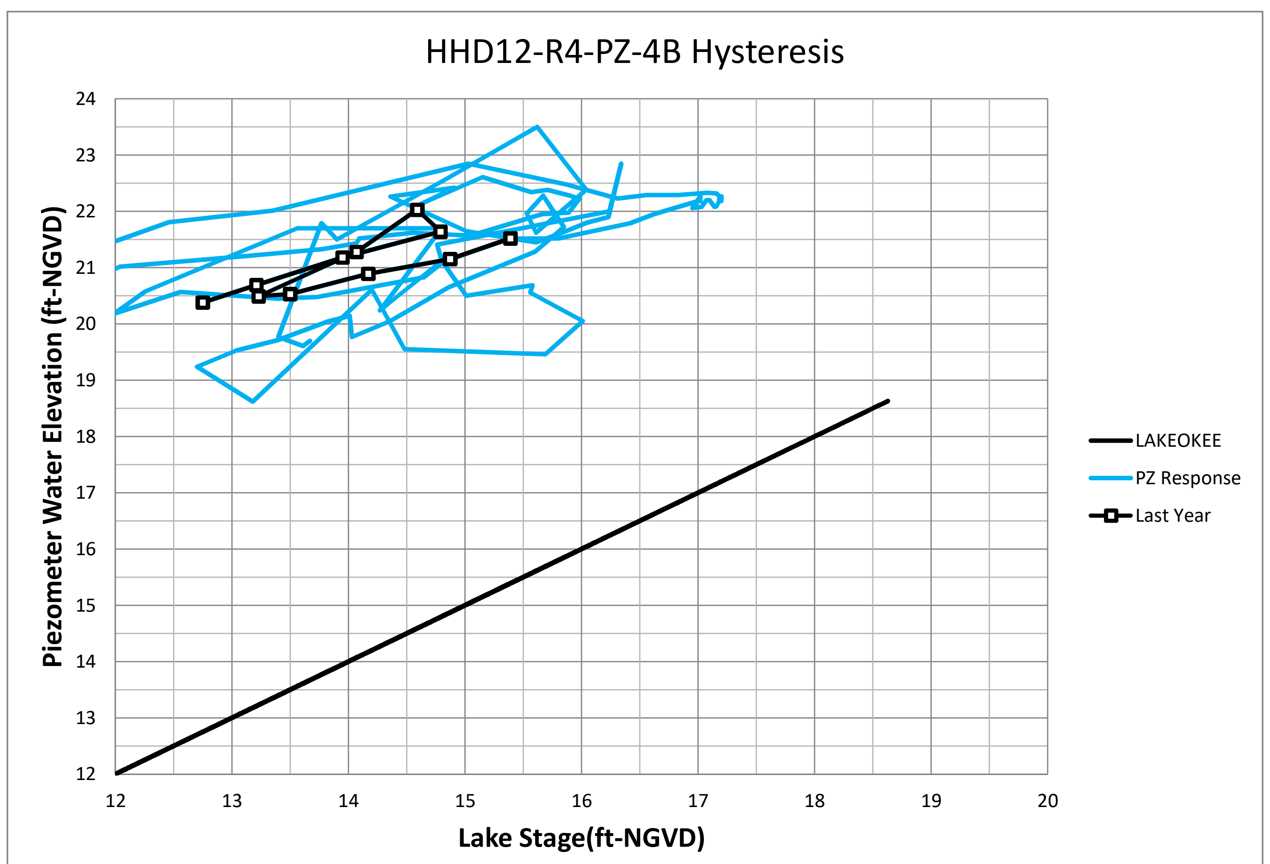


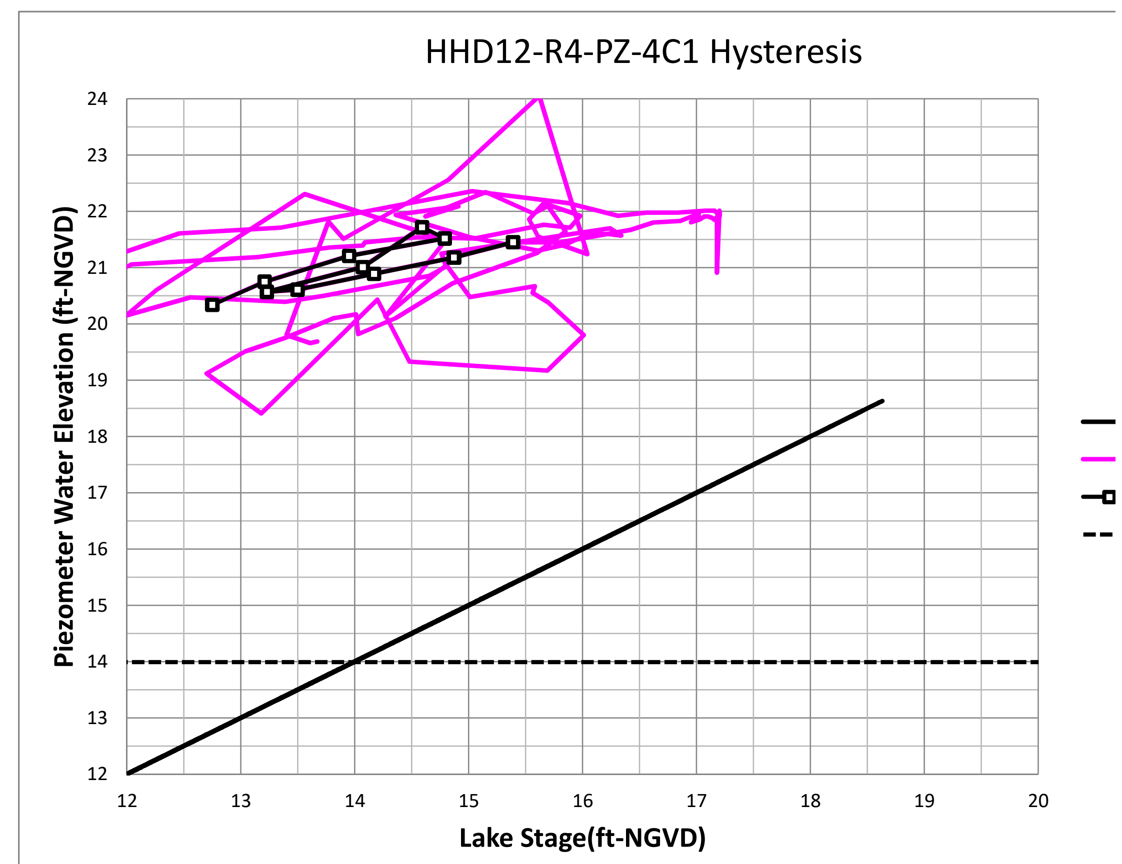
Herbert Hoover Dike- Lake Okeechobee, Florida

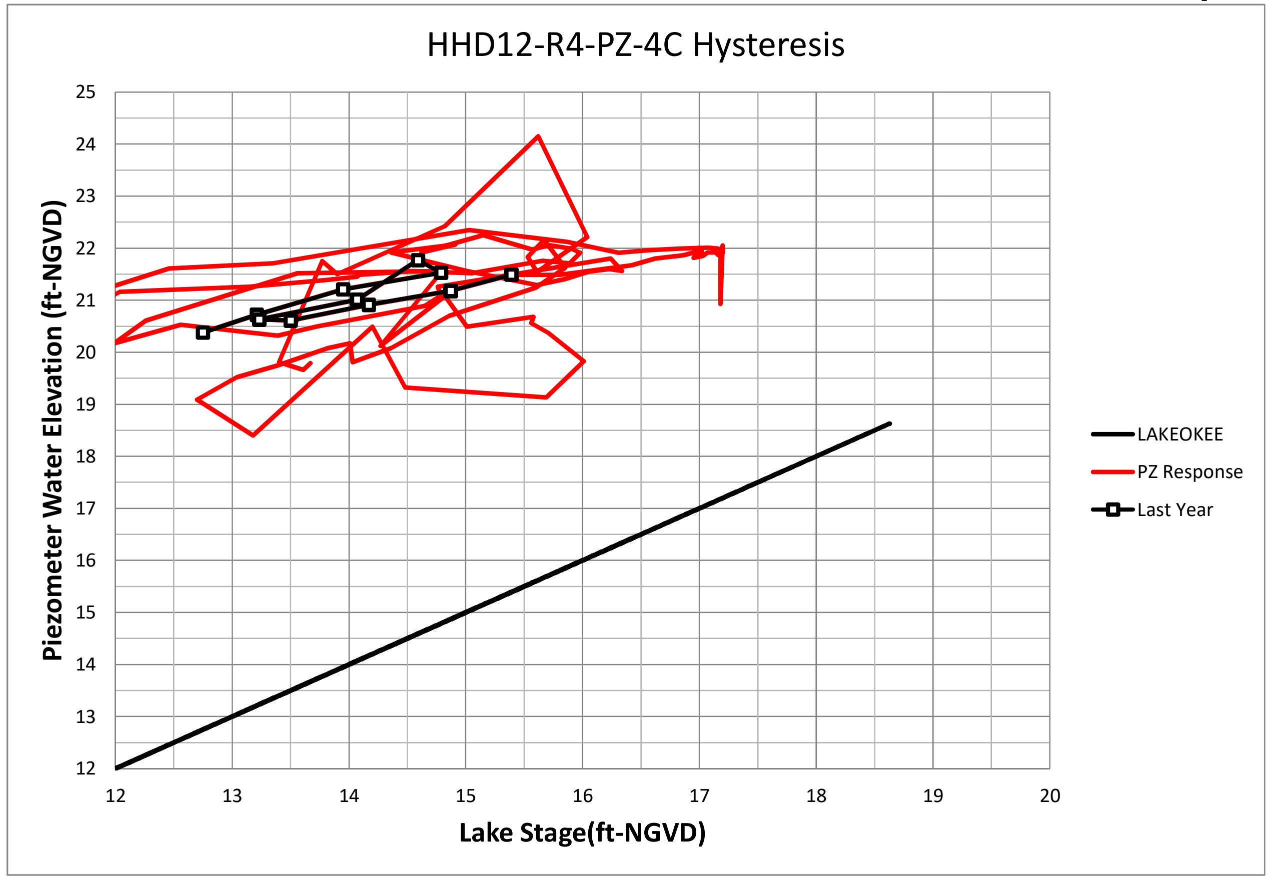
Instrumentation Update










HHD12-R4-PZ-4C Hysteresis
25
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12
Piezometer Water Elevation (ft-NGVD)
12
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16
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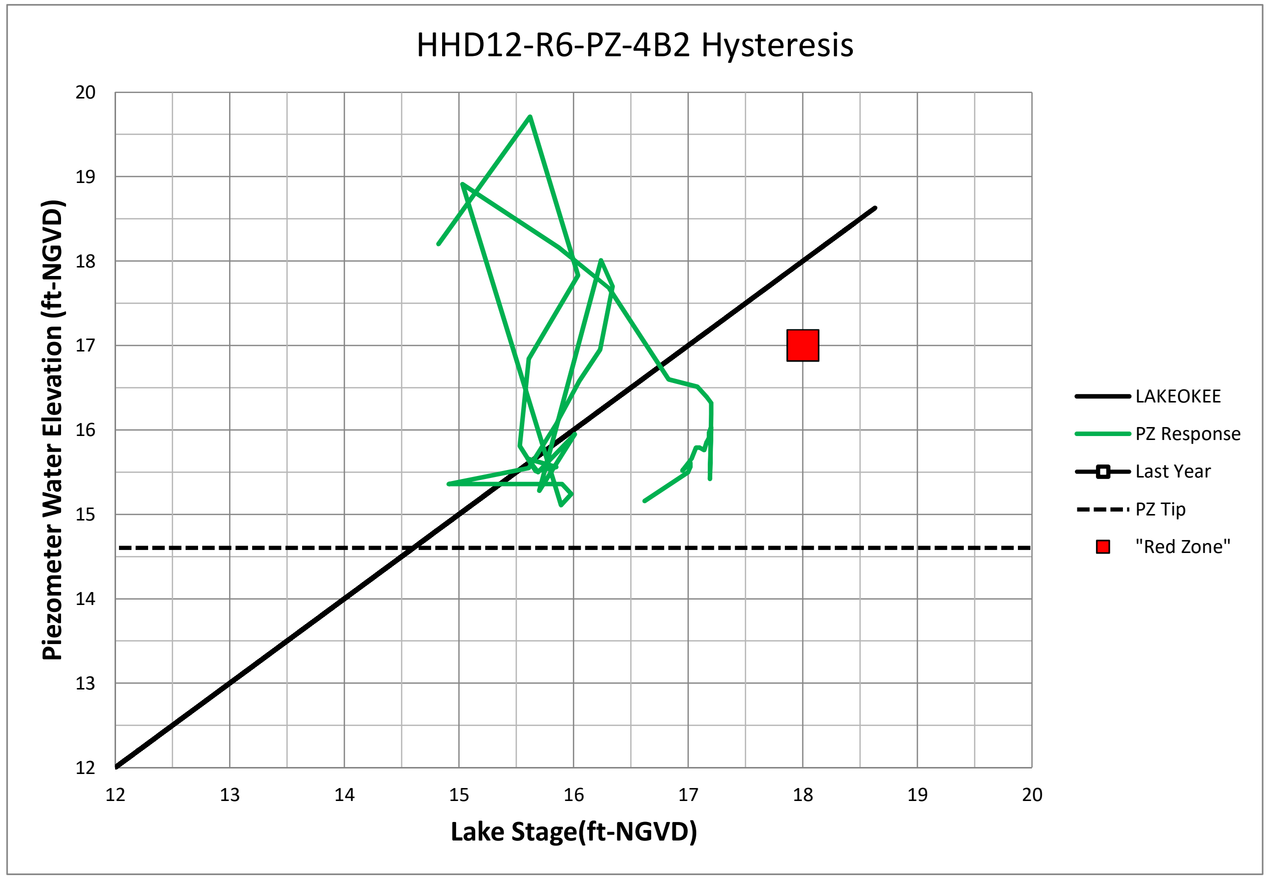
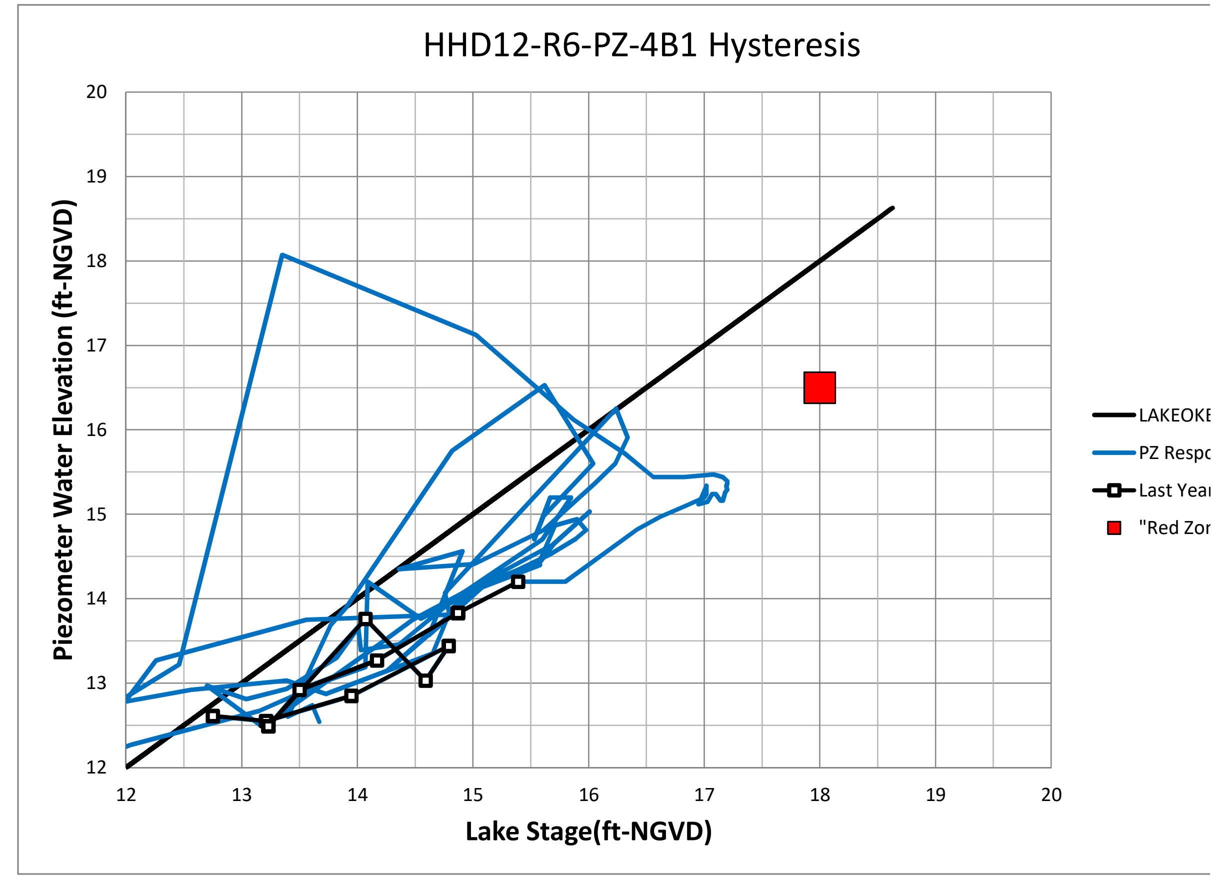
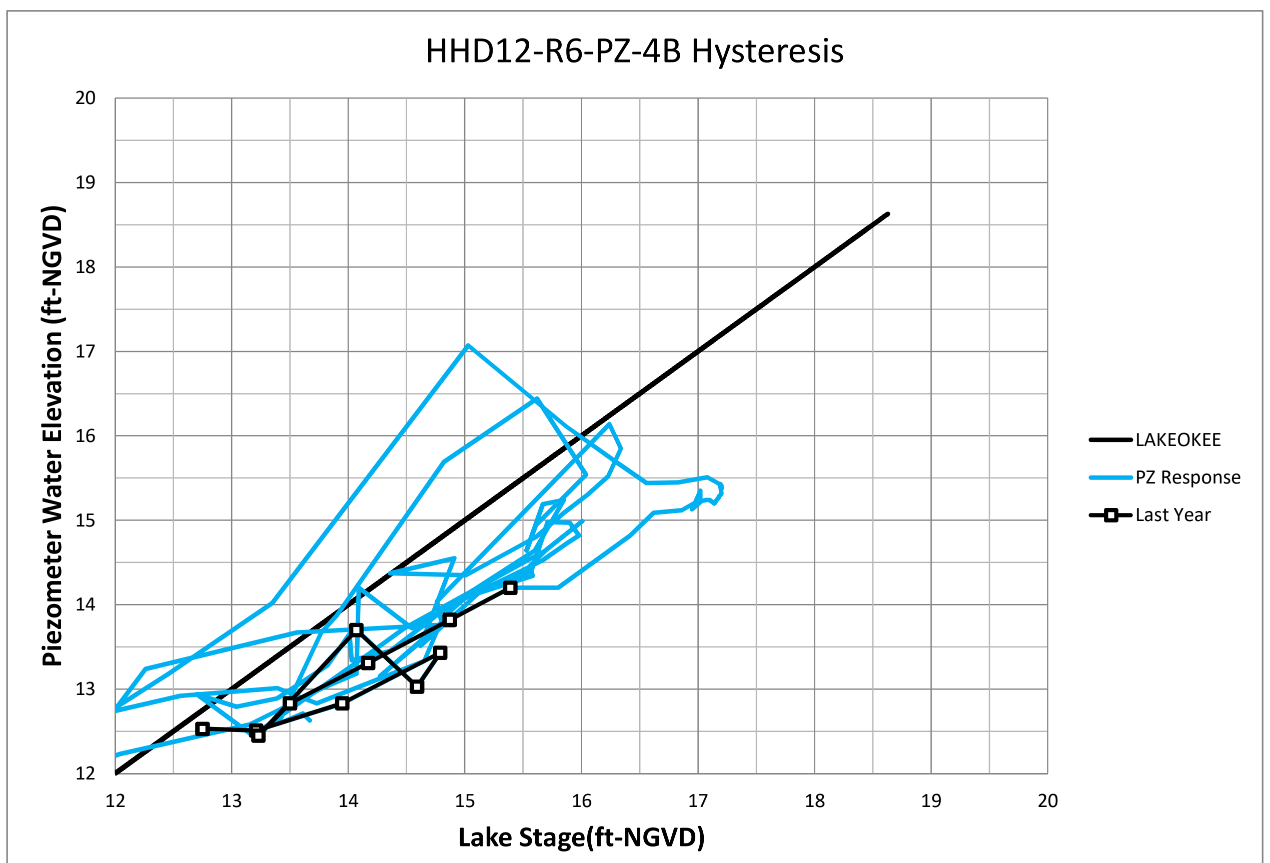
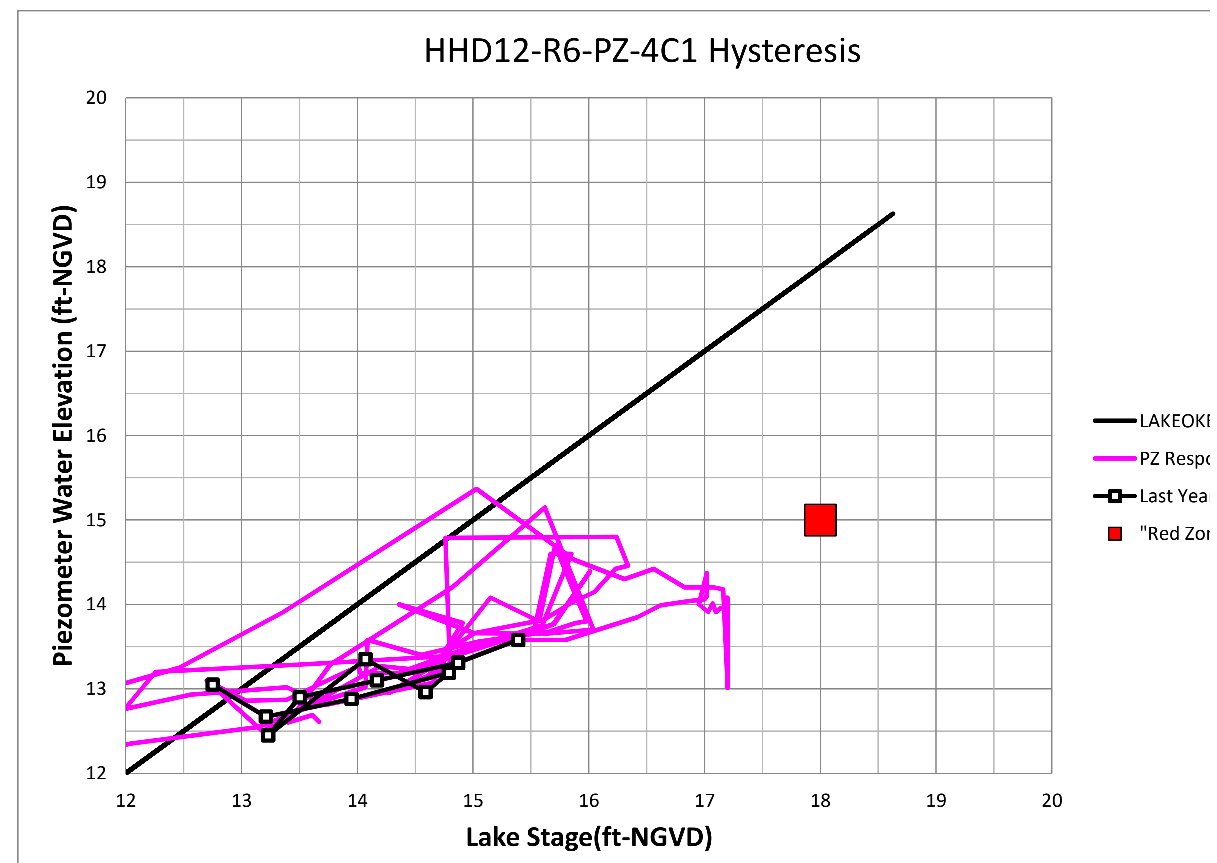
20
Lake Stage(ft-NGVD)
LAKEOKEE
PZ Response
Last Year

