

Radar Rainfall Analysis

April 2020 Summary Report



Improving our region's water quality

Prepared for 3 Rivers Wet Weather

June 1, 2020



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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 (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-km² grid domain shapefile containing 2313 1-km² 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-km² 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-km² 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-km² pixels were achieved using software developed at Vieux.

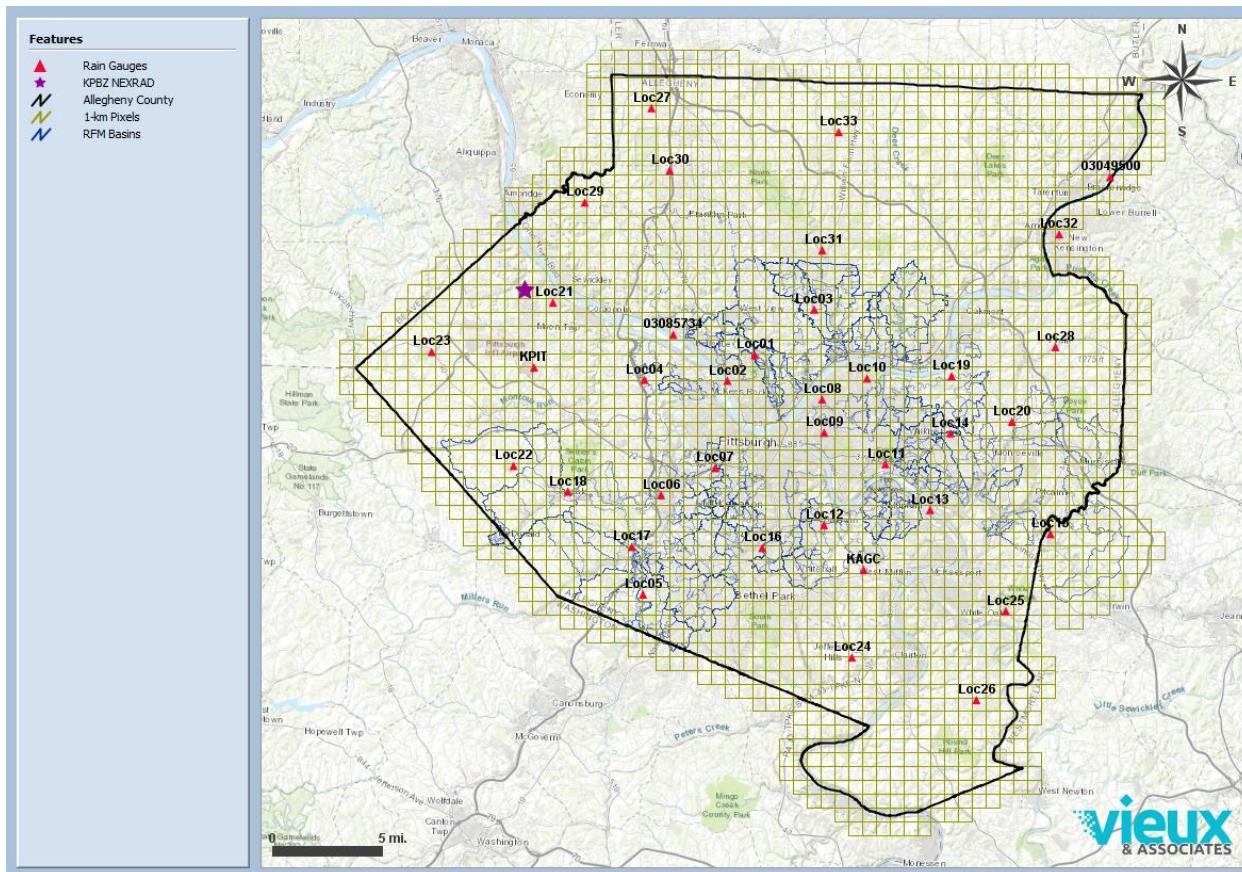


Figure 1. Spatial Distribution of the Rain Gauge Network, KPBZ NEXRAD, RFM Basins and 1-km² Pixels

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-km² 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 2020-04-01 00:00 EDT to 2020-05-01 00:00 EDT. Shapefiles of the 1-km pixels, RFM basins and RFM sheds are located in the Shapefiles subfolder.

1-km² Pixel CSV metadata:

- Individual CSV files are provided for each pixel.
- The pixel filenames use a "Ryyymm_" (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 April 2020 are shown in Figure 2. The rainfall amounts for the 2313 1-km² pixels range from 3.9 to 6.3 inches with a mean of 5.0 inches. The rainfall amounts for the 440 RFM basins range from 4.5 to 5.7 inches with a mean of 5.1 inches. The rainfall amounts for the 871 RFM sheds range from 4.5 to 5.7 inches with a mean of 5.1 inches.

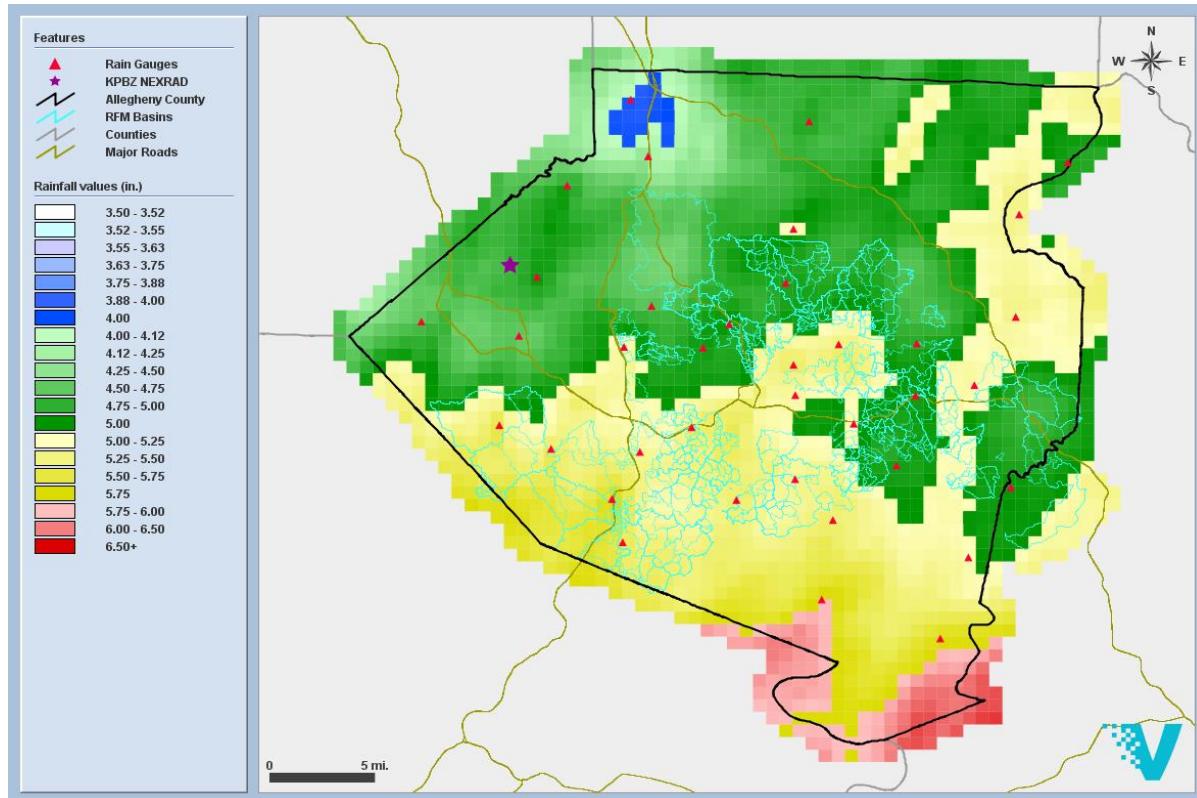


Figure 2. GARR Storm Total for April 2020

GARR was processed continuously at five-minute increments and covers the period from 2020-04-01 00:00 EDT to 2020-05-01 00:00 EDT. Eight rainfall events were identified as having met the storm definition during April 2020. The GARR statistics for each event are listed in Table 2. Eight of the events were split into multiple sub-event periods to improve gauge-adjustment of the radar, resulting in a total of thirty-five 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 eight 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 thirty-five event and sub-event periods, the event CAD averaged 2.0%, indicating that the mean GARR agrees with the mean gauge accumulation to within $\pm 1.0\%$.

Table 2. Storm Events and GARR Statistics

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E1a	KPBZ LII	2020-04-07	2020-04-07 06:05	2020-04-07 10:15	28	0.069	0.815	24.0	2.4
E1b	KPBZ LII	2020-04-07	2020-04-07 10:20	2020-04-07 14:00	13	0.054	0.775	29.5	1.8
E2a	KPBZ LII	2020-04-08	2020-04-07 22:05	2020-04-08 01:45	29	0.190	0.787	32.3	3.8
E2b	KPBZ LII	2020-04-08	2020-04-08 01:50	2020-04-08 03:45	31	0.385	0.756	33.0	0.8
E2c	KPBZ LII	2020-04-08	2020-04-08 03:50	2020-04-08 07:00	8	0.034	0.604	65.8	0.9
E3a	KPBZ LII	2020-04-09	2020-04-08 23:05	2020-04-09 06:00	23	0.137	0.769	30.6	1.3
E3b	Gauge Only	2020-04-09	2020-04-09 06:05	2020-04-09 08:45	30	0.013	---	---	---
E3c	KPBZ LII	2020-04-09	2020-04-09 08:50	2020-04-09 14:00	14	0.052	0.915	20.3	1.8
E4a	KPBZ LII	2020-04-12	2020-04-12 17:05	2020-04-12 22:30	21	0.070	1.221	21.6	4.2
E4b	KPBZ LII	2020-04-12	2020-04-12 22:35	2020-04-13 00:00	33	0.122	0.923	12.0	2.1
E4c	KPBZ LII	2020-04-12	2020-04-13 00:05	2020-04-13 08:00	16	0.065	0.677	50.4	1.1
E5a	KPBZ LII	2020-04-13	2020-04-13 08:05	2020-04-13 10:15	33	0.208	1.176	14.8	1.5
E5b	KPBZ LII	2020-04-13	2020-04-13 10:20	2020-04-13 12:00	32	0.120	1.142	14.0	1.2
E5c	KPBZ LII	2020-04-13	2020-04-13 12:05	2020-04-13 17:00	25	0.081	0.671	49.8	2.9
E6a	KPBZ LII	2020-04-17	2020-04-17 11:05	2020-04-17 16:45	3	0.047	0.536	93.2	1.0
E6b	KPBZ LII	2020-04-17	2020-04-17 16:50	2020-04-17 18:15	30	0.068	0.572	82.5	3.1
E6c	KPBZ LII	2020-04-17	2020-04-17 18:20	2020-04-17 21:30	27	0.263	0.864	26.4	1.5

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E6d	KPBZ LII	2020-04-17	2020-04-17 21:35	2020-04-17 23:15	27	0.138	0.873	17.4	1.7
E6e	KPBZ LII	2020-04-17	2020-04-17 23:20	2020-04-18 01:30	28	0.144	0.677	50.8	2.2
E6f	KPBZ LII	2020-04-17	2020-04-18 01:35	2020-04-18 05:00	25	0.070	0.581	80.2	2.2
E7a	KPBZ LII	2020-04-26	2020-04-25 16:05	2020-04-25 23:00	3	0.020	1.162	15.7	0.1
E7b	KPBZ LII	2020-04-26	2020-04-25 23:05	2020-04-26 03:30	3	0.028	0.688	45.4	0.5
E7c	KPBZ LII	2020-04-26	2020-04-26 03:35	2020-04-26 08:00	26	0.127	1.244	18.6	1.4
E7d	KPBZ LII	2020-04-26	2020-04-26 08:05	2020-04-26 10:15	28	0.242	1.223	18.4	1.3
E7e	KPBZ LII	2020-04-26	2020-04-26 10:20	2020-04-26 11:30	24	0.094	0.580	66.2	3.9
E7f	KPBZ LII	2020-04-26	2020-04-26 11:35	2020-04-26 14:00	28	0.198	1.409	26.6	2.1
E7g	KPBZ LII	2020-04-26	2020-04-26 14:05	2020-04-26 17:00	27	0.276	1.317	24.7	1.7
E7h	KPBZ LII	2020-04-26	2020-04-26 17:05	2020-04-26 18:30	29	0.103	1.100	16.7	1.9
E7i	KPBZ LII	2020-04-26	2020-04-26 18:35	2020-04-27 04:00	24	0.131	0.777	28.0	2.1
E8a	KPBZ LII	2020-04-30	2020-04-29 11:05	2020-04-29 22:00	16	0.056	0.917	18.9	4.3
E8b	KPBZ LII	2020-04-30	2020-04-29 22:05	2020-04-29 23:45	23	0.141	0.995	9.7	2.5
E8c	KPBZ LII	2020-04-30	2020-04-29 23:50	2020-04-30 01:00	27	0.221	1.152	16.8	1.4
E8d	KPBZ LII	2020-04-30	2020-04-30 01:05	2020-04-30 03:00	29	0.150	1.674	39.4	1.4
E8e	KPBZ LII	2020-04-30	2020-04-30 03:05	2020-04-30 05:00	30	0.160	1.193	21.6	2.0
E8f	KPBZ LII	2020-04-30	2020-04-30 05:05	2020-04-30 10:00	32	0.166	0.777	32.1	2.3

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 - J. CDPs are useful for visualizing rain gauge performance. Figure 3 shows the rainfall accumulation at the Moon TWP (Loc21) gauge during the 2020-04-08 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.

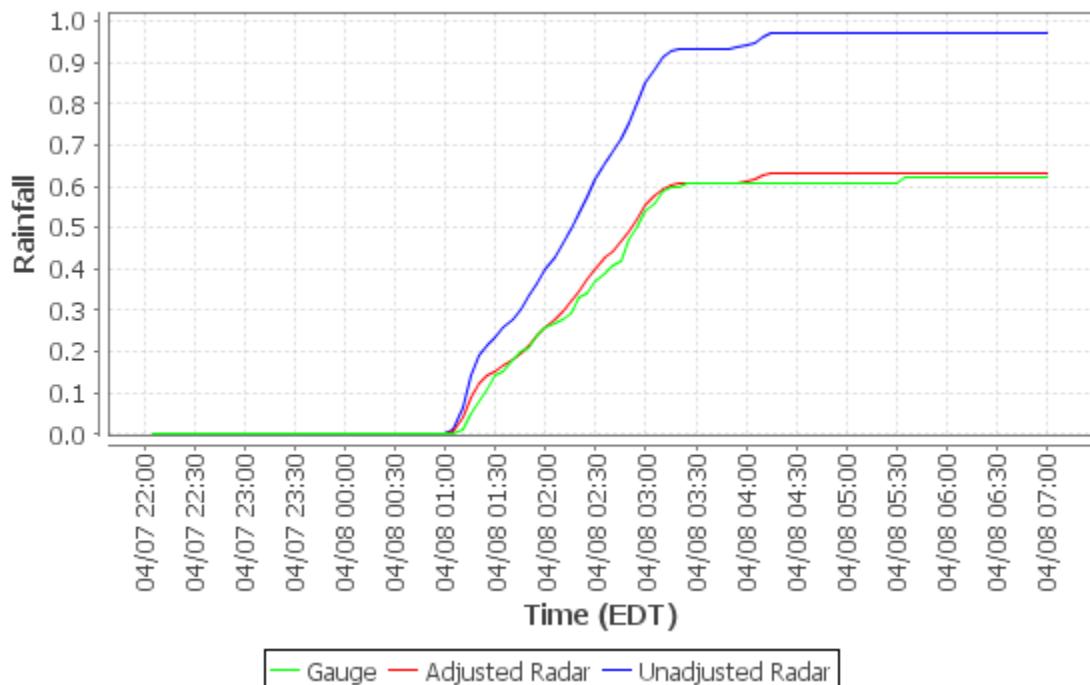


Figure 3. CDP Showing Rain Gauge Versus Unadjusted Radar Versus GARR

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
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>>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<<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: 2020-04-07

The analysis period was from 2020-04-07 06:00 EDT to 2020-04-07 14:00 EDT. The event was then split into two sub-event periods at 2020-04-07 10:15 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.

A convective 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 - 7 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-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.1 - 0.2 inches with a mean of 0.1 inches. The GARR amounts for the 440 RFM basins range from 0.1 - 0.2 inches with a mean of 0.1 inches. The GARR amounts for the 871 RFM sheds range from 0.1 - 0.2 inches with a mean of 0.1 inches. Table 8 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 5. GARR Statistics for Event 1

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E1a	KPBZ LII	2020-04-07	2020-04-07 06:05	2020-04-07 10:15	28	0.069	0.815	24.0	2.4
E1b	KPBZ LII	2020-04-07	2020-04-07 10:20	2020-04-07 14:00	13	0.054	0.775	29.5	1.8

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.11	0.08	-0.01	-14.3	
KPIT	Greater Pittsburgh Int'l	0.10	0.11	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.07	0.09	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc06	Carnegie Transit Time	0.07	0.08	0.07	0.00	0.0	
Loc07	Greentree Munic Bldg	0.08	0.10	0.08	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.10	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.10	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.09	0.07	0.00	0.0	
Loc12	Baldwin	0.06	0.08	0.06	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc13	M-59 Access Shaft	0.08	0.10	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc15	Trafford Maint Bldg	0.06	0.09	0.06	0.00	0.0	
Loc16	Castle Shannon	0.09	0.09	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.09	0.10	0.09	0.00	0.0	
Loc18	Oakdale Pump Station	0.08	0.10	0.08	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.07	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.07	0.05	0.00	0.0	
Loc21	Moon TWP	0.09	0.12	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.11	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.07	0.08	0.07	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.09	0.07	0.00	0.0	
Loc27	Marshall TWP	0.06	0.07	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.08	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.07	0.09	0.07	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.09	0.08	0.01	11.1	
Loc08	AC Health Dept Bldg	0.09	0.11	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	Z
KAGC	Pittsburgh Allegheny Cty	0.05	---	---	---	---	U
Loc01	PWSA-Montana St.	0.06	---	---	---	---	U
Loc05	Upper St. Clair	0.09	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc26	Elizabeth TWP Municipal Bldg	0.04	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.04	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

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

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.11	0.15	0.11	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.06	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.09	0.07	0.00	0.0	
Loc14	Churchill Munic Bldg	0.05	0.07	0.05	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.09	0.13	0.09	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.11	0.07	0.00	0.0	
Loc27	Marshall TWP	0.11	0.13	0.11	0.00	0.0	
Loc28	Plum Municipal Bldg	0.12	0.15	0.12	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.14	0.14	0.14	0.00	0.0	
Loc30	McCandless Twn Hall	0.11	0.14	0.11	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.14	0.11	0.00	0.0	
Loc32	Arnold	0.12	0.19	0.12	0.00	0.0	
Loc33	Richland TWP	0.10	0.11	0.10	0.00	0.0	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.02	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.05	---	---	---	---	U
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.01	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.02	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.04	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.05	---	---	---	---	MSTT

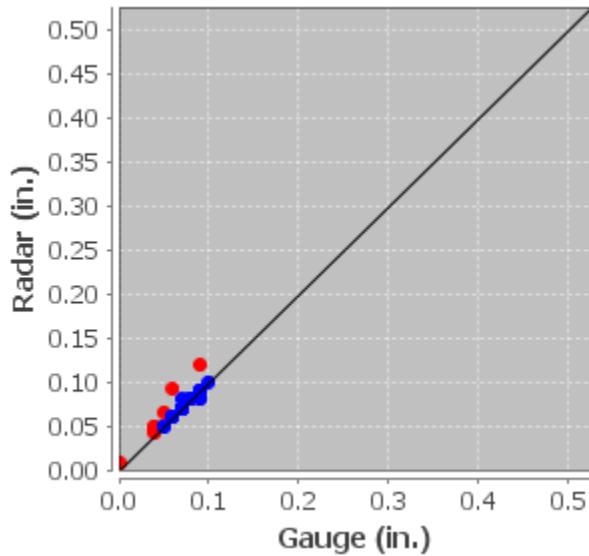


Figure 4. Scatter Plot of RG Pairs for Event 1a

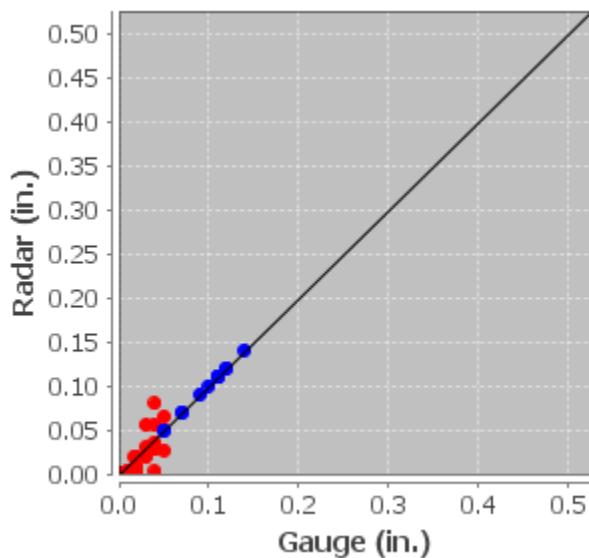


Figure 5. Scatter Plot of RG Pairs for Event 1b

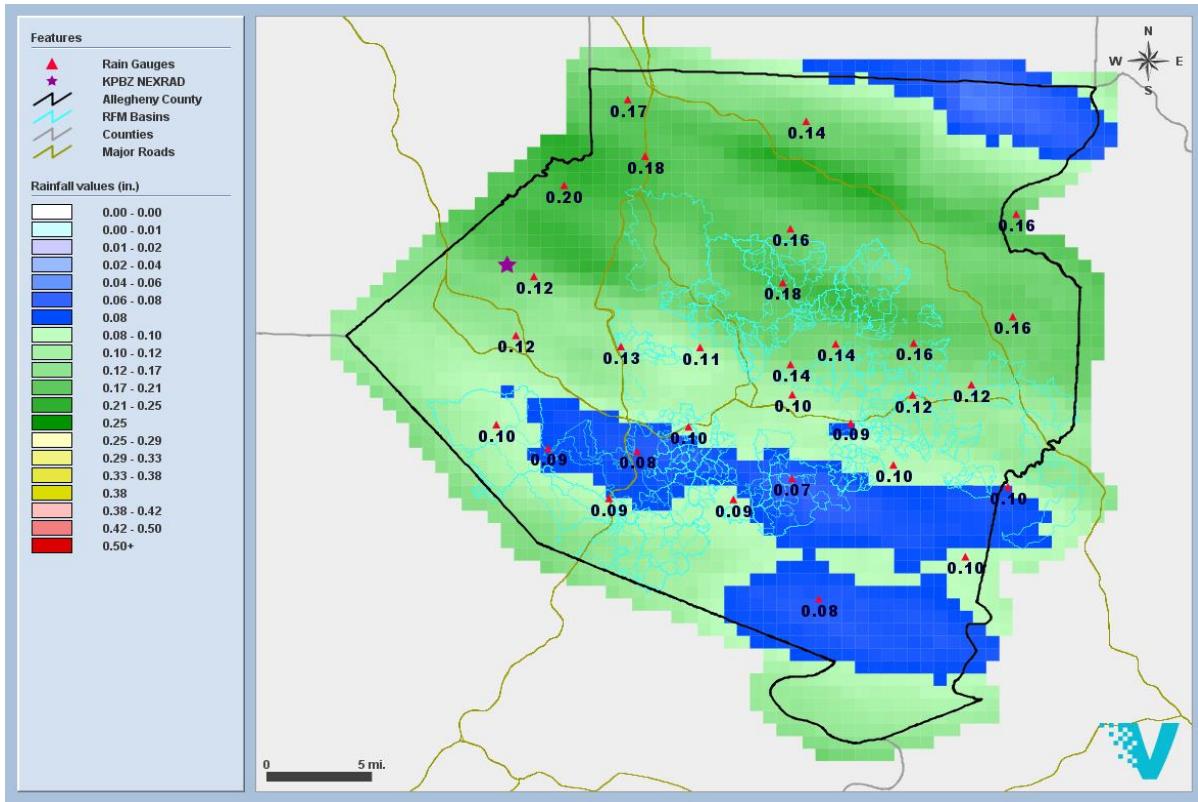


Figure 6. GARR Storm Total for Event 1

Table 8. Depth Duration Frequency Analyses for Event 1

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.067	119139	2020-04-07 09:20	<1 yr.
30 minutes	0.112	119139	2020-04-07 09:30	<1 yr.
1 hour	0.140	131152	2020-04-07 09:55	<1 yr.
2 hour	0.187	151120	2020-04-07 11:40	<1 yr.
3 hour	0.221	151120	2020-04-07 11:50	<1 yr.
6 hour	0.221	151120	2020-04-07 12:00	<1 yr.

