

# Radar Rainfall Analysis

## March 2021 Summary Report



Prepared for 3 Rivers Wet Weather

April 26, 2021



301 David L. Boren Blvd., Suite 3050  
Norman, Oklahoma 73072  
[www.vieuxinc.com](http://www.vieuxinc.com)

# TABLE OF CONTENTS

<b>Glossary .....</b>	<b>3</b>
<b>Overview .....</b>	<b>4</b>
Methodology .....	6
Metadata.....	8
<b>Gauge-Adjusted Radar Rainfall (GARR) .....</b>	<b>9</b>
<b>Events .....</b>	<b>13</b>
Event 1: 2021-03-11 .....	13
Event 2: 2021-03-18 .....	19
Event 3: 2021-03-28 .....	37
Event 4: 2021-03-31 .....	50
<b>Appendices.....</b>	<b>57</b>
Appendix A - Gauge Performance Exclusion Table .....	59
Appendix B - Gauge Statistical Criteria Exclusion Table .....	70
Appendix C - Event 1 (2021-03-11) CDPs.....	79
Appendix D - Event 2 (2021-03-18) CDPs .....	99
Appendix E - Event 3 (2021-03-28) CDPs.....	119
Appendix F - Event 4 (2021-03-31) CDPs .....	139

## Glossary

---

**Average Difference (AD)** – Average of the absolute percentage differences between the rain gauge data and uncalibrated radar data sampled over the gauges.

**Bias Correction Factor** – Bias is a systematic error that can be corrected through calibration. The correction factor is the sum of the gauges divided by the sum of the sampled radar values over the gauges.

**Calibrated Average Difference (CAD)** – Average of the absolute percentage differences between the rain gauges and local bias calibrated radar data sampled over the gauges.

**Cumulative Distribution Plot (CDP)** – A graph depicting the accumulation of a rain gauge and the unadjusted/adjusted radar over that gauge.

**Decibels of Reflectance (dBZ)** – The logarithmic scale for measuring radar reflectivity factor or a measure of reflectivity of a radar signal off a remote object.

**Gauge Adjusted Radar Rainfall (GARR)** – Bias corrected radar rainfall through comparison with rain gauges.

**KCCX** – Federal Communications Commission (FCC) call sign for the NEXRAD near State College, PA.

**KPBZ** – Federal Communications Commission (FCC) call sign for the NEXRAD near Pittsburgh, PA.

**Level II** – The Level II radar products are the highest resolution, and consist of the base data that includes reflectivity measured in decibels of reflectance (dBZ) among Doppler velocity and spectrum width.

**Level III** – The Level III radar products are derivative products from Level II, and consist of horizontal and vertical reflectivity among other products.

**Local Bias (LB)** – An approach to adjusting radar rainfall that uses the ratio of gauge to radar accumulations from surrounding gauges, with the closest gauge having the most weight.

**Minimum Storm Total Threshold (MSTT)** – A check used to remove radar/gauge pairs whose cumulative radar and/or gauge values for a given event period were below 0.05 inches.

**Next Generation RADAR (NEXRAD)** – A network of S-band (10.5-cm wavelength) radars operated by the National Weather Service.

**Radio Detection and Ranging (RADAR)** – An electronic instrument used for the detection and ranging of distant objects of such composition that they scatter or reflect radio energy.

**Radar-Gauge (RG)** – A pair of rainfall accumulations measured by the rain gauge and the radar rainfall accumulation sampled above the gauge.

**Z-R relationship** – An empirical relationship between radar reflectivity factor  $Z$  ( $\text{mm}^6 \text{m}^{-3}$ ) and rain rate  $R$  ( $\text{mm hr}^{-1}$ ). Radar reflectivity factor is dependent on the rain drop size distribution. [ $Z = aR^b$ , where  $a$  and  $b$  are empirically derived constants]

- **Convective** – generally used for convective (i.e. thunderstorms) rainfall [ $Z = 300R^{1.4}$ ]
- **Eastern U.S. Cool Stratiform** – generally used for cool season, non-convective rainfall that occurs east of the Continental Divide [ $Z = 130R^{2.0}$ ]

## Overview

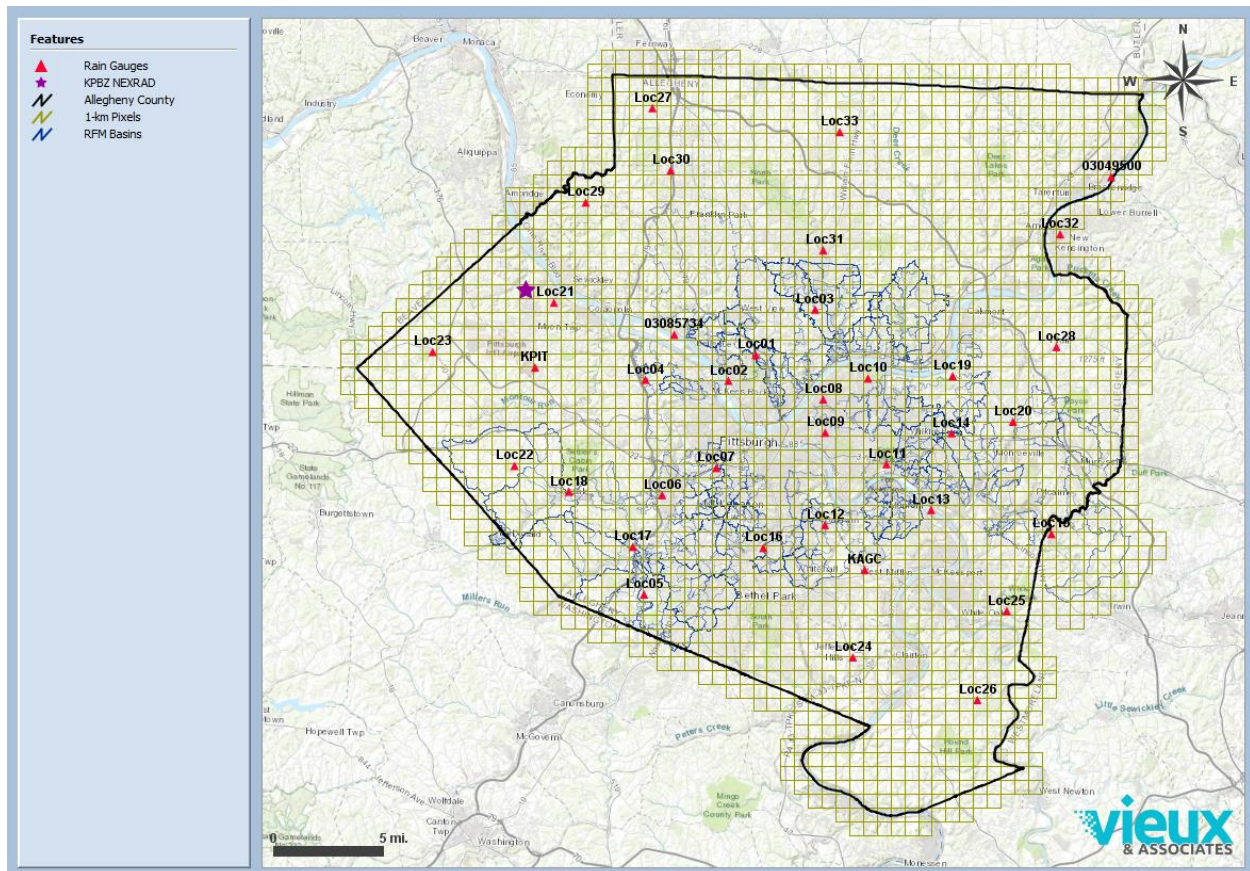
Vieux & Associates, Inc. (Vieux) processes radar and rain gauge data for 3 Rivers Wet Weather (3RWW). During each month, radar and rain gauge data are segmented into qualified storm event periods and then Quality Controlled (QC). To produce QC gauge-adjusted radar rainfall (GARR), both radar and rain gauge data are reviewed manually to remove inconsistent data. While only qualified rainfall events are included in this report, the RainVieux online database contains continuous data where QC rain gauge and radar data are available during the inter-event periods. QC is performed to remove anomalous radar data and inconsistent rain gauges during both the qualified and inter-event periods.

Radar data used in production of GARR is produced by the National Weather Service (NWS) Next Generation Radar (NEXRAD) system. NEXRAD Level II radar data are often referred to as Base Data and contain the full spatial/temporal/data resolution data from the radar. Level II radar data measures reflectivity in decibels of reflectance (dBZ), and at a spatial resolution of 0.5-degree by 0.25-km every 4 – 10 minutes with a data resolution of 0.5 dBZ amounting to 256 data levels of data. Level III reflectivity radar data have the same data and temporal resolution, but a reduced spatial resolution of 1-degree by 1-km.

The primary radar data source used to process this period was Level II NEXRAD data from KPBZ located near Pittsburgh, PA. The succession of data used gives priority to Level II followed by Level III products. If KPBZ Level II NEXRAD data are unavailable, then KPBZ Level III Q1 is substituted. If no radar data are available from KPBZ, then Level III Q0 NEXRAD data from KCCX (State College, PA) are used. In the event that all radar sources are unavailable or if the radar provides insufficient rainfall information, then a gauge-only product that spatially distributes point rainfall estimates is used. All radar data were processed into five-minute increments.

Because the radar measures reflectivity in polar coordinates centered on the radar installation, the 1-degree azimuth increases in width as range increases from the radar. Range resolution of the Level II radar data is 1-km and is measured out to 230 km from the radar. Due to the proximity of KPBZ to the study area, the polar coordinates defining horizontal resolution over Allegheny County range from 0.1 – 0.9 km, whereas KCCX ranges from 2.5 – 3.6 km. The radar data represented in these polar coordinates are sampled through spatial averaging into a Cartesian grid of uniform resolution, i.e. 1x1 km. An advantage of the Cartesian grid is that one radar can be substituted for the other without changing the grid resolution, as would be necessary if polar coordinates were used for output of rainfall information at 1x1 km spatial resolution. The Cartesian grid used was defined by a 1-km<sup>2</sup> grid domain shapefile containing 2313 1-km<sup>2</sup> pixels covering the study area. CDM Smith provided two basin shapefiles consisting of 440 RFM basins and 871 RFM sheds that are located within the 1-km<sup>2</sup> pixel domain.

Rain gauge data from as many as 37 gauges were used to adjust the radar. 3RWW provided rain data in 5-minute increments for 33 stations. In addition, rain gauge data were obtained from two United States Geological Survey (USGS) stations and two NWS Automated Surface Observing System (ASOS) stations. Figure 1 depicts the spatial distribution of the rain gauge network, KPBZ NEXRAD, RFM basins and 1-km<sup>2</sup> pixels. For the gauges shown in Figure 1, the ID, name and source of each gauge is listed in Table 1. Radar data review, preparation and sampling the radar over the gauges and 1-km<sup>2</sup> pixels were achieved using software developed at Vieux.



**Figure 1. Spatial Distribution of the Rain Gauge Network, KPBZ NEXRAD, RFM Basins and 1-km<sup>2</sup> Pixels**

**Table 1. Rain Gauge ID, Name and Source**

Gauge ID	Gauge Name	Source
Loc01	PWSA-Montana St.	3RWW
Loc02	ALCOSAN WWTP Lab	3RWW
Loc03	Shaler Munic Bldg	3RWW
Loc04	Kennedy Twp PS	3RWW
Loc05	Upper St. Clair	3RWW
Loc06	Carnegie Transit Time	3RWW
Loc07	Greentree Munic Bldg	3RWW
Loc08	AC Health Dept Bldg	3RWW
Loc09	Univ of Pittsburgh	3RWW
Loc10	PWSA-Highland Park	3RWW
Loc11	M-46 Access Shaft	3RWW
Loc12	Baldwin	3RWW
Loc13	M-59 Access Shaft	3RWW

Gauge ID	Gauge Name	Source
Loc14	Churchill Munic Bldg	3RWW
Loc15	Trafford Maint Bldg	3RWW
Loc16	Castle Shannon	3RWW
Loc17	Chartiers Pump Station	3RWW
Loc18	Oakdale Pump Station	3RWW
Loc19	Sandy Creek Eq Facility	3RWW
Loc20	Gascola Eq Facility	3RWW
Loc21	Moon TWP	3RWW
Loc22	North Fayette TWP	3RWW
Loc23	Clinton Munic Bldg	3RWW
Loc24	Jefferson Hills	3RWW
Loc25	White Oak Public Works Bldg	3RWW
Loc26	Elizabeth TWP Municipal Bldg	3RWW
Loc27	Marshall TWP	3RWW
Loc28	Plum Municipal Bldg	3RWW
Loc29	Bell Acres Munic Bldg	3RWW
Loc30	McCandless Twn Hall	3RWW
Loc31	Hampton Municipal Bldg	3RWW
Loc32	Arnold	3RWW
Loc33	Richland TWP	3RWW
KAGC	Pittsburgh Allegheny Cty	NWS - ASOS
KPIT	Greater Pittsburgh Int'l	NWS - ASOS
03049500	Allegheny River at Natrona	USGS
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	USGS

The 37 rain gauges and the two NWS NEXRAD radars are used to produce gauge-adjusted radar rainfall (GARR). The methodology used in production of the GARR and the dataset metadata are described in the following sections.

## Methodology

Radar and rain gauge data are segmented into qualified storm event periods and then Quality Controlled (QC). Qualified rainfall events are defined based on the storm event definition where, for any given hour, at least 50% of all working 3RWW gauges have an accumulation of 0.05 inches. Only qualified rainfall events are included in the report, while the RainVieux online database contains continuous data. Both the qualified and inter-event periods receive QC to remove anomalous radar data and inconsistent rain gauges.

Statistical control of the data makes radar rainfall measurements more accurate. By statistical comparison between the radar and rain gauge accumulations during a GARR period, certain gauges may be identified as statistical outliers and excluded for all or part of an event. Radar data

is enhanced by correcting it for systematic errors called bias, which helps improve the accuracy of the rainfall product. The bias correction factors are multiplicative factors applied to the radar that enhances the accuracy of the radar rainfall for any accumulation period. By adjusting the radar data with rain gauge data, better maps of rainfall are produced than either sensor system could produce alone.

In the production of GARR, radar rainfall is bias corrected through comparison with rain gauge accumulations. To the extent possible, individual gauges are combined to cover the target area for use in bias adjustment. The method of adjustment depends on the hydrologic application and the spatial extent of the area of interest. The local bias (LB) approach to adjusting the radar rainfall uses the ratio of gauge to radar accumulations from surrounding gauges with the closest gauge having the most weight. The LB approach distributes the variation of bias over the region, and is computed and applied within each event period.

The LB uses the ratio between the sum of each gauge divided by the sum of the sampled radar values over each gauge. Gauge and radar accumulations were computed for each event period. A minimum storm total threshold (MSTT) check was used to remove radar/gauge (RG) pairs whose R or G cumulative values for a given event period were below a chosen threshold (i.e. 0.05 inches for this study). The remaining RG pairs were then checked for statistical outliers. Those RG pairs with individual bias ( $G/R$ ) or average difference ( $((G-R)/G)$ ) values greater than three standard deviations from the mean were then excluded from being used to adjust the radar.

After RG pairs have been removed on an event basis by either the MSTT, outlier check or gauge performance review, there must be at least two remaining RG pairs to proceed with gauge-adjustment of the radar. The individual biases of the remaining RG pairs are then distributed spatially over the analysis area using the LB weighted distance method. The resulting LB value over each radar bin is the multiplicative factor that adjusts the radar. For example, a bias of 1.5 can be interpreted as a 33% underestimation by the radar. The statistical measures reported are 1) average difference (AD) and 2) calibrated average difference (CAD). Both of these statistical measures are expressed as an absolute percentage about the mean of  $G/R$  accumulations for each event period. GARR is then spatially aggregated from the final adjusted radar bins to the basins and 1-km<sup>2</sup> pixels using an area-averaged technique.

After bias correction, though generally small, differences between rain gauge and radar rainfall accumulations still exist due to sampling differences or local meteorological conditions among other reasons. A major reason for departures is that radar collects data by averaging reflectivity over a 1-degree by 1-km sample volume, while rain gauges measure at a point. Another source of difference is that radar measures above the ground, while rain gauges measure close to the ground. Further, updrafts and downdrafts during storms can decrease or increase rain rates, respectively. However, radar cannot detect local wind effects, while rain gauges can be affected. Differences between the radar data and the rain gauge data are also affected by precipitation processes associated with the type of storm, which also are affected by the season of the year.

## Metadata

Data accompanying this document provides a continuous rainfall record of all 2313 1-km pixels, 440 RFM basins and 871 RFM sheds in 15-minute intervals. The data are provided in CSV format for the period from 2021-03-01 00:00 EST to 2021-04-01 00:00 EDT. Shapefiles of the 1-km pixels, RFM basins and RFM sheds are located in the Shapefiles subfolder.

### 1-km<sup>2</sup> Pixel CSV metadata:

- Individual CSV files are provided for each pixel.
- The pixel filenames use a "Ryymm\_" (i.e. R, year, month) prefix in front of the pixel ID.
- The comma-delimited text files contain a header row in the 1st row and time/data values beginning on the 2nd row.
- The time/data columns consist of Month, Day, Year, Hour, Minute, Rainfall and Source, where R represents EOM GARR quality.
- Time stamps are in EST/EDT.
- Data values represent 15-min accumulation (inches) at end of interval.
- The 1-km Pixel ID field that was used from the shapefile DBF is "PIXEL".

### Basin CSV metadata:

- Individual CSV files are provided for each RFM Basin and RFM Shed.
- The RFM Basin filenames use a "P-" prefix and a "yyyymmG" (i.e. year, month, G) suffix in front and after the RFM Basin ID.
- The RFM Shed filenames use a "P-" prefix and a "yyyymmN" (i.e. year, month, N) suffix in front and after the RFM Shed ID.
- The comma-delimited text files contain a header row in the 1st row and time/data values beginning on the 2nd row.
- The 1st column contains the date (yyyy/mm/dd hh:mm) and the 2nd column contains the corresponding rainfall value.
- Time stamps are in EST/EDT.
- Data values represent 15-min accumulation (inches) at end of interval.
- The RFM Basin ID field that was used from the shapefile DBF is "DS\_METERNA".
- The RFM Shed ID field that was used from the shapefile DBF is "DELINID".

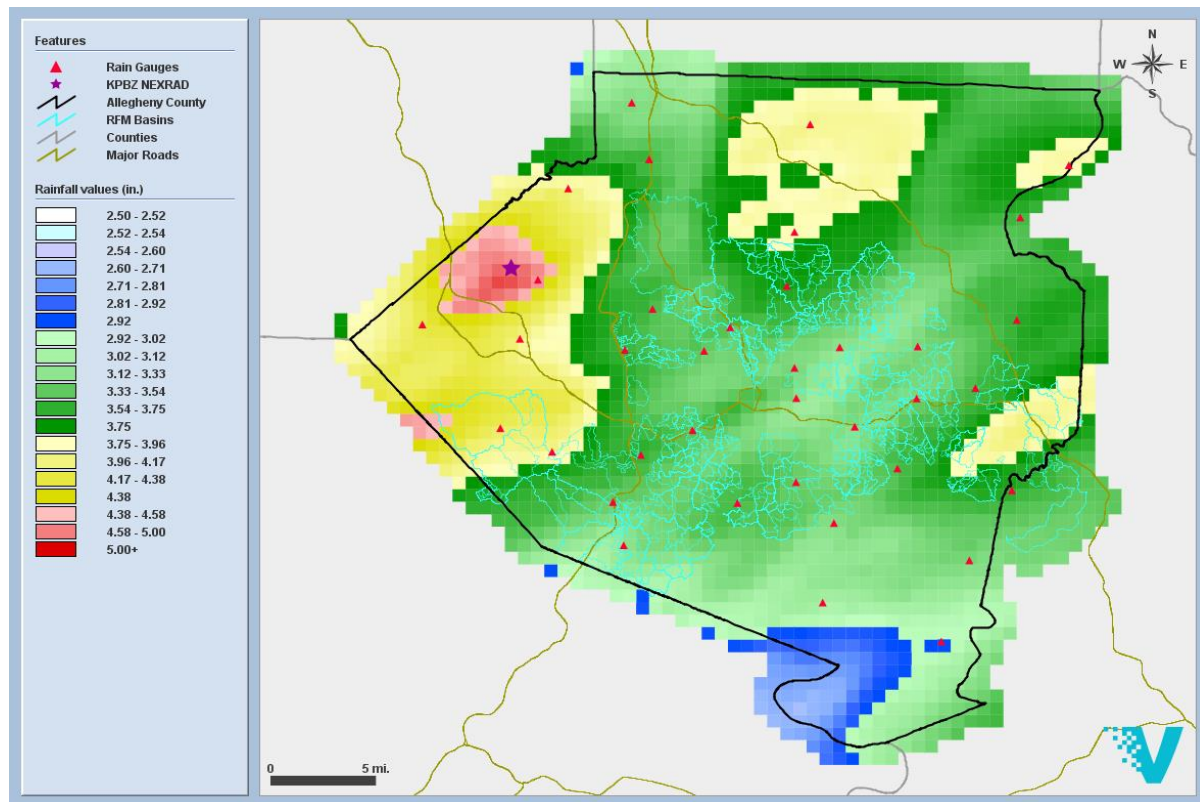
### Shapefile metadata:

- NAD 1983, State Plane Pennsylvania South (feet).



## Gauge-Adjusted Radar Rainfall (GARR)

Rainfall totals for March 2021 are shown in Figure 2. The rainfall amounts for the 2313 1-km<sup>2</sup> pixels range from 2.6 to 4.8 inches with a mean of 3.5 inches. The rainfall amounts for the 440 RFM basins range from 3.0 to 4.2 inches with a mean of 3.4 inches. The rainfall amounts for the 871 RFM sheds range from 3.0 to 4.2 inches with a mean of 3.4 inches.



**Figure 2. GARR Storm Total for March 2021**

GARR was processed continuously at five-minute increments and covers the period from 2021-03-01 00:00 EST to 2021-04-01 00:00 EDT. Four rainfall events were identified as having met the storm definition during March 2021. The GARR statistics for each event are listed in Table 2. Four of the events were split into multiple sub-event periods to improve gauge-adjustment of the radar, resulting in a total of twenty-two event and sub-event periods. The events that were split into multiple periods are shown in the **Event#** column with the letter "a", "b", "c", etc. appended to the event number (e.g., E1a, E1b, E1c). The **Source** column shows what rainfall source was used to produce GARR for each event or sub-event period. The listed **Event Date** shown in Table 2 corresponds to the day or portion of the day when most of the rainfall occurred for that GARR event period. All four rainfall events are discussed in more detail in the following Events section.

The **Bias** value shown in Table 2 is the sum of the gauges divided by the sum of the sampled radar values over the gauges. Those rain events with the lowest CAD values shown in Table 2 represent the best agreement between GARR and gauge values for all radar/gauge pairs used to adjust the radar. On average, lower values of CAD imply higher statistical confidence in the reliability of the

dataset. Typically, stratiform rainfall events (i.e., low spatial variability) have lower CAD values than convective rainfall events (i.e., high spatial variability). Based on all twenty-two event and sub-event periods, the event CAD averaged 2.1%, indicating that the mean GARR agrees with the mean gauge accumulation to within  $\pm 1.1\%$ .

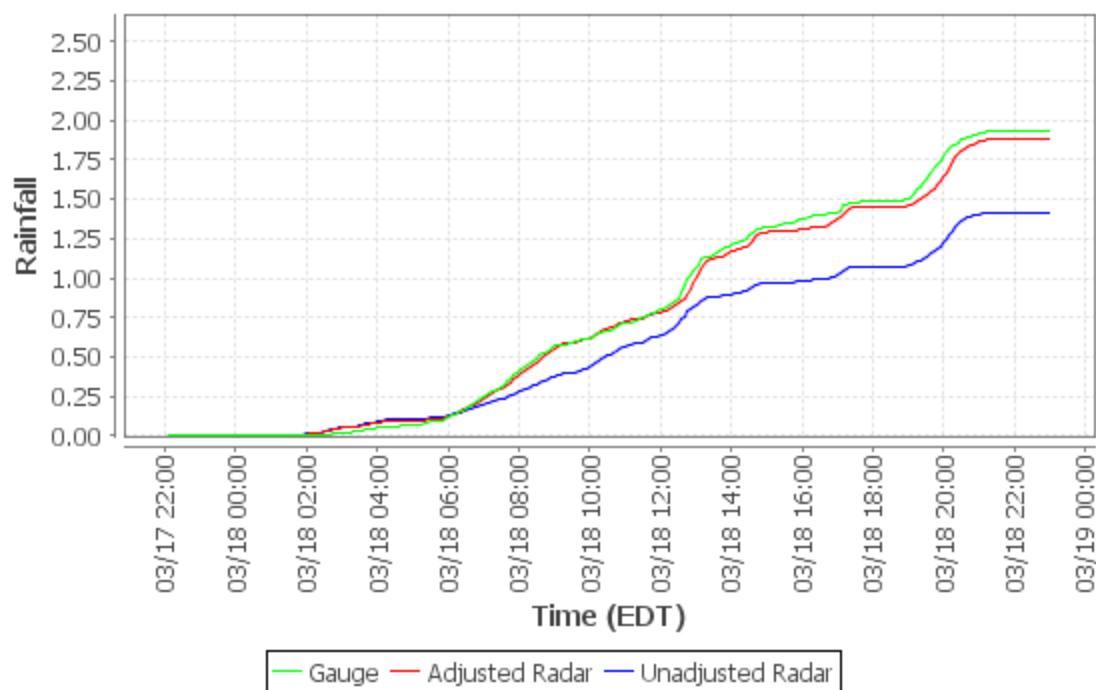
**Table 2. Storm Events and GARR Statistics**

Event #	Source	Event Date	Start Time (EST/EDT)	End Time (EST/EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
<a href="#">E1a</a>	KPBZ LII	2021-03-11	2021-03-11 19:05	2021-03-11 23:00	31	0.134	1.013	10.4	1.1
<a href="#">E1b</a>	KPBZ LII	2021-03-11	2021-03-11 23:05	2021-03-12 01:00	35	0.093	0.671	57.2	4.6
<a href="#">E1c</a>	Gauge Only	2021-03-11	2021-03-12 01:05	2021-03-12 08:00	32	0.044	---	---	---
<a href="#">E2a</a>	KPBZ LII	2021-03-18	2021-03-17 22:05	2021-03-18 06:00	31	0.100	0.724	41.1	2.9
<a href="#">E2b</a>	KPBZ LII	2021-03-18	2021-03-18 06:05	2021-03-18 09:30	30	0.491	1.759	43.0	1.1
<a href="#">E2c</a>	KPBZ LII	2021-03-18	2021-03-18 09:35	2021-03-18 11:30	31	0.168	0.757	31.7	1.8
<a href="#">E2d</a>	KPBZ LII	2021-03-18	2021-03-18 11:35	2021-03-18 12:45	28	0.118	0.953	16.0	2.5
<a href="#">E2e</a>	KPBZ LII	2021-03-18	2021-03-18 12:50	2021-03-18 14:00	24	0.225	2.311	56.4	1.1
<a href="#">E2f</a>	KPBZ LII	2021-03-18	2021-03-18 14:05	2021-03-18 15:45	25	0.087	1.325	38.8	2.7
<a href="#">E2g</a>	KPBZ LII	2021-03-18	2021-03-18 15:50	2021-03-18 17:00	10	0.074	1.324	26.6	0.7
<a href="#">E2h</a>	KPBZ LII	2021-03-18	2021-03-18 17:05	2021-03-18 19:00	30	0.223	1.085	30.5	3.2
<a href="#">E2i</a>	KPBZ LII	2021-03-18	2021-03-18 19:05	2021-03-18 23:00	28	0.155	0.825	39.2	2.5
<a href="#">E3a</a>	KPBZ LII	2021-03-28	2021-03-28 02:05	2021-03-28 05:45	32	0.176	0.965	15.7	2.5
<a href="#">E3b</a>	KPBZ LII	2021-03-28	2021-03-28 05:50	2021-03-28 06:45	32	0.183	1.679	39.9	2.2
<a href="#">E3c</a>	KPBZ LII	2021-03-28	2021-03-28 06:50	2021-03-28 08:00	8	0.039	0.727	36.2	1.6
<a href="#">E3d</a>	Gauge Only	2021-03-28	2021-03-28 08:05	2021-03-28 11:00	30	0.049	---	---	---
<a href="#">E3e</a>	KPBZ LII	2021-03-28	2021-03-28 11:05	2021-03-28 12:30	26	0.099	1.101	18.1	3.2

Event #	Source	Event Date	Start Time (EST/EDT)	End Time (EST/EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
<a href="#">E3f</a>	KPBZ LII	2021-03-28	2021-03-28 12:35	2021-03-28 14:00	7	0.041	0.741	43.5	2.3
<a href="#">E3g</a>	KPBZ LII	2021-03-28	2021-03-28 14:05	2021-03-28 17:00	4	0.035	0.724	38.2	3.0
<a href="#">E4a</a>	KPBZ LII	2021-03-31	2021-03-31 01:05	2021-03-31 06:00	6	0.047	0.676	50.5	0.0
<a href="#">E4b</a>	KPBZ LII	2021-03-31	2021-03-31 06:05	2021-03-31 10:00	30	0.238	1.135	12.5	1.0
<a href="#">E4c</a>	Gauge Only	2021-03-31	2021-03-31 10:05	2021-03-31 15:00	32	0.018	---	---	---

Statistical review of the data can provide an indication of data quality. Depending on the quality of the radar and gauge data, CAD values for individual events less than 10% are considered excellent, 10 - 20% are considered good, and 20 - 30% are considered fair. However, CAD may not serve as a reliable indicator of data quality when abrupt changes in bias occur within the analysis period, particularly when compensating over- and under-estimation results due to using an assumed Z-R relationship throughout the period while atmospheric conditions merit different Z-R coefficients. The effects from abrupt changes in Z-R are mitigated by splitting the event periods.

Rain gauges were analyzed to identify those that were not consistent with the radar or surrounding gauges. Cumulative Distribution Plots (CDPs) at each gauge location showing gauge, unadjusted radar and GARR values were produced for each rainfall event and are presented in Appendices C - F. CDPs are useful for visualizing rain gauge performance. Figure 3 shows the rainfall accumulation at the Oakdale Pump Station(Loc18) gauge during the 2021-03-18 event as measured by the gauge (green), unadjusted radar (blue), and gauge-adjusted radar (red). Rain gauges that are not performing consistently with the radar or surrounding gauges have characteristics such as clogs, synchronization or other mechanical/transmission malfunctions that can be visually identified in the CDP graph.



**Figure 3. CDP Showing Rain Gauge Versus Unadjusted Radar Versus GARR**

Reasons for not using gauges in rainfall analysis include clogs, significant under- or over-reporting of rainfall, gauges that stop reporting during rainfall, or a combination of these reasons. A list of possible reasons for not using a gauge based on CDP analysis is shown in Table 3. Those gauges that were excluded from analysis based on gauge performance are shown in [Appendix A](#). Additional gauges were not used to adjust the radar for a given event or sub-event period if they did not meet the statistical criteria outlined in the Methodology section. A list of reasons for not using a gauge based on statistical criteria is shown in Table 4. The gauges listed in [Appendix B](#) did not meet statistical criteria for gauge-adjustment of the radar and were not used to adjust the radar.

**Table 3. Reasons for Gauge Exclusion Based on Performance**

Reason	Explanation
Clog (C)	Gauge appeared to be clogged
Zero (Z)	Gauge did not report any rainfall while radar rainfall estimates reported significant rainfall
Stop (S)	Gauge appeared to stop reporting rainfall while radar rainfall estimates reported significant rainfall
Over (O)	Gauge appeared to significantly over-report rainfall as compared to radar rainfall estimates and surrounding gauges (e.g. anomalously high rainfall values caused by field calibration, data transmission error, or switch malfunctions)
Under (U)	Gauge appeared to significantly under-report as compared to radar rainfall estimates and surrounding Gauges (e.g. half-tipper)
Sync (SY)	Gauge appeared to be reporting out-of-sync with the radar rainfall estimates

Reason	Explanation
Frozen/Melt (F/M)	Gauge not reporting properly due to frozen or melting precipitation
Other (T)	Combination of multiple reasons
No Data (ND)	Gauge reported "no data" for a significant amount of time

**Table 4. Reasons for Gauge Exclusion Based on Statistical Criteria**

Reason	Explanation
Minimum Storm Total Threshold (MSTT)	The radar or gauge cumulative sum during the event or sub-event period was less than MSTT
Outlier Based on Mean Field Bias (OMFB)	The RG pair bias (G/R) was greater than three standard deviations from the mean bias (e.g. $G \gg R$ )
Outlier Based on Average Difference (OAD)	The RG pair average difference $((G-R)/G)$ was greater than three standard deviations from the mean average difference (e.g. $G \ll R$ )

A synopsis for each event is described below in terms of the specific processing protocol applied to each event period as well as specific GARR information.

## Events

### Event 1: 2021-03-11

The analysis period was from 2021-03-11 19:00 EST to 2021-03-12 08:00 EST. The event was then split into three sub-event periods at 2021-03-11 23:00 EST and 2021-03-12 01:00 EST to improve gauge adjustment of the radar. Gauge Only was used during Event 1c since all radar sources were either unavailable or provided insufficient rainfall information.

The gauges listed in [Appendix A](#) were not used to adjust the radar due to inconsistencies between the gauge and the radar or surrounding gauges, or they did not have data available for this event. The gauges listed in [Appendix B](#) were not used to adjust the radar since they did not meet statistical criteria for gauge-adjustment.

The Eastern U.S. cool season stratiform Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 5 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 6 - 8 summarize the results for each RG pair used for final radar adjustment, where  $G_i$  is the gauge estimate,  $R_i$  is the non-adjusted radar estimate,  $R_i^*$  is the GARR estimate, and Diff\* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 4 - 5 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 6 depicts the GARR storm total over the 1-km<sup>2</sup> pixels. The GARR amounts for the 2313 1-km<sup>2</sup> pixels range from 0.2 - 0.4 inches with a mean of 0.3 inches. The GARR amounts for the 440 RFM basins range from 0.2 - 0.4 inches with a mean of 0.3 inches. The GARR amounts

for the 871 RFM sheds range from 0.2 - 0.4 inches with a mean of 0.3 inches. Table 9 shows the Depth Duration Frequency (DDF) maximum values for the 1-km<sup>2</sup> pixels.

**Table 5. GARR Statistics for Event 1**

Event #	Radar	Event Date	Start Time (EST)	End Time (EST)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E1a	KPBZ LII	2021-03-11	2021-03-11 19:05	2021-03-11 23:00	31	0.134	1.013	10.4	1.1
E1b	KPBZ LII	2021-03-11	2021-03-11 23:05	2021-03-12 01:00	35	0.093	0.671	57.2	4.6
E1c	Gauge Only	2021-03-11	2021-03-12 01:05	2021-03-12 08:00	32	0.044	---	---	---

**Table 6. Summary of Individual RG Pairs for Event 1a**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.12	0.15	0.12	0.00	0.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.10	0.11	0.10	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.16	0.17	0.16	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.12	0.14	0.12	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.14	0.15	0.14	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.12	0.12	0.12	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.14	0.13	0.14	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.14	0.14	0.14	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.13	0.14	0.13	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.13	0.15	0.13	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.12	0.12	0.12	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.12	0.13	0.12	0.00	0.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.11	0.12	0.11	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.11	0.14	0.11	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.13	0.13	0.13	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.12	0.12	0.12	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.20	0.14	0.20	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.14	0.16	0.14	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.15	0.16	0.15	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.19	0.13	0.19	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.16	0.15	0.16	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.11	0.09	0.11	0.00	0.0	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.09	0.08	0.09	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.08	0.07	0.08	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.13	0.13	0.13	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.17	0.15	0.17	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.15	0.16	0.15	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.15	0.15	0.15	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.12	0.12	0.12	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.18	0.14	0.18	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.15	0.15	0.14	0.01	6.7	
<a href="#">03049500</a>	Allegheny River at Natrona	0.08	---	---	---	---	U
<a href="#">Loc01</a>	PWSA-Montana St.	0.09	---	---	---	---	U
<a href="#">Loc04</a>	Kennedy Twp PS	0.10	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	0.04	---	---	---	---	C
<a href="#">Loc20</a>	Gascola Eq Facility	0.10	---	---	---	---	OAD
<a href="#">Loc30</a>	McCandless Twn Hall	0.11	---	---	---	---	U

**Table 7. Summary of Individual RG Pairs for Event 1b**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.12	0.07	-0.01	-16.7	
<a href="#">Loc01</a>	PWSA-Montana St.	0.06	0.13	0.07	-0.01	-16.7	
<a href="#">Loc17</a>	Chartiers Pump Station	0.06	0.12	0.07	-0.01	-16.7	
<a href="#">Loc10</a>	PWSA-Highland Park	0.07	0.11	0.08	-0.01	-14.3	
<a href="#">Loc11</a>	M-46 Access Shaft	0.07	0.16	0.08	-0.01	-14.3	
<a href="#">Loc20</a>	Gascola Eq Facility	0.10	0.18	0.11	-0.01	-10.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.08	0.15	0.08	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.07	0.11	0.07	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.13	0.15	0.13	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.08	0.13	0.08	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.07	0.12	0.07	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.09	0.16	0.09	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.12	0.15	0.12	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.06	0.13	0.06	0.00	0.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.06	0.13	0.06	0.00	0.0	



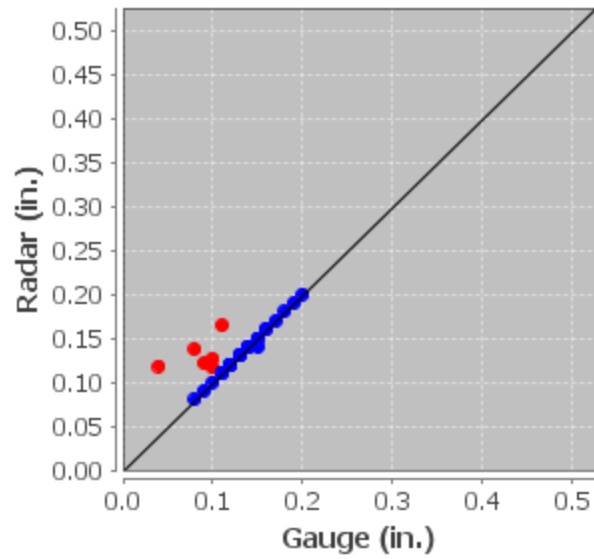
Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc14</a>	Churchill Munic Bldg	0.09	0.16	0.09	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.07	0.13	0.07	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.08	0.11	0.08	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.07	0.10	0.07	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.08	0.09	0.08	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.10	0.11	0.10	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.07	0.14	0.07	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.10	0.18	0.10	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.08	0.20	0.08	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.12	0.12	0.12	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.05	0.05	0.05	0.00	0.0	
<a href="#">Loc30</a>	McCandless Twn Hall	0.07	0.10	0.07	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.10	0.10	0.10	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.18	0.16	0.18	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.13	0.12	0.13	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.09	0.11	0.08	0.01	11.1	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.09	0.11	0.08	0.01	11.1	
<a href="#">Loc04</a>	Kennedy Twp PS	0.08	0.11	0.07	0.01	12.5	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.07	0.10	0.06	0.01	14.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.12	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	0.13	---	---	---	---	C

**Table 8. Summary of Individual RG Pairs for Event 1c**

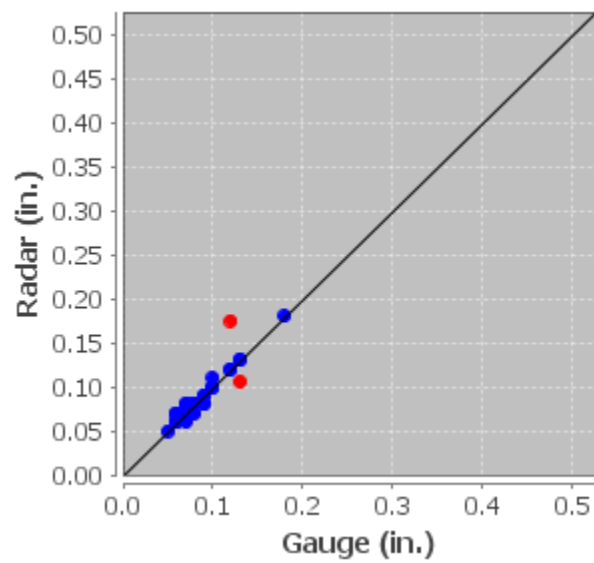
Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc13</a>	M-59 Access Shaft	0.01	---	---	---	---	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.01	---	---	---	---	
<a href="#">Loc11</a>	M-46 Access Shaft	0.02	---	---	---	---	
<a href="#">Loc12</a>	Baldwin	0.02	---	---	---	---	
<a href="#">Loc24</a>	Jefferson Hills	0.02	---	---	---	---	
<a href="#">Loc27</a>	Marshall TWP	0.02	---	---	---	---	
<a href="#">Loc05</a>	Upper St. Clair	0.03	---	---	---	---	
<a href="#">Loc16</a>	Castle Shannon	0.03	---	---	---	---	
<a href="#">Loc17</a>	Chartiers Pump Station	0.03	---	---	---	---	



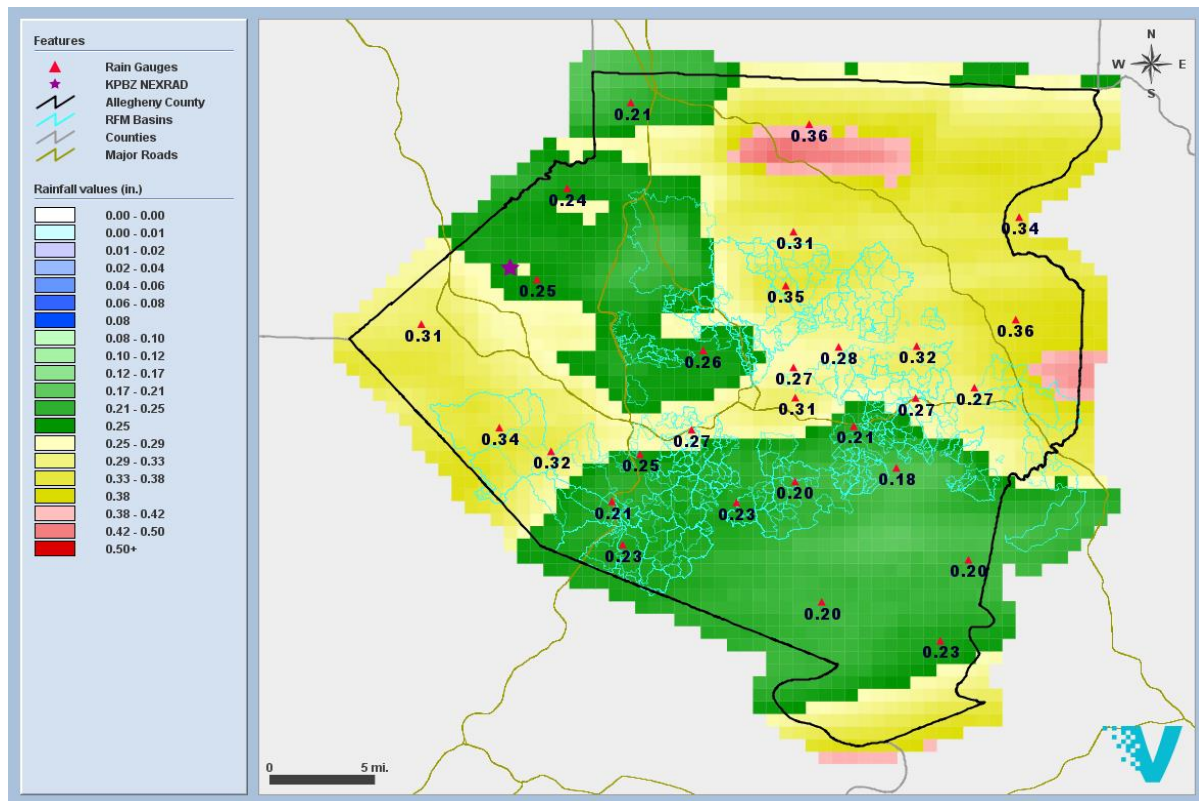
<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc21</a>	Moon TWP	0.03	---	---	---	---	
<a href="#">Loc30</a>	McCandless Twn Hall	0.03	---	---	---	---	
<a href="#">Loc01</a>	PWSA-Montana St.	0.04	---	---	---	---	
<a href="#">Loc04</a>	Kennedy Twp PS	0.04	---	---	---	---	
<a href="#">Loc06</a>	Carnegie Transit Time	0.04	---	---	---	---	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.04	---	---	---	---	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.04	---	---	---	---	
<a href="#">Loc18</a>	Oakdale Pump Station	0.04	---	---	---	---	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.04	---	---	---	---	
<a href="#">Loc32</a>	Arnold	0.04	---	---	---	---	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.05	---	---	---	---	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.05	---	---	---	---	
<a href="#">Loc33</a>	Richland TWP	0.05	---	---	---	---	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.06	---	---	---	---	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.07	---	---	---	---	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.07	---	---	---	---	
<a href="#">Loc20</a>	Gascola Eq Facility	0.07	---	---	---	---	
<a href="#">Loc22</a>	North Fayette TWP	0.07	---	---	---	---	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.07	---	---	---	---	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.07	---	---	---	---	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.08	---	---	---	---	
<a href="#">Loc10</a>	PWSA-Highland Park	0.08	---	---	---	---	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.09	---	---	---	---	
<a href="#">03049500</a>	Allegheny River at Natrona	0.04	---	---	---	---	T
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	T
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.03	---	---	---	---	T
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.04	---	---	---	---	T
<a href="#">Loc15</a>	Trafford Maint Bldg	0.07	---	---	---	---	C



**Figure 4. Scatter Plot of RG Pairs for Event 1a**



**Figure 5. Scatter Plot of RG Pairs for Event 1b**



**Figure 6. GARR Storm Total for Event 1**

**Table 9. Depth Duration Frequency Analyses for Event 1**

Duration	Depth (in)	Pixel	Time (EST)	Frequency
15 minutes	0.069	172136	2021-03-12 00:05	<1 yr.
30 minutes	0.110	172136	2021-03-12 00:10	<1 yr.
1 hour	0.166	170126	2021-03-12 00:15	<1 yr.
2 hour	0.251	170122	2021-03-12 00:10	<1 yr.
3 hour	0.331	152167	2021-03-12 00:40	<1 yr.
6 hour	0.429	149119	2021-03-12 02:40	<1 yr.
12 hour	0.430	149119	2021-03-12 08:00	<1 yr.

## Event 2: 2021-03-18

The analysis period was from 2021-03-17 22:00 EDT to 2021-03-18 23:00 EDT. The event was then split into nine sub-event periods at 2021-03-18 06:00 EDT, 2021-03-18 09:30 EDT, 2021-03-18 11:30 EDT, 2021-03-18 12:45 EDT, 2021-03-18 14:00 EDT, 2021-03-18 15:45 EDT, 2021-03-18 17:00 EDT and 2021-03-18 19:00 EDT to improve gauge adjustment of the radar.

The gauges listed in [Appendix A](#) were not used to adjust the radar due to inconsistencies between the gauge and the radar or surrounding gauges, or they did not have data available for this event.

The gauges listed in [Appendix B](#) were not used to adjust the radar since they did not meet statistical criteria for gauge-adjustment.

The Eastern U.S. cool season stratiform Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 10 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 11 - 19 summarize the results for each RG pair used for final radar adjustment, where  $G_i$  is the gauge estimate,  $R_i$  is the non-adjusted radar estimate,  $R_i^*$  is the GARR estimate, and Diff\* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 7 - 15 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 16 depicts the GARR storm total over the 1-km<sup>2</sup> pixels. The GARR amounts for the 2313 1-km<sup>2</sup> pixels range from 0.8 - 2.8 inches with a mean of 1.6 inches. The GARR amounts for the 440 RFM basins range from 1.3 - 2.2 inches with a mean of 1.6 inches. The GARR amounts for the 871 RFM sheds range from 1.3 - 2.2 inches with a mean of 1.6 inches. Table 20 shows the Depth Duration Frequency (DDF) maximum values for the 1-km<sup>2</sup> pixels.

**Table 10. GARR Statistics for Event 2**

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E2a	KPBZ LII	2021-03-18	2021-03-17 22:05	2021-03-18 06:00	31	0.100	0.724	41.1	2.9
E2b	KPBZ LII	2021-03-18	2021-03-18 06:05	2021-03-18 09:30	30	0.491	1.759	43.0	1.1
E2c	KPBZ LII	2021-03-18	2021-03-18 09:35	2021-03-18 11:30	31	0.168	0.757	31.7	1.8
E2d	KPBZ LII	2021-03-18	2021-03-18 11:35	2021-03-18 12:45	28	0.118	0.953	16.0	2.5
E2e	KPBZ LII	2021-03-18	2021-03-18 12:50	2021-03-18 14:00	24	0.225	2.311	56.4	1.1
E2f	KPBZ LII	2021-03-18	2021-03-18 14:05	2021-03-18 15:45	25	0.087	1.325	38.8	2.7
E2g	KPBZ LII	2021-03-18	2021-03-18 15:50	2021-03-18 17:00	10	0.074	1.324	26.6	0.7
E2h	KPBZ LII	2021-03-18	2021-03-18 17:05	2021-03-18 19:00	30	0.223	1.085	30.5	3.2
E2i	KPBZ LII	2021-03-18	2021-03-18 19:05	2021-03-18 23:00	28	0.155	0.825	39.2	2.5

**Table 11. Summary of Individual RG Pairs for Event 2a**

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc14</a>	Churchill Munic Bldg	0.06	0.10	0.07	-0.01	-16.7	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.16	0.10	0.00	0.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.08	0.09	0.08	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.14	0.21	0.14	0.00	0.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.06	0.10	0.06	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.05	0.09	0.05	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.07	0.11	0.07	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.09	0.10	0.09	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.08	0.08	0.08	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.05	0.08	0.05	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.05	0.08	0.05	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.07	0.09	0.07	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.07	0.09	0.07	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.07	0.09	0.07	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.06	0.10	0.06	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.09	0.10	0.09	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.12	0.13	0.12	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.07	0.09	0.07	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.08	0.11	0.08	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.12	0.23	0.12	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.15	0.18	0.15	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.15	0.21	0.15	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.06	0.10	0.06	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.09	0.10	0.09	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.07	0.11	0.07	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.13	0.20	0.13	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.08	0.12	0.08	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.13	0.20	0.13	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.11	0.12	0.11	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.20	0.22	0.20	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.11	0.14	0.10	0.01	9.1	
<a href="#">03049500</a>	Allegheny River at Natrona	0.06	---	---	---	---	U
<a href="#">Loc09</a>	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.04	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	0.00	---	---	---	---	ND

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc30</a>	McCandless Twn Hall	0.10	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	0.00	---	---	---	---	ND

**Table 12. Summary of Individual RG Pairs for Event 2b**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.48	0.32	0.50	-0.02	-4.2	
<a href="#">Loc05</a>	Upper St. Clair	0.38	0.23	0.39	-0.01	-2.6	
<a href="#">Loc16</a>	Castle Shannon	0.40	0.25	0.41	-0.01	-2.5	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.43	0.25	0.44	-0.01	-2.3	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.51	0.30	0.52	-0.01	-2.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.49	0.28	0.50	-0.01	-2.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.61	0.35	0.62	-0.01	-1.6	
<a href="#">03049500</a>	Allegheny River at Natrona	0.44	0.24	0.44	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.55	0.34	0.55	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.53	0.29	0.53	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.52	0.30	0.52	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.48	0.26	0.48	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.49	0.27	0.49	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.44	0.25	0.44	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.47	0.27	0.47	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.52	0.27	0.52	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.57	0.37	0.57	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.39	0.22	0.39	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.42	0.24	0.42	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.39	0.22	0.39	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.47	0.31	0.47	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.54	0.28	0.54	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.55	0.36	0.55	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.60	0.30	0.60	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.53	0.27	0.53	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.63	0.31	0.62	0.01	1.6	
<a href="#">Loc04</a>	Kennedy Twp PS	0.55	0.32	0.54	0.01	1.8	
<a href="#">Loc06</a>	Carnegie Transit Time	0.52	0.27	0.51	0.01	1.9	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.63	0.34	0.61	0.02	3.2	
<a href="#">Loc12</a>	Baldwin	0.50	0.26	0.48	0.02	4.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.70	---	---	---	---	O
<a href="#">Loc13</a>	M-59 Access Shaft	0.37	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc21</a>	Moon TWP	0.47	---	---	---	---	U
<a href="#">Loc22</a>	North Fayette TWP	0.41	---	---	---	---	U
<a href="#">Loc30</a>	McCandless Twn Hall	0.32	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND

**Table 13. Summary of Individual RG Pairs for Event 2c**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc16</a>	Castle Shannon	0.11	0.16	0.12	-0.01	-9.1	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.16	0.26	0.17	-0.01	-6.3	
<a href="#">Loc01</a>	PWSA-Montana St.	0.19	0.28	0.20	-0.01	-5.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.17	0.21	0.17	0.00	0.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.10	0.12	0.10	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.28	0.33	0.28	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.20	0.29	0.20	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.18	0.26	0.18	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.14	0.16	0.14	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.18	0.23	0.18	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.18	0.25	0.18	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.15	0.23	0.15	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.12	0.17	0.12	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.11	0.14	0.11	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.18	0.21	0.18	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.16	0.20	0.16	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.13	0.17	0.13	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.11	0.15	0.11	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.19	0.25	0.19	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.23	0.33	0.23	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.07	0.06	0.07	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.08	0.09	0.08	0.00	0.0	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.06	0.06	0.06	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.14	0.24	0.14	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.11	0.15	0.11	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.29	0.39	0.29	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.26	0.34	0.26	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.24	0.31	0.24	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.21	0.27	0.20	0.01	4.8	
<a href="#">Loc10</a>	PWSA-Highland Park	0.19	0.24	0.18	0.01	5.3	
<a href="#">Loc12</a>	Baldwin	0.16	0.16	0.15	0.01	6.3	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.17	---	---	---	---	U
<a href="#">Loc13</a>	M-59 Access Shaft	0.13	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc21</a>	Moon TWP	0.23	---	---	---	---	U
<a href="#">Loc30</a>	McCandless Twn Hall	0.16	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND

**Table 14. Summary of Individual RG Pairs for Event 2d**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc17</a>	Chartiers Pump Station	0.11	0.16	0.12	-0.01	-9.1	
<a href="#">Loc01</a>	PWSA-Montana St.	0.16	0.18	0.17	-0.01	-6.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.09	0.08	0.09	0.00	0.0	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.16	0.18	0.16	0.00	0.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.12	0.13	0.12	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.21	0.19	0.21	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.19	0.18	0.19	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.17	0.18	0.17	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.12	0.13	0.12	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.10	0.12	0.10	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.08	0.10	0.08	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.09	0.09	0.09	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.09	0.07	0.09	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.08	0.06	0.08	0.00	0.0	



Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc16</a>	Castle Shannon	0.09	0.10	0.09	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.10	0.09	0.10	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.24	0.22	0.24	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.14	0.19	0.14	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.18	0.22	0.18	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.12	0.15	0.12	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.10	0.09	0.10	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.14	0.13	0.14	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.05	0.08	0.05	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.12	0.15	0.12	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.22	0.18	0.21	0.01	4.5	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.19	0.19	0.18	0.01	5.3	
<a href="#">Loc05</a>	Upper St. Clair	0.12	0.14	0.11	0.01	8.3	
<a href="#">Loc12</a>	Baldwin	0.10	0.08	0.09	0.01	10.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.10	---	---	---	---	U
<a href="#">Loc13</a>	M-59 Access Shaft	0.05	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc18</a>	Oakdale Pump Station	0.25	---	---	---	---	O
<a href="#">Loc20</a>	Gascola Eq Facility	0.09	---	---	---	---	OMFB
<a href="#">Loc28</a>	Plum Municipal Bldg	0.08	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.05	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND
<a href="#">Loc33</a>	Richland TWP	0.04	---	---	---	---	MSTT

**Table 15. Summary of Individual RG Pairs for Event 2e**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.22	0.11	0.23	-0.01	-4.5	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.24	0.10	0.25	-0.01	-4.2	
<a href="#">Loc17</a>	Chartiers Pump Station	0.24	0.10	0.25	-0.01	-4.2	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.24	0.12	0.24	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.25	0.11	0.25	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.23	0.11	0.23	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.24	0.11	0.24	0.00	0.0	

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc07</a>	Greentree Munic Bldg	0.26	0.12	0.26	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.25	0.10	0.25	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.31	0.10	0.31	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.22	0.10	0.22	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.30	0.10	0.30	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.23	0.11	0.23	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.23	0.11	0.23	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.24	0.09	0.24	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.27	0.15	0.27	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.21	0.06	0.21	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.21	0.07	0.21	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.22	0.11	0.22	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.22	0.11	0.22	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.19	0.12	0.19	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.27	0.10	0.26	0.01	3.7	
<a href="#">Loc04</a>	Kennedy Twp PS	0.24	0.11	0.23	0.01	4.2	
<a href="#">Loc05</a>	Upper St. Clair	0.23	0.08	0.22	0.01	4.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.15	---	---	---	---	U
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.18	---	---	---	---	U
<a href="#">Loc01</a>	PWSA-Montana St.	0.19	---	---	---	---	U
<a href="#">Loc08</a>	AC Health Dept Bldg	0.20	---	---	---	---	U
<a href="#">Loc13</a>	M-59 Access Shaft	0.08	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc18</a>	Oakdale Pump Station	0.21	---	---	---	---	U
<a href="#">Loc21</a>	Moon TWP	0.17	---	---	---	---	U
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.13	---	---	---	---	MSTT
<a href="#">Loc27</a>	Marshall TWP	0.17	---	---	---	---	U
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.21	---	---	---	---	OAD
<a href="#">Loc30</a>	McCandless Twn Hall	0.11	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND

**Table 16. Summary of Individual RG Pairs for Event 2f**

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc09</a>	Univ of Pittsburgh	0.09	0.06	0.10	-0.01	-11.1	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.09	0.08	0.10	-0.01	-11.1	
<a href="#">Loc22</a>	North Fayette TWP	0.11	0.09	0.12	-0.01	-9.1	
<a href="#">Loc17</a>	Chartiers Pump Station	0.14	0.06	0.15	-0.01	-7.1	
<a href="#">03049500</a>	Allegheny River at Natrona	0.06	0.06	0.06	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.11	0.09	0.11	0.00	0.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.11	0.07	0.11	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.11	0.06	0.11	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.10	0.07	0.10	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.12	0.08	0.12	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.15	0.07	0.15	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.09	0.05	0.09	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.12	0.08	0.12	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.15	0.06	0.15	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.10	0.08	0.10	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.15	0.20	0.15	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.09	0.18	0.09	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.12	0.10	0.12	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.11	0.20	0.11	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.09	0.07	0.09	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.09	0.06	0.09	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.14	0.05	0.13	0.01	7.1	
<a href="#">Loc18</a>	Oakdale Pump Station	0.14	0.08	0.13	0.01	7.1	
<a href="#">Loc20</a>	Gascola Eq Facility	0.14	0.09	0.13	0.01	7.1	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.11	0.06	0.10	0.01	9.1	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	---	---	---	---	U
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.12	---	---	---	---	O
<a href="#">Loc06</a>	Carnegie Transit Time	0.11	---	---	---	---	U
<a href="#">Loc12</a>	Baldwin	0.20	---	---	---	---	O
<a href="#">Loc13</a>	M-59 Access Shaft	0.19	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc21</a>	Moon TWP	0.08	---	---	---	---	U
<a href="#">Loc24</a>	Jefferson Hills	0.06	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.05	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc30</a>	McCandless Twn Hall	0.04	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND

**Table 17. Summary of Individual RG Pairs for Event 2g**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.17	0.10	0.17	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.12	0.06	0.12	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.10	0.08	0.10	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.08	0.05	0.08	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.13	0.08	0.13	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.09	0.06	0.09	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.17	0.14	0.17	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.13	0.14	0.13	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.08	0.07	0.08	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.12	0.11	0.12	0.00	0.0	
<a href="#">03049500</a>	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
<a href="#">Loc01</a>	PWSA-Montana St.	0.07	---	---	---	---	MSTT
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.08	---	---	---	---	MSTT
<a href="#">Loc03</a>	Shaler Munic Bldg	0.07	---	---	---	---	MSTT
<a href="#">Loc04</a>	Kennedy Twp PS	0.06	---	---	---	---	MSTT
<a href="#">Loc06</a>	Carnegie Transit Time	0.03	---	---	---	---	MSTT
<a href="#">Loc07</a>	Greentree Munic Bldg	0.08	---	---	---	---	MSTT
<a href="#">Loc08</a>	AC Health Dept Bldg	0.08	---	---	---	---	MSTT
<a href="#">Loc09</a>	Univ of Pittsburgh	0.07	---	---	---	---	MSTT
<a href="#">Loc10</a>	PWSA-Highland Park	0.06	---	---	---	---	MSTT
<a href="#">Loc11</a>	M-46 Access Shaft	0.08	---	---	---	---	MSTT
<a href="#">Loc12</a>	Baldwin	0.09	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.04	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc16</a>	Castle Shannon	0.07	---	---	---	---	MSTT
<a href="#">Loc17</a>	Chartiers Pump Station	0.02	---	---	---	---	MSTT
<a href="#">Loc18</a>	Oakdale Pump Station	0.07	---	---	---	---	MSTT

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.07	---	---	---	---	MSTT
<a href="#">Loc21</a>	Moon TWP	0.05	---	---	---	---	U
<a href="#">Loc22</a>	North Fayette TWP	0.04	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.04	---	---	---	---	U
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.06	---	---	---	---	MSTT
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND
<a href="#">Loc33</a>	Richland TWP	0.05	---	---	---	---	MSTT