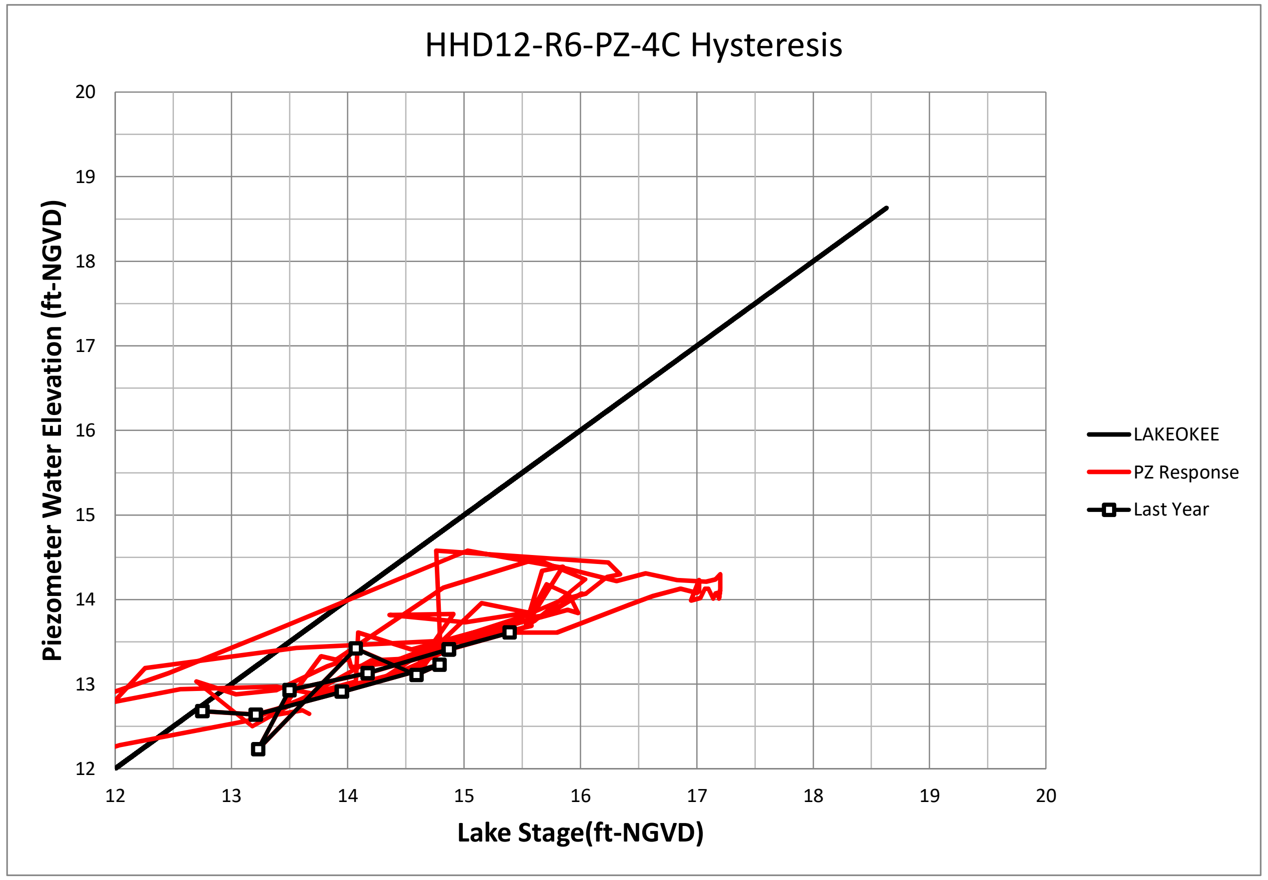
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update










HHD12-R6-PZ-4C Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
12
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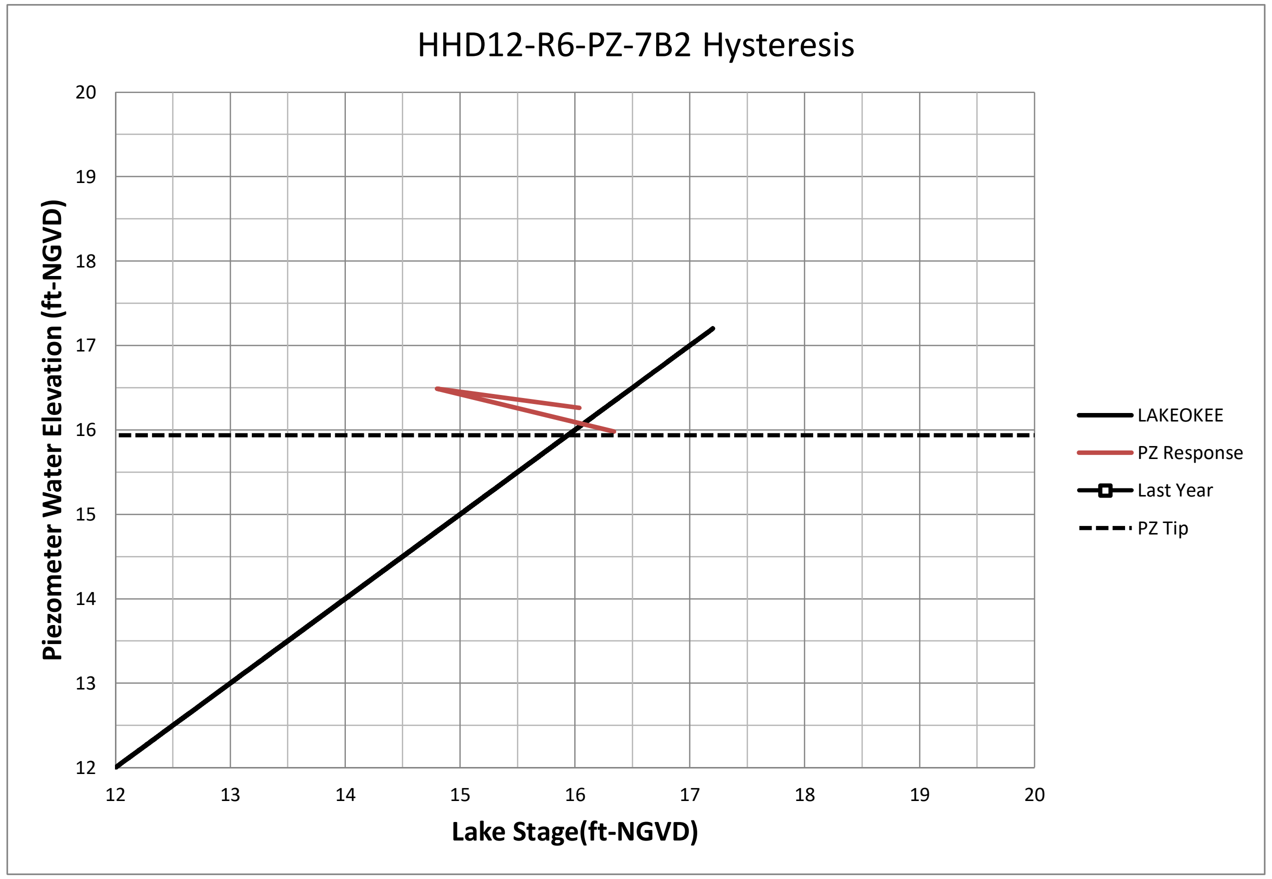
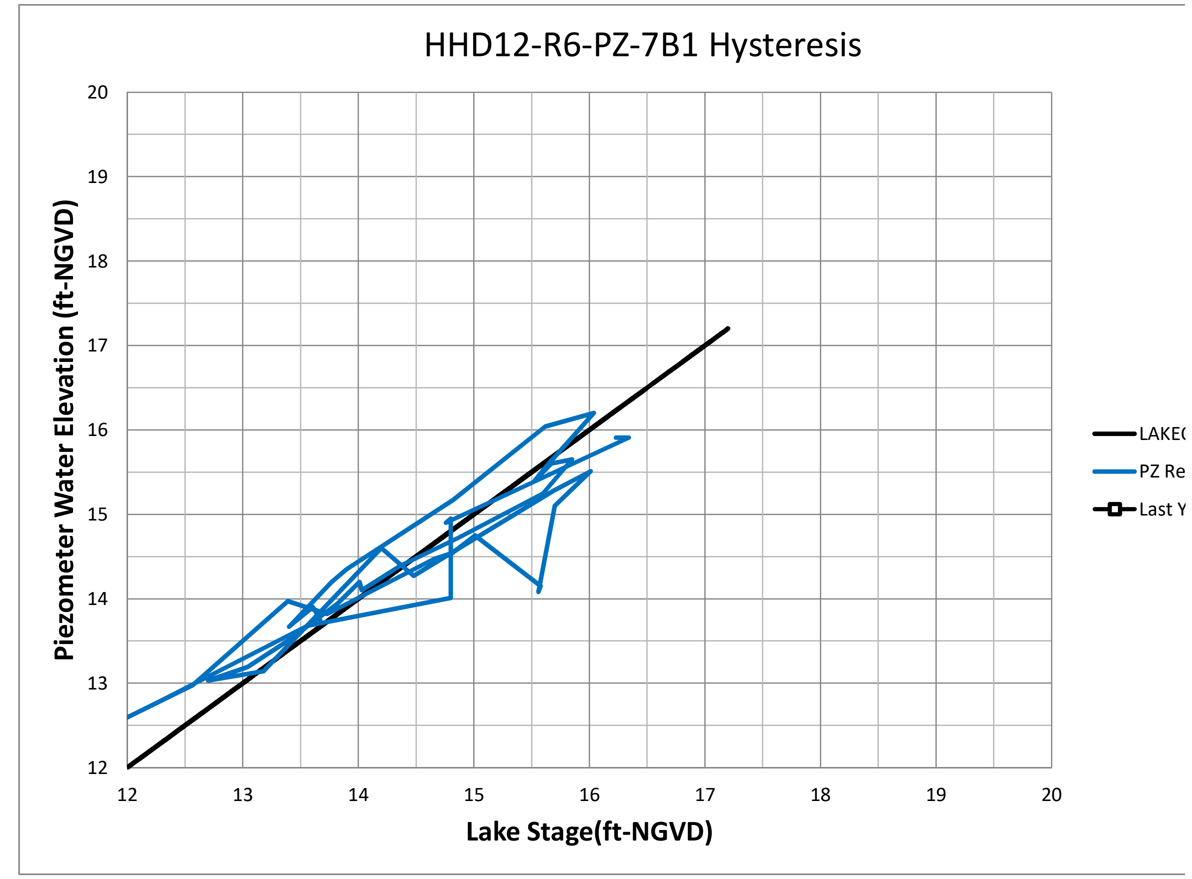
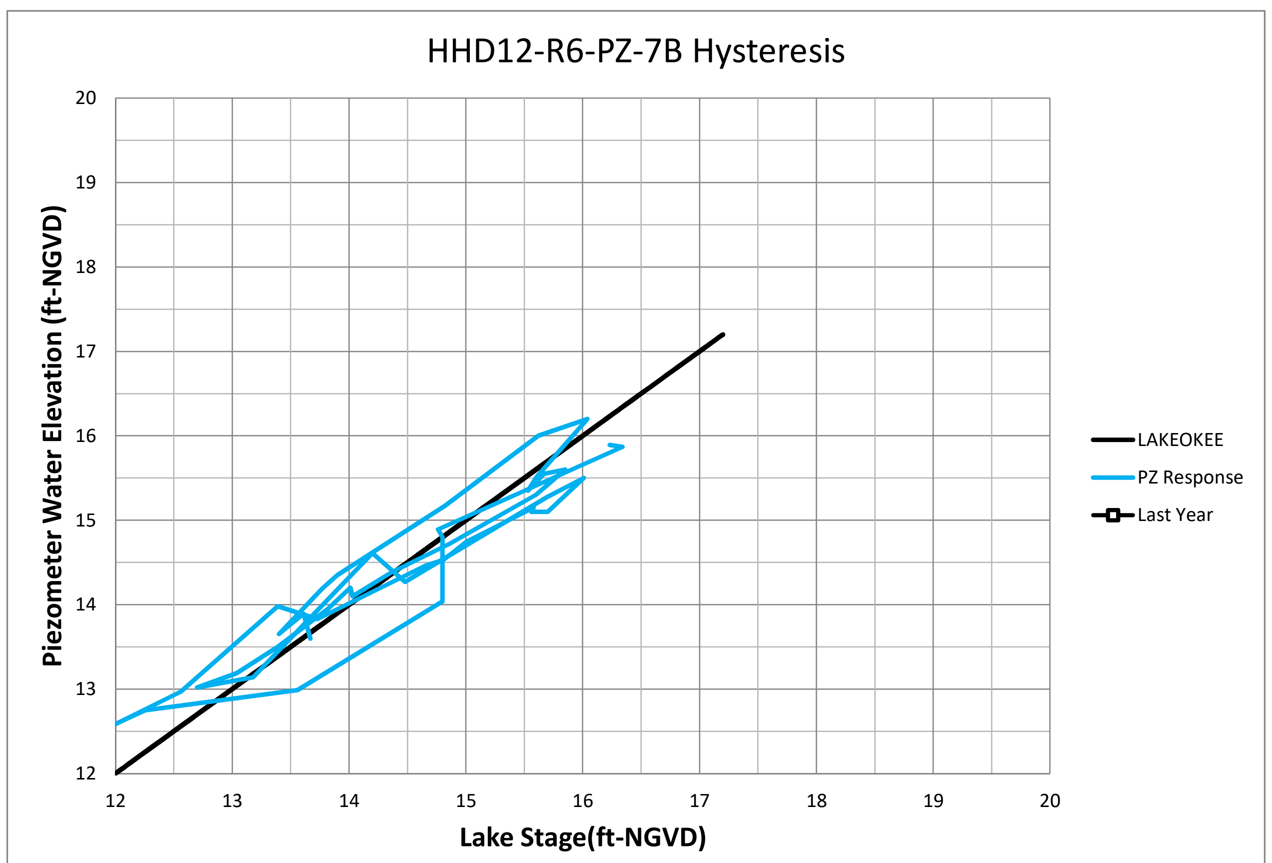
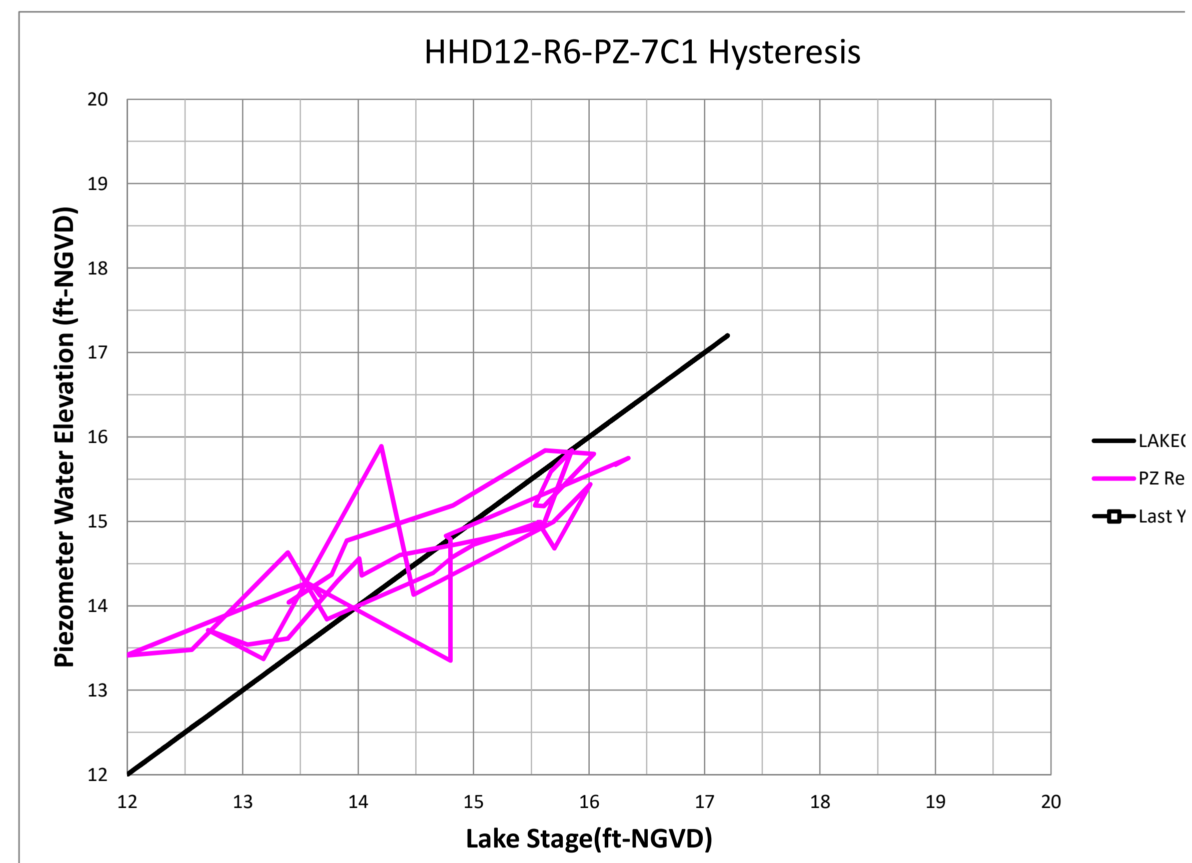
LAKEOKEE
PZ Response
Last Year