Event 2: 2020-04-08

The analysis period was from 2020-04-07 22:00 EDT to 2020-04-08 07:00 EDT. The event was then split into three sub-event periods at 2020-04-08 01:45 EDT and 2020-04-08 03:45 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.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 9 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 10 - 12 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 - 9 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 10 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.4 - 1.0 inches with a mean of 0.6 inches. The GARR amounts for the 440 RFM basins range from 0.5 - 0.7 inches with a mean of 0.6 inches. The GARR amounts for the 871 RFM sheds range from 0.5 - 0.7 inches with a mean of 0.6 inches. Table 13 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 9. 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	2020-04-08	2020-04-07 22:05	2020-04-08 01:45	29	0.190	0.787	32.3	3.8
E2b	KPBZ LII	2020-04-08	2020-04-08 01:50	2020-04-08 03:45	31	0.385	0.756	33.0	0.8
E2c	KPBZ LII	2020-04-08	2020-04-08 03:50	2020-04-08 07:00	8	0.034	0.604	65.8	0.9

Table 10. Summary of Individual RG Pairs for Event 2a

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.20	0.12	-0.02	-20.0	
Loc02	ALCOSAN WWTP Lab	0.10	0.15	0.12	-0.02	-20.0	
Loc30	McCandless Twin Hall	0.16	0.28	0.17	-0.01	-6.3	
Loc03	Shaler Munic Bldg	0.18	0.21	0.19	-0.01	-5.6	
Loc06	Carnegie Transit Time	0.19	0.31	0.20	-0.01	-5.3	
03049500	Allegheny River at Natrona	0.29	0.34	0.29	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.13	0.25	0.13	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.19	0.14	0.00	0.0	
Loc10	PWSA-Highland Park	0.18	0.16	0.18	0.00	0.0	
Loc12	Baldwin	0.15	0.18	0.15	0.00	0.0	
Loc13	M-59 Access Shaft	0.15	0.16	0.15	0.00	0.0	
Loc15	Trafford Maint Bldg	0.12	0.13	0.12	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.18	0.24	0.18	0.00	0.0	
Loc18	Oakdale Pump Station	0.23	0.29	0.23	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.13	0.18	0.13	0.00	0.0	
Loc20	Gascola Eq Facility	0.11	0.17	0.11	0.00	0.0	
Loc22	North Fayette TWP	0.22	0.29	0.22	0.00	0.0	
Loc24	Jefferson Hills	0.13	0.17	0.13	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.11	0.16	0.11	0.00	0.0	
Loc28	Plum Municipal Bldg	0.16	0.16	0.16	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.20	0.28	0.20	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.16	0.17	0.16	0.00	0.0	
Loc32	Arnold	0.22	0.21	0.22	0.00	0.0	
Loc33	Richland TWP	0.30	0.32	0.30	0.00	0.0	
Loc27	Marshall TWP	0.30	0.36	0.29	0.01	3.3	
Loc17	Chartiers Pump Station	0.22	0.27	0.21	0.01	4.5	
Loc21	Moon TWP	0.20	0.30	0.19	0.01	5.0	
Loc04	Kennedy Twp PS	0.16	0.19	0.15	0.01	6.3	
Loc01	PWSA-Montana St.	0.21	0.19	0.18	0.03	14.3	
KAGC	Pittsburgh Allegheny Cty	0.09	---	---	---	---	U
Loc05	Upper St. Clair	0.12	---	---	---	---	U
Loc08	AC Health Dept Bldg	0.06	---	---	---	---	U
Loc09	Univ of Pittsburgh	0.09	---	---	---	---	U
Loc11	M-46 Access Shaft	0.12	---	---	---	---	U
Loc14	Churchill Munic Bldg	0.08	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc26	Elizabeth TWP Municipal Bldg	0.05	---	---	---	---	U

Table 11. Summary of Individual RG Pairs for Event 2b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.36	0.53	0.37	-0.01	-2.8	
KPIT	Greater Pittsburgh Int'l	0.37	0.54	0.37	0.00	0.0	
Loc01	PWSA-Montana St.	0.43	0.58	0.43	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.41	0.55	0.41	0.00	0.0	
Loc03	Shaler Munic Bldg	0.47	0.58	0.47	0.00	0.0	
Loc04	Kennedy Twp PS	0.36	0.55	0.36	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.33	0.45	0.33	0.00	0.0	
Loc07	Greentree Munic Bldg	0.33	0.47	0.33	0.00	0.0	
Loc09	Univ of Pittsburgh	0.34	0.48	0.34	0.00	0.0	
Loc11	M-46 Access Shaft	0.32	0.46	0.32	0.00	0.0	
Loc14	Churchill Munic Bldg	0.35	0.50	0.35	0.00	0.0	
Loc15	Trafford Maint Bldg	0.37	0.44	0.37	0.00	0.0	
Loc16	Castle Shannon	0.31	0.41	0.31	0.00	0.0	
Loc17	Chartiers Pump Station	0.32	0.42	0.32	0.00	0.0	
Loc18	Oakdale Pump Station	0.33	0.43	0.33	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.41	0.56	0.41	0.00	0.0	
Loc20	Gascola Eq Facility	0.36	0.53	0.36	0.00	0.0	
Loc21	Moon TWP	0.41	0.63	0.41	0.00	0.0	
Loc22	North Fayette TWP	0.33	0.45	0.33	0.00	0.0	
Loc24	Jefferson Hills	0.30	0.38	0.30	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.27	0.35	0.27	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.25	0.34	0.25	0.00	0.0	
Loc27	Marshall TWP	0.43	0.51	0.43	0.00	0.0	
Loc28	Plum Municipal Bldg	0.47	0.58	0.47	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.45	0.58	0.45	0.00	0.0	
Loc30	McCandless Twn Hall	0.43	0.53	0.43	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.48	0.56	0.48	0.00	0.0	
Loc32	Arnold	0.49	0.56	0.49	0.00	0.0	
Loc33	Richland TWP	0.43	0.55	0.43	0.00	0.0	
Loc10	PWSA-Highland Park	0.39	0.51	0.38	0.01	2.6	
Loc12	Baldwin	0.35	0.42	0.34	0.01	2.9	
03049500	Allegheny River at Natrona	0.38	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.35	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.26	---	---	---	---	U
Loc05	Upper St. Clair	0.29	---	---	---	---	U
Loc13	M-59 Access Shaft	0.26	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 12. Summary of Individual RG Pairs for Event 2c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.09	0.15	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.09	0.06	0.00	0.0	
Loc16	Castle Shannon	0.05	0.09	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.14	0.08	0.00	0.0	
Loc18	Oakdale Pump Station	0.07	0.11	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.11	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.06	0.12	0.06	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.07	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.06	---	---	---	---	O
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.01	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.01	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.04	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.03	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	S
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT
Loc27	Marshall TWP	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.02	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

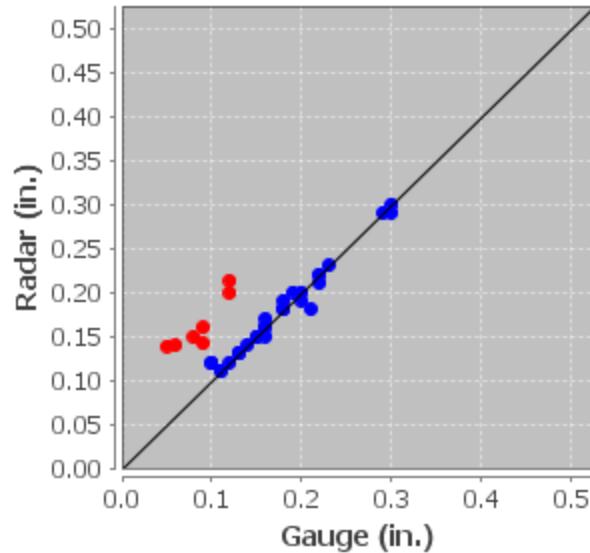


Figure 7. Scatter Plot of RG Pairs for Event 2a

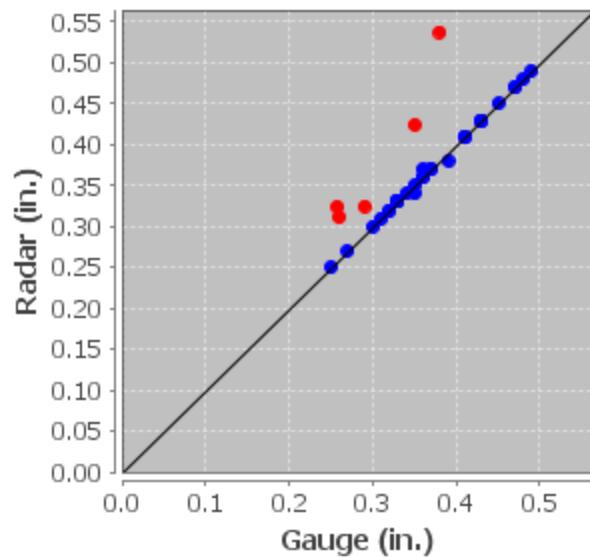


Figure 8. Scatter Plot of RG Pairs for Event 2b

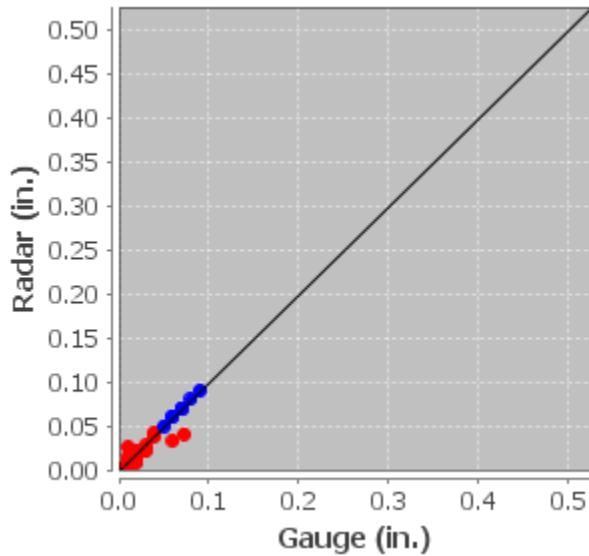


Figure 9. Scatter Plot of RG Pairs for Event 2c

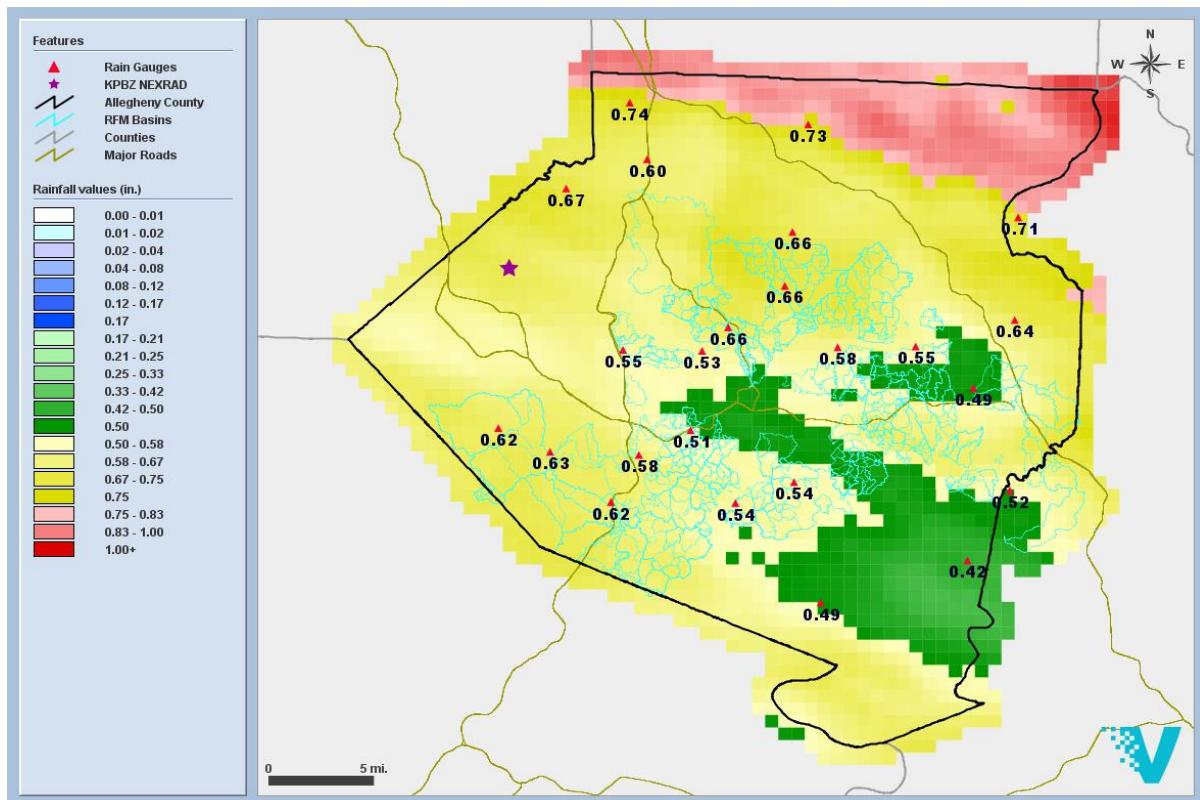


Figure 10. GARR Storm Total for Event 2

Table 13. Depth Duration Frequency Analyses for Event 2

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.266	157117	2020-04-08 01:20	<1 yr.
30 minutes	0.336	156116	2020-04-08 01:35	<1 yr.
1 hour	0.631	174116	2020-04-08 02:15	<1 yr.
2 hour	0.958	174116	2020-04-08 03:05	<1 yr.
3 hour	0.963	174116	2020-04-08 03:10	<1 yr.
6 hour	0.963	174116	2020-04-08 04:00	<1 yr.

Event 3: 2020-04-09

The analysis period was from 2020-04-08 23:00 EDT to 2020-04-09 14:00 EDT. The event was then split into three sub-event periods at 2020-04-09 06:00 EDT and 2020-04-09 08:45 EDT to improve gauge adjustment of the radar. Gauge Only was used during Event 3b 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 14 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 15 - 17 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 11 - 12 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 13 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.0 - 0.5 inches with a mean of 0.2 inches. The GARR amounts for the 440 RFM basins range from 0.1 - 0.4 inches with a mean of 0.2 inches. The GARR amounts for the 871 RFM sheds range from 0.1 - 0.4 inches with a mean of 0.2 inches. Table 18 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 14. 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	2020-04-09	2020-04-08 23:05	2020-04-09 06:00	23	0.137	0.769	30.6	1.3
E3b	Gauge Only	2020-04-09	2020-04-09 06:05	2020-04-09 08:45	30	0.013	---	---	---

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E3c	KPBZ LII	2020-04-09	2020-04-09 08:50	2020-04-09 14:00	14	0.052	0.915	20.3	1.8

Table 15. Summary of Individual RG Pairs for Event 3a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc20	Gascola Eq Facility	0.17	0.26	0.18	-0.01	-5.9	
Loc09	Univ of Pittsburgh	0.19	0.27	0.20	-0.01	-5.3	
KAGC	Pittsburgh Allegheny Cty	0.23	0.30	0.23	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.07	0.11	0.07	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.15	0.11	0.00	0.0	
Loc04	Kennedy Twp PS	0.13	0.14	0.13	0.00	0.0	
Loc05	Upper St. Clair	0.19	0.25	0.19	0.00	0.0	
Loc06	Carnegie Transit Time	0.21	0.26	0.21	0.00	0.0	
Loc07	Greentree Munic Bldg	0.22	0.26	0.22	0.00	0.0	
Loc10	PWSA-Highland Park	0.15	0.17	0.15	0.00	0.0	
Loc12	Baldwin	0.23	0.31	0.23	0.00	0.0	
Loc13	M-59 Access Shaft	0.25	0.32	0.25	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.25	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.21	0.37	0.21	0.00	0.0	
Loc16	Castle Shannon	0.21	0.29	0.21	0.00	0.0	
Loc17	Chartiers Pump Station	0.21	0.27	0.21	0.00	0.0	
Loc18	Oakdale Pump Station	0.23	0.24	0.23	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.14	0.17	0.14	0.00	0.0	
Loc22	North Fayette TWP	0.20	0.22	0.20	0.00	0.0	
Loc24	Jefferson Hills	0.35	0.42	0.35	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.32	0.44	0.32	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.29	0.41	0.29	0.00	0.0	
Loc11	M-46 Access Shaft	0.22	0.26	0.21	0.01	4.5	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.01	---	---	---	---	S
Loc03	Shaler Munic Bldg	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.26	---	---	---	---	O

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.00	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.13	---	---	---	---	OMFB
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.02	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 16. Summary of Individual RG Pairs for Event 3b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.00	---	---	---	---	
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	
Loc04	Kennedy Twp PS	0.00	---	---	---	---	
Loc08	AC Health Dept Bldg	0.00	---	---	---	---	
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	
Loc10	PWSA-Highland Park	0.00	---	---	---	---	
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	
Loc18	Oakdale Pump Station	0.00	---	---	---	---	
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	
Loc22	North Fayette TWP	0.00	---	---	---	---	
Loc27	Marshall TWP	0.00	---	---	---	---	
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	
Loc30	McCandless Twn Hall	0.00	---	---	---	---	
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	
Loc33	Richland TWP	0.00	---	---	---	---	
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	
Loc07	Greentree Munic Bldg	0.01	---	---	---	---	
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	
Loc32	Arnold	0.01	---	---	---	---	
Loc06	Carnegie Transit Time	0.02	---	---	---	---	
Loc16	Castle Shannon	0.02	---	---	---	---	
Loc20	Gascola Eq Facility	0.02	---	---	---	---	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc26	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	
Loc05	Upper St. Clair	0.03	---	---	---	---	
Loc24	Jefferson Hills	0.03	---	---	---	---	
Loc12	Baldwin	0.04	---	---	---	---	
Loc17	Chartiers Pump Station	0.04	---	---	---	---	
Loc13	M-59 Access Shaft	0.05	---	---	---	---	
Loc25	White Oak Public Works Bldg	0.05	---	---	---	---	
Loc11	M-46 Access Shaft	0.06	---	---	---	---	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	T
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	T
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	T
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	T
Loc15	Trafford Maint Bldg	0.09	---	---	---	---	O
Loc21	Moon TWP	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 17. Summary of Individual RG Pairs for Event 3c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.06	0.09	0.06	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.09	0.10	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.06	0.06	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.09	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.09	0.11	0.09	0.00	0.0	
Loc13	M-59 Access Shaft	0.06	0.07	0.06	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.08	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.07	0.06	0.07	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.10	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
Loc27	Marshall TWP	0.10	0.08	0.10	0.00	0.0	
Loc30	McCandless Twn Hall	0.06	0.06	0.06	0.00	0.0	
Loc33	Richland TWP	0.07	0.06	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.10	0.10	0.09	0.01	10.0	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.02	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.03	---	---	---	---	MSTT
Loc21	Moon TWP	ND	---	---	---	---	ND
Loc22	North Fayette TWP	0.02	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT

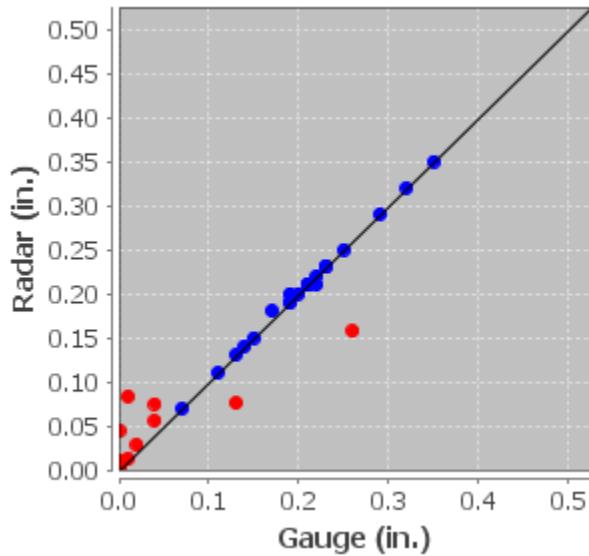


Figure 11. Scatter Plot of RG Pairs for Event 3a

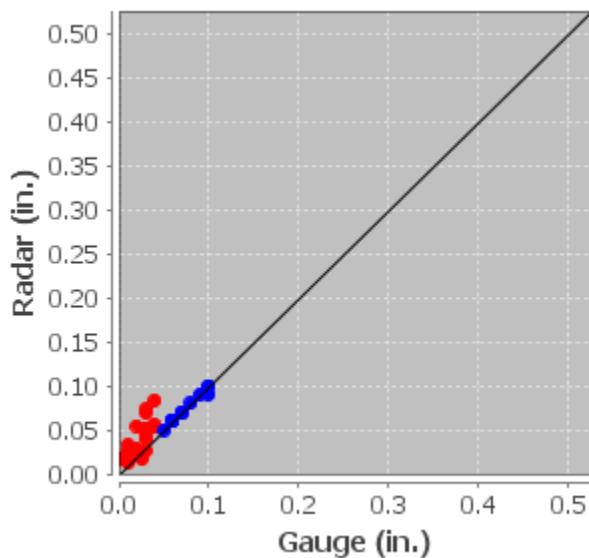


Figure 12. Scatter Plot of RG Pairs for Event 3c

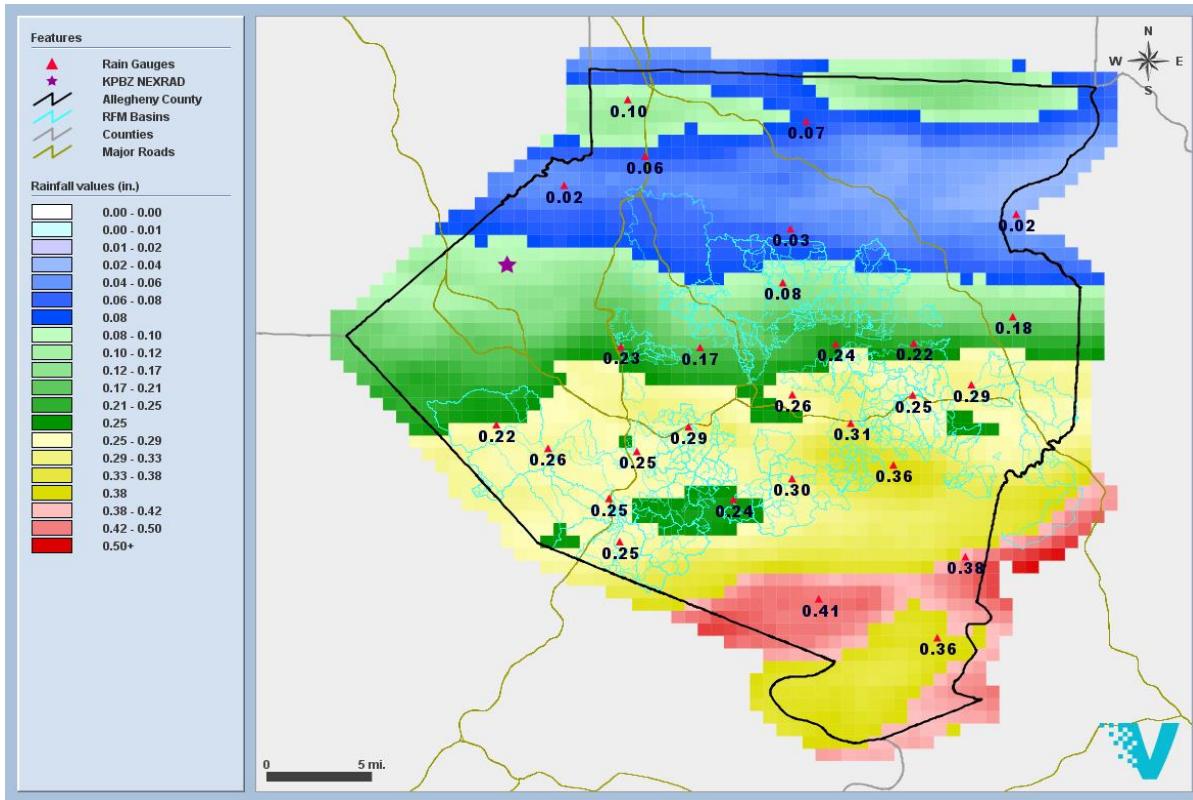


Figure 13. GARR Storm Total for Event 3

Table 18. Depth Duration Frequency Analyses for Event 3

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.130	153167	2020-04-09 03:20	<1 yr.
30 minutes	0.218	166156	2020-04-09 03:30	<1 yr.
1 hour	0.365	168152	2020-04-09 03:25	<1 yr.
2 hour	0.431	168152	2020-04-09 03:40	<1 yr.
3 hour	0.431	168152	2020-04-09 03:40	<1 yr.
6 hour	0.457	168152	2020-04-09 08:15	<1 yr.
12 hour	0.499	168152	2020-04-09 11:00	<1 yr.