**Table 18. Summary of Individual RG Pairs for Event 2h**

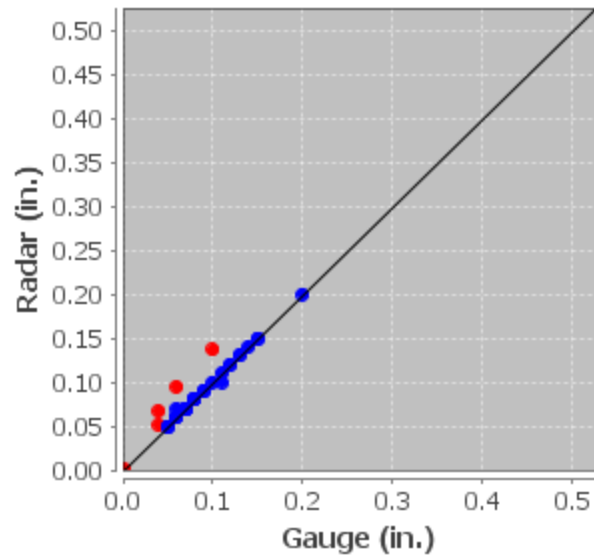
Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc08</a>	AC Health Dept Bldg	0.10	0.14	0.12	-0.02	-20.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.10	0.14	0.11	-0.01	-10.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.12	0.15	0.13	-0.01	-8.3	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.32	0.24	0.34	-0.02	-6.3	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.13	0.17	0.13	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.19	0.22	0.19	0.00	0.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.10	0.13	0.10	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.09	0.12	0.09	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.11	0.12	0.11	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.13	0.08	0.13	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.12	0.09	0.12	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.22	0.19	0.22	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.27	0.17	0.27	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.08	0.06	0.08	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.23	0.32	0.23	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.08	0.06	0.08	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.20	0.27	0.20	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.41	0.20	0.41	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.37	0.26	0.37	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.29	0.17	0.29	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.14	0.26	0.14	0.00	0.0	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc28</a>	Plum Municipal Bldg	0.23	0.22	0.23	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.10	0.16	0.10	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.11	0.12	0.11	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.25	0.23	0.24	0.01	4.0	
<a href="#">Loc16</a>	Castle Shannon	0.24	0.11	0.23	0.01	4.2	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.19	0.18	0.18	0.01	5.3	
<a href="#">Loc10</a>	PWSA-Highland Park	0.15	0.14	0.14	0.01	6.7	
<a href="#">Loc17</a>	Chartiers Pump Station	0.14	0.06	0.13	0.01	7.1	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.12	0.12	0.11	0.01	8.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.22	---	---	---	---	U
<a href="#">Loc05</a>	Upper St. Clair	0.13	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.35	---	---	---	---	C
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc30</a>	McCandless Twn Hall	0.07	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	ND	---	---	---	---	ND
<a href="#">Loc33</a>	Richland TWP	0.17	---	---	---	---	OAD

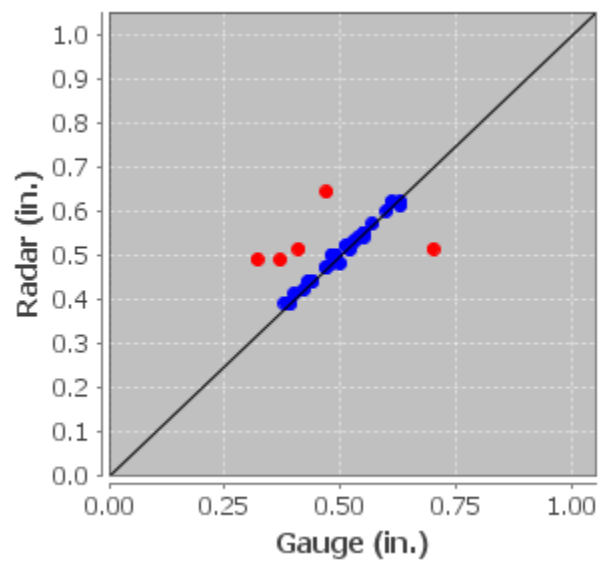
**Table 19. Summary of Individual RG Pairs for Event 2i**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc10</a>	PWSA-Highland Park	0.10	0.17	0.11	-0.01	-10.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.14	0.29	0.15	-0.01	-7.1	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.15	0.28	0.16	-0.01	-6.7	
<a href="#">03049500</a>	Allegheny River at Natrona	0.17	0.16	0.17	0.00	0.0	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.15	0.15	0.15	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.34	0.33	0.34	0.00	0.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.07	0.07	0.07	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.09	0.11	0.09	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.07	0.07	0.07	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.18	0.18	0.18	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.08	0.12	0.08	0.00	0.0	
<a href="#">Loc06</a>	Carnegie Transit Time	0.25	0.37	0.25	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.09	0.12	0.09	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.09	0.12	0.09	0.00	0.0	

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc11</a>	M-46 Access Shaft	0.11	0.14	0.11	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.07	0.10	0.07	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.10	0.18	0.10	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.53	0.44	0.53	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.36	0.34	0.36	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.06	0.13	0.06	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.13	0.23	0.13	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.23	0.21	0.23	0.00	0.0	
<a href="#">Loc30</a>	McCandless Twn Hall	0.16	0.25	0.16	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.14	0.13	0.14	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.14	0.30	0.14	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.43	0.34	0.42	0.01	2.3	
<a href="#">Loc20</a>	Gascola Eq Facility	0.18	0.25	0.17	0.01	5.6	
<a href="#">Loc17</a>	Chartiers Pump Station	0.17	0.21	0.16	0.01	5.9	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.07	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.27	---	---	---	---	C
<a href="#">Loc14</a>	Churchill Munic Bldg	0.10	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc21</a>	Moon TWP	0.24	---	---	---	---	U
<a href="#">Loc24</a>	Jefferson Hills	0.02	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
<a href="#">Loc32</a>	Arnold	0.00	---	---	---	---	ND

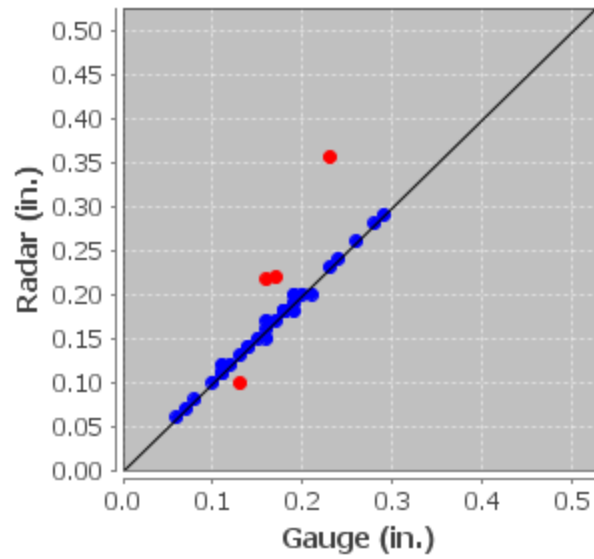


**Figure 7. Scatter Plot of RG Pairs for Event 2a**

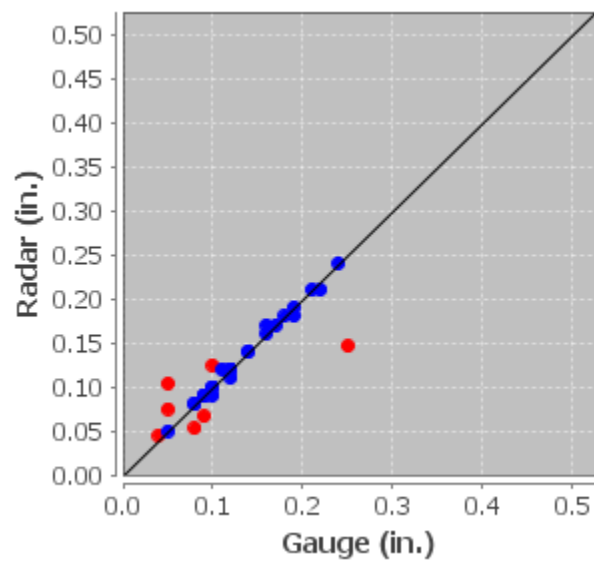


**Figure 8. Scatter Plot of RG Pairs for Event 2b**

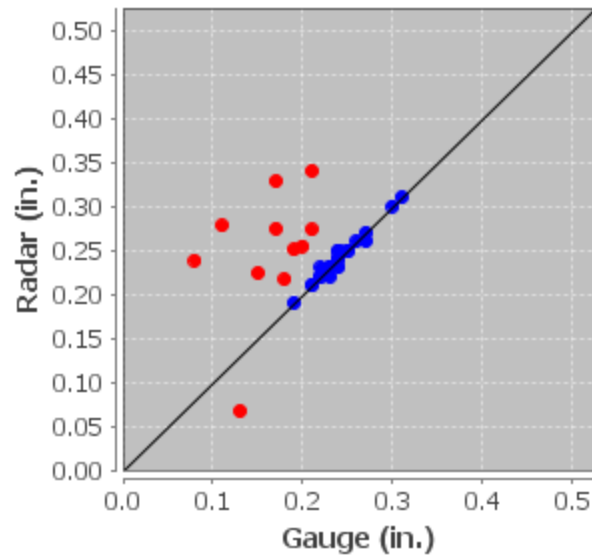




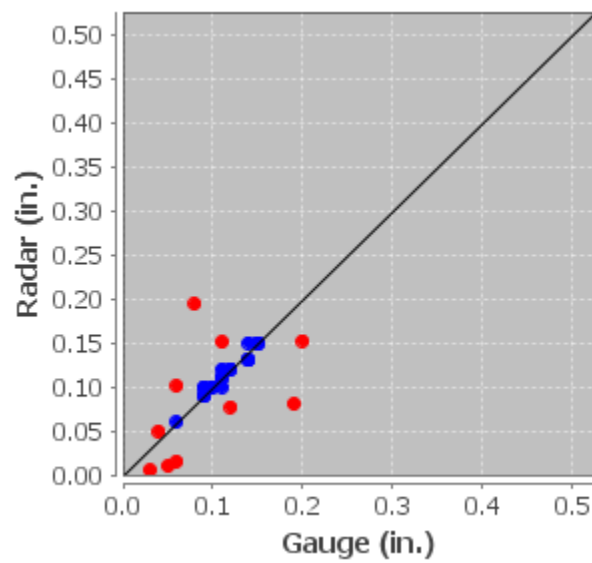
**Figure 9. Scatter Plot of RG Pairs for Event 2c**



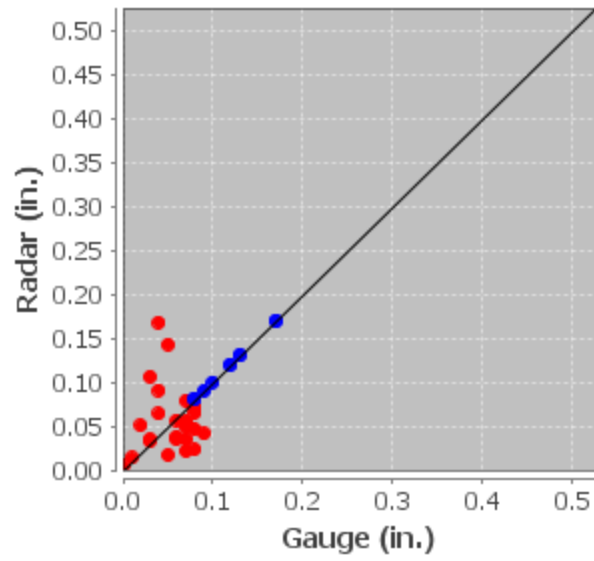
**Figure 10. Scatter Plot of RG Pairs for Event 2d**



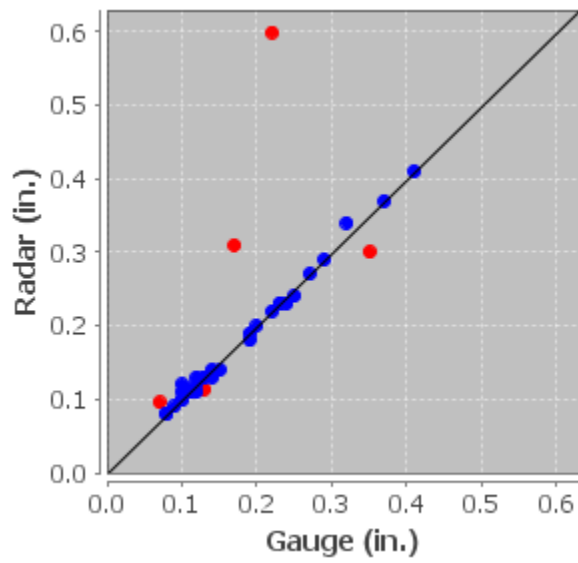
**Figure 11. Scatter Plot of RG Pairs for Event 2e**



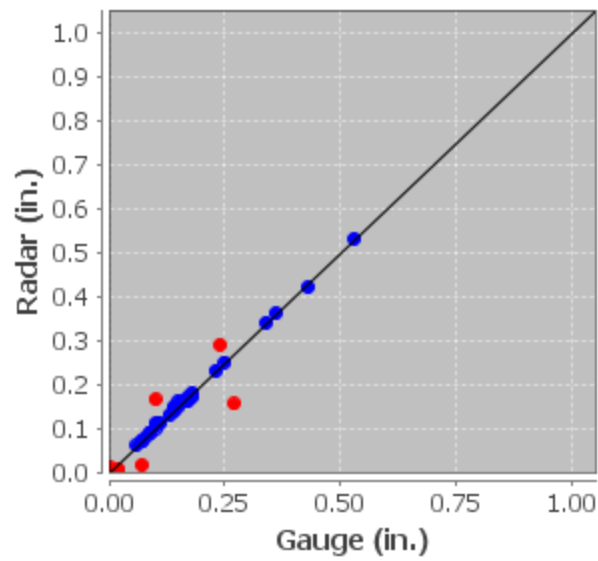
**Figure 12. Scatter Plot of RG Pairs for Event 2f**



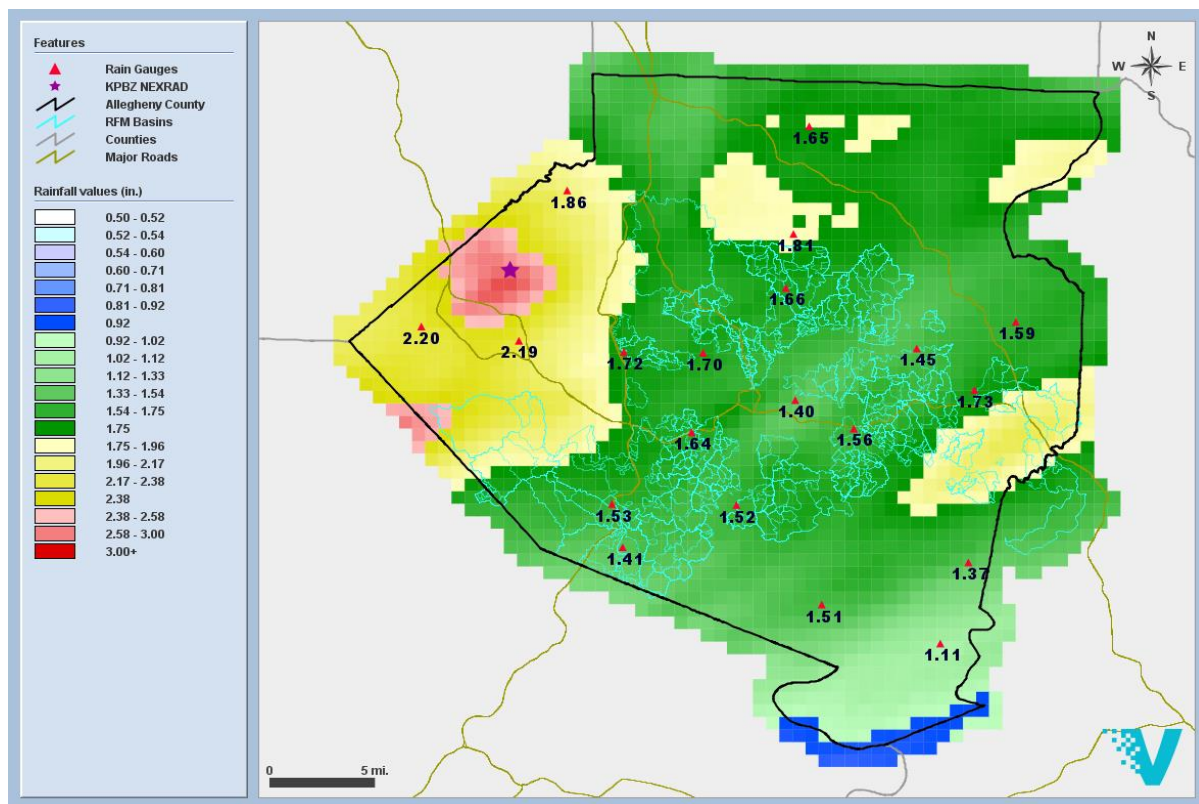
**Figure 13. Scatter Plot of RG Pairs for Event 2g**



**Figure 14. Scatter Plot of RG Pairs for Event 2h**



**Figure 15. Scatter Plot of RG Pairs for Event 2i**



**Figure 16. GARR Storm Total for Event 2**

**Table 20. Depth Duration Frequency Analyses for Event 2**

<b>Duration</b>	<b>Depth (in)</b>	<b>Pixel</b>	<b>Time (EDT)</b>	<b>Frequency</b>
15 minutes	0.257	120140	2021-03-18 20:05	<1 yr.
30 minutes	0.472	120140	2021-03-18 20:15	<1 yr.
1 hour	0.683	120140	2021-03-18 20:25	<1 yr.
2 hour	0.914	120140	2021-03-18 20:35	<1 yr.
3 hour	0.983	120140	2021-03-18 20:45	<1 yr.
6 hour	1.338	128129	2021-03-18 13:40	<1 yr.
12 hour	2.193	127129	2021-03-18 18:00	2 yr.
24 hour	2.762	127129	2021-03-18 22:00	2 yr.

### Event 3: 2021-03-28

The analysis period was from 2021-03-28 02:00 EDT to 2021-03-28 17:00 EDT. The event was then split into seven sub-event periods at 2021-03-28 05:45 EDT, 2021-03-28 06:45 EDT, 2021-03-28 08:00 EDT, 2021-03-28 11:00 EDT, 2021-03-28 12:30 EDT and 2021-03-28 14:00 EDT to improve gauge adjustment of the radar. Gauge Only was used during Event 3d since all radar sources were either unavailable or provided insufficient rainfall information.

The gauges listed in [Appendix A](#) were not used to adjust the radar due to inconsistencies between the gauge and the radar or surrounding gauges, or they did not have data available for this event. The gauges listed in [Appendix B](#) were not used to adjust the radar since they did not meet statistical criteria for gauge-adjustment.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 21 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 22 - 28 summarize the results for each RG pair used for final radar adjustment, where  $G_i$  is the gauge estimate,  $R_i$  is the non-adjusted radar estimate,  $R_i^*$  is the GARR estimate, and  $\text{Diff}^*$  (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 17 - 22 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 23 depicts the GARR storm total over the 1-km<sup>2</sup> pixels. The GARR amounts for the 2313 1-km<sup>2</sup> pixels range from 0.3 - 0.9 inches with a mean of 0.6 inches. The GARR amounts for the 440 RFM basins range from 0.4 - 0.8 inches with a mean of 0.6 inches. The GARR amounts for the 871 RFM sheds range from 0.4 - 0.8 inches with a mean of 0.6 inches. Table 29 shows the Depth Duration Frequency (DDF) maximum values for the 1-km<sup>2</sup> pixels.

**Table 21. GARR Statistics for Event 3**

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E3a	KPBZ LII	2021-03-28	2021-03-28 02:05	2021-03-28 05:45	32	0.176	0.965	15.7	2.5
E3b	KPBZ LII	2021-03-28	2021-03-28 05:50	2021-03-28 06:45	32	0.183	1.679	39.9	2.2
E3c	KPBZ LII	2021-03-28	2021-03-28 06:50	2021-03-28 08:00	8	0.039	0.727	36.2	1.6
E3d	Gauge Only	2021-03-28	2021-03-28 08:05	2021-03-28 11:00	30	0.049	---	---	---
E3e	KPBZ LII	2021-03-28	2021-03-28 11:05	2021-03-28 12:30	26	0.099	1.101	18.1	3.2
E3f	KPBZ LII	2021-03-28	2021-03-28 12:35	2021-03-28 14:00	7	0.041	0.741	43.5	2.3
E3g	KPBZ LII	2021-03-28	2021-03-28 14:05	2021-03-28 17:00	4	0.035	0.724	38.2	3.0

**Table 22. Summary of Individual RG Pairs for Event 3a**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.19	0.23	0.21	-0.02	-10.5	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.11	0.16	0.12	-0.01	-9.1	
<a href="#">Loc11</a>	M-46 Access Shaft	0.13	0.16	0.14	-0.01	-7.7	
<a href="#">Loc12</a>	Baldwin	0.14	0.16	0.15	-0.01	-7.1	
<a href="#">Loc06</a>	Carnegie Transit Time	0.21	0.24	0.22	-0.01	-4.8	
<a href="#">Loc22</a>	North Fayette TWP	0.27	0.25	0.28	-0.01	-3.7	
<a href="#">Loc01</a>	PWSA-Montana St.	0.19	0.18	0.19	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.20	0.19	0.20	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.15	0.15	0.15	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.20	0.21	0.20	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.21	0.22	0.21	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.16	0.18	0.16	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.13	0.16	0.13	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.24	0.24	0.24	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.09	0.13	0.09	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.36	0.35	0.36	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.35	0.33	0.35	0.00	0.0	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc24</a>	Jefferson Hills	0.13	0.11	0.13	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.13	0.12	0.13	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.12	0.13	0.12	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.21	0.22	0.21	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.09	0.13	0.09	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.28	0.32	0.28	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.12	0.15	0.12	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.08	0.12	0.08	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.18	0.20	0.18	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.31	0.24	0.30	0.01	3.2	
<a href="#">Loc16</a>	Castle Shannon	0.23	0.18	0.22	0.01	4.3	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.17	0.17	0.16	0.01	5.9	
<a href="#">Loc04</a>	Kennedy Twp PS	0.28	0.24	0.26	0.02	7.1	
<a href="#">Loc13</a>	M-59 Access Shaft	0.14	0.13	0.13	0.01	7.1	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.12	0.14	0.11	0.01	8.3	
<a href="#">03049500</a>	Allegheny River at Natrona	0.04	---	---	---	---	U
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.11	---	---	---	---	U
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.25	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc30</a>	McCandless Twn Hall	0.01	---	---	---	---	S

**Table 23. Summary of Individual RG Pairs for Event 3b**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.15	0.11	0.16	-0.01	-6.7	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.15	0.11	0.16	-0.01	-6.7	
<a href="#">Loc20</a>	Gascola Eq Facility	0.15	0.11	0.16	-0.01	-6.7	
<a href="#">Loc11</a>	M-46 Access Shaft	0.16	0.11	0.17	-0.01	-6.3	
<a href="#">Loc06</a>	Carnegie Transit Time	0.17	0.11	0.18	-0.01	-5.9	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.18	0.11	0.19	-0.01	-5.6	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.16	0.08	0.16	0.00	0.0	
<a href="#">Loc01</a>	PWSA-Montana St.	0.18	0.12	0.18	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.18	0.12	0.18	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.20	0.13	0.20	0.00	0.0	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc05</a>	Upper St. Clair	0.20	0.10	0.20	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.18	0.11	0.18	0.00	0.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.17	0.11	0.17	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.18	0.10	0.18	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.16	0.08	0.16	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.18	0.12	0.18	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.17	0.08	0.17	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.14	0.07	0.14	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.13	0.09	0.13	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.14	0.08	0.14	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.17	0.07	0.17	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.20	0.13	0.20	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.21	0.10	0.21	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.24	0.15	0.24	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.23	0.16	0.23	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.22	0.13	0.22	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.29	0.12	0.28	0.01	3.4	
<a href="#">Loc10</a>	PWSA-Highland Park	0.21	0.12	0.20	0.01	4.8	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.20	0.11	0.19	0.01	5.0	
<a href="#">Loc12</a>	Baldwin	0.20	0.10	0.19	0.01	5.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.19	0.12	0.18	0.01	5.3	
<a href="#">Loc04</a>	Kennedy Twp PS	0.18	0.11	0.17	0.01	5.6	
<a href="#">03049500</a>	Allegheny River at Natrona	0.18	---	---	---	---	U
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc21</a>	Moon TWP	0.13	---	---	---	---	U
<a href="#">Loc27</a>	Marshall TWP	0.12	---	---	---	---	OAD
<a href="#">Loc30</a>	McCandless Twn Hall	0.02	---	---	---	---	S

**Table 24. Summary of Individual RG Pairs for Event 3c**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03049500</a>	Allegheny River at Natrona	0.08	0.16	0.08	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.06	0.06	0.06	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.06	0.09	0.06	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.05	0.08	0.05	0.00	0.0	



<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc20</a>	Gascola Eq Facility	0.05	0.05	0.05	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.07	0.07	0.07	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.08	0.09	0.08	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.08	0.13	0.08	0.00	0.0	
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.05	---	---	---	---	O
<a href="#">Loc01</a>	PWSA-Montana St.	0.01	---	---	---	---	U
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
<a href="#">Loc04</a>	Kennedy Twp PS	0.01	---	---	---	---	U
<a href="#">Loc05</a>	Upper St. Clair	0.01	---	---	---	---	MSTT
<a href="#">Loc06</a>	Carnegie Transit Time	0.03	---	---	---	---	MSTT
<a href="#">Loc07</a>	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc08</a>	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
<a href="#">Loc09</a>	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
<a href="#">Loc11</a>	M-46 Access Shaft	0.02	---	---	---	---	MSTT
<a href="#">Loc12</a>	Baldwin	0.02	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.00	---	---	---	---	MSTT
<a href="#">Loc14</a>	Churchill Munic Bldg	0.04	---	---	---	---	MSTT
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc16</a>	Castle Shannon	0.00	---	---	---	---	MSTT
<a href="#">Loc17</a>	Chartiers Pump Station	0.01	---	---	---	---	MSTT
<a href="#">Loc18</a>	Oakdale Pump Station	0.02	---	---	---	---	MSTT
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
<a href="#">Loc21</a>	Moon TWP	0.02	---	---	---	---	MSTT
<a href="#">Loc22</a>	North Fayette TWP	0.04	---	---	---	---	MSTT
<a href="#">Loc23</a>	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc24</a>	Jefferson Hills	0.01	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc27</a>	Marshall TWP	0.01	---	---	---	---	MSTT
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.02	---	---	---	---	MSTT
<a href="#">Loc33</a>	Richland TWP	0.04	---	---	---	---	MSTT

**Table 25. Summary of Individual RG Pairs for Event 3d**

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc32</a>	Arnold	0.00	---	---	---	---	
<a href="#">Loc10</a>	PWSA-Highland Park	0.02	---	---	---	---	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.02	---	---	---	---	
<a href="#">Loc20</a>	Gascola Eq Facility	0.02	---	---	---	---	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.02	---	---	---	---	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.03	---	---	---	---	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.03	---	---	---	---	
<a href="#">Loc11</a>	M-46 Access Shaft	0.03	---	---	---	---	
<a href="#">Loc12</a>	Baldwin	0.03	---	---	---	---	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.03	---	---	---	---	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	
<a href="#">Loc13</a>	M-59 Access Shaft	0.04	---	---	---	---	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.04	---	---	---	---	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.05	---	---	---	---	
<a href="#">Loc27</a>	Marshall TWP	0.05	---	---	---	---	
<a href="#">Loc05</a>	Upper St. Clair	0.06	---	---	---	---	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.06	---	---	---	---	
<a href="#">Loc16</a>	Castle Shannon	0.06	---	---	---	---	
<a href="#">Loc21</a>	Moon TWP	0.06	---	---	---	---	
<a href="#">Loc04</a>	Kennedy Twp PS	0.07	---	---	---	---	
<a href="#">Loc06</a>	Carnegie Transit Time	0.07	---	---	---	---	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.07	---	---	---	---	
<a href="#">Loc18</a>	Oakdale Pump Station	0.07	---	---	---	---	
<a href="#">Loc22</a>	North Fayette TWP	0.07	---	---	---	---	
<a href="#">Loc24</a>	Jefferson Hills	0.07	---	---	---	---	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.07	---	---	---	---	
<a href="#">Loc17</a>	Chartiers Pump Station	0.08	---	---	---	---	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.08	---	---	---	---	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.08	---	---	---	---	
<a href="#">Loc33</a>	Richland TWP	0.08	---	---	---	---	
<a href="#">03049500</a>	Allegheny River at Natrona	0.01	---	---	---	---	T
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	T
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.04	---	---	---	---	T
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.02	---	---	---	---	T
<a href="#">Loc01</a>	PWSA-Montana St.	0.01	---	---	---	---	U

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc30</a>	McCandless Twn Hall	0.03	---	---	---	---	U

**Table 26. Summary of Individual RG Pairs for Event 3e**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc14</a>	Churchill Munic Bldg	0.05	0.06	0.06	-0.01	-20.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.08	0.12	0.09	-0.01	-12.5	
<a href="#">Loc06</a>	Carnegie Transit Time	0.09	0.12	0.10	-0.01	-11.1	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.14	0.13	0.14	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.13	0.14	0.13	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.17	0.14	0.17	0.00	0.0	
<a href="#">Loc04</a>	Kennedy Twp PS	0.15	0.13	0.15	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.06	0.08	0.06	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.10	0.10	0.10	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.13	0.09	0.13	0.00	0.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.08	0.06	0.08	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.07	0.06	0.07	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.12	0.11	0.12	0.00	0.0	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.08	0.09	0.08	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.05	0.06	0.05	0.00	0.0	
<a href="#">Loc21</a>	Moon TWP	0.16	0.12	0.16	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.16	0.13	0.16	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.14	0.08	0.14	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.08	0.07	0.08	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.09	0.09	0.09	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.14	0.09	0.14	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.16	0.12	0.16	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.12	0.11	0.12	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.12	0.13	0.12	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.10	0.10	0.09	0.01	10.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.08	0.05	0.07	0.01	12.5	
<a href="#">03049500</a>	Allegheny River at Natrona	0.05	---	---	---	---	U
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	---	---	---	---	U

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.03	---	---	---	---	MSTT
<a href="#">Loc01</a>	PWSA-Montana St.	0.10	---	---	---	---	U
<a href="#">Loc08</a>	AC Health Dept Bldg	0.07	---	---	---	---	U
<a href="#">Loc12</a>	Baldwin	0.04	---	---	---	---	MSTT
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc24</a>	Jefferson Hills	0.02	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.01	---	---	---	---	S

**Table 27. Summary of Individual RG Pairs for Event 3f**

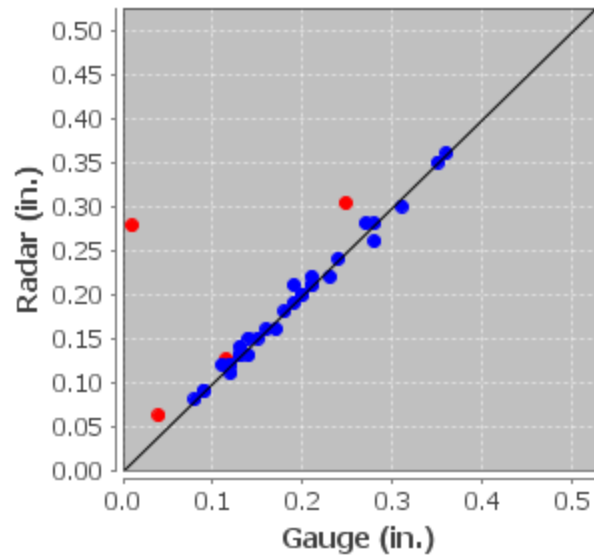
Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc03</a>	Shaler Munic Bldg	0.07	0.05	0.07	0.00	0.0	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.05	0.05	0.05	0.00	0.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.05	0.10	0.05	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.06	0.11	0.06	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.05	0.07	0.05	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.09	0.12	0.08	0.01	11.1	
<a href="#">03049500</a>	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.02	---	---	---	---	MSTT
<a href="#">Loc01</a>	PWSA-Montana St.	0.03	---	---	---	---	MSTT
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
<a href="#">Loc04</a>	Kennedy Twp PS	0.02	---	---	---	---	MSTT
<a href="#">Loc05</a>	Upper St. Clair	0.02	---	---	---	---	MSTT
<a href="#">Loc06</a>	Carnegie Transit Time	0.04	---	---	---	---	MSTT
<a href="#">Loc08</a>	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc09</a>	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
<a href="#">Loc10</a>	PWSA-Highland Park	0.02	---	---	---	---	MSTT
<a href="#">Loc11</a>	M-46 Access Shaft	0.02	---	---	---	---	MSTT
<a href="#">Loc12</a>	Baldwin	0.03	---	---	---	---	MSTT
<a href="#">Loc14</a>	Churchill Munic Bldg	0.02	---	---	---	---	MSTT

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc16</a>	Castle Shannon	0.05	---	---	---	---	MSTT
<a href="#">Loc17</a>	Chartiers Pump Station	0.02	---	---	---	---	MSTT
<a href="#">Loc18</a>	Oakdale Pump Station	0.03	---	---	---	---	MSTT
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.02	---	---	---	---	MSTT
<a href="#">Loc21</a>	Moon TWP	0.04	---	---	---	---	MSTT
<a href="#">Loc22</a>	North Fayette TWP	0.06	---	---	---	---	MSTT
<a href="#">Loc23</a>	Clinton Munic Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc24</a>	Jefferson Hills	0.04	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.08	---	---	---	---	MSTT
<a href="#">Loc27</a>	Marshall TWP	0.03	---	---	---	---	MSTT
<a href="#">Loc28</a>	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.01	---	---	---	---	U
<a href="#">Loc32</a>	Arnold	0.04	---	---	---	---	MSTT
<a href="#">Loc33</a>	Richland TWP	0.03	---	---	---	---	MSTT

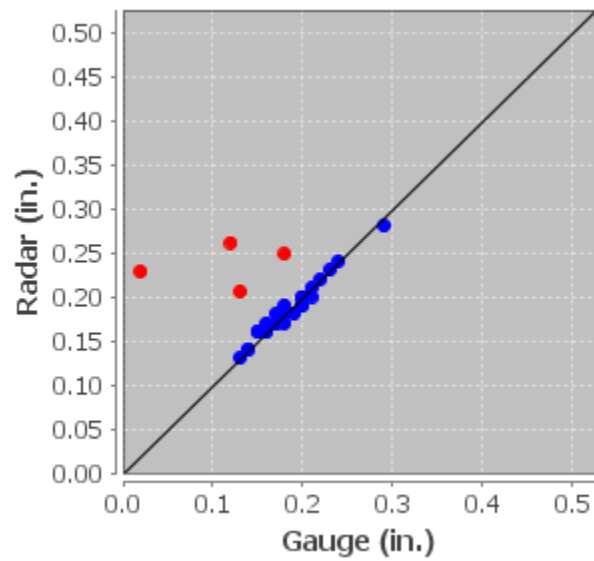
**Table 28. Summary of Individual RG Pairs for Event 3g**

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc11</a>	M-46 Access Shaft	0.05	0.08	0.05	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.05	0.07	0.05	0.00	0.0	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.05	0.06	0.05	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.05	0.07	0.05	0.00	0.0	
<a href="#">03049500</a>	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.05	---	---	---	---	MSTT
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.02	---	---	---	---	MSTT
<a href="#">Loc01</a>	PWSA-Montana St.	0.02	---	---	---	---	MSTT
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
<a href="#">Loc03</a>	Shaler Munic Bldg	0.04	---	---	---	---	MSTT
<a href="#">Loc04</a>	Kennedy Twp PS	0.01	---	---	---	---	MSTT
<a href="#">Loc05</a>	Upper St. Clair	0.02	---	---	---	---	MSTT
<a href="#">Loc06</a>	Carnegie Transit Time	0.03	---	---	---	---	MSTT

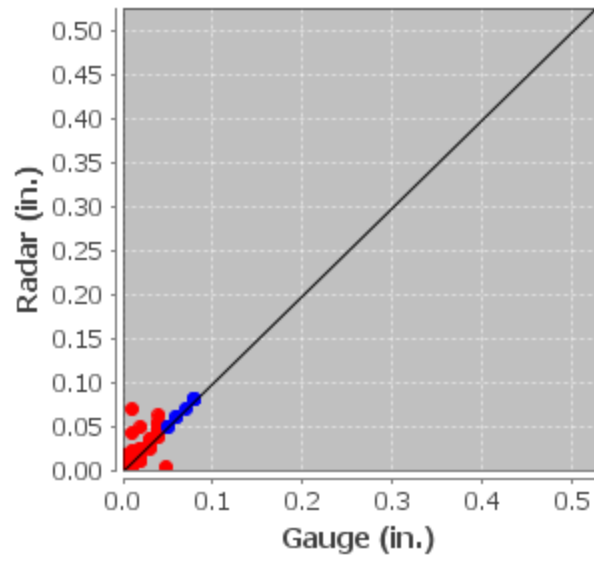
<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc07</a>	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc08</a>	AC Health Dept Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc09</a>	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
<a href="#">Loc10</a>	PWSA-Highland Park	0.02	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.02	---	---	---	---	MSTT
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc16</a>	Castle Shannon	0.04	---	---	---	---	MSTT
<a href="#">Loc17</a>	Chartiers Pump Station	0.03	---	---	---	---	MSTT
<a href="#">Loc18</a>	Oakdale Pump Station	0.03	---	---	---	---	MSTT
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
<a href="#">Loc21</a>	Moon TWP	0.01	---	---	---	---	MSTT
<a href="#">Loc22</a>	North Fayette TWP	0.02	---	---	---	---	MSTT
<a href="#">Loc23</a>	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc24</a>	Jefferson Hills	0.02	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	MSTT
<a href="#">Loc27</a>	Marshall TWP	0.01	---	---	---	---	MSTT
<a href="#">Loc28</a>	Plum Municipal Bldg	0.13	---	---	---	---	O
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.01	---	---	---	---	S
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc32</a>	Arnold	0.01	---	---	---	---	MSTT
<a href="#">Loc33</a>	Richland TWP	0.03	---	---	---	---	MSTT



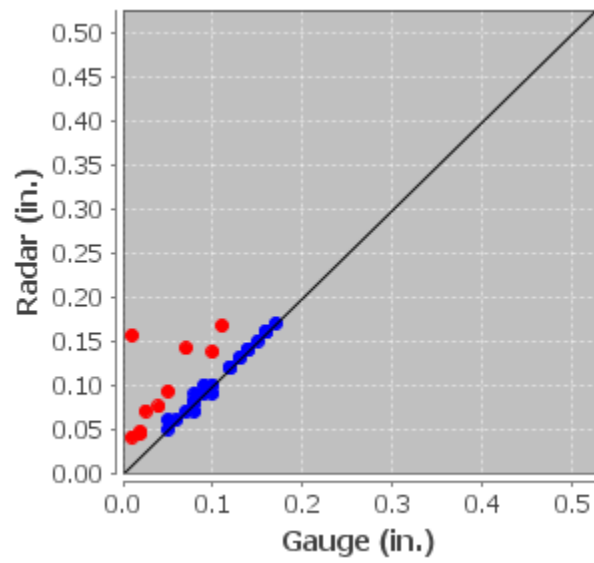
**Figure 17. Scatter Plot of RG Pairs for Event 3a**



**Figure 18. Scatter Plot of RG Pairs for Event 3b**

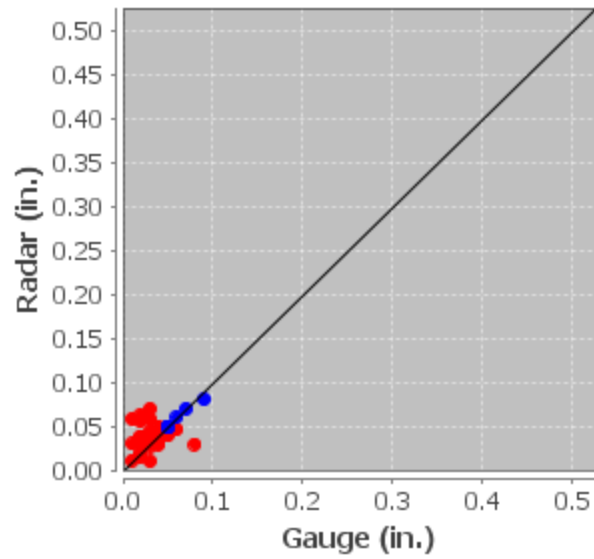


**Figure 19. Scatter Plot of RG Pairs for Event 3c**

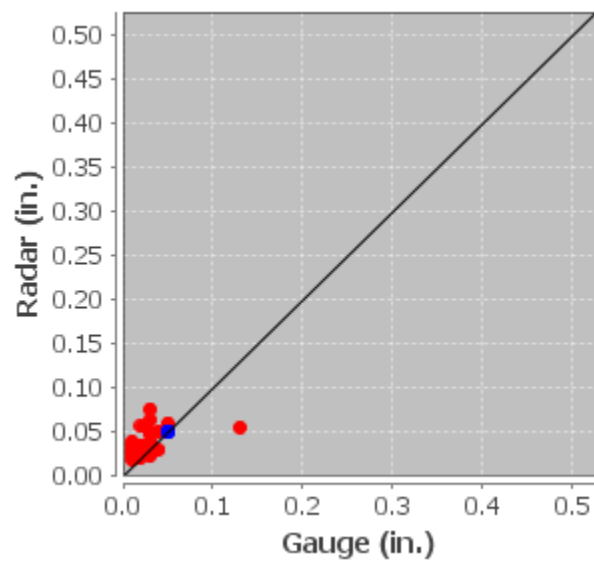


**Figure 20. Scatter Plot of RG Pairs for Event 3e**

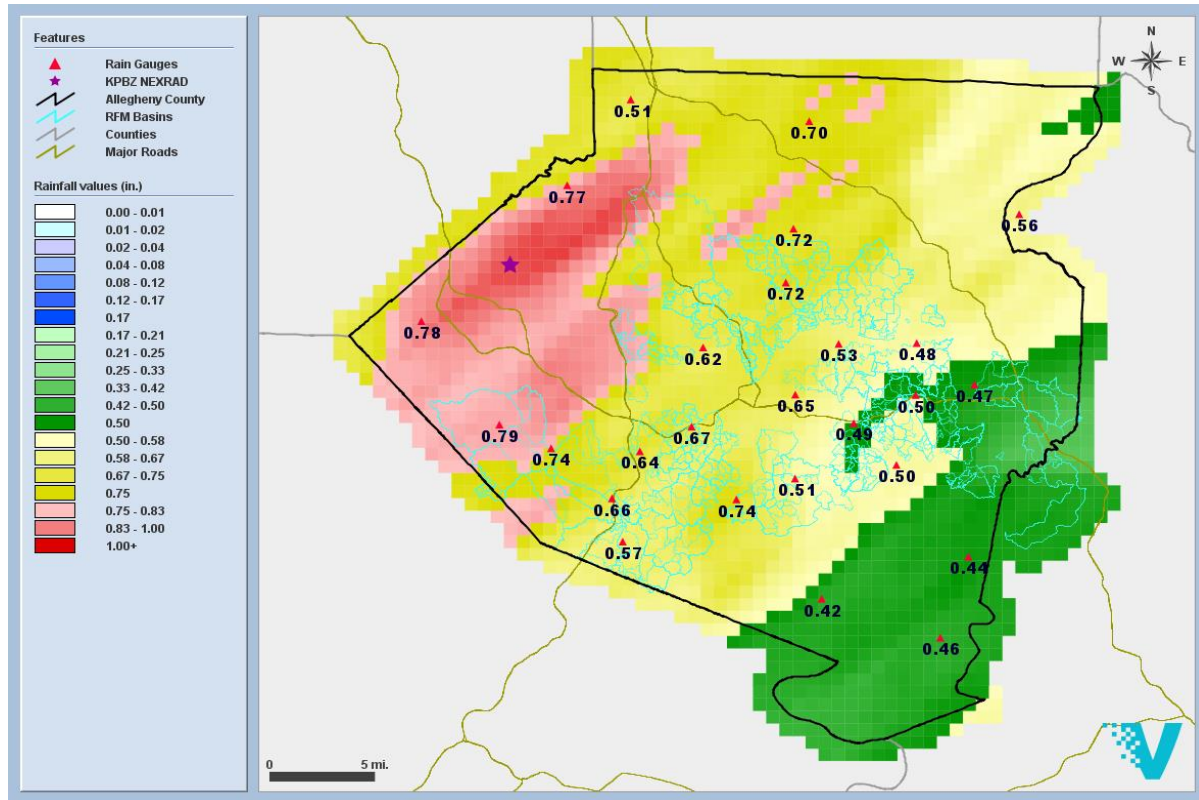




**Figure 21. Scatter Plot of RG Pairs for Event 3f**



**Figure 22. Scatter Plot of RG Pairs for Event 3g**



**Figure 23. GARR Storm Total for Event 3**

**Table 29. Depth Duration Frequency Analyses for Event 3**

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.154	144148	2021-03-28 06:10	<1 yr.
30 minutes	0.217	144148	2021-03-28 06:15	<1 yr.
1 hour	0.351	129127	2021-03-28 05:50	<1 yr.
2 hour	0.559	131127	2021-03-28 06:35	<1 yr.
3 hour	0.631	130128	2021-03-28 07:10	<1 yr.
6 hour	0.659	130128	2021-03-28 10:25	<1 yr.
12 hour	0.919	133126	2021-03-28 14:35	<1 yr.

## Event 4: 2021-03-31

The analysis period was from 2021-03-31 01:00 EDT to 2021-03-31 15:00 EDT. The event was then split into three sub-event periods at 2021-03-31 06:00 EDT and 2021-03-31 10:00 EDT to improve gauge adjustment of the radar. Gauge Only was used during Event 4c since all radar sources were either unavailable or provided insufficient rainfall information.

The gauges listed in [Appendix A](#) were not used to adjust the radar due to inconsistencies between the gauge and the radar or surrounding gauges, or they did not have data available for this event.

The gauges listed in [Appendix B](#) were not used to adjust the radar since they did not meet statistical criteria for gauge-adjustment.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 30 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 31 - 33 summarize the results for each RG pair used for final radar adjustment, where  $G_i$  is the gauge estimate,  $R_i$  is the non-adjusted radar estimate,  $R_i^*$  is the GARR estimate, and  $\text{Diff}^*$  (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 24 - 25 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 26 depicts the GARR storm total over the 1-km<sup>2</sup> pixels. The GARR amounts for the 2313 1-km<sup>2</sup> pixels range from 0.2 - 0.5 inches with a mean of 0.3 inches. The GARR amounts for the 440 RFM basins range from 0.2 - 0.3 inches with a mean of 0.3 inches. The GARR amounts for the 871 RFM sheds range from 0.2 - 0.4 inches with a mean of 0.3 inches. Table 34 shows the Depth Duration Frequency (DDF) maximum values for the 1-km<sup>2</sup> pixels.

**Table 30. GARR Statistics for Event 4**

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E4a	KPBZ LII	2021-03-31	2021-03-31 01:05	2021-03-31 06:00	6	0.047	0.676	50.5	0.0
E4b	KPBZ LII	2021-03-31	2021-03-31 06:05	2021-03-31 10:00	30	0.238	1.135	12.5	1.0
E4c	Gauge Only	2021-03-31	2021-03-31 10:05	2021-03-31 15:00	32	0.018	---	---	---

**Table 31. Summary of Individual RG Pairs for Event 4a**

Gauge ID	Name	$G_i$ (in)	$R_i$ (in)	$R_i^*$ (in)	$\text{Diff}^*$ (in)	$\text{Diff}^*$ (%)	Flag
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.07	0.11	0.07	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.06	0.09	0.06	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.07	0.13	0.07	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.09	0.15	0.09	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.11	0.17	0.11	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.11	0.11	0.11	0.00	0.0	
<a href="#">03049500</a>	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	U
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.02	---	---	---	---	MSTT
<a href="#">Loc01</a>	PWSA-Montana St.	0.02	---	---	---	---	MSTT

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
<a href="#">Loc03</a>	Shaler Munic Bldg	0.03	---	---	---	---	MSTT
<a href="#">Loc04</a>	Kennedy Twp PS	0.12	---	---	---	---	O
<a href="#">Loc05</a>	Upper St. Clair	0.02	---	---	---	---	MSTT
<a href="#">Loc06</a>	Carnegie Transit Time	0.01	---	---	---	---	MSTT
<a href="#">Loc07</a>	Greentree Munic Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc08</a>	AC Health Dept Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc09</a>	Univ of Pittsburgh	0.01	---	---	---	---	MSTT
<a href="#">Loc10</a>	PWSA-Highland Park	0.01	---	---	---	---	MSTT
<a href="#">Loc11</a>	M-46 Access Shaft	0.01	---	---	---	---	MSTT
<a href="#">Loc12</a>	Baldwin	0.01	---	---	---	---	MSTT
<a href="#">Loc13</a>	M-59 Access Shaft	0.01	---	---	---	---	MSTT
<a href="#">Loc14</a>	Churchill Munic Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc16</a>	Castle Shannon	0.02	---	---	---	---	MSTT
<a href="#">Loc17</a>	Chartiers Pump Station	0.02	---	---	---	---	MSTT
<a href="#">Loc18</a>	Oakdale Pump Station	0.04	---	---	---	---	MSTT
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
<a href="#">Loc20</a>	Gascola Eq Facility	0.01	---	---	---	---	MSTT
<a href="#">Loc21</a>	Moon TWP	0.00	---	---	---	---	Z
<a href="#">Loc24</a>	Jefferson Hills	0.01	---	---	---	---	MSTT
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc28</a>	Plum Municipal Bldg	0.01	---	---	---	---	MSTT
<a href="#">Loc30</a>	McCandless Twn Hall	0.00	---	---	---	---	Z
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.04	---	---	---	---	MSTT
<a href="#">Loc32</a>	Arnold	0.00	---	---	---	---	MSTT

**Table 32. Summary of Individual RG Pairs for Event 4b**

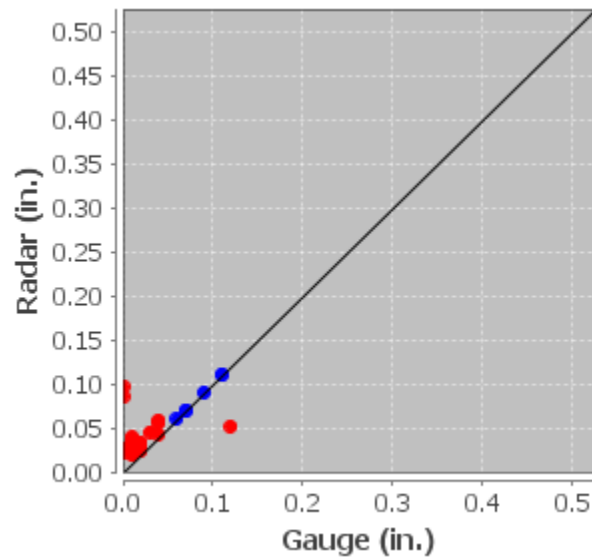
Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.20	0.22	0.21	-0.01	-5.0	
<a href="#">Loc13</a>	M-59 Access Shaft	0.21	0.23	0.22	-0.01	-4.8	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.22	0.21	0.23	-0.01	-4.5	

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.19	0.19	0.19	0.00	0.0	
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.18	0.16	0.18	0.00	0.0	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.20	0.20	0.20	0.00	0.0	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.27	0.22	0.27	0.00	0.0	
<a href="#">Loc05</a>	Upper St. Clair	0.21	0.19	0.21	0.00	0.0	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.24	0.22	0.24	0.00	0.0	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.23	0.21	0.23	0.00	0.0	
<a href="#">Loc10</a>	PWSA-Highland Park	0.23	0.22	0.23	0.00	0.0	
<a href="#">Loc11</a>	M-46 Access Shaft	0.23	0.22	0.23	0.00	0.0	
<a href="#">Loc12</a>	Baldwin	0.23	0.22	0.23	0.00	0.0	
<a href="#">Loc17</a>	Chartiers Pump Station	0.22	0.18	0.22	0.00	0.0	
<a href="#">Loc18</a>	Oakdale Pump Station	0.22	0.17	0.22	0.00	0.0	
<a href="#">Loc20</a>	Gascola Eq Facility	0.24	0.24	0.24	0.00	0.0	
<a href="#">Loc22</a>	North Fayette TWP	0.21	0.15	0.21	0.00	0.0	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.20	0.15	0.20	0.00	0.0	
<a href="#">Loc24</a>	Jefferson Hills	0.22	0.20	0.22	0.00	0.0	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.25	0.23	0.25	0.00	0.0	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.28	0.24	0.28	0.00	0.0	
<a href="#">Loc27</a>	Marshall TWP	0.21	0.19	0.21	0.00	0.0	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.28	0.24	0.28	0.00	0.0	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.28	0.20	0.28	0.00	0.0	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.27	0.21	0.27	0.00	0.0	
<a href="#">Loc32</a>	Arnold	0.24	0.24	0.24	0.00	0.0	
<a href="#">Loc33</a>	Richland TWP	0.29	0.20	0.29	0.00	0.0	
<a href="#">Loc16</a>	Castle Shannon	0.27	0.20	0.26	0.01	3.7	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.26	0.24	0.25	0.01	3.8	
<a href="#">Loc06</a>	Carnegie Transit Time	0.24	0.19	0.23	0.01	4.2	
<a href="#">03049500</a>	Allegheny River at Natrona	0.19	---	---	---	---	U
<a href="#">Loc01</a>	PWSA-Montana St.	0.17	---	---	---	---	U
<a href="#">Loc04</a>	Kennedy Twp PS	0.29	---	---	---	---	O
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.20	---	---	---	---	U
<a href="#">Loc21</a>	Moon TWP	0.00	---	---	---	---	Z
<a href="#">Loc30</a>	McCandless Twn Hall	0.00	---	---	---	---	Z

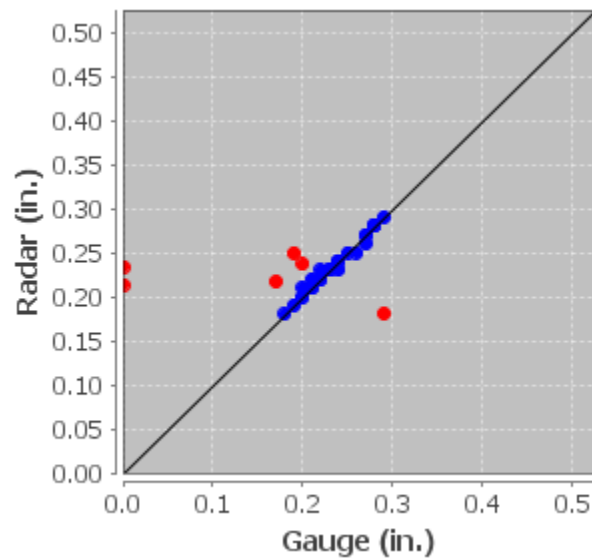
**Table 33. Summary of Individual RG Pairs for Event 4c**

<b>Gauge ID</b>	<b>Name</b>	<b>G<sub>i</sub> (in)</b>	<b>R<sub>i</sub> (in)</b>	<b>R<sub>i</sub>* (in)</b>	<b>Diff* (in)</b>	<b>Diff* (%)</b>	<b>Flag</b>
<a href="#">Loc21</a>	Moon TWP	0.00	---	---	---	---	
<a href="#">Loc27</a>	Marshall TWP	0.00	---	---	---	---	
<a href="#">Loc29</a>	Bell Acres Munic Bldg	0.00	---	---	---	---	
<a href="#">Loc30</a>	McCandless Twn Hall	0.00	---	---	---	---	
<a href="#">Loc10</a>	PWSA-Highland Park	0.01	---	---	---	---	
<a href="#">Loc13</a>	M-59 Access Shaft	0.01	---	---	---	---	
<a href="#">Loc14</a>	Churchill Munic Bldg	0.01	---	---	---	---	
<a href="#">Loc19</a>	Sandy Creek Eq Facility	0.01	---	---	---	---	
<a href="#">Loc20</a>	Gascola Eq Facility	0.01	---	---	---	---	
<a href="#">Loc23</a>	Clinton Munic Bldg	0.01	---	---	---	---	
<a href="#">Loc24</a>	Jefferson Hills	0.01	---	---	---	---	
<a href="#">Loc01</a>	PWSA-Montana St.	0.02	---	---	---	---	
<a href="#">Loc02</a>	ALCOSAN WWTP Lab	0.02	---	---	---	---	
<a href="#">Loc07</a>	Greentree Munic Bldg	0.02	---	---	---	---	
<a href="#">Loc08</a>	AC Health Dept Bldg	0.02	---	---	---	---	
<a href="#">Loc09</a>	Univ of Pittsburgh	0.02	---	---	---	---	
<a href="#">Loc11</a>	M-46 Access Shaft	0.02	---	---	---	---	
<a href="#">Loc12</a>	Baldwin	0.02	---	---	---	---	
<a href="#">Loc18</a>	Oakdale Pump Station	0.02	---	---	---	---	
<a href="#">Loc22</a>	North Fayette TWP	0.02	---	---	---	---	
<a href="#">Loc25</a>	White Oak Public Works Bldg	0.02	---	---	---	---	
<a href="#">Loc28</a>	Plum Municipal Bldg	0.02	---	---	---	---	
<a href="#">Loc31</a>	Hampton Municipal Bldg	0.02	---	---	---	---	
<a href="#">Loc33</a>	Richland TWP	0.02	---	---	---	---	
<a href="#">Loc03</a>	Shaler Munic Bldg	0.03	---	---	---	---	
<a href="#">Loc05</a>	Upper St. Clair	0.03	---	---	---	---	
<a href="#">Loc17</a>	Chartiers Pump Station	0.03	---	---	---	---	
<a href="#">Loc26</a>	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	
<a href="#">Loc32</a>	Arnold	0.03	---	---	---	---	
<a href="#">Loc04</a>	Kennedy Twp PS	0.04	---	---	---	---	
<a href="#">Loc06</a>	Carnegie Transit Time	0.04	---	---	---	---	
<a href="#">Loc16</a>	Castle Shannon	0.04	---	---	---	---	
<a href="#">03049500</a>	Allegheny River at Natrona	0.00	---	---	---	---	T
<a href="#">03085734</a>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	T
<a href="#">KAGC</a>	Pittsburgh Allegheny Cty	0.02	---	---	---	---	T

Gauge ID	Name	G <sub>i</sub> (in)	R <sub>i</sub> (in)	R <sub>i</sub> * (in)	Diff* (in)	Diff* (%)	Flag
<a href="#">KPIT</a>	Greater Pittsburgh Int'l	0.00	---	---	---	---	T
<a href="#">Loc15</a>	Trafford Maint Bldg	ND	---	---	---	---	ND

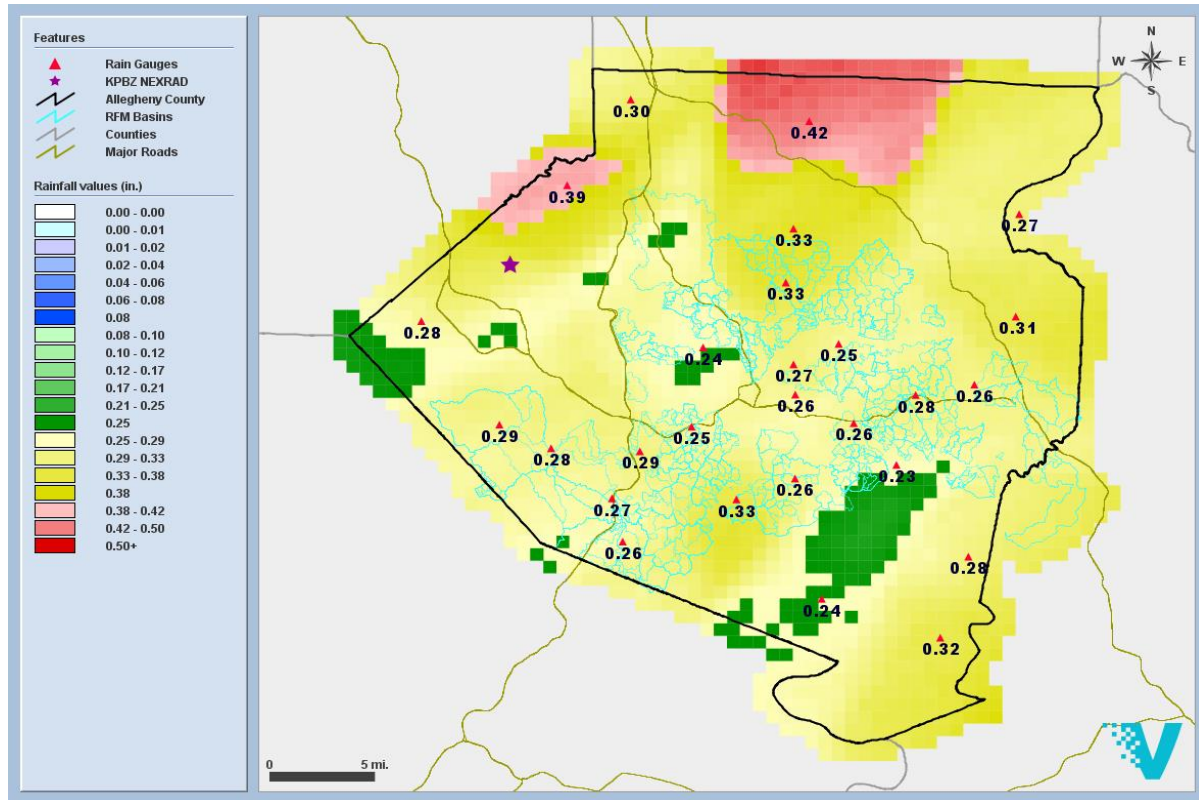


**Figure 24. Scatter Plot of RG Pairs for Event 4a**



**Figure 25. Scatter Plot of RG Pairs for Event 4b**





**Figure 26. GARR Storm Total for Event 4**

**Table 34. Depth Duration Frequency Analyses for Event 4**

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.060	165164	2021-03-31 07:50	<1 yr.
30 minutes	0.105	157120	2021-03-31 07:40	<1 yr.
1 hour	0.184	165164	2021-03-31 08:10	<1 yr.
2 hour	0.287	158119	2021-03-31 08:05	<1 yr.
3 hour	0.345	158119	2021-03-31 08:45	<1 yr.
6 hour	0.446	147112	2021-03-31 09:10	<1 yr.
12 hour	0.466	147112	2021-03-31 13:25	<1 yr.