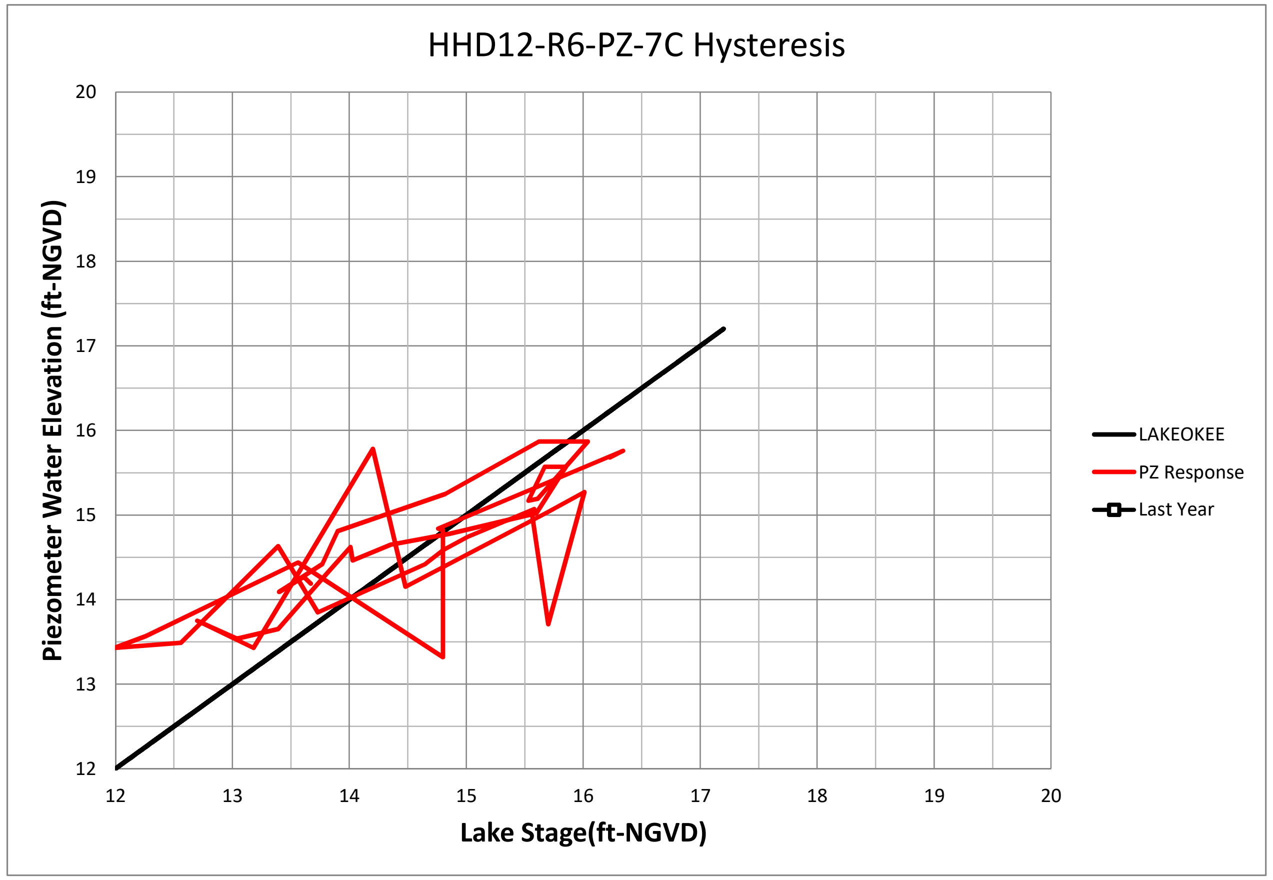
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update










HHD12-R6-PZ-7C Hysteresis
Piezometer Water Elevation (ft-NGVD)
Lake Stage(ft-NGVD)
12
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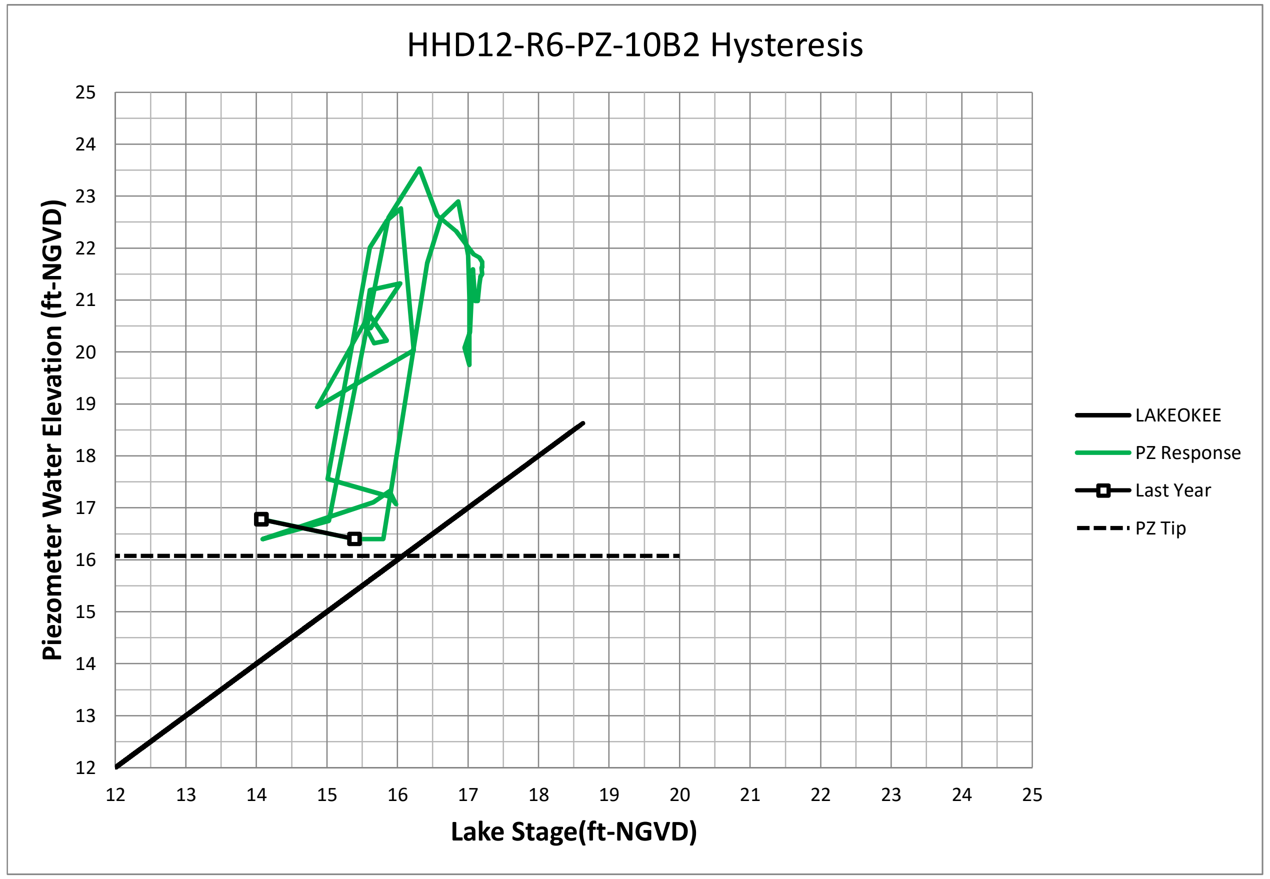
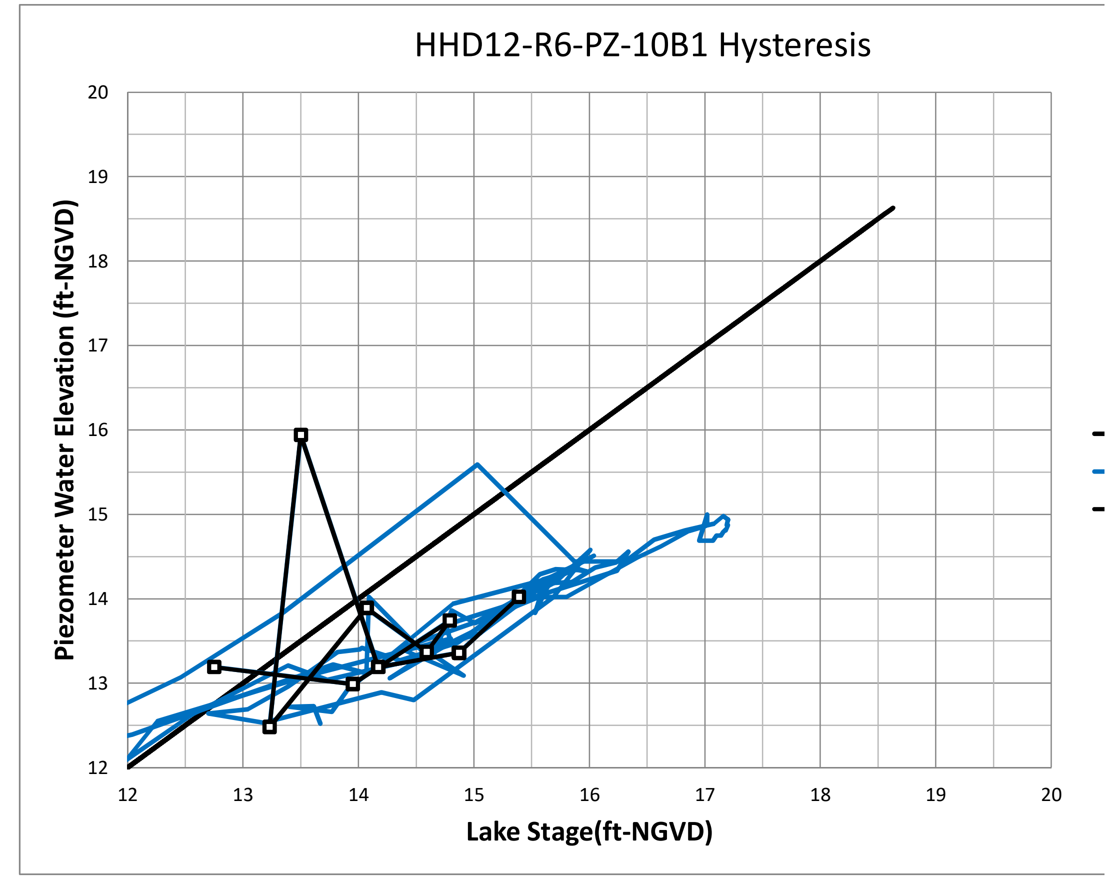
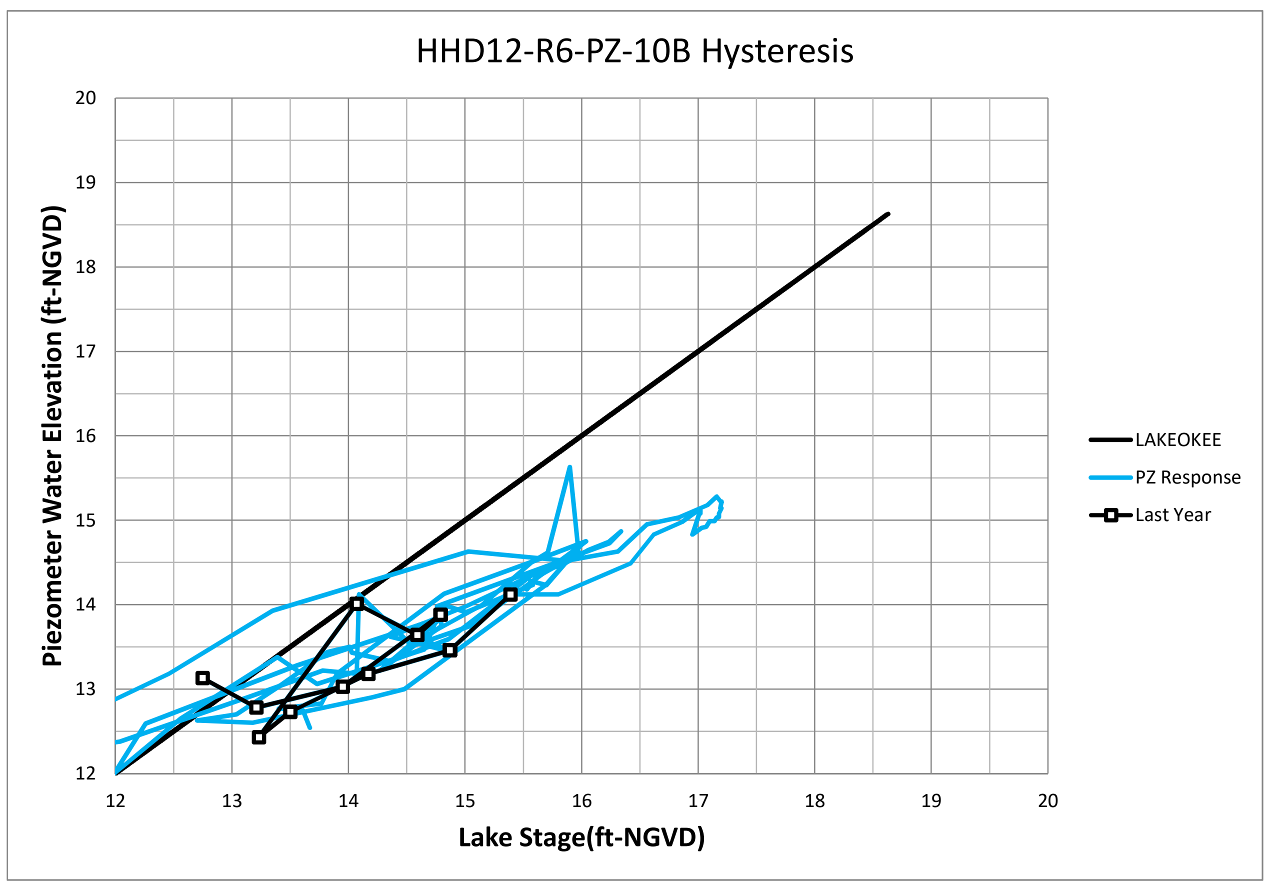
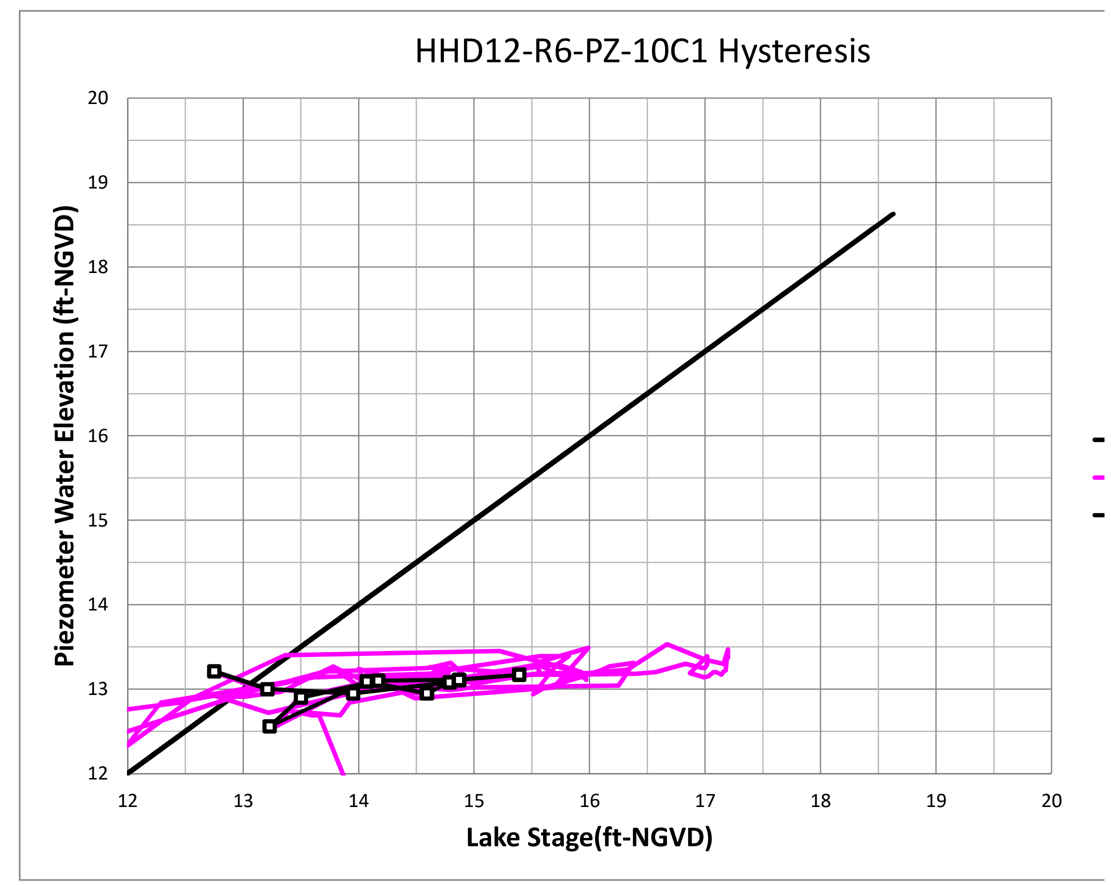
LAKEOKEE
PZ Response
Last Year

Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

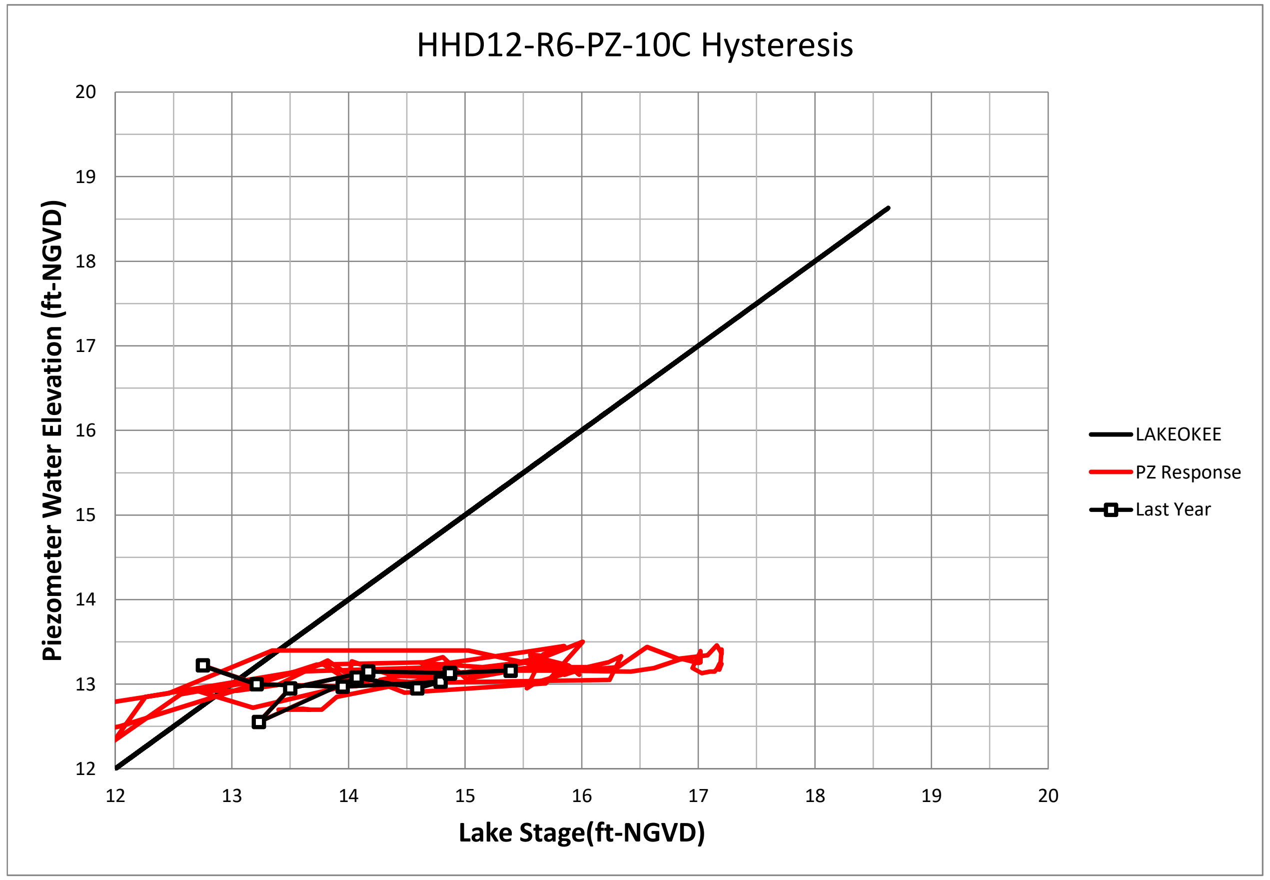




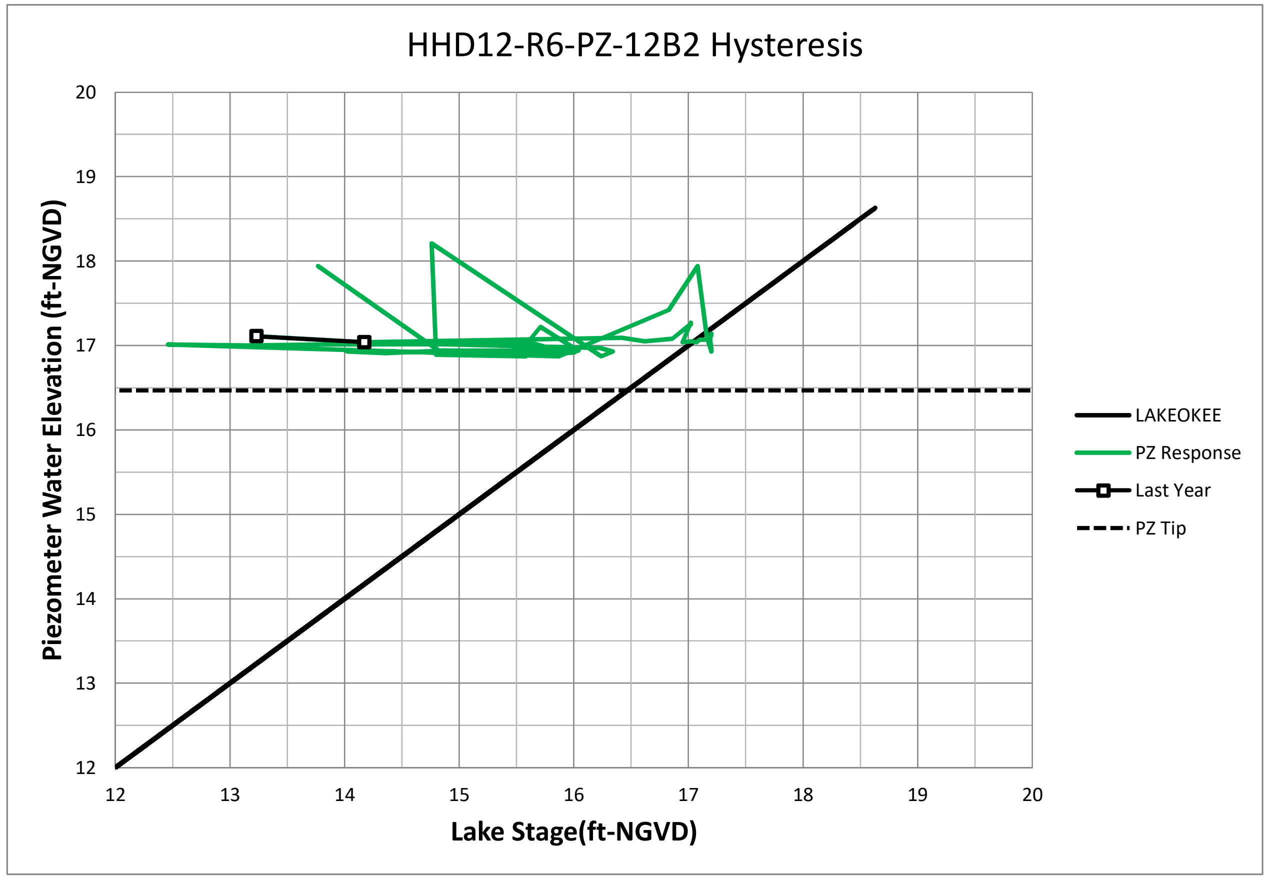


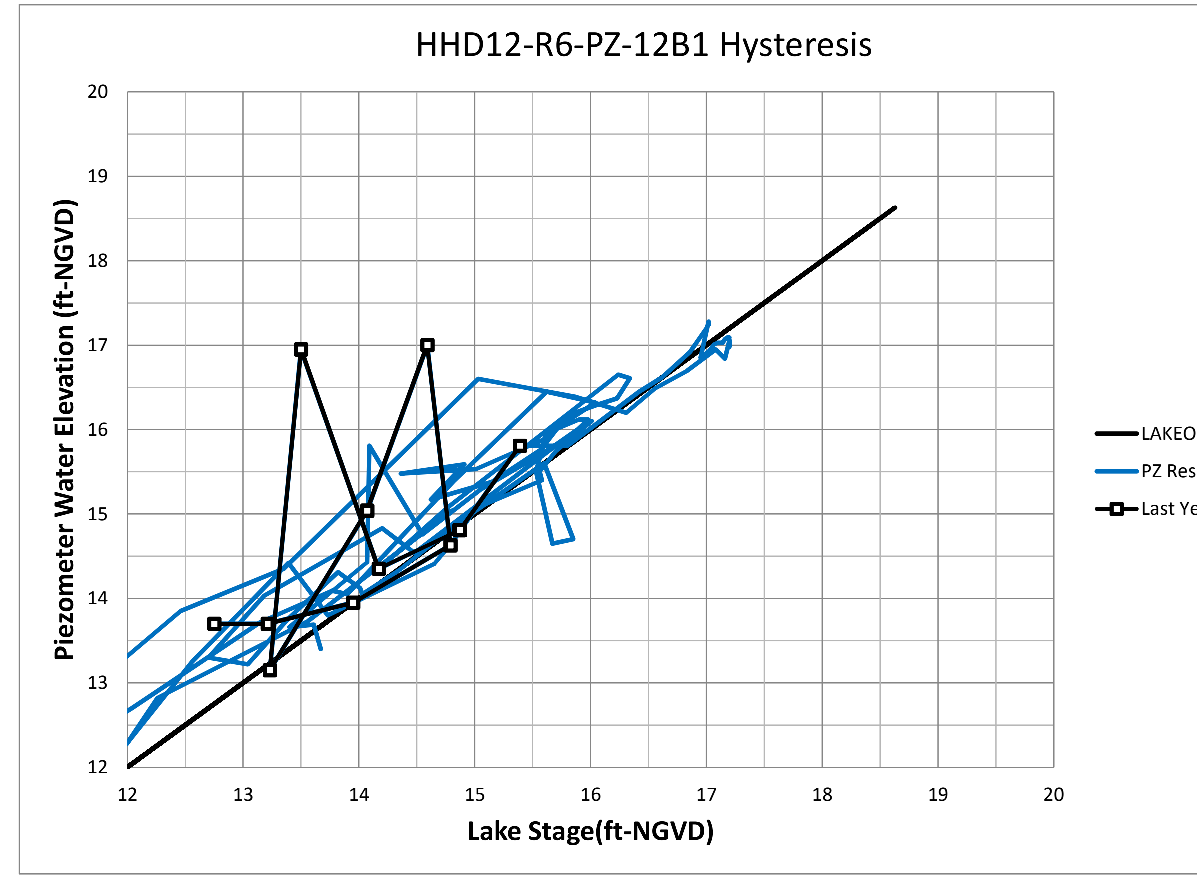


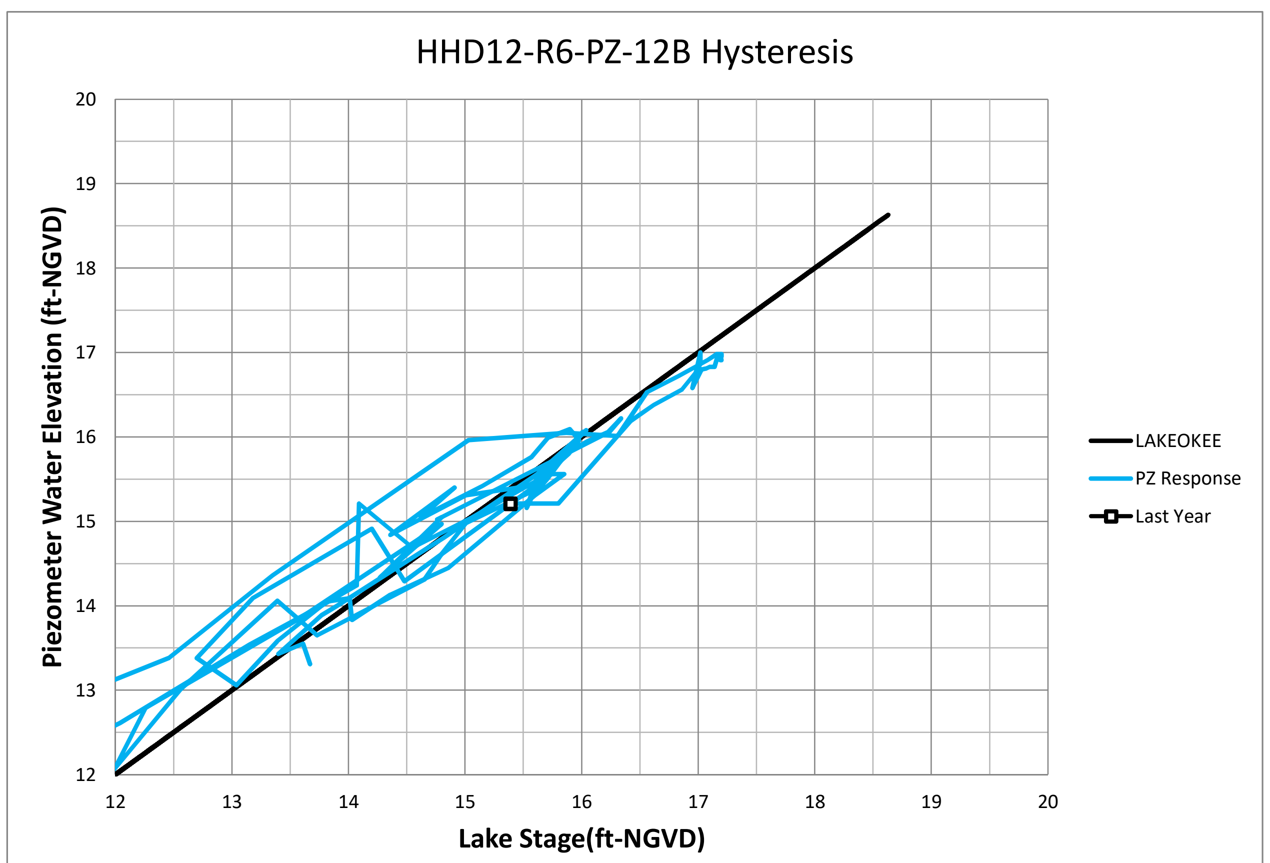
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