Event 4: 2020-04-12

The analysis period was from 2020-04-12 17:00 EDT to 2020-04-13 08:00 EDT. The event was then split into three sub-event periods at 2020-04-12 22:30 EDT and 2020-04-13 00:00 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.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 19 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 20 - 22 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 14 - 16 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 17 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² 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 - 0.3 inches with a mean of 0.3 inches. Table 23 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 19. 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	2020-04-12	2020-04-12 17:05	2020-04-12 22:30	21	0.070	1.221	21.6	4.2
E4b	KPBZ LII	2020-04-12	2020-04-12 22:35	2020-04-13 00:00	33	0.122	0.923	12.0	2.1
E4c	KPBZ LII	2020-04-12	2020-04-13 00:05	2020-04-13 08:00	16	0.065	0.677	50.4	1.1

Table 20. Summary of Individual RG Pairs for Event 4a

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.06	0.06	0.07	-0.01	-16.7	
Loc10	PWSA-Highland Park	0.06	0.08	0.07	-0.01	-16.7	
Loc09	Univ of Pittsburgh	0.10	0.11	0.11	-0.01	-10.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.06	0.08	0.00	0.0	
Loc03	Shaler Munic Bldg	0.06	0.06	0.06	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.06	0.09	0.00	0.0	
Loc05	Upper St. Clair	0.12	0.10	0.12	0.00	0.0	
Loc06	Carnegie Transit Time	0.14	0.11	0.14	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.11	0.14	0.00	0.0	
Loc12	Baldwin	0.07	0.06	0.07	0.00	0.0	
Loc15	Trafford Maint Bldg	0.07	0.06	0.07	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.12	0.10	0.12	0.00	0.0	
Loc17	Chartiers Pump Station	0.14	0.11	0.14	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.09	0.13	0.00	0.0	
Loc21	Moon TWP	0.05	0.05	0.05	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.06	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.07	0.11	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.06	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.06	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.10	0.07	0.09	0.01	10.0	
Loc08	AC Health Dept Bldg	0.14	0.12	0.12	0.02	14.3	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.06	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	U
Loc13	M-59 Access Shaft	0.06	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.06	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.04	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.04	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.06	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.02	---	---	---	---	MSTT
Loc33	Richland TWP	0.03	---	---	---	---	MSTT

Table 21. Summary of Individual RG Pairs for Event 4b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.13	0.15	0.14	-0.01	-7.7	
Loc19	Sandy Creek Eq Facility	0.13	0.15	0.14	-0.01	-7.7	
KAGC	Pittsburgh Allegheny Cty	0.12	0.12	0.12	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.07	0.09	0.07	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.11	0.14	0.11	0.00	0.0	
Loc03	Shaler Munic Bldg	0.15	0.19	0.15	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.11	0.11	0.00	0.0	
Loc05	Upper St. Clair	0.11	0.12	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.11	0.11	0.11	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.14	0.12	0.00	0.0	
Loc10	PWSA-Highland Park	0.15	0.15	0.15	0.00	0.0	
Loc11	M-46 Access Shaft	0.13	0.13	0.13	0.00	0.0	
Loc12	Baldwin	0.12	0.11	0.12	0.00	0.0	
Loc13	M-59 Access Shaft	0.14	0.14	0.14	0.00	0.0	
Loc15	Trafford Maint Bldg	0.10	0.11	0.10	0.00	0.0	
Loc16	Castle Shannon	0.11	0.11	0.11	0.00	0.0	
Loc17	Chartiers Pump Station	0.10	0.10	0.10	0.00	0.0	
Loc18	Oakdale Pump Station	0.08	0.08	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.14	0.15	0.14	0.00	0.0	
Loc21	Moon TWP	0.09	0.12	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.06	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.09	0.11	0.09	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.10	0.12	0.10	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.10	0.10	0.10	0.00	0.0	
Loc27	Marshall TWP	0.12	0.12	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.17	0.18	0.17	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.13	0.11	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.14	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.17	0.21	0.17	0.00	0.0	
Loc32	Arnold	0.14	0.17	0.14	0.00	0.0	
Loc33	Richland TWP	0.19	0.19	0.19	0.00	0.0	
Loc14	Churchill Munic Bldg	0.18	0.16	0.17	0.01	5.6	
Loc09	Univ of Pittsburgh	0.14	0.13	0.13	0.01	7.1	
03049500	Allegheny River at Natrona	0.13	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.08	---	---	---	---	U
Loc01	PWSA-Montana St.	0.10	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 22. Summary of Individual RG Pairs for Event 4c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.05	0.08	0.05	0.00	0.0	
Loc09	Univ of Pittsburgh	0.05	0.05	0.05	0.00	0.0	
Loc12	Baldwin	0.05	0.06	0.05	0.00	0.0	
Loc14	Churchill Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.07	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.06	0.07	0.06	0.00	0.0	
Loc21	Moon TWP	0.05	0.10	0.05	0.00	0.0	
Loc22	North Fayette TWP	0.08	0.07	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.07	0.05	0.00	0.0	
Loc27	Marshall TWP	0.09	0.13	0.09	0.00	0.0	
Loc28	Plum Municipal Bldg	0.05	0.09	0.05	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.09	0.14	0.09	0.00	0.0	
Loc30	McCandless Twn Hall	0.08	0.15	0.08	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.12	0.07	0.00	0.0	
Loc32	Arnold	0.06	0.10	0.06	0.00	0.0	
Loc33	Richland TWP	0.14	0.20	0.14	0.00	0.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.04	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.04	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT

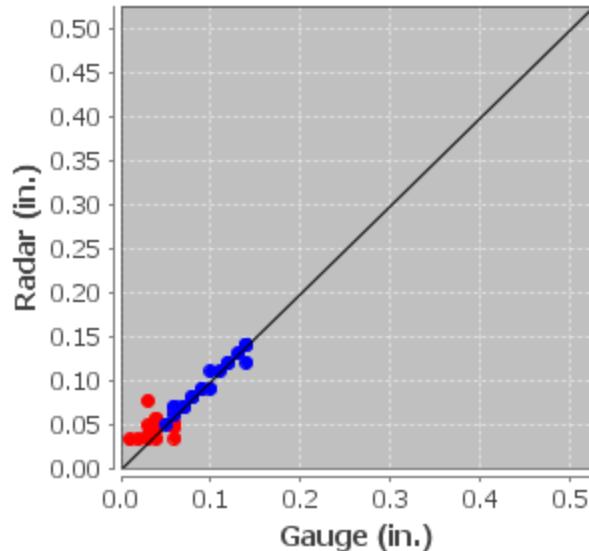


Figure 14. Scatter Plot of RG Pairs for Event 4a

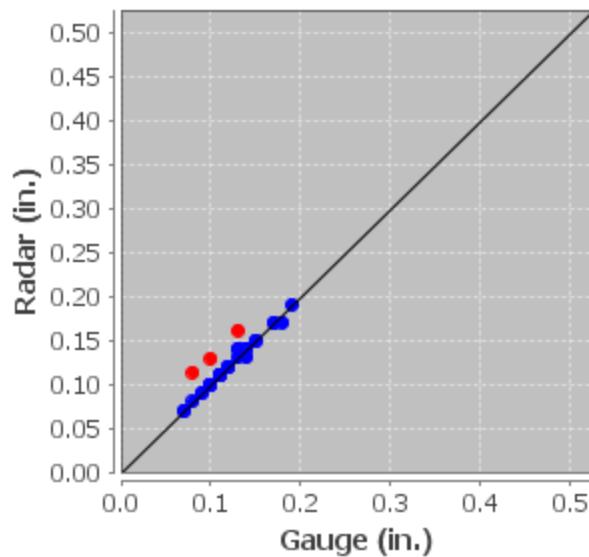


Figure 15. Scatter Plot of RG Pairs for Event 4b

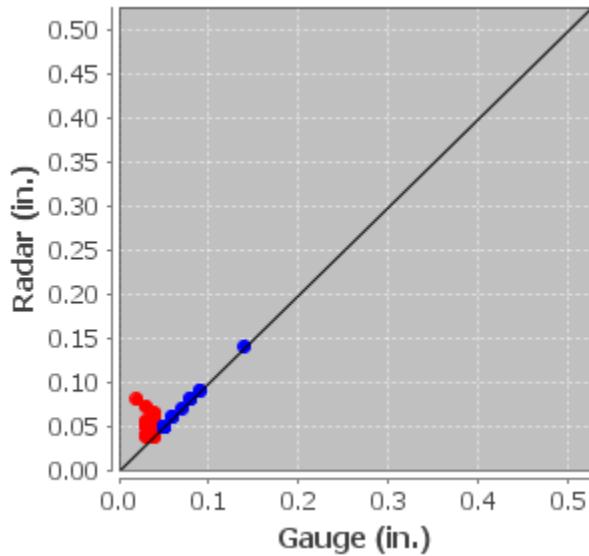


Figure 16. Scatter Plot of RG Pairs for Event 4c

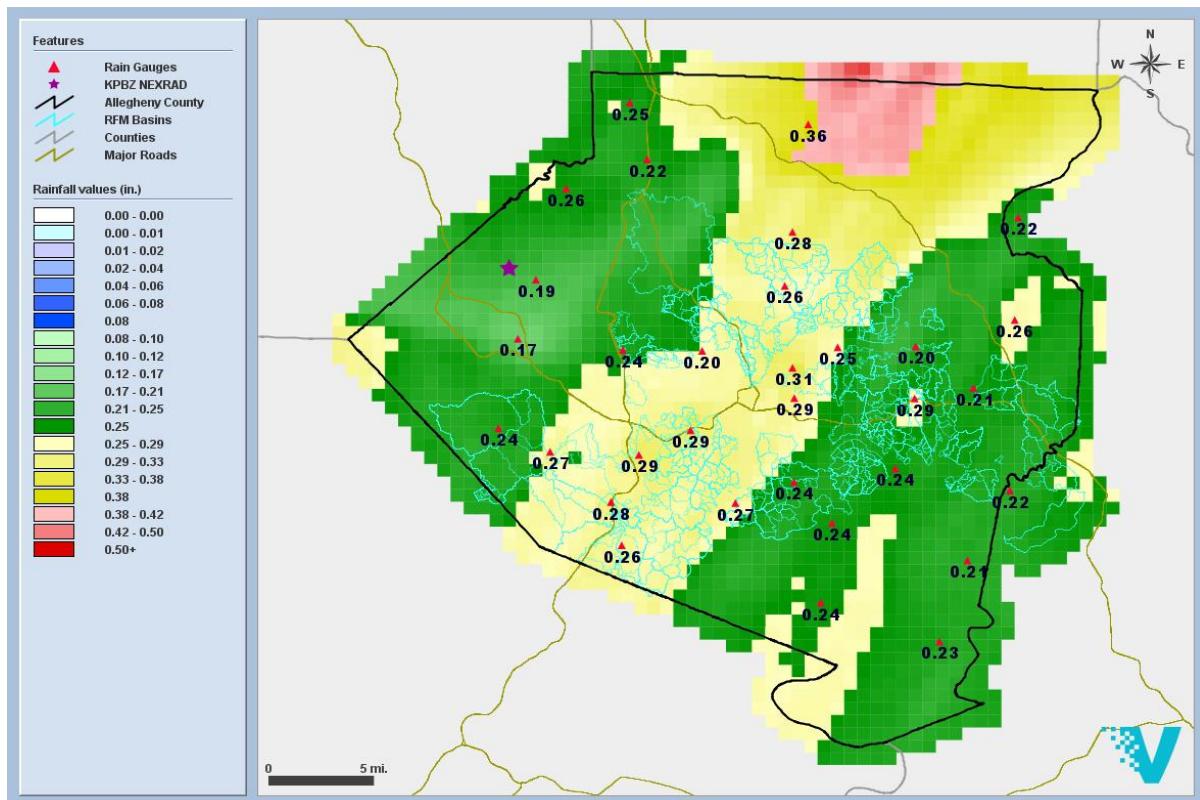


Figure 17. GARR Storm Total for Event 4

Table 23. Depth Duration Frequency Analyses for Event 4

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.104	150136	2020-04-12 22:35	<1 yr.
30 minutes	0.152	150136	2020-04-12 22:45	<1 yr.
1 hour	0.224	158119	2020-04-12 23:25	<1 yr.
2 hour	0.282	158119	2020-04-13 00:05	<1 yr.
3 hour	0.399	155112	2020-04-13 01:30	<1 yr.
6 hour	0.454	155112	2020-04-13 01:55	<1 yr.
12 hour	0.463	155112	2020-04-13 06:25	<1 yr.

Event 5: 2020-04-13

The analysis period was from 2020-04-13 08:00 EDT to 2020-04-13 17:00 EDT. The event was then split into three sub-event periods at 2020-04-13 10:15 EDT and 2020-04-13 12:00 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.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 24 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 25 - 27 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 18 - 20 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 21 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.2 - 0.6 inches with a mean of 0.4 inches. The GARR amounts for the 440 RFM basins range from 0.3 - 0.6 inches with a mean of 0.4 inches. The GARR amounts for the 871 RFM sheds range from 0.2 - 0.6 inches with a mean of 0.4 inches. Table 28 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 24. GARR Statistics for Event 5

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E5a	KPBZ LII	2020-04-13	2020-04-13 08:05	2020-04-13 10:15	33	0.208	1.176	14.8	1.5
E5b	KPBZ LII	2020-04-13	2020-04-13 10:20	2020-04-13 12:00	32	0.120	1.142	14.0	1.2

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E5c	KPBZ LII	2020-04-13	2020-04-13 12:05	2020-04-13 17:00	25	0.081	0.671	49.8	2.9

Table 25. Summary of Individual RG Pairs for Event 5a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc12	Baldwin	0.18	0.16	0.19	-0.01	-5.6	
Loc30	McCandless Twn Hall	0.18	0.18	0.19	-0.01	-5.6	
Loc14	Churchill Munic Bldg	0.19	0.19	0.20	-0.01	-5.3	
Loc09	Univ of Pittsburgh	0.22	0.20	0.23	-0.01	-4.5	
03049500	Allegheny River at Natrona	0.27	0.24	0.27	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.22	0.18	0.22	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.17	0.15	0.17	0.00	0.0	
Loc04	Kennedy Twp PS	0.26	0.21	0.26	0.00	0.0	
Loc05	Upper St. Clair	0.15	0.13	0.15	0.00	0.0	
Loc06	Carnegie Transit Time	0.15	0.12	0.15	0.00	0.0	
Loc07	Greentree Munic Bldg	0.20	0.16	0.20	0.00	0.0	
Loc08	AC Health Dept Bldg	0.26	0.23	0.26	0.00	0.0	
Loc11	M-46 Access Shaft	0.19	0.18	0.19	0.00	0.0	
Loc13	M-59 Access Shaft	0.19	0.18	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.22	0.17	0.22	0.00	0.0	
Loc16	Castle Shannon	0.15	0.14	0.15	0.00	0.0	
Loc17	Chartiers Pump Station	0.20	0.17	0.20	0.00	0.0	
Loc18	Oakdale Pump Station	0.22	0.18	0.22	0.00	0.0	
Loc20	Gascola Eq Facility	0.21	0.19	0.21	0.00	0.0	
Loc21	Moon TWP	0.33	0.32	0.33	0.00	0.0	
Loc24	Jefferson Hills	0.20	0.13	0.20	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.17	0.15	0.17	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.29	0.21	0.29	0.00	0.0	
Loc28	Plum Municipal Bldg	0.25	0.22	0.25	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.21	0.20	0.21	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.27	0.23	0.27	0.00	0.0	
Loc32	Arnold	0.28	0.26	0.28	0.00	0.0	
Loc33	Richland TWP	0.24	0.18	0.24	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc22	North Fayette TWP	0.35	0.25	0.34	0.01	2.9	
Loc10	PWSA-Highland Park	0.30	0.25	0.29	0.01	3.3	
KAGC	Pittsburgh Allegheny Cty	0.19	0.13	0.18	0.01	5.3	
Loc19	Sandy Creek Eq Facility	0.19	0.15	0.18	0.01	5.3	
Loc27	Marshall TWP	0.19	0.15	0.18	0.01	5.3	
KPIT	Greater Pittsburgh Int'l	0.22	---	---	---	---	U
Loc01	PWSA-Montana St.	0.13	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.11	---	---	---	---	C
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 26. Summary of Individual RG Pairs for Event 5b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.12	0.12	0.13	-0.01	-8.3	
03049500	Allegheny River at Natrona	0.13	0.12	0.13	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.06	0.06	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.14	0.13	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.07	0.08	0.07	0.00	0.0	
Loc05	Upper St. Clair	0.17	0.14	0.17	0.00	0.0	
Loc06	Carnegie Transit Time	0.09	0.07	0.09	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.11	0.14	0.00	0.0	
Loc08	AC Health Dept Bldg	0.14	0.15	0.14	0.00	0.0	
Loc09	Univ of Pittsburgh	0.23	0.23	0.23	0.00	0.0	
Loc10	PWSA-Highland Park	0.15	0.15	0.15	0.00	0.0	
Loc11	M-46 Access Shaft	0.14	0.13	0.14	0.00	0.0	
Loc12	Baldwin	0.13	0.13	0.13	0.00	0.0	
Loc13	M-59 Access Shaft	0.16	0.15	0.16	0.00	0.0	
Loc15	Trafford Maint Bldg	0.08	0.06	0.08	0.00	0.0	
Loc16	Castle Shannon	0.12	0.13	0.12	0.00	0.0	
Loc17	Chartiers Pump Station	0.11	0.09	0.11	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.11	0.13	0.00	0.0	
Loc20	Gascola Eq Facility	0.17	0.14	0.17	0.00	0.0	
Loc21	Moon TWP	0.09	0.08	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.13	0.11	0.13	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.15	0.10	0.15	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.09	0.07	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.12	0.08	0.12	0.00	0.0	
Loc27	Marshall TWP	0.19	0.17	0.19	0.00	0.0	
Loc28	Plum Municipal Bldg	0.17	0.13	0.17	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.14	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.15	0.13	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.10	0.11	0.00	0.0	
Loc32	Arnold	0.18	0.14	0.18	0.00	0.0	
Loc33	Richland TWP	0.13	0.09	0.13	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.19	0.16	0.18	0.01	5.3	
KAGC	Pittsburgh Allegheny Cty	0.18	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.14	---	---	---	---	O
Loc01	PWSA-Montana St.	0.09	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.15	---	---	---	---	C
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 27. Summary of Individual RG Pairs for Event 5c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.08	0.13	0.09	-0.01	-12.5	
Loc16	Castle Shannon	0.08	0.10	0.09	-0.01	-12.5	
Loc08	AC Health Dept Bldg	0.13	0.29	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.08	0.15	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.12	0.16	0.12	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.12	0.24	0.12	0.00	0.0	
Loc12	Baldwin	0.08	0.06	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.12	0.23	0.12	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.05	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.10	0.08	0.00	0.0	
Loc18	Oakdale Pump Station	0.07	0.05	0.07	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.18	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.17	0.31	0.17	0.00	0.0	
Loc21	Moon TWP	0.07	0.10	0.07	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.10	0.13	0.10	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.10	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.12	0.13	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.06	0.13	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.12	0.15	0.12	0.00	0.0	
Loc30	McCandless Twn Hall	0.13	0.14	0.13	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.18	0.13	0.00	0.0	
Loc32	Arnold	0.10	0.12	0.10	0.00	0.0	
Loc33	Richland TWP	0.05	0.05	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.14	0.23	0.13	0.01	7.1	
Loc04	Kennedy Twp PS	0.13	0.18	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.06	---	---	---	---	U
Loc01	PWSA-Montana St.	0.06	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.14	---	---	---	---	C
Loc06	Carnegie Transit Time	0.05	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.01	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.02	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT

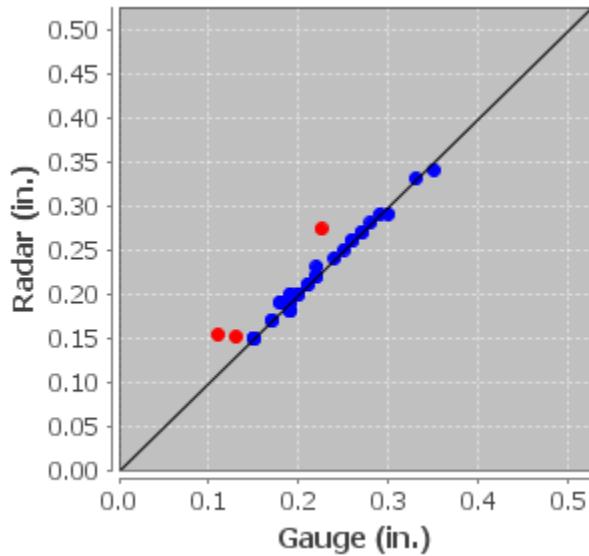


Figure 18. Scatter Plot of RG Pairs for Event 5a

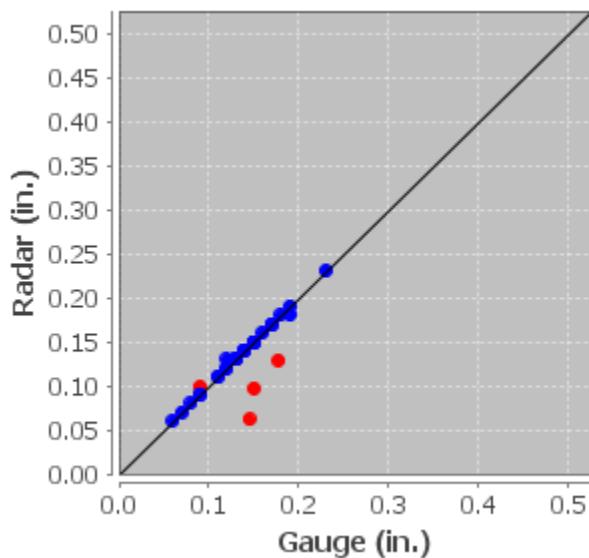


Figure 19. Scatter Plot of RG Pairs for Event 5b

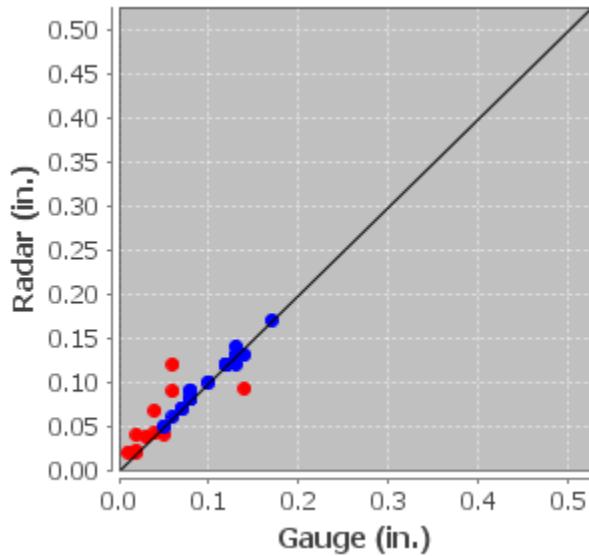


Figure 20. Scatter Plot of RG Pairs for Event 5c

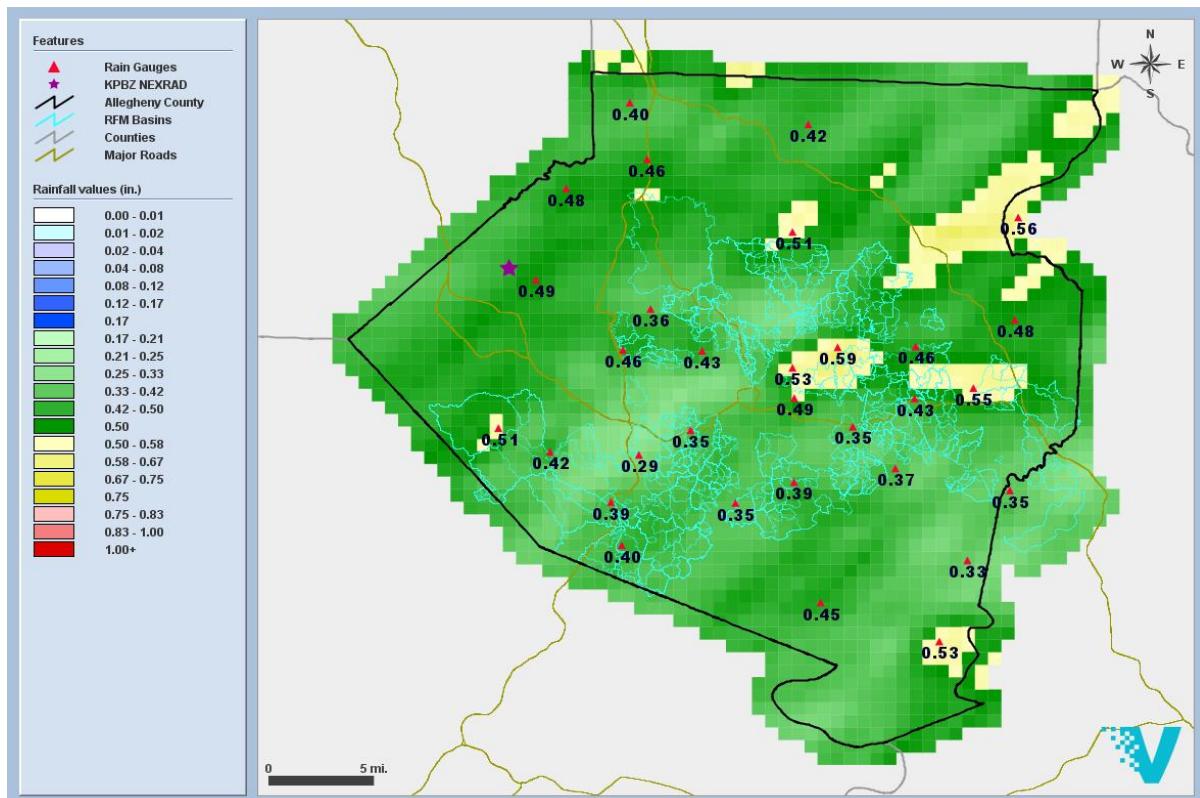


Figure 21. GARR Storm Total for Event 5

Table 28. Depth Duration Frequency Analyses for Event 5

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.189	130129	2020-04-13 09:45	<1 yr.
30 minutes	0.266	130129	2020-04-13 10:00	<1 yr.
1 hour	0.353	125140	2020-04-13 10:10	<1 yr.
2 hour	0.463	127141	2020-04-13 11:00	<1 yr.
3 hour	0.541	161125	2020-04-13 12:40	<1 yr.
6 hour	0.622	153135	2020-04-13 14:00	<1 yr.