## Appendices

[Appendix A](#) - Gauge Performance Exclusion Table  
[Appendix B](#) - Gauge Statistical Criteria Exclusion Table  
[Appendix C](#) - Event 1 (2021-03-11) CDPs  
[Appendix D](#) - Event 2 (2021-03-18) CDPs  
[Appendix E](#) - Event 3 (2021-03-28) CDPs  
[Appendix F](#) - Event 4 (2021-03-31) CDPs

### Appendix A - Gauge Performance Exclusion Table

Reason	Explanation
Clog (C)	Gauge appeared to be clogged
Zero (Z)	Gauge did not report any rainfall while radar rainfall estimates reported significant rainfall
Stop (S)	Gauge appeared to stop reporting rainfall while radar rainfall estimates reported significant rainfall
Over (O)	Gauge appeared to significantly over-report rainfall as compared to radar rainfall estimates and surrounding gauges (e.g. anomalously high rainfall values caused by field calibration, data transmission error, or switch malfunctions)
Under (U)	Gauge appeared to significantly under-report as compared to radar rainfall estimates and surrounding Gauges (e.g. half-tipper)
Sync (SY)	Gauge appeared to be reporting out-of-sync with the radar rainfall estimates
Frozen/Melt (F/M)	Gauge not reporting properly due to frozen or melting precipitation
Other (T)	Combination of multiple reasons
No Data (ND)	Gauge reported "no data" for a significant amount of time

Event #	<a href="#">E1a</a>	<a href="#">E1b</a>	<a href="#">E1c</a>	<a href="#">E2a</a>	<a href="#">E2b</a>
Event Date	2021-03-11	2021-03-11	2021-03-11	2021-03-18	2021-03-18
Start Time (EST/EDT)	2021-03-11 19:05	2021-03-11 23:05	2021-03-12 01:05	2021-03-17 22:05	2021-03-18 06:05
End Time (EST/EDT)	2021-03-11 23:00	2021-03-12 01:00	2021-03-12 08:00	2021-03-18 06:00	2021-03-18 09:30
Loc01	U				
Loc02					
Loc03					
Loc04	U				
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					O
Loc11					
Loc12					
Loc13				U	C
Loc14					
Loc15	C	C	C	ND	ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					U
Loc22					U
Loc23					
Loc24					
Loc25					

Event #	<a href="#">E1a</a>	<a href="#">E1b</a>	<a href="#">E1c</a>	<a href="#">E2a</a>	<a href="#">E2b</a>
Event Date	2021-03-11	2021-03-11	2021-03-11	2021-03-18	2021-03-18
Start Time (EST/EDT)	2021-03-11 19:05	2021-03-11 23:05	2021-03-12 01:05	2021-03-17 22:05	2021-03-18 06:05
End Time (EST/EDT)	2021-03-11 23:00	2021-03-12 01:00	2021-03-12 08:00	2021-03-18 06:00	2021-03-18 09:30
Loc26					
Loc27					
Loc28					
Loc29					
Loc30	U			U	U
Loc31					
Loc32				ND	ND
Loc33					
KAGC			T		
KPIT			T		
03049500	U	U	T	U	
03085734			T		

Event #	<a href="#">E2c</a>	<a href="#">E2d</a>	<a href="#">E2e</a>	<a href="#">E2f</a>	<a href="#">E2g</a>
Event Date	2021-03-18	2021-03-18	2021-03-18	2021-03-18	2021-03-18
Start Time (EST/EDT)	2021-03-18 09:35	2021-03-18 11:35	2021-03-18 12:50	2021-03-18 14:05	2021-03-18 15:50
End Time (EST/EDT)	2021-03-18 11:30	2021-03-18 12:45	2021-03-18 14:00	2021-03-18 15:45	2021-03-18 17:00
Loc01			U		
Loc02					
Loc03					
Loc04					
Loc05					
Loc06		U		U	
Loc07					
Loc08			U		
Loc09					
Loc10					
Loc11					
Loc12				O	
Loc13	C	C	C	C	C
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18		O	U		
Loc19					
Loc20					
Loc21	U		U	U	U
Loc22					
Loc23					

Event #	<a href="#">E2c</a>	<a href="#">E2d</a>	<a href="#">E2e</a>	<a href="#">E2f</a>	<a href="#">E2g</a>
Event Date	2021-03-18	2021-03-18	2021-03-18	2021-03-18	2021-03-18
Start Time (EST/EDT)	2021-03-18 09:35	2021-03-18 11:35	2021-03-18 12:50	2021-03-18 14:05	2021-03-18 15:50
End Time (EST/EDT)	2021-03-18 11:30	2021-03-18 12:45	2021-03-18 14:00	2021-03-18 15:45	2021-03-18 17:00
Loc24					
Loc25					
Loc26					
Loc27			U		
Loc28					
Loc29					
Loc30	U	U	U	U	U
Loc31					
Loc32	ND	ND	ND	ND	ND
Loc33					
KAGC			U	O	
KPIT					
03049500			U		
03085734	U			U	

Event #	<a href="#">E2h</a>	<a href="#">E2i</a>	<a href="#">E3a</a>	<a href="#">E3b</a>	<a href="#">E3c</a>
Event Date	2021-03-18	2021-03-18	2021-03-28	2021-03-28	2021-03-28
Start Time (EST/EDT)	2021-03-18 17:05	2021-03-18 19:05	2021-03-28 02:05	2021-03-28 05:50	2021-03-28 06:50
End Time (EST/EDT)	2021-03-18 19:00	2021-03-18 23:00	2021-03-28 05:45	2021-03-28 06:45	2021-03-28 08:00
Loc01					U
Loc02					
Loc03					
Loc04					U
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13	C	C			
Loc14		U			
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21		U		U	
Loc22					
Loc23					



Event #	<a href="#">E2h</a>	<a href="#">E2i</a>	<a href="#">E3a</a>	<a href="#">E3b</a>	<a href="#">E3c</a>
Event Date	2021-03-18	2021-03-18	2021-03-28	2021-03-28	2021-03-28
Start Time (EST/EDT)	2021-03-18 17:05	2021-03-18 19:05	2021-03-28 02:05	2021-03-28 05:50	2021-03-28 06:50
End Time (EST/EDT)	2021-03-18 19:00	2021-03-18 23:00	2021-03-28 05:45	2021-03-28 06:45	2021-03-28 08:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30	U		S	S	
Loc31					
Loc32	ND	ND			
Loc33					
KAGC			U		O
KPIT			U		
03049500	U		U	U	
03085734					

Event #	<a href="#">E3d</a>	<a href="#">E3e</a>	<a href="#">E3f</a>	<a href="#">E3g</a>	<a href="#">E4a</a>
Event Date	2021-03-28	2021-03-28	2021-03-28	2021-03-28	2021-03-31
Start Time (EST/EDT)	2021-03-28 08:05	2021-03-28 11:05	2021-03-28 12:35	2021-03-28 14:05	2021-03-31 01:05
End Time (EST/EDT)	2021-03-28 11:00	2021-03-28 12:30	2021-03-28 14:00	2021-03-28 17:00	2021-03-31 06:00
Loc01	U	U			
Loc02					
Loc03					
Loc04					O
Loc05					
Loc06					
Loc07					
Loc08		U			
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					Z
Loc22					
Loc23					

Event #	<a href="#">E3d</a>	<a href="#">E3e</a>	<a href="#">E3f</a>	<a href="#">E3g</a>	<a href="#">E4a</a>
Event Date	2021-03-28	2021-03-28	2021-03-28	2021-03-28	2021-03-31
Start Time (EST/EDT)	2021-03-28 08:05	2021-03-28 11:05	2021-03-28 12:35	2021-03-28 14:05	2021-03-31 01:05
End Time (EST/EDT)	2021-03-28 11:00	2021-03-28 12:30	2021-03-28 14:00	2021-03-28 17:00	2021-03-31 06:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28				O	
Loc29					
Loc30	U	S	U	S	Z
Loc31					
Loc32					
Loc33					
KAGC	T				
KPIT	T				
03049500	T	U			
03085734	T	U			U

<b>Event #</b>	<b><a href="#">E4b</a></b>	<b><a href="#">E4c</a></b>
<b>Event Date</b>	<b>2021-03-31</b>	<b>2021-03-31</b>
<b>Start Time (EST/EDT)</b>	2021-03-31 06:05	2021-03-31 10:05
<b>End Time (EST/EDT)</b>	2021-03-31 10:00	2021-03-31 15:00
Loc01	U	
Loc02		
Loc03		
Loc04	O	
Loc05		
Loc06		
Loc07		
Loc08		
Loc09		
Loc10		
Loc11		
Loc12		
Loc13		
Loc14		
Loc15	ND	ND
Loc16		
Loc17		
Loc18		
Loc19	U	
Loc20		
Loc21	Z	
Loc22		
Loc23		
Loc24		
Loc25		

<b>Event #</b>	<b><a href="#">E4b</a></b>	<b><a href="#">E4c</a></b>
<b>Event Date</b>	<b>2021-03-31</b>	<b>2021-03-31</b>
<b>Start Time (EST/EDT)</b>	2021-03-31 06:05	2021-03-31 10:05
<b>End Time (EST/EDT)</b>	2021-03-31 10:00	2021-03-31 15:00
Loc26		
Loc27		
Loc28		
Loc29		
Loc30	Z	
Loc31		
Loc32		
Loc33		
KAGC		T
KPIT		T
03049500	U	T
03085734		T

### Appendix B - Gauge Statistical Criteria Exclusion Table

Reason	Explanation
Minimum Storm Total Threshold (MSTT)	The radar or gauge cumulative sum during the event or sub-event period was less than MSTT
Outlier Based on Mean Field Bias (OMFB)	The RG pair bias ( $G/R$ ) was greater than three standard deviations from the mean bias (e.g. $G \gg R$ )
Outlier Based on Average Difference (OAD)	The RG pair average difference ( $(G-R)/G$ ) was greater than three standard deviations from the mean average difference (e.g. $G \ll R$ )

Event #	<a href="#">E1a</a>	<a href="#">E1b</a>	<a href="#">E2a</a>	<a href="#">E2b</a>	<a href="#">E2c</a>
Event Date	2021-03-11	2021-03-11	2021-03-18	2021-03-18	2021-03-18
Start Time (EST/EDT)	2021-03-11 19:05	2021-03-11 23:05	2021-03-17 22:05	2021-03-18 06:05	2021-03-18 09:35
End Time (EST/EDT)	2021-03-11 23:00	2021-03-12 01:00	2021-03-18 06:00	2021-03-18 09:30	2021-03-18 11:30
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09			MSTT		
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20	OAD				
Loc21					
Loc22					
Loc23					
Loc24					

<b>Event #</b>	<b><a href="#">E1a</a></b>	<b><a href="#">E1b</a></b>	<b><a href="#">E2a</a></b>	<b><a href="#">E2b</a></b>	<b><a href="#">E2c</a></b>
<b>Event Date</b>	<b>2021-03-11</b>	<b>2021-03-11</b>	<b>2021-03-18</b>	<b>2021-03-18</b>	<b>2021-03-18</b>
<b>Start Time (EST/EDT)</b>	2021-03-11 19:05	2021-03-11 23:05	2021-03-17 22:05	2021-03-18 06:05	2021-03-18 09:35
<b>End Time (EST/EDT)</b>	2021-03-11 23:00	2021-03-12 01:00	2021-03-18 06:00	2021-03-18 09:30	2021-03-18 11:30
<b>Source</b>	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500					
03085734					



Event #	<a href="#">E2d</a>	<a href="#">E2e</a>	<a href="#">E2f</a>	<a href="#">E2g</a>	<a href="#">E2h</a>
Event Date	2021-03-18	2021-03-18	2021-03-18	2021-03-18	2021-03-18
Start Time (EDT)	2021-03-18 11:35	2021-03-18 12:50	2021-03-18 14:05	2021-03-18 15:50	2021-03-18 17:05
End Time (EDT)	2021-03-18 12:45	2021-03-18 14:00	2021-03-18 15:45	2021-03-18 17:00	2021-03-18 19:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01				MSTT	
Loc02				MSTT	
Loc03				MSTT	
Loc04				MSTT	
Loc05					MSTT
Loc06				MSTT	
Loc07				MSTT	
Loc08				MSTT	
Loc09				MSTT	
Loc10				MSTT	
Loc11				MSTT	
Loc12				MSTT	
Loc13					
Loc14					
Loc15					
Loc16				MSTT	
Loc17				MSTT	
Loc18				MSTT	
Loc19				MSTT	
Loc20	OMFB				
Loc21					
Loc22				MSTT	

<b>Event #</b>	<b><u>E2d</u></b>	<b><u>E2e</u></b>	<b><u>E2f</u></b>	<b><u>E2g</u></b>	<b><u>E2h</u></b>
<b>Event Date</b>	<b>2021-03-18</b>	<b>2021-03-18</b>	<b>2021-03-18</b>	<b>2021-03-18</b>	<b>2021-03-18</b>
<b>Start Time (EDT)</b>	2021-03-18 11:35	2021-03-18 12:50	2021-03-18 14:05	2021-03-18 15:50	2021-03-18 17:05
<b>End Time (EDT)</b>	2021-03-18 12:45	2021-03-18 14:00	2021-03-18 15:45	2021-03-18 17:00	2021-03-18 19:00
<b>Source</b>	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23					
Loc24			MSTT		
Loc25			MSTT	MSTT	
Loc26		MSTT	MSTT	MSTT	
Loc27					
Loc28	MSTT				
Loc29		OAD			
Loc30					
Loc31				MSTT	
Loc32					
Loc33	MSTT			MSTT	OAD
KAGC					
KPIT					
03049500				MSTT	
03085734				MSTT	

Event #	<a href="#">E2i</a>	<a href="#">E3a</a>	<a href="#">E3b</a>	<a href="#">E3c</a>	<a href="#">E3e</a>
Event Date	2021-03-18	2021-03-28	2021-03-28	2021-03-28	2021-03-28
Start Time (EDT)	2021-03-18 19:05	2021-03-28 02:05	2021-03-28 05:50	2021-03-28 06:50	2021-03-28 11:05
End Time (EDT)	2021-03-18 23:00	2021-03-28 05:45	2021-03-28 06:45	2021-03-28 08:00	2021-03-28 12:30
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01					
Loc02				MSTT	
Loc03					
Loc04					
Loc05				MSTT	
Loc06				MSTT	
Loc07				MSTT	
Loc08				MSTT	
Loc09				MSTT	
Loc10					
Loc11				MSTT	
Loc12				MSTT	MSTT
Loc13				MSTT	
Loc14				MSTT	
Loc15					
Loc16				MSTT	
Loc17				MSTT	
Loc18				MSTT	
Loc19				MSTT	
Loc20					
Loc21				MSTT	
Loc22				MSTT	

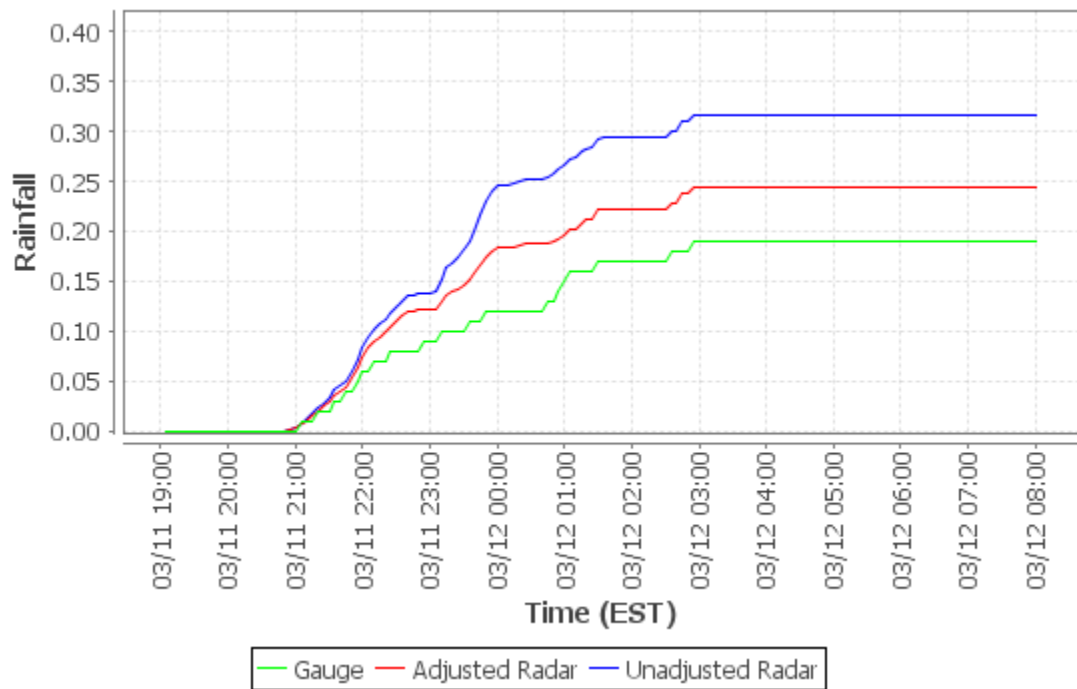
<b>Event #</b>	<b><a href="#">E2i</a></b>	<b><a href="#">E3a</a></b>	<b><a href="#">E3b</a></b>	<b><a href="#">E3c</a></b>	<b><a href="#">E3e</a></b>
<b>Event Date</b>	<b>2021-03-18</b>	<b>2021-03-28</b>	<b>2021-03-28</b>	<b>2021-03-28</b>	<b>2021-03-28</b>
<b>Start Time (EDT)</b>	2021-03-18 19:05	2021-03-28 02:05	2021-03-28 05:50	2021-03-28 06:50	2021-03-28 11:05
<b>End Time (EDT)</b>	2021-03-18 23:00	2021-03-28 05:45	2021-03-28 06:45	2021-03-28 08:00	2021-03-28 12:30
<b>Source</b>	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23				MSTT	
Loc24	MSTT			MSTT	MSTT
Loc25	MSTT			MSTT	MSTT
Loc26	MSTT			MSTT	MSTT
Loc27			OAD	MSTT	
Loc28					
Loc29				MSTT	
Loc30				MSTT	
Loc31					
Loc32					
Loc33				MSTT	
KAGC	MSTT				MSTT
KPIT					
03049500					
03085734				MSTT	

<b>Event #</b>	<a href="#"><u>E3f</u></a>	<a href="#"><u>E3g</u></a>	<a href="#"><u>E4a</u></a>	<a href="#"><u>E4b</u></a>
<b>Event Date</b>	<b>2021-03-28</b>	<b>2021-03-28</b>	<b>2021-03-31</b>	<b>2021-03-31</b>
<b>Start Time (EDT)</b>	2021-03-28 12:35	2021-03-28 14:05	2021-03-31 01:05	2021-03-31 06:05
<b>End Time (EDT)</b>	2021-03-28 14:00	2021-03-28 17:00	2021-03-31 06:00	2021-03-31 10:00
<b>Source</b>	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01	MSTT	MSTT	MSTT	
Loc02	MSTT	MSTT	MSTT	
Loc03		MSTT	MSTT	
Loc04	MSTT	MSTT		
Loc05	MSTT	MSTT	MSTT	
Loc06	MSTT	MSTT	MSTT	
Loc07		MSTT	MSTT	
Loc08	MSTT	MSTT	MSTT	
Loc09	MSTT	MSTT	MSTT	
Loc10	MSTT	MSTT	MSTT	
Loc11	MSTT		MSTT	
Loc12	MSTT		MSTT	
Loc13		MSTT	MSTT	
Loc14	MSTT		MSTT	
Loc15				
Loc16	MSTT	MSTT	MSTT	
Loc17	MSTT	MSTT	MSTT	
Loc18	MSTT	MSTT	MSTT	
Loc19	MSTT	MSTT	MSTT	
Loc20			MSTT	
Loc21	MSTT	MSTT		
Loc22	MSTT	MSTT		

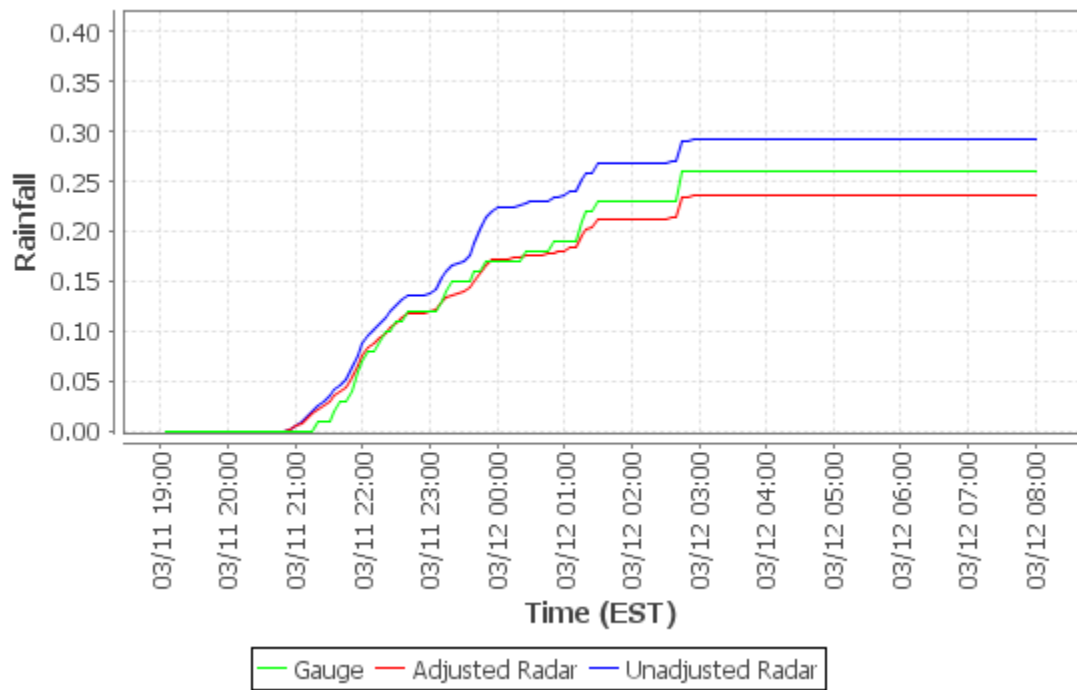
<b>Event #</b>	<b><a href="#">E3f</a></b>	<b><a href="#">E3g</a></b>	<b><a href="#">E4a</a></b>	<b><a href="#">E4b</a></b>
<b>Event Date</b>	<b>2021-03-28</b>	<b>2021-03-28</b>	<b>2021-03-31</b>	<b>2021-03-31</b>
<b>Start Time (EDT)</b>	2021-03-28 12:35	2021-03-28 14:05	2021-03-31 01:05	2021-03-31 06:05
<b>End Time (EDT)</b>	2021-03-28 14:00	2021-03-28 17:00	2021-03-31 06:00	2021-03-31 10:00
<b>Source</b>	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23	MSTT	MSTT		
Loc24	MSTT	MSTT	MSTT	
Loc25		MSTT	MSTT	
Loc26	MSTT	MSTT	MSTT	
Loc27	MSTT	MSTT		
Loc28	MSTT		MSTT	
Loc29	MSTT	MSTT		
Loc30				
Loc31		MSTT	MSTT	
Loc32	MSTT	MSTT	MSTT	
Loc33	MSTT	MSTT		
KAGC		MSTT	MSTT	
KPIT	MSTT	MSTT		
03049500	MSTT	MSTT	MSTT	
03085734	MSTT	MSTT		

## **Appendix C - Event 1 (2021-03-11) CDPs**

Cumulative Distribution Plot - PWSA-Montana St. (Loc01)

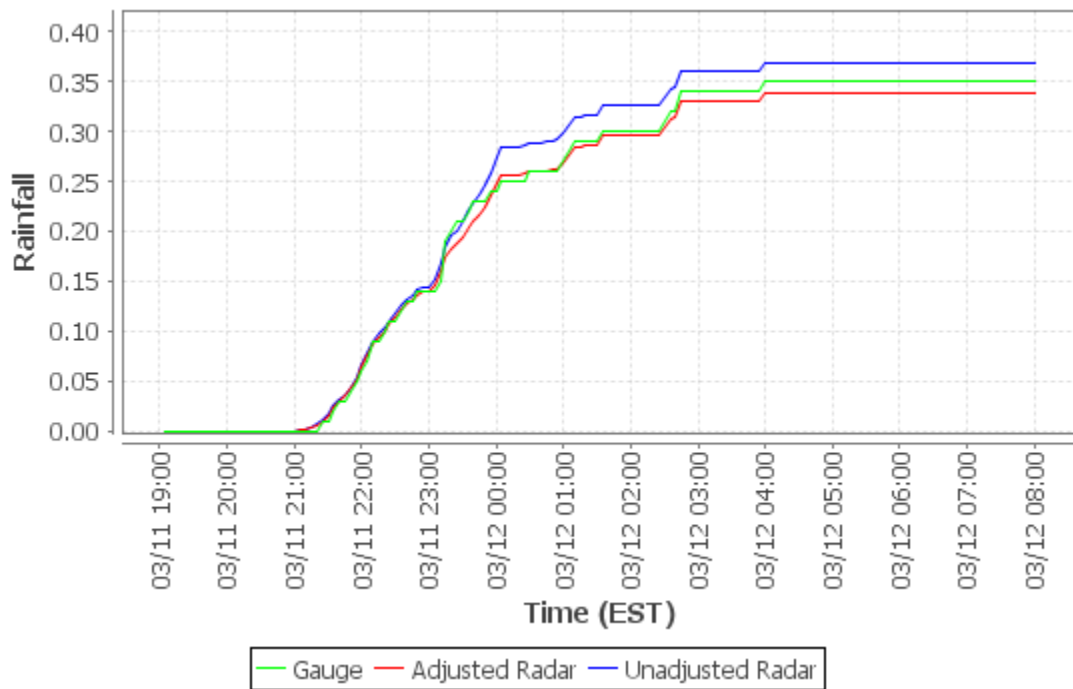


Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)

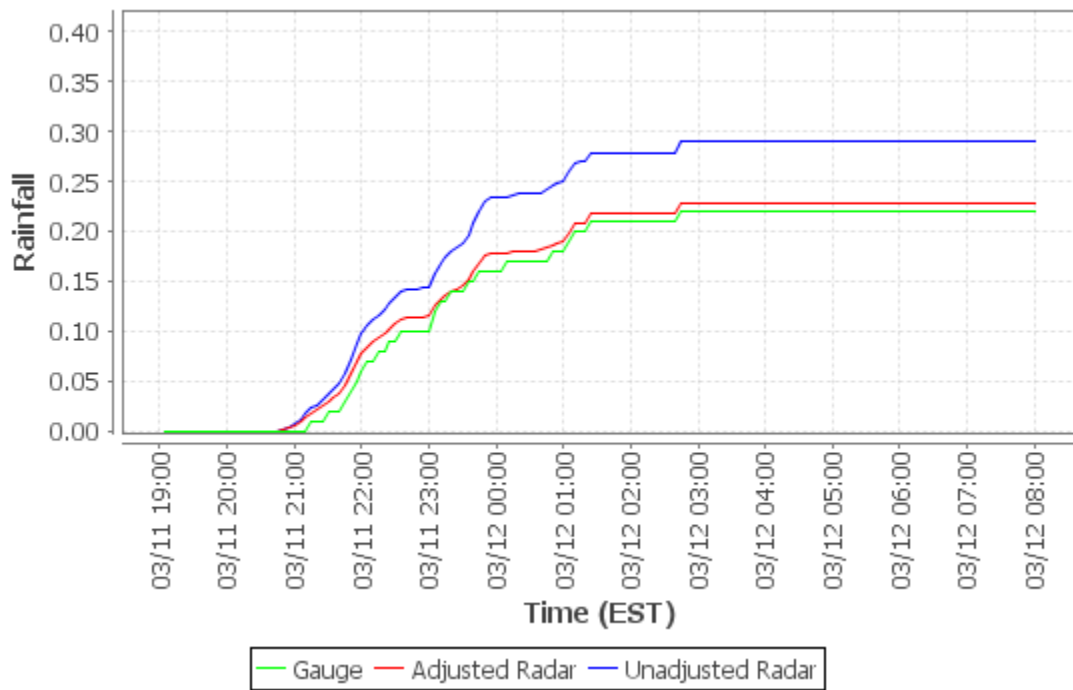




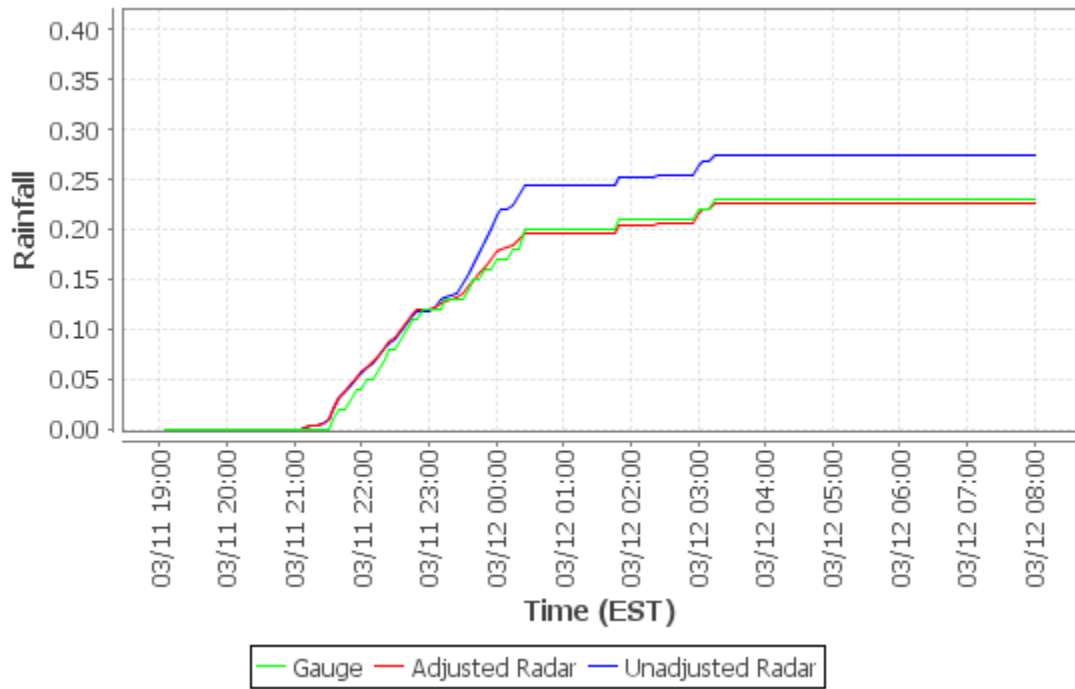
**Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)**



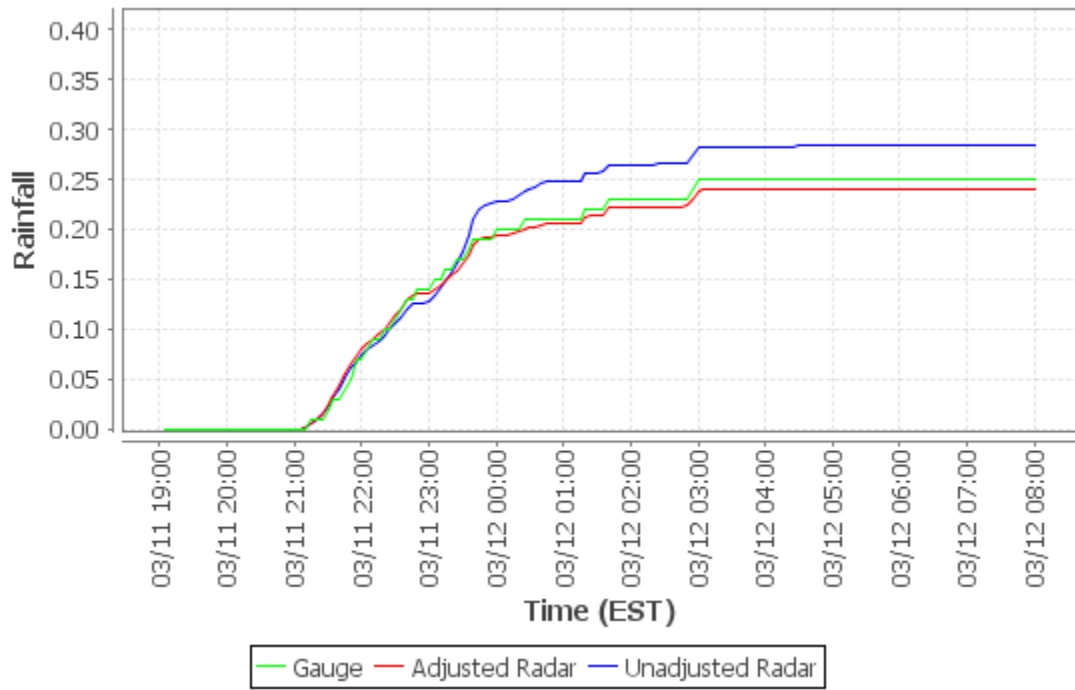
**Cumulative Distribution Plot - Kennedy Twp PS (Loc04)**



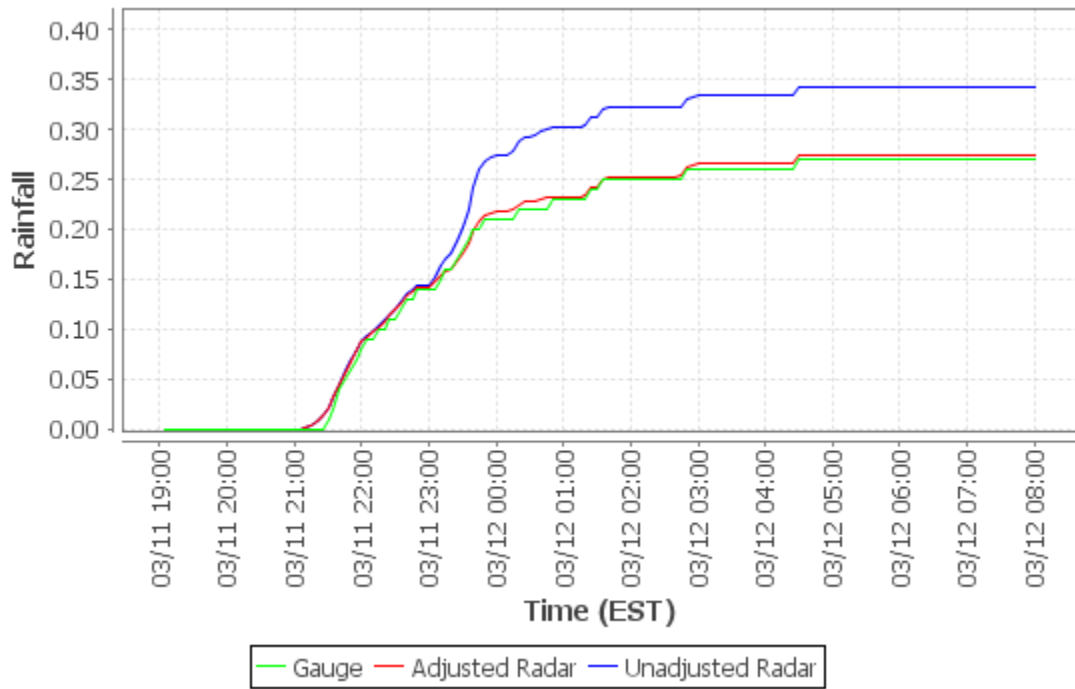
**Cumulative Distribution Plot - Upper St. Clair (Loc05)**



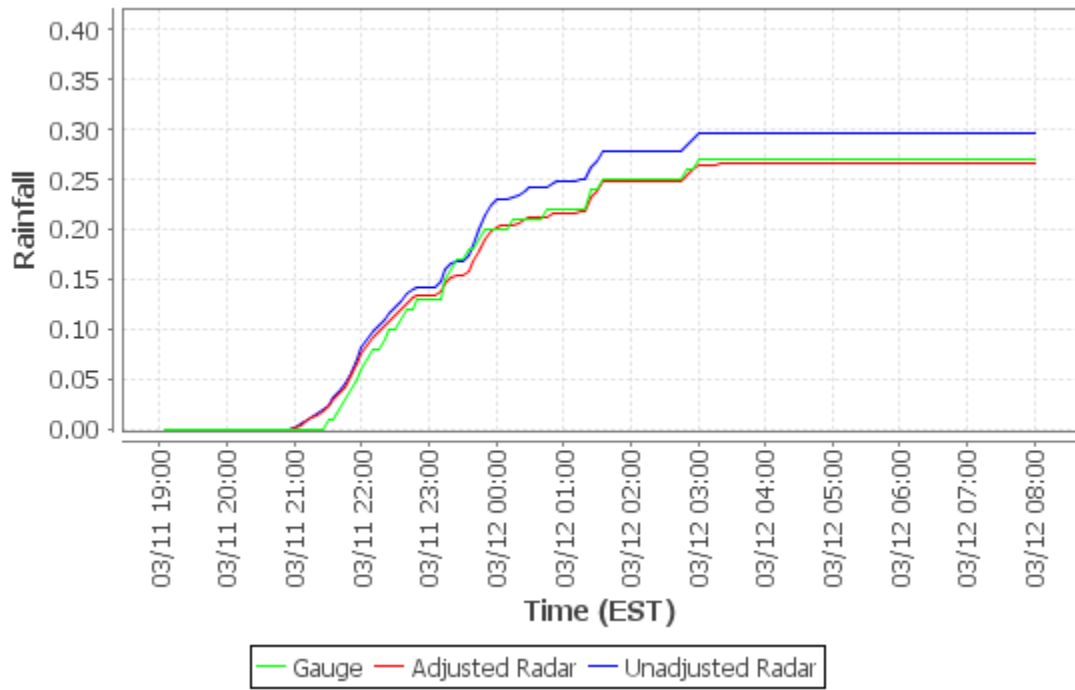
**Cumulative Distribution Plot - Carnegie Transit Time (Loc06)**



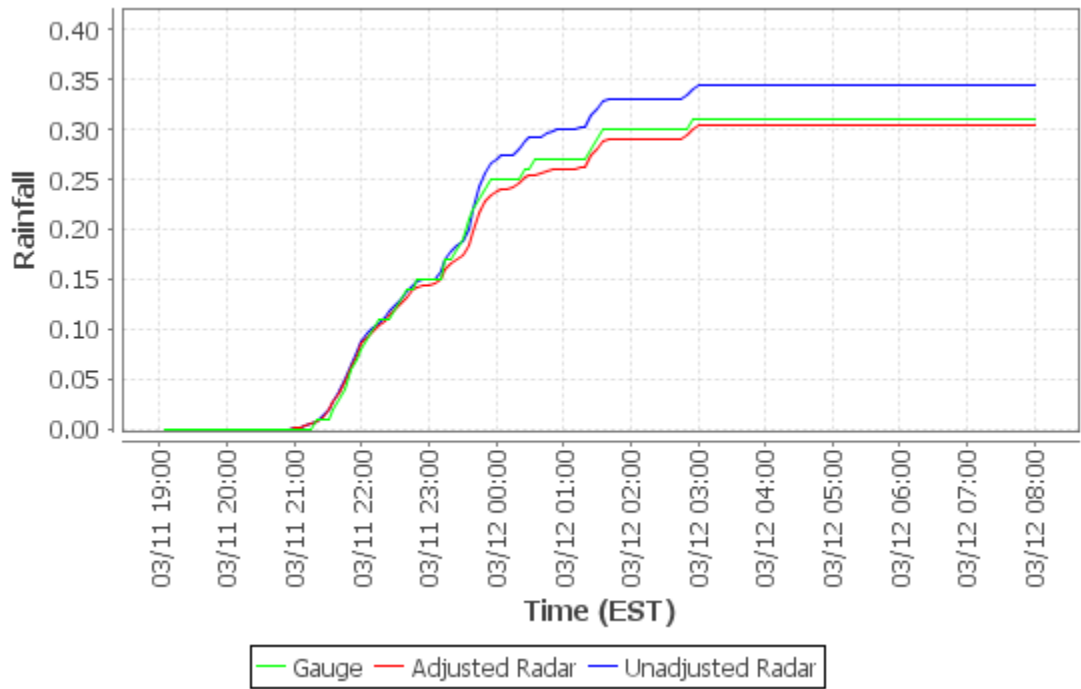
**Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)**



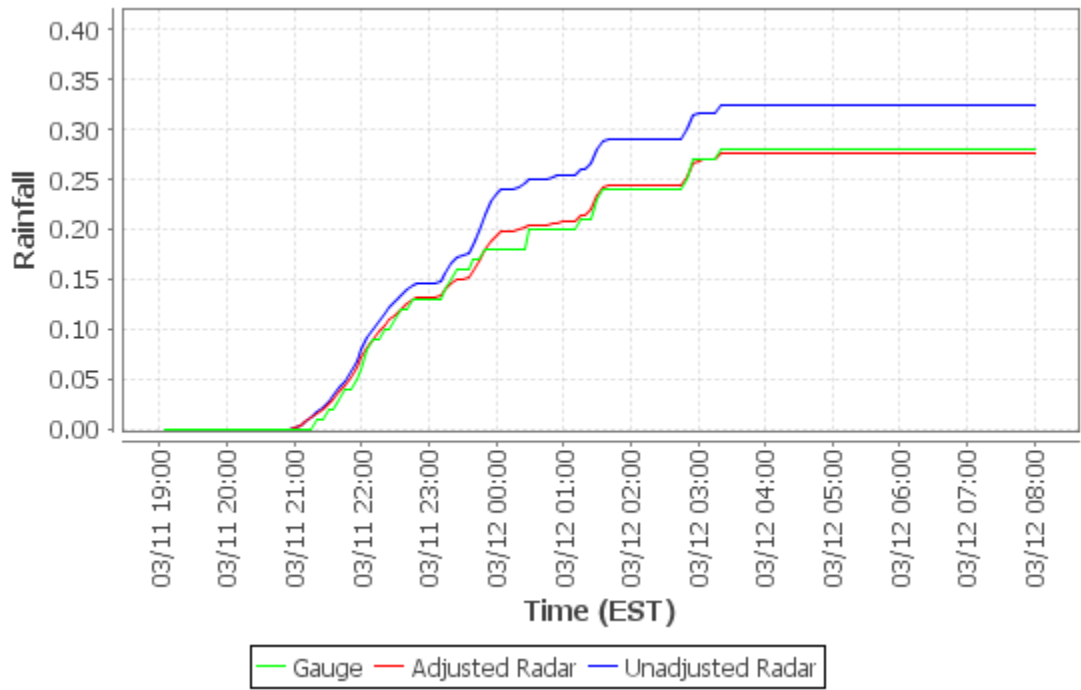
**Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)**



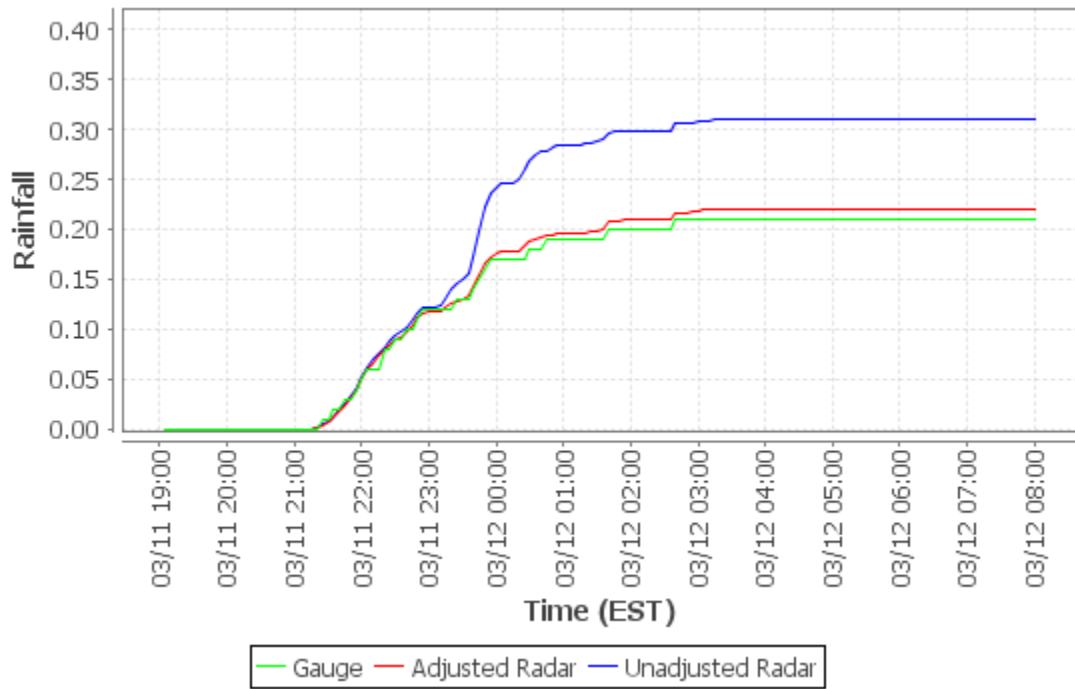
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



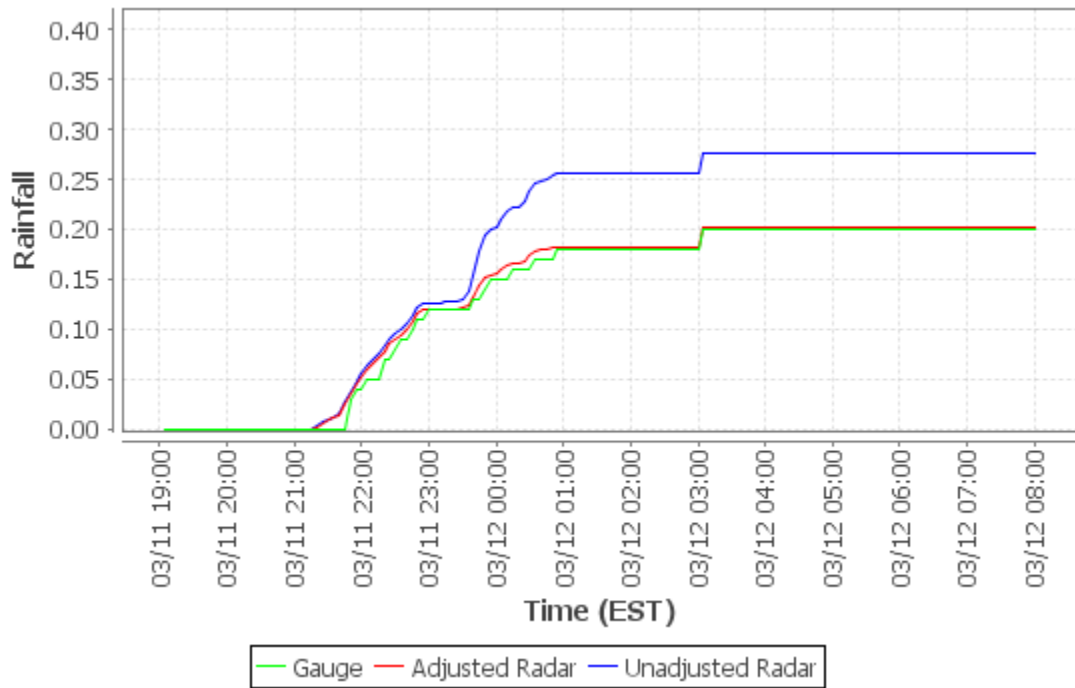
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



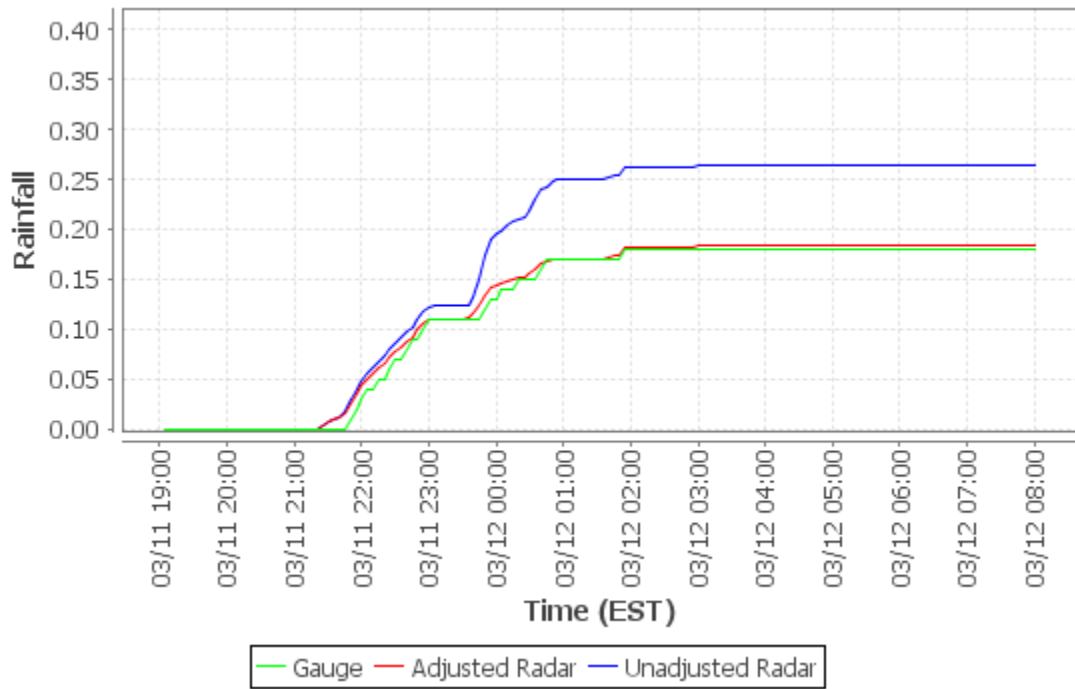
**Cumulative Distribution Plot - M-46 Access Shaft (Loc11)**



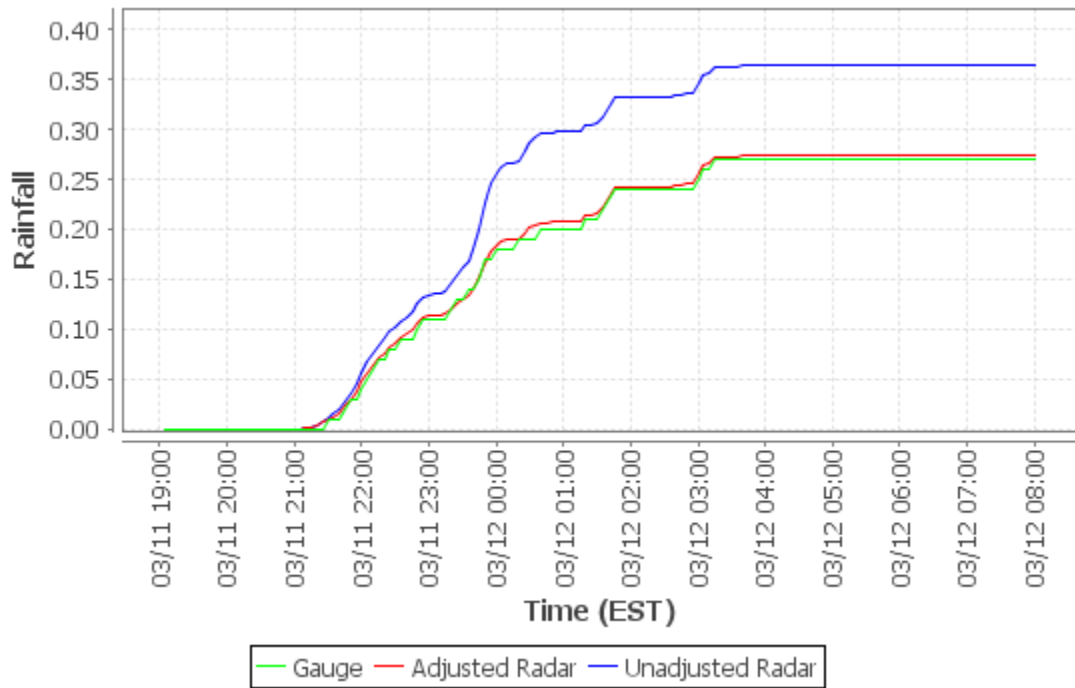
**Cumulative Distribution Plot - Baldwin (Loc12)**



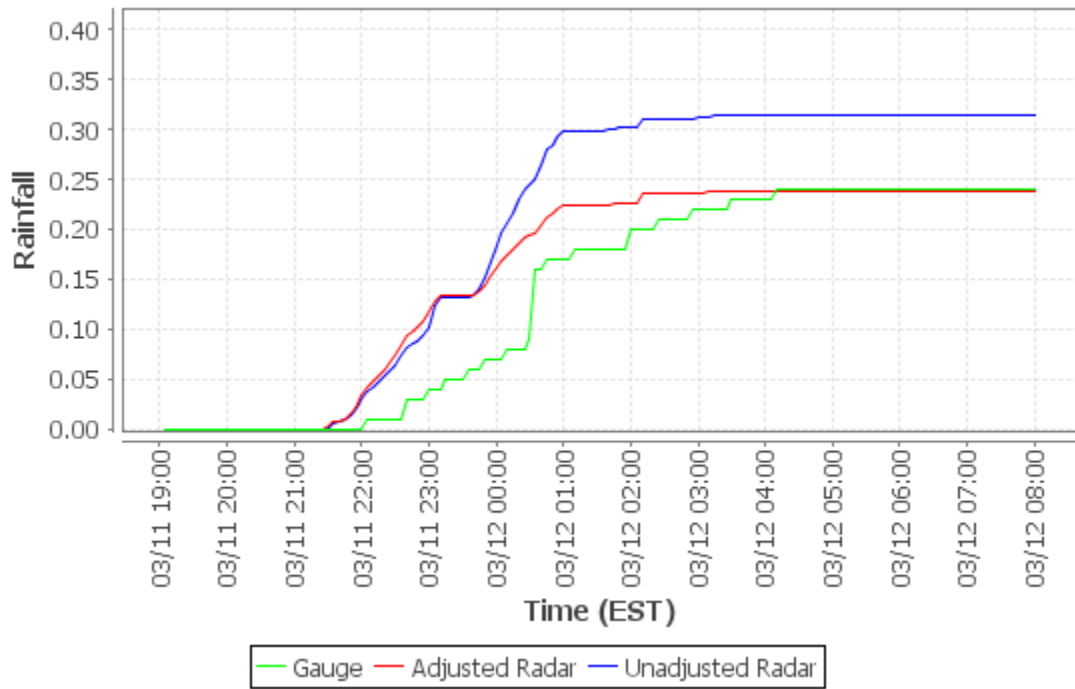
**Cumulative Distribution Plot - M-59 Access Shaft (Loc13)**



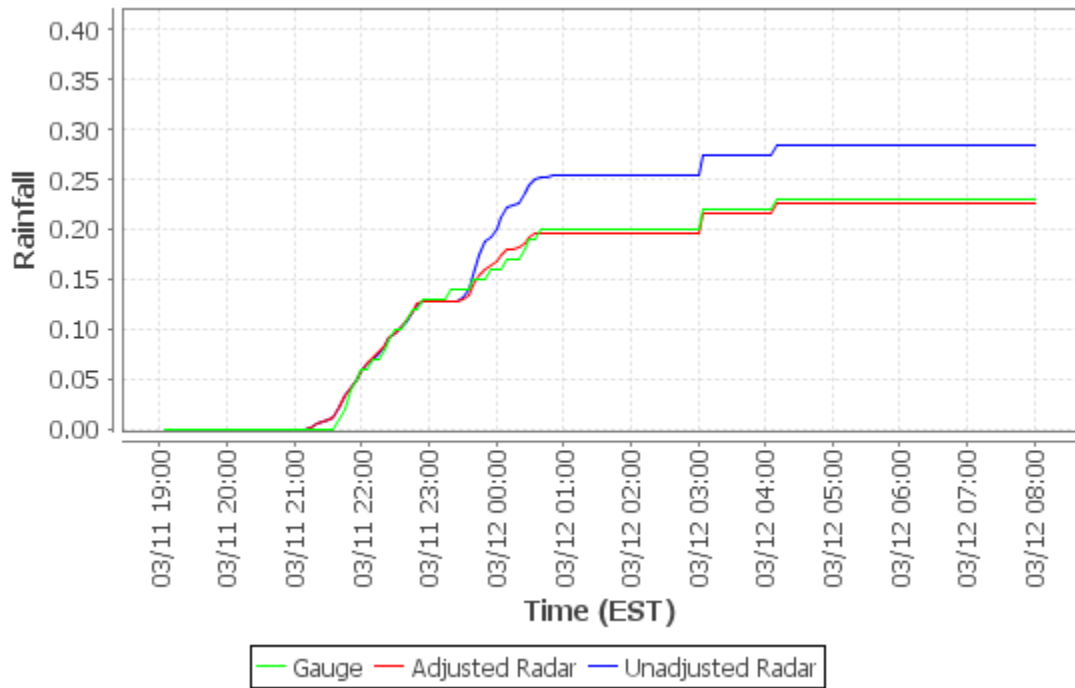
**Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)**



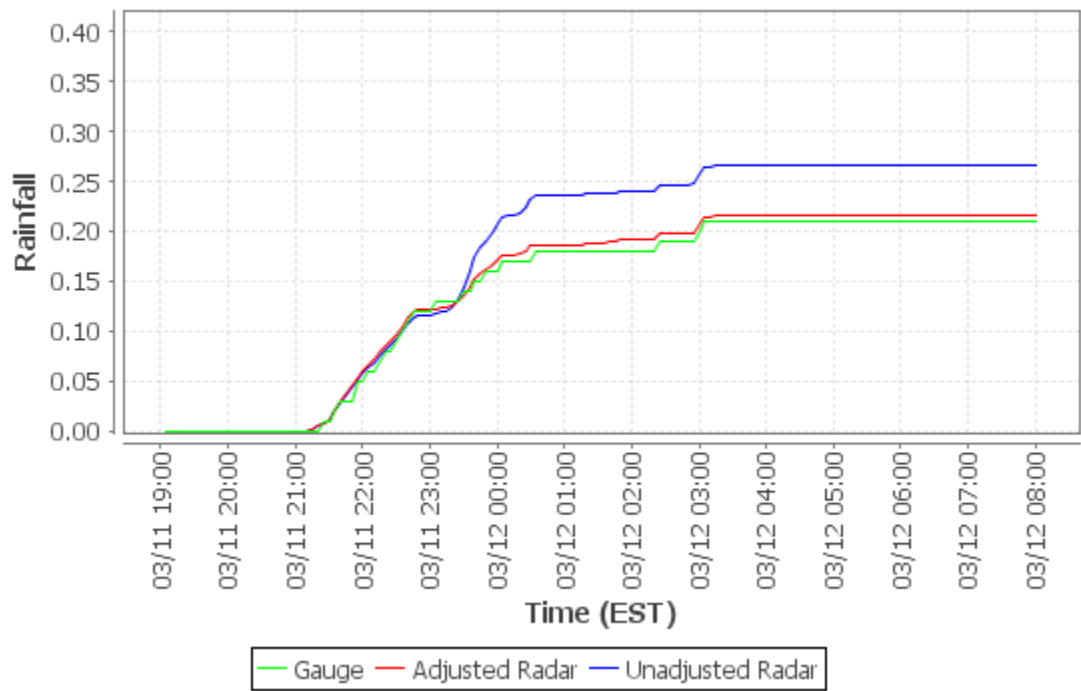
**Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)**



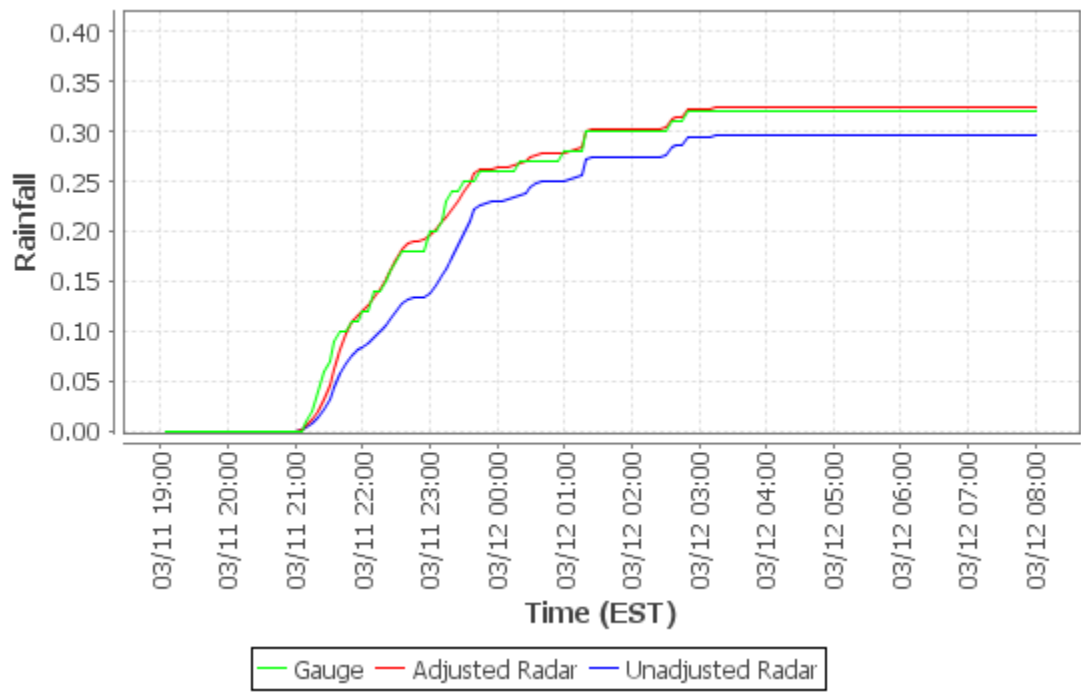
**Cumulative Distribution Plot - Castle Shannon (Loc16)**



Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

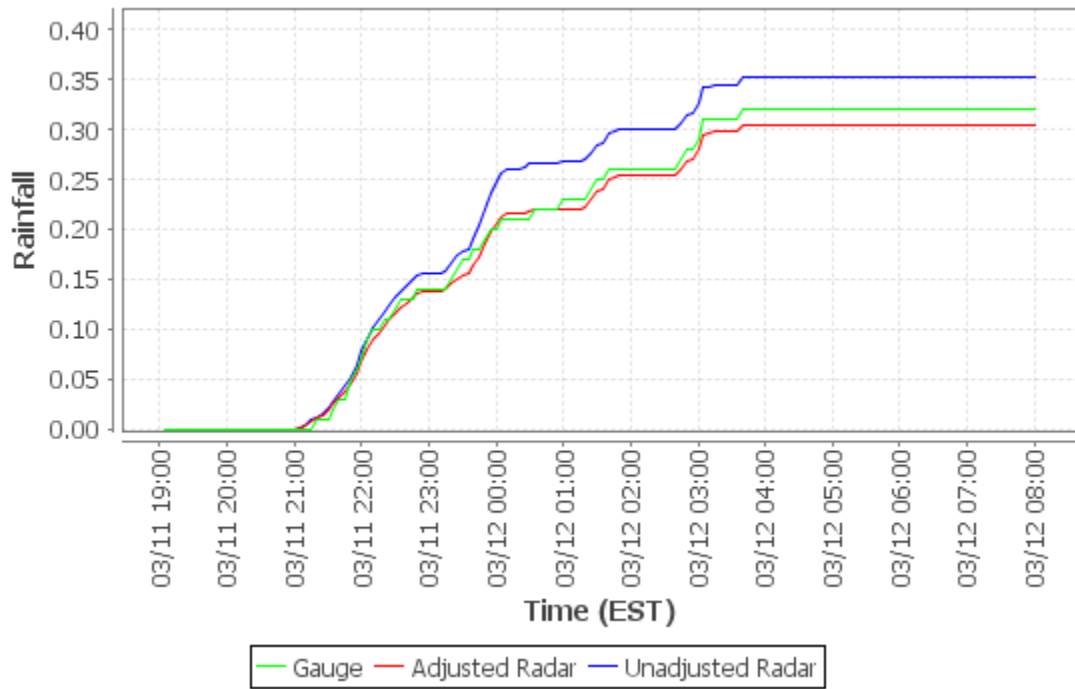


Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

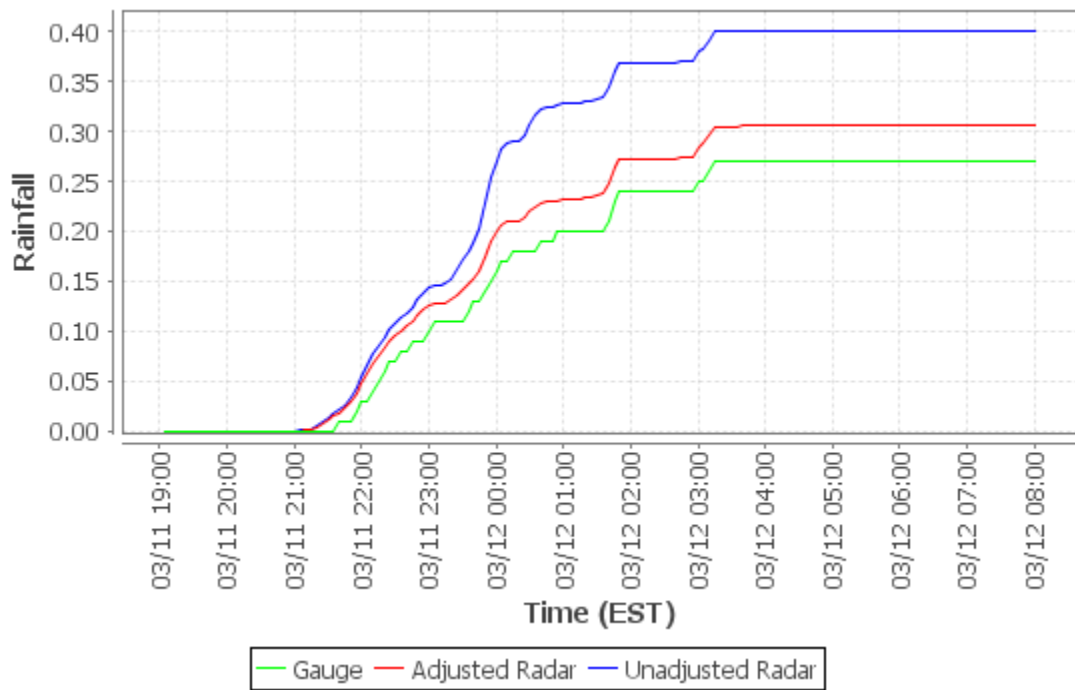




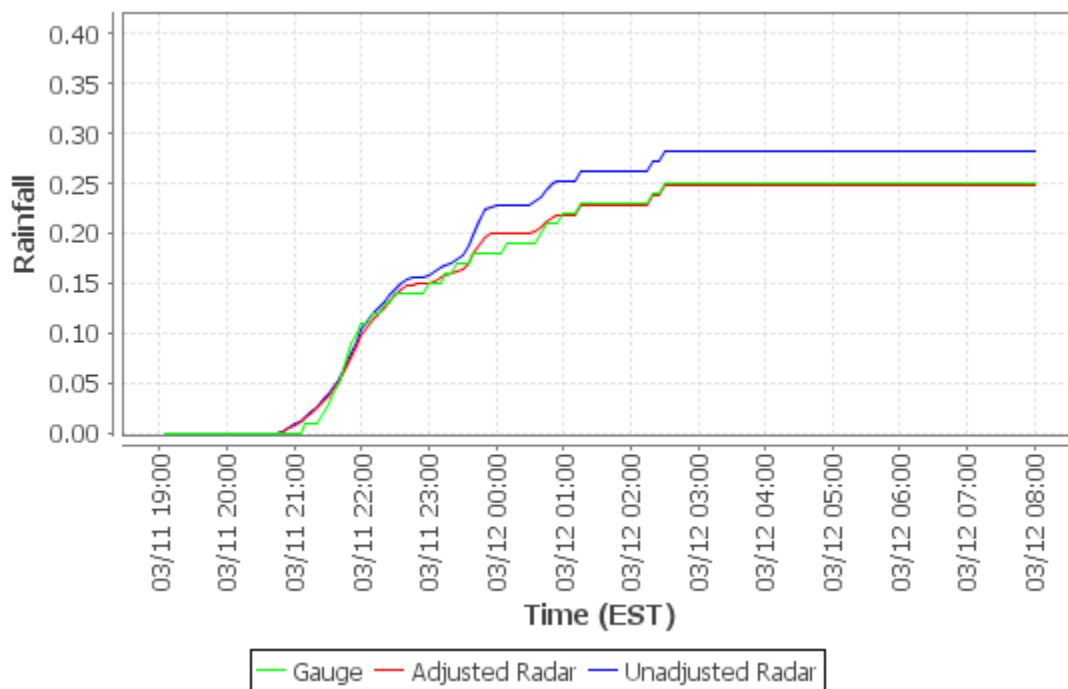
**Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)**



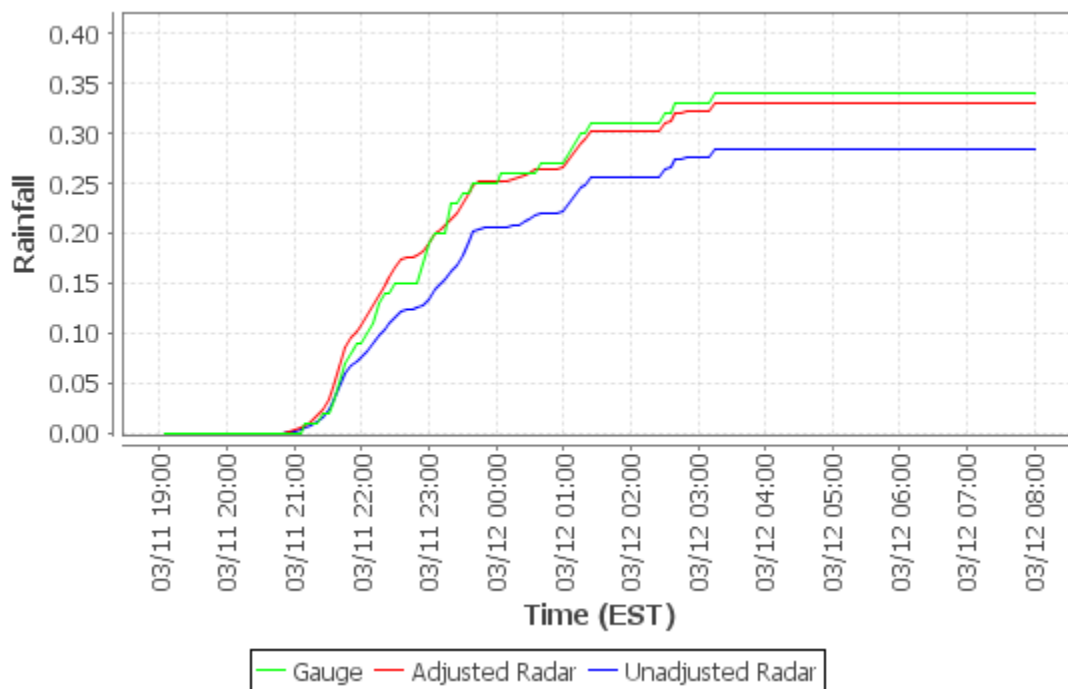
**Cumulative Distribution Plot - Gascola Eq Facility (Loc20)**



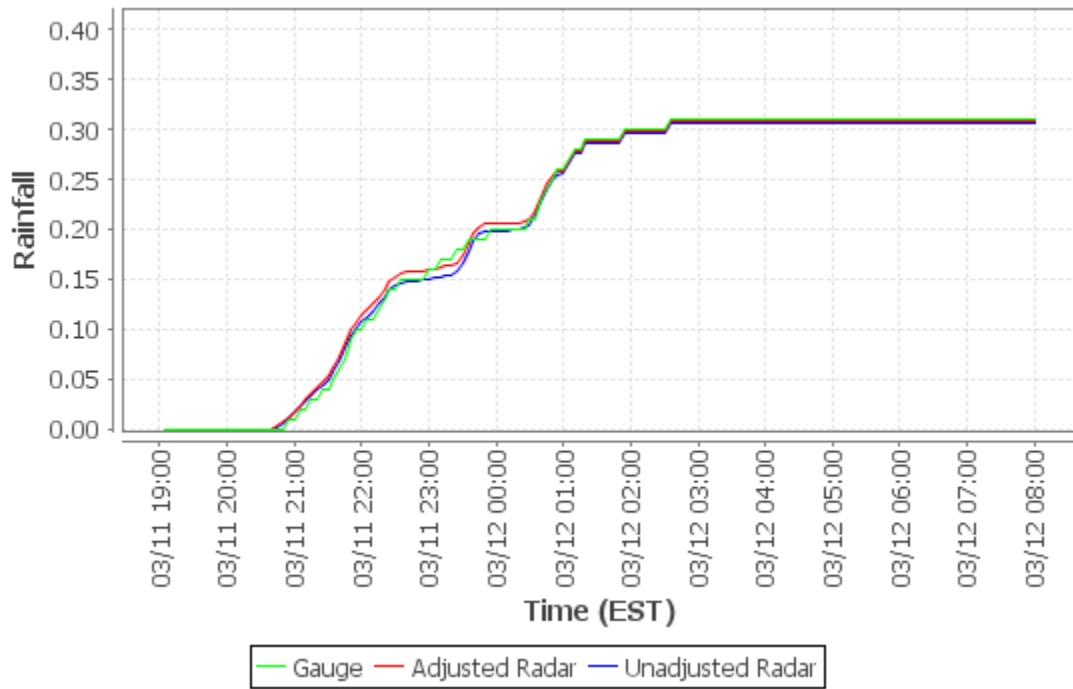
**Cumulative Distribution Plot - Moon TWP (Loc21)**



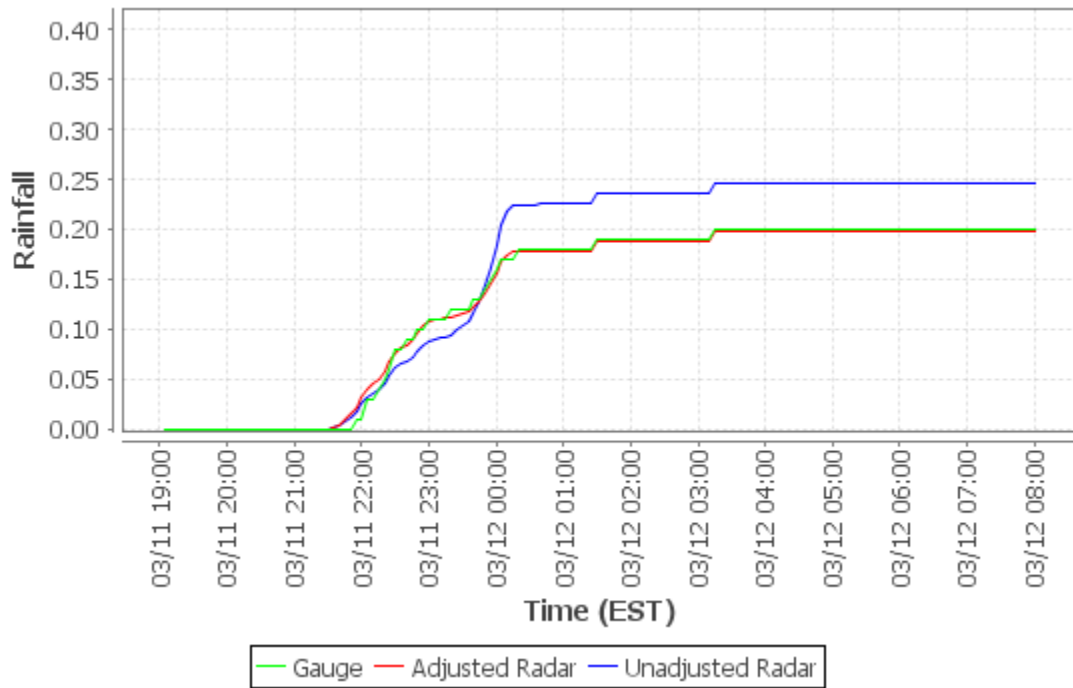
**Cumulative Distribution Plot - North Fayette TWP (Loc22)**



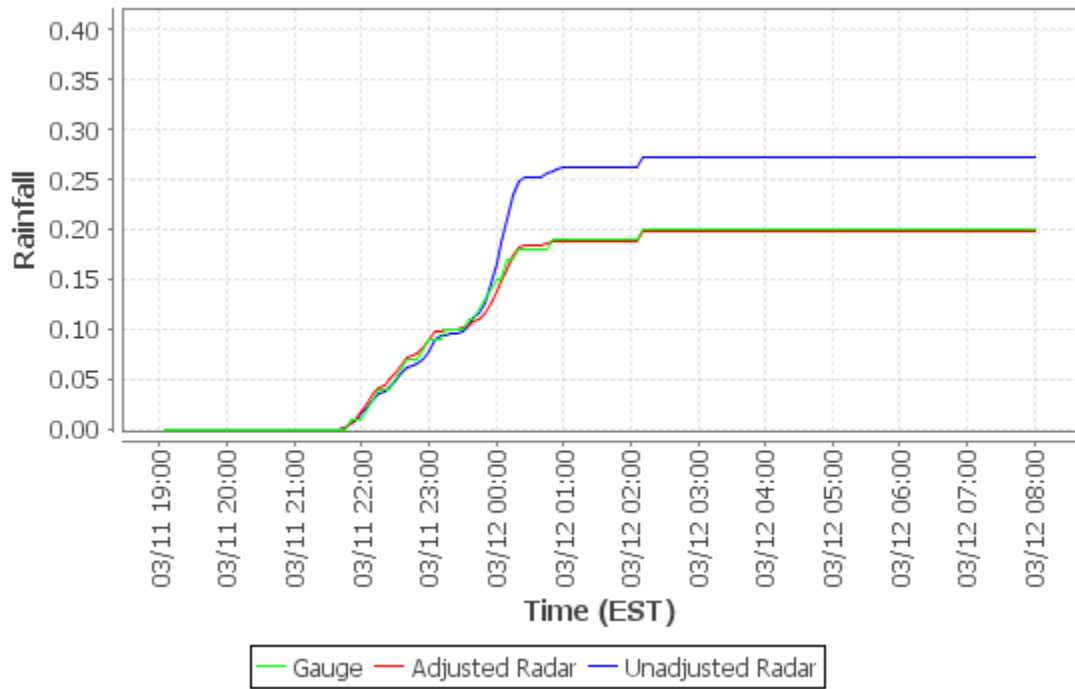
**Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)**



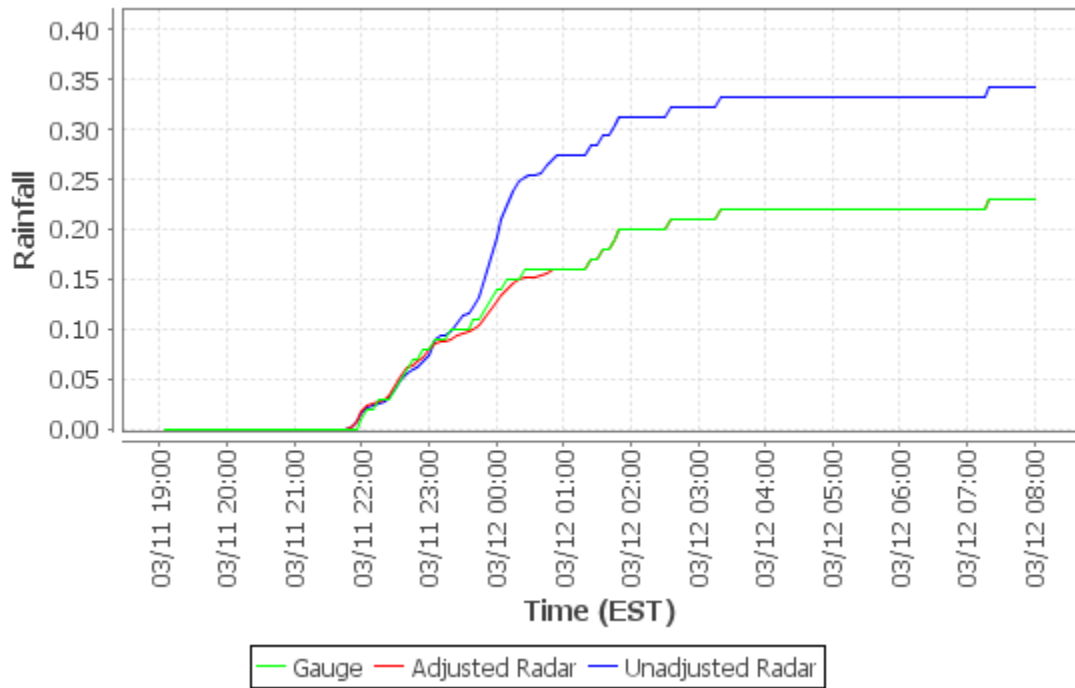
**Cumulative Distribution Plot - Jefferson Hills (Loc24)**



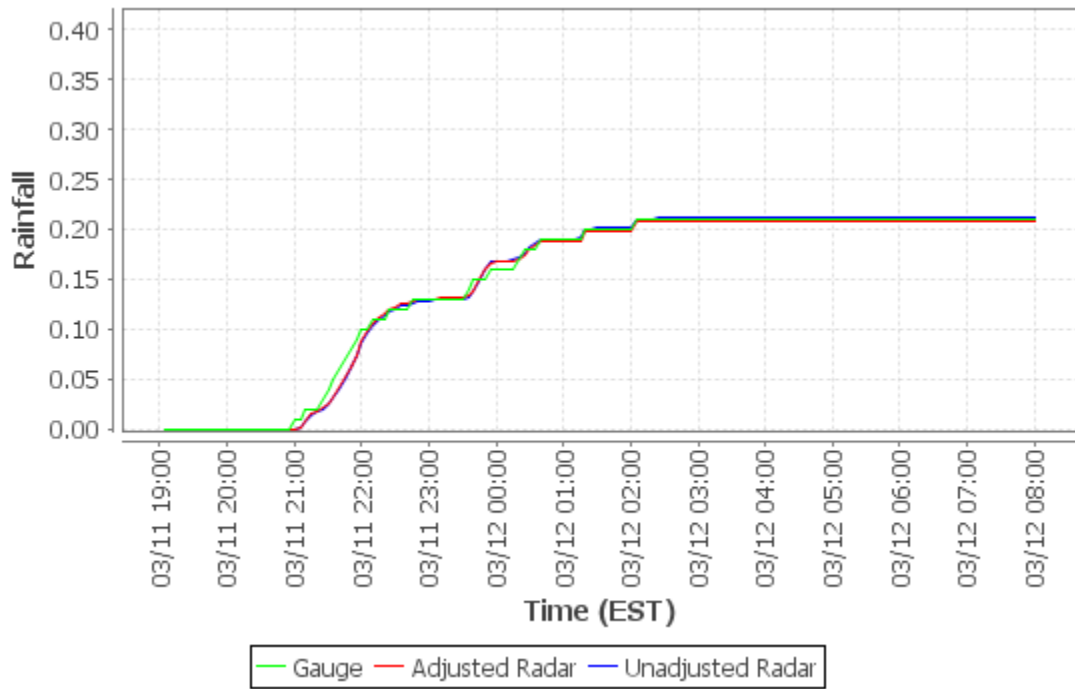
**Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)**



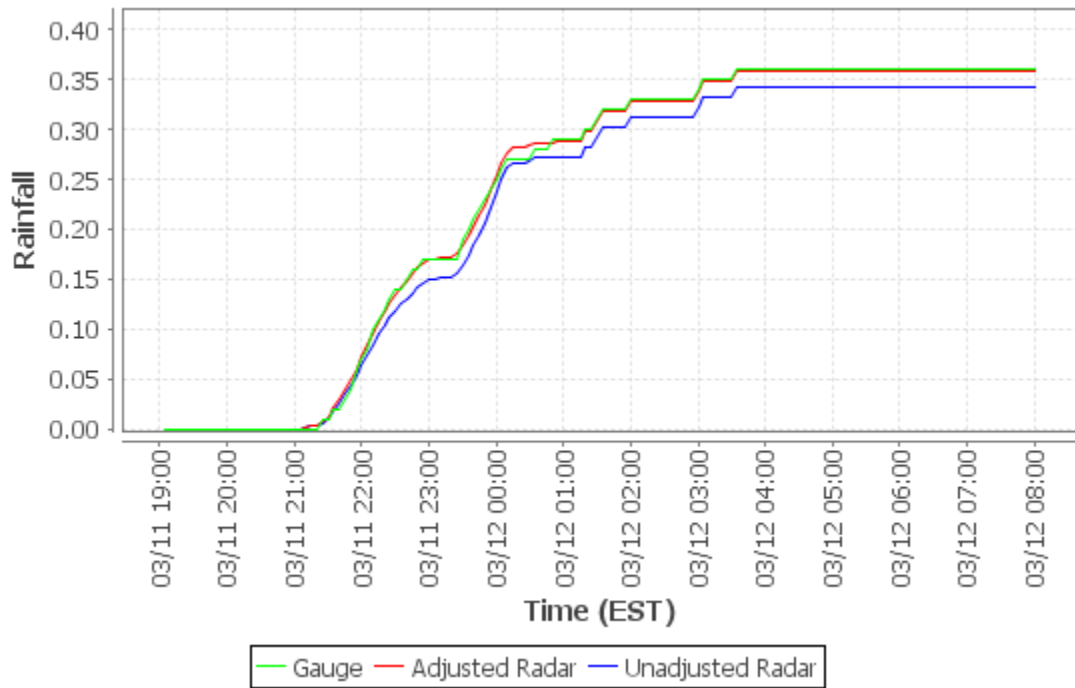
**Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)**



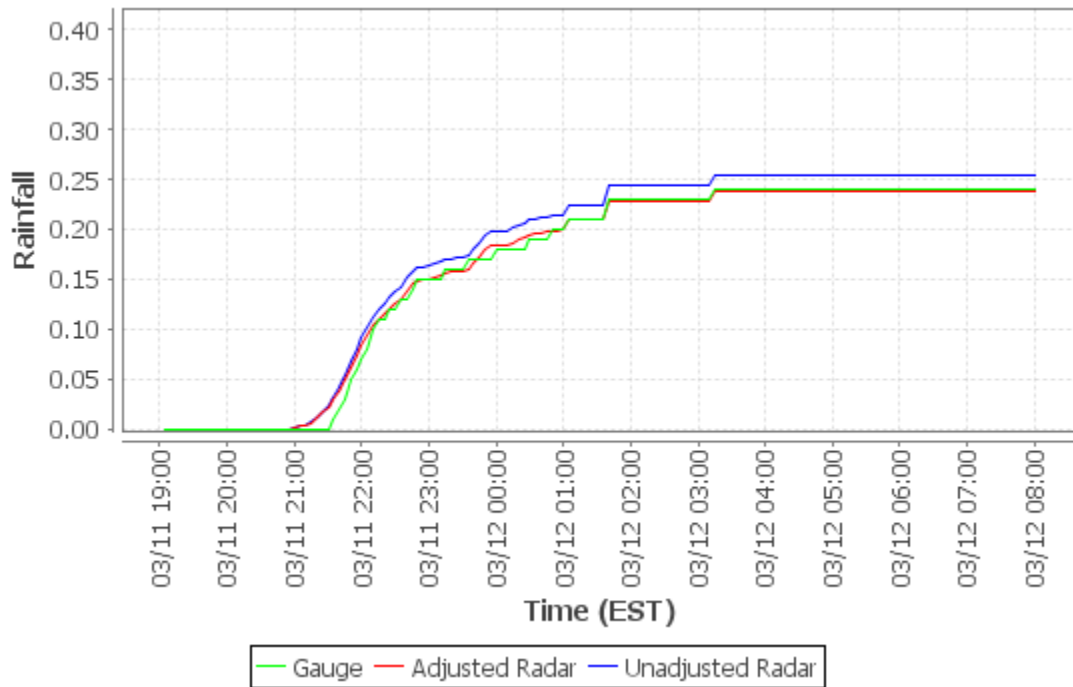
**Cumulative Distribution Plot - Marshall TWP (Loc27)**



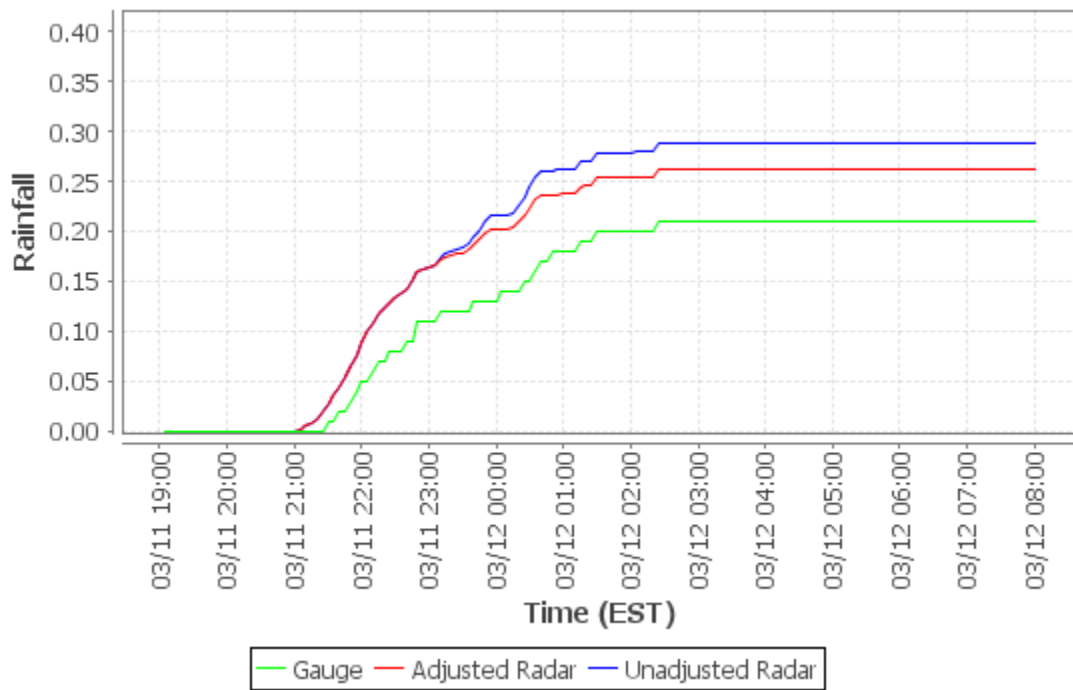
**Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)**



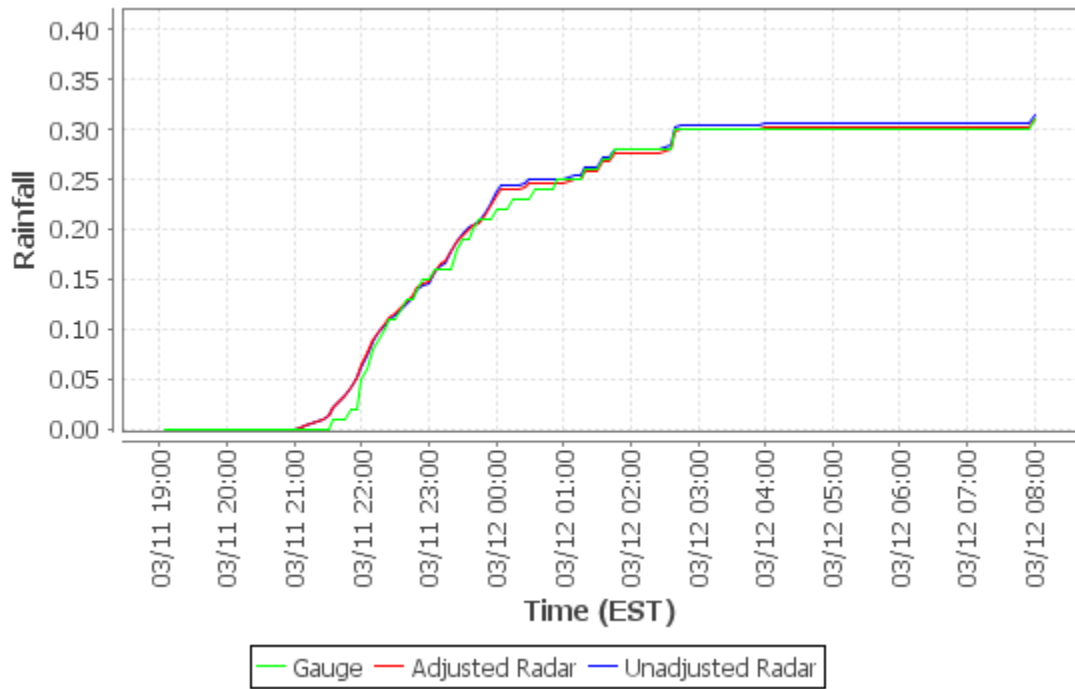
**Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)**



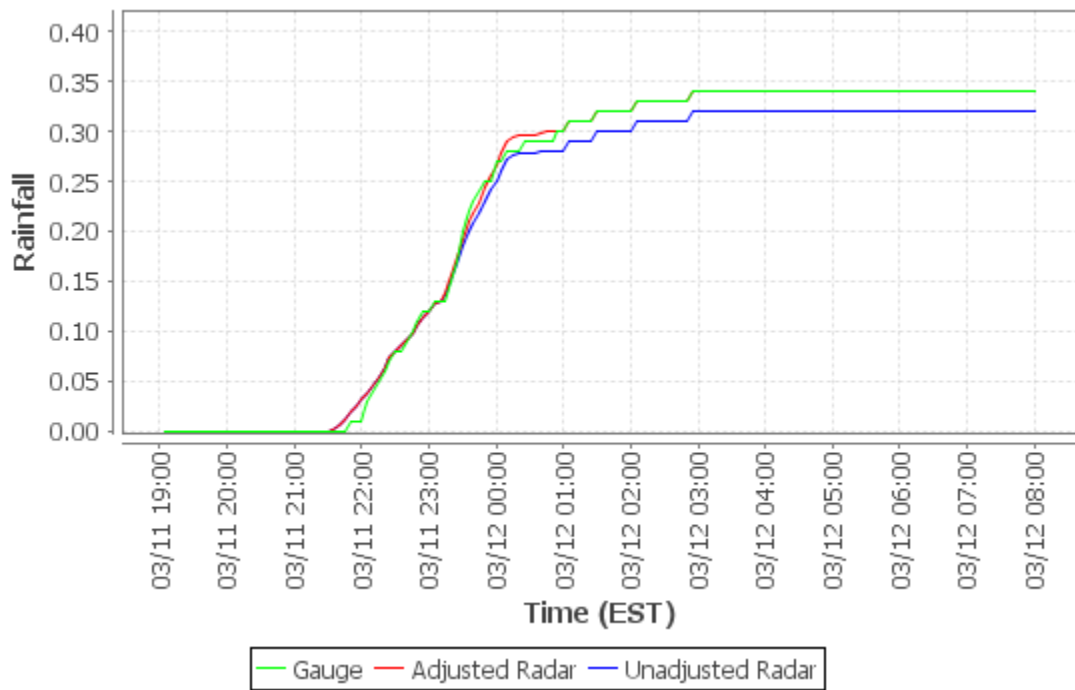
**Cumulative Distribution Plot - McCandless Twn Hall (Loc30)**



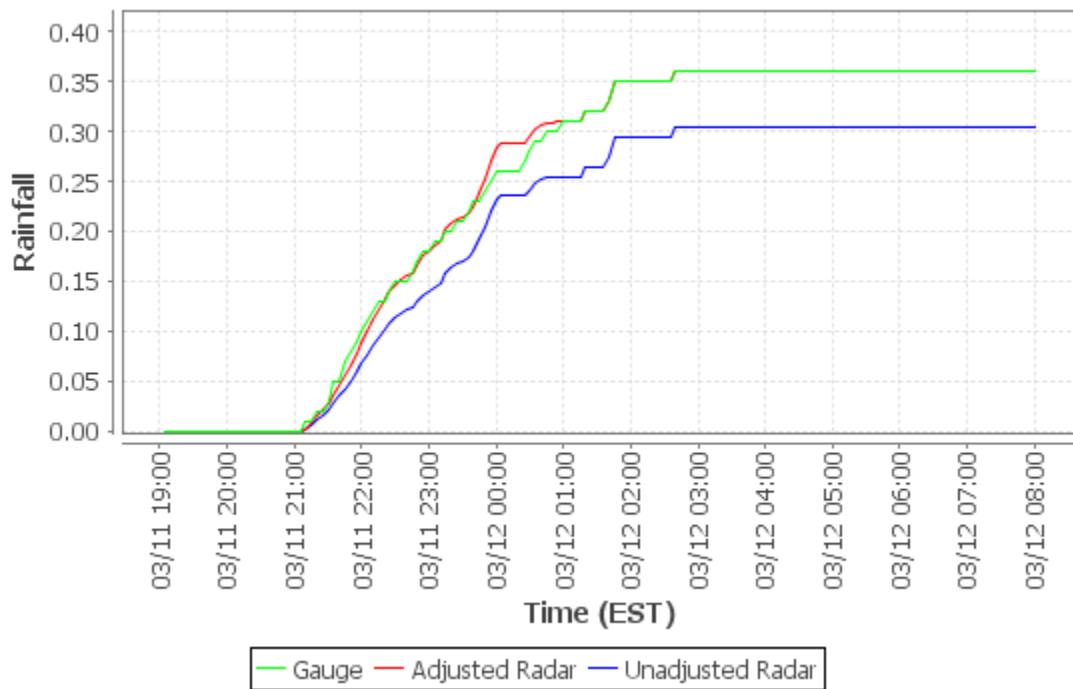
**Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)**



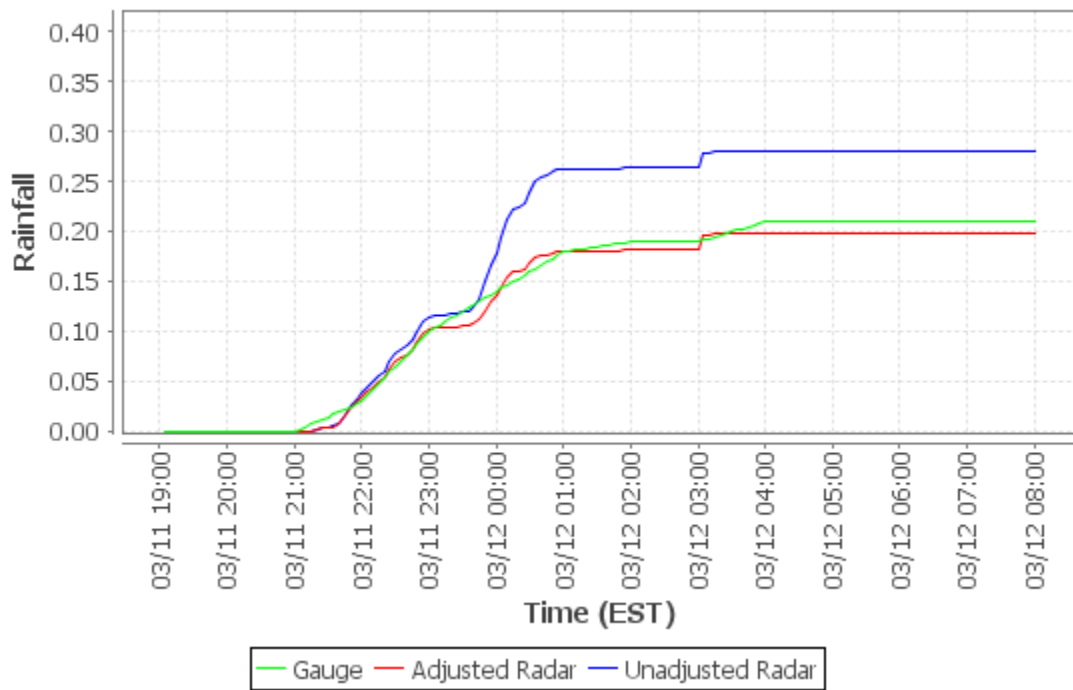
**Cumulative Distribution Plot - Arnold (Loc32)**



**Cumulative Distribution Plot - Richland TWP (Loc33)**

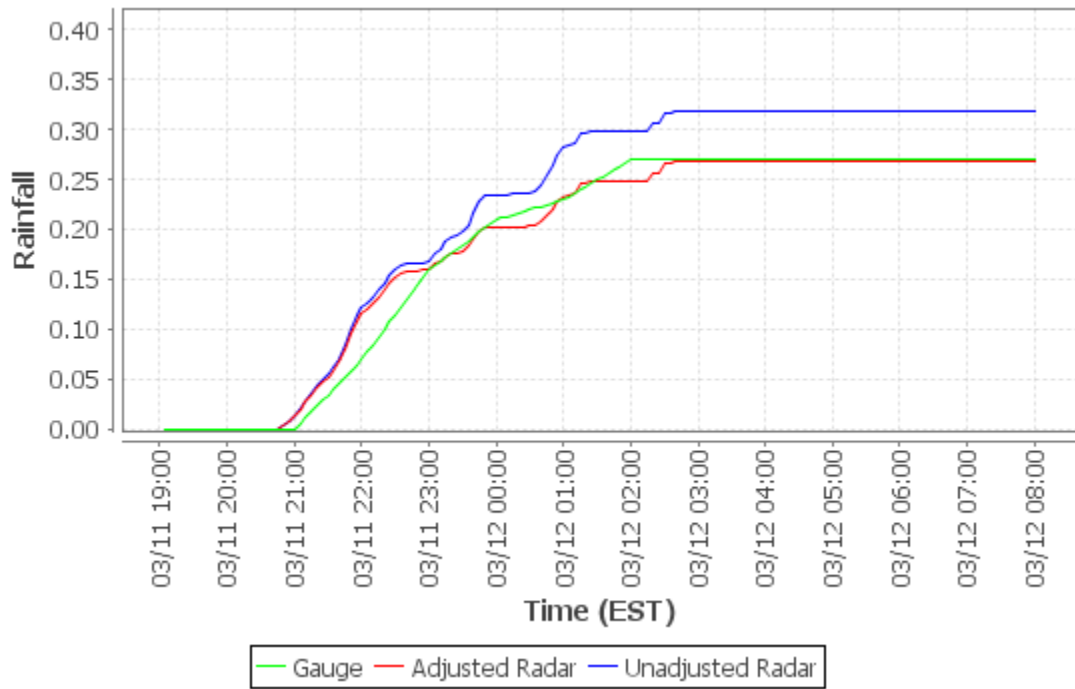


**Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)**

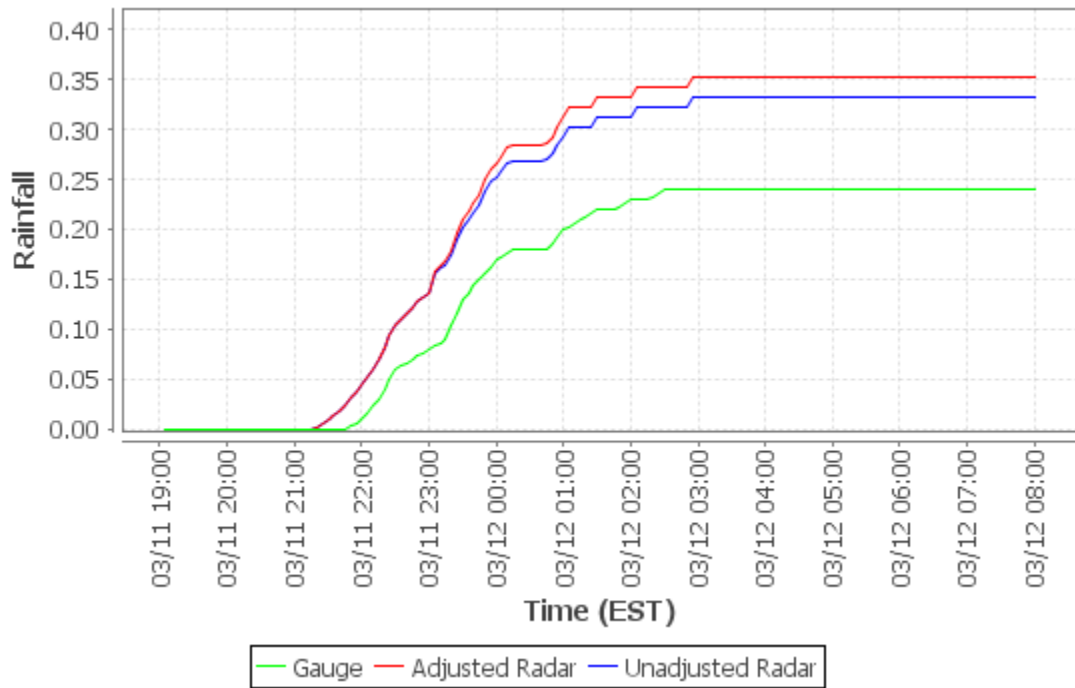




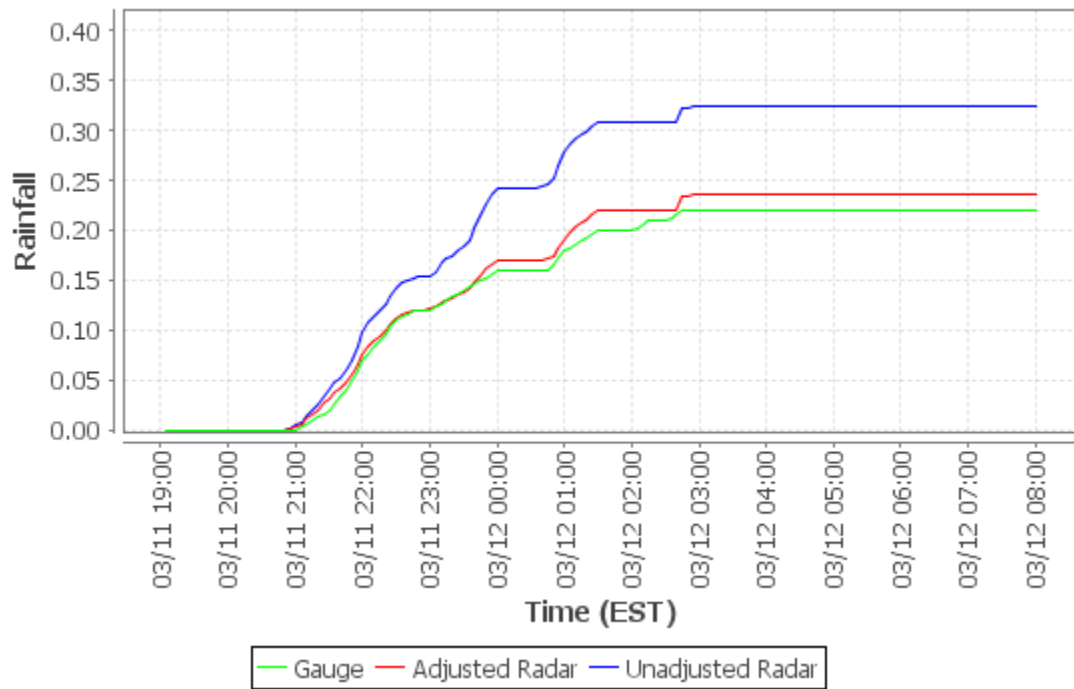
**Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)**



**Cumulative Distribution Plot - Allegheny River at Natrona (03049500)**

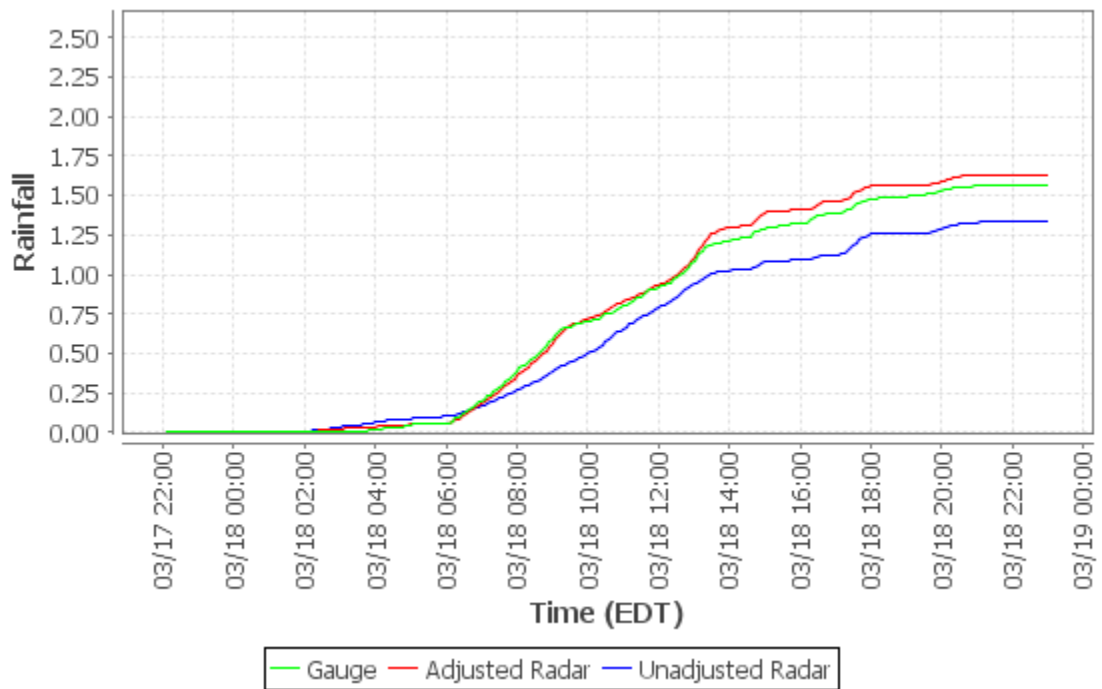


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth  
(03085734)**

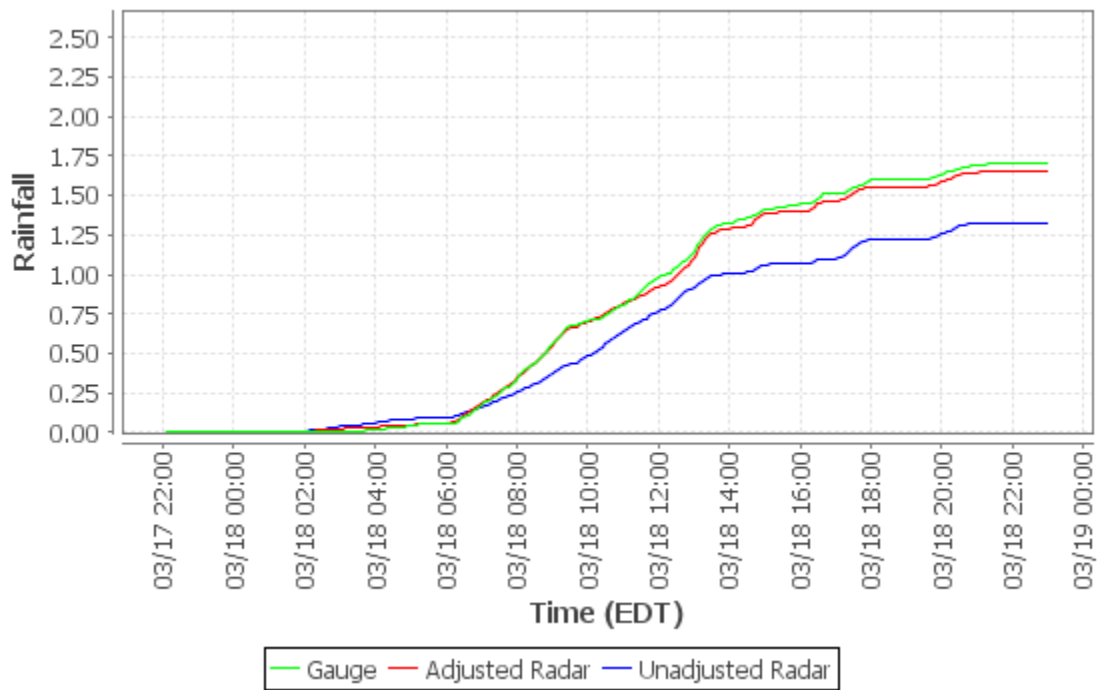


## **Appendix D - Event 2 (2021-03-18) CDPs**

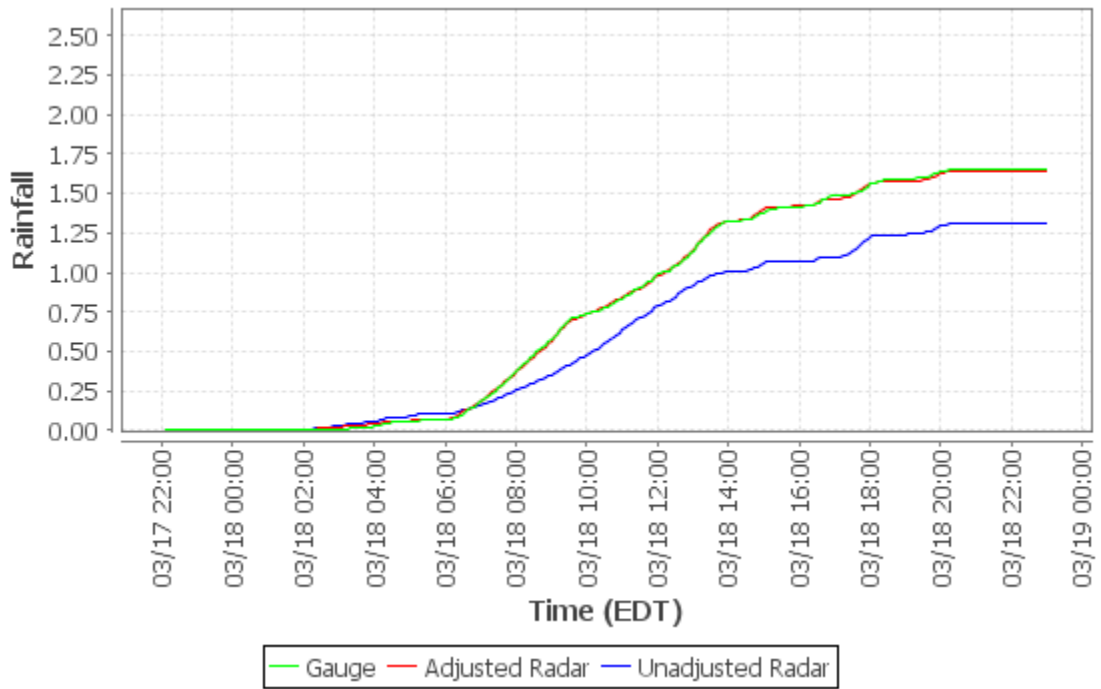
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



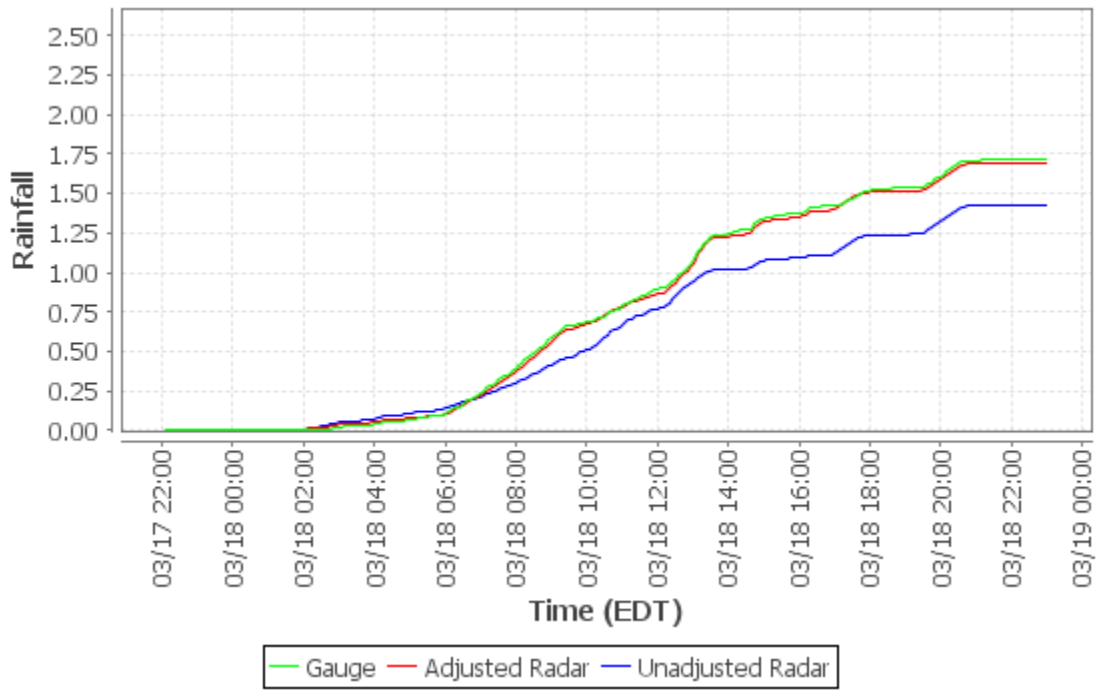
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



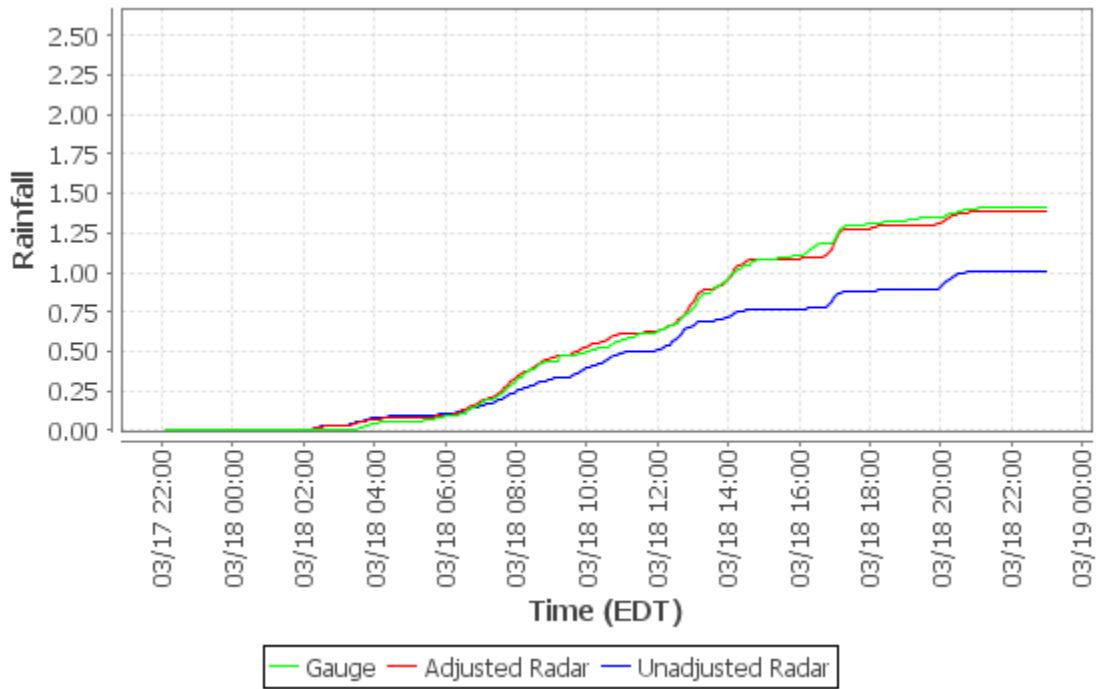
**Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)**



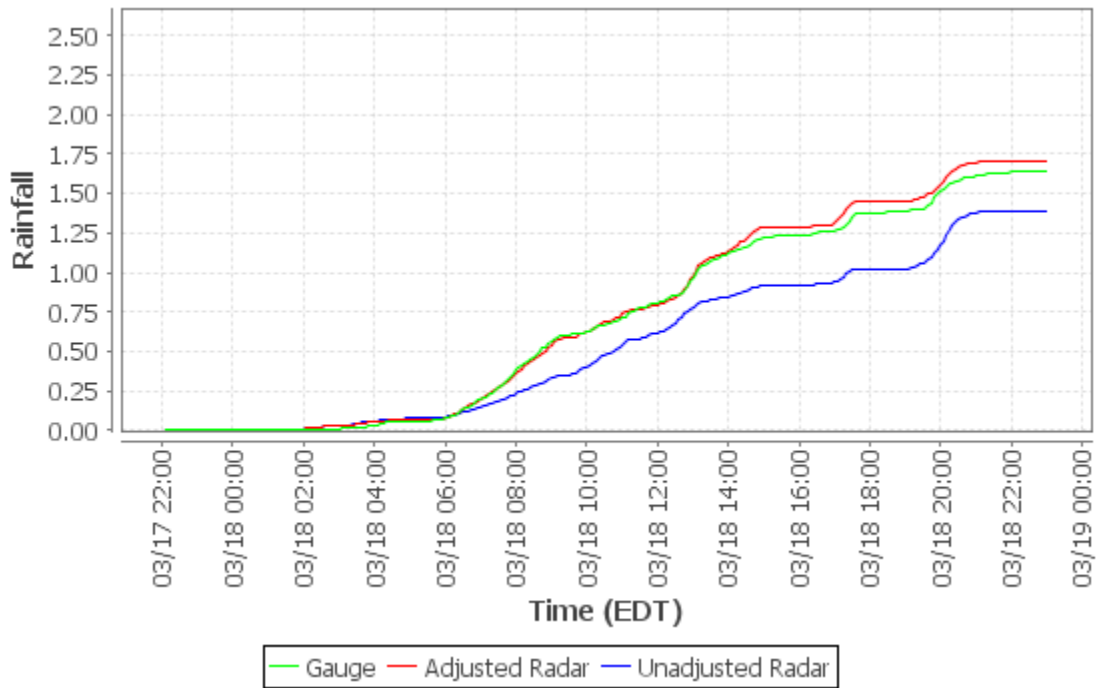
**Cumulative Distribution Plot - Kennedy Twp PS (Loc04)**



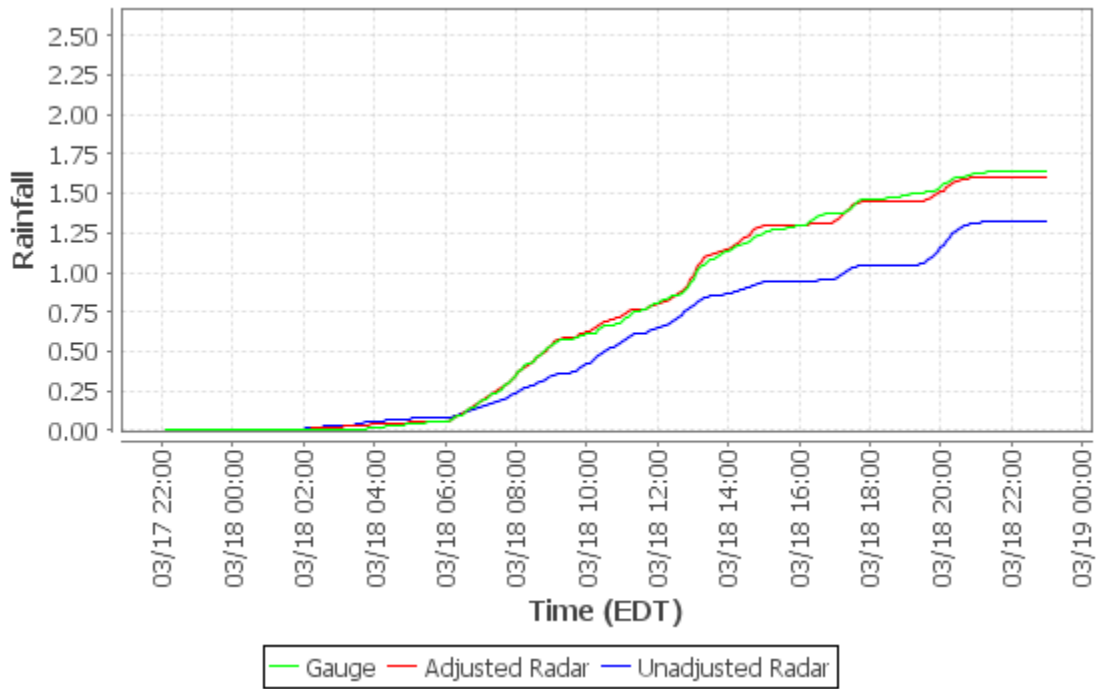
**Cumulative Distribution Plot - Upper St. Clair (Loc05)**