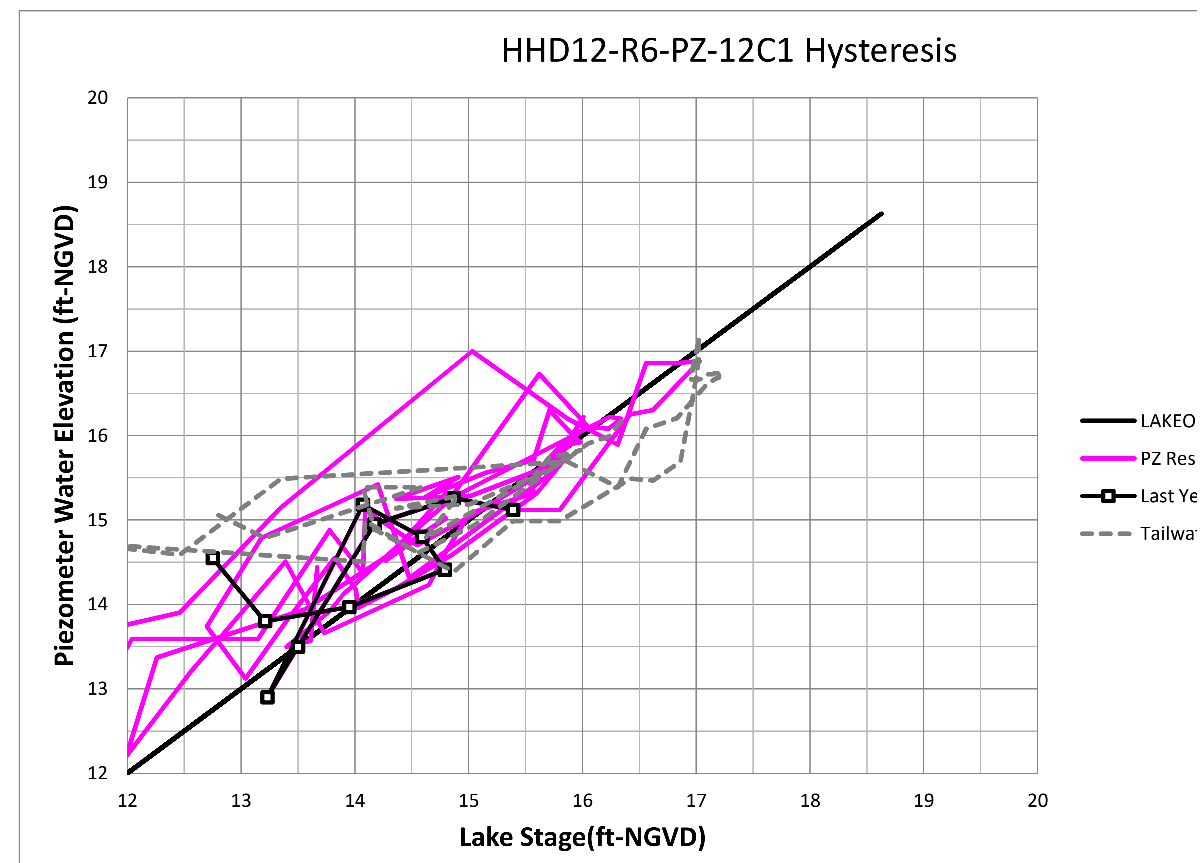


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

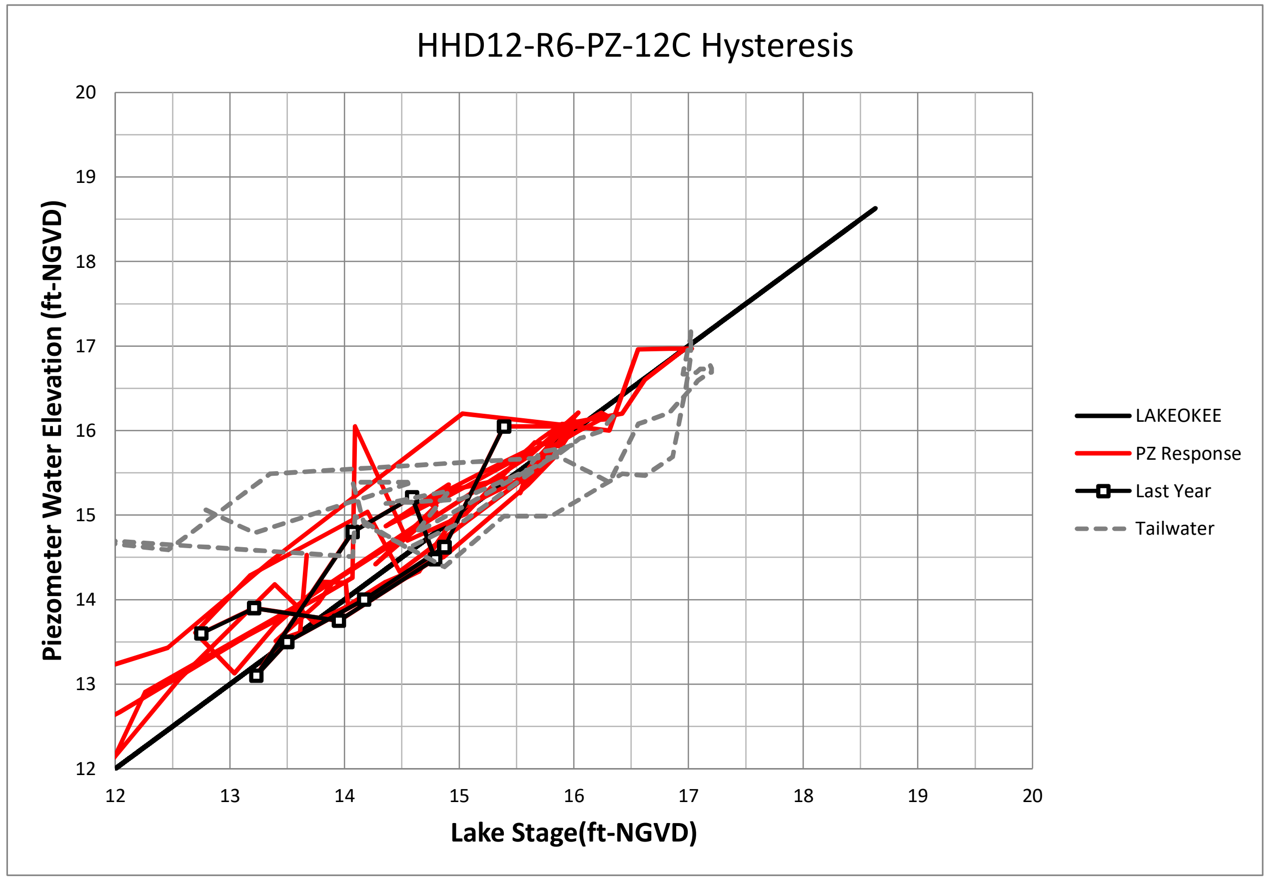




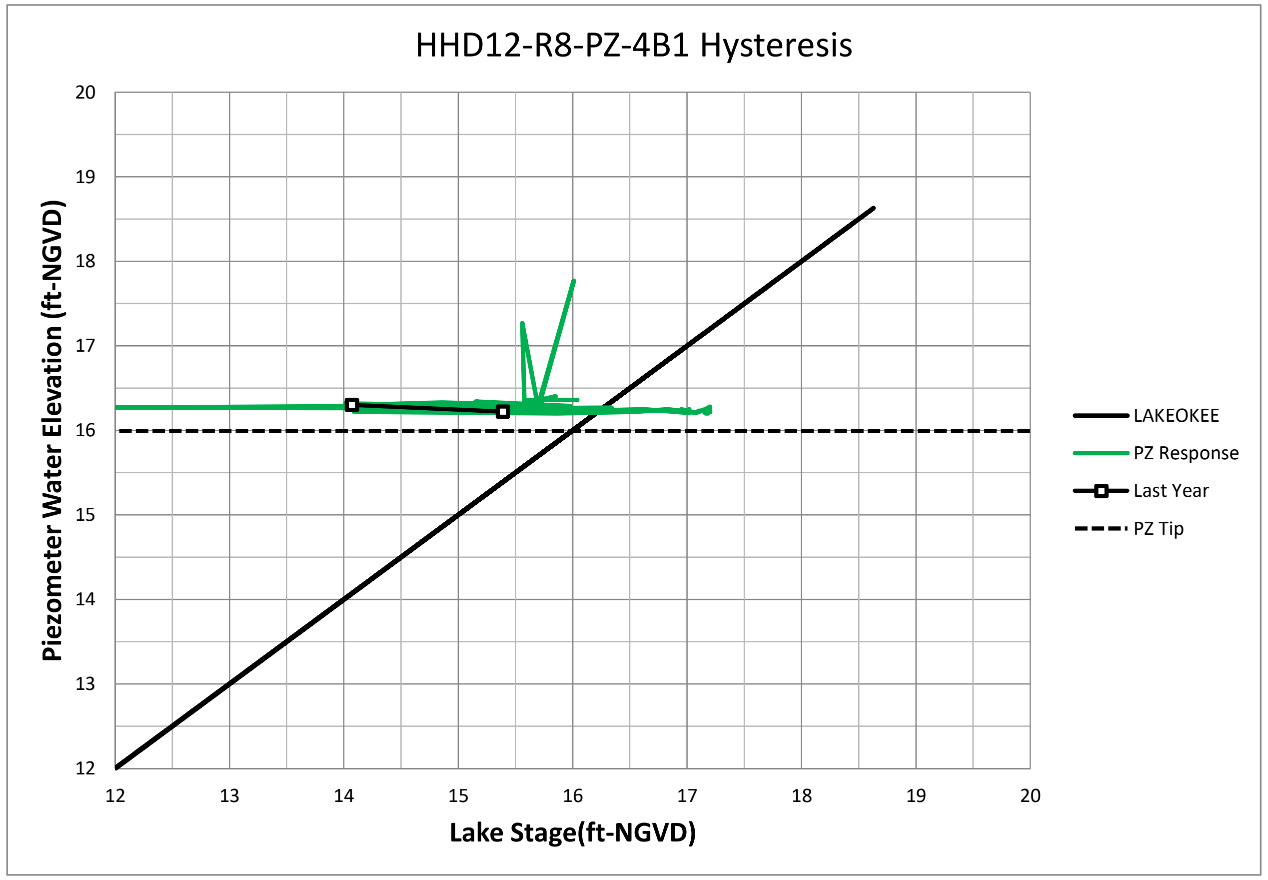


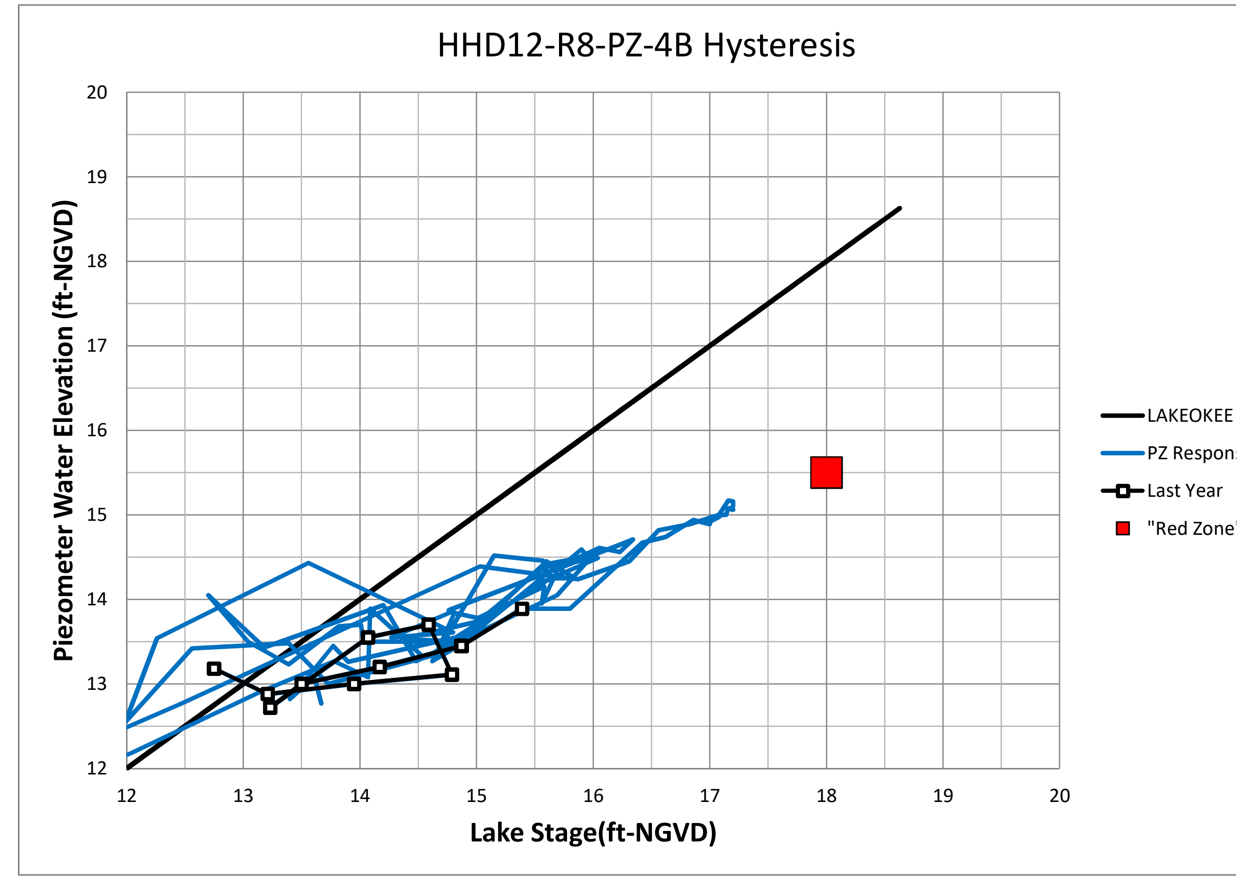


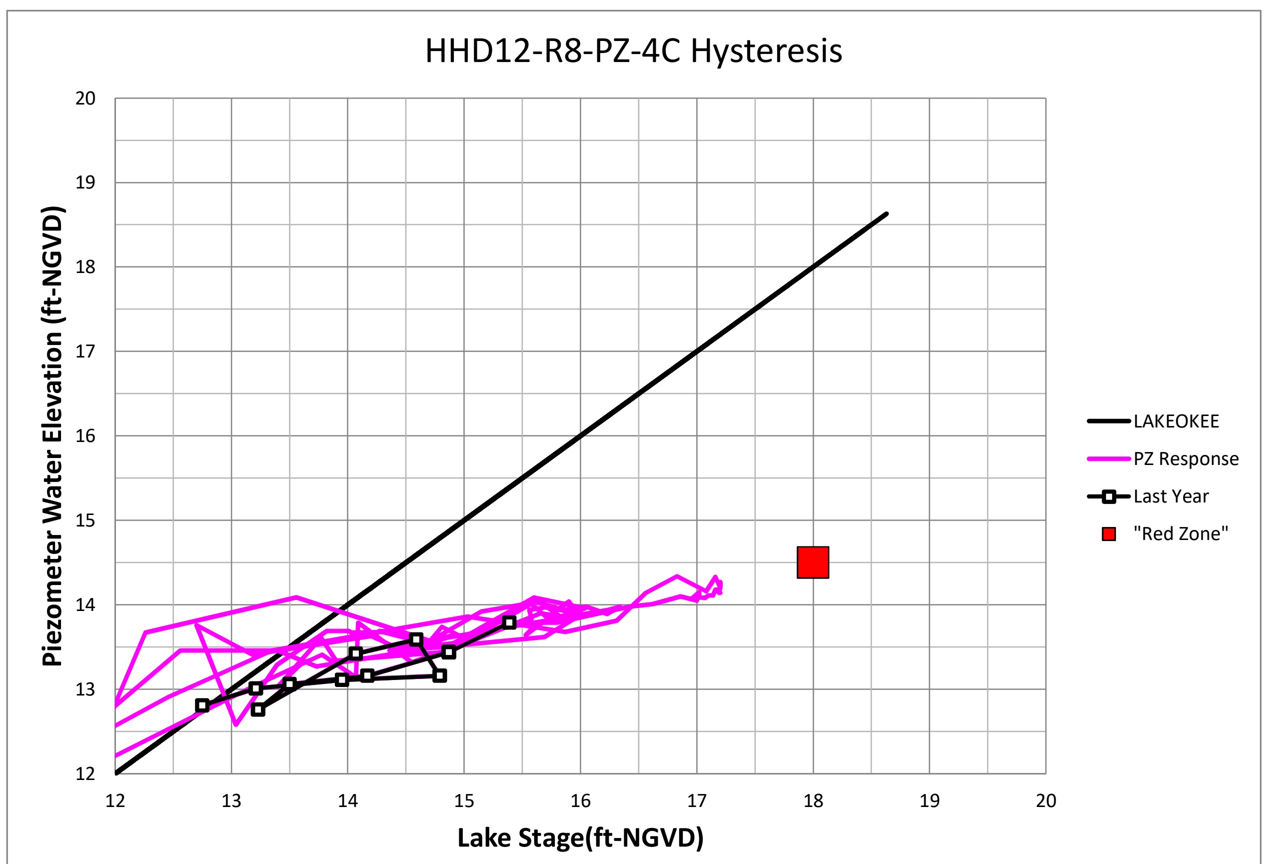
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update