Event 6: 2020-04-17

The analysis period was from 2020-04-17 11:00 EDT to 2020-04-18 05:00 EDT. The event was then split into six sub-event periods at 2020-04-17 16:45 EDT, 2020-04-17 18:15 EDT, 2020-04-17 21:30 EDT, 2020-04-17 23:15 EDT and 2020-04-18 01:30 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 29 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 30 - 35 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 22 - 27 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 28 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.4 - 1.0 inches with a mean of 0.7 inches. The GARR amounts for the 440 RFM basins range from 0.6 - 0.9 inches with a mean of 0.8 inches. The GARR amounts for the 871 RFM sheds range from 0.6 - 0.9 inches with a mean of 0.8 inches. Table 36 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 29. GARR Statistics for Event 6

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E6a	KPBZ LII	2020-04-17	2020-04-17 11:05	2020-04-17 16:45	3	0.047	0.536	93.2	1.0
E6b	KPBZ LII	2020-04-17	2020-04-17 16:50	2020-04-17 18:15	30	0.068	0.572	82.5	3.1

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E6c	KPBZ LII	2020-04-17	2020-04-17 18:20	2020-04-17 21:30	27	0.263	0.864	26.4	1.5
E6d	KPBZ LII	2020-04-17	2020-04-17 21:35	2020-04-17 23:15	27	0.138	0.873	17.4	1.7
E6e	KPBZ LII	2020-04-17	2020-04-17 23:20	2020-04-18 01:30	28	0.144	0.677	50.8	2.2
E6f	KPBZ LII	2020-04-17	2020-04-18 01:35	2020-04-18 05:00	25	0.070	0.581	80.2	2.2

Table 30. Summary of Individual RG Pairs for Event 6a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc29	Bell Acres Munic Bldg	0.07	0.10	0.07	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.12	0.05	0.00	0.0	
Loc33	Richland TWP	0.05	0.10	0.05	0.00	0.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.02	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.03	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	C
Loc04	Kennedy Twp PS	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.01	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.01	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.01	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.01	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.01	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	ND
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.01	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc21	Moon TWP	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.02	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.03	---	---	---	---	MSTT

Table 31. Summary of Individual RG Pairs for Event 6b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.05	0.14	0.06	-0.01	-20.0	
Loc09	Univ of Pittsburgh	0.06	0.13	0.07	-0.01	-16.7	
03049500	Allegheny River at Natrona	0.08	0.09	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.09	0.08	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.09	0.12	0.09	0.00	0.0	
Loc04	Kennedy Twp PS	0.08	0.10	0.08	0.00	0.0	
Loc05	Upper St. Clair	0.06	0.13	0.06	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.11	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.12	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.09	0.14	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.15	0.06	0.00	0.0	
Loc12	Baldwin	0.05	0.15	0.05	0.00	0.0	
Loc13	M-59 Access Shaft	0.05	0.15	0.05	0.00	0.0	
Loc16	Castle Shannon	0.06	0.14	0.06	0.00	0.0	
Loc17	Chartiers Pump Station	0.06	0.12	0.06	0.00	0.0	
Loc18	Oakdale Pump Station	0.06	0.11	0.06	0.00	0.0	
Loc20	Gascola Eq Facility	0.06	0.13	0.06	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.07	0.08	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.10	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.09	0.17	0.09	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.08	0.12	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.12	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.08	0.12	0.08	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
Loc32	Arnold	0.11	0.12	0.11	0.00	0.0	
Loc33	Richland TWP	0.05	0.09	0.05	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.16	0.07	0.01	12.5	
Loc08	AC Health Dept Bldg	0.08	0.13	0.07	0.01	12.5	
Loc19	Sandy Creek Eq Facility	0.08	0.14	0.07	0.01	12.5	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	---	---	---	---	U
Loc01	PWSA-Montana St.	0.05	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.07	---	---	---	---	C
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.04	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT

Table 32. Summary of Individual RG Pairs for Event 6c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc20	Gascola Eq Facility	0.20	0.38	0.21	-0.01	-5.0	
KAGC	Pittsburgh Allegheny Cty	0.22	0.36	0.23	-0.01	-4.5	
Loc13	M-59 Access Shaft	0.22	0.37	0.23	-0.01	-4.5	
KPIT	Greater Pittsburgh Int'l	0.24	0.26	0.25	-0.01	-4.2	
Loc17	Chartiers Pump Station	0.27	0.25	0.28	-0.01	-3.7	
Loc07	Greentree Munic Bldg	0.31	0.28	0.32	-0.01	-3.2	
Loc02	ALCOSAN WWTP Lab	0.29	0.28	0.29	0.00	0.0	
Loc04	Kennedy Twp PS	0.25	0.27	0.25	0.00	0.0	
Loc08	AC Health Dept Bldg	0.29	0.29	0.29	0.00	0.0	
Loc10	PWSA-Highland Park	0.28	0.30	0.28	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.23	0.31	0.23	0.00	0.0	
Loc14	Churchill Munic Bldg	0.23	0.36	0.23	0.00	0.0	
Loc18	Oakdale Pump Station	0.34	0.27	0.34	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.25	0.37	0.25	0.00	0.0	
Loc22	North Fayette TWP	0.32	0.27	0.32	0.00	0.0	
Loc24	Jefferson Hills	0.25	0.35	0.25	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.22	0.38	0.22	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.21	0.34	0.21	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.26	0.26	0.26	0.00	0.0	
Loc30	McCandless Twn Hall	0.22	0.24	0.22	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.30	0.28	0.30	0.00	0.0	
Loc32	Arnold	0.33	0.38	0.33	0.00	0.0	
Loc33	Richland TWP	0.25	0.28	0.25	0.00	0.0	
Loc06	Carnegie Transit Time	0.33	0.27	0.32	0.01	3.0	
Loc21	Moon TWP	0.32	0.29	0.31	0.01	3.1	
Loc09	Univ of Pittsburgh	0.28	0.28	0.27	0.01	3.6	
Loc12	Baldwin	0.22	0.27	0.21	0.01	4.5	
03049500	Allegheny River at Natrona	0.20	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.21	---	---	---	---	U
Loc01	PWSA-Montana St.	0.20	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.25	---	---	---	---	C
Loc05	Upper St. Clair	0.20	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.19	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.05	---	---	---	---	U
Loc28	Plum Municipal Bldg	0.36	---	---	---	---	O

Table 33. Summary of Individual RG Pairs for Event 6d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.13	0.20	0.14	-0.01	-7.7	
KPIT	Greater Pittsburgh Int'l	0.12	0.11	0.12	0.00	0.0	
Loc01	PWSA-Montana St.	0.11	0.12	0.11	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.11	0.12	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.16	0.17	0.16	0.00	0.0	
Loc07	Greentree Munic Bldg	0.17	0.17	0.17	0.00	0.0	
Loc08	AC Health Dept Bldg	0.13	0.16	0.13	0.00	0.0	
Loc10	PWSA-Highland Park	0.13	0.17	0.13	0.00	0.0	
Loc11	M-46 Access Shaft	0.16	0.19	0.16	0.00	0.0	
Loc12	Baldwin	0.15	0.19	0.15	0.00	0.0	
Loc16	Castle Shannon	0.15	0.18	0.15	0.00	0.0	
Loc17	Chartiers Pump Station	0.18	0.18	0.18	0.00	0.0	
Loc18	Oakdale Pump Station	0.17	0.15	0.17	0.00	0.0	
Loc20	Gascola Eq Facility	0.17	0.21	0.17	0.00	0.0	
Loc21	Moon TWP	0.10	0.10	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.15	0.15	0.15	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.21	0.15	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.13	0.21	0.13	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.19	0.21	0.19	0.00	0.0	
Loc28	Plum Municipal Bldg	0.18	0.21	0.18	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.10	0.11	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.10	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.10	0.11	0.10	0.00	0.0	
Loc33	Richland TWP	0.10	0.15	0.10	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.20	0.18	0.01	5.3	
Loc09	Univ of Pittsburgh	0.16	0.18	0.15	0.01	6.3	
Loc02	ALCOSAN WWTP Lab	0.13	0.13	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.08	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.11	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.07	---	---	---	---	C
Loc05	Upper St. Clair	0.11	---	---	---	---	U
Loc13	M-59 Access Shaft	0.12	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	Z
Loc32	Arnold	0.10	---	---	---	---	OAD

Table 34. Summary of Individual RG Pairs for Event 6e

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.13	0.24	0.15	-0.02	-15.4	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	0.20	0.12	-0.01	-9.1	
Loc19	Sandy Creek Eq Facility	0.14	0.27	0.15	-0.01	-7.1	
KPIT	Greater Pittsburgh Int'l	0.14	0.19	0.14	0.00	0.0	
Loc01	PWSA-Montana St.	0.13	0.21	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.13	0.20	0.13	0.00	0.0	
Loc06	Carnegie Transit Time	0.16	0.20	0.16	0.00	0.0	
Loc07	Greentree Munic Bldg	0.16	0.21	0.16	0.00	0.0	
Loc11	M-46 Access Shaft	0.19	0.26	0.19	0.00	0.0	
Loc12	Baldwin	0.17	0.26	0.17	0.00	0.0	
Loc16	Castle Shannon	0.17	0.25	0.17	0.00	0.0	
Loc17	Chartiers Pump Station	0.17	0.20	0.17	0.00	0.0	
Loc18	Oakdale Pump Station	0.15	0.19	0.15	0.00	0.0	
Loc20	Gascola Eq Facility	0.19	0.27	0.19	0.00	0.0	
Loc21	Moon TWP	0.11	0.17	0.11	0.00	0.0	
Loc22	North Fayette TWP	0.14	0.18	0.14	0.00	0.0	
Loc24	Jefferson Hills	0.20	0.27	0.20	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.18	0.27	0.18	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.22	0.27	0.22	0.00	0.0	
Loc28	Plum Municipal Bldg	0.18	0.26	0.18	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.10	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.09	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.23	0.13	0.00	0.0	
Loc32	Arnold	0.12	0.26	0.12	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.27	0.18	0.01	5.3	
Loc09	Univ of Pittsburgh	0.17	0.25	0.16	0.01	5.9	
Loc10	PWSA-Highland Park	0.17	0.25	0.16	0.01	5.9	
Loc04	Kennedy Twp PS	0.14	0.20	0.13	0.01	7.1	
03049500	Allegheny River at Natrona	0.08	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.15	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.08	---	---	---	---	C
Loc05	Upper St. Clair	0.15	---	---	---	---	U
Loc13	M-59 Access Shaft	0.14	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.00	---	---	---	---	Z
Loc33	Richland TWP	0.07	---	---	---	---	OAD

Table 35. Summary of Individual RG Pairs for Event 6f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.05	0.15	0.06	-0.01	-20.0	
KPIT	Greater Pittsburgh Int'l	0.06	0.08	0.07	-0.01	-16.7	
KAGC	Pittsburgh Allegheny Cty	0.09	0.15	0.09	0.00	0.0	
Loc01	PWSA-Montana St.	0.09	0.15	0.09	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.08	0.13	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.11	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.10	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.07	0.13	0.07	0.00	0.0	
Loc08	AC Health Dept Bldg	0.06	0.14	0.06	0.00	0.0	
Loc10	PWSA-Highland Park	0.06	0.14	0.06	0.00	0.0	
Loc11	M-46 Access Shaft	0.05	0.15	0.05	0.00	0.0	
Loc12	Baldwin	0.08	0.15	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.15	0.07	0.00	0.0	
Loc16	Castle Shannon	0.09	0.15	0.09	0.00	0.0	
Loc18	Oakdale Pump Station	0.06	0.08	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.14	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.14	0.07	0.00	0.0	
Loc21	Moon TWP	0.08	0.07	0.08	0.00	0.0	
Loc22	North Fayette TWP	0.06	0.08	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.06	0.14	0.06	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.15	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.09	0.14	0.09	0.00	0.0	
Loc28	Plum Municipal Bldg	0.12	0.13	0.12	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.13	0.08	0.00	0.0	
Loc32	Arnold	0.10	0.12	0.10	0.00	0.0	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.10	---	---	---	---	C

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.05	---	---	---	---	U
Loc13	M-59 Access Shaft	0.04	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc17	Chartiers Pump Station	0.04	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	Z
Loc29	Bell Acres Munic Bldg	0.03	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

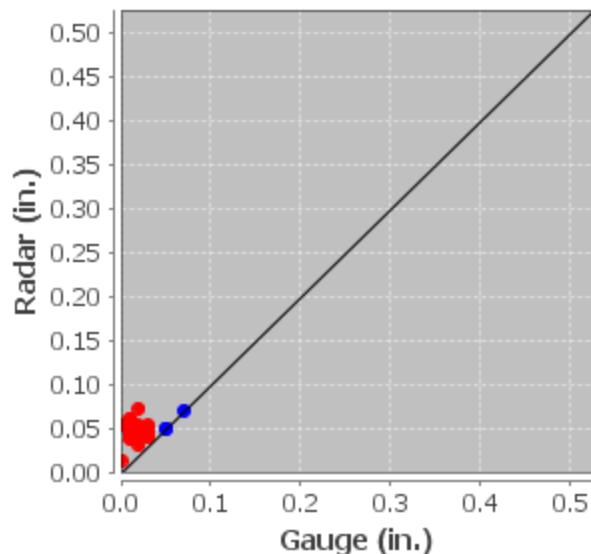


Figure 22. Scatter Plot of RG Pairs for Event 6a

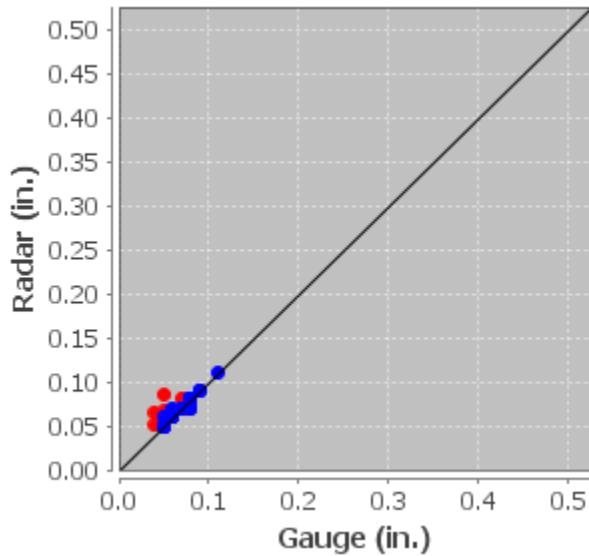


Figure 23. Scatter Plot of RG Pairs for Event 6b

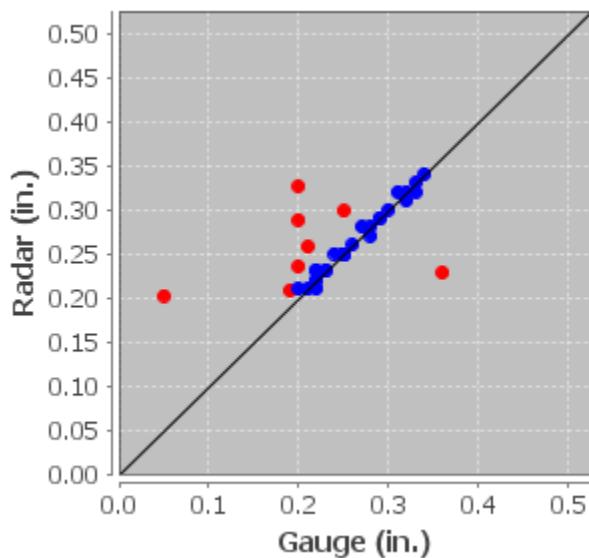


Figure 24. Scatter Plot of RG Pairs for Event 6c

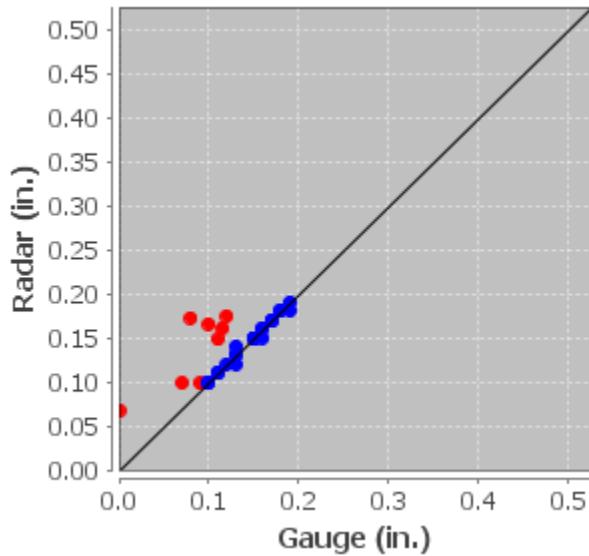


Figure 25. Scatter Plot of RG Pairs for Event 6d

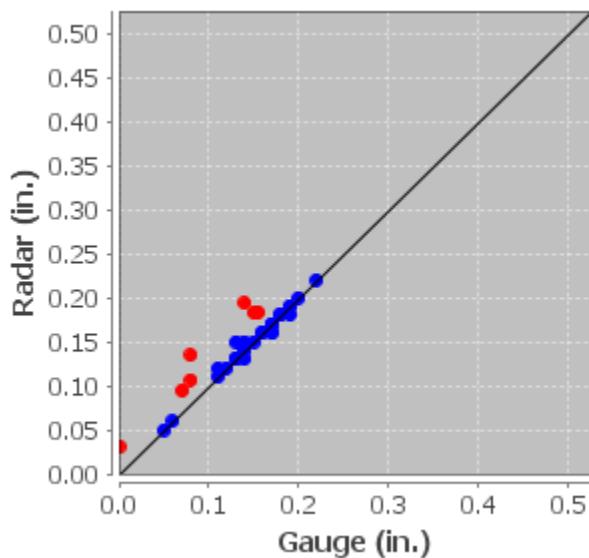


Figure 26. Scatter Plot of RG Pairs for Event 6e

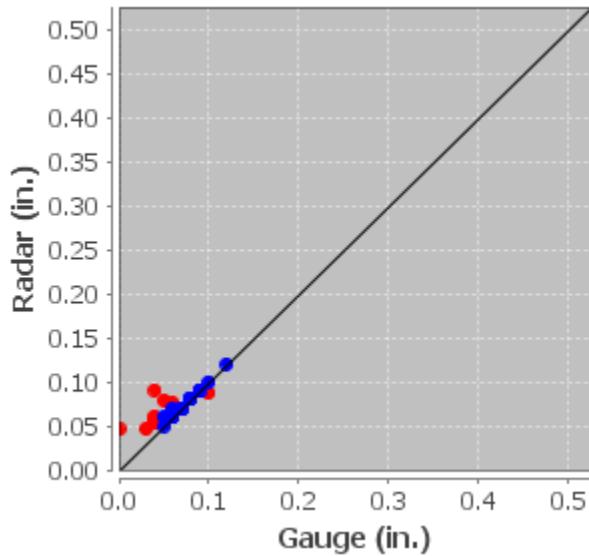


Figure 27. Scatter Plot of RG Pairs for Event 6f

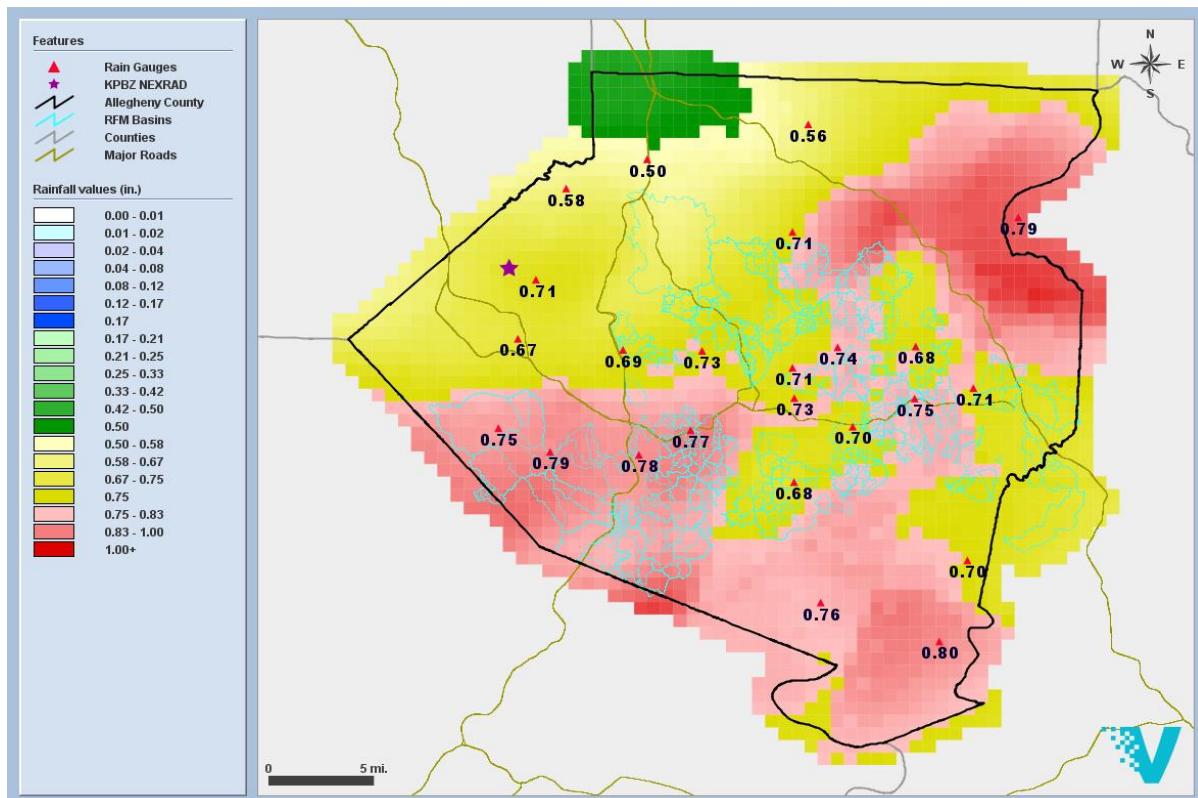


Figure 28. GARR Storm Total for Event 6

Table 36. Depth Duration Frequency Analyses for Event 6

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.038	135146	2020-04-17 21:50	<1 yr.
30 minutes	0.069	140145	2020-04-17 20:35	<1 yr.
1 hour	0.132	155124	2020-04-17 20:25	<1 yr.
2 hour	0.258	157123	2020-04-17 20:55	<1 yr.
3 hour	0.371	157124	2020-04-17 21:10	<1 yr.
6 hour	0.627	157124	2020-04-17 23:35	<1 yr.
12 hour	0.945	168130	2020-04-18 02:45	<1 yr.