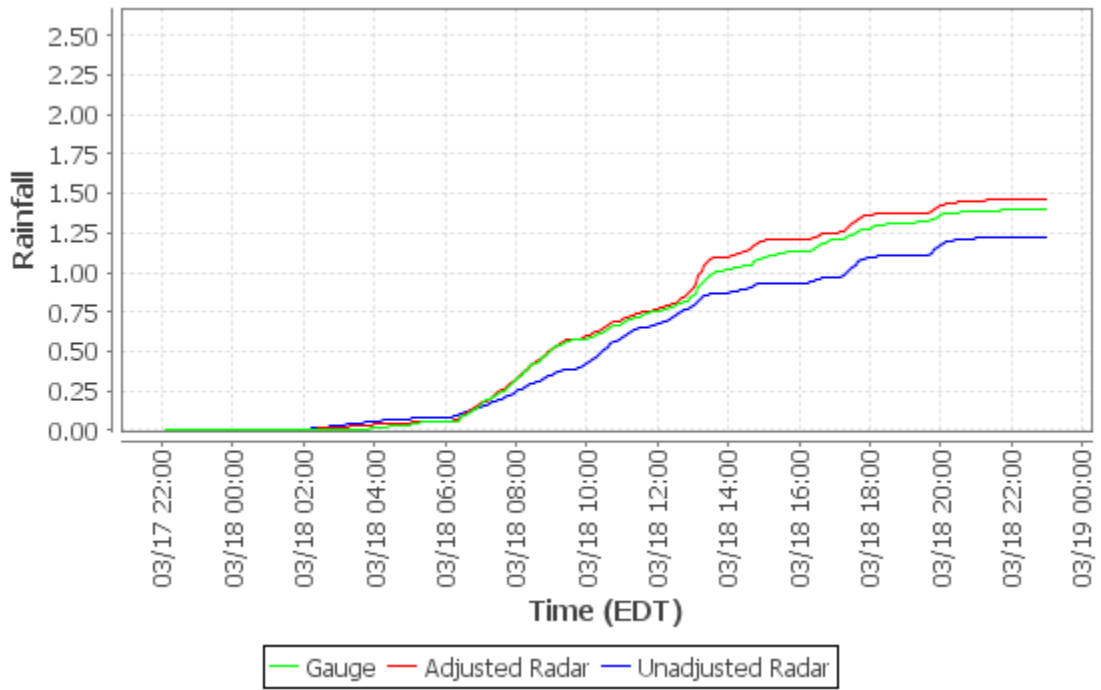
**Cumulative Distribution Plot - Carnegie Transit Time (Loc06)**



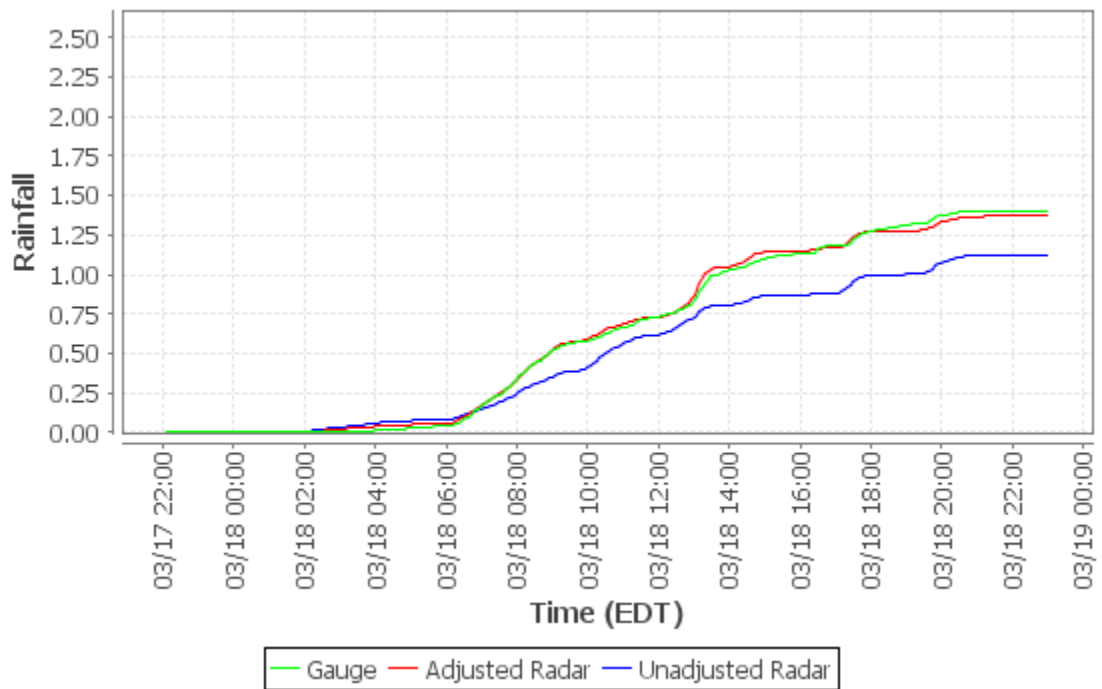
**Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)**



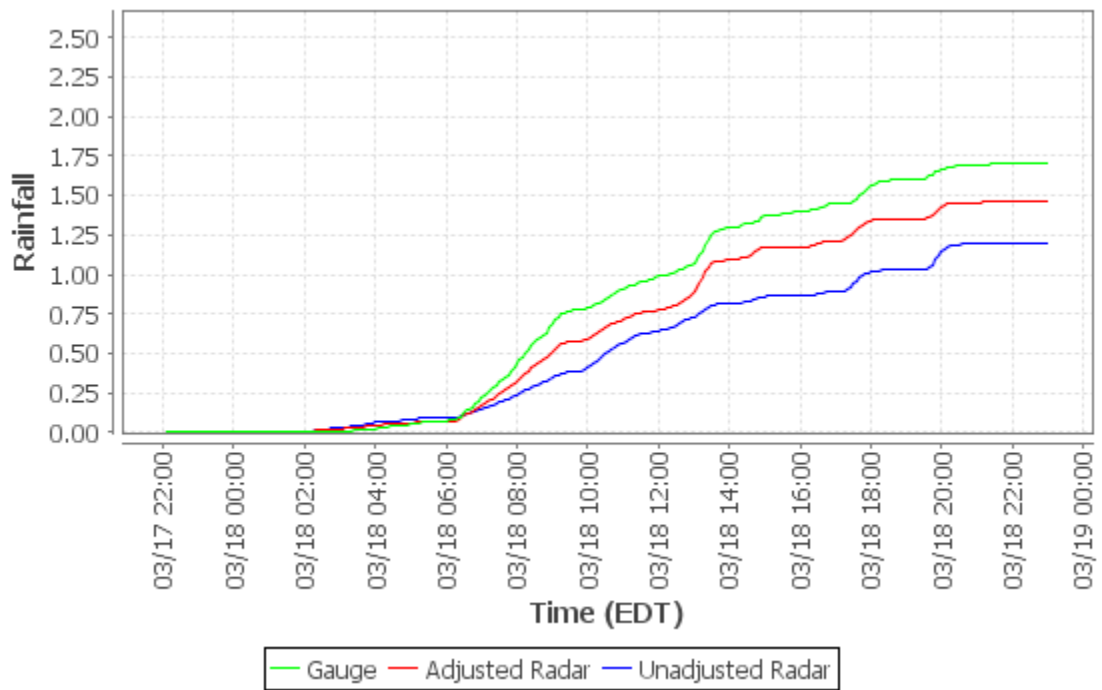
**Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)**



**Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)**

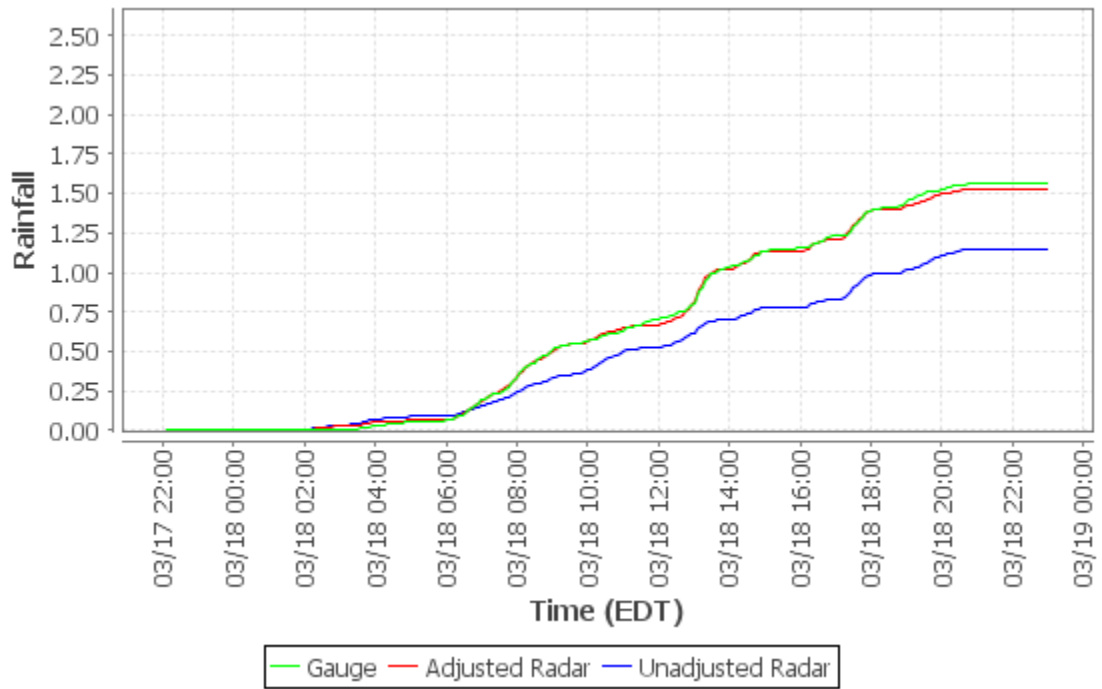


**Cumulative Distribution Plot - PWSA-Highland Park (Loc10)**

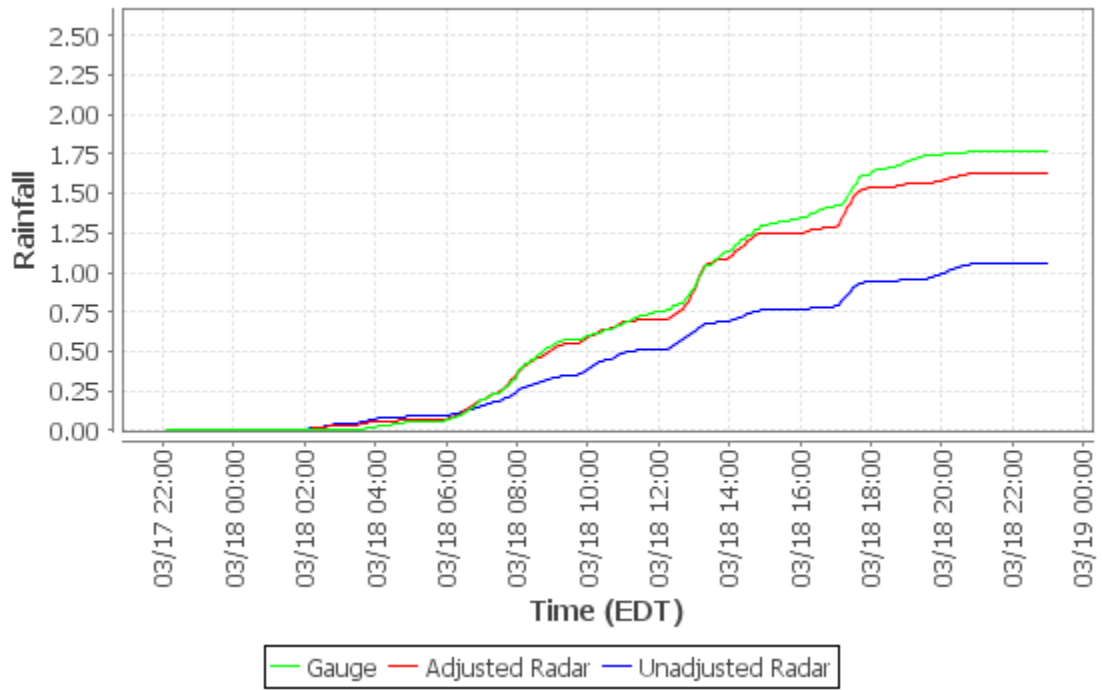




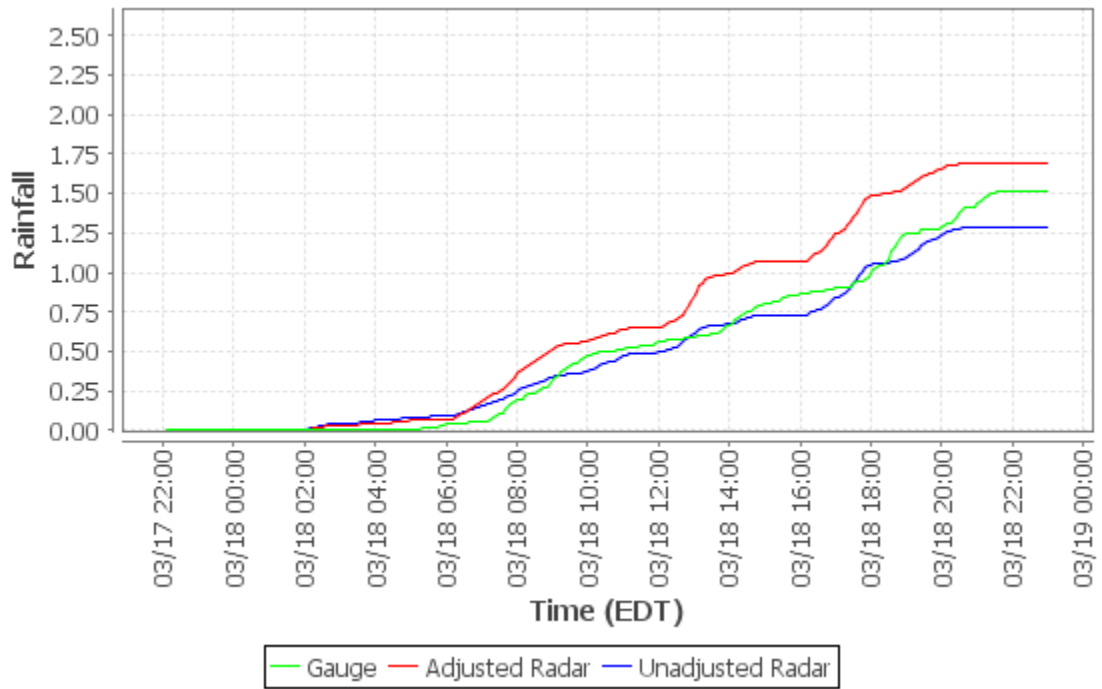
**Cumulative Distribution Plot - M-46 Access Shaft (Loc11)**



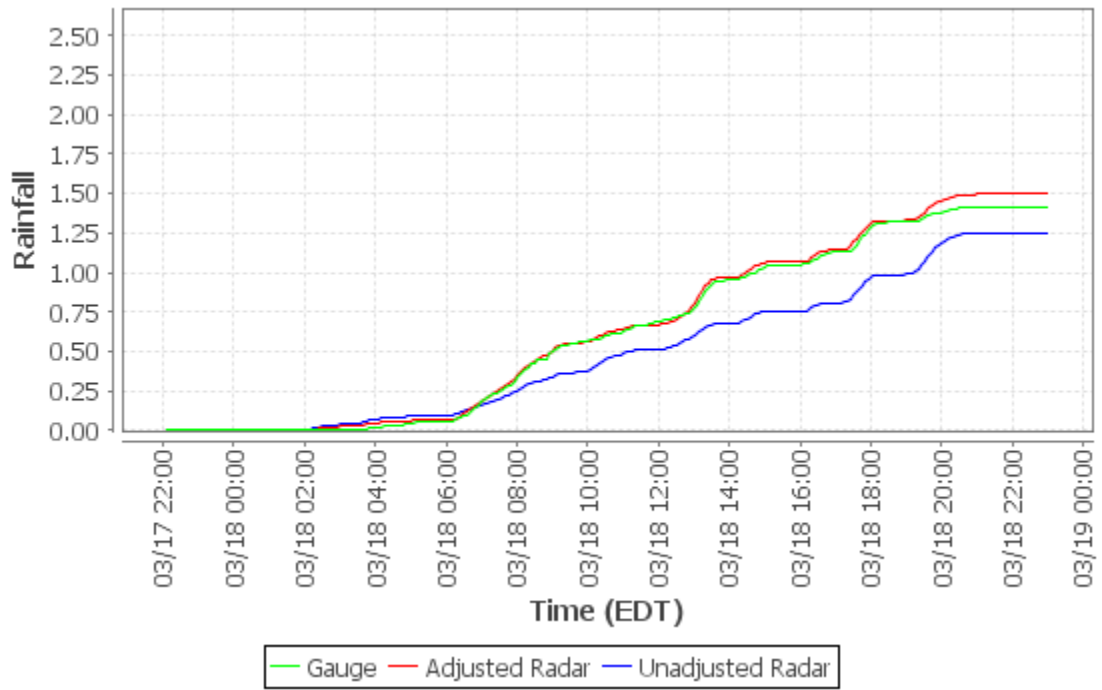
**Cumulative Distribution Plot - Baldwin (Loc12)**



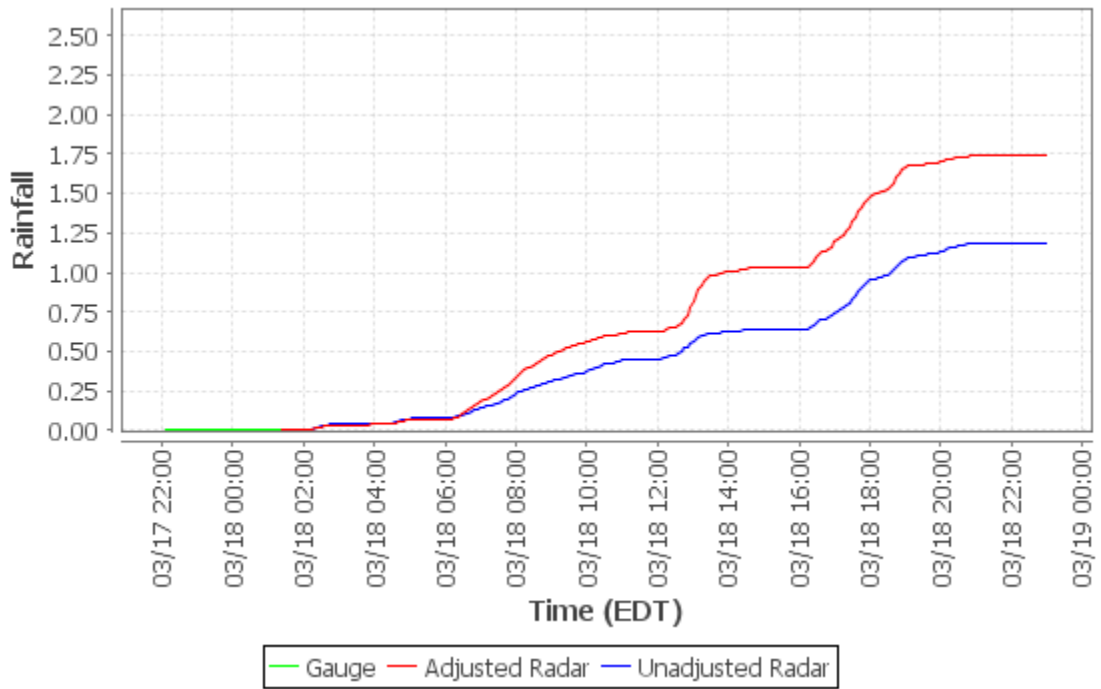
**Cumulative Distribution Plot - M-59 Access Shaft (Loc13)**



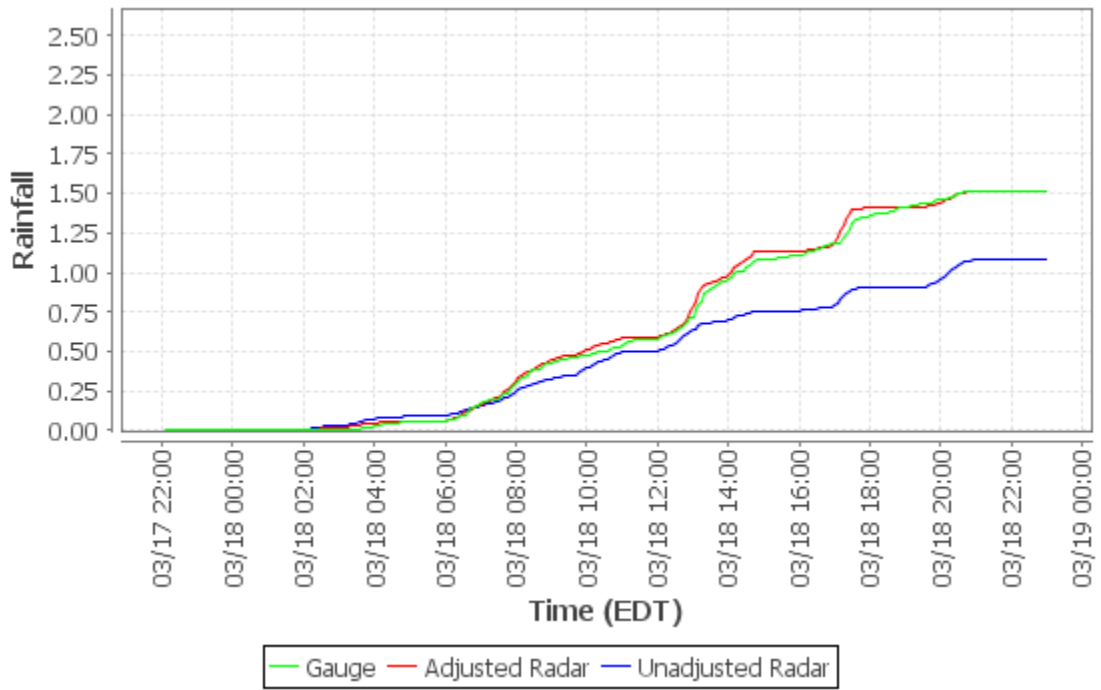
**Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)**



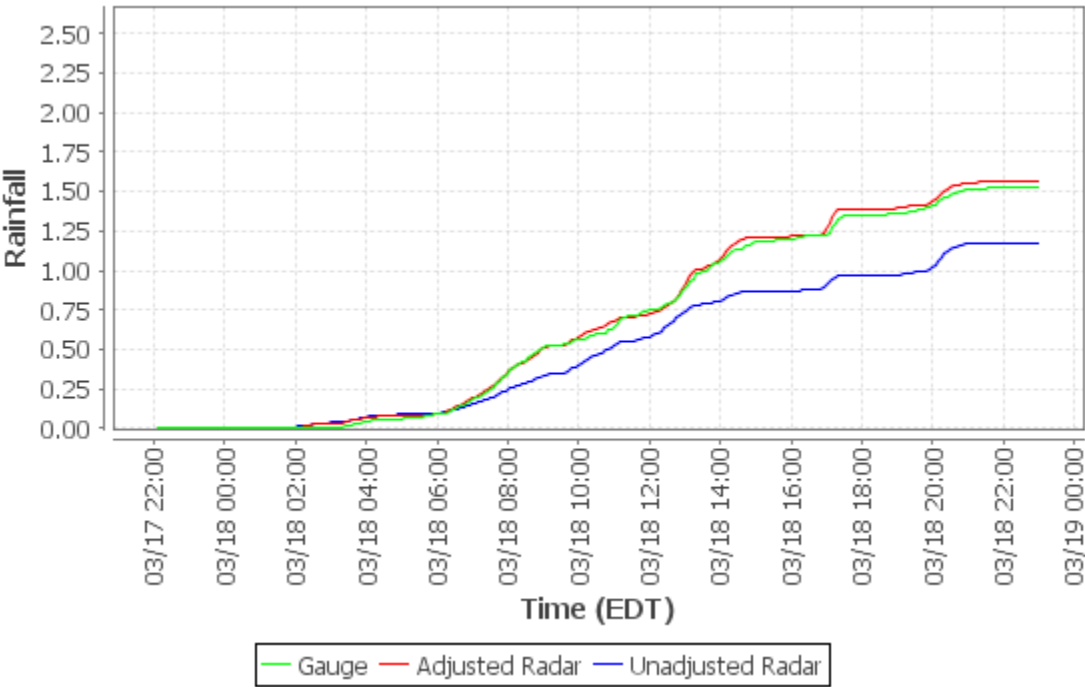
**Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)**



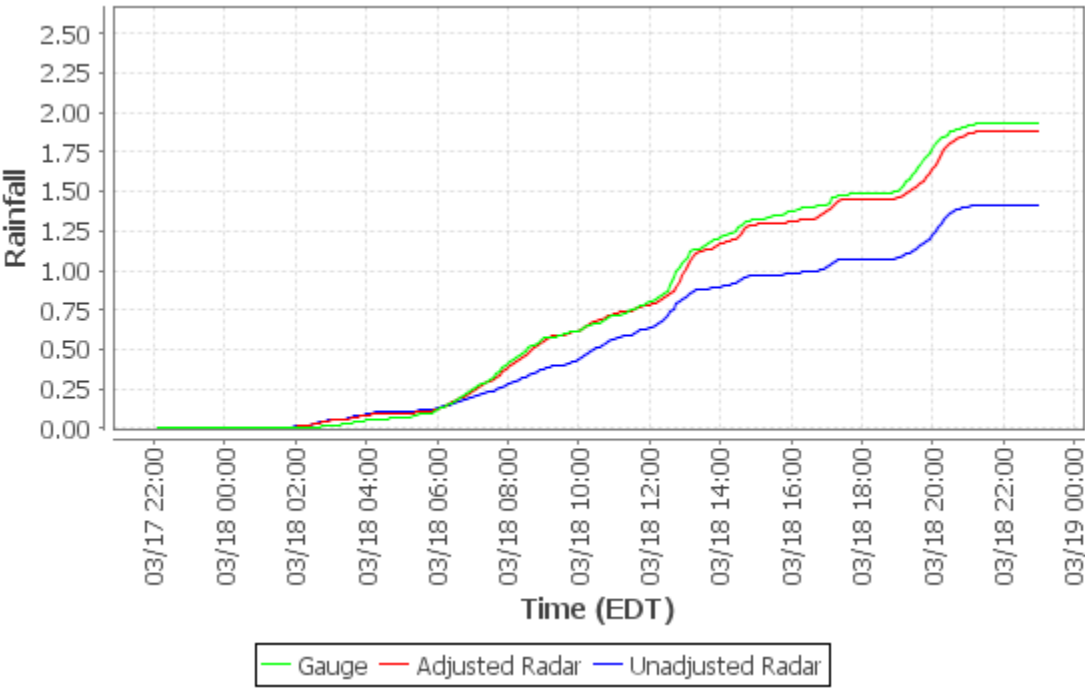
**Cumulative Distribution Plot - Castle Shannon (Loc16)**



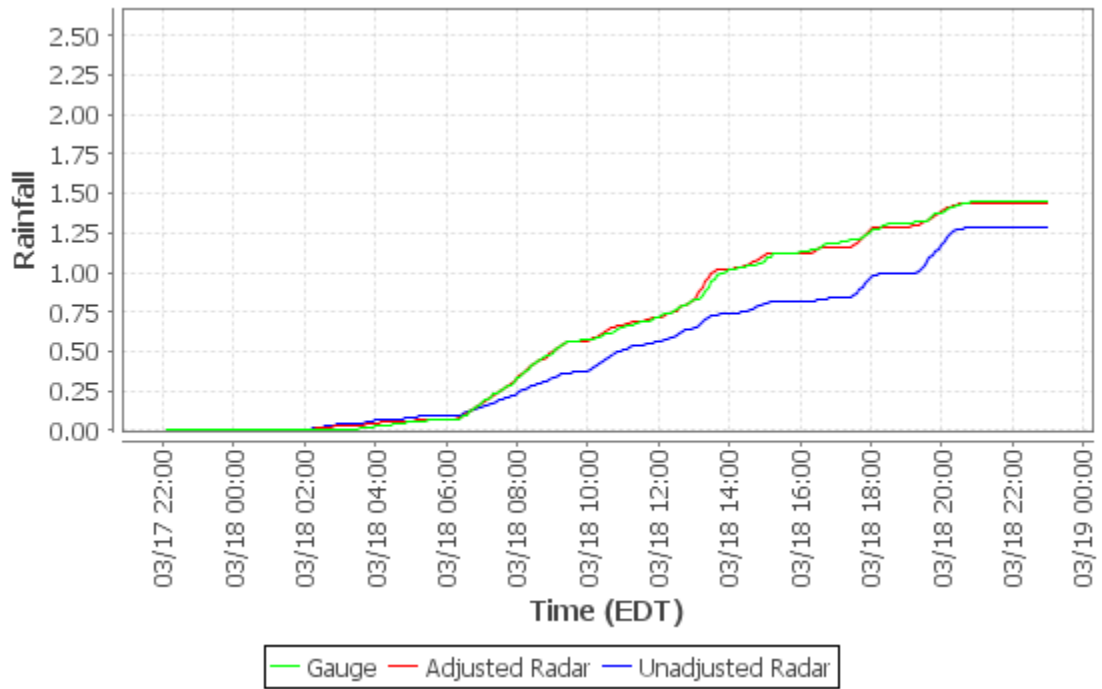
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



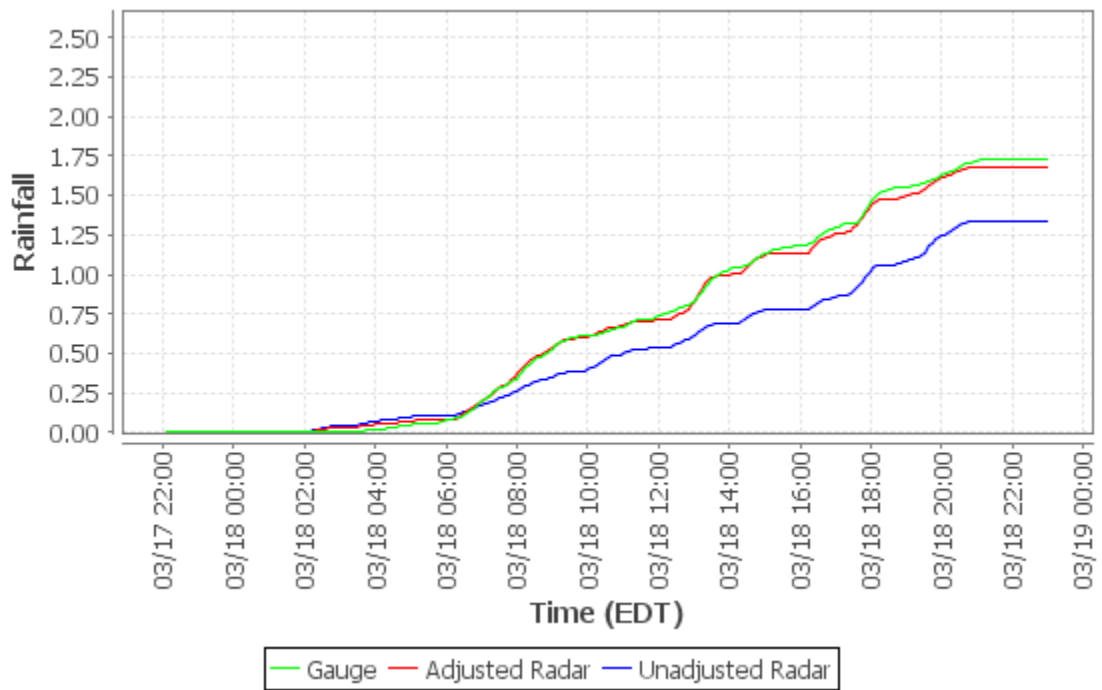
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



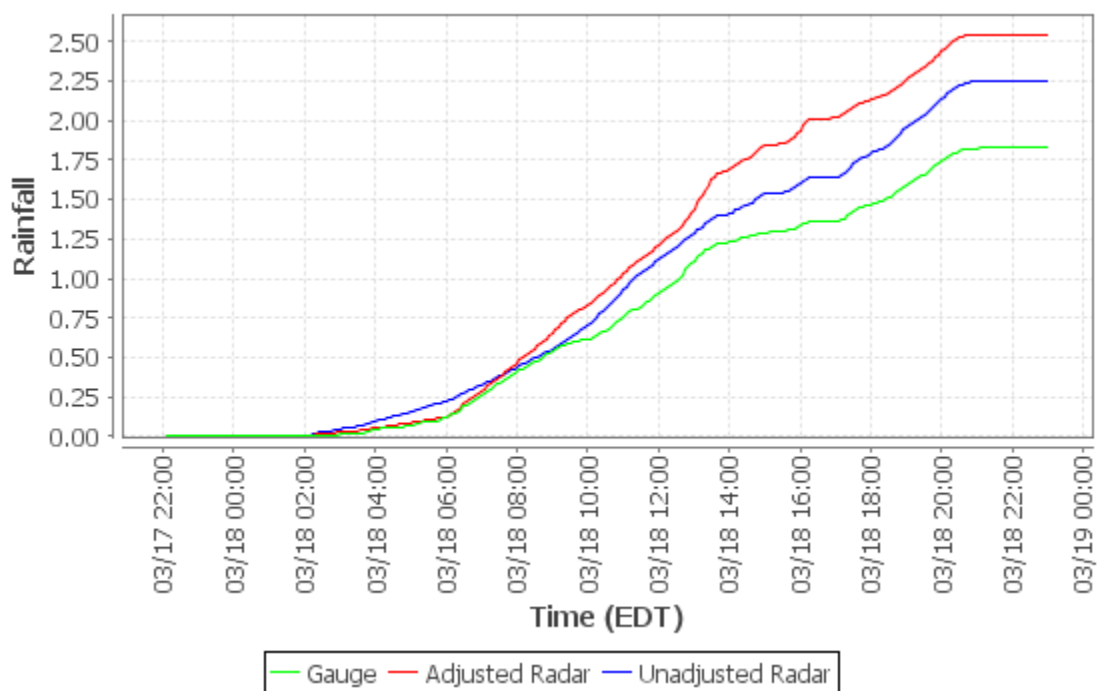
**Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)**



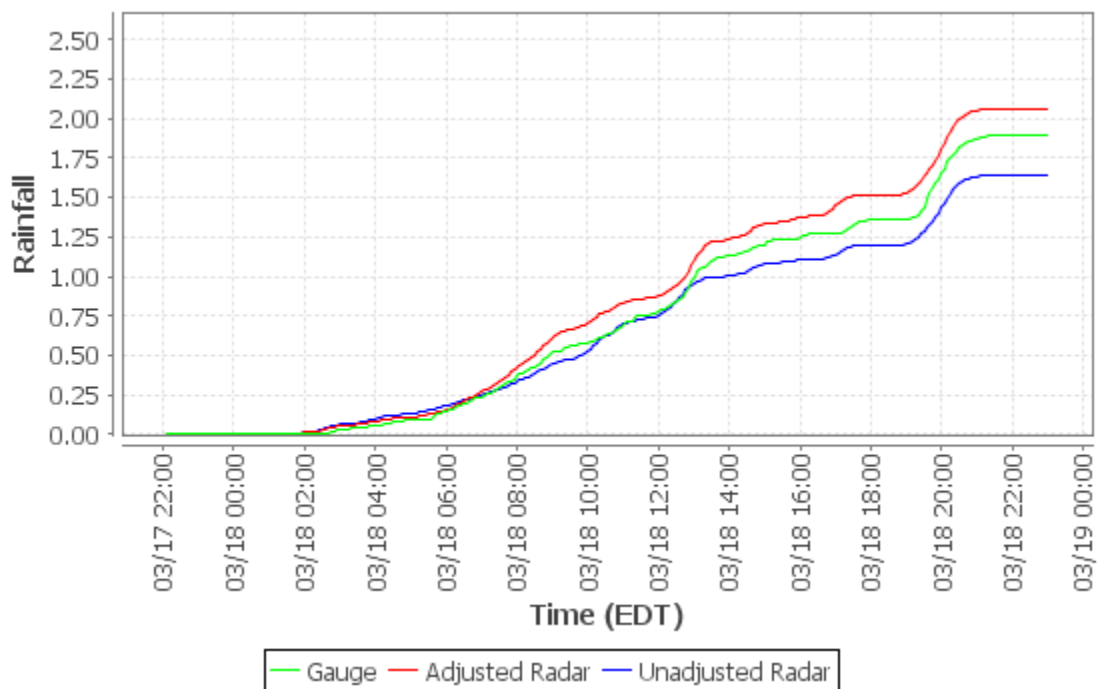
**Cumulative Distribution Plot - Gascola Eq Facility (Loc20)**



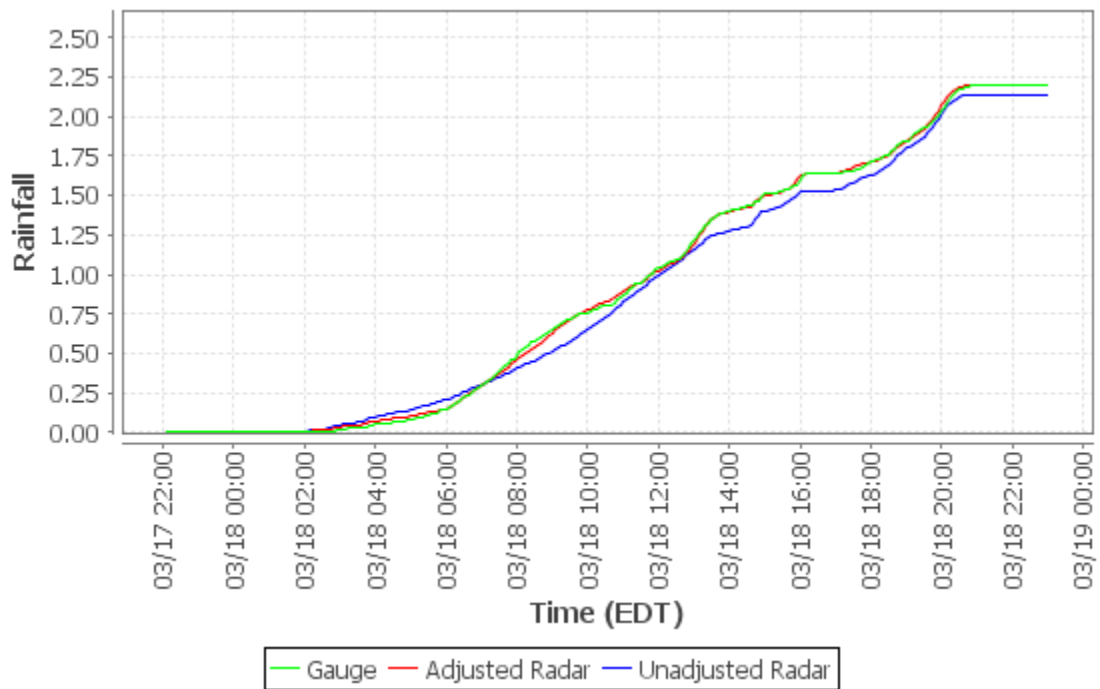
**Cumulative Distribution Plot - Moon TWP (Loc21)**



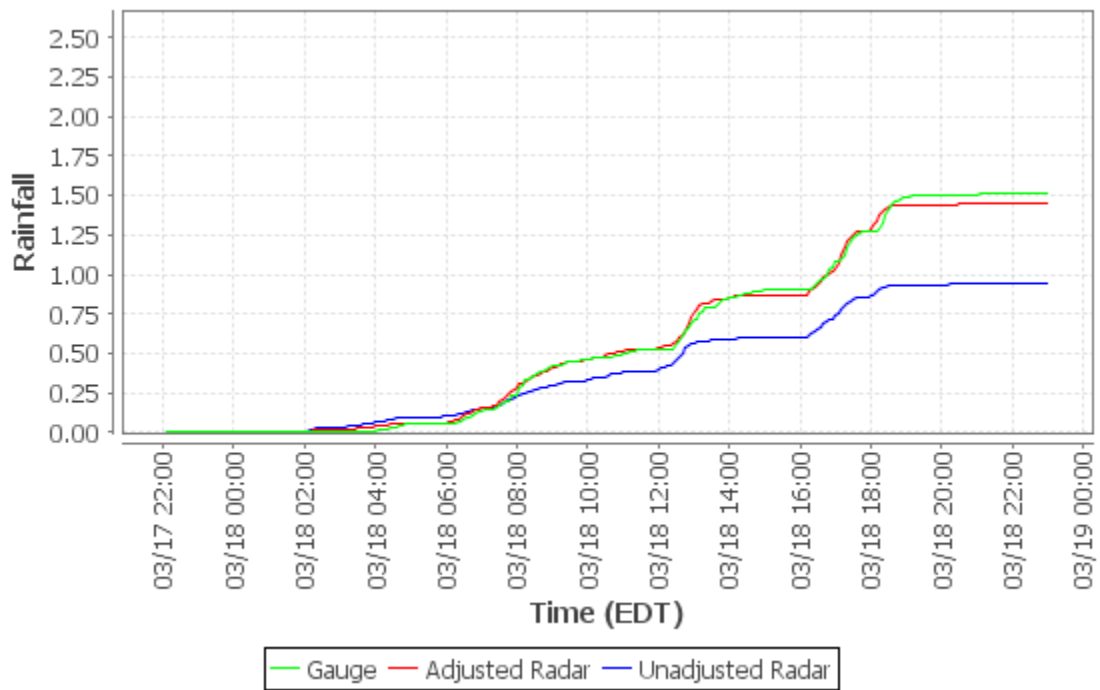
**Cumulative Distribution Plot - North Fayette TWP (Loc22)**



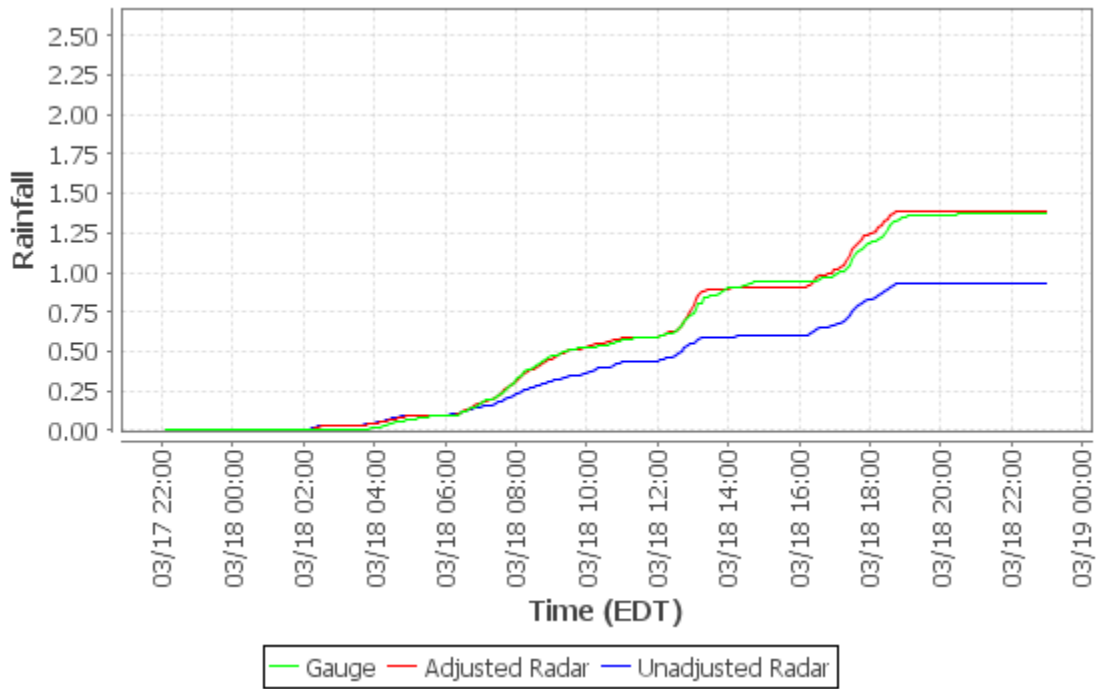
**Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)**



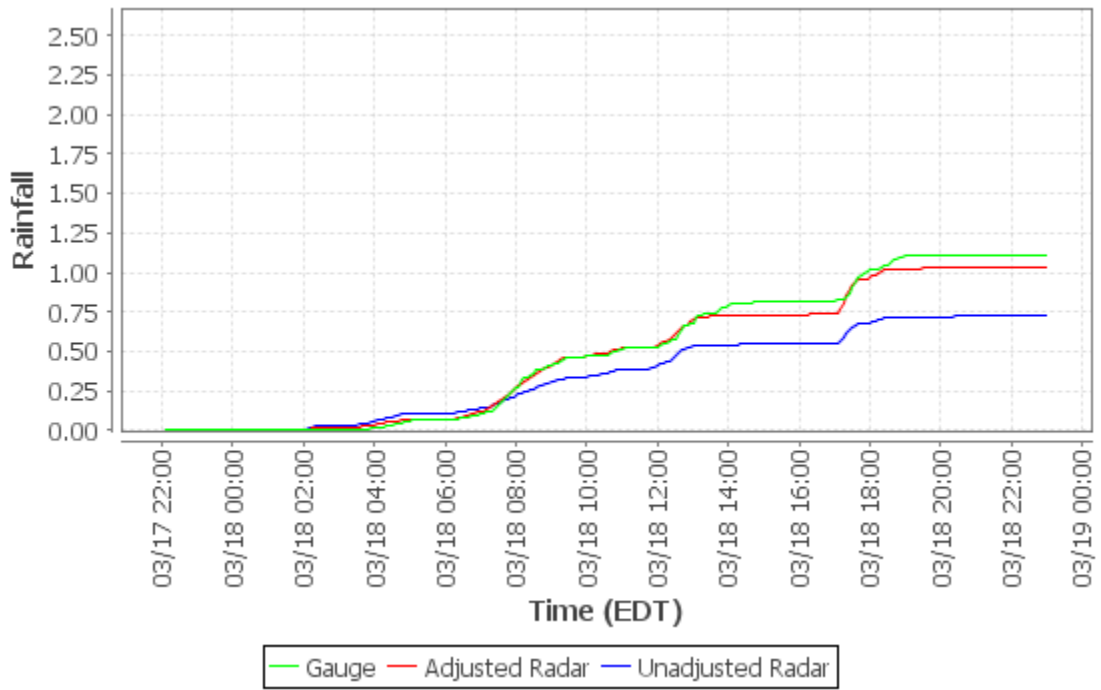
**Cumulative Distribution Plot - Jefferson Hills (Loc24)**



**Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)**

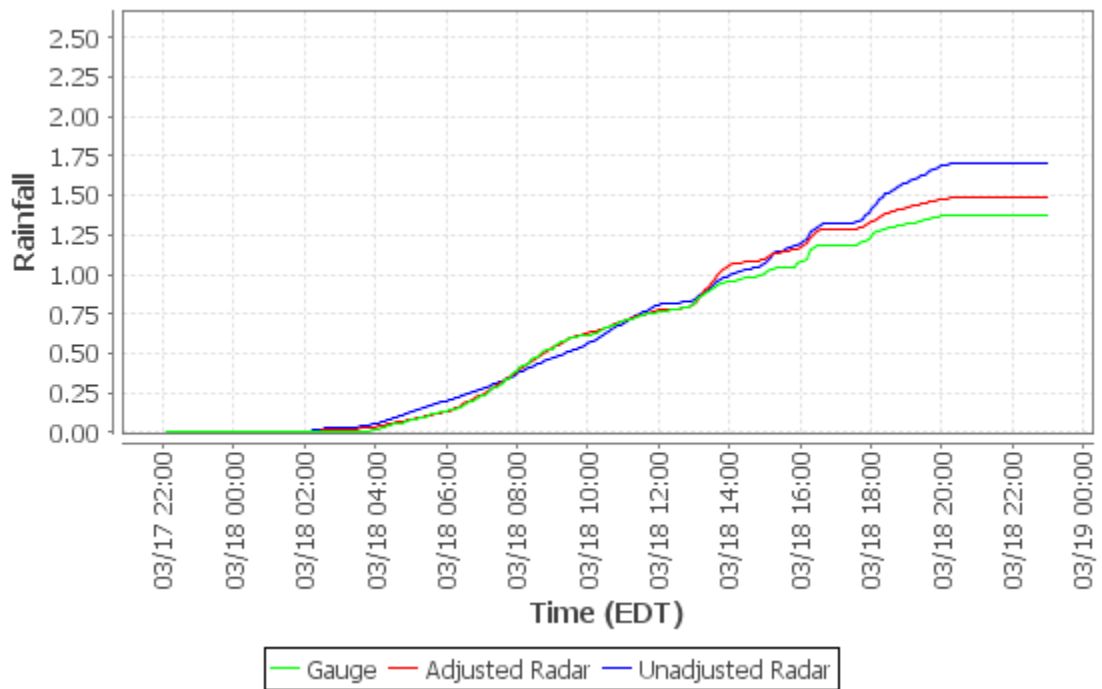


**Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)**

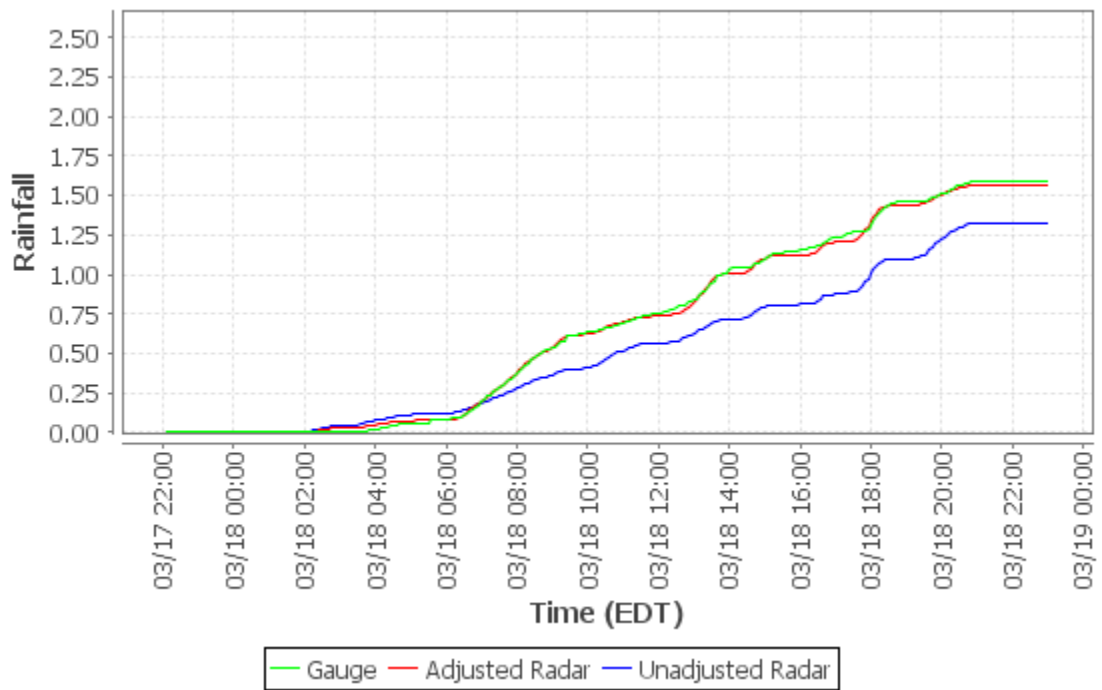




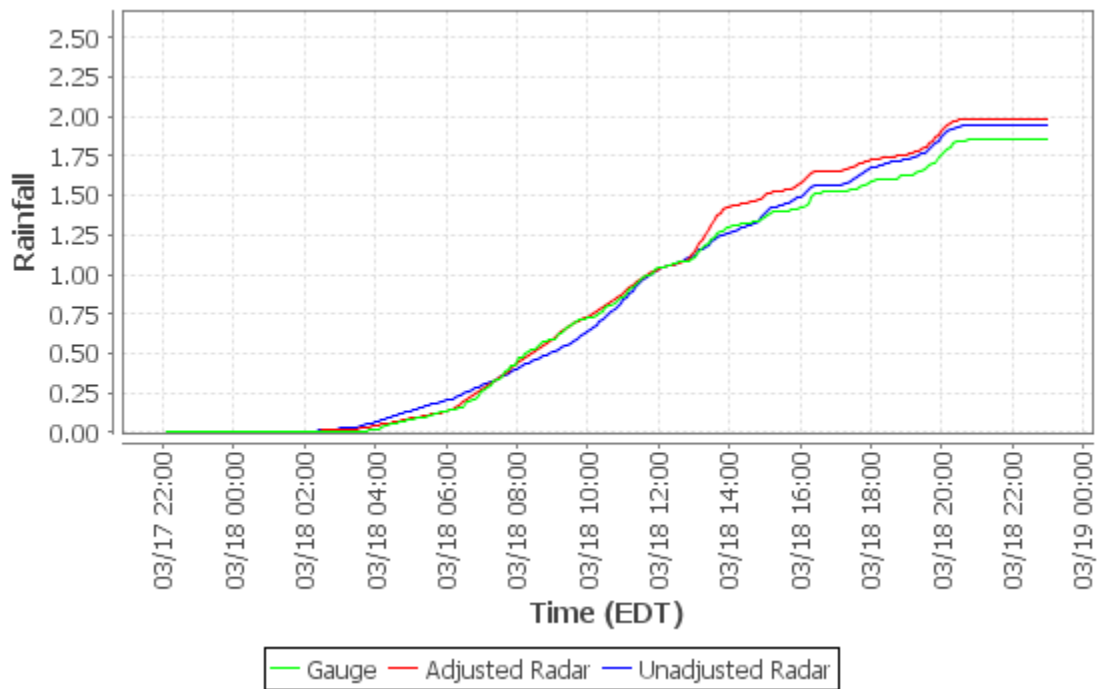
**Cumulative Distribution Plot - Marshall TWP (Loc27)**



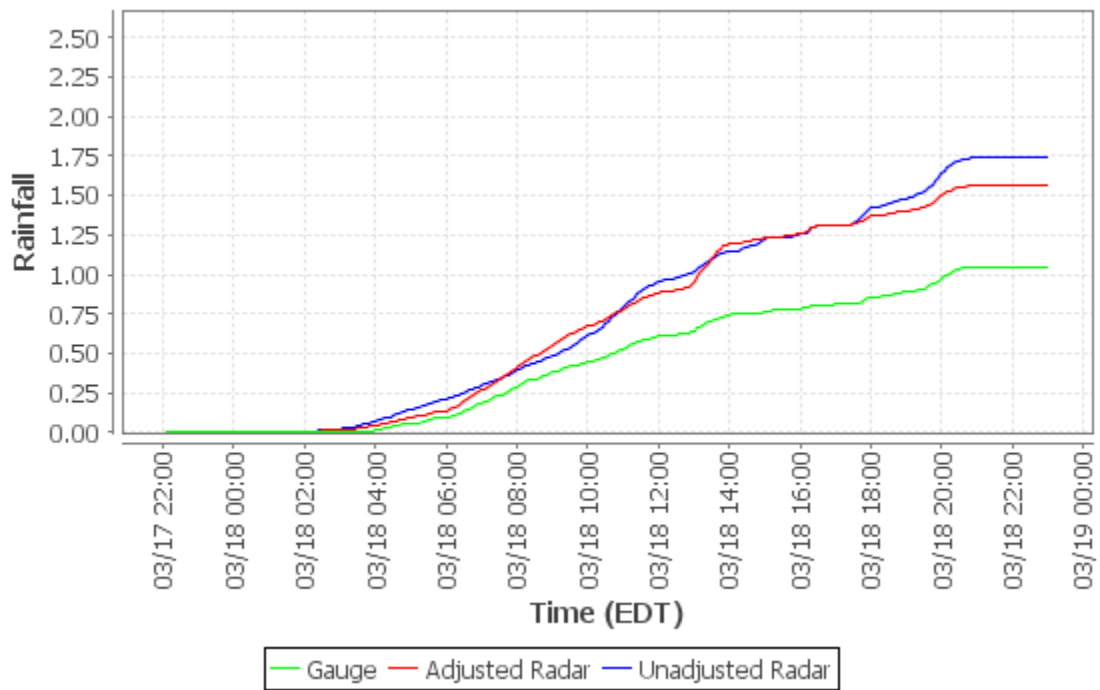
**Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)**



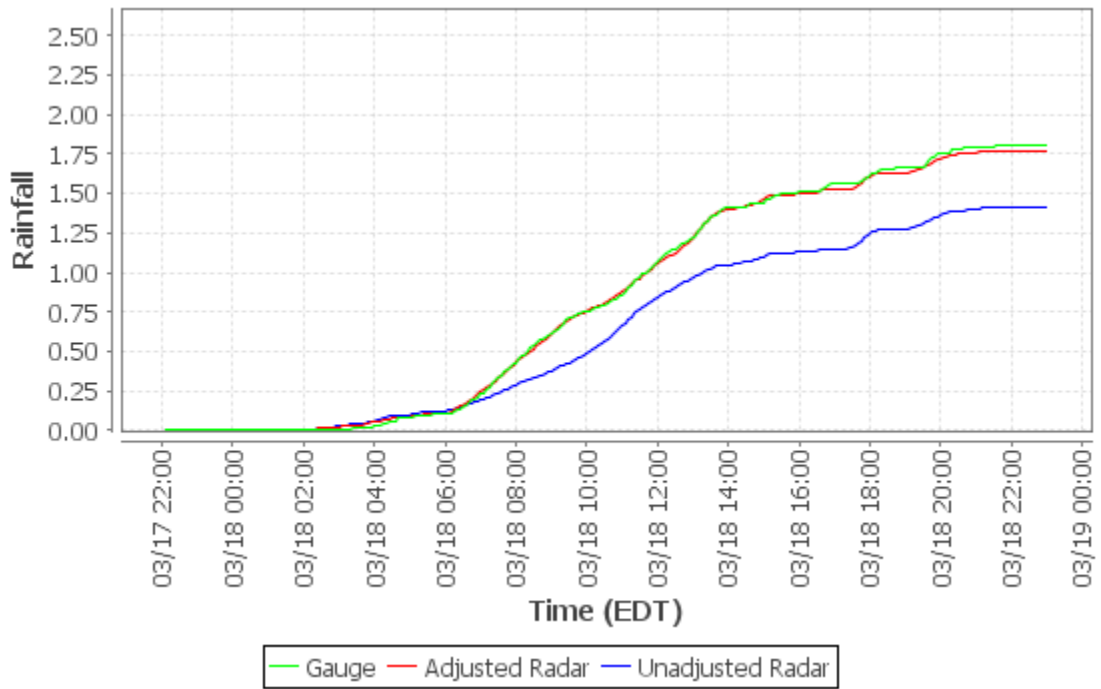
**Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)**



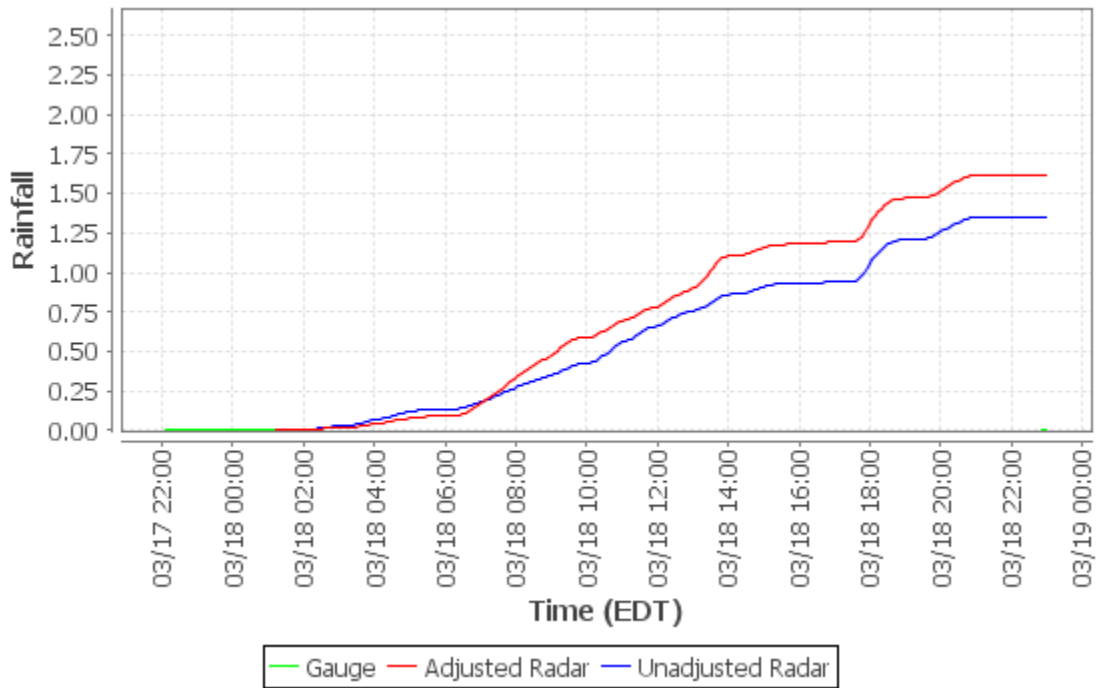
**Cumulative Distribution Plot - McCandless Twn Hall (Loc30)**