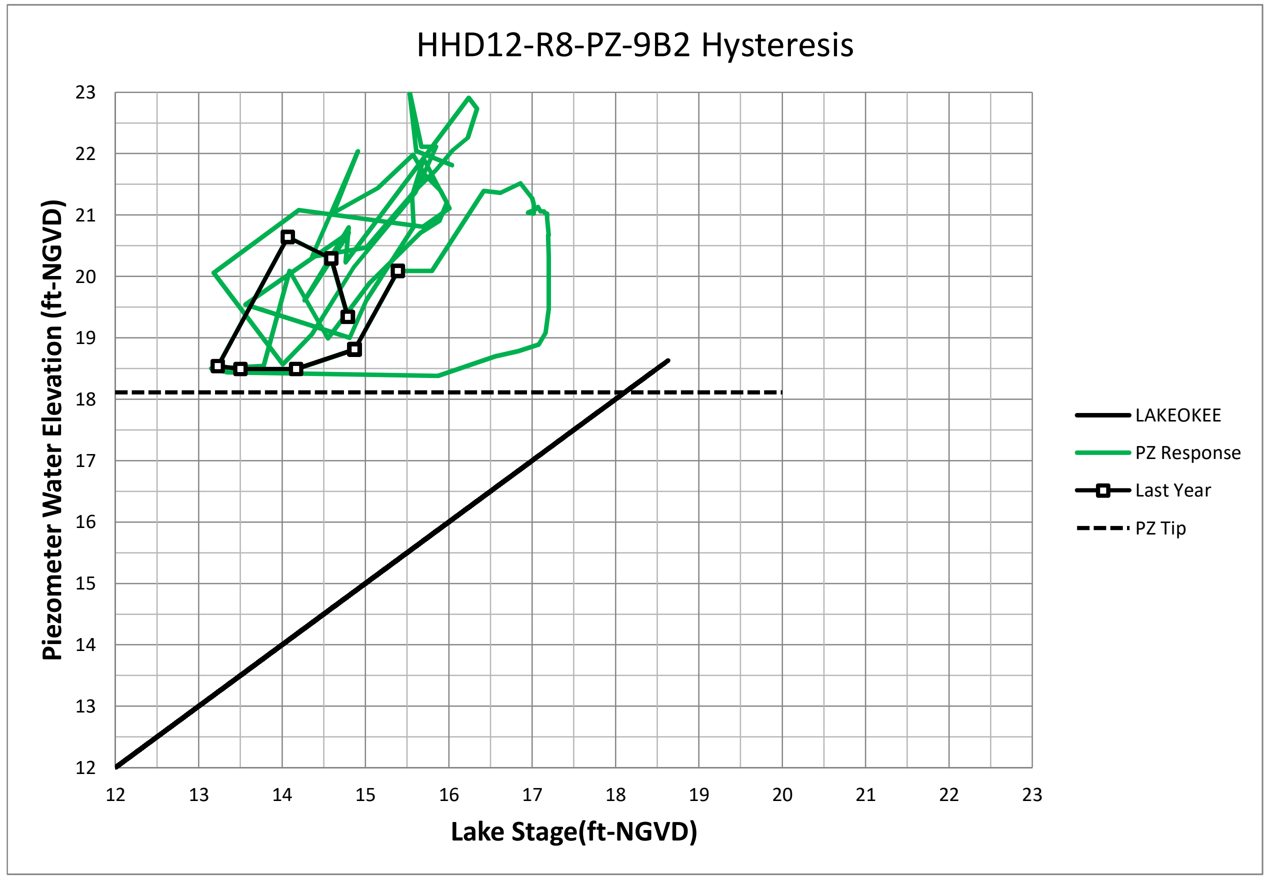
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