Event 7: 2020-04-26

The analysis period was from 2020-04-25 16:00 EDT to 2020-04-27 04:00 EDT. The event was then split into nine sub-event periods at 2020-04-25 23:00 EDT, 2020-04-26 03:30 EDT, 2020-04-26 08:00 EDT, 2020-04-26 10:15 EDT, 2020-04-26 11:30 EDT, 2020-04-26 14:00 EDT, 2020-04-26 17:00 EDT and 2020-04-26 18:30 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 37 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 38 - 46 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 29 - 37 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 38 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.6 - 1.9 inches with a mean of 1.2 inches. The GARR amounts for the 440 RFM basins range from 1.0 - 1.7 inches with a mean of 1.3 inches. The GARR amounts for the 871 RFM sheds range from 1.0 - 1.7 inches with a mean of 1.3 inches. Table 47 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 37. GARR Statistics for Event 7

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E7a	KPBZ LII	2020-04-26	2020-04-25 16:05	2020-04-25 23:00	3	0.020	1.162	15.7	0.1
E7b	KPBZ LII	2020-04-26	2020-04-25 23:05	2020-04-26 03:30	3	0.028	0.688	45.4	0.5
E7c	KPBZ LII	2020-04-26	2020-04-26 03:35	2020-04-26 08:00	26	0.127	1.244	18.6	1.4
E7d	KPBZ LII	2020-04-26	2020-04-26 08:05	2020-04-26 10:15	28	0.242	1.223	18.4	1.3
E7e	KPBZ LII	2020-04-26	2020-04-26 10:20	2020-04-26 11:30	24	0.094	0.580	66.2	3.9
E7f	KPBZ LII	2020-04-26	2020-04-26 11:35	2020-04-26 14:00	28	0.198	1.409	26.6	2.1
E7g	KPBZ LII	2020-04-26	2020-04-26 14:05	2020-04-26 17:00	27	0.276	1.317	24.7	1.7
E7h	KPBZ LII	2020-04-26	2020-04-26 17:05	2020-04-26 18:30	29	0.103	1.100	16.7	1.9
E7i	KPBZ LII	2020-04-26	2020-04-26 18:35	2020-04-27 04:00	24	0.131	0.777	28.0	2.1

Table 38. Summary of Individual RG Pairs for Event 7a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.14	0.11	0.14	0.00	0.0	
Loc22	North Fayette TWP	0.15	0.12	0.15	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.12	0.11	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.04	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.00	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc07	Greentree Munic Bldg	0.00	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.00	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.00	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.02	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 39. Summary of Individual RG Pairs for Event 7b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.05	0.07	0.05	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.08	0.05	0.00	0.0	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	Z
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	C
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.02	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.02	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.04	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.04	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	MSTT
Loc27	Marshall TWP	0.04	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.03	---	---	---	---	MSTT
Loc33	Richland TWP	0.03	---	---	---	---	MSTT

Table 40. Summary of Individual RG Pairs for Event 7c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc22	North Fayette TWP	0.10	0.10	0.11	-0.01	-10.0	
KAGC	Pittsburgh Allegheny Cty	0.12	0.09	0.13	-0.01	-8.3	
Loc01	PWSA-Montana St.	0.14	0.13	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.13	0.10	0.13	0.00	0.0	
Loc06	Carnegie Transit Time	0.15	0.11	0.15	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.12	0.14	0.00	0.0	
Loc08	AC Health Dept Bldg	0.13	0.11	0.13	0.00	0.0	
Loc09	Univ of Pittsburgh	0.13	0.11	0.13	0.00	0.0	
Loc12	Baldwin	0.13	0.10	0.13	0.00	0.0	
Loc16	Castle Shannon	0.12	0.11	0.12	0.00	0.0	
Loc17	Chartiers Pump Station	0.16	0.11	0.16	0.00	0.0	
Loc18	Oakdale Pump Station	0.14	0.11	0.14	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.12	0.09	0.12	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.07	0.08	0.00	0.0	
Loc21	Moon TWP	0.11	0.10	0.11	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.12	0.15	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.12	0.11	0.12	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.15	0.12	0.15	0.00	0.0	
Loc28	Plum Municipal Bldg	0.06	0.05	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.09	0.11	0.00	0.0	
Loc30	McCandless Twn Hall	0.09	0.08	0.09	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.14	0.11	0.14	0.00	0.0	
Loc32	Arnold	0.12	0.10	0.12	0.00	0.0	
Loc33	Richland TWP	0.18	0.11	0.18	0.00	0.0	
Loc10	PWSA-Highland Park	0.15	0.11	0.14	0.01	6.7	
Loc14	Churchill Munic Bldg	0.14	0.09	0.13	0.01	7.1	
03049500	Allegheny River at Natrona	0.07	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	Z
Loc02	ALCOSAN WWTP Lab	0.10	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.17	---	---	---	---	C
Loc05	Upper St. Clair	0.13	---	---	---	---	U
Loc11	M-46 Access Shaft	0.10	---	---	---	---	U
Loc13	M-59 Access Shaft	0.11	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.05	---	---	---	---	U

Table 41. Summary of Individual RG Pairs for Event 7d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.21	0.18	0.22	-0.01	-4.8	
KAGC	Pittsburgh Allegheny Cty	0.23	0.17	0.24	-0.01	-4.3	
Loc08	AC Health Dept Bldg	0.23	0.20	0.24	-0.01	-4.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.25	0.25	0.26	-0.01	-4.0	
Loc01	PWSA-Montana St.	0.26	0.23	0.26	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.26	0.24	0.26	0.00	0.0	
Loc07	Greentree Munic Bldg	0.22	0.21	0.22	0.00	0.0	
Loc09	Univ of Pittsburgh	0.24	0.20	0.24	0.00	0.0	
Loc12	Baldwin	0.27	0.19	0.27	0.00	0.0	
Loc14	Churchill Munic Bldg	0.21	0.16	0.21	0.00	0.0	
Loc16	Castle Shannon	0.23	0.18	0.23	0.00	0.0	
Loc17	Chartiers Pump Station	0.29	0.24	0.29	0.00	0.0	
Loc18	Oakdale Pump Station	0.29	0.23	0.29	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.21	0.17	0.21	0.00	0.0	
Loc20	Gascola Eq Facility	0.25	0.19	0.25	0.00	0.0	
Loc21	Moon TWP	0.26	0.27	0.26	0.00	0.0	
Loc24	Jefferson Hills	0.25	0.17	0.25	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.27	0.17	0.27	0.00	0.0	
Loc27	Marshall TWP	0.20	0.18	0.20	0.00	0.0	
Loc28	Plum Municipal Bldg	0.20	0.17	0.20	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.25	0.23	0.25	0.00	0.0	
Loc30	McCandless Twn Hall	0.21	0.20	0.21	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.24	0.18	0.24	0.00	0.0	
Loc32	Arnold	0.18	0.13	0.18	0.00	0.0	
Loc33	Richland TWP	0.25	0.17	0.25	0.00	0.0	
Loc04	Kennedy Twp PS	0.28	0.24	0.27	0.01	3.6	
Loc10	PWSA-Highland Park	0.25	0.19	0.24	0.01	4.0	
Loc13	M-59 Access Shaft	0.24	0.17	0.23	0.01	4.2	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
03049500	Allegheny River at Natrona	0.13	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	Z
Loc03	Shaler Munic Bldg	0.15	---	---	---	---	C
Loc05	Upper St. Clair	0.20	---	---	---	---	U
Loc06	Carnegie Transit Time	0.35	---	---	---	---	O
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc22	North Fayette TWP	0.21	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc26	Elizabeth TWP Municipal Bldg	0.34	---	---	---	---	O

Table 42. Summary of Individual RG Pairs for Event 7e

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.07	0.08	0.08	-0.01	-14.3	
Loc20	Gascola Eq Facility	0.07	0.13	0.08	-0.01	-14.3	
Loc22	North Fayette TWP	0.07	0.19	0.08	-0.01	-14.3	
Loc01	PWSA-Montana St.	0.12	0.21	0.13	-0.01	-8.3	
Loc02	ALCOSAN WWTP Lab	0.12	0.19	0.12	0.00	0.0	
Loc04	Kennedy Twp PS	0.13	0.23	0.13	0.00	0.0	
Loc05	Upper St. Clair	0.06	0.07	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc10	PWSA-Highland Park	0.10	0.10	0.10	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.08	0.06	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.09	0.07	0.00	0.0	
Loc16	Castle Shannon	0.05	0.07	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.09	0.08	0.00	0.0	
Loc18	Oakdale Pump Station	0.09	0.15	0.09	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.12	0.08	0.00	0.0	
Loc21	Moon TWP	0.13	0.36	0.13	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.16	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.20	0.43	0.20	0.00	0.0	
Loc30	McCandless Twn Hall	0.15	0.36	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.16	0.27	0.16	0.00	0.0	
Loc32	Arnold	0.13	0.24	0.13	0.00	0.0	
Loc33	Richland TWP	0.17	0.33	0.17	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.10	0.09	0.09	0.01	10.0	
Loc09	Univ of Pittsburgh	0.08	0.06	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.12	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.08	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	Z
Loc03	Shaler Munic Bldg	0.09	---	---	---	---	C
Loc12	Baldwin	0.07	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.05	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.08	---	---	---	---	MSTT
Loc27	Marshall TWP	0.12	---	---	---	---	U

Table 43. Summary of Individual RG Pairs for Event 7f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc22	North Fayette TWP	0.13	0.12	0.14	-0.01	-7.7	
Loc11	M-46 Access Shaft	0.18	0.15	0.19	-0.01	-5.6	
Loc14	Churchill Munic Bldg	0.18	0.16	0.19	-0.01	-5.6	
Loc06	Carnegie Transit Time	0.22	0.18	0.23	-0.01	-4.5	
Loc12	Baldwin	0.27	0.20	0.28	-0.01	-3.7	
KAGC	Pittsburgh Allegheny Cty	0.33	0.21	0.33	0.00	0.0	
Loc01	PWSA-Montana St.	0.16	0.15	0.16	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.16	0.14	0.16	0.00	0.0	
Loc04	Kennedy Twp PS	0.19	0.13	0.19	0.00	0.0	
Loc07	Greentree Munic Bldg	0.19	0.17	0.19	0.00	0.0	
Loc09	Univ of Pittsburgh	0.19	0.13	0.19	0.00	0.0	
Loc10	PWSA-Highland Park	0.16	0.11	0.16	0.00	0.0	
Loc16	Castle Shannon	0.27	0.21	0.27	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.18	0.14	0.18	0.00	0.0	
Loc21	Moon TWP	0.16	0.15	0.16	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.48	0.24	0.48	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.20	0.13	0.20	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.22	0.11	0.22	0.00	0.0	
Loc28	Plum Municipal Bldg	0.18	0.13	0.18	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.26	0.22	0.26	0.00	0.0	
Loc30	McCandless Twn Hall	0.13	0.13	0.13	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.25	0.16	0.25	0.00	0.0	
Loc32	Arnold	0.19	0.10	0.19	0.00	0.0	
Loc33	Richland TWP	0.13	0.07	0.13	0.00	0.0	
Loc13	M-59 Access Shaft	0.29	0.18	0.28	0.01	3.4	
Loc20	Gascola Eq Facility	0.27	0.17	0.26	0.01	3.7	
Loc17	Chartiers Pump Station	0.24	0.16	0.23	0.01	4.2	
Loc18	Oakdale Pump Station	0.20	0.13	0.19	0.01	5.0	
03049500	Allegheny River at Natrona	0.09	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.13	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.11	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.13	---	---	---	---	C
Loc05	Upper St. Clair	0.25	---	---	---	---	U
Loc08	AC Health Dept Bldg	0.13	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.05	---	---	---	---	S

Table 44. Summary of Individual RG Pairs for Event 7g

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.21	0.20	0.22	-0.01	-4.8	
Loc01	PWSA-Montana St.	0.30	0.22	0.31	-0.01	-3.3	
Loc16	Castle Shannon	0.32	0.25	0.33	-0.01	-3.1	
Loc10	PWSA-Highland Park	0.33	0.25	0.34	-0.01	-3.0	
Loc14	Churchill Munic Bldg	0.33	0.30	0.34	-0.01	-3.0	
Loc05	Upper St. Clair	0.35	0.29	0.36	-0.01	-2.9	
Loc11	M-46 Access Shaft	0.34	0.30	0.35	-0.01	-2.9	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc22	North Fayette TWP	0.35	0.28	0.36	-0.01	-2.9	
Loc06	Carnegie Transit Time	0.36	0.30	0.37	-0.01	-2.8	
Loc07	Greentree Munic Bldg	0.39	0.30	0.39	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.27	0.24	0.27	0.00	0.0	
Loc20	Gascola Eq Facility	0.35	0.29	0.35	0.00	0.0	
Loc21	Moon TWP	0.27	0.16	0.27	0.00	0.0	
Loc24	Jefferson Hills	0.44	0.29	0.44	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.42	0.31	0.42	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.39	0.32	0.39	0.00	0.0	
Loc28	Plum Municipal Bldg	0.31	0.24	0.31	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.09	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.09	0.05	0.09	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.17	0.12	0.17	0.00	0.0	
Loc32	Arnold	0.16	0.08	0.16	0.00	0.0	
Loc17	Chartiers Pump Station	0.45	0.34	0.44	0.01	2.2	
Loc08	AC Health Dept Bldg	0.43	0.28	0.42	0.01	2.3	
Loc12	Baldwin	0.41	0.28	0.40	0.01	2.4	
Loc18	Oakdale Pump Station	0.40	0.27	0.39	0.01	2.5	
Loc02	ALCOSAN WWTP Lab	0.32	0.22	0.31	0.01	3.1	
Loc04	Kennedy Twp PS	0.26	0.21	0.25	0.01	3.8	
03049500	Allegheny River at Natrona	0.08	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.30	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.21	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.10	---	---	---	---	C
Loc09	Univ of Pittsburgh	0.27	---	---	---	---	U
Loc13	M-59 Access Shaft	0.26	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	Z
Loc33	Richland TWP	0.06	---	---	---	---	MSTT

Table 45. Summary of Individual RG Pairs for Event 7h

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.07	0.08	0.08	-0.01	-14.3	
KAGC	Pittsburgh Allegheny Cty	0.15	0.13	0.16	-0.01	-6.7	
KPIT	Greater Pittsburgh Int'l	0.09	0.11	0.09	0.00	0.0	
Loc01	PWSA-Montana St.	0.08	0.11	0.08	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.08	0.10	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.11	0.11	0.00	0.0	
Loc05	Upper St. Clair	0.16	0.14	0.16	0.00	0.0	
Loc07	Greentree Munic Bldg	0.16	0.12	0.16	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.10	0.12	0.00	0.0	
Loc09	Univ of Pittsburgh	0.13	0.10	0.13	0.00	0.0	
Loc10	PWSA-Highland Park	0.12	0.10	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.13	0.12	0.13	0.00	0.0	
Loc13	M-59 Access Shaft	0.14	0.12	0.14	0.00	0.0	
Loc14	Churchill Munic Bldg	0.11	0.09	0.11	0.00	0.0	
Loc16	Castle Shannon	0.16	0.12	0.16	0.00	0.0	
Loc17	Chartiers Pump Station	0.18	0.15	0.18	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.14	0.13	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.07	0.08	0.00	0.0	
Loc21	Moon TWP	0.09	0.11	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.13	0.13	0.13	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.12	0.15	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.12	0.12	0.12	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.13	0.12	0.13	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.06	0.09	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.10	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.07	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.12	0.10	0.12	0.00	0.0	
Loc32	Arnold	0.07	0.07	0.07	0.00	0.0	
Loc12	Baldwin	0.21	0.12	0.19	0.02	9.5	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	C
Loc06	Carnegie Transit Time	0.11	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.03	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 46. Summary of Individual RG Pairs for Event 7i

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.15	0.23	0.16	-0.01	-6.7	
Loc14	Churchill Munic Bldg	0.15	0.22	0.16	-0.01	-6.7	
Loc07	Greentree Munic Bldg	0.18	0.24	0.19	-0.01	-5.6	
Loc12	Baldwin	0.20	0.29	0.21	-0.01	-5.0	
KAGC	Pittsburgh Allegheny Cty	0.23	0.30	0.23	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.12	0.14	0.12	0.00	0.0	
Loc01	PWSA-Montana St.	0.13	0.14	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.13	0.11	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.12	0.10	0.00	0.0	
Loc10	PWSA-Highland Park	0.15	0.19	0.15	0.00	0.0	
Loc11	M-46 Access Shaft	0.14	0.23	0.14	0.00	0.0	
Loc16	Castle Shannon	0.23	0.29	0.23	0.00	0.0	
Loc17	Chartiers Pump Station	0.15	0.19	0.15	0.00	0.0	
Loc21	Moon TWP	0.10	0.10	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.13	0.16	0.13	0.00	0.0	
Loc24	Jefferson Hills	0.20	0.30	0.20	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.19	0.28	0.19	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.18	0.27	0.18	0.00	0.0	
Loc28	Plum Municipal Bldg	0.20	0.20	0.20	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.10	0.08	0.00	0.0	
Loc32	Arnold	0.11	0.17	0.11	0.00	0.0	
Loc20	Gascola Eq Facility	0.20	0.21	0.19	0.01	5.0	
Loc06	Carnegie Transit Time	0.18	0.20	0.17	0.01	5.6	
Loc18	Oakdale Pump Station	0.15	0.15	0.14	0.01	6.7	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.16	---	---	---	---	C
Loc08	AC Health Dept Bldg	0.09	---	---	---	---	U

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.10	---	---	---	---	U
Loc13	M-59 Access Shaft	0.13	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.13	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.03	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.05	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.05	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