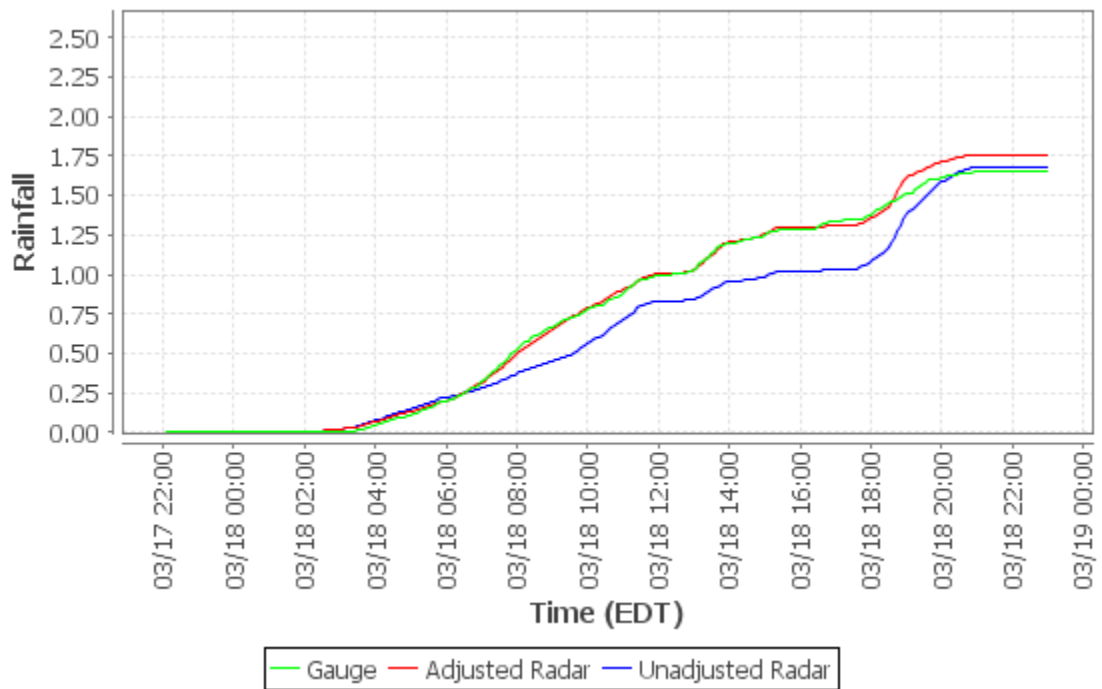
**Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)**



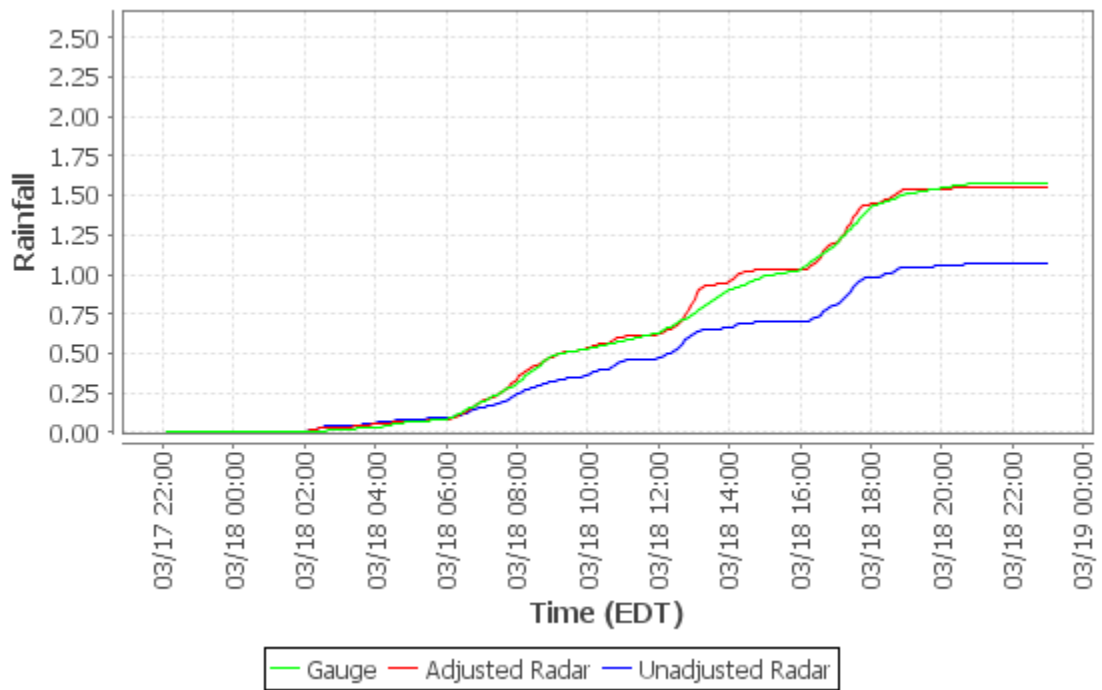
**Cumulative Distribution Plot - Arnold (Loc32)**



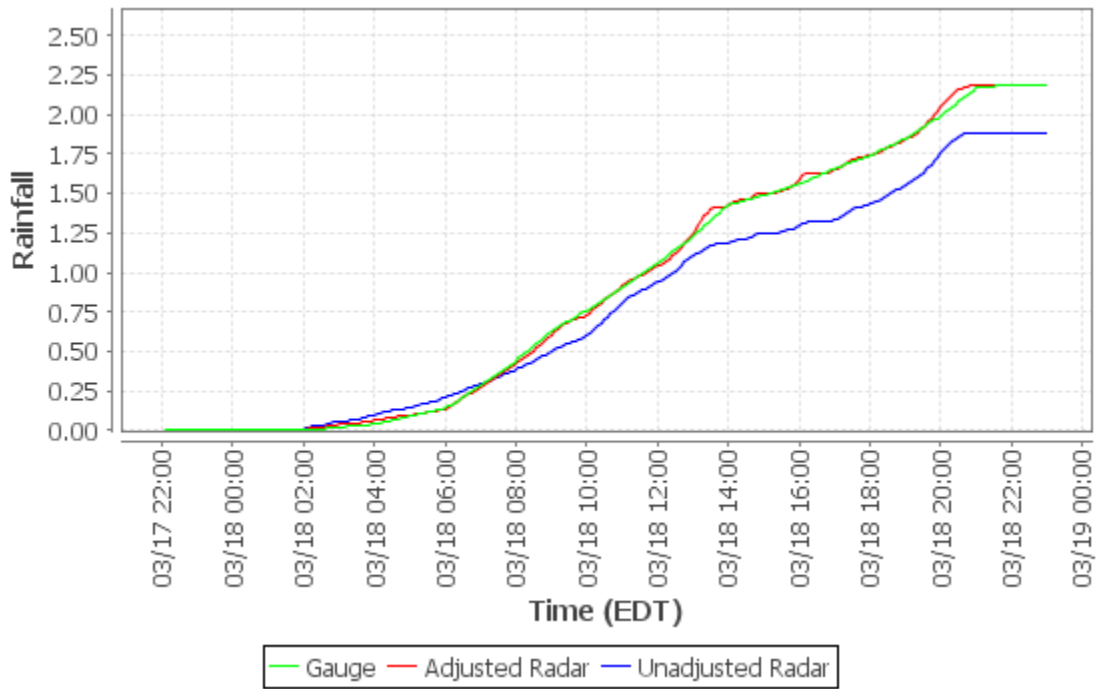
**Cumulative Distribution Plot - Richland TWP (Loc33)**



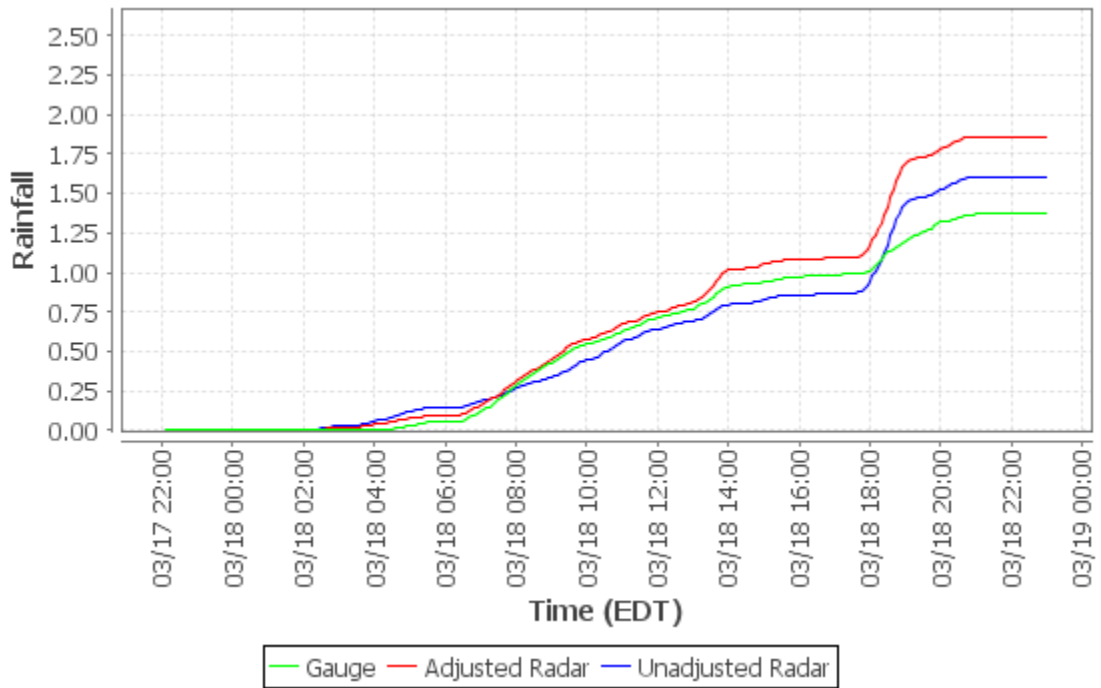
**Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)**



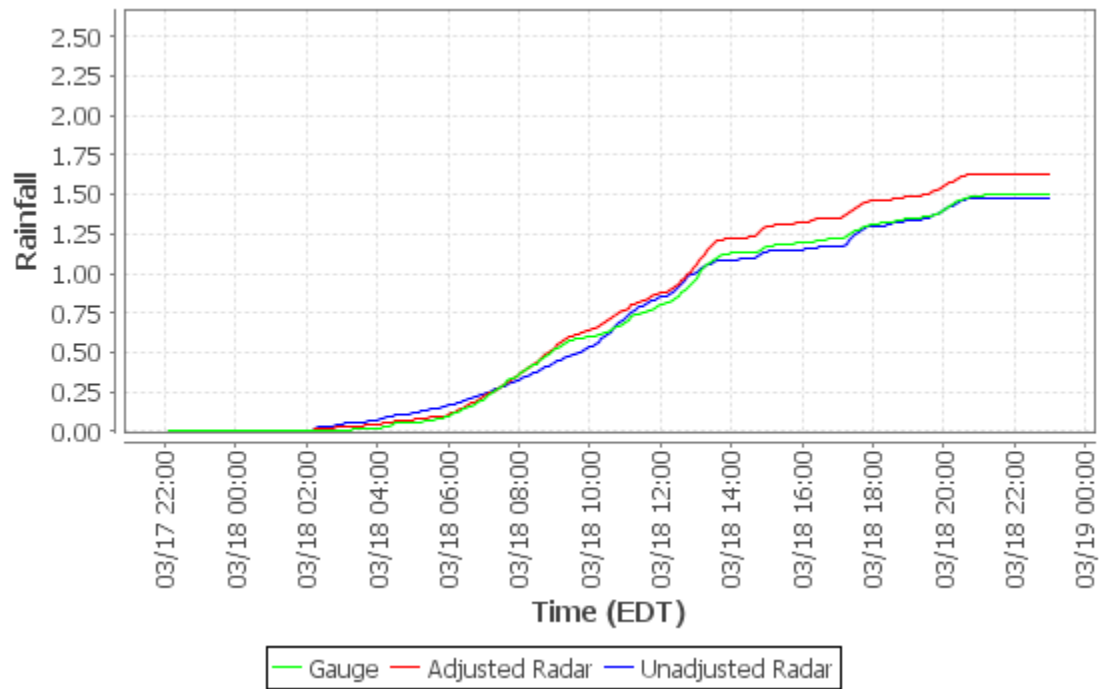
**Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)**



**Cumulative Distribution Plot - Allegheny River at Natrona (03049500)**

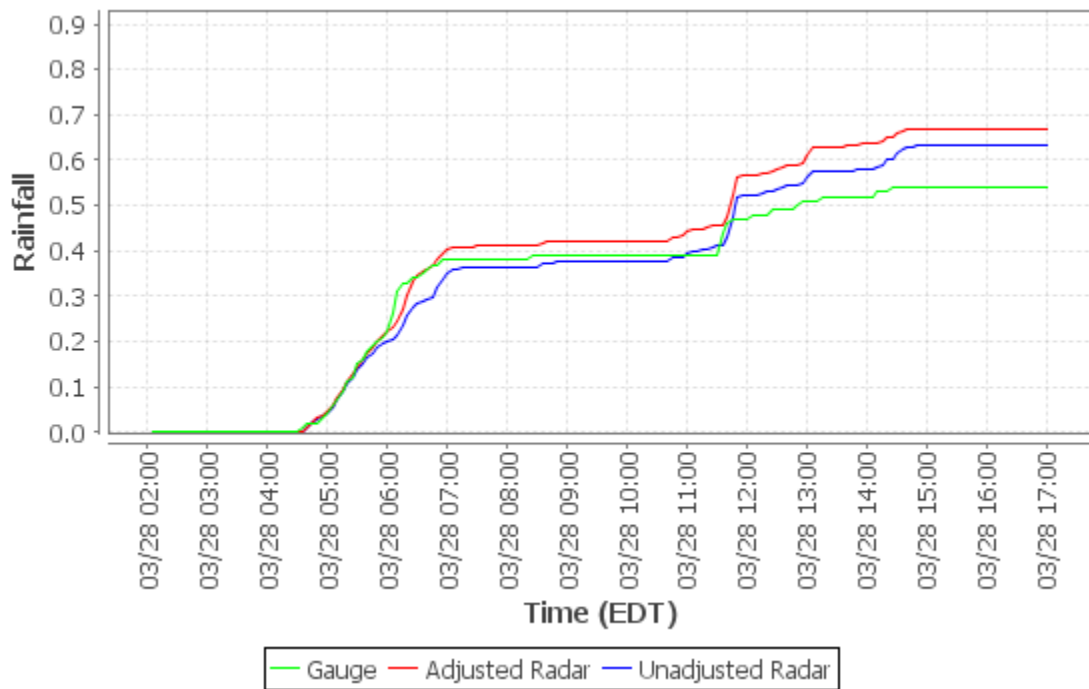


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth  
(03085734)**

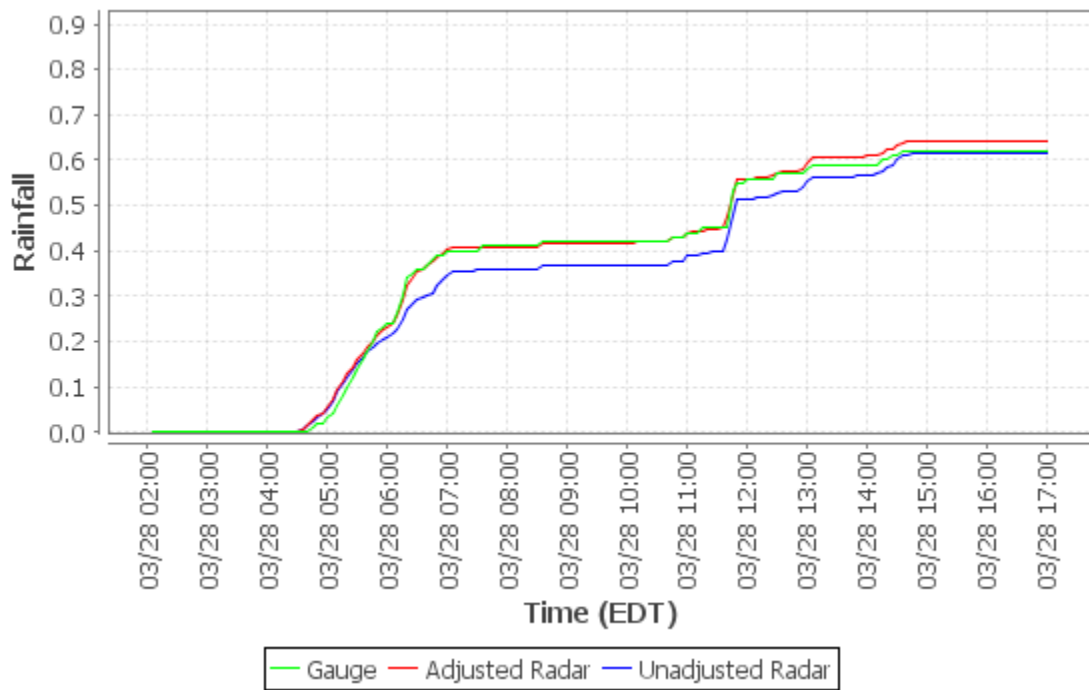


## **Appendix E - Event 3 (2021-03-28) CDPs**

**Cumulative Distribution Plot - PWSA-Montana St. (Loc01)**

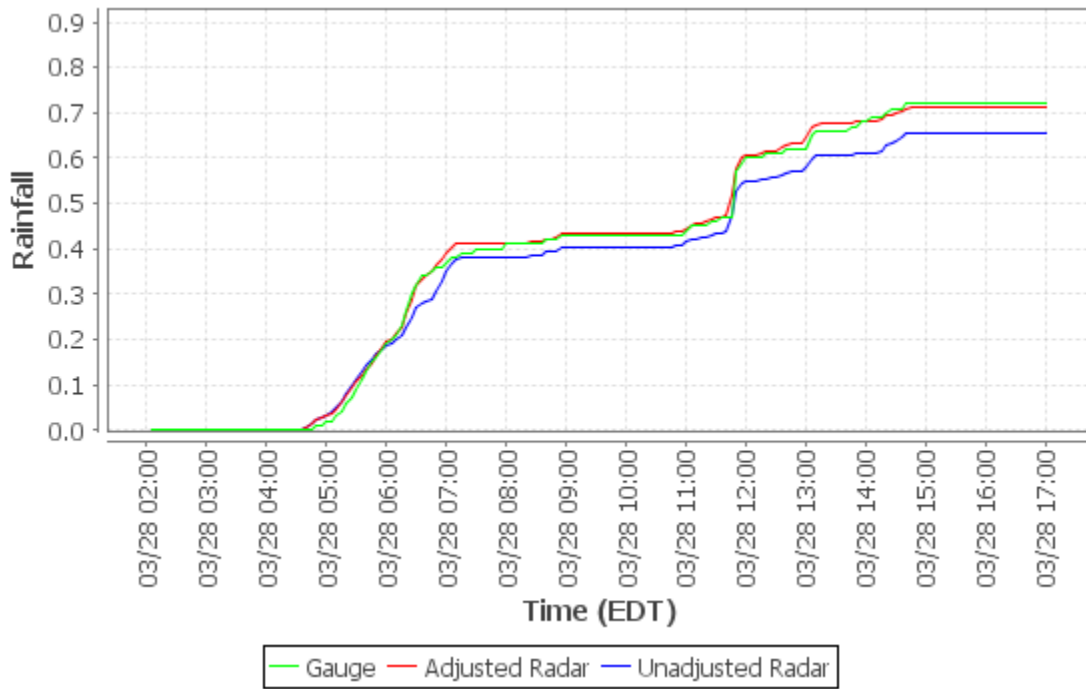


**Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)**

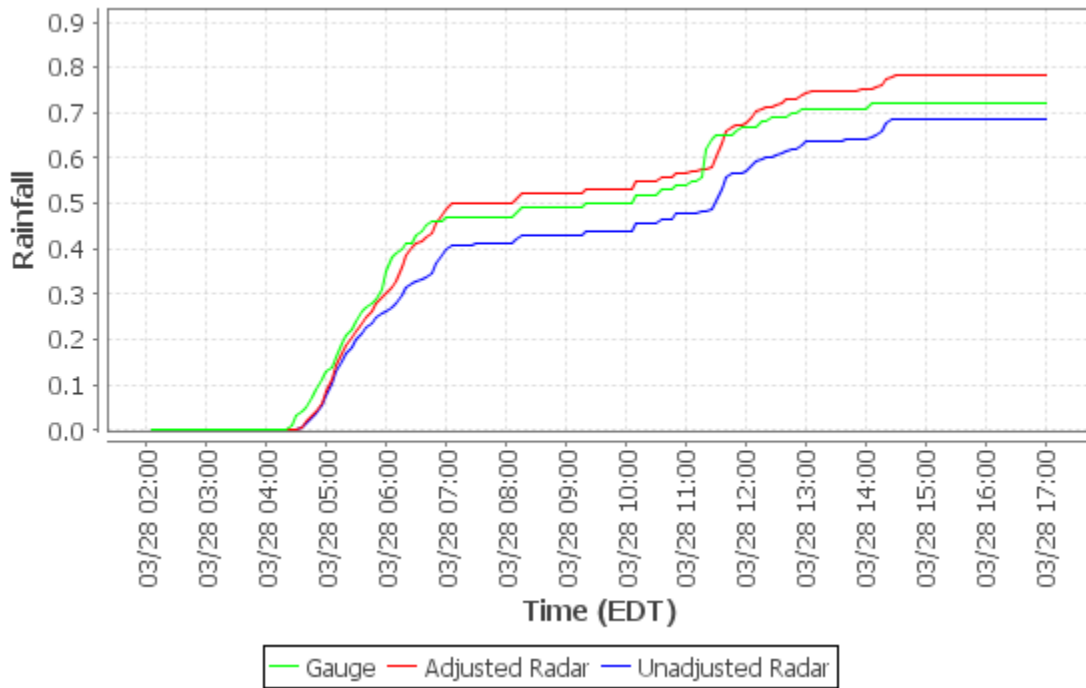




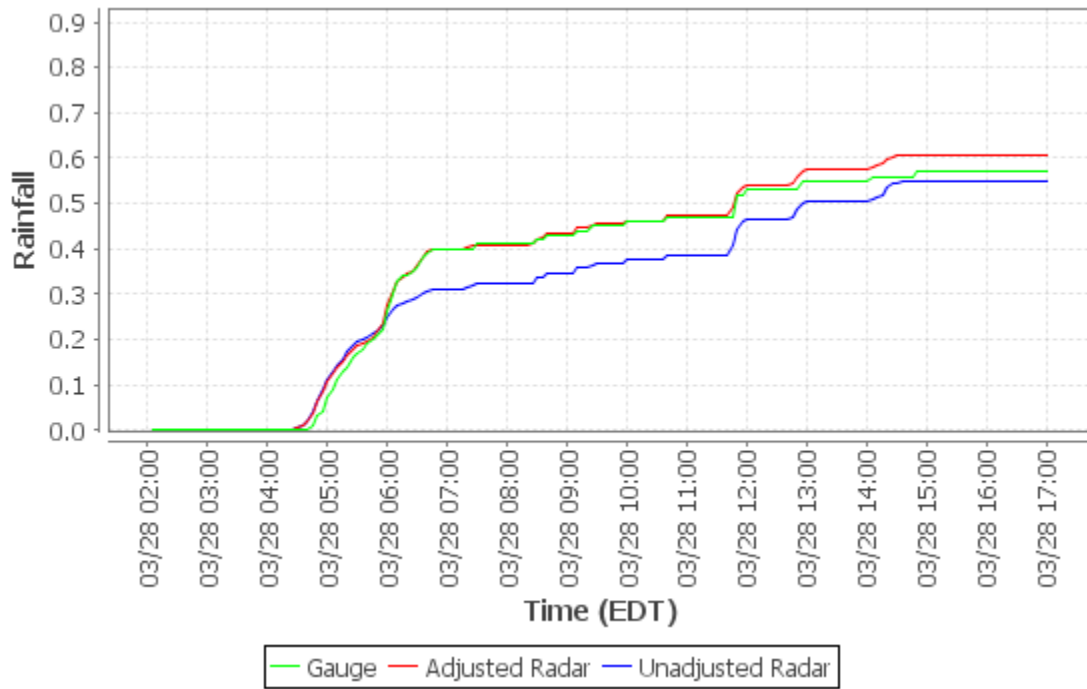
**Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)**



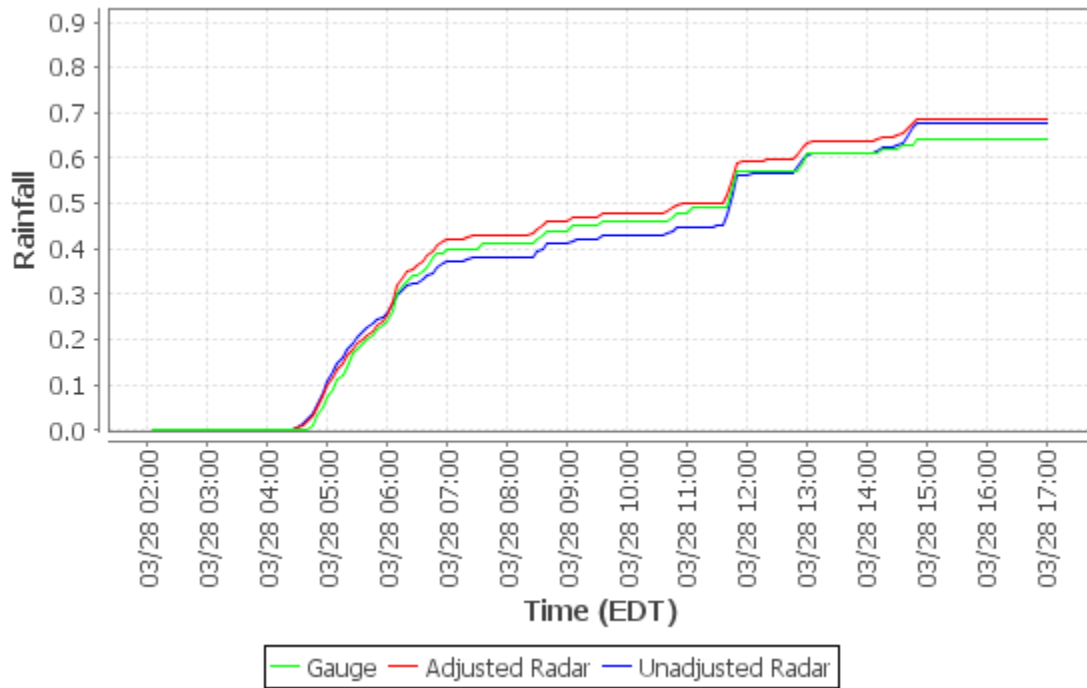
**Cumulative Distribution Plot - Kennedy Twp PS (Loc04)**



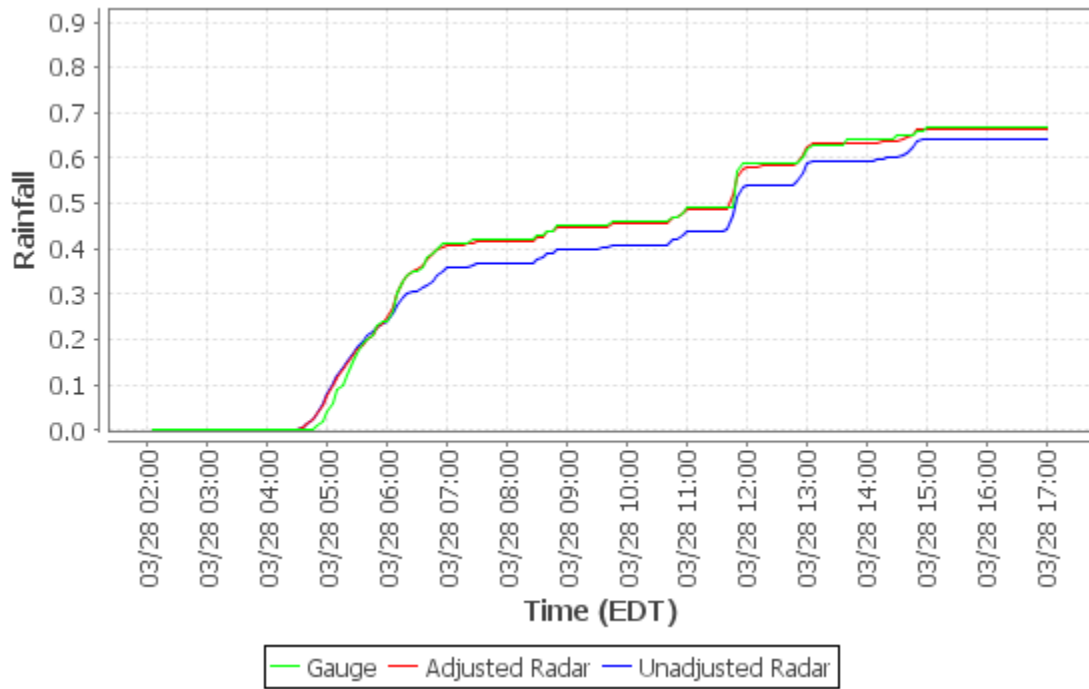
**Cumulative Distribution Plot - Upper St. Clair (Loc05)**



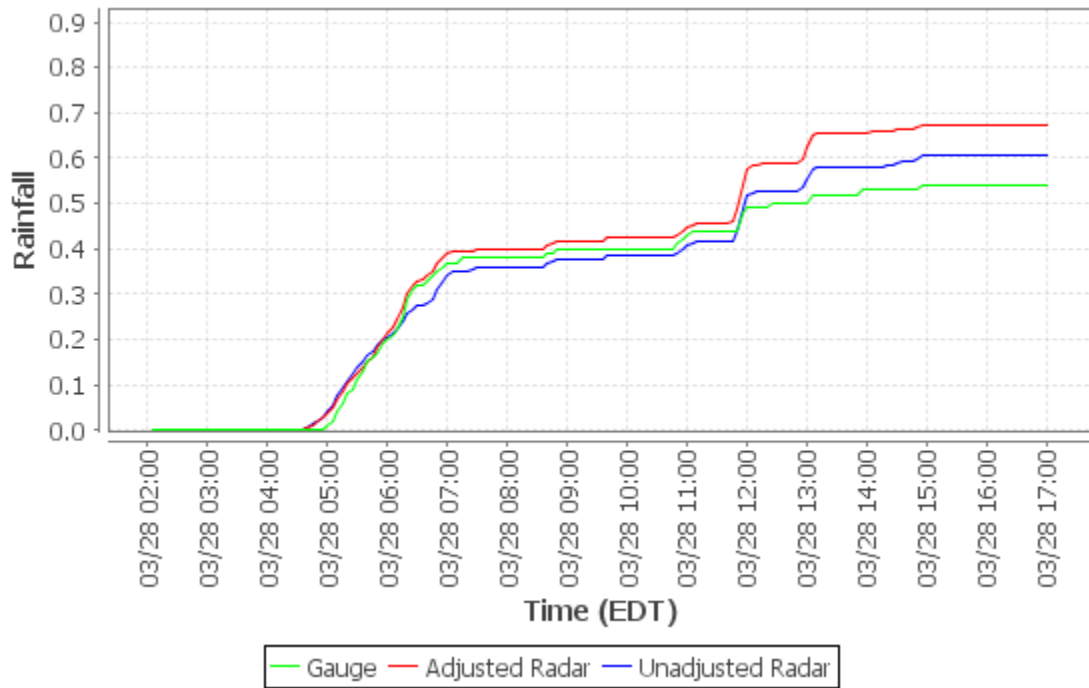
**Cumulative Distribution Plot - Carnegie Transit Time (Loc06)**



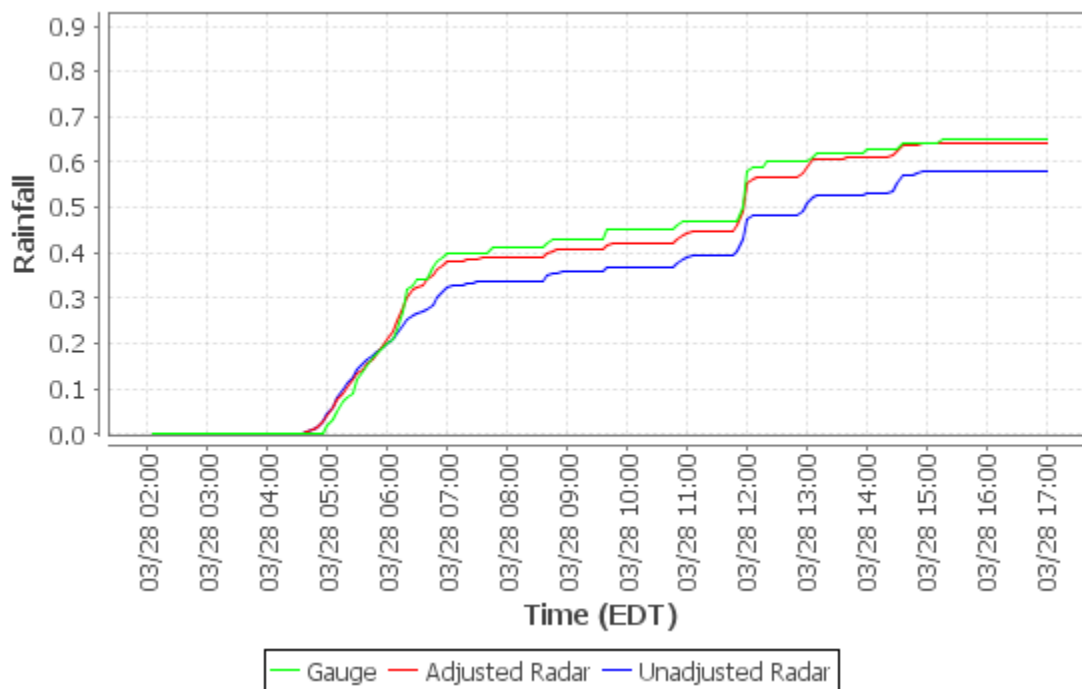
**Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)**



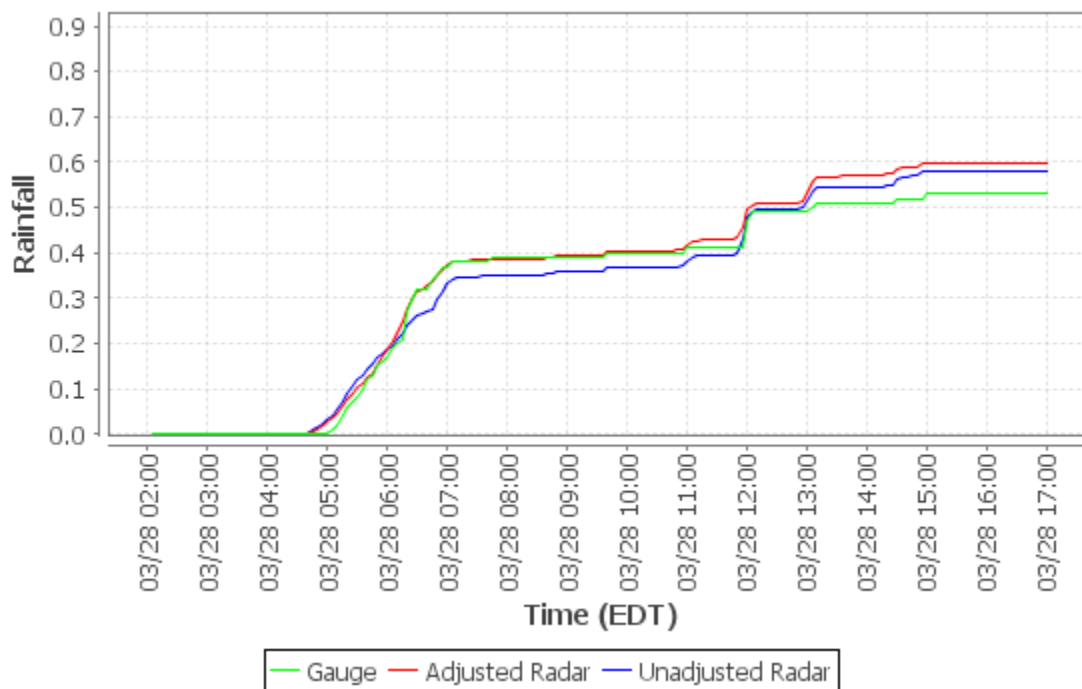
**Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)**



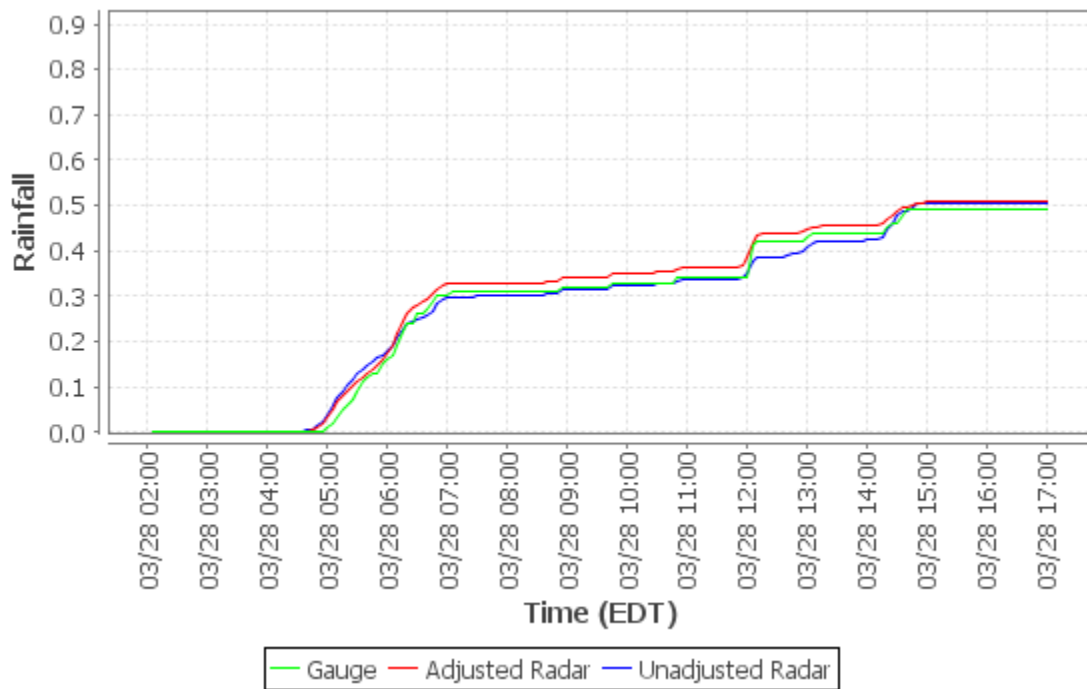
**Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)**



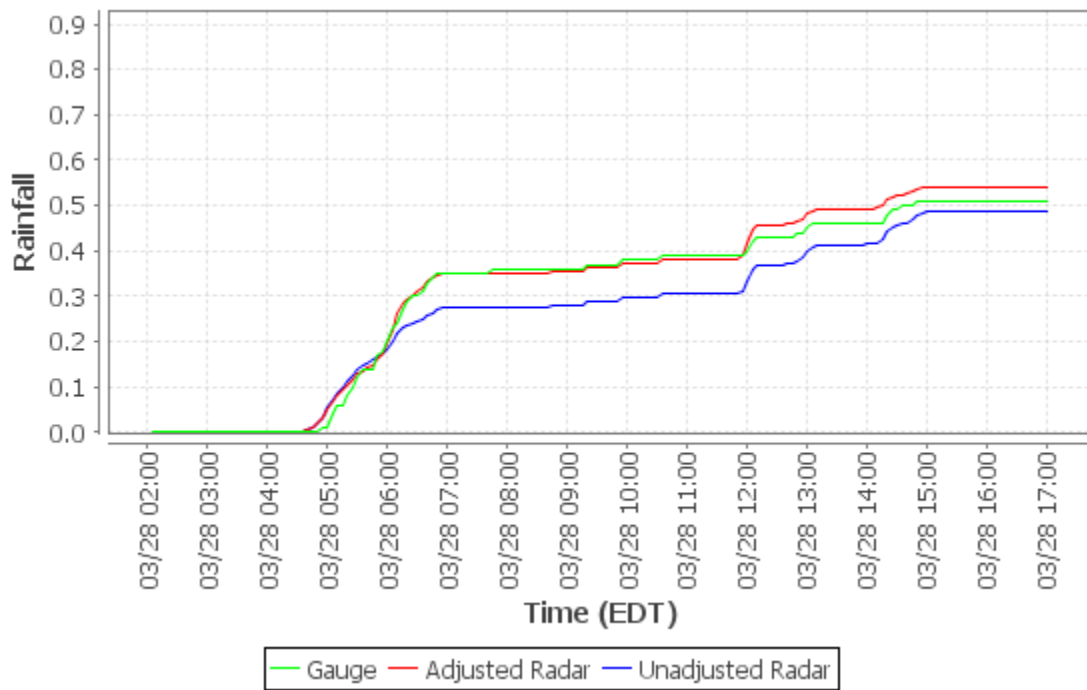
**Cumulative Distribution Plot - PWSA-Highland Park (Loc10)**



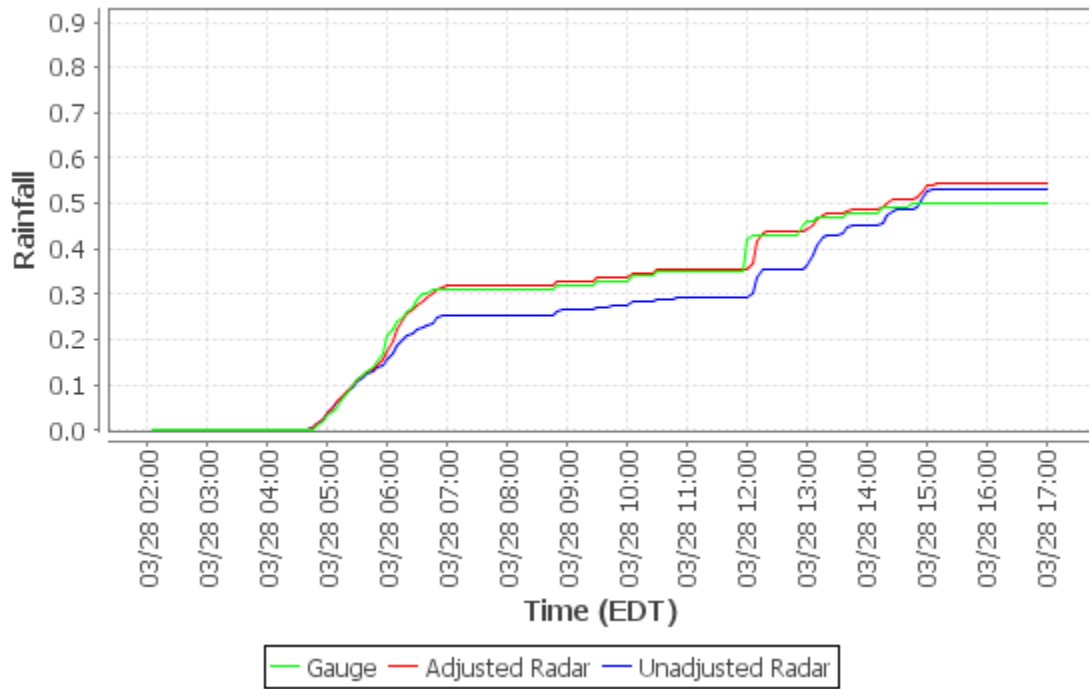
**Cumulative Distribution Plot - M-46 Access Shaft (Loc11)**



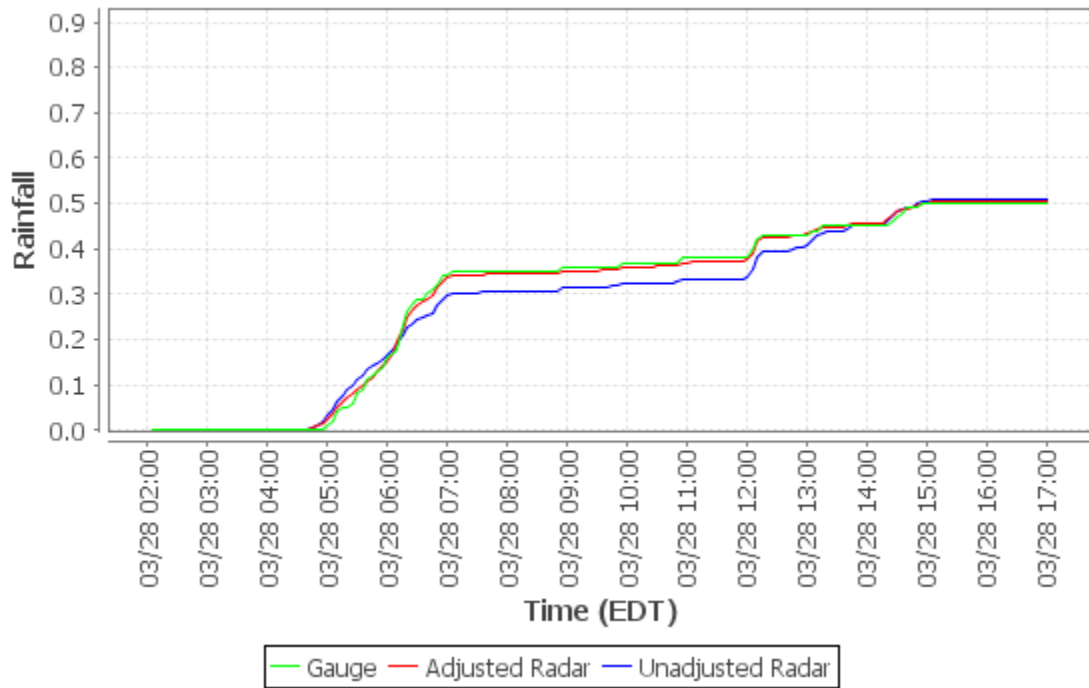
**Cumulative Distribution Plot - Baldwin (Loc12)**



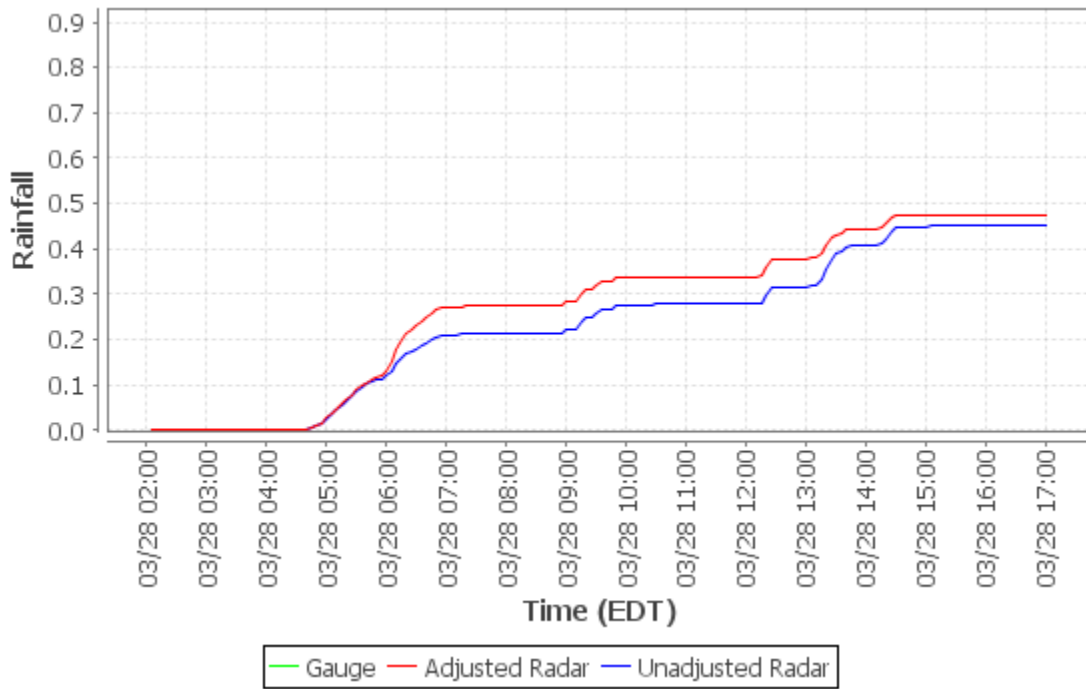
**Cumulative Distribution Plot - M-59 Access Shaft (Loc13)**



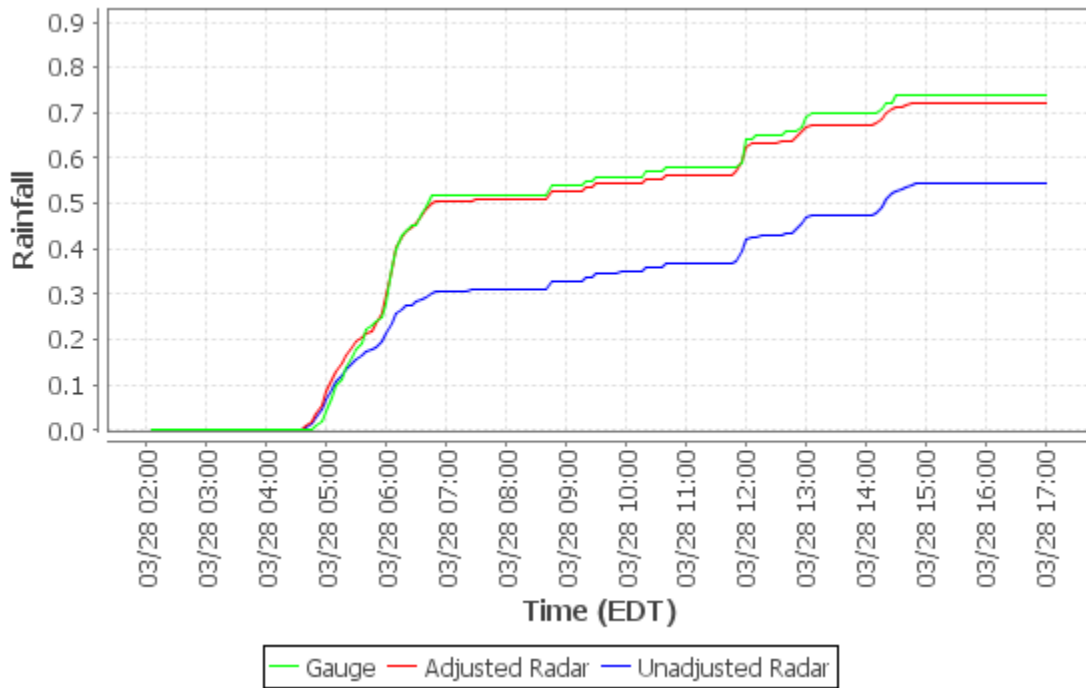
**Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)**



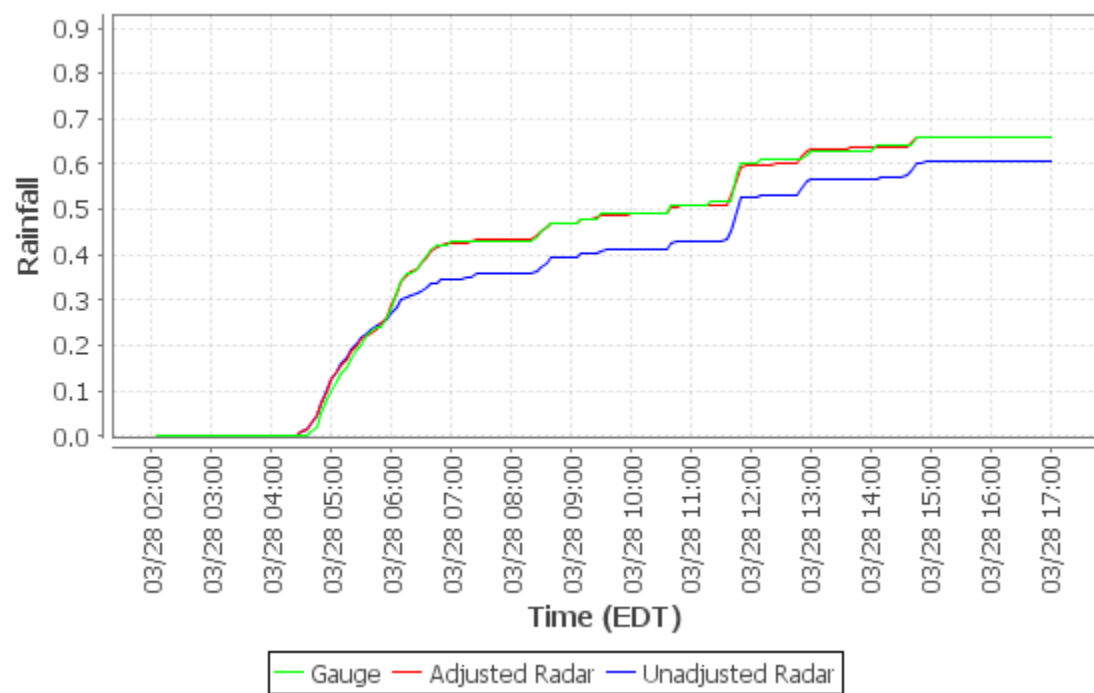
**Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)**



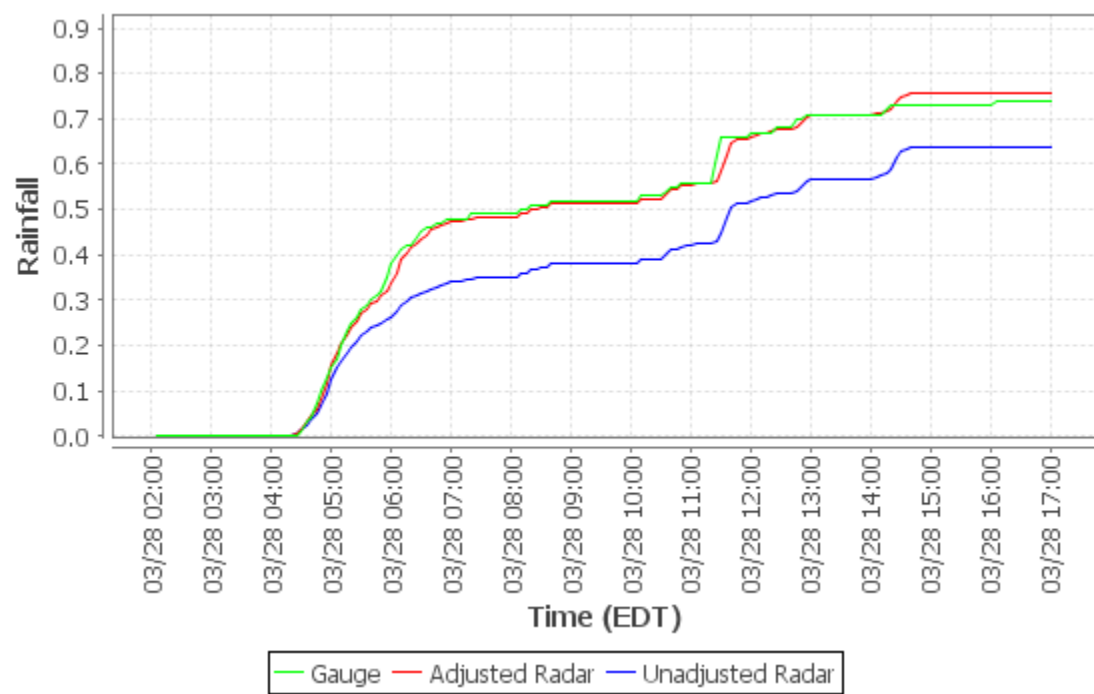
**Cumulative Distribution Plot - Castle Shannon (Loc16)**



Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

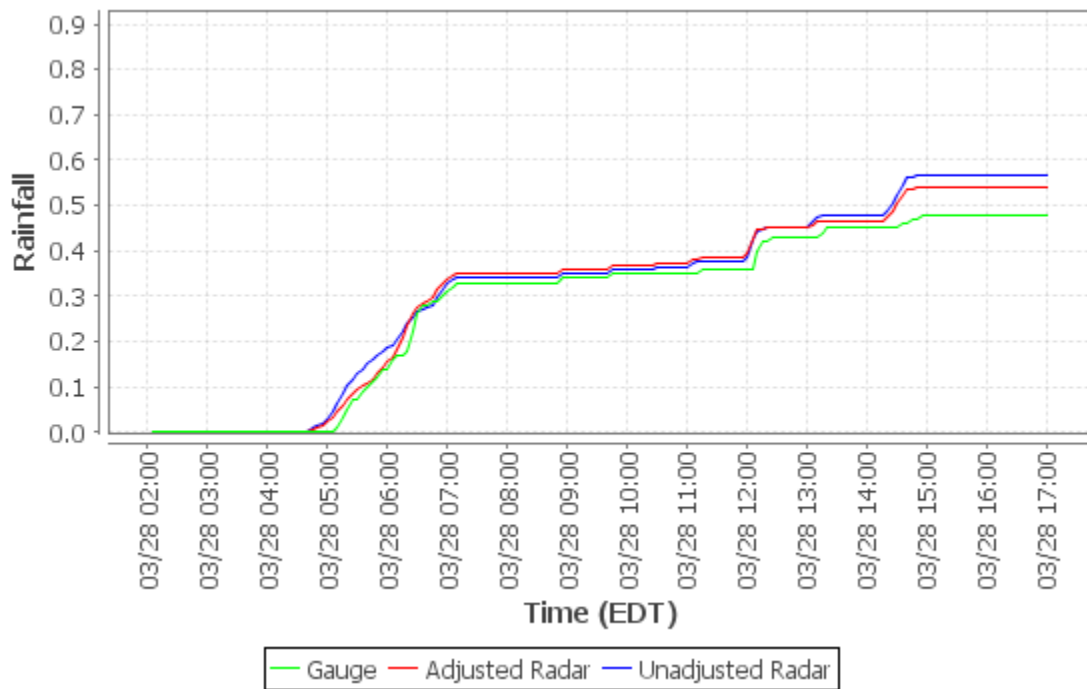


Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

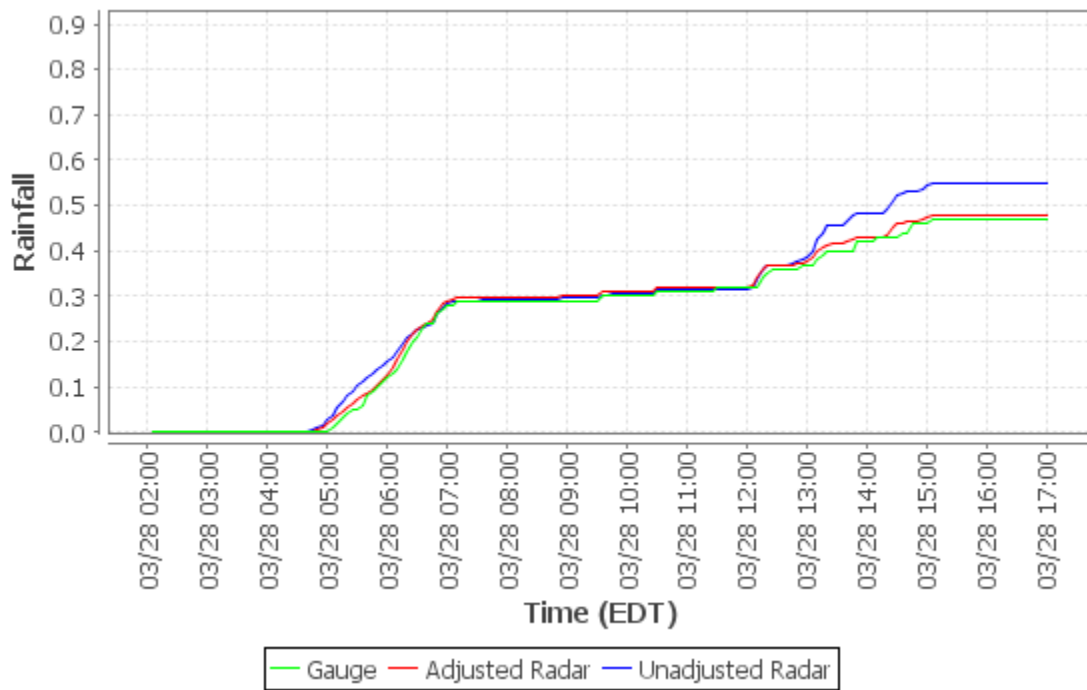




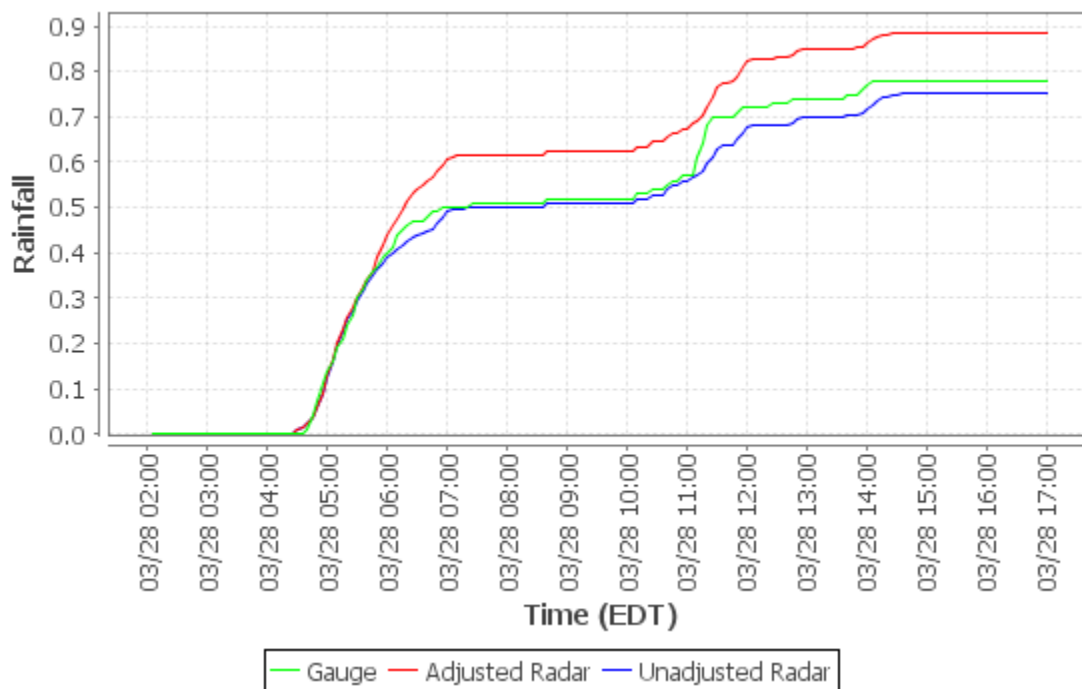
**Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)**