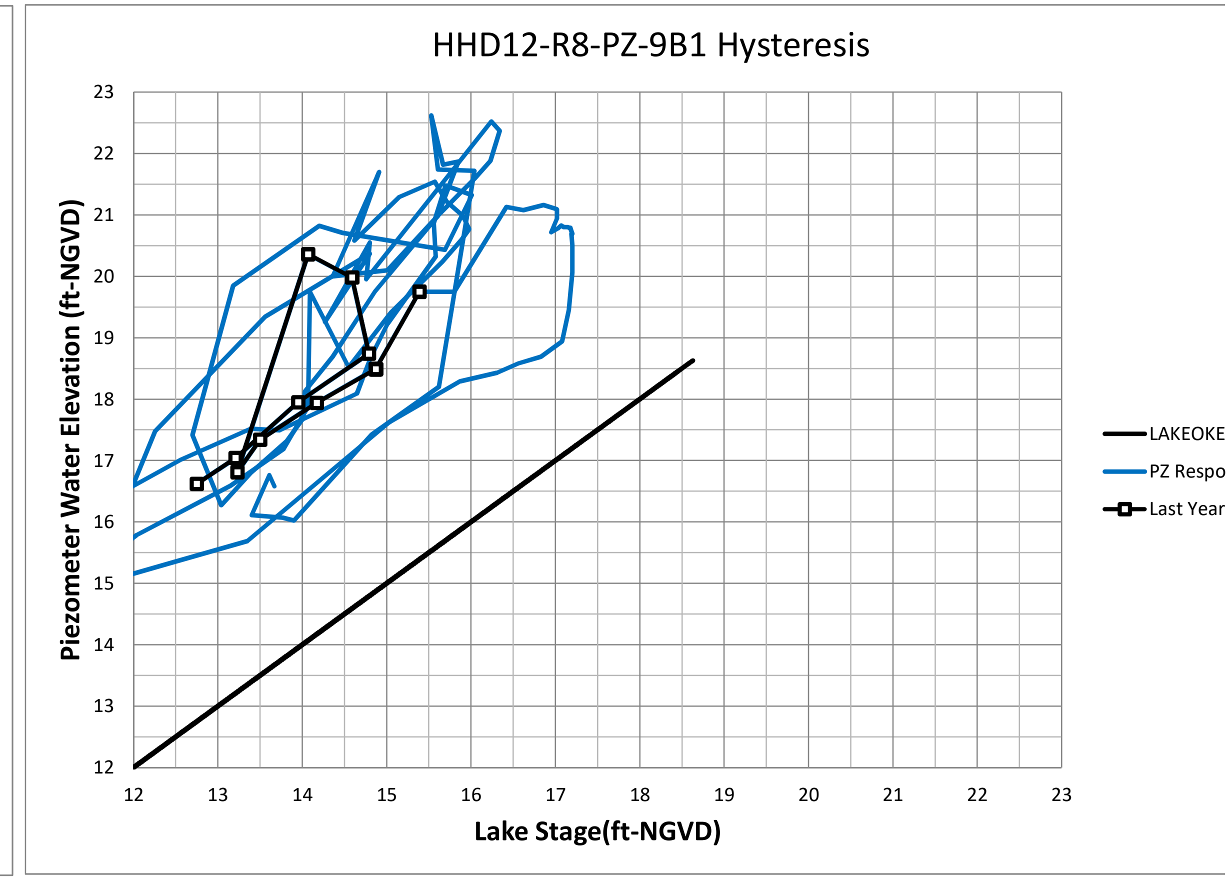


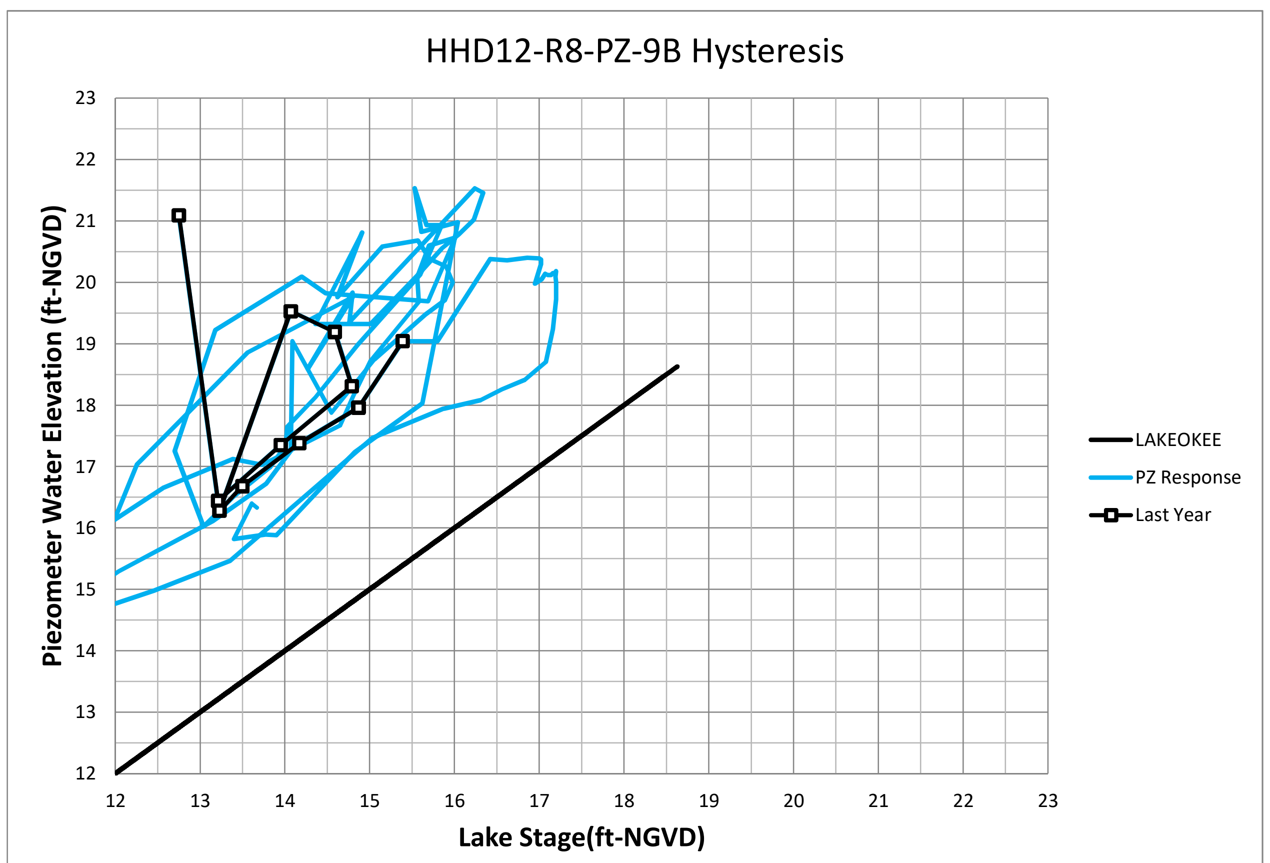


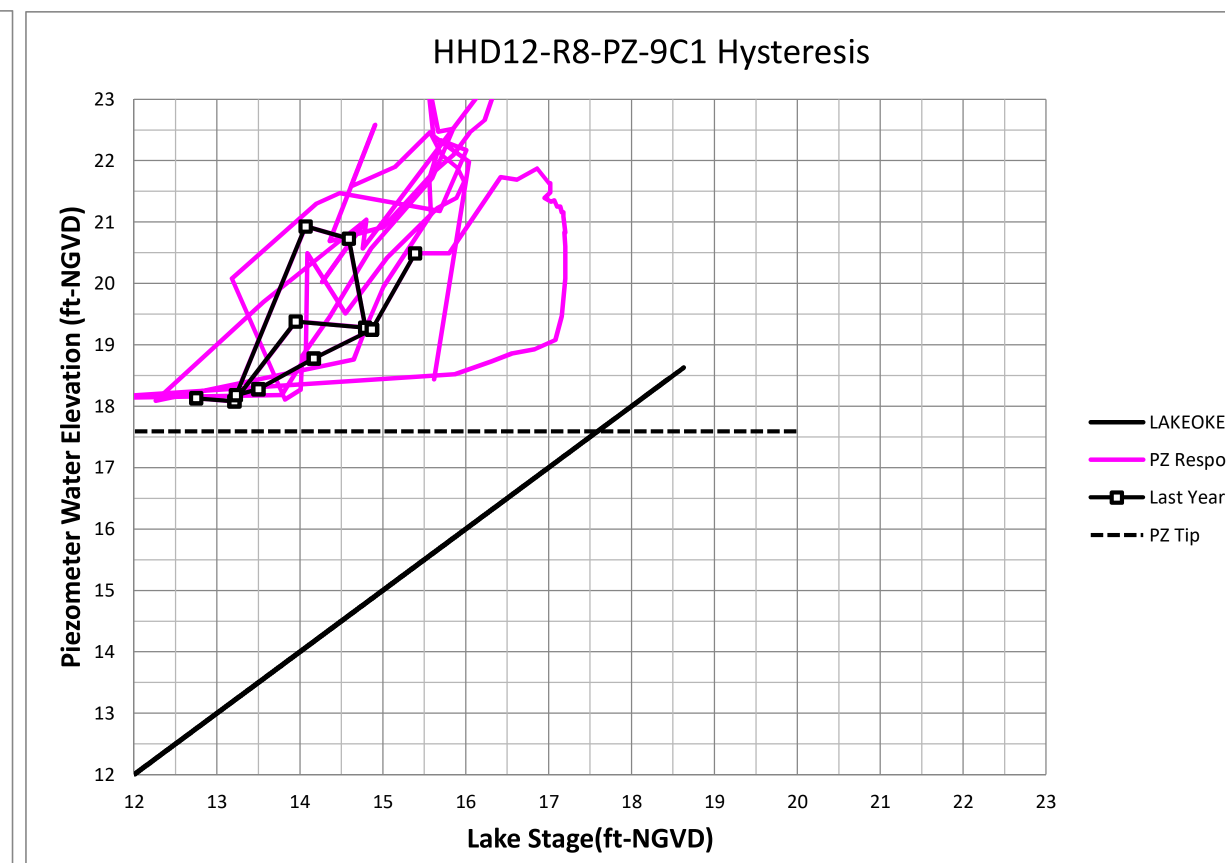


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

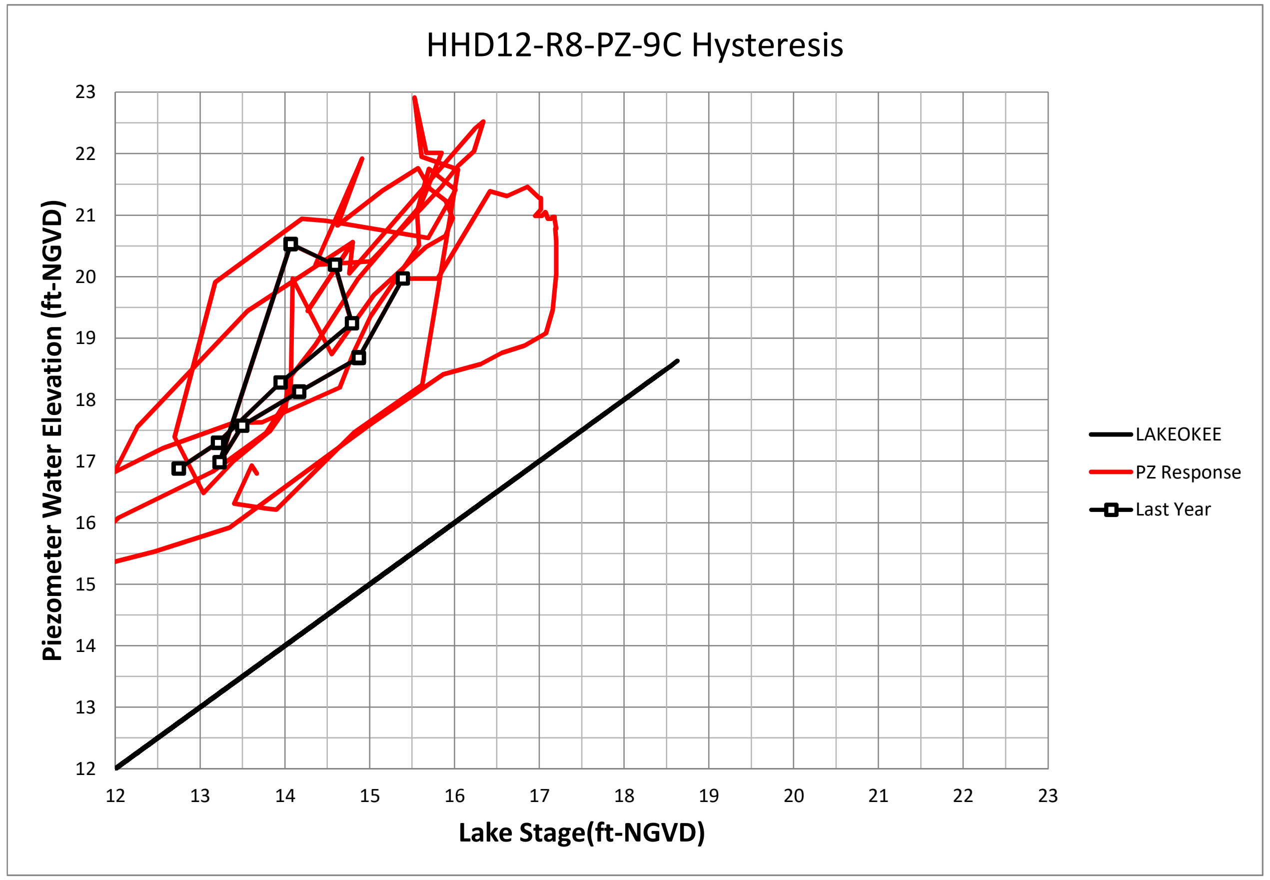






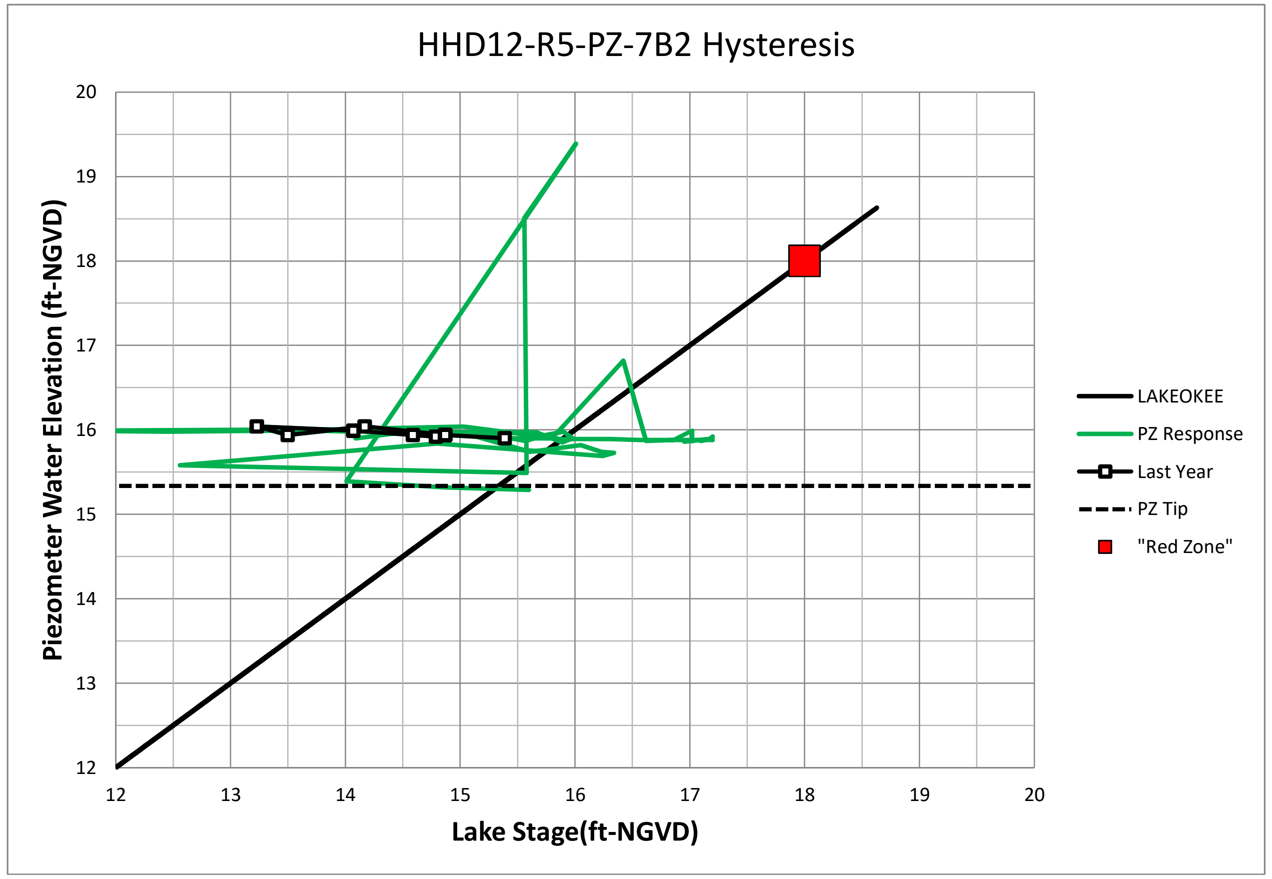


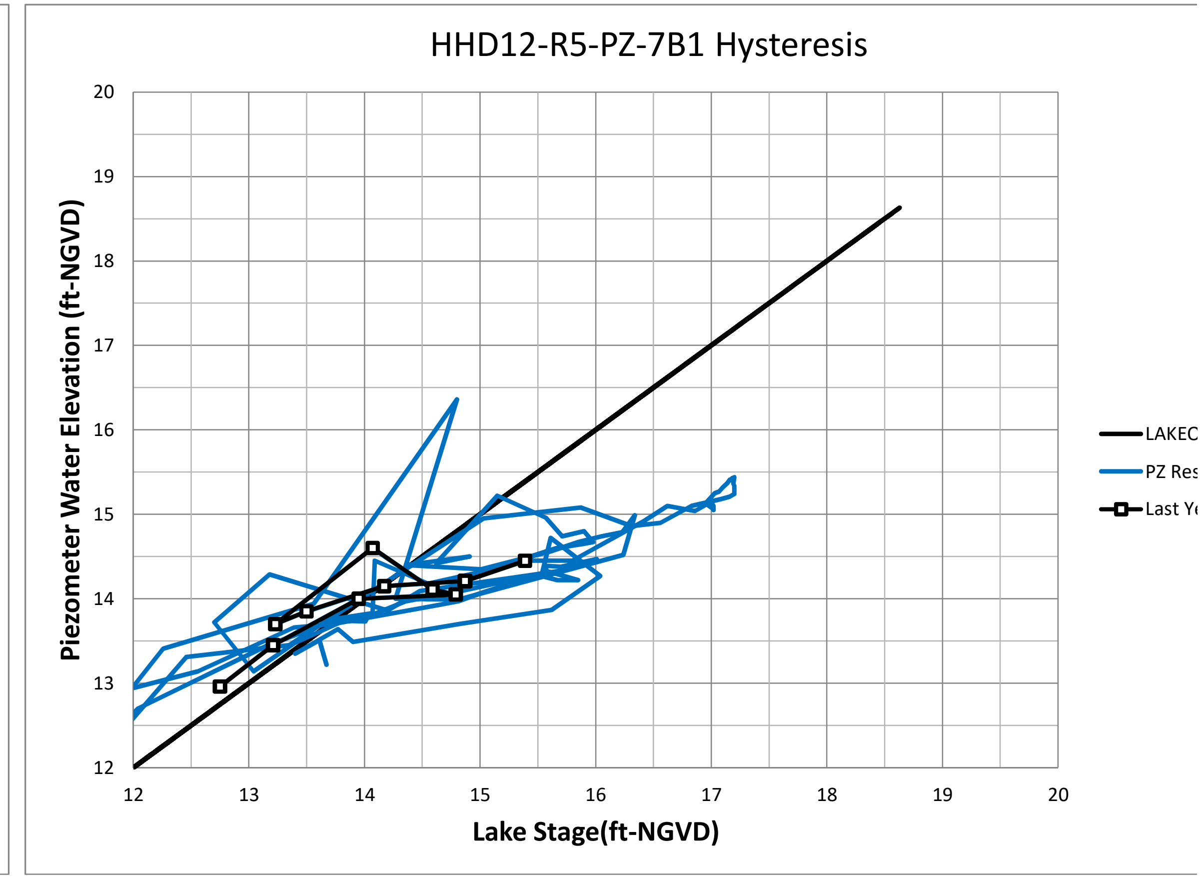
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

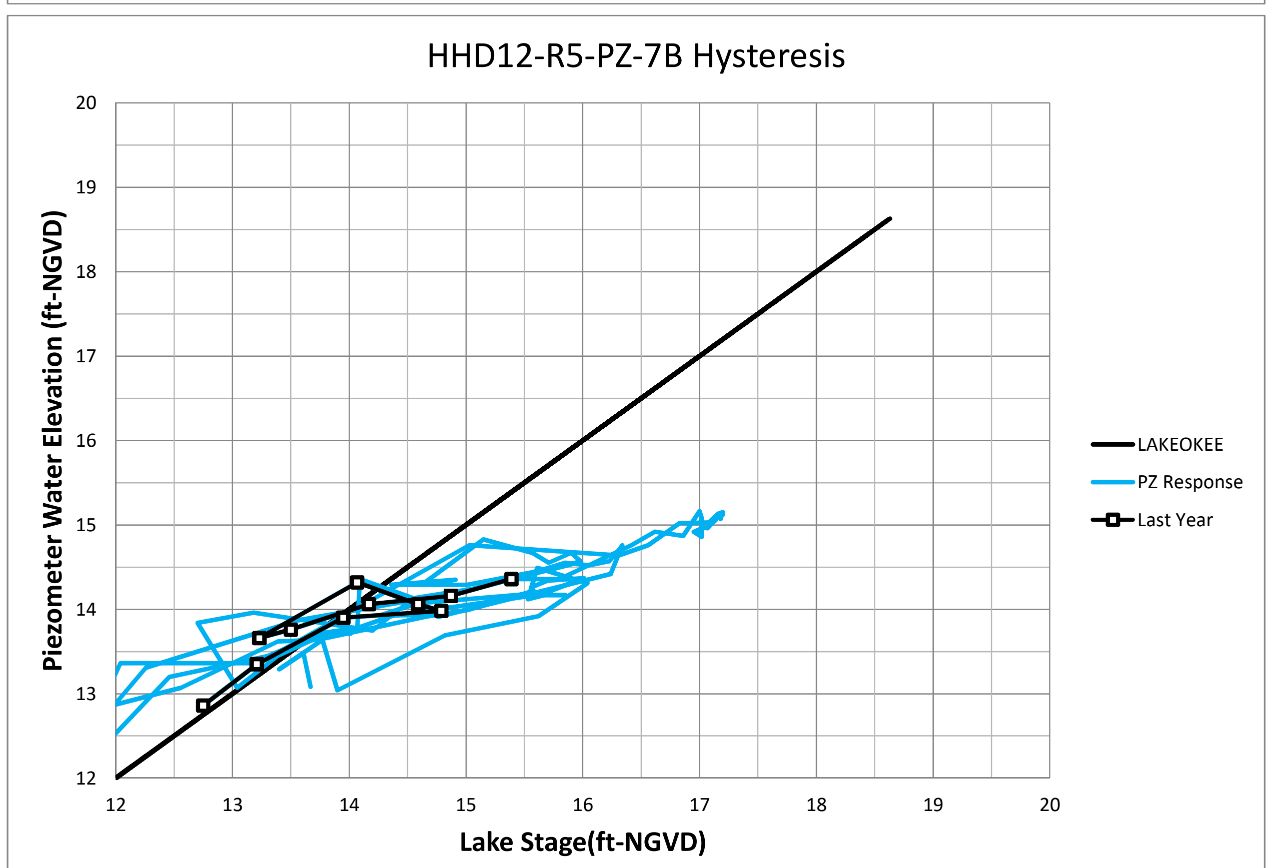


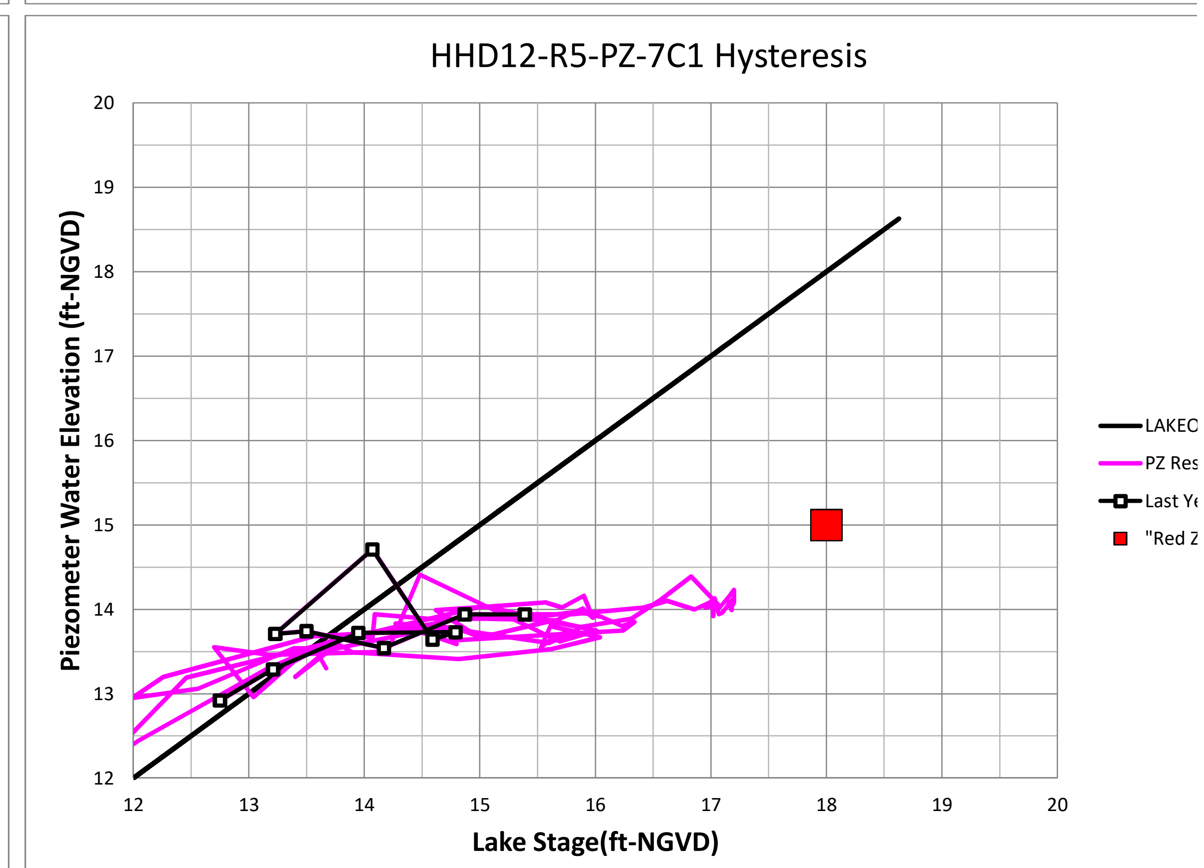
Herbert Hoover Dike- Lake Okeechobee, Florida