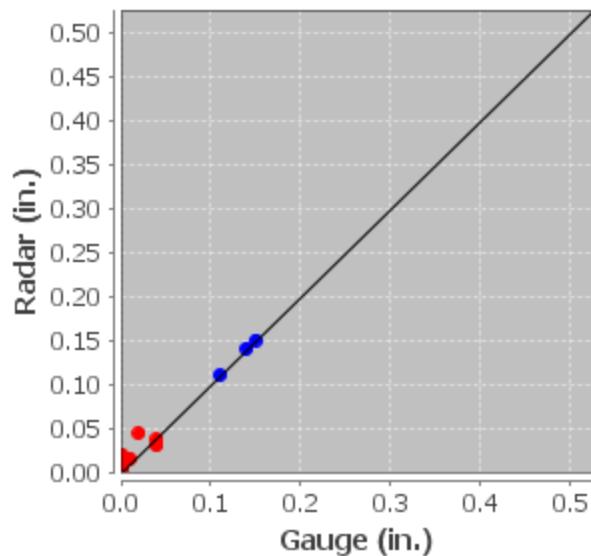


Figure 29. Scatter Plot of RG Pairs for Event 7a

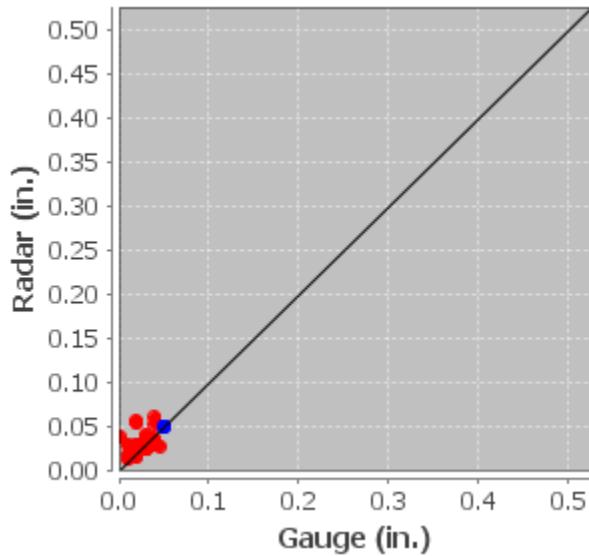


Figure 30. Scatter Plot of RG Pairs for Event 7b

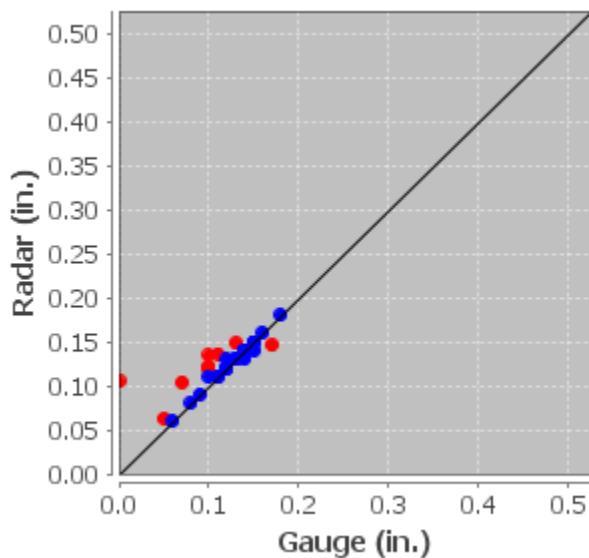


Figure 31. Scatter Plot of RG Pairs for Event 7c

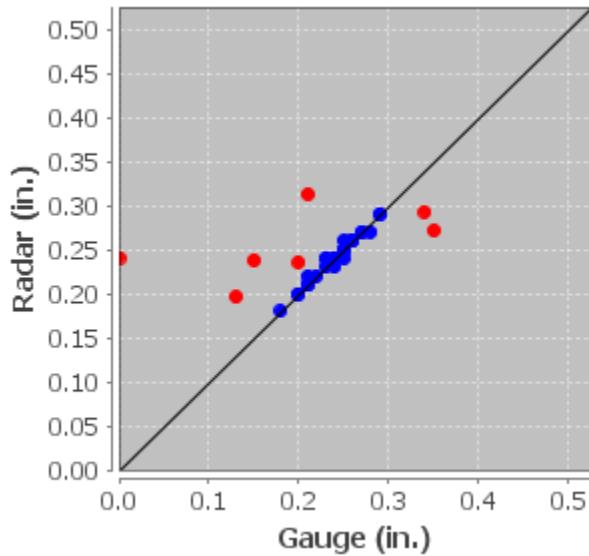


Figure 32. Scatter Plot of RG Pairs for Event 7d

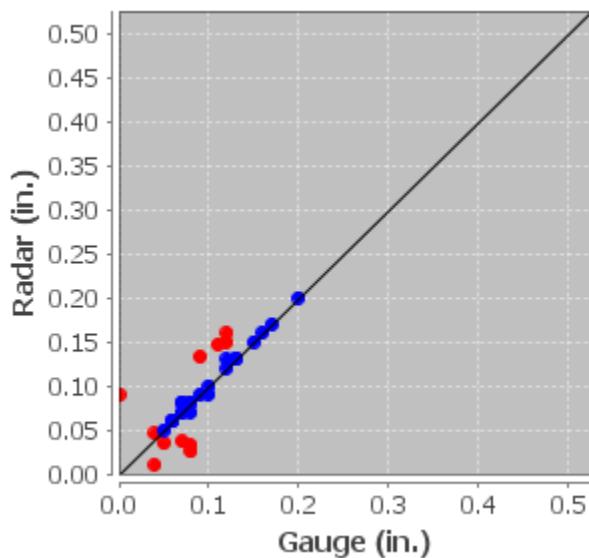


Figure 33. Scatter Plot of RG Pairs for Event 7e

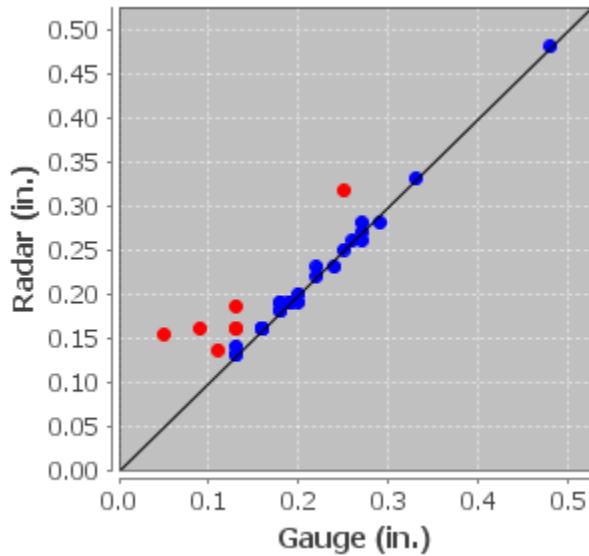


Figure 34. Scatter Plot of RG Pairs for Event 7f

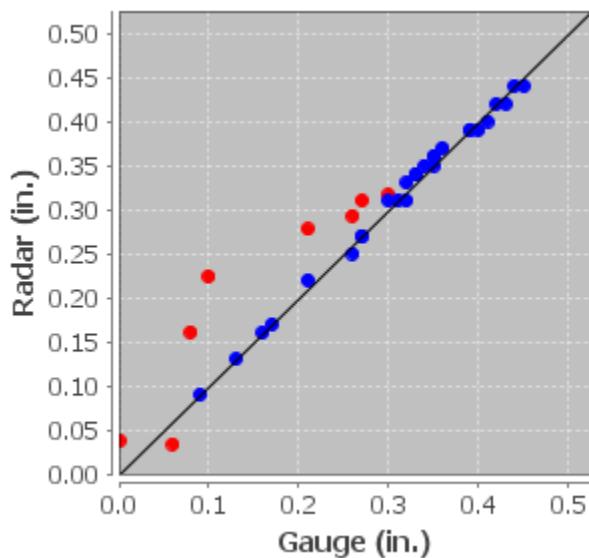


Figure 35. Scatter Plot of RG Pairs for Event 7g

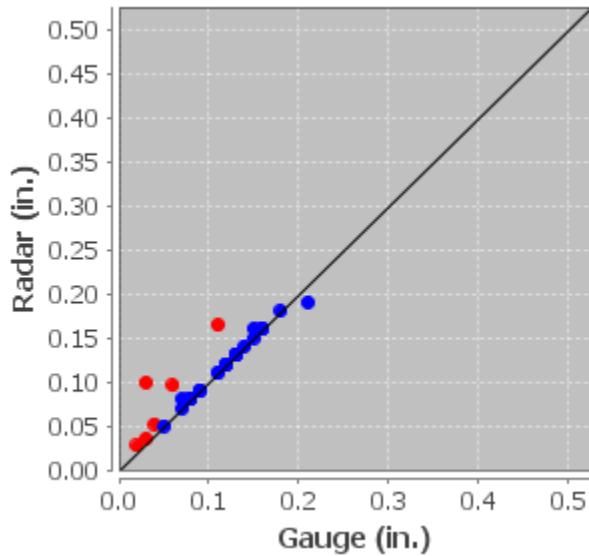


Figure 36. Scatter Plot of RG Pairs for Event 7h

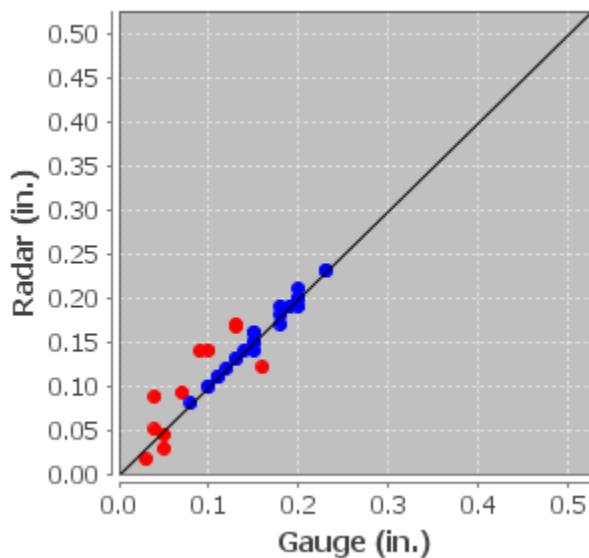


Figure 37. Scatter Plot of RG Pairs for Event 7i

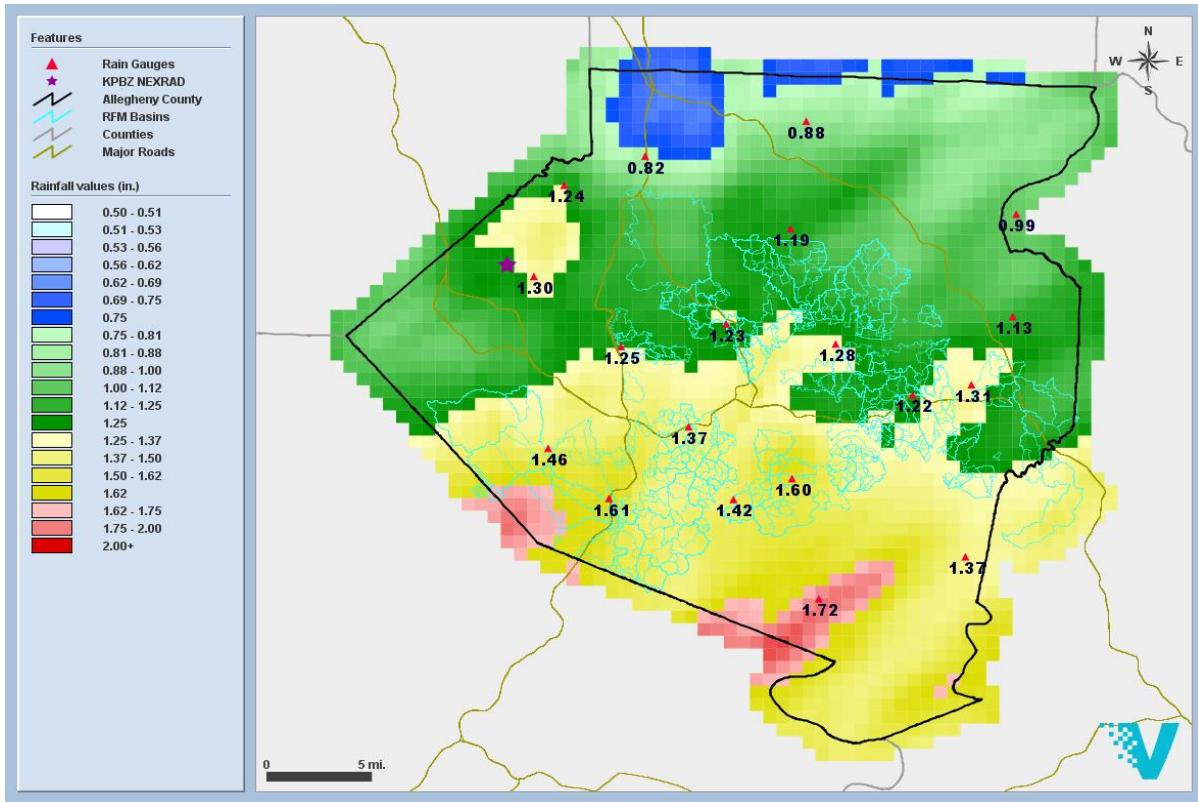


Figure 38. GARR Storm Total for Event 7

Table 47. Depth Duration Frequency Analyses for Event 7

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.156	152155	2020-04-26 14:05	<1 yr.
30 minutes	0.263	152155	2020-04-26 14:10	<1 yr.
1 hour	0.375	151156	2020-04-26 14:20	<1 yr.
2 hour	0.539	152155	2020-04-26 14:15	<1 yr.
3 hour	0.681	152155	2020-04-26 14:20	<1 yr.
6 hour	1.120	149158	2020-04-26 17:10	<1 yr.
12 hour	1.592	149158	2020-04-26 20:05	<1 yr.
24 hour	1.866	149158	2020-04-26 21:20	<1 yr.

Event 8: 2020-04-30

The analysis period was from 2020-04-29 11:00 EDT to 2020-04-30 10:00 EDT. The event was then split into six sub-event periods at 2020-04-29 22:00 EDT, 2020-04-29 23:45 EDT, 2020-04-30 01:00 EDT, 2020-04-30 03:00 EDT and 2020-04-30 05:00 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.

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 48 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 49 - 54 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 39 - 44 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 45 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.7 - 1.3 inches with a mean of 0.9 inches. The GARR amounts for the 440 RFM basins range from 0.7 - 1.0 inches with a mean of 0.8 inches. The GARR amounts for the 871 RFM sheds range from 0.7 - 1.0 inches with a mean of 0.9 inches. Table 55 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 48. GARR Statistics for Event 8

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E8a	KPBZ LII	2020-04-30	2020-04-29 11:05	2020-04-29 22:00	16	0.056	0.917	18.9	4.3
E8b	KPBZ LII	2020-04-30	2020-04-29 22:05	2020-04-29 23:45	23	0.141	0.995	9.7	2.5
E8c	KPBZ LII	2020-04-30	2020-04-29 23:50	2020-04-30 01:00	27	0.221	1.152	16.8	1.4
E8d	KPBZ LII	2020-04-30	2020-04-30 01:05	2020-04-30 03:00	29	0.150	1.674	39.4	1.4
E8e	KPBZ LII	2020-04-30	2020-04-30 03:05	2020-04-30 05:00	30	0.160	1.193	21.6	2.0
E8f	KPBZ LII	2020-04-30	2020-04-30 05:05	2020-04-30 10:00	32	0.166	0.777	32.1	2.3

Table 49. Summary of Individual RG Pairs for Event 8a

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.05	0.05	0.06	-0.01	-20.0	
Loc11	M-46 Access Shaft	0.05	0.08	0.06	-0.01	-20.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.08	0.08	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.05	0.06	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc10	PWSA-Highland Park	0.06	0.07	0.06	0.00	0.0	
Loc12	Baldwin	0.08	0.08	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.05	0.07	0.05	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.06	0.07	0.06	0.00	0.0	
Loc20	Gascola Eq Facility	0.06	0.08	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.07	0.08	0.07	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.09	0.09	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.09	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.08	0.08	0.08	0.00	0.0	
Loc32	Arnold	0.05	0.06	0.05	0.00	0.0	
Loc09	Univ of Pittsburgh	0.08	0.06	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.05	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	U
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.03	---	---	---	---	MSTT
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.04	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

Table 50. Summary of Individual RG Pairs for Event 8b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.17	0.21	0.18	-0.01	-5.9	
Loc11	M-46 Access Shaft	0.19	0.24	0.20	-0.01	-5.3	
Loc02	ALCOSAN WWTP Lab	0.21	0.23	0.22	-0.01	-4.8	
Loc06	Carnegie Transit Time	0.22	0.23	0.23	-0.01	-4.5	
Loc21	Moon TWP	0.23	0.27	0.24	-0.01	-4.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.26	0.25	0.27	-0.01	-3.8	
Loc18	Oakdale Pump Station	0.26	0.28	0.27	-0.01	-3.8	
KAGC	Pittsburgh Allegheny Cty	0.19	0.21	0.19	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.23	0.21	0.23	0.00	0.0	
Loc01	PWSA-Montana St.	0.18	0.19	0.18	0.00	0.0	
Loc07	Greentree Munic Bldg	0.21	0.20	0.21	0.00	0.0	
Loc08	AC Health Dept Bldg	0.15	0.16	0.15	0.00	0.0	
Loc09	Univ of Pittsburgh	0.13	0.14	0.13	0.00	0.0	
Loc10	PWSA-Highland Park	0.14	0.13	0.14	0.00	0.0	
Loc12	Baldwin	0.14	0.14	0.14	0.00	0.0	
Loc16	Castle Shannon	0.20	0.19	0.20	0.00	0.0	
Loc24	Jefferson Hills	0.19	0.22	0.19	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.24	0.24	0.24	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.23	0.23	0.23	0.00	0.0	
Loc17	Chartiers Pump Station	0.39	0.33	0.38	0.01	2.6	
Loc04	Kennedy Twp PS	0.32	0.26	0.31	0.01	3.1	
Loc22	North Fayette TWP	0.30	0.29	0.29	0.01	3.3	
Loc30	McCandless Twn Hall	0.25	0.21	0.24	0.01	4.0	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc05	Upper St. Clair	0.19	---	---	---	---	U
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.05	---	---	---	---	OAD

Table 51. Summary of Individual RG Pairs for Event 8c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.08	0.09	0.09	-0.01	-12.5	
Loc14	Churchill Munic Bldg	0.29	0.27	0.30	-0.01	-3.4	
KAGC	Pittsburgh Allegheny Cty	0.20	0.16	0.20	0.00	0.0	
Loc01	PWSA-Montana St.	0.21	0.20	0.21	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.18	0.17	0.18	0.00	0.0	
Loc04	Kennedy Twp PS	0.16	0.13	0.16	0.00	0.0	
Loc07	Greentree Munic Bldg	0.18	0.13	0.18	0.00	0.0	
Loc08	AC Health Dept Bldg	0.22	0.17	0.22	0.00	0.0	
Loc09	Univ of Pittsburgh	0.19	0.14	0.19	0.00	0.0	
Loc11	M-46 Access Shaft	0.17	0.16	0.17	0.00	0.0	
Loc12	Baldwin	0.15	0.13	0.15	0.00	0.0	
Loc16	Castle Shannon	0.27	0.21	0.27	0.00	0.0	
Loc17	Chartiers Pump Station	0.15	0.12	0.15	0.00	0.0	
Loc18	Oakdale Pump Station	0.12	0.08	0.12	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.32	0.28	0.32	0.00	0.0	
Loc21	Moon TWP	0.13	0.11	0.13	0.00	0.0	
Loc22	North Fayette TWP	0.08	0.06	0.08	0.00	0.0	
Loc24	Jefferson Hills	0.23	0.15	0.23	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.34	0.33	0.34	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.39	0.34	0.39	0.00	0.0	
Loc28	Plum Municipal Bldg	0.40	0.42	0.40	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.12	0.09	0.12	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.27	0.26	0.27	0.00	0.0	
Loc32	Arnold	0.54	0.55	0.54	0.00	0.0	
Loc33	Richland TWP	0.51	0.44	0.51	0.00	0.0	
Loc10	PWSA-Highland Park	0.20	0.14	0.19	0.01	5.0	
Loc30	McCandless Twn Hall	0.17	0.11	0.16	0.01	5.9	
03049500	Allegheny River at Natrona	0.19	---	---	---	---	U

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.12	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.17	---	---	---	---	O
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc05	Upper St. Clair	0.07	---	---	---	---	U
Loc06	Carnegie Transit Time	0.10	---	---	---	---	U
Loc13	M-59 Access Shaft	0.18	---	---	---	---	U
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc20	Gascola Eq Facility	0.35	---	---	---	---	U
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND

Table 52. Summary of Individual RG Pairs for Event 8d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.12	0.08	0.13	-0.01	-8.3	
Loc20	Gascola Eq Facility	0.15	0.10	0.16	-0.01	-6.7	
KAGC	Pittsburgh Allegheny Cty	0.12	0.07	0.12	0.00	0.0	
Loc01	PWSA-Montana St.	0.11	0.07	0.11	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.07	0.11	0.00	0.0	
Loc04	Kennedy Twp PS	0.12	0.08	0.12	0.00	0.0	
Loc05	Upper St. Clair	0.13	0.08	0.13	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.07	0.12	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.07	0.12	0.00	0.0	
Loc09	Univ of Pittsburgh	0.11	0.07	0.11	0.00	0.0	
Loc10	PWSA-Highland Park	0.13	0.08	0.13	0.00	0.0	
Loc12	Baldwin	0.11	0.06	0.11	0.00	0.0	
Loc13	M-59 Access Shaft	0.16	0.09	0.16	0.00	0.0	
Loc16	Castle Shannon	0.11	0.06	0.11	0.00	0.0	
Loc17	Chartiers Pump Station	0.12	0.08	0.12	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.08	0.13	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.16	0.09	0.16	0.00	0.0	
Loc21	Moon TWP	0.14	0.10	0.14	0.00	0.0	
Loc22	North Fayette TWP	0.13	0.09	0.13	0.00	0.0	
Loc24	Jefferson Hills	0.13	0.08	0.13	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.17	0.11	0.17	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc26	Elizabeth TWP Municipal Bldg	0.18	0.10	0.18	0.00	0.0	
Loc28	Plum Municipal Bldg	0.24	0.12	0.24	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.09	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.12	0.08	0.12	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.12	0.07	0.12	0.00	0.0	
Loc32	Arnold	0.24	0.12	0.24	0.00	0.0	
Loc33	Richland TWP	0.14	0.07	0.14	0.00	0.0	
Loc14	Churchill Munic Bldg	0.18	0.09	0.17	0.01	5.6	
03049500	Allegheny River at Natrona	0.17	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.11	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc06	Carnegie Transit Time	0.15	---	---	---	---	O
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	Z

Table 53. Summary of Individual RG Pairs for Event 8e

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.10	0.08	0.11	-0.01	-10.0	
Loc19	Sandy Creek Eq Facility	0.10	0.09	0.11	-0.01	-10.0	
KAGC	Pittsburgh Allegheny Cty	0.12	0.09	0.13	-0.01	-8.3	
Loc02	ALCOSAN WWTP Lab	0.13	0.13	0.14	-0.01	-7.7	
Loc22	North Fayette TWP	0.21	0.22	0.22	-0.01	-4.8	
KPIT	Greater Pittsburgh Int'l	0.20	0.25	0.20	0.00	0.0	
Loc01	PWSA-Montana St.	0.15	0.13	0.15	0.00	0.0	
Loc04	Kennedy Twp PS	0.19	0.17	0.19	0.00	0.0	
Loc05	Upper St. Clair	0.20	0.18	0.20	0.00	0.0	
Loc07	Greentree Munic Bldg	0.18	0.13	0.18	0.00	0.0	
Loc08	AC Health Dept Bldg	0.14	0.11	0.14	0.00	0.0	
Loc09	Univ of Pittsburgh	0.14	0.11	0.14	0.00	0.0	
Loc10	PWSA-Highland Park	0.13	0.09	0.13	0.00	0.0	
Loc13	M-59 Access Shaft	0.12	0.09	0.12	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.17	0.12	0.17	0.00	0.0	
Loc17	Chartiers Pump Station	0.20	0.18	0.20	0.00	0.0	
Loc20	Gascola Eq Facility	0.10	0.08	0.10	0.00	0.0	
Loc21	Moon TWP	0.22	0.26	0.22	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.11	0.15	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.12	0.09	0.12	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.16	0.10	0.16	0.00	0.0	
Loc28	Plum Municipal Bldg	0.13	0.09	0.13	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.25	0.24	0.25	0.00	0.0	
Loc30	McCandless Twn Hall	0.20	0.18	0.20	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.10	0.13	0.00	0.0	
Loc32	Arnold	0.14	0.09	0.14	0.00	0.0	
Loc33	Richland TWP	0.14	0.09	0.14	0.00	0.0	
Loc18	Oakdale Pump Station	0.23	0.20	0.22	0.01	4.3	
Loc12	Baldwin	0.16	0.10	0.15	0.01	6.3	
Loc14	Churchill Munic Bldg	0.13	0.09	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.10	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.13	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc06	Carnegie Transit Time	0.25	---	---	---	---	O
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	Z

Table 54. Summary of Individual RG Pairs for Event 8f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.14	0.24	0.15	-0.01	-7.1	
Loc20	Gascola Eq Facility	0.14	0.26	0.15	-0.01	-7.1	
KAGC	Pittsburgh Allegheny Cty	0.17	0.24	0.18	-0.01	-5.9	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.12	0.18	0.12	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.11	0.10	0.11	0.00	0.0	
Loc01	PWSA-Montana St.	0.14	0.22	0.14	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.13	0.20	0.13	0.00	0.0	
Loc04	Kennedy Twp PS	0.12	0.15	0.12	0.00	0.0	
Loc05	Upper St. Clair	0.14	0.15	0.14	0.00	0.0	
Loc07	Greentree Munic Bldg	0.16	0.18	0.16	0.00	0.0	
Loc08	AC Health Dept Bldg	0.18	0.24	0.18	0.00	0.0	
Loc10	PWSA-Highland Park	0.17	0.24	0.17	0.00	0.0	
Loc11	M-46 Access Shaft	0.18	0.23	0.18	0.00	0.0	
Loc13	M-59 Access Shaft	0.16	0.23	0.16	0.00	0.0	
Loc16	Castle Shannon	0.18	0.18	0.18	0.00	0.0	
Loc17	Chartiers Pump Station	0.13	0.14	0.13	0.00	0.0	
Loc18	Oakdale Pump Station	0.11	0.09	0.11	0.00	0.0	
Loc21	Moon TWP	0.11	0.13	0.11	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.07	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.18	0.25	0.18	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.19	0.29	0.19	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.21	0.32	0.21	0.00	0.0	
Loc28	Plum Municipal Bldg	0.19	0.27	0.19	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.16	0.15	0.16	0.00	0.0	
Loc30	McCandless Twn Hall	0.17	0.20	0.17	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.19	0.25	0.19	0.00	0.0	
Loc32	Arnold	0.19	0.29	0.19	0.00	0.0	
Loc33	Richland TWP	0.21	0.26	0.21	0.00	0.0	
Loc12	Baldwin	0.21	0.22	0.20	0.01	4.8	
Loc09	Univ of Pittsburgh	0.19	0.23	0.18	0.01	5.3	
Loc14	Churchill Munic Bldg	0.18	0.23	0.17	0.01	5.6	
Loc06	Carnegie Transit Time	0.17	0.16	0.16	0.01	5.9	
03049500	Allegheny River at Natrona	0.12	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	C
Loc15	Trafford Maint Bldg	ND	---	---	---	---	ND
Loc23	Clinton Munic Bldg	ND	---	---	---	---	ND
Loc27	Marshall TWP	0.01	---	---	---	---	S