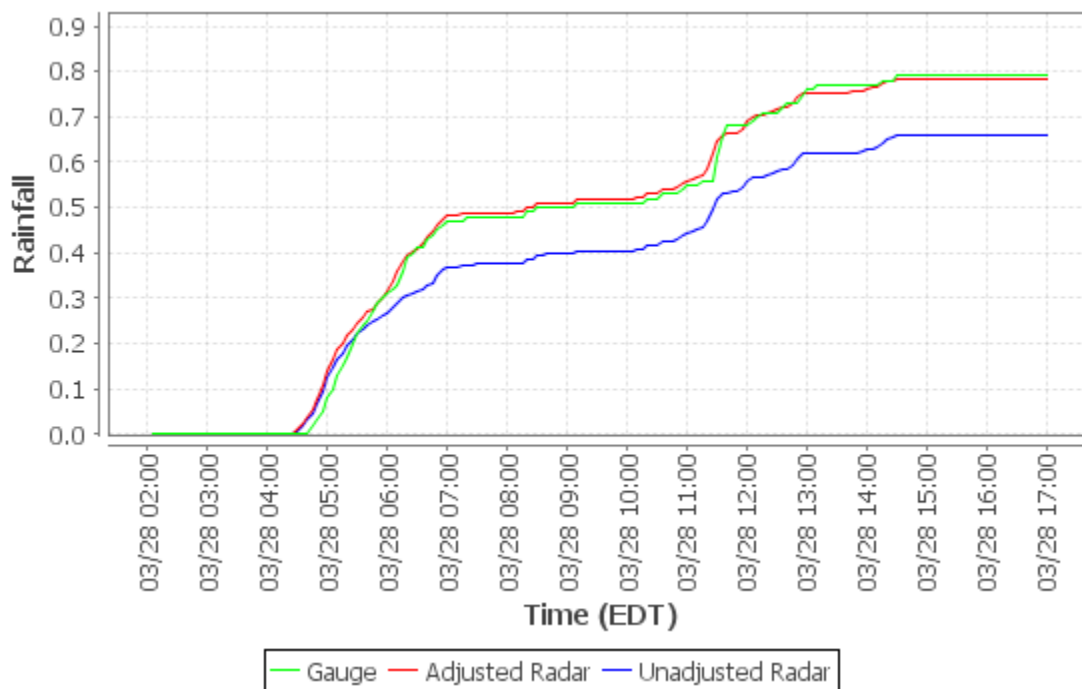
**Cumulative Distribution Plot - Gascola Eq Facility (Loc20)**



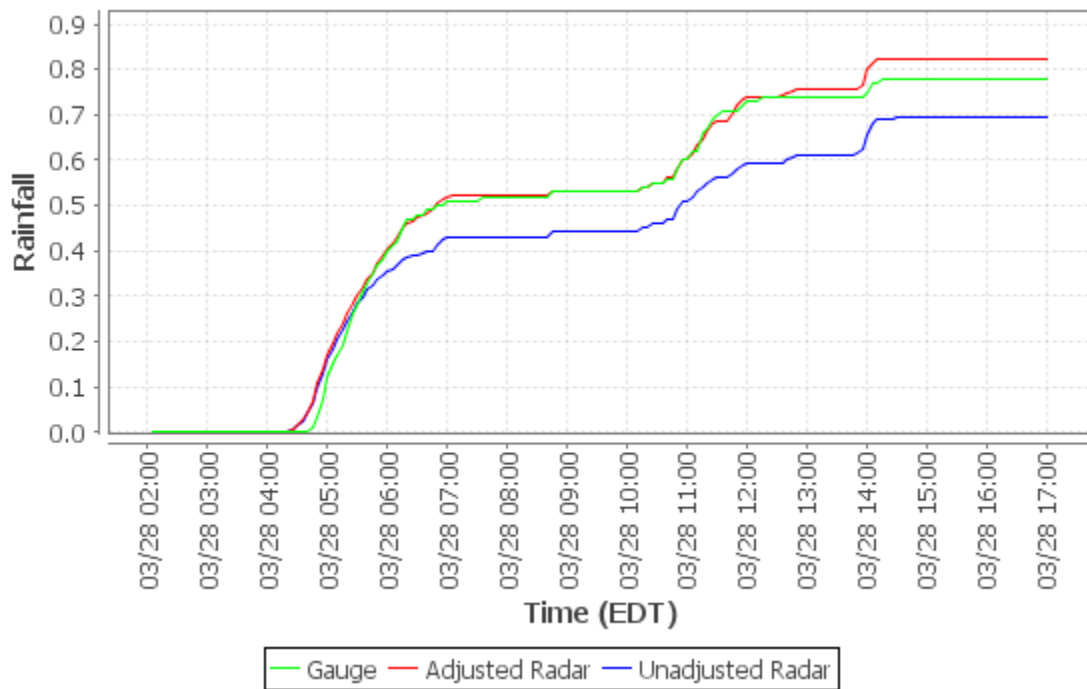
**Cumulative Distribution Plot - Moon TWP (Loc21)**



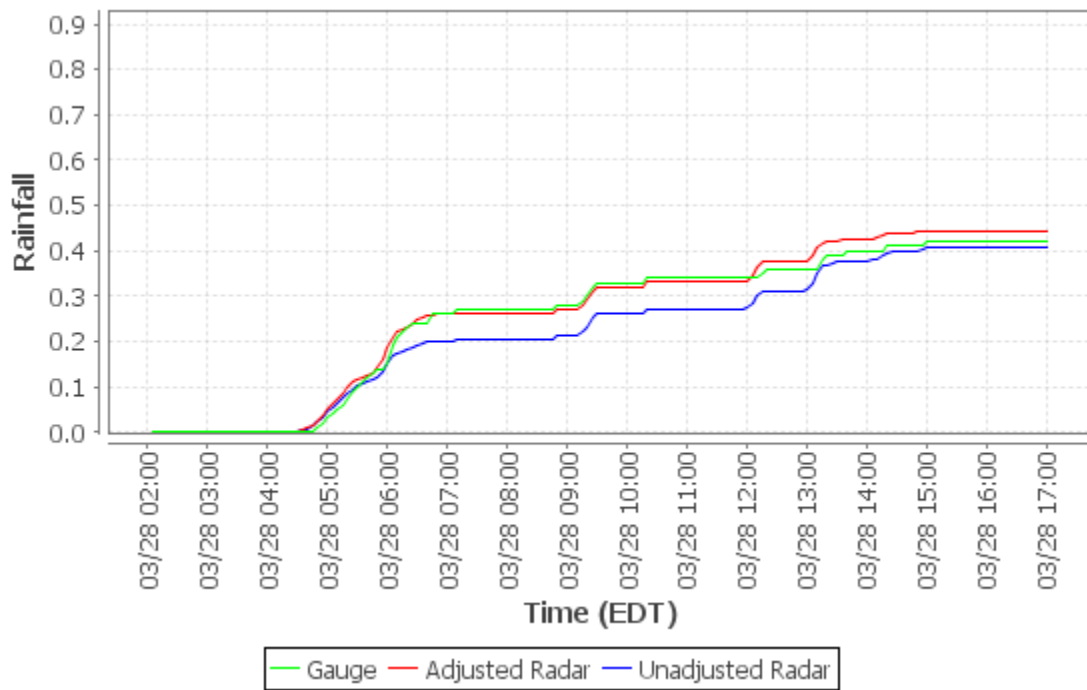
**Cumulative Distribution Plot - North Fayette TWP (Loc22)**



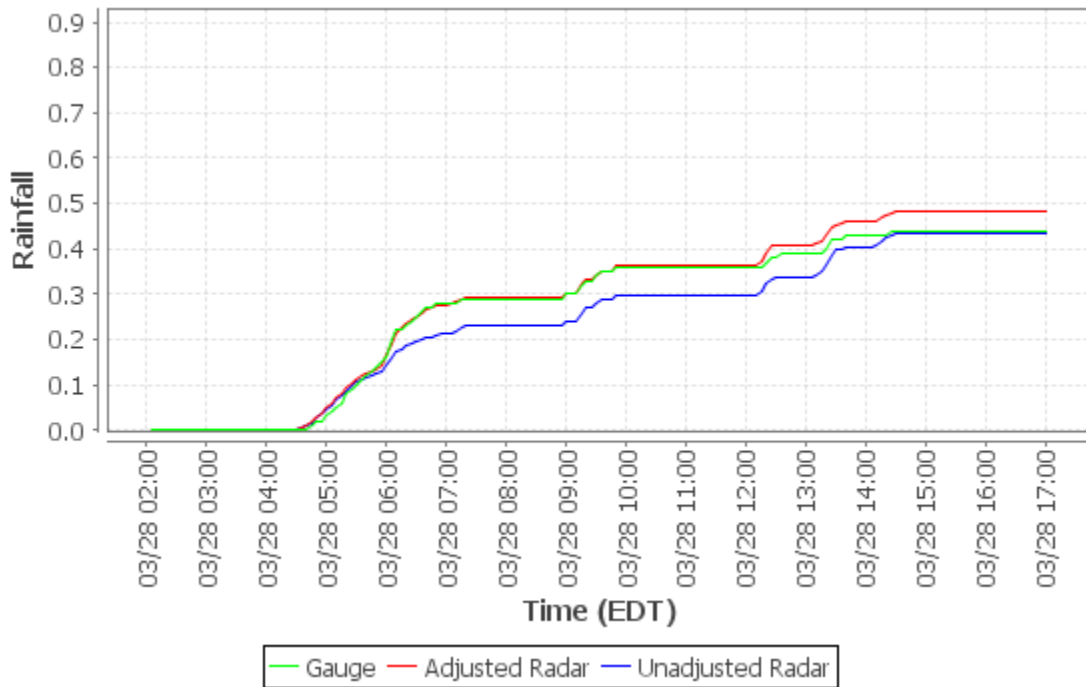
**Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)**



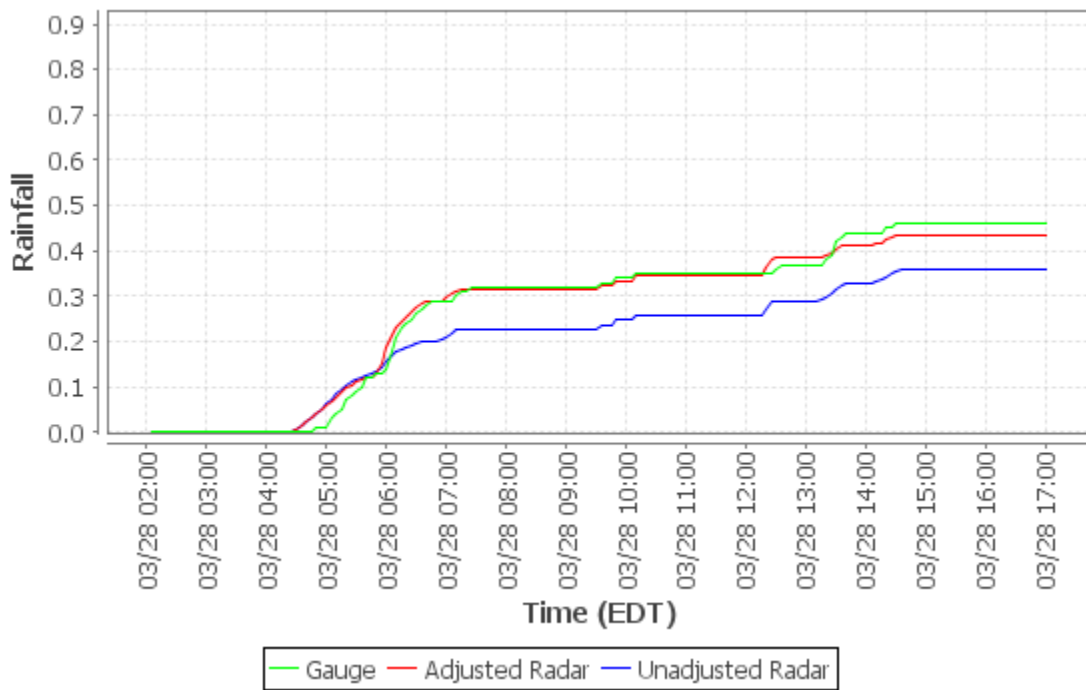
**Cumulative Distribution Plot - Jefferson Hills (Loc24)**



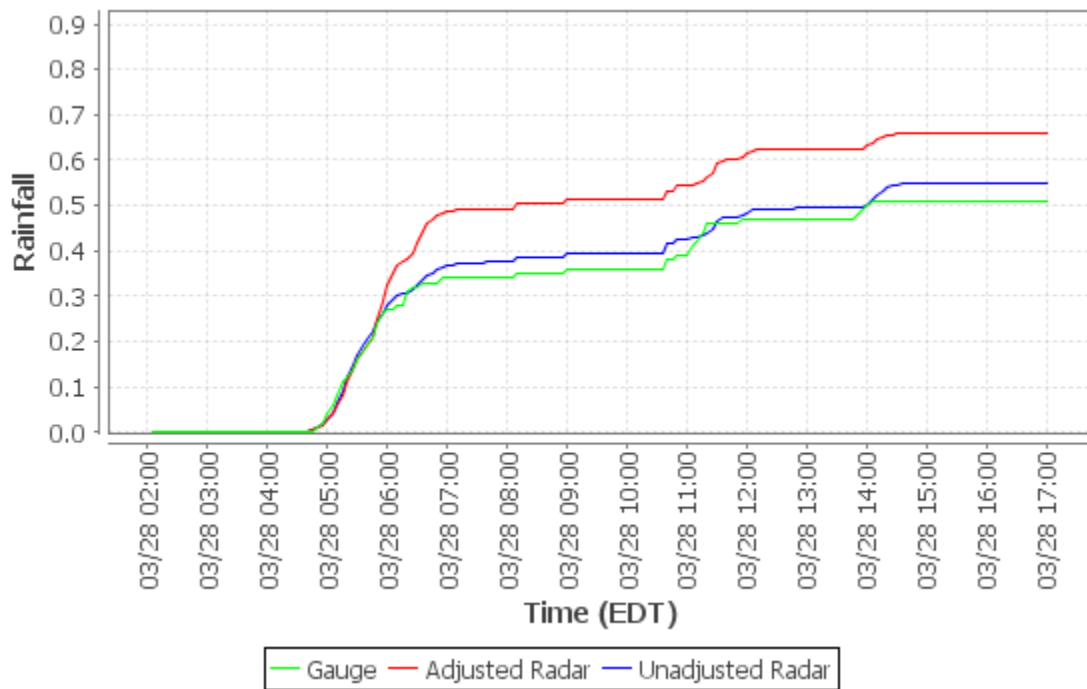
**Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)**



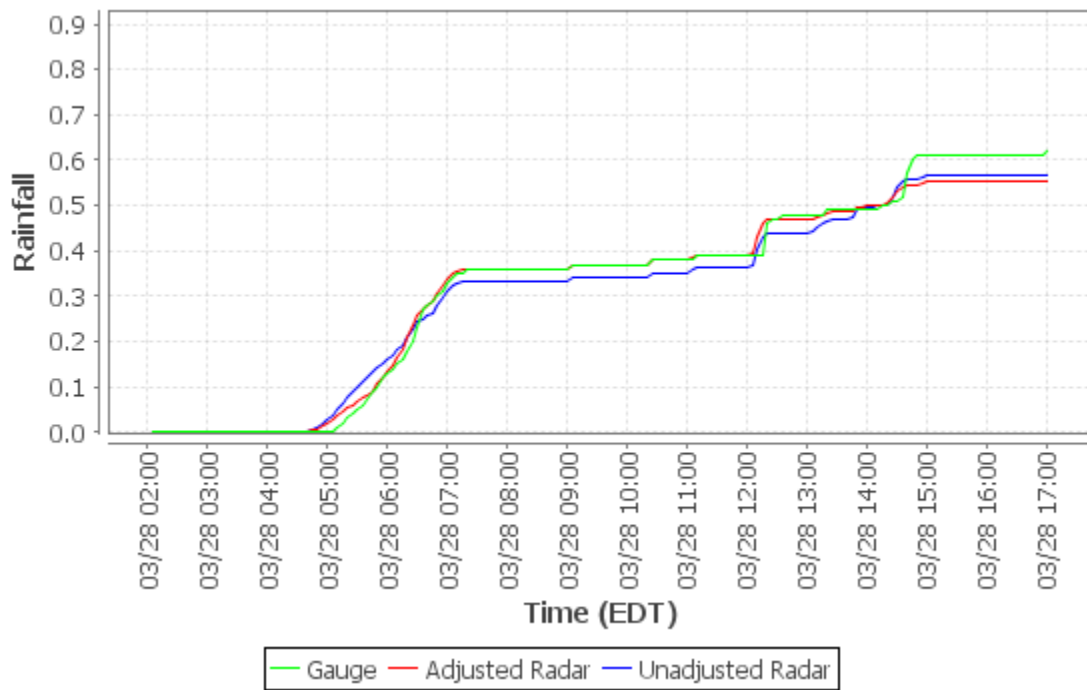
**Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)**



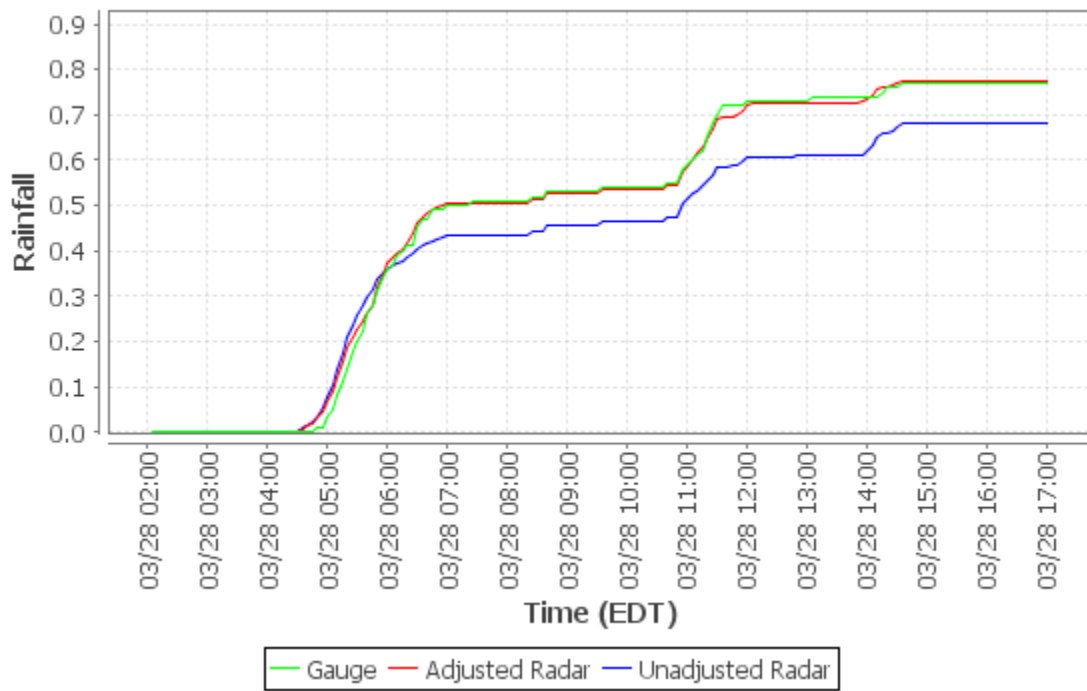
**Cumulative Distribution Plot - Marshall TWP (Loc27)**



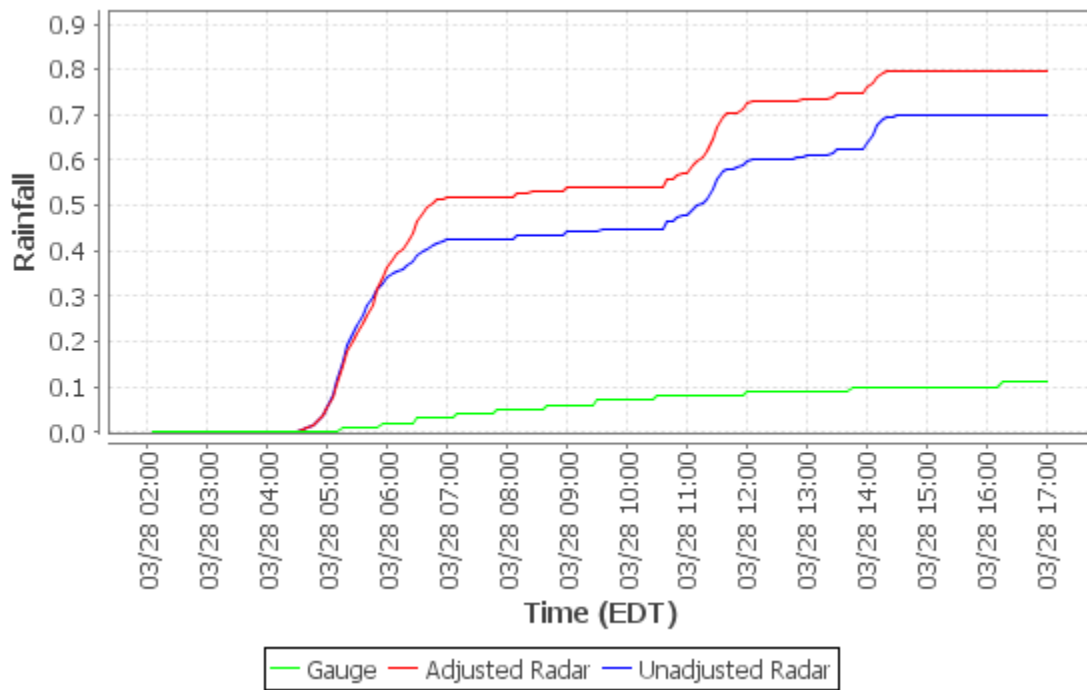
**Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)**



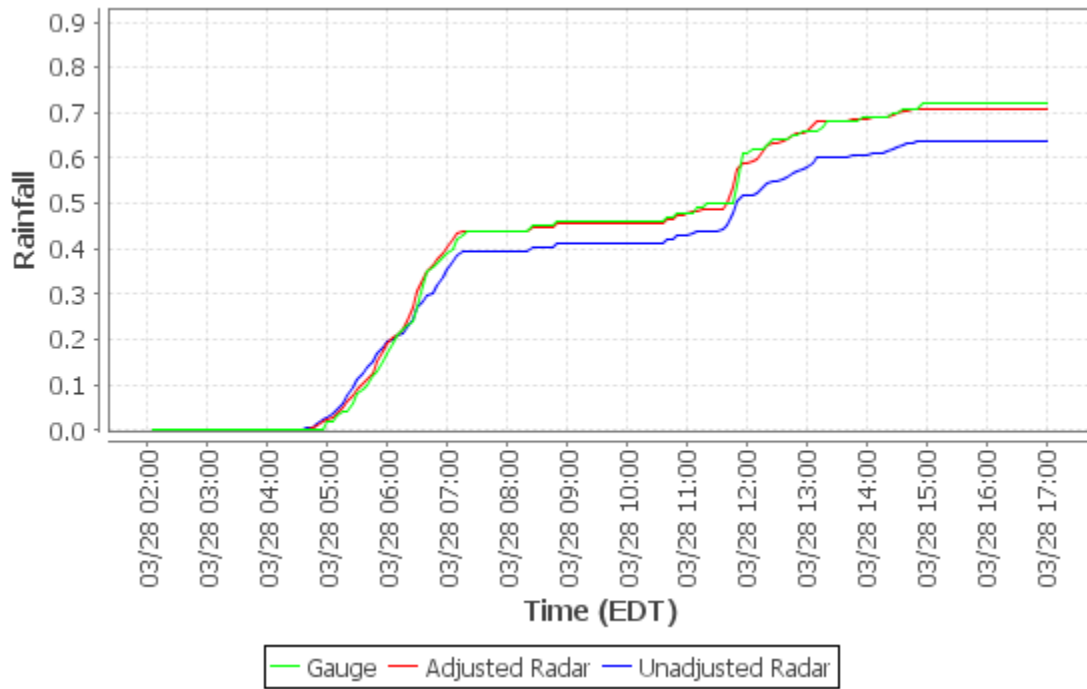
**Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)**



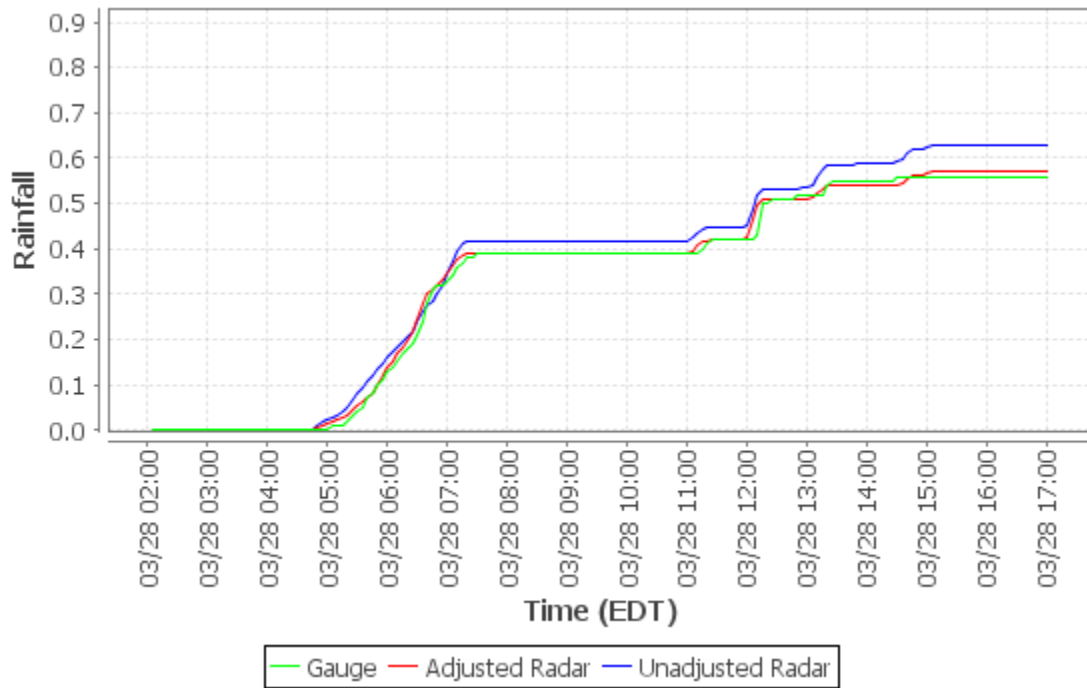
**Cumulative Distribution Plot - McCandless Twn Hall (Loc30)**



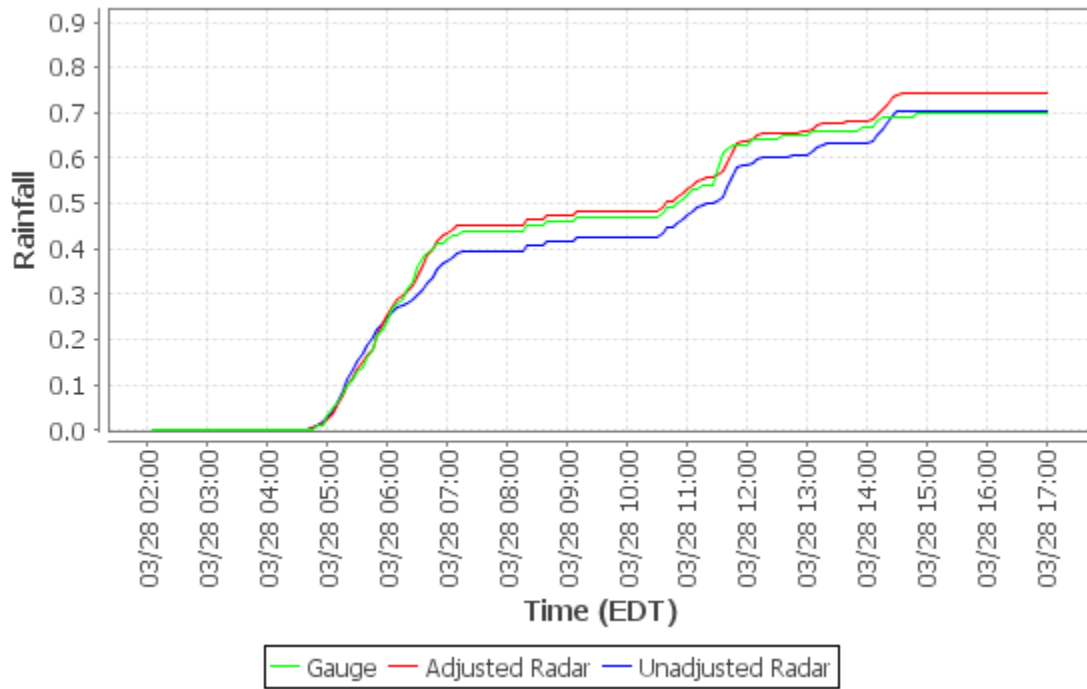
**Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)**



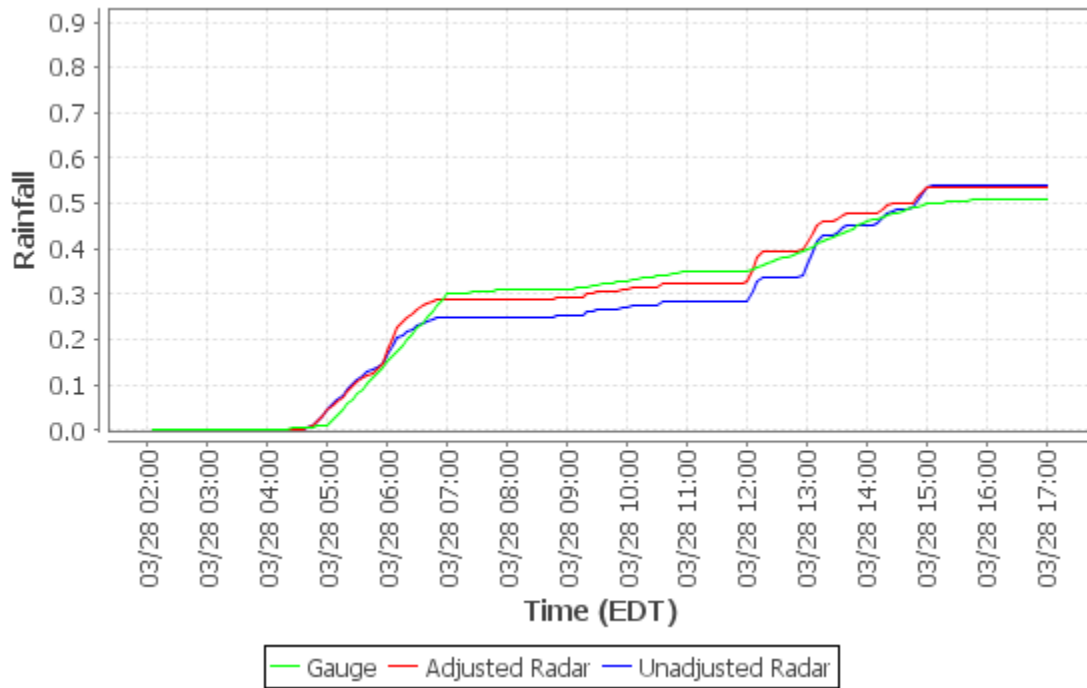
**Cumulative Distribution Plot - Arnold (Loc32)**



**Cumulative Distribution Plot - Richland TWP (Loc33)**

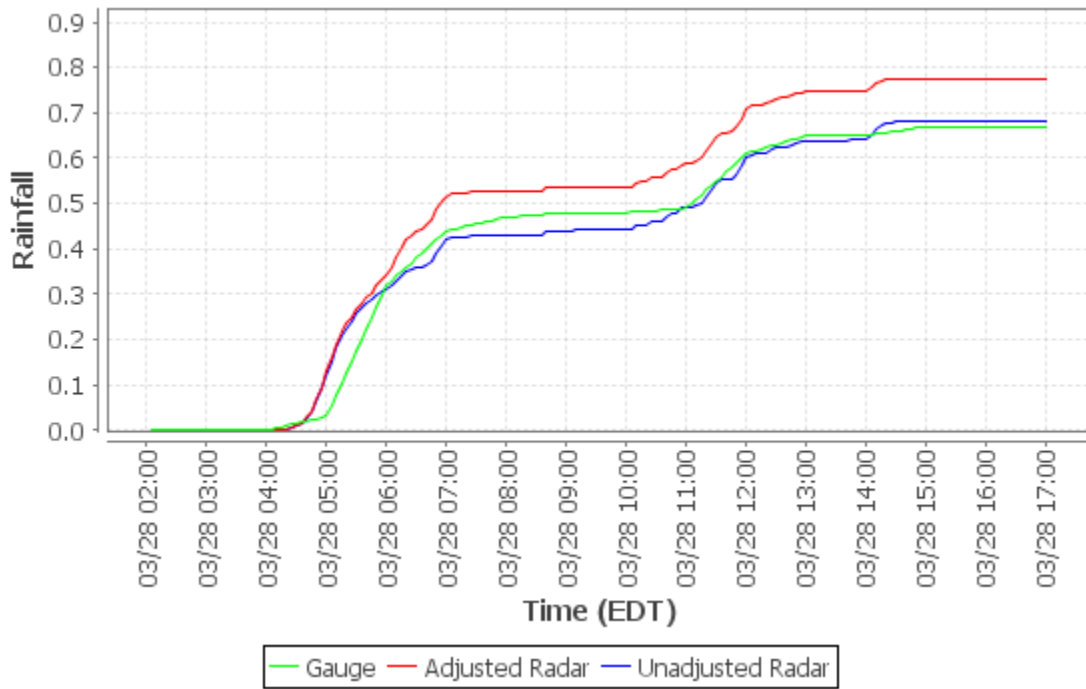


**Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)**

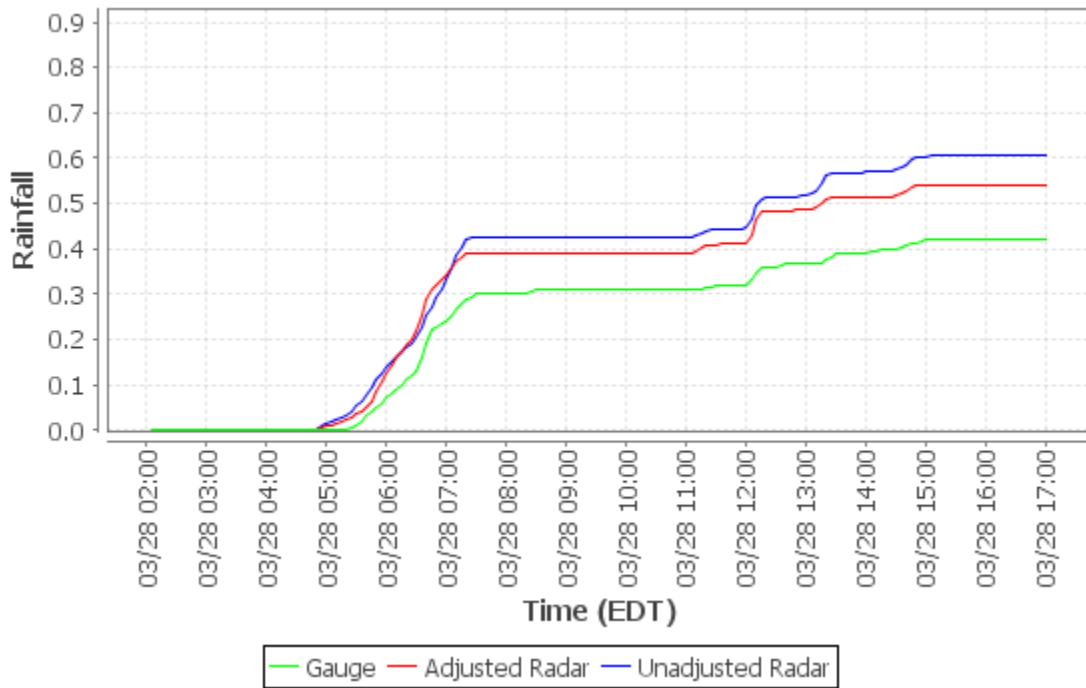




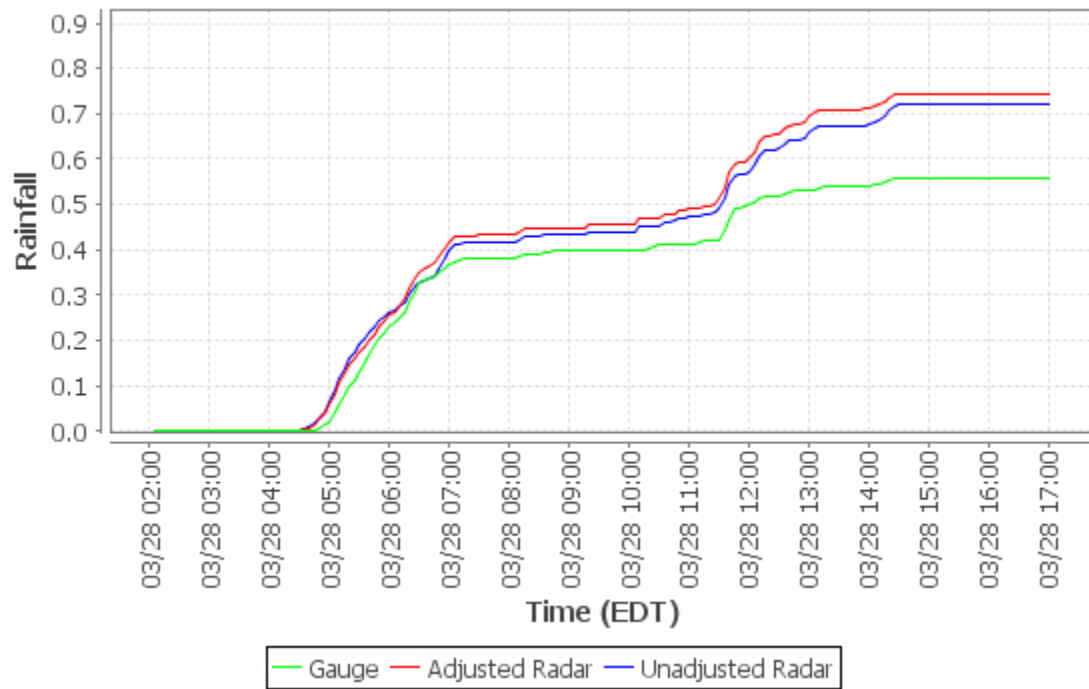
**Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)**



**Cumulative Distribution Plot - Allegheny River at Natrona (03049500)**

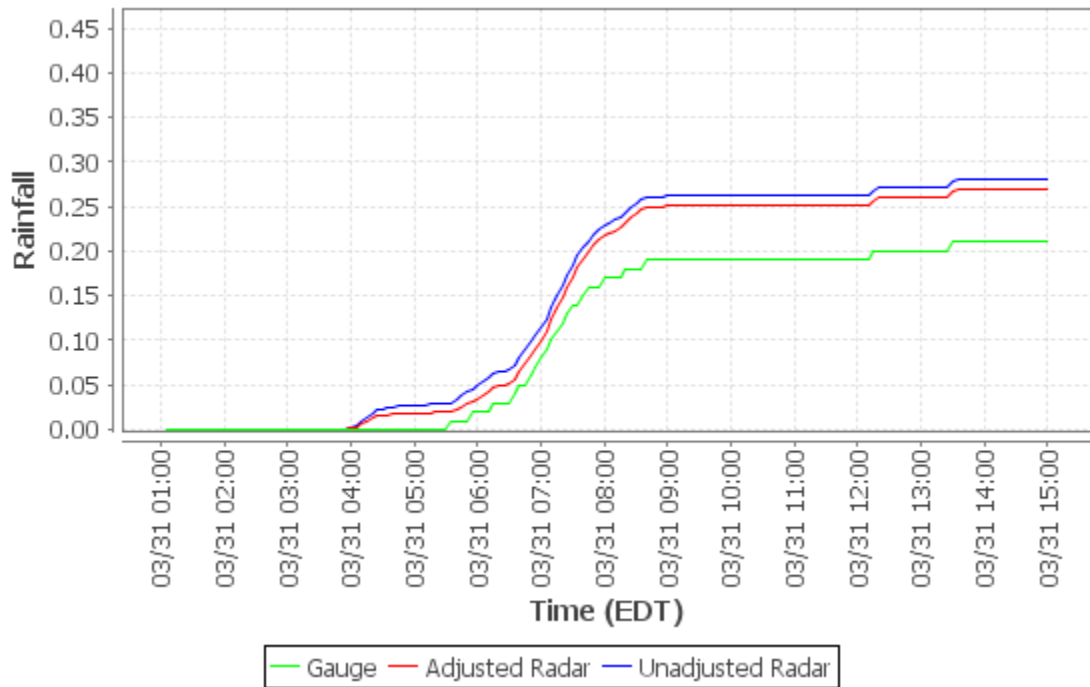


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth  
(03085734)**

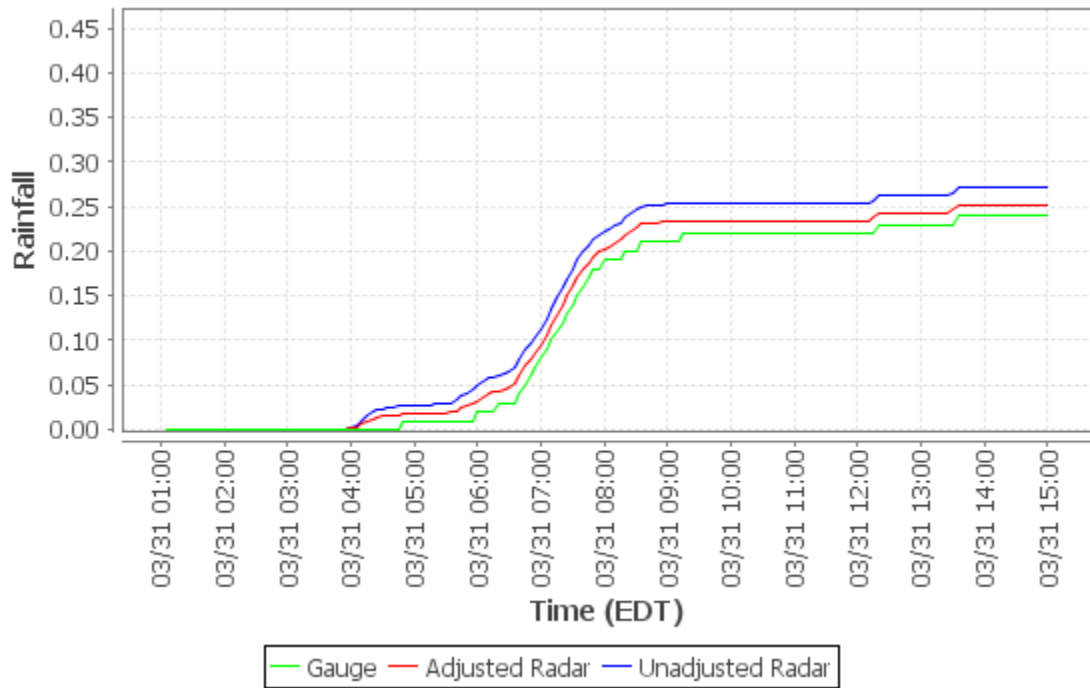


## **Appendix F - Event 4 (2021-03-31) CDPs**

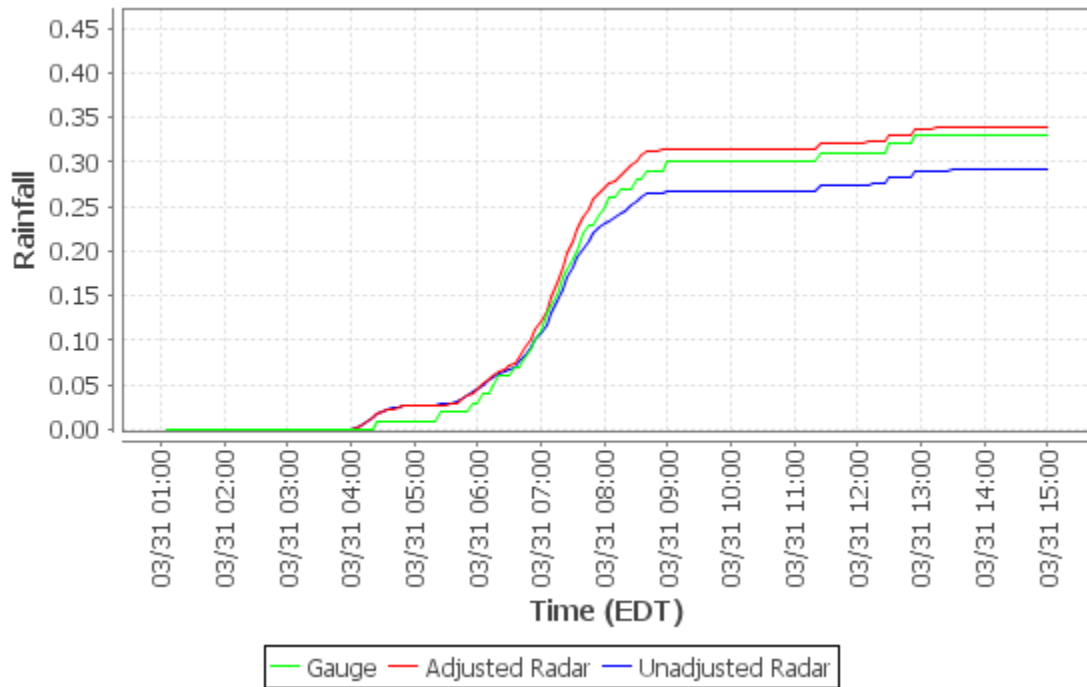
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



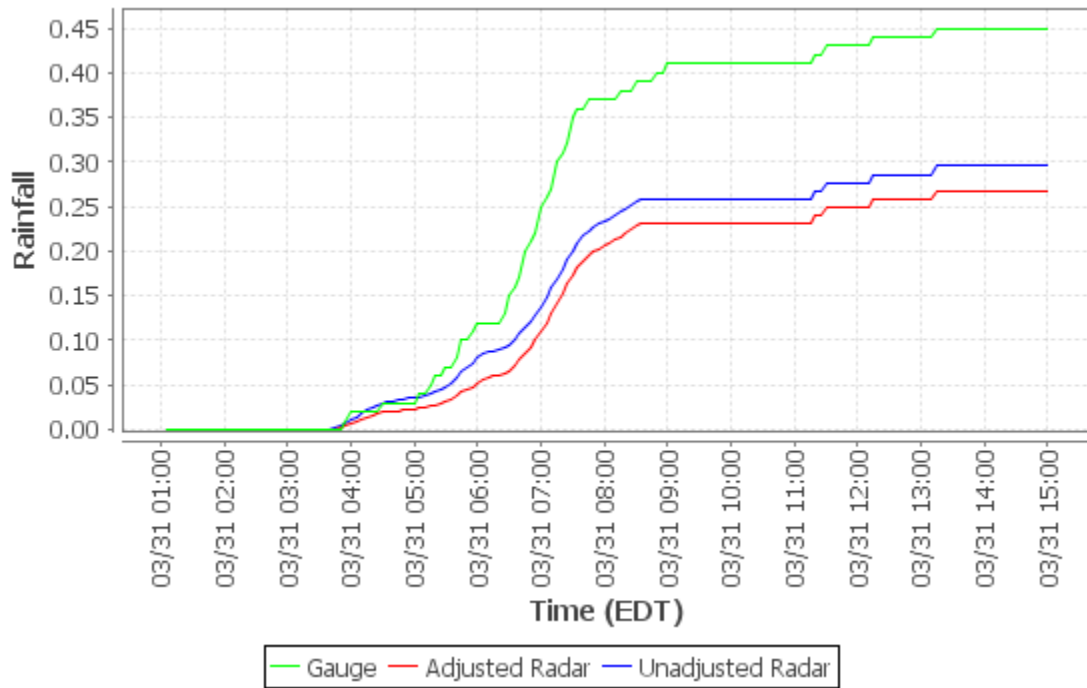
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



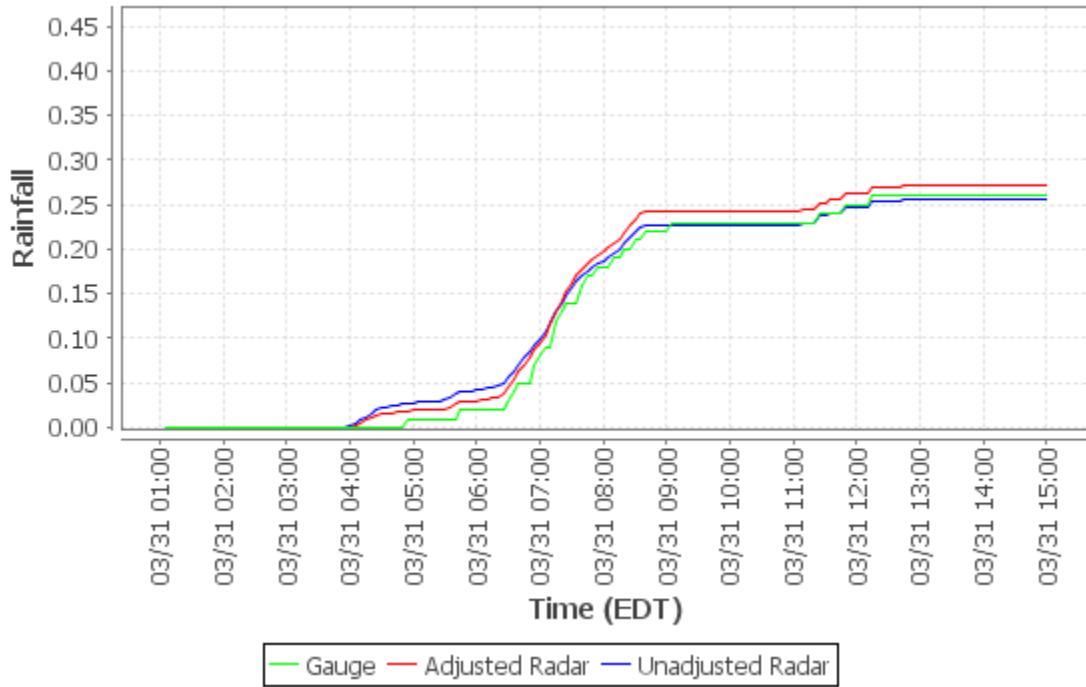
**Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)**



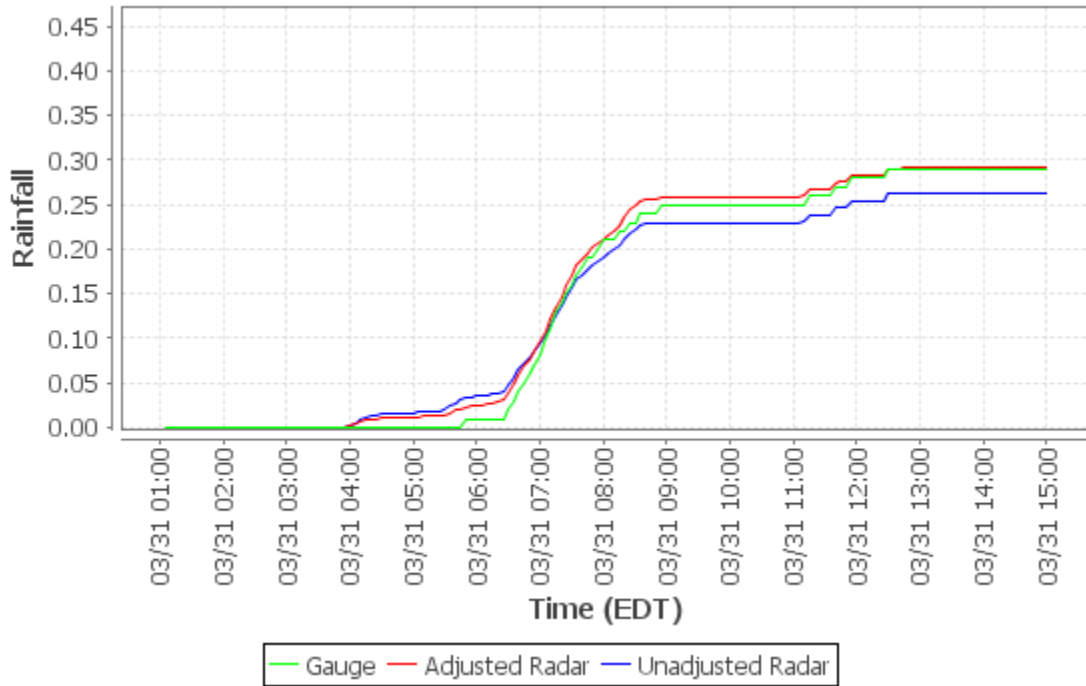
**Cumulative Distribution Plot - Kennedy Twp PS (Loc04)**



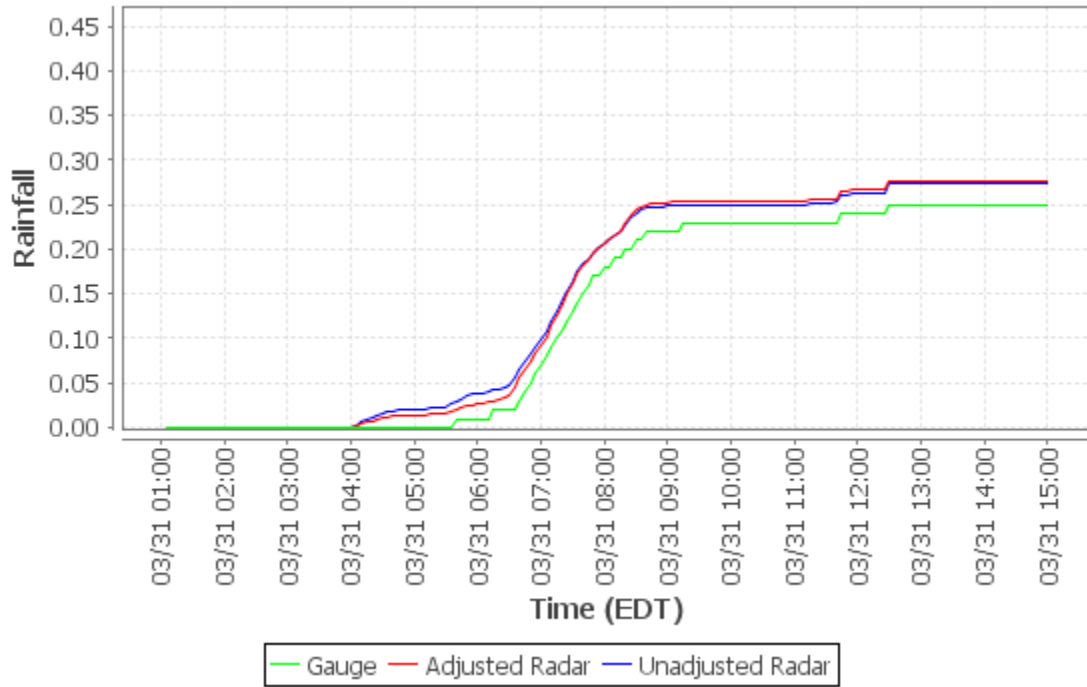
**Cumulative Distribution Plot - Upper St. Clair (Loc05)**



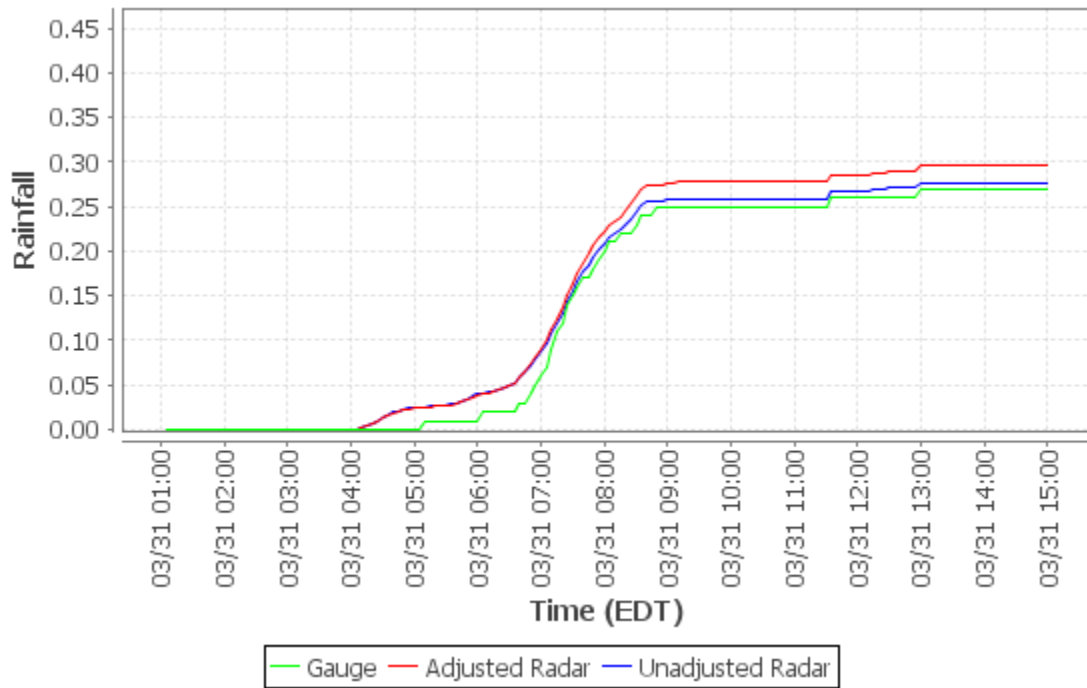
**Cumulative Distribution Plot - Carnegie Transit Time (Loc06)**



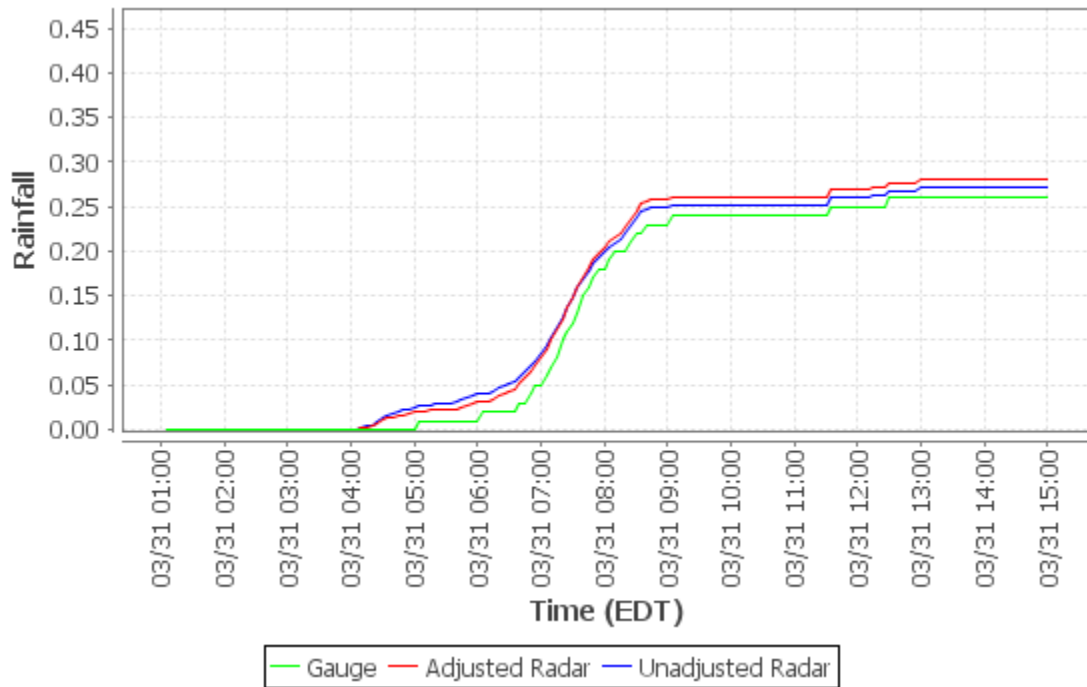
**Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)**



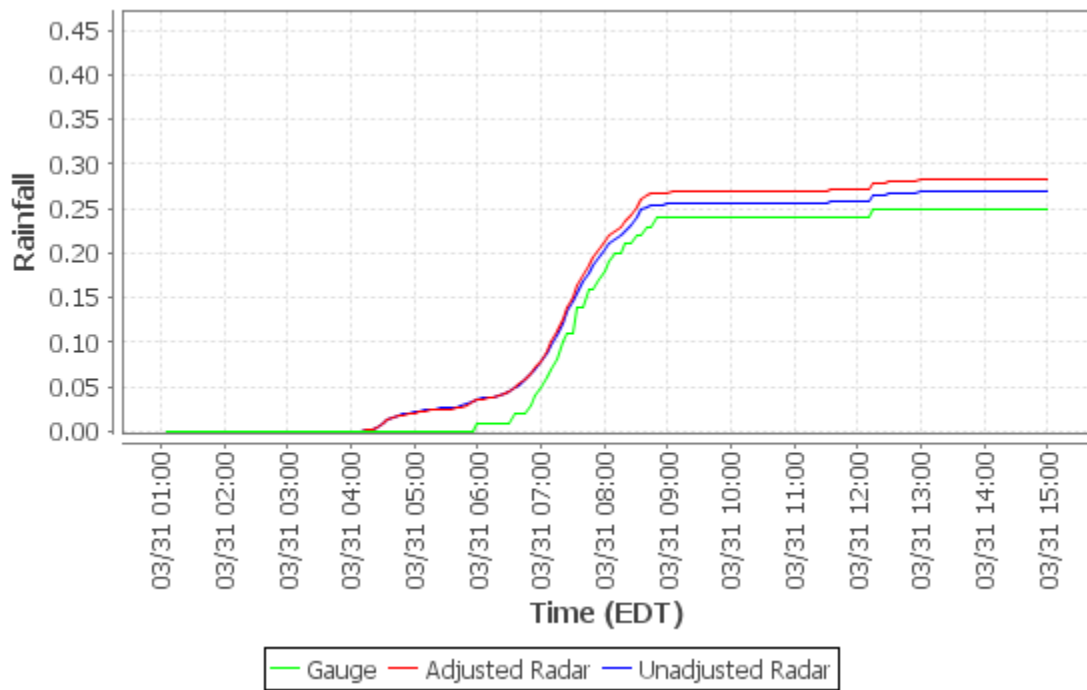
**Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)**



**Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)**

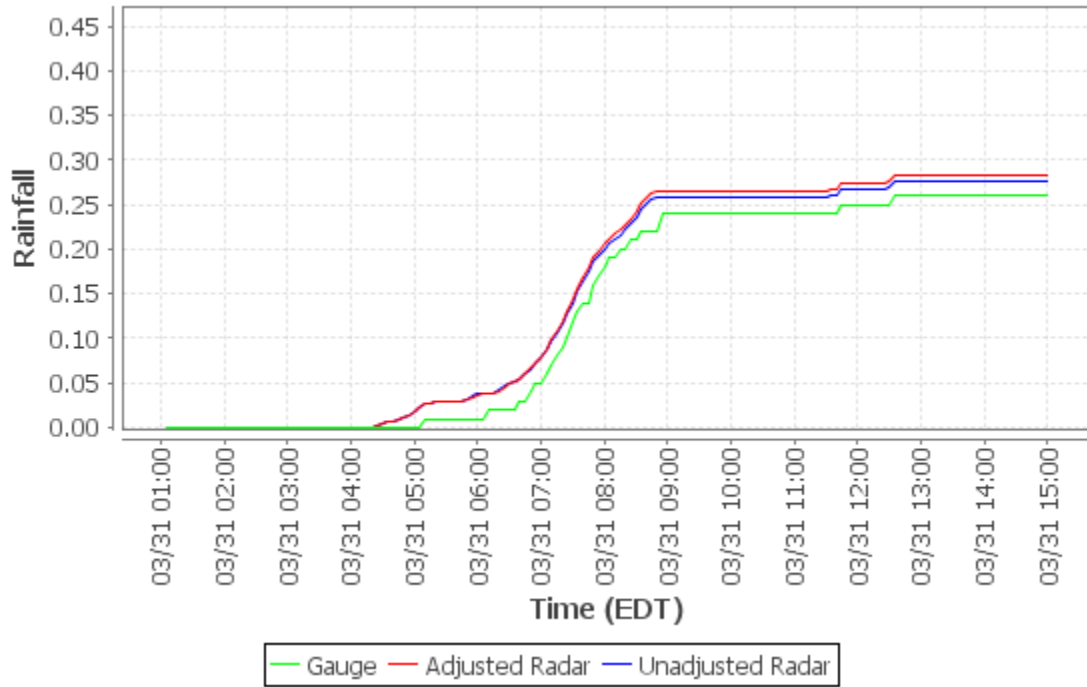


**Cumulative Distribution Plot - PWSA-Highland Park (Loc10)**

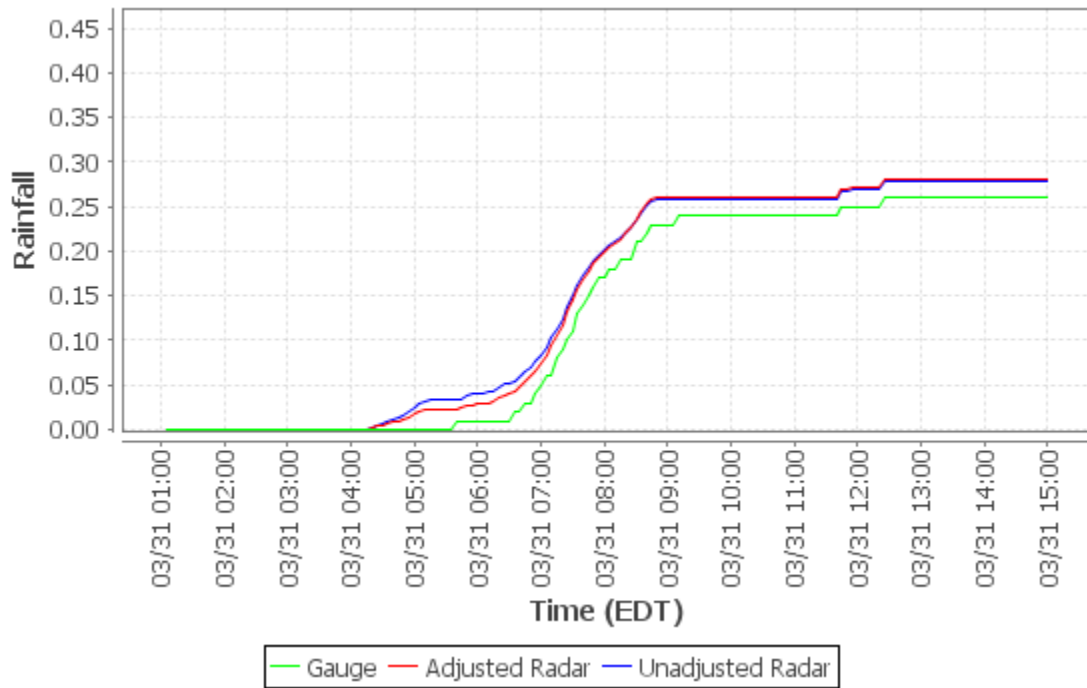




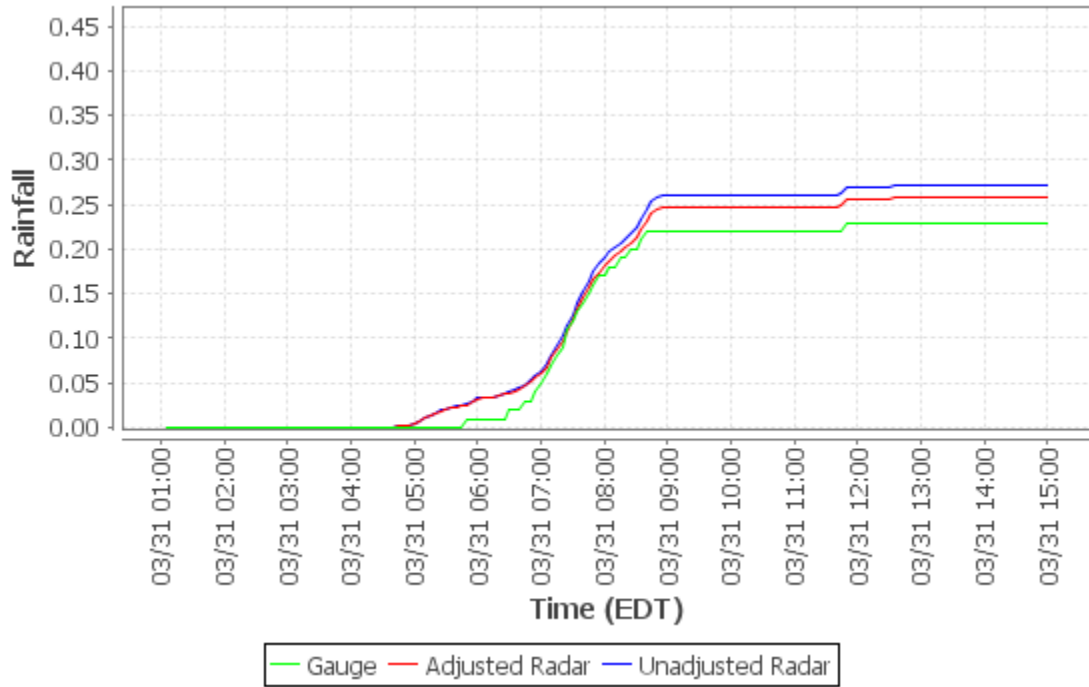
**Cumulative Distribution Plot - M-46 Access Shaft (Loc11)**



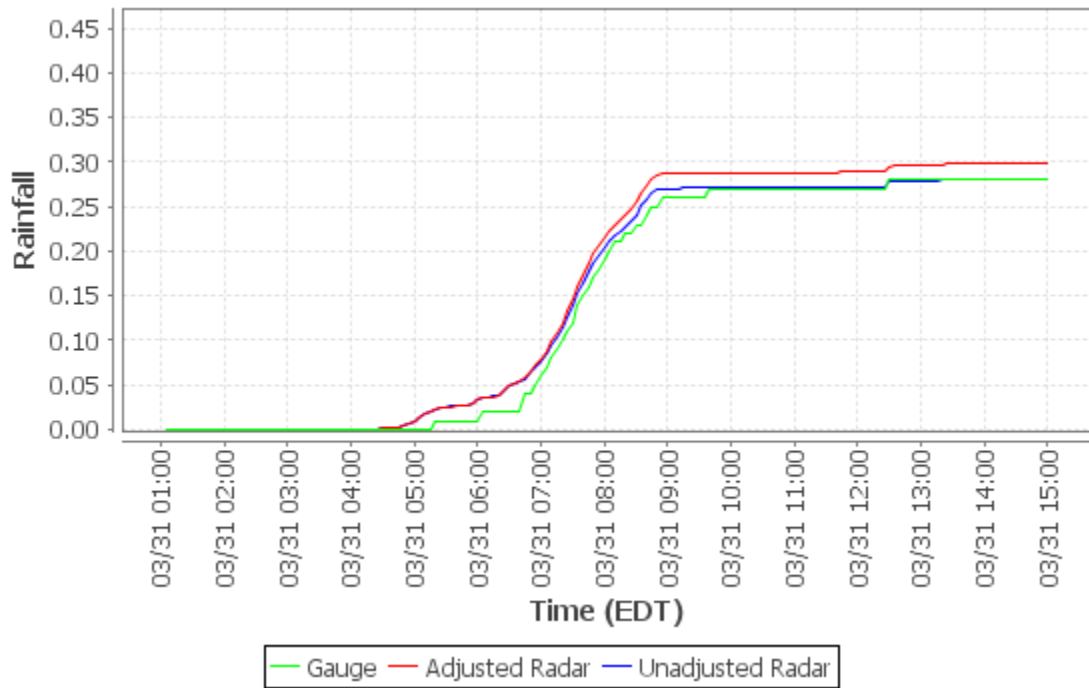
**Cumulative Distribution Plot - Baldwin (Loc12)**



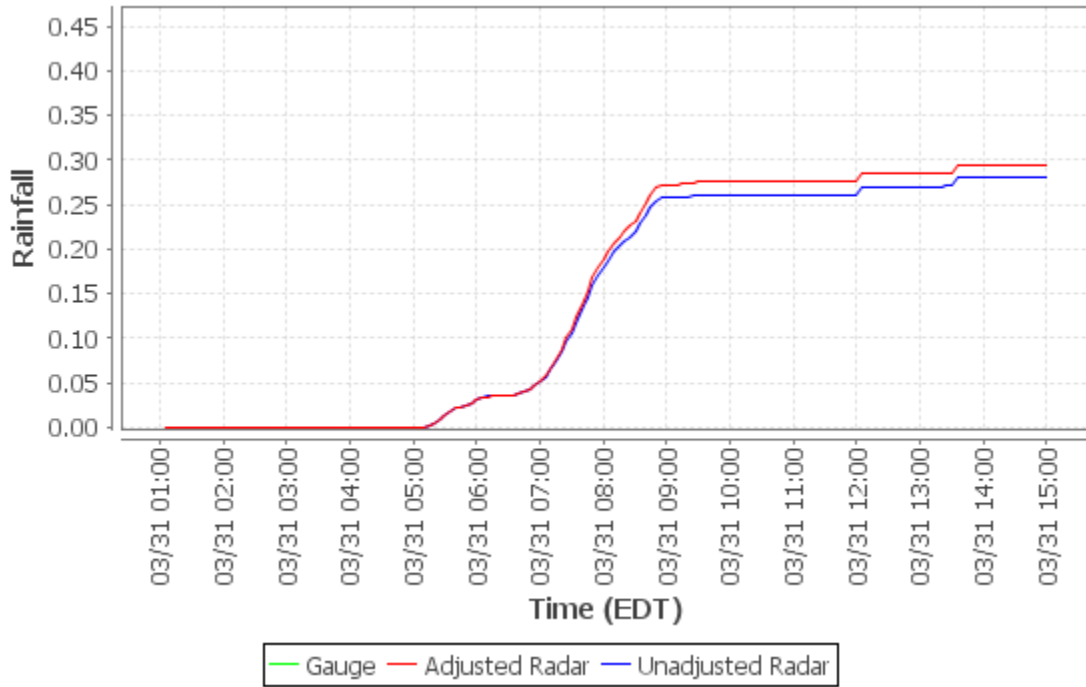
**Cumulative Distribution Plot - M-59 Access Shaft (Loc13)**



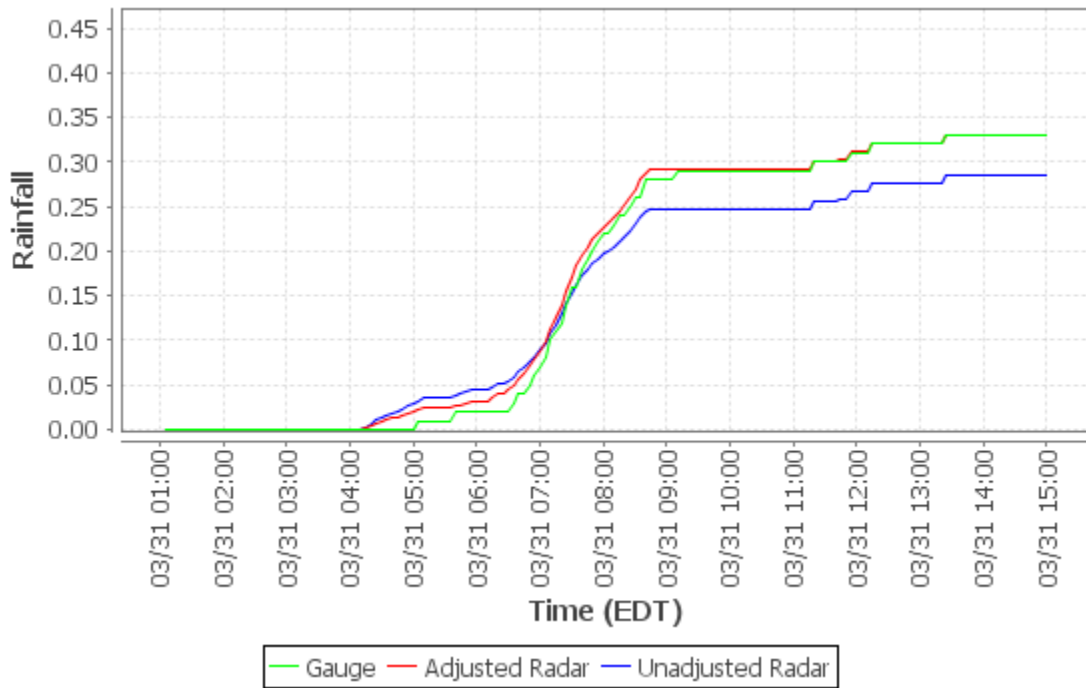
**Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)**



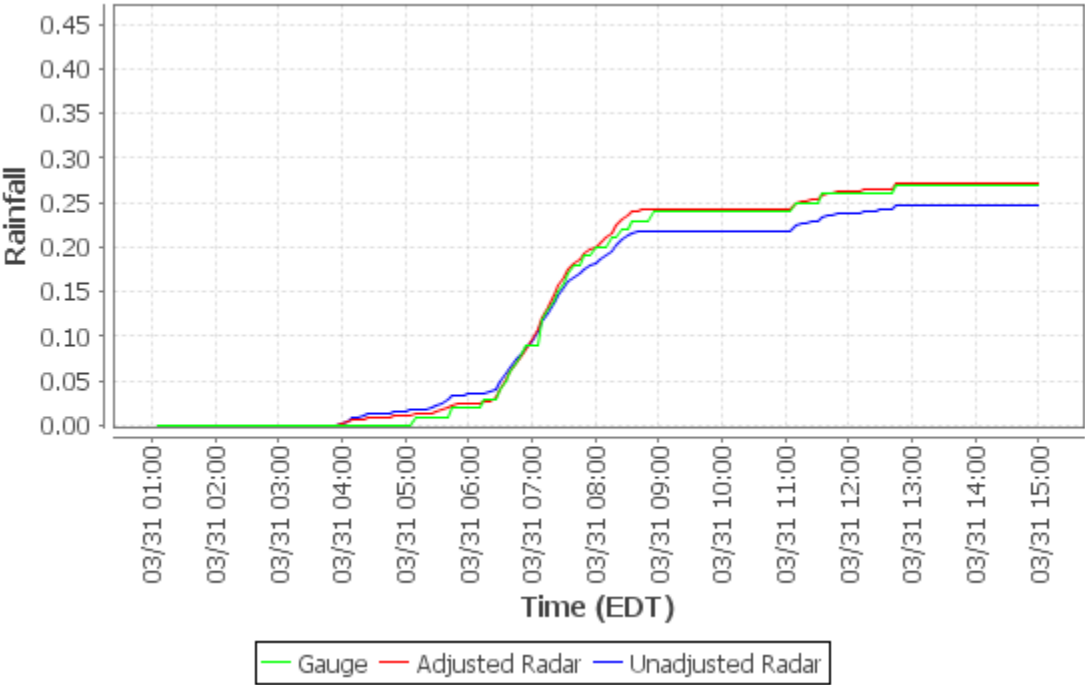
**Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)**



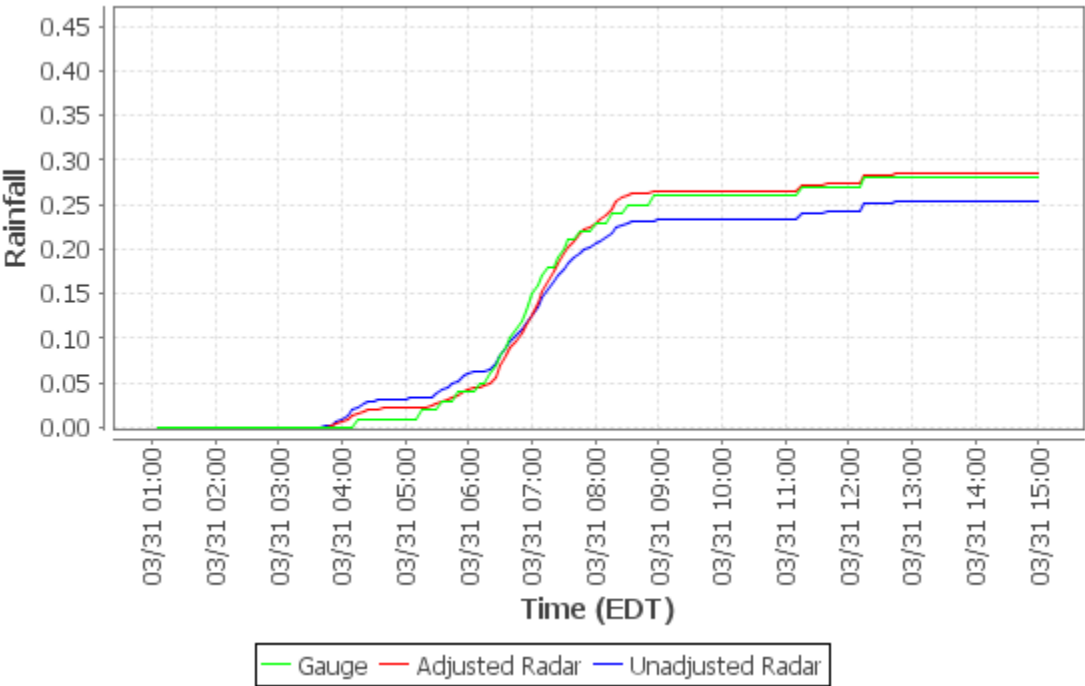
**Cumulative Distribution Plot - Castle Shannon (Loc16)**



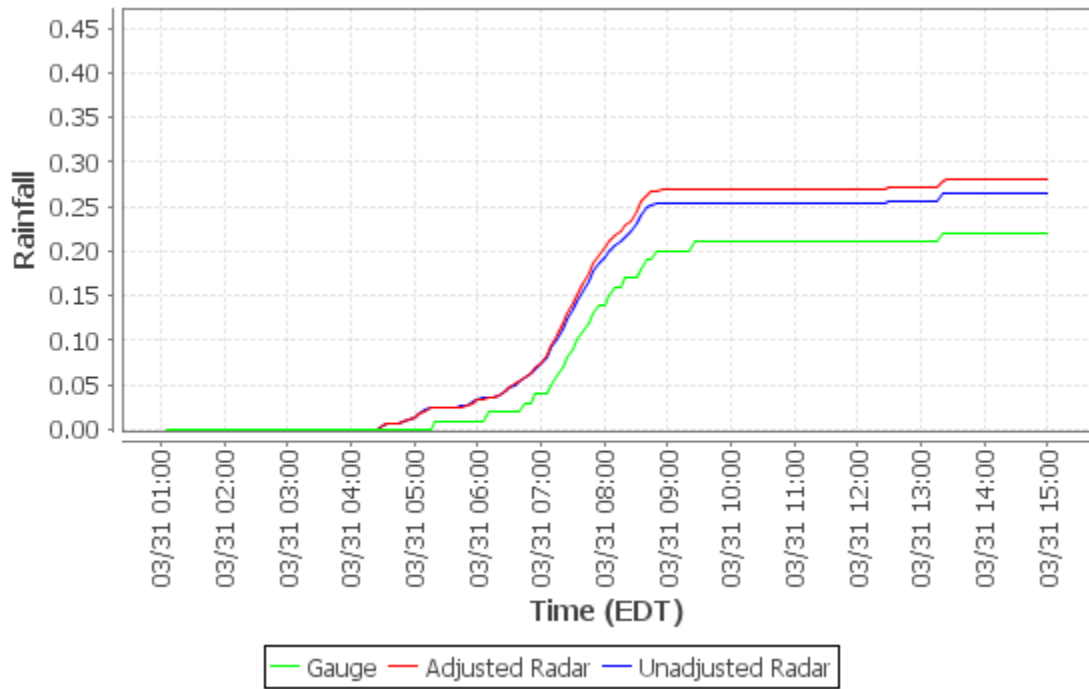
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



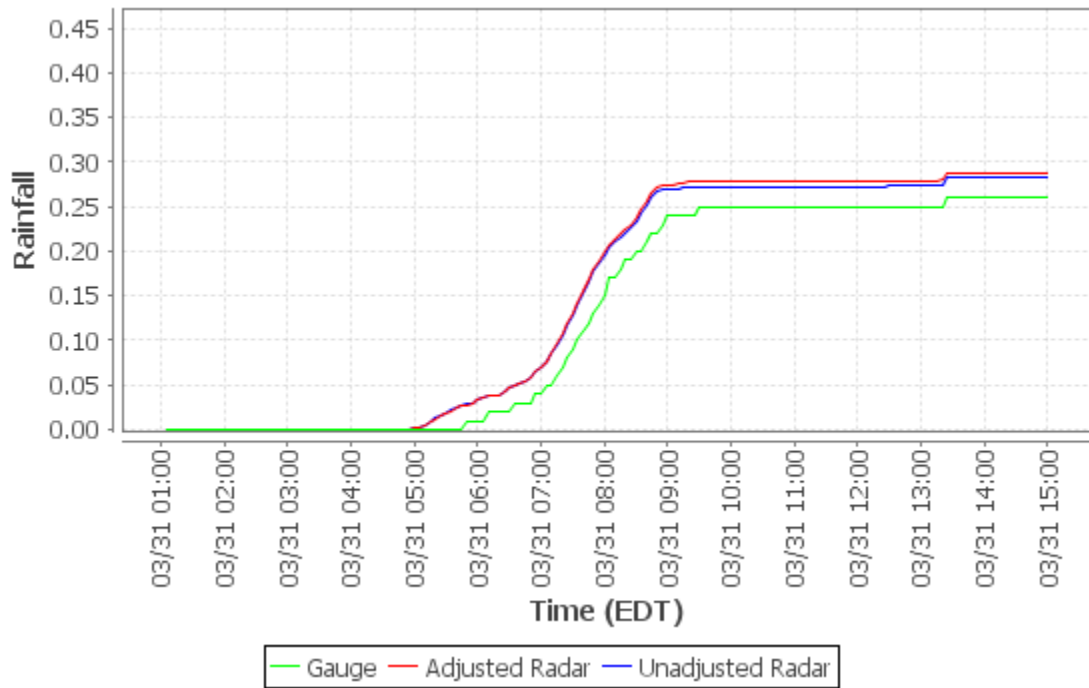
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



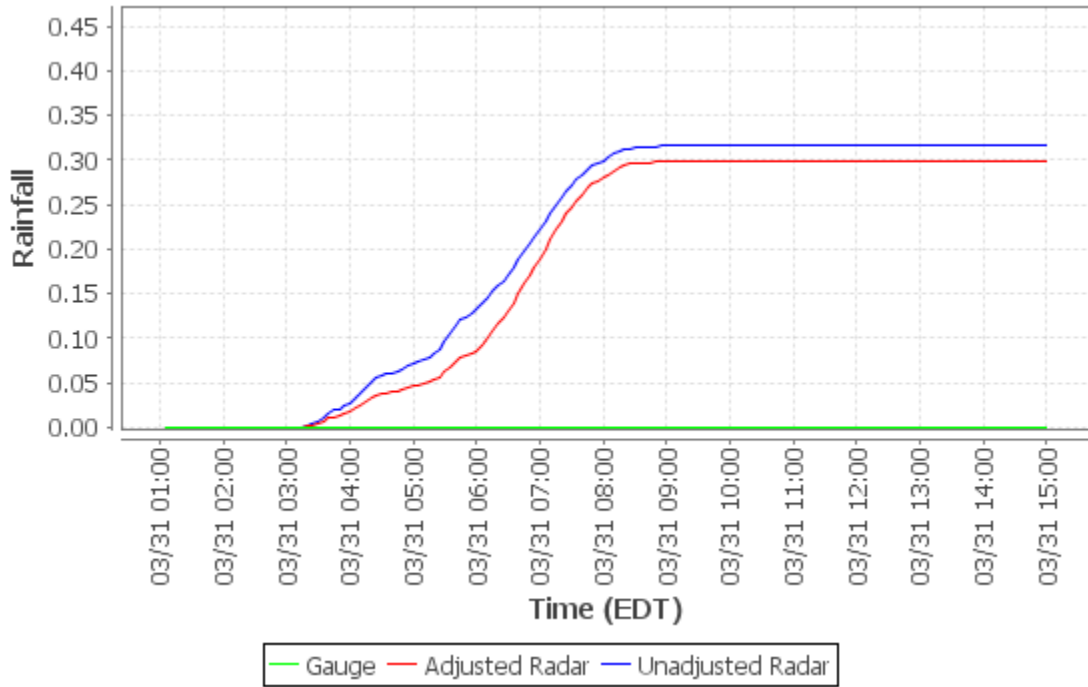
**Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)**



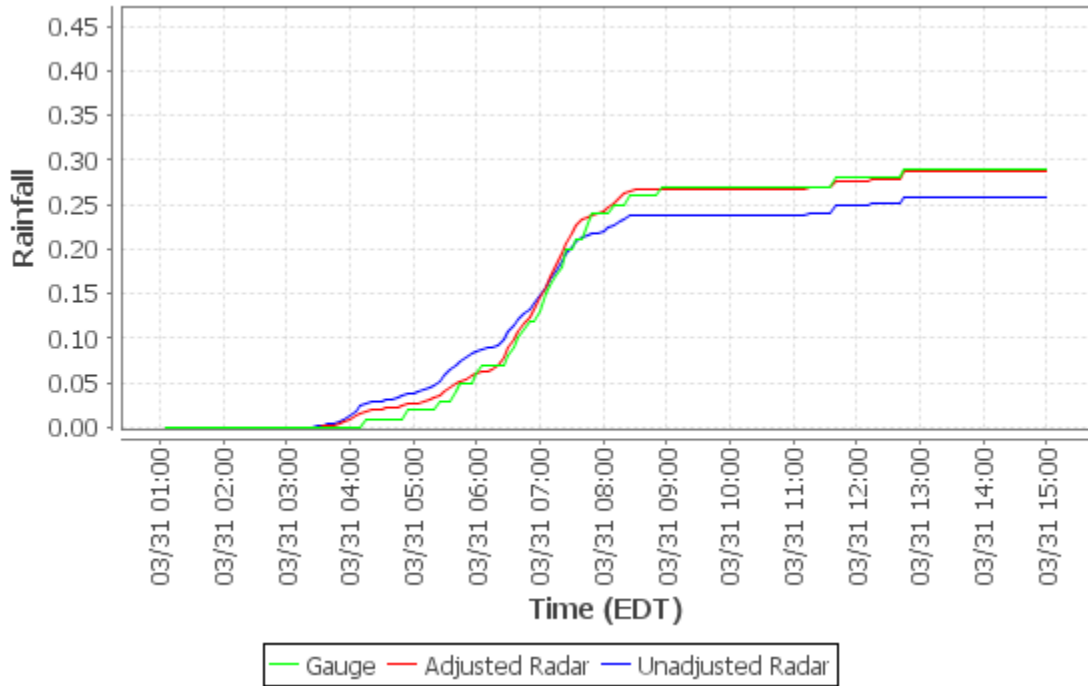
**Cumulative Distribution Plot - Gascola Eq Facility (Loc20)**



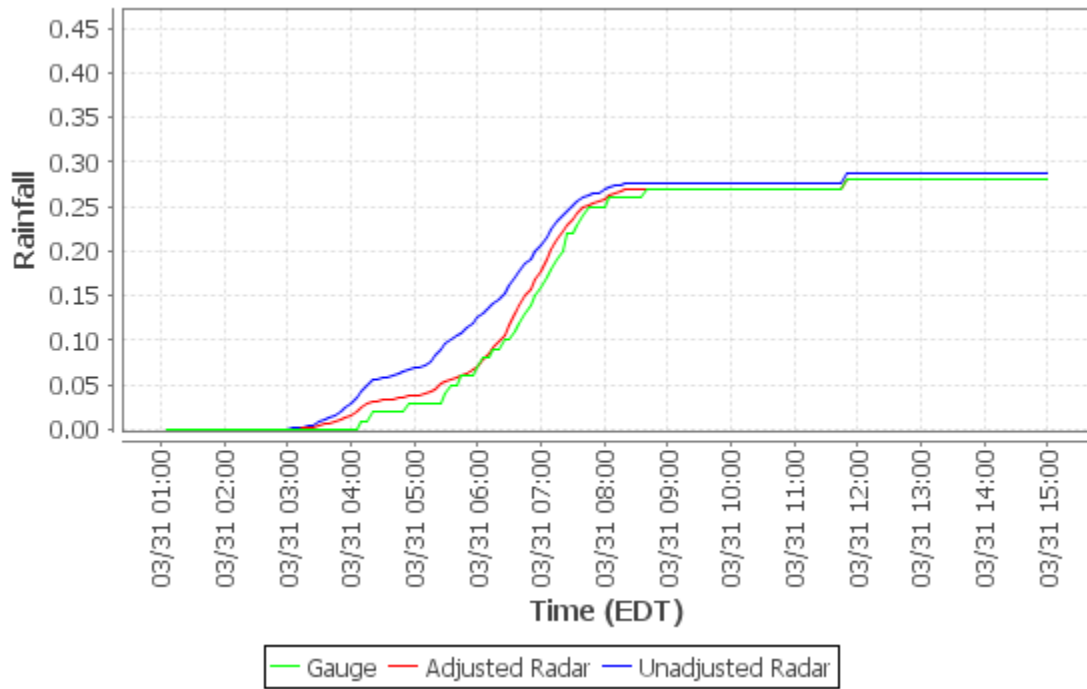
**Cumulative Distribution Plot - Moon TWP (Loc21)**



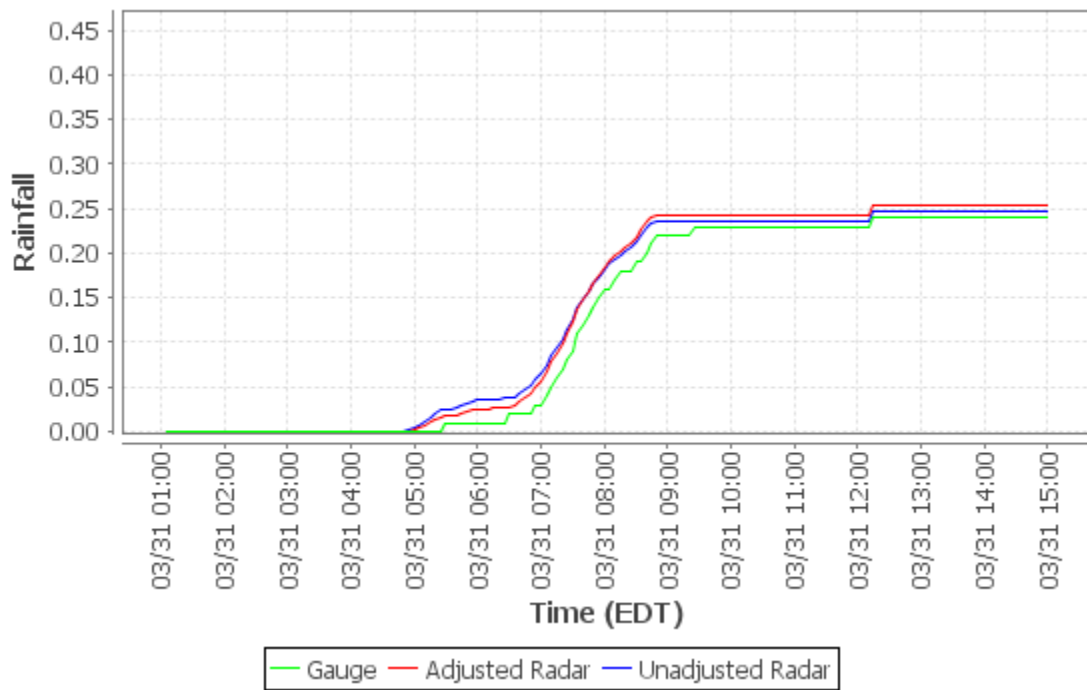
**Cumulative Distribution Plot - North Fayette TWP (Loc22)**



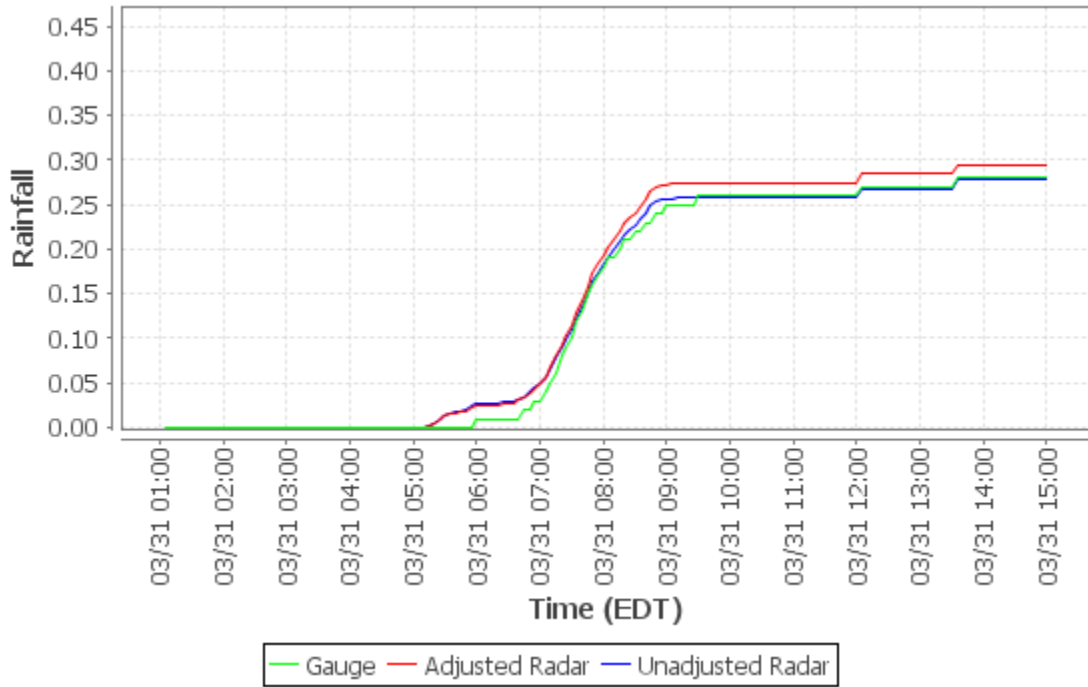
**Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)**



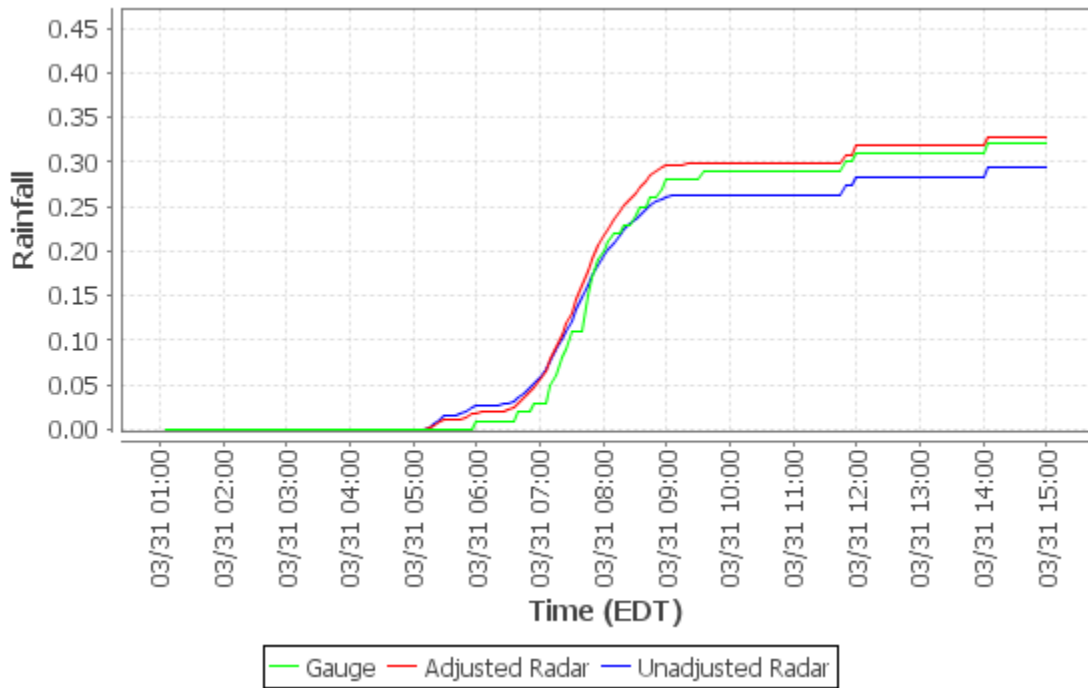
**Cumulative Distribution Plot - Jefferson Hills (Loc24)**



**Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)**

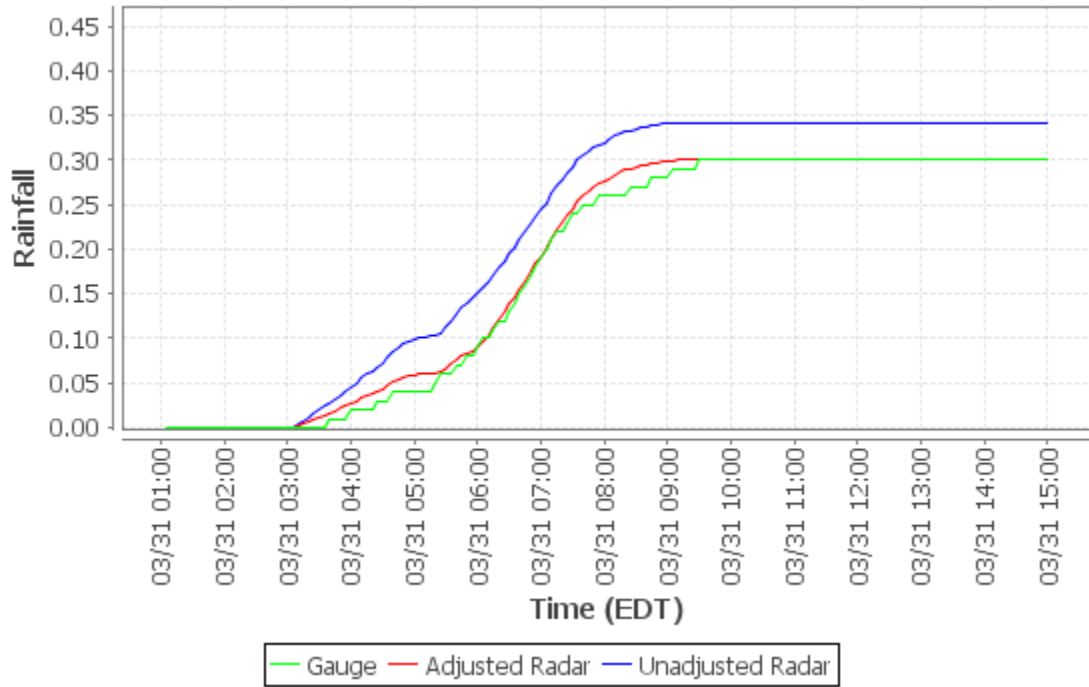


**Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)**

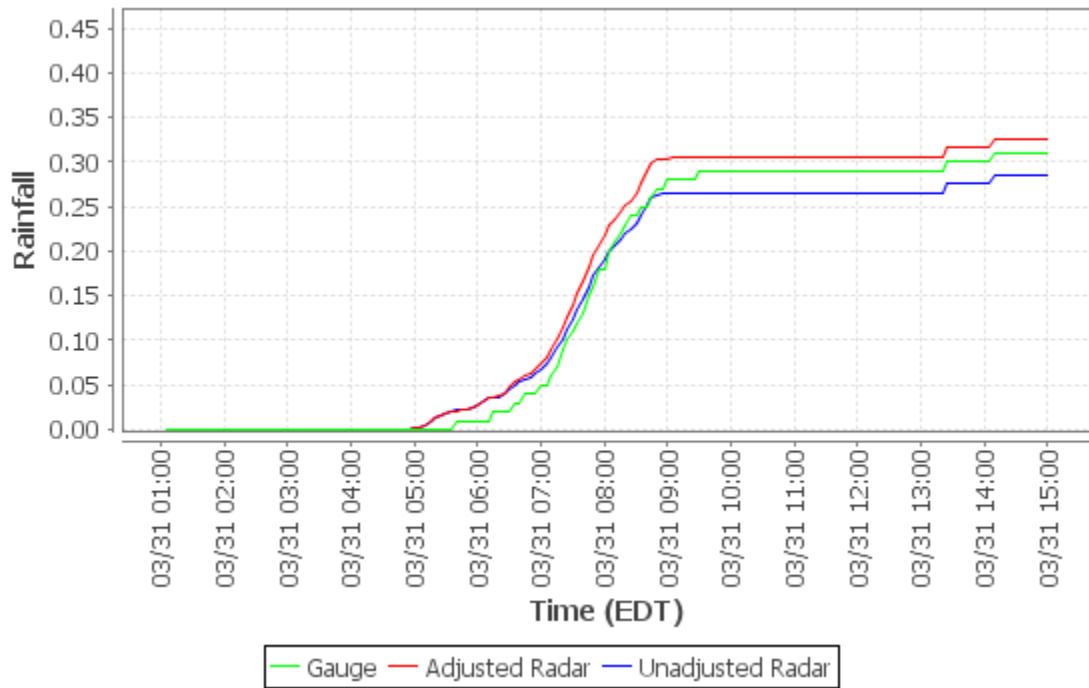




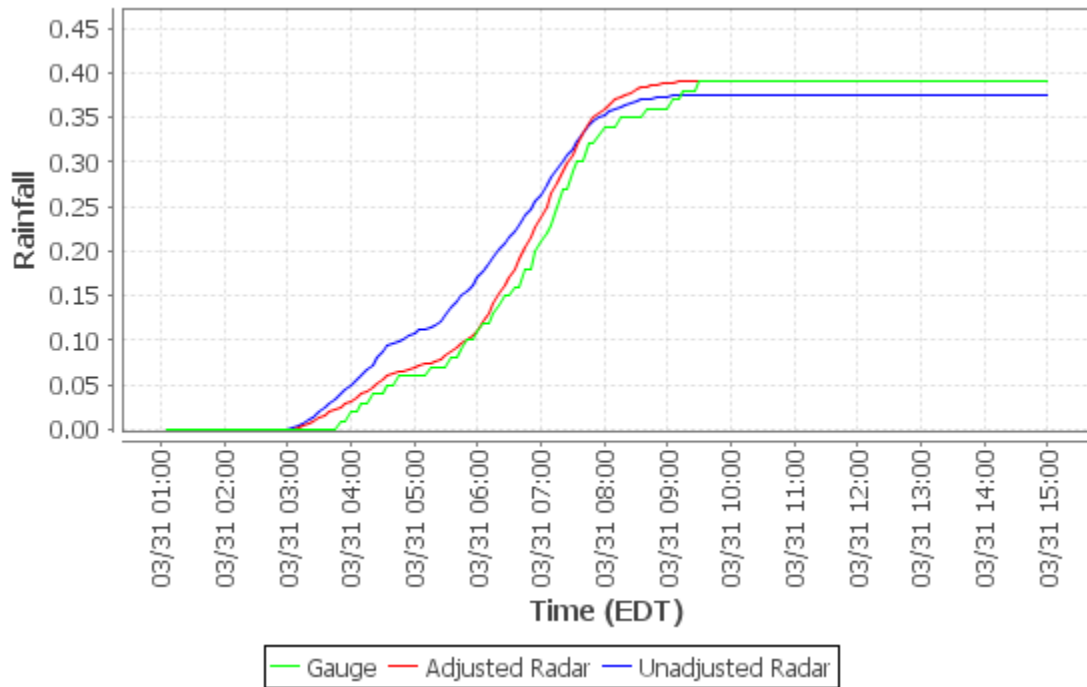
**Cumulative Distribution Plot - Marshall TWP (Loc27)**



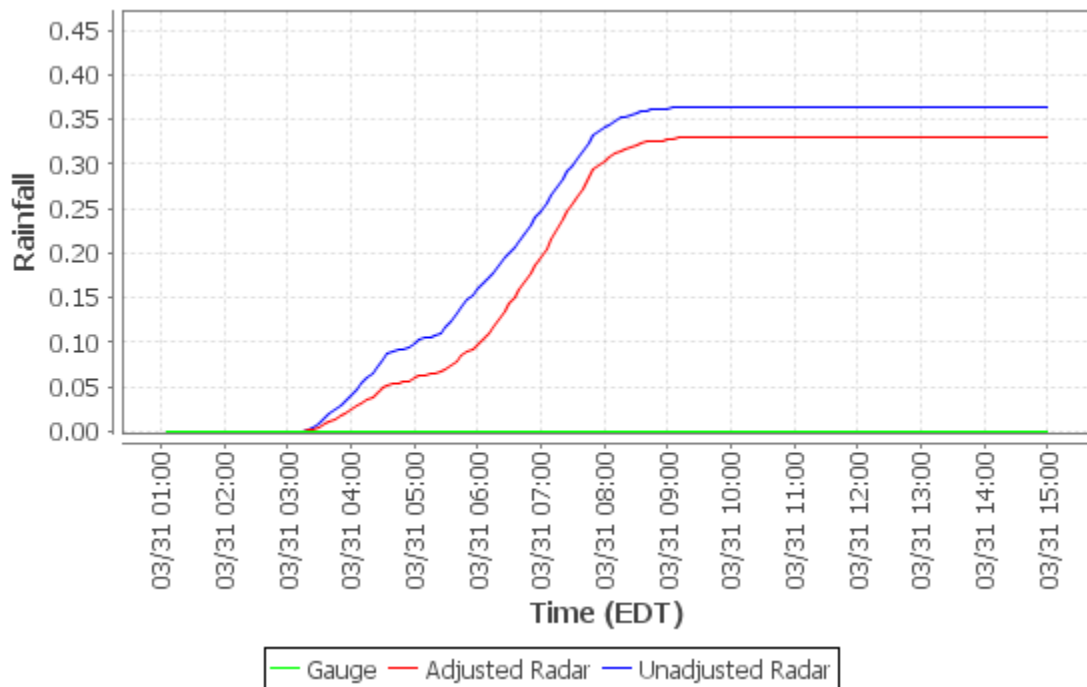
**Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)**



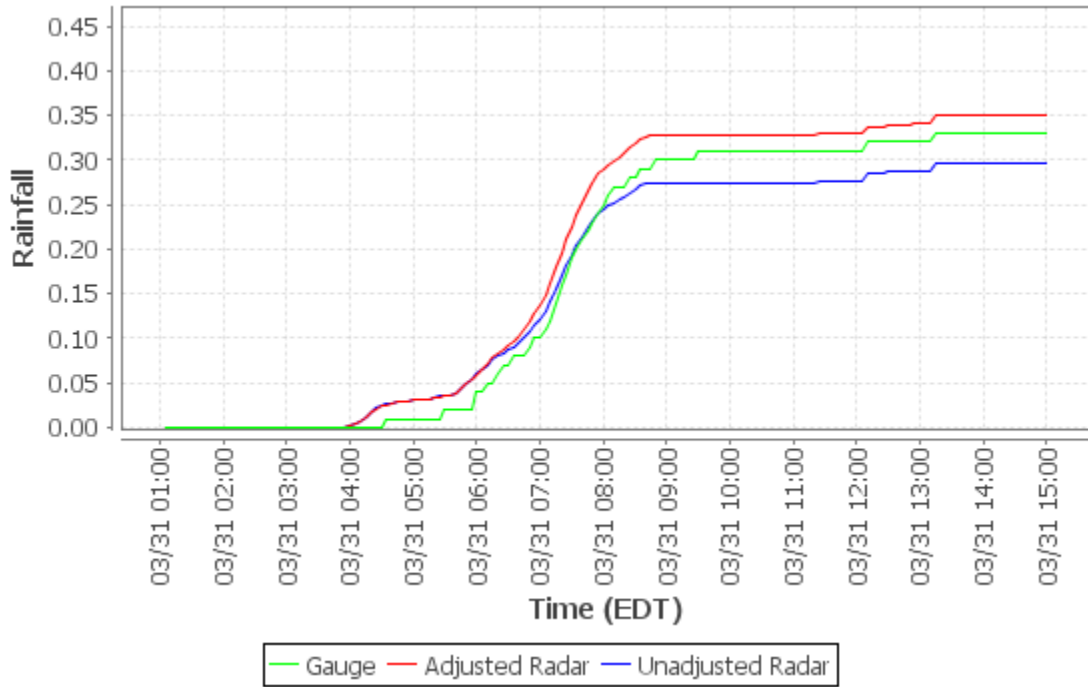
**Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)**



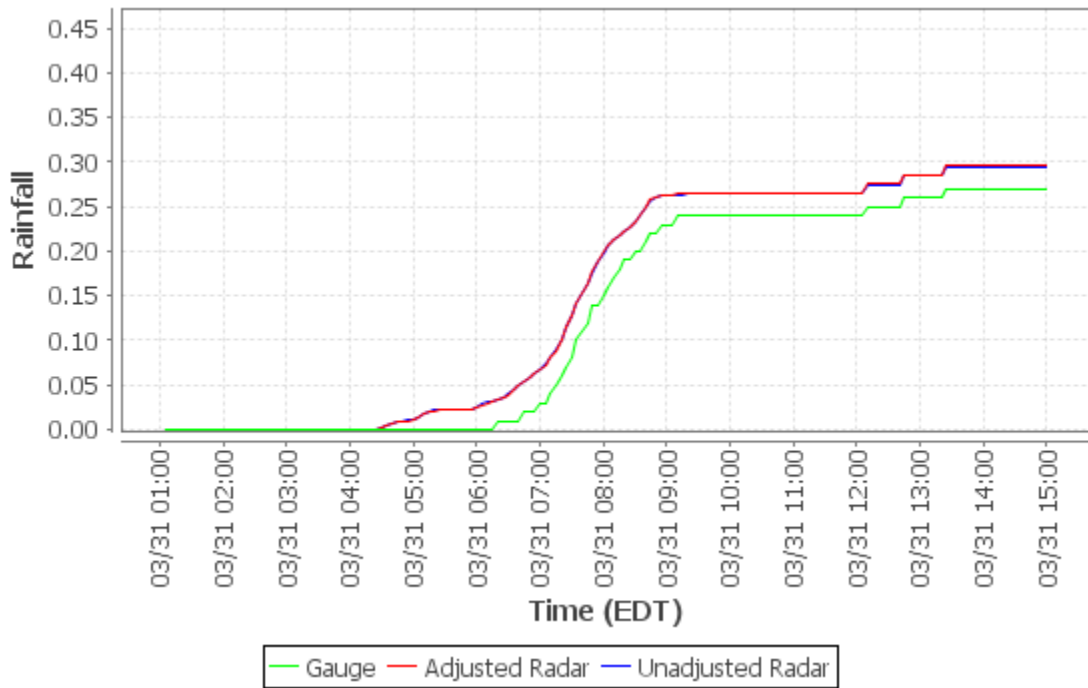
**Cumulative Distribution Plot - McCandless Twn Hall (Loc30)**



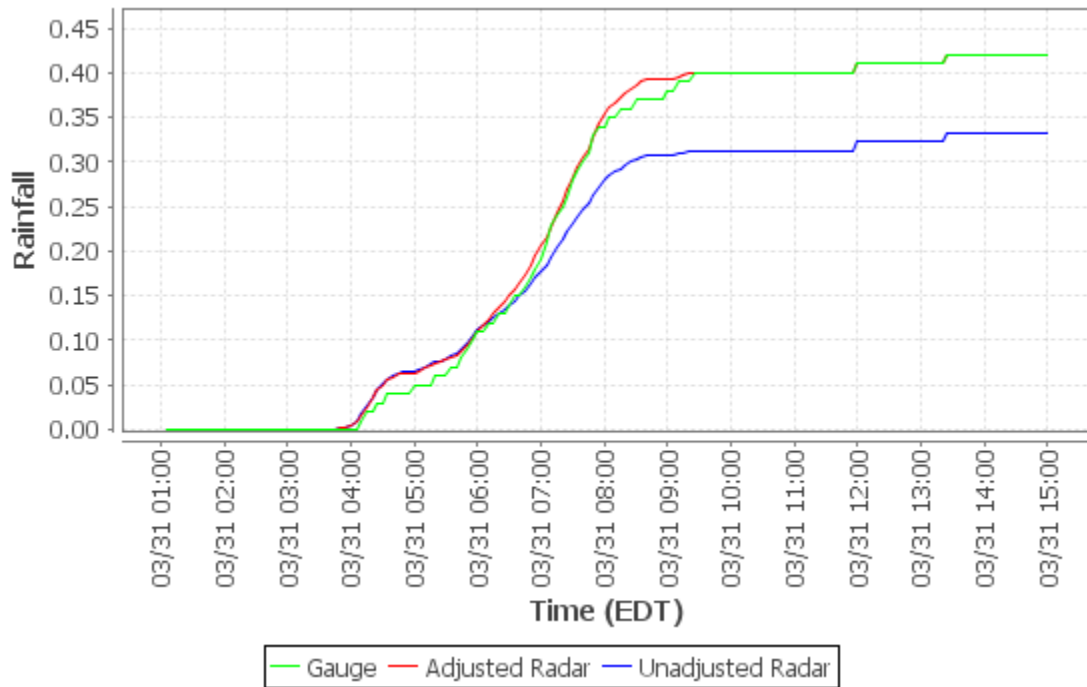
**Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)**



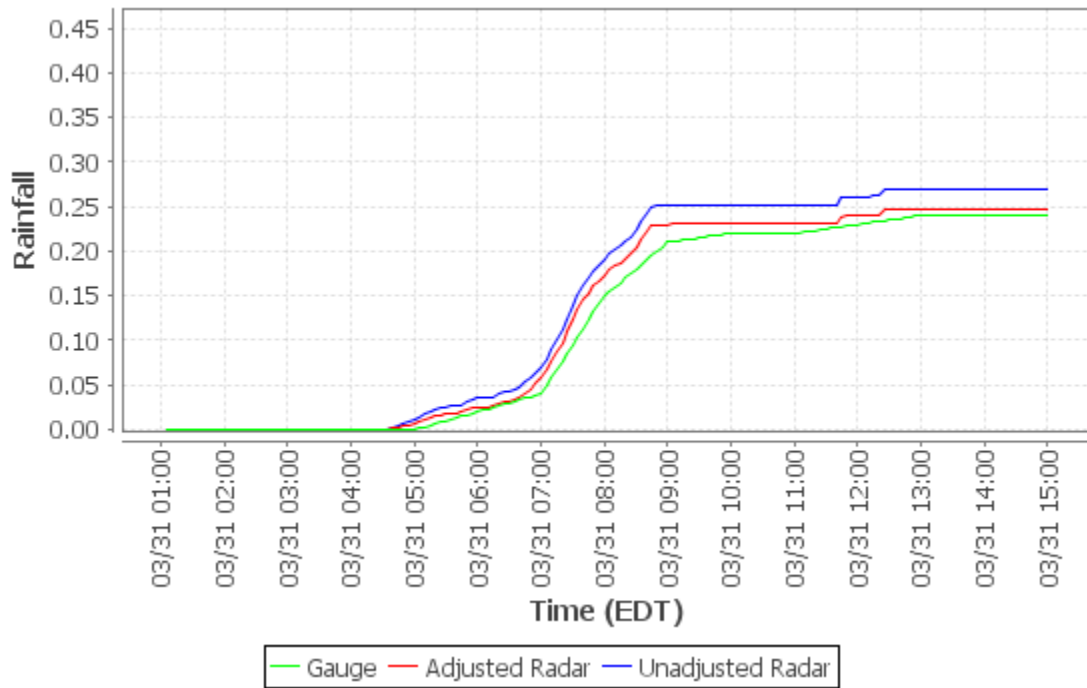
**Cumulative Distribution Plot - Arnold (Loc32)**



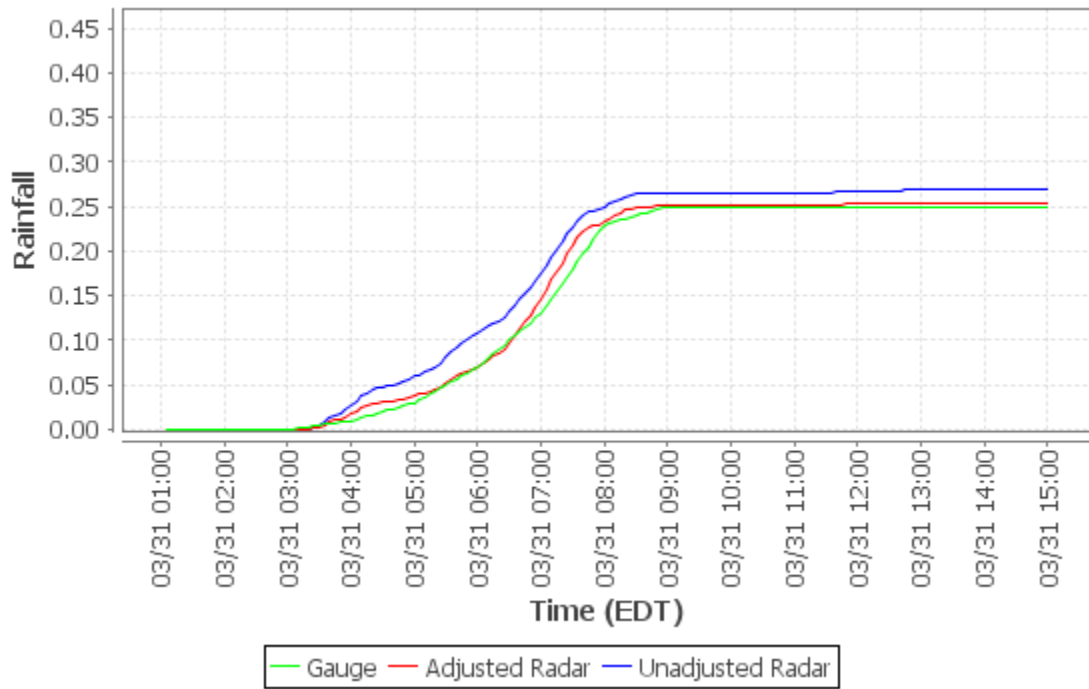
**Cumulative Distribution Plot - Richland TWP (Loc33)**



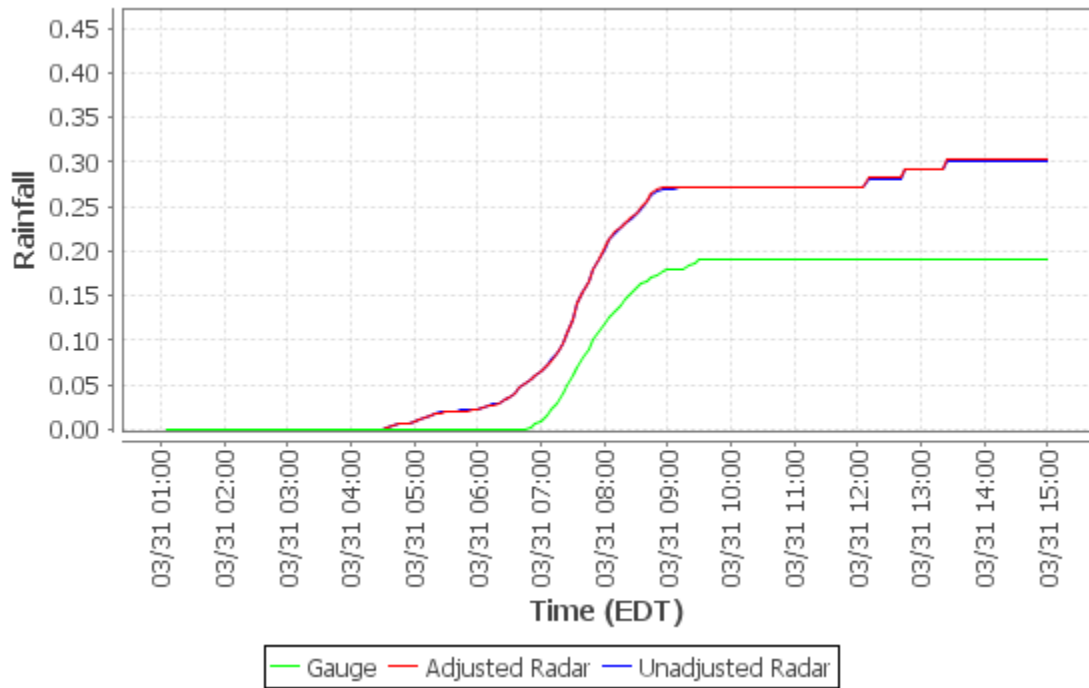
**Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)**



**Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)**



**Cumulative Distribution Plot - Allegheny River at Natrona (03049500)**



**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth  
(03085734)**