Instrumentation Update

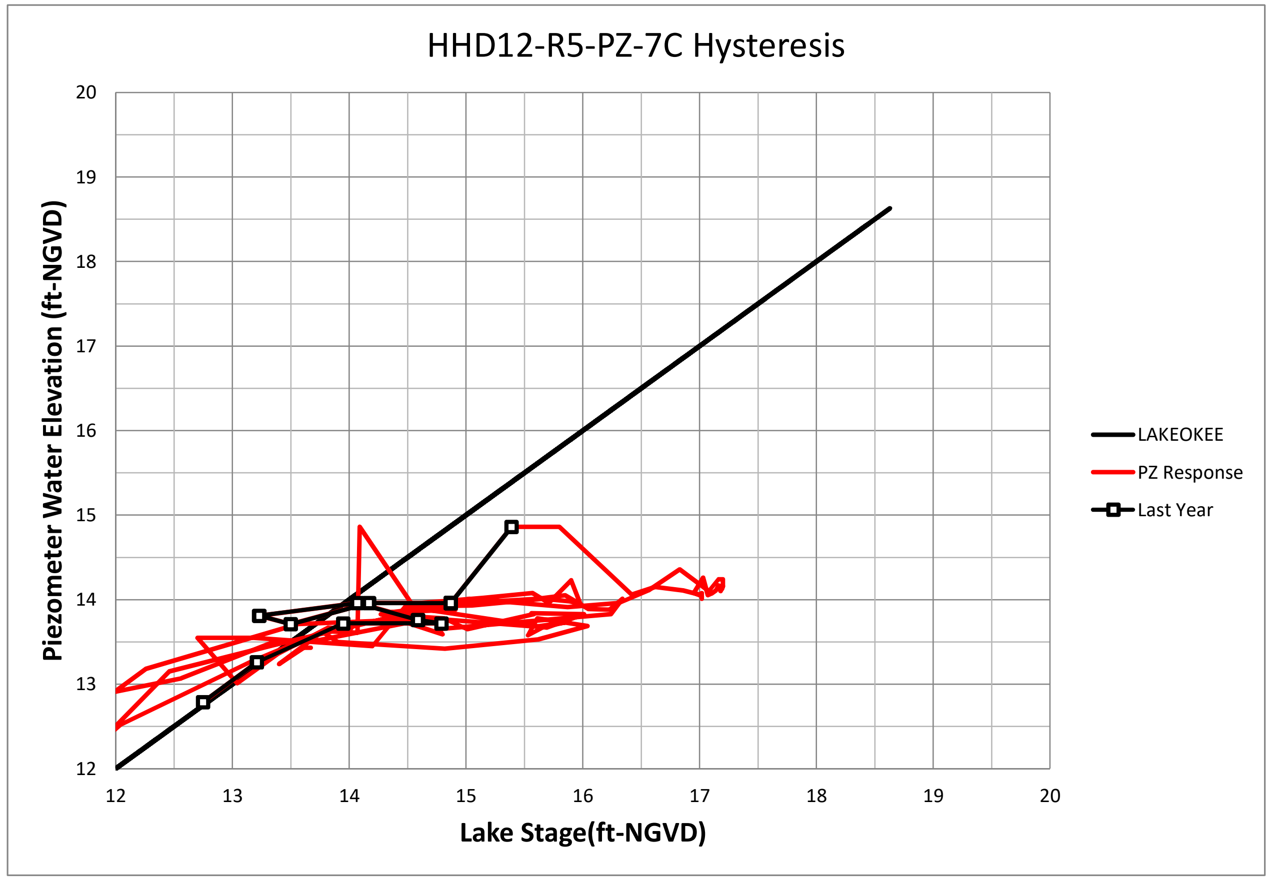




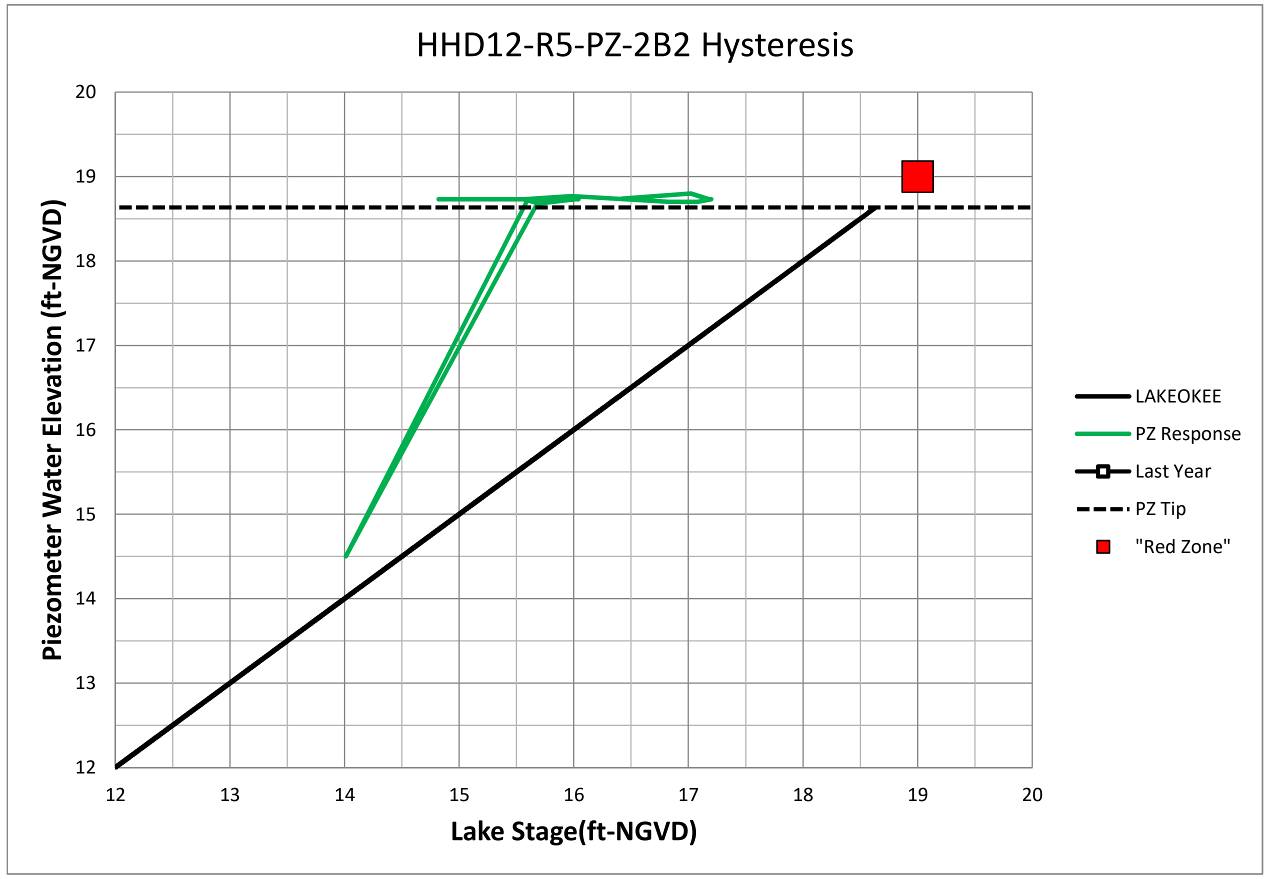


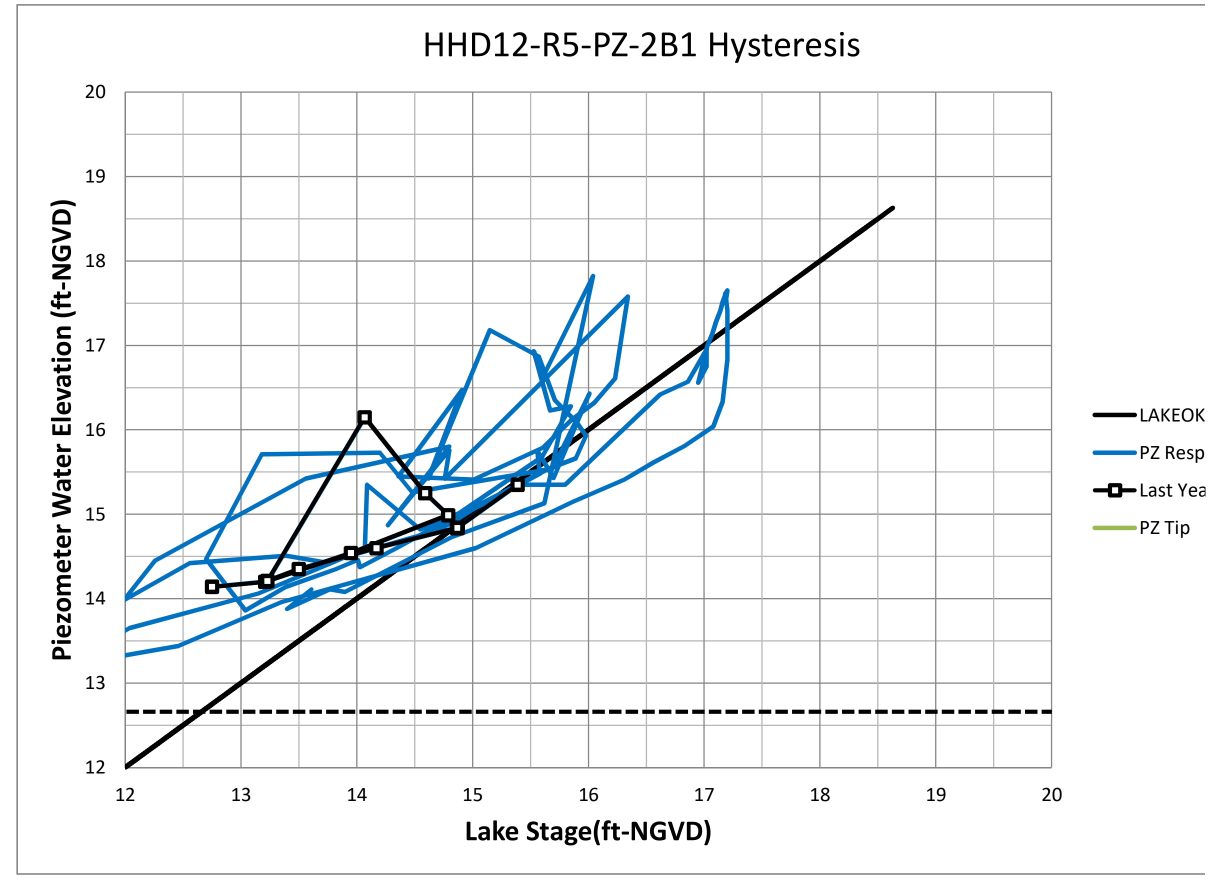


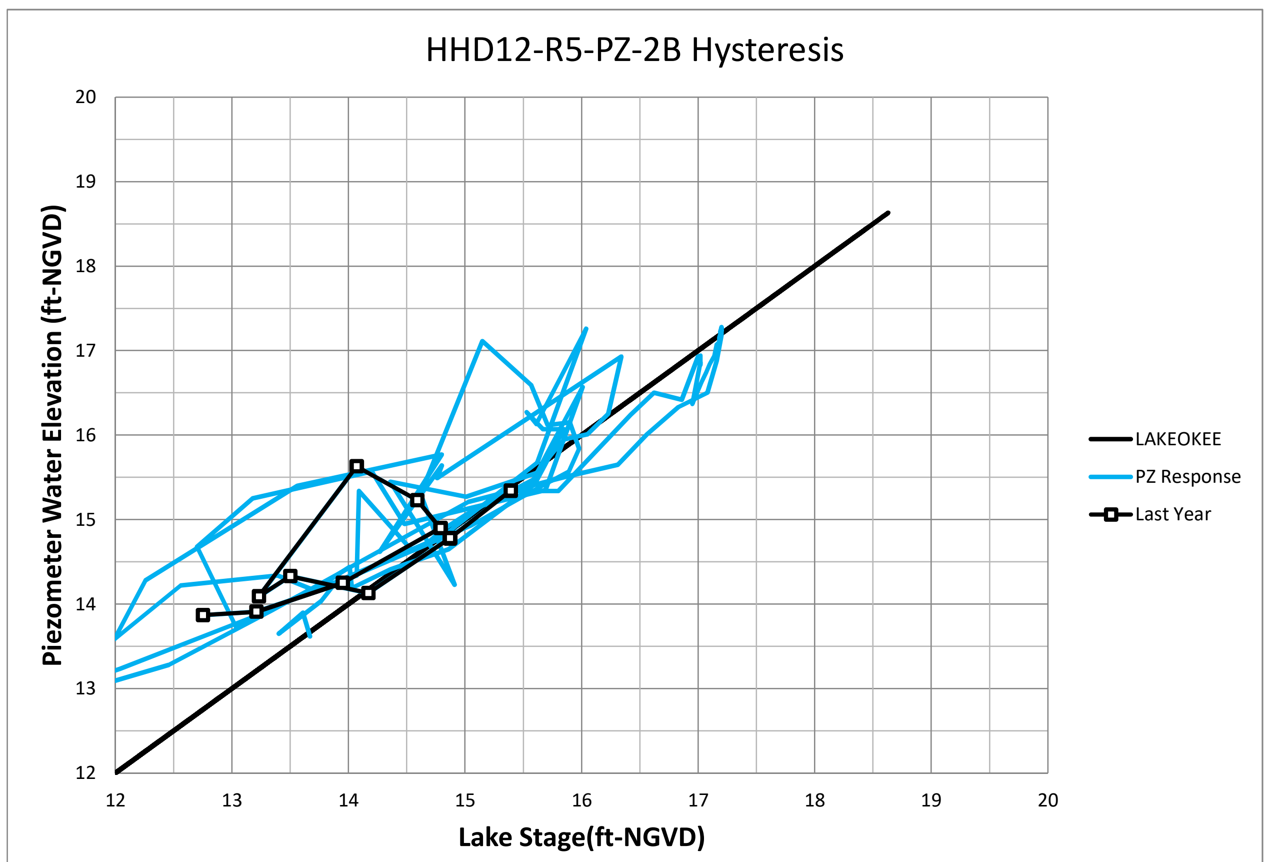
Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update

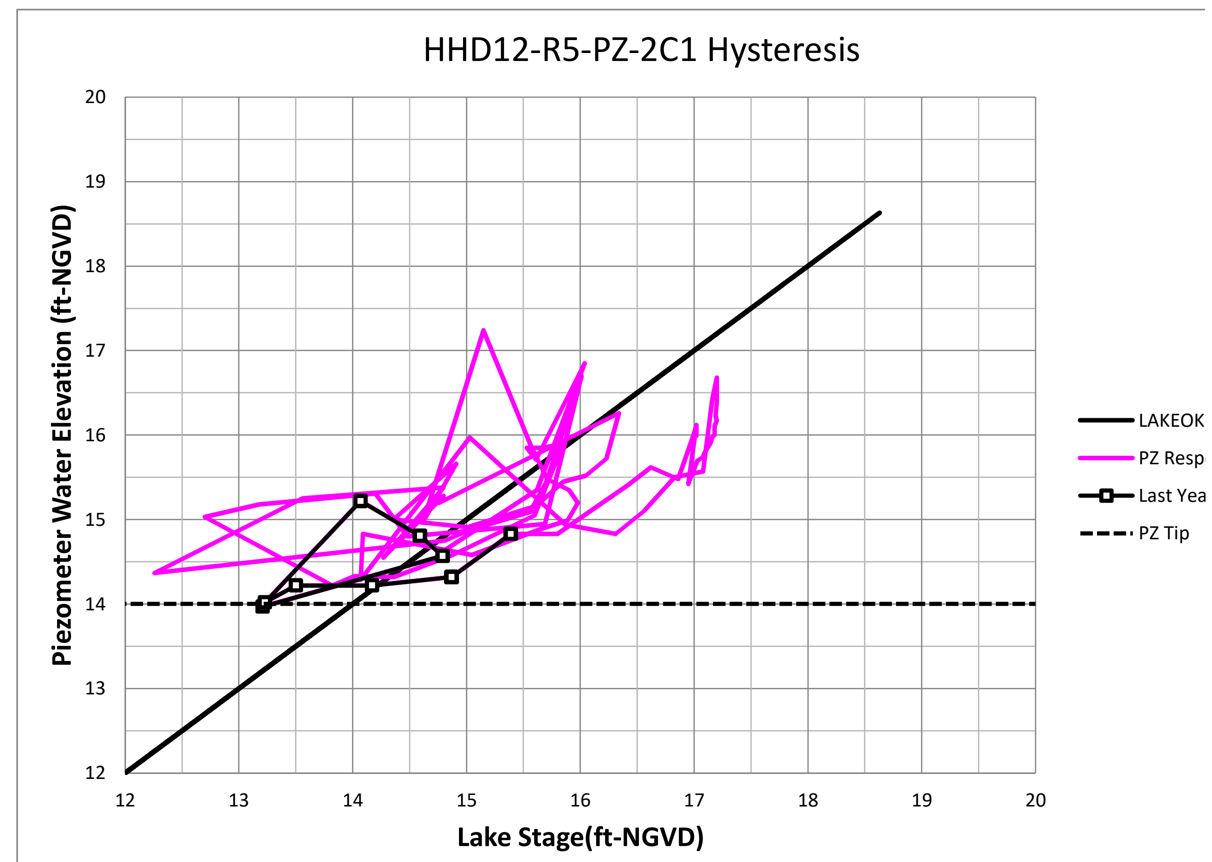


Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update









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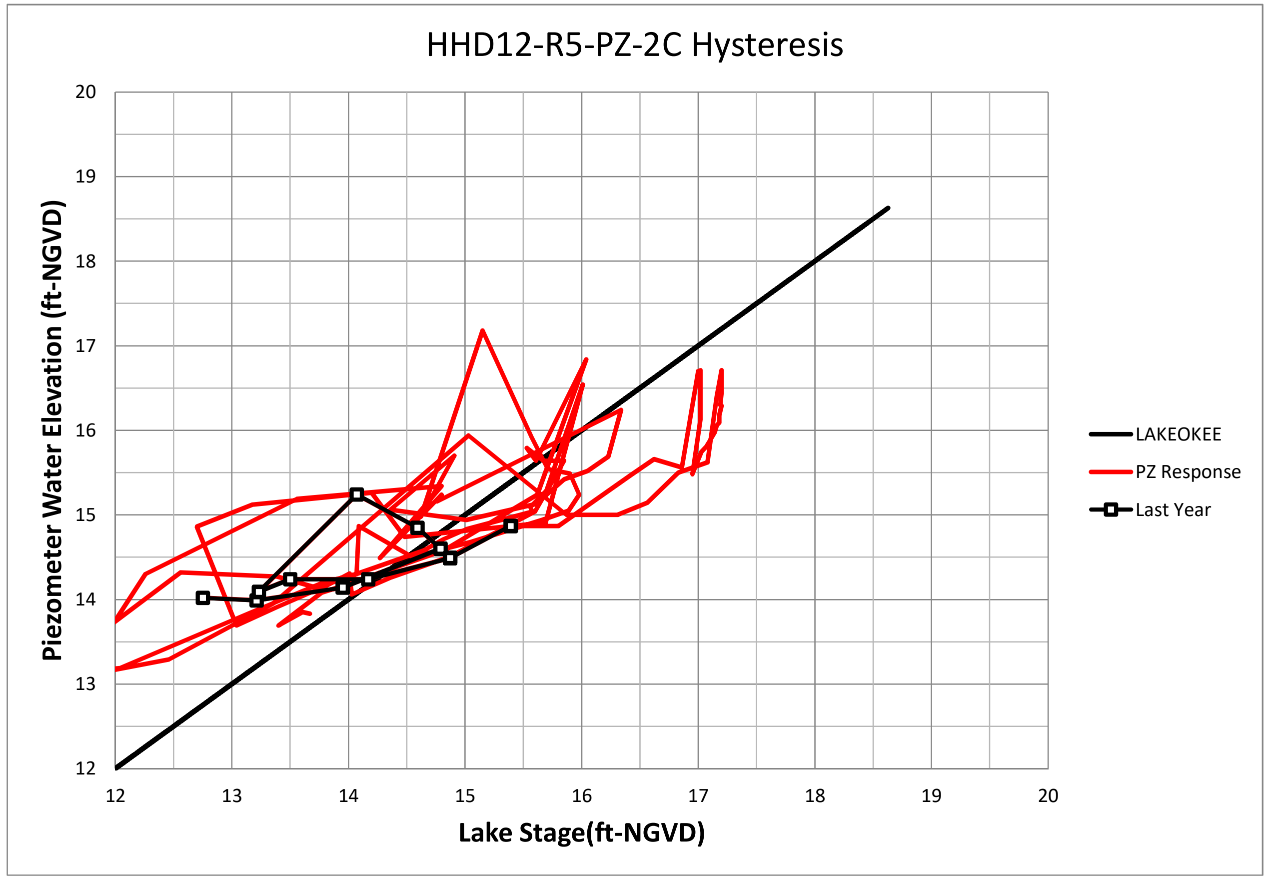
Instrumentation Update



Herbert Hoover Dike- Lake Okeechobee, Florida
Instrumentation Update