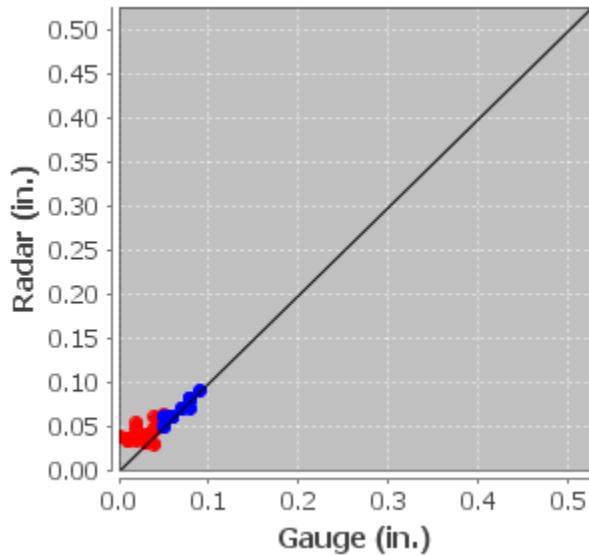


Figure 39. Scatter Plot of RG Pairs for Event 8a

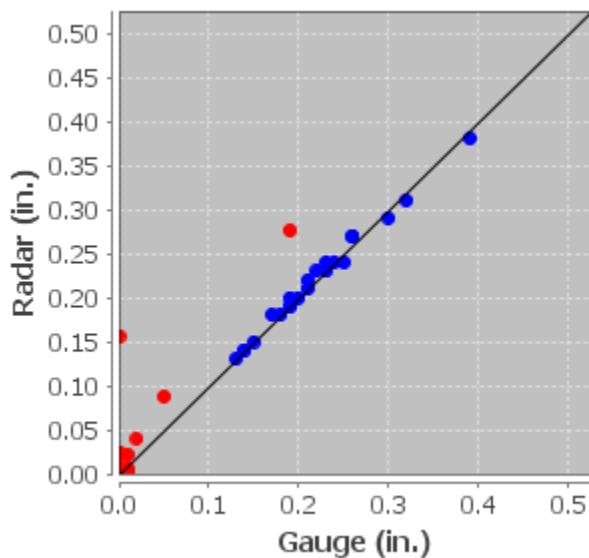


Figure 40. Scatter Plot of RG Pairs for Event 8b

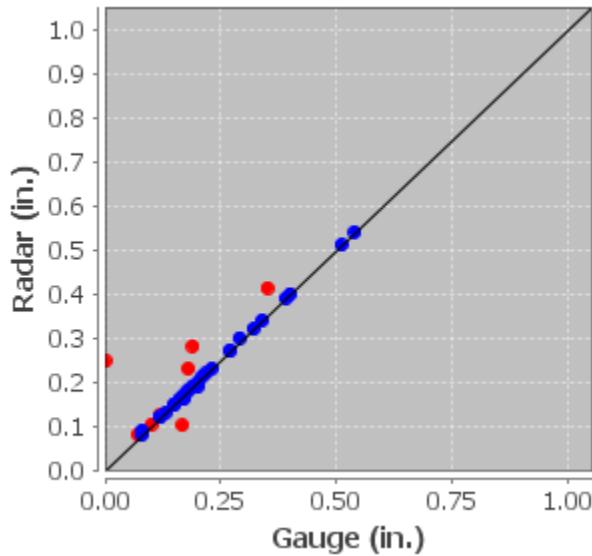


Figure 41. Scatter Plot of RG Pairs for Event 8c

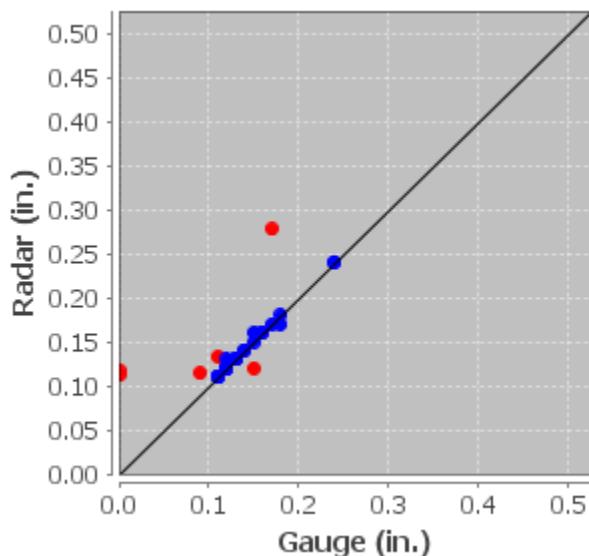


Figure 42. Scatter Plot of RG Pairs for Event 8d

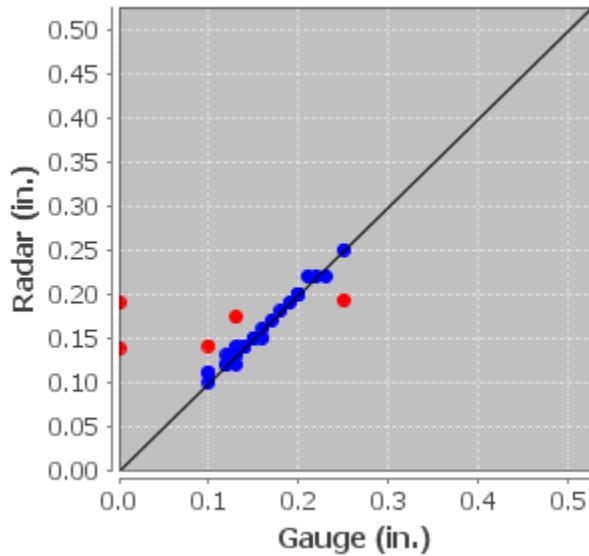


Figure 43. Scatter Plot of RG Pairs for Event 8e

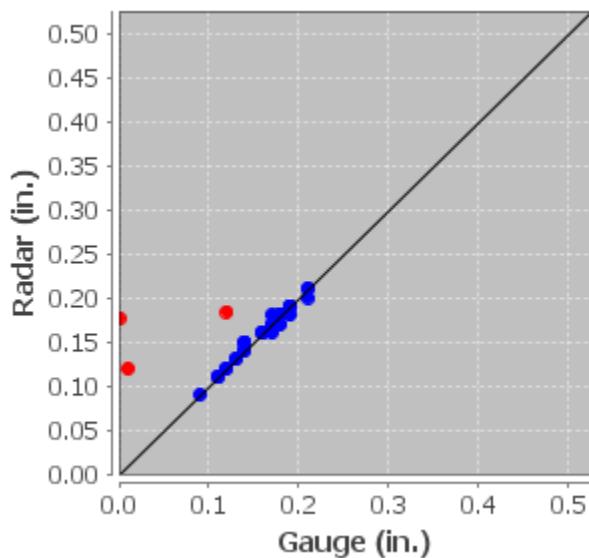


Figure 44. Scatter Plot of RG Pairs for Event 8f

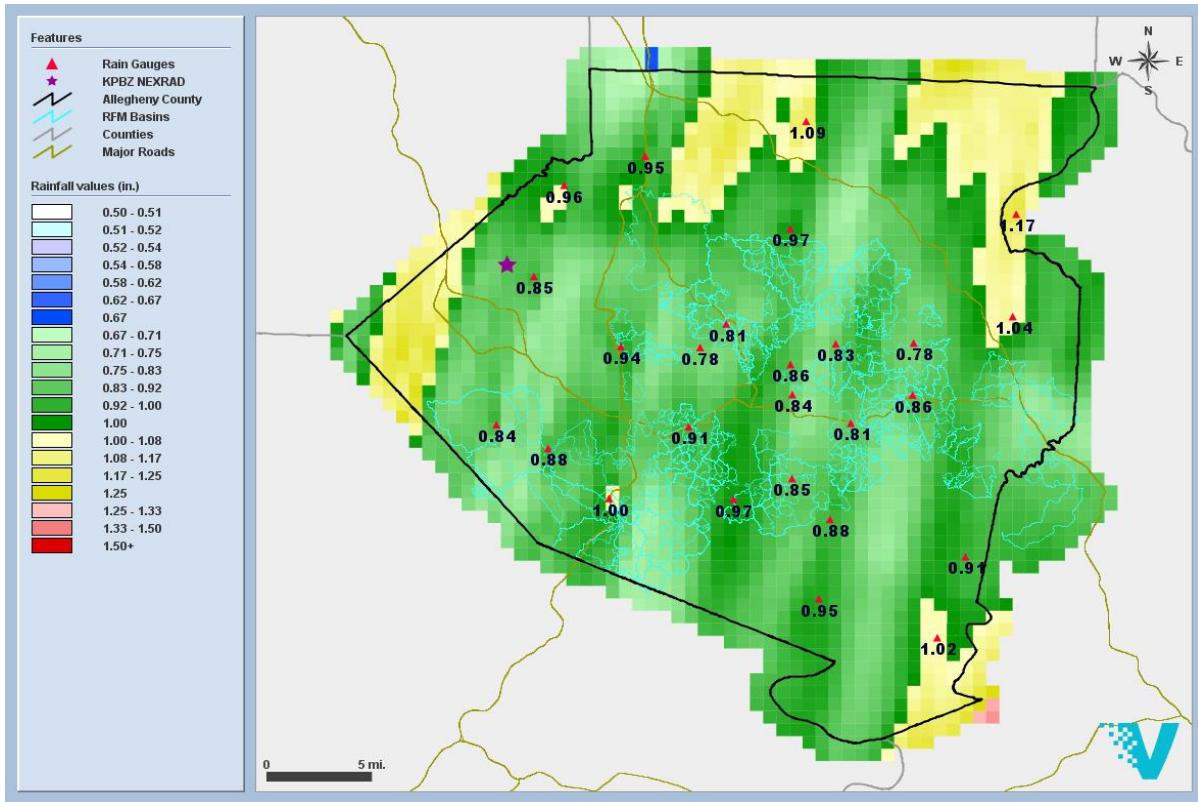


Figure 45. GARR Storm Total for Event 8

Table 55. Depth Duration Frequency Analyses for Event 8

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.411	120135	2020-04-29 22:50	<1 yr.
30 minutes	0.615	120135	2020-04-29 23:00	<1 yr.
1 hour	0.666	120135	2020-04-29 23:10	<1 yr.
2 hour	0.760	120135	2020-04-30 00:05	<1 yr.
3 hour	0.809	162112	2020-04-30 02:45	<1 yr.
6 hour	1.070	165164	2020-04-30 06:05	<1 yr.
12 hour	1.304	165164	2020-04-30 07:00	<1 yr.

Appendices

- [Appendix A](#) - Gauge Performance Exclusion Table
- [Appendix B](#) - Gauge Statistical Criteria Exclusion Table
- [Appendix C](#) - Event 1 (2020-04-07) CDPs
- [Appendix D](#) - Event 2 (2020-04-08) CDPs
- [Appendix E](#) - Event 3 (2020-04-09) CDPs
- [Appendix F](#) - Event 4 (2020-04-12) CDPs
- [Appendix G](#) - Event 5 (2020-04-13) CDPs
- [Appendix H](#) - Event 6 (2020-04-17) CDPs
- [Appendix I](#) - Event 7 (2020-04-26) CDPs
- [Appendix J](#) - Event 8 (2020-04-30) 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 #	E1a	E1b	E2a	E2b	E2c
Event Date	2020-04-07	2020-04-07	2020-04-08	2020-04-08	2020-04-08
Start Time (EDT)	2020-04-07 06:05	2020-04-07 10:20	2020-04-07 22:05	2020-04-08 01:50	2020-04-08 03:50
End Time (EDT)	2020-04-07 10:15	2020-04-07 14:00	2020-04-08 01:45	2020-04-08 03:45	2020-04-08 07:00
Loc01	U	U			
Loc02					
Loc03					
Loc04					
Loc05	U		U	U	
Loc06					
Loc07					
Loc08			U		
Loc09			U		
Loc10					
Loc11			U		
Loc12					
Loc13				U	
Loc14			U		
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					S
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26			U		
Loc27					
Loc28					

Event #	<u>E1a</u>	<u>E1b</u>	<u>E2a</u>	<u>E2b</u>	<u>E2c</u>
Event Date	2020-04-07	2020-04-07	2020-04-08	2020-04-08	2020-04-08
Start Time (EDT)	2020-04-07 06:05	2020-04-07 10:20	2020-04-07 22:05	2020-04-08 01:50	2020-04-08 03:50
End Time (EDT)	2020-04-07 10:15	2020-04-07 14:00	2020-04-08 01:45	2020-04-08 03:45	2020-04-08 07:00
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC	U		U	U	O
KPIT					O
03049500	Z	U		U	
03085734		U		U	

Event #	<u>E3a</u>	<u>E3b</u>	<u>E3c</u>	<u>E4a</u>	<u>E4b</u>
Event Date	2020-04-09	2020-04-09	2020-04-09	2020-04-12	2020-04-12
Start Time (EDT)	2020-04-08 23:05	2020-04-09 06:05	2020-04-09 08:50	2020-04-12 17:05	2020-04-12 22:35
End Time (EDT)	2020-04-09 06:00	2020-04-09 08:45	2020-04-09 14:00	2020-04-12 22:30	2020-04-13 00:00
Loc01	S				U
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08	O				
Loc09					
Loc10					
Loc11				U	
Loc12					
Loc13					
Loc14					
Loc15		O			
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21	ND	ND	ND		
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26					

Event #	<u>E3a</u>	<u>E3b</u>	<u>E3c</u>	<u>E4a</u>	<u>E4b</u>
Event Date	2020-04-09	2020-04-09	2020-04-09	2020-04-12	2020-04-12
Start Time (EDT)	2020-04-08 23:05	2020-04-09 06:05	2020-04-09 08:50	2020-04-12 17:05	2020-04-12 22:35
End Time (EDT)	2020-04-09 06:00	2020-04-09 08:45	2020-04-09 14:00	2020-04-12 22:30	2020-04-13 00:00
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC		T			
KPIT		T			
03049500		T		U	U
03085734		T		U	U

Event #	E4c	E5a	E5b	E5c	E6a
Event Date	2020-04-12	2020-04-13	2020-04-13	2020-04-13	2020-04-17
Start Time (EDT)	2020-04-13 00:05	2020-04-13 08:05	2020-04-13 10:20	2020-04-13 12:05	2020-04-17 11:05
End Time (EDT)	2020-04-13 08:00	2020-04-13 10:15	2020-04-13 12:00	2020-04-13 17:00	2020-04-17 16:45
Loc01		U	U	U	
Loc02					
Loc03		C	C	C	C
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26					

Event #	<u>E4c</u>	<u>E5a</u>	<u>E5b</u>	<u>E5c</u>	<u>E6a</u>
Event Date	2020-04-12	2020-04-13	2020-04-13	2020-04-13	2020-04-17
Start Time (EDT)	2020-04-13 00:05	2020-04-13 08:05	2020-04-13 10:20	2020-04-13 12:05	2020-04-17 11:05
End Time (EDT)	2020-04-13 08:00	2020-04-13 10:15	2020-04-13 12:00	2020-04-13 17:00	2020-04-17 16:45
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC			O	U	
KPIT		U	O		
03049500	U			U	U
03085734					

Event #	E6b	E6c	E6d	E6e	E6f
Event Date	2020-04-17	2020-04-17	2020-04-17	2020-04-17	2020-04-17
Start Time (EDT)	2020-04-17 16:50	2020-04-17 18:20	2020-04-17 21:35	2020-04-17 23:20	2020-04-18 01:35
End Time (EDT)	2020-04-17 18:15	2020-04-17 21:30	2020-04-17 23:15	2020-04-18 01:30	2020-04-18 05:00
Loc01	U	U			
Loc02					
Loc03	C	C	C	C	C
Loc04					
Loc05		U	U	U	U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13			U	U	U
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16		U			
Loc17					U
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26					

Event #	<u>E6b</u>	<u>E6c</u>	<u>E6d</u>	<u>E6e</u>	<u>E6f</u>
Event Date	2020-04-17	2020-04-17	2020-04-17	2020-04-17	2020-04-17
Start Time (EDT)	2020-04-17 16:50	2020-04-17 18:20	2020-04-17 21:35	2020-04-17 23:20	2020-04-18 01:35
End Time (EDT)	2020-04-17 18:15	2020-04-17 21:30	2020-04-17 23:15	2020-04-18 01:30	2020-04-18 05:00
Loc27		U	Z	Z	Z
Loc28		O			
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC			U	U	
KPIT					
03049500		U	U	U	U
03085734	U	U	U		U

Event #	E7a	E7b	E7c	E7d	E7e
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-26
Start Time (EDT)	2020-04-25 16:05	2020-04-25 23:05	2020-04-26 03:35	2020-04-26 08:05	2020-04-26 10:20
End Time (EDT)	2020-04-25 23:00	2020-04-26 03:30	2020-04-26 08:00	2020-04-26 10:15	2020-04-26 11:30
Loc01					
Loc02			U		
Loc03		C	C	C	C
Loc04					
Loc05			U	U	
Loc06				O	
Loc07					
Loc08					
Loc09					
Loc10					
Loc11			U		
Loc12					
Loc13			U		
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22				U	
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26				O	

Event #	<u>E7a</u>	<u>E7b</u>	<u>E7c</u>	<u>E7d</u>	<u>E7e</u>
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-26
Start Time (EDT)	2020-04-25 16:05	2020-04-25 23:05	2020-04-26 03:35	2020-04-26 08:05	2020-04-26 10:20
End Time (EDT)	2020-04-25 23:00	2020-04-26 03:30	2020-04-26 08:00	2020-04-26 10:15	2020-04-26 11:30
Loc27			U		U
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					O
KPIT		Z	Z	Z	Z
03049500			U	U	U
03085734			U		U

Event #	E7f	E7g	E7h	E7i	E8a
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-30
Start Time (EDT)	2020-04-26 11:35	2020-04-26 14:05	2020-04-26 17:05	2020-04-26 18:35	2020-04-29 11:05
End Time (EDT)	2020-04-26 14:00	2020-04-26 17:00	2020-04-26 18:30	2020-04-27 04:00	2020-04-29 22:00
Loc01					
Loc02					
Loc03	C	C	C	C	C
Loc04					
Loc05	U				
Loc06			U		
Loc07					
Loc08	U			U	
Loc09		U		U	
Loc10					
Loc11					
Loc12					
Loc13		U		U	
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18					
Loc19				U	
Loc20					
Loc21					
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26					

Event #	E7f	E7g	E7h	E7i	E8a
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-30
Start Time (EDT)	2020-04-26 11:35	2020-04-26 14:05	2020-04-26 17:05	2020-04-26 18:35	2020-04-29 11:05
End Time (EDT)	2020-04-26 14:00	2020-04-26 17:00	2020-04-26 18:30	2020-04-27 04:00	2020-04-29 22:00
Loc27	S	Z			
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC		U			
KPIT	U	U			U
03049500	U	U	U	U	
03085734	U		U	U	

Event #	<u>E8b</u>	<u>E8c</u>	<u>E8d</u>	<u>E8e</u>	<u>E8f</u>
Event Date	2020-04-30	2020-04-30	2020-04-30	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-29 22:05	2020-04-29 23:50	2020-04-30 01:05	2020-04-30 03:05	2020-04-30 05:05
End Time (EDT)	2020-04-29 23:45	2020-04-30 01:00	2020-04-30 03:00	2020-04-30 05:00	2020-04-30 10:00
Loc01					
Loc02					
Loc03	C	C	C	C	C
Loc04					
Loc05	U	U			
Loc06		U	O	O	
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13		U			
Loc14					
Loc15	ND	ND	ND	ND	ND
Loc16					
Loc17					
Loc18					
Loc19					
Loc20		U			
Loc21					
Loc22					
Loc23	ND	ND	ND	ND	ND
Loc24					
Loc25					
Loc26					

Event #	<u>E8b</u>	<u>E8c</u>	<u>E8d</u>	<u>E8e</u>	<u>E8f</u>
Event Date	2020-04-30	2020-04-30	2020-04-30	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-29 22:05	2020-04-29 23:50	2020-04-30 01:05	2020-04-30 03:05	2020-04-30 05:05
End Time (EDT)	2020-04-29 23:45	2020-04-30 01:00	2020-04-30 03:00	2020-04-30 05:00	2020-04-30 10:00
Loc27			Z	Z	S
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT		O	U		
03049500		U	U	U	U
03085734		U	U	U	

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>>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<<R)

Event #	E1a	E1b	E2a	E2b	E2c
Event Date	2020-04-07	2020-04-07	2020-04-08	2020-04-08	2020-04-08
Start Time (EDT)	2020-04-07 06:05	2020-04-07 10:20	2020-04-07 22:05	2020-04-08 01:50	2020-04-08 03:50
End Time (EDT)	2020-04-07 10:15	2020-04-07 14:00	2020-04-08 01:45	2020-04-08 03:45	2020-04-08 07:00
Source	KPBZ LII				
Loc01					MSTT
Loc02		MSTT			MSTT
Loc03					MSTT
Loc04		MSTT			MSTT
Loc05		MSTT			
Loc06		MSTT			
Loc07		MSTT			MSTT
Loc08					MSTT
Loc09		MSTT			MSTT
Loc10					MSTT
Loc11		MSTT			MSTT
Loc12		MSTT			MSTT
Loc13		MSTT			MSTT
Loc14					MSTT
Loc15		MSTT			MSTT
Loc16		MSTT			
Loc17		MSTT			
Loc18		MSTT			
Loc19					MSTT
Loc20					MSTT
Loc21		MSTT			
Loc22		MSTT			
Loc23					
Loc24		MSTT			
Loc25		MSTT			MSTT
Loc26	MSTT	MSTT			
Loc27					MSTT

Event #	<u>E1a</u>	<u>E1b</u>	<u>E2a</u>	<u>E2b</u>	<u>E2c</u>
Event Date	2020-04-07	2020-04-07	2020-04-08	2020-04-08	2020-04-08
Start Time (EDT)	2020-04-07 06:05	2020-04-07 10:20	2020-04-07 22:05	2020-04-08 01:50	2020-04-08 03:50
End Time (EDT)	2020-04-07 10:15	2020-04-07 14:00	2020-04-08 01:45	2020-04-08 03:45	2020-04-08 07:00
Source	KPBZ LII				
Loc28	MSTT				MSTT
Loc29					MSTT
Loc30					MSTT
Loc31					MSTT
Loc32	MSTT				MSTT
Loc33	MSTT				MSTT
KAGC		MSTT			
KPIT		MSTT			
03049500					MSTT
03085734					MSTT

Event #	E3a	E3c	E4a	E4b	E4c
Event Date	2020-04-09	2020-04-09	2020-04-12	2020-04-12	2020-04-12
Start Time (EDT)	2020-04-08 23:05	2020-04-09 08:50	2020-04-12 17:05	2020-04-12 22:35	2020-04-13 00:05
End Time (EDT)	2020-04-09 06:00	2020-04-09 14:00	2020-04-12 22:30	2020-04-13 00:00	2020-04-13 08:00
Source	KPBZ LII				
Loc01		MSTT			MSTT
Loc02					MSTT
Loc03	MSTT	MSTT			
Loc04					MSTT
Loc05		MSTT			MSTT
Loc06		MSTT			MSTT
Loc07					MSTT
Loc08		MSTT			MSTT
Loc09					
Loc10					MSTT
Loc11		MSTT			MSTT
Loc12		MSTT			
Loc13			MSTT		MSTT
Loc14			MSTT		
Loc15					
Loc16		MSTT			MSTT
Loc17		MSTT			MSTT
Loc18		MSTT			
Loc19			MSTT		MSTT
Loc20			MSTT		MSTT
Loc21					
Loc22		MSTT			
Loc23					
Loc24		MSTT			MSTT
Loc25		MSTT			MSTT

Event #	E3a	E3c	E4a	E4b	E4c
Event Date	2020-04-09	2020-04-09	2020-04-12	2020-04-12	2020-04-12
Start Time (EDT)	2020-04-08 23:05	2020-04-09 08:50	2020-04-12 17:05	2020-04-12 22:35	2020-04-13 00:05
End Time (EDT)	2020-04-09 06:00	2020-04-09 14:00	2020-04-12 22:30	2020-04-13 00:00	2020-04-13 08:00
Source	KPBZ LII				
Loc26					
Loc27	MSTT		MSTT		
Loc28	OMFB	MSTT	MSTT		
Loc29	MSTT	MSTT	MSTT		
Loc30	MSTT		MSTT		
Loc31	MSTT	MSTT	MSTT		
Loc32	MSTT	MSTT	MSTT		
Loc33	MSTT		MSTT		
KAGC		MSTT			MSTT
KPIT		MSTT	MSTT		MSTT
03049500	MSTT	MSTT			
03085734	MSTT	MSTT			MSTT

Event #	<u>E5a</u>	<u>E5b</u>	<u>E5c</u>	<u>E6a</u>	<u>E6b</u>
Event Date	2020-04-13	2020-04-13	2020-04-13	2020-04-17	2020-04-17
Start Time (EDT)	2020-04-13 08:05	2020-04-13 10:20	2020-04-13 12:05	2020-04-17 11:05	2020-04-17 16:50
End Time (EDT)	2020-04-13 10:15	2020-04-13 12:00	2020-04-13 17:00	2020-04-17 16:45	2020-04-17 18:15
Source	KPBZ LII				
Loc01				MSTT	
Loc02				MSTT	
Loc03					
Loc04				MSTT	
Loc05				MSTT	
Loc06			MSTT	MSTT	
Loc07			MSTT	MSTT	
Loc08				MSTT	
Loc09			MSTT	MSTT	
Loc10				MSTT	
Loc11			MSTT	MSTT	
Loc12				MSTT	
Loc13			MSTT	MSTT	
Loc14				MSTT	
Loc15					
Loc16				MSTT	
Loc17				MSTT	
Loc18				MSTT	
Loc19				MSTT	
Loc20				MSTT	
Loc21				MSTT	
Loc22			MSTT	MSTT	
Loc23					
Loc24				MSTT	
Loc25				MSTT	

Event #	E5a	E5b	E5c	E6a	E6b
Event Date	2020-04-13	2020-04-13	2020-04-13	2020-04-17	2020-04-17
Start Time (EDT)	2020-04-13 08:05	2020-04-13 10:20	2020-04-13 12:05	2020-04-17 11:05	2020-04-17 16:50
End Time (EDT)	2020-04-13 10:15	2020-04-13 12:00	2020-04-13 17:00	2020-04-17 16:45	2020-04-17 18:15
Source	KPBZ LII				
Loc26				MSTT	
Loc27			MSTT	MSTT	MSTT
Loc28				MSTT	
Loc29					
Loc30					MSTT
Loc31				MSTT	
Loc32				MSTT	
Loc33					
KAGC				MSTT	
KPIT				MSTT	
03049500					
03085734				MSTT	

Event #	E6c	E6d	E6e	E6f	E7a
Event Date	2020-04-17	2020-04-17	2020-04-17	2020-04-17	2020-04-26
Start Time (EDT)	2020-04-17 18:20	2020-04-17 21:35	2020-04-17 23:20	2020-04-18 01:35	2020-04-25 16:05
End Time (EDT)	2020-04-17 21:30	2020-04-17 23:15	2020-04-18 01:30	2020-04-18 05:00	2020-04-25 23:00
Source	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					MSTT
Loc14					MSTT
Loc15					
Loc16					MSTT
Loc17					MSTT
Loc18					MSTT
Loc19					MSTT
Loc20					MSTT
Loc21					
Loc22					
Loc23					
Loc24					MSTT
Loc25					MSTT

Event #	E6c	E6d	E6e	E6f	E7a
Event Date	2020-04-17	2020-04-17	2020-04-17	2020-04-17	2020-04-26
Start Time (EDT)	2020-04-17 18:20	2020-04-17 21:35	2020-04-17 23:20	2020-04-18 01:35	2020-04-25 16:05
End Time (EDT)	2020-04-17 21:30	2020-04-17 23:15	2020-04-18 01:30	2020-04-18 05:00	2020-04-25 23:00
Source	KPBZ LII				
Loc26					MSTT
Loc27					MSTT
Loc28					MSTT
Loc29				MSTT	
Loc30				MSTT	MSTT
Loc31					MSTT
Loc32		OAD			MSTT
Loc33			OAD	MSTT	MSTT
KAGC					MSTT
KPIT					MSTT
03049500					MSTT
03085734					MSTT

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-26
Start Time (EDT)	2020-04-25 23:05	2020-04-26 03:35	2020-04-26 08:05	2020-04-26 10:20	2020-04-26 11:35
End Time (EDT)	2020-04-26 03:30	2020-04-26 08:00	2020-04-26 10:15	2020-04-26 11:30	2020-04-26 14:00
Source	KPBZ LII				
Loc01	MSTT				
Loc02	MSTT				
Loc03					
Loc04					
Loc05	MSTT				
Loc06	MSTT				
Loc07	MSTT				
Loc08	MSTT				
Loc09	MSTT				
Loc10	MSTT				
Loc11	MSTT				
Loc12	MSTT			MSTT	
Loc13	MSTT			MSTT	
Loc14	MSTT				
Loc15					
Loc16	MSTT				
Loc17	MSTT				
Loc18	MSTT				
Loc19	MSTT				
Loc20	MSTT				
Loc21	MSTT				
Loc22	MSTT				
Loc23					
Loc24	MSTT			MSTT	
Loc25	MSTT			MSTT	

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-26	2020-04-26
Start Time (EDT)	2020-04-25 23:05	2020-04-26 03:35	2020-04-26 08:05	2020-04-26 10:20	2020-04-26 11:35
End Time (EDT)	2020-04-26 03:30	2020-04-26 08:00	2020-04-26 10:15	2020-04-26 11:30	2020-04-26 14:00
Source	KPBZ LII				
Loc26	MSTT			MSTT	
Loc27	MSTT				
Loc28	MSTT				
Loc29					
Loc30					
Loc31	MSTT				
Loc32	MSTT				
Loc33	MSTT				
KAGC	MSTT				
KPIT					
03049500	MSTT				
03085734	MSTT				

Event #	E7g	E7h	E7i	E8a	E8b
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-26 14:05	2020-04-26 17:05	2020-04-26 18:35	2020-04-29 11:05	2020-04-29 22:05
End Time (EDT)	2020-04-26 17:00	2020-04-26 18:30	2020-04-27 04:00	2020-04-29 22:00	2020-04-29 23:45
Source	KPBZ LII				
Loc01				MSTT	
Loc02				MSTT	
Loc03					
Loc04				MSTT	
Loc05				MSTT	
Loc06				MSTT	
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					MSTT
Loc14					MSTT
Loc15					
Loc16				MSTT	
Loc17				MSTT	
Loc18				MSTT	
Loc19					MSTT
Loc20					MSTT
Loc21				MSTT	
Loc22				MSTT	
Loc23					
Loc24					
Loc25					MSTT

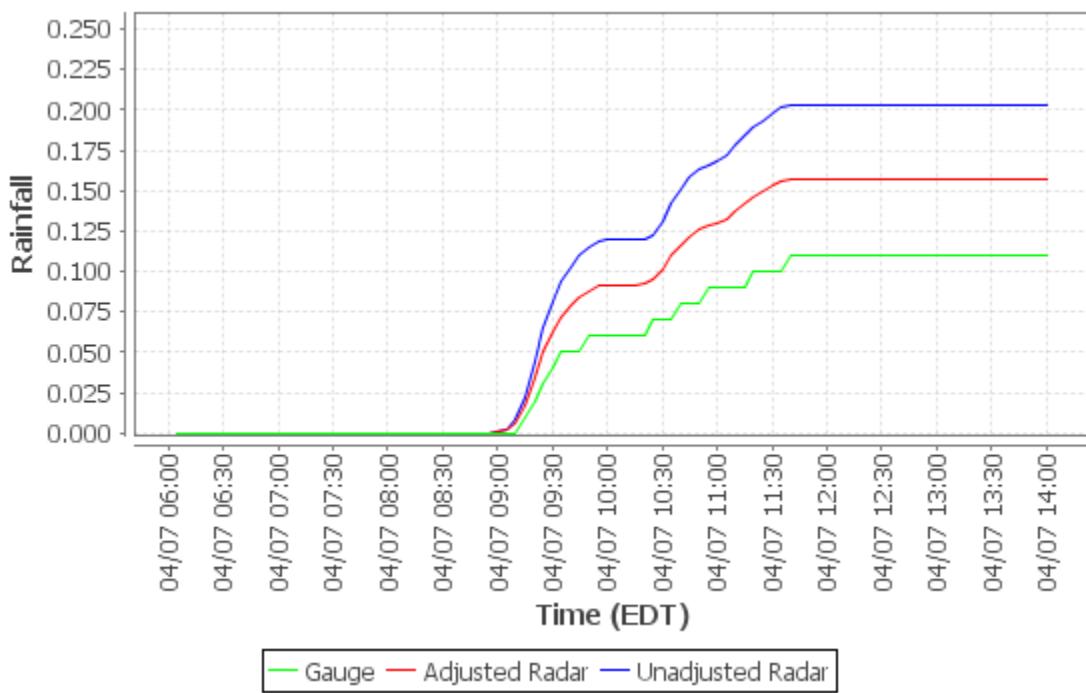
Event #	<u>E7g</u>	<u>E7h</u>	<u>E7i</u>	<u>E8a</u>	<u>E8b</u>
Event Date	2020-04-26	2020-04-26	2020-04-26	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-26 14:05	2020-04-26 17:05	2020-04-26 18:35	2020-04-29 11:05	2020-04-29 22:05
End Time (EDT)	2020-04-26 17:00	2020-04-26 18:30	2020-04-27 04:00	2020-04-29 22:00	2020-04-29 23:45
Source	KPBZ LII				
Loc26					MSTT
Loc27		MSTT	MSTT	MSTT	
Loc28					MSTT
Loc29			MSTT	MSTT	
Loc30			MSTT	MSTT	
Loc31				MSTT	
Loc32					MSTT
Loc33	MSTT	MSTT	MSTT	MSTT	OAD
KAGC					
KPIT					
03049500				MSTT	MSTT
03085734				MSTT	

Event #	<u>E8c</u>	<u>E8d</u>	<u>E8e</u>	<u>E8f</u>
Event Date	2020-04-30	2020-04-30	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-29 23:50	2020-04-30 01:05	2020-04-30 03:05	2020-04-30 05:05
End Time (EDT)	2020-04-30 01:00	2020-04-30 03:00	2020-04-30 05:00	2020-04-30 10:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01				
Loc02				
Loc03				
Loc04				
Loc05				
Loc06				
Loc07				
Loc08				
Loc09				
Loc10				
Loc11				
Loc12				
Loc13				
Loc14				
Loc15				
Loc16				
Loc17				
Loc18				
Loc19				
Loc20				
Loc21				
Loc22				
Loc23				
Loc24				
Loc25				
Loc26				
Loc27				

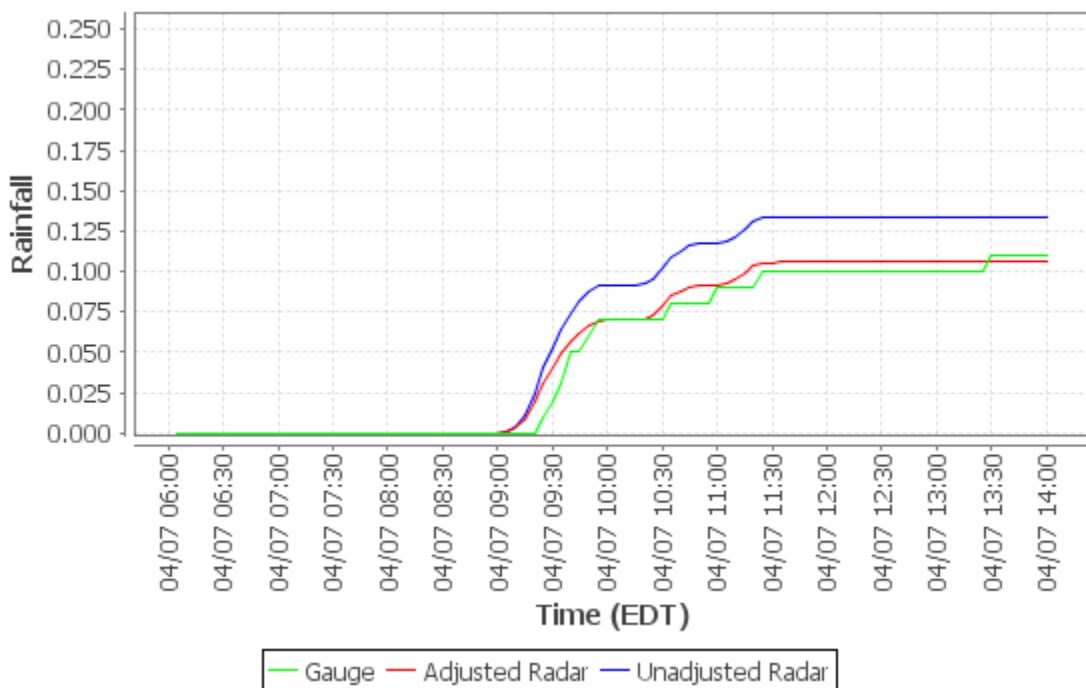
Event #	E8c	E8d	E8e	E8f
Event Date	2020-04-30	2020-04-30	2020-04-30	2020-04-30
Start Time (EDT)	2020-04-29 23:50	2020-04-30 01:05	2020-04-30 03:05	2020-04-30 05:05
End Time (EDT)	2020-04-30 01:00	2020-04-30 03:00	2020-04-30 05:00	2020-04-30 10:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc28				
Loc29				
Loc30				
Loc31				
Loc32				
Loc33				
KAGC				
KPIT				
03049500				
03085734				

Appendix C - Event 1 (2020-04-07) CDPs

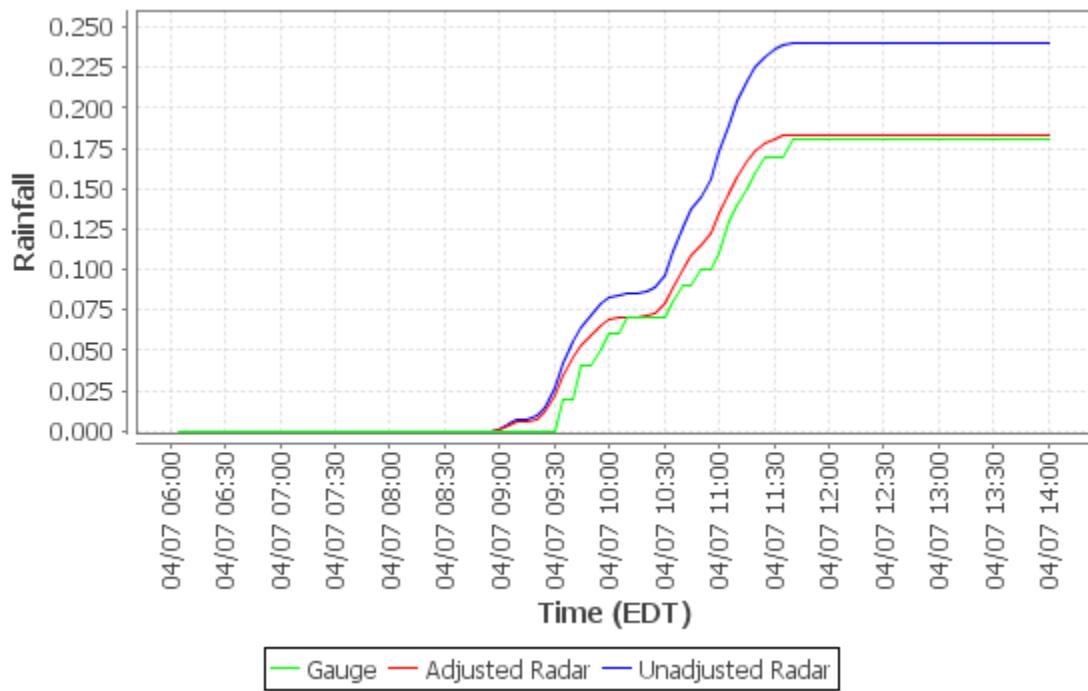
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



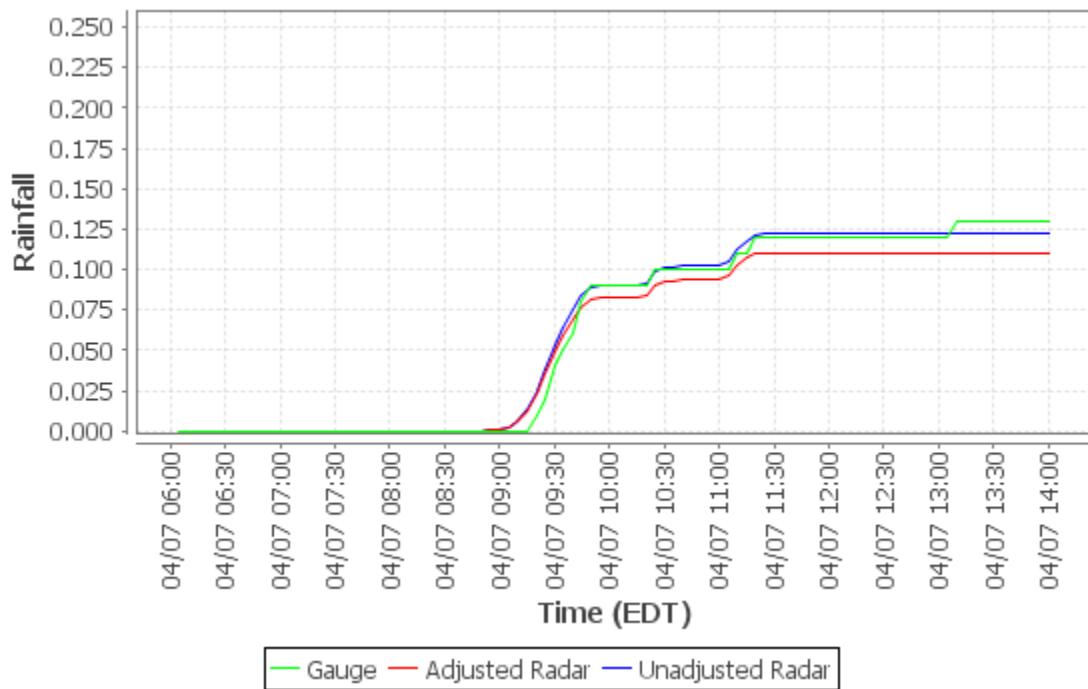
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



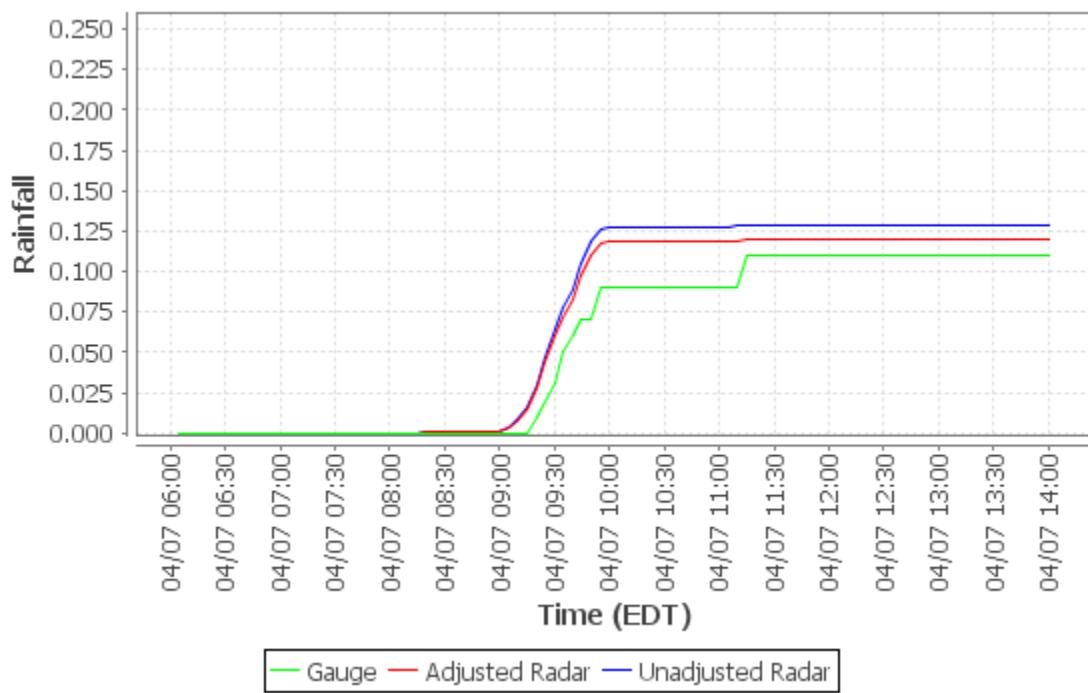
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



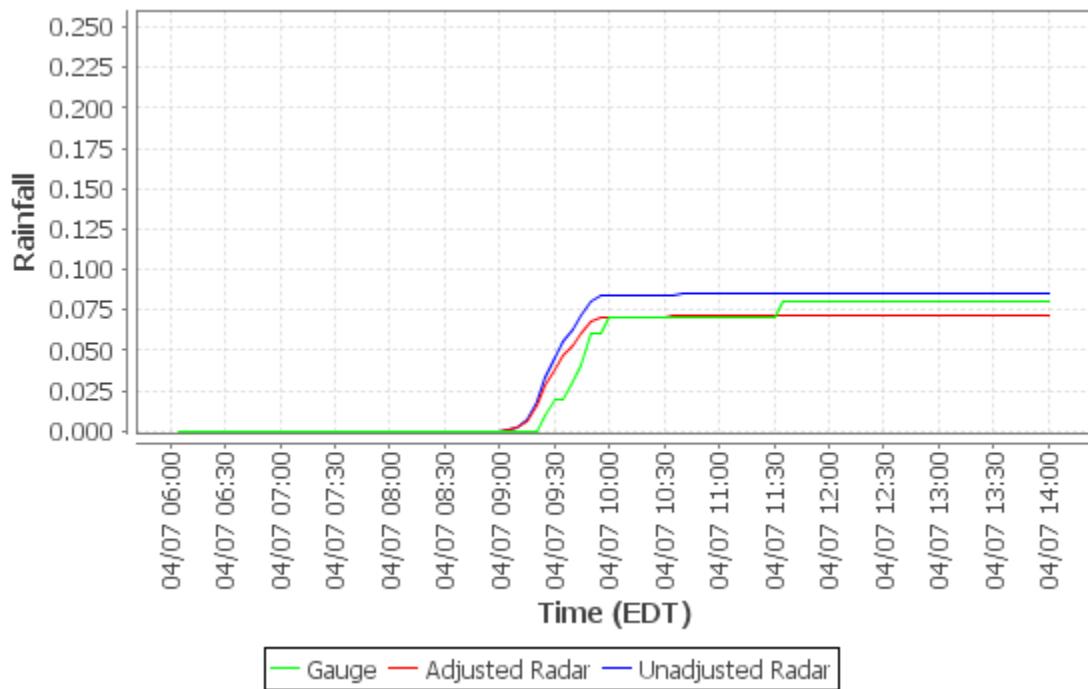
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



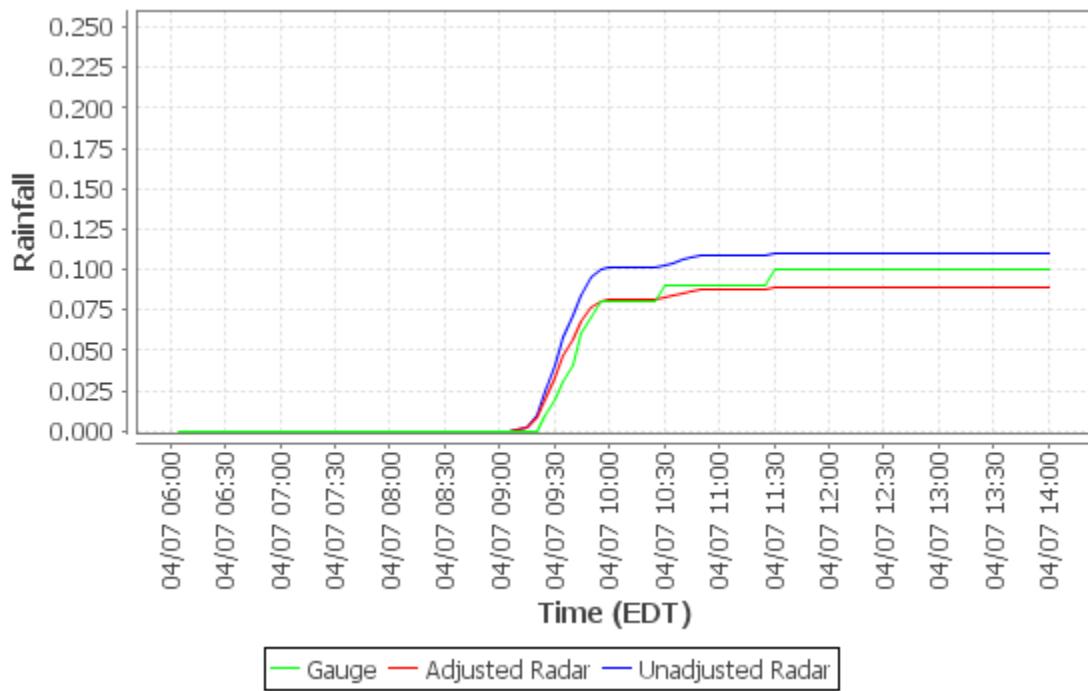
Cumulative Distribution Plot - Upper St. Clair (Loc05)



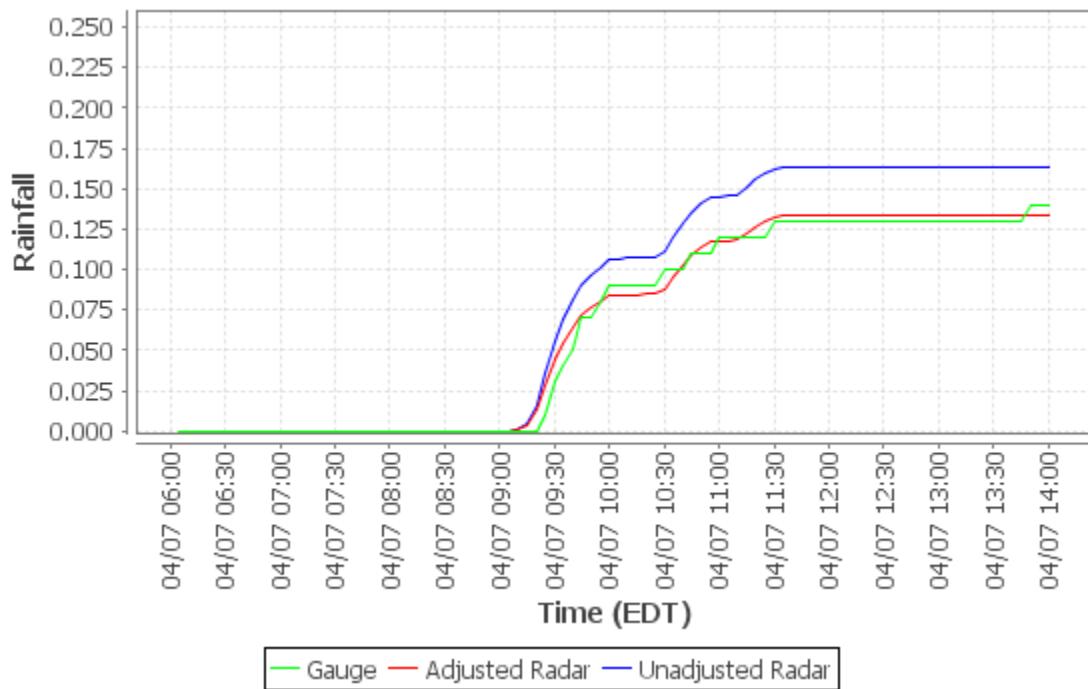
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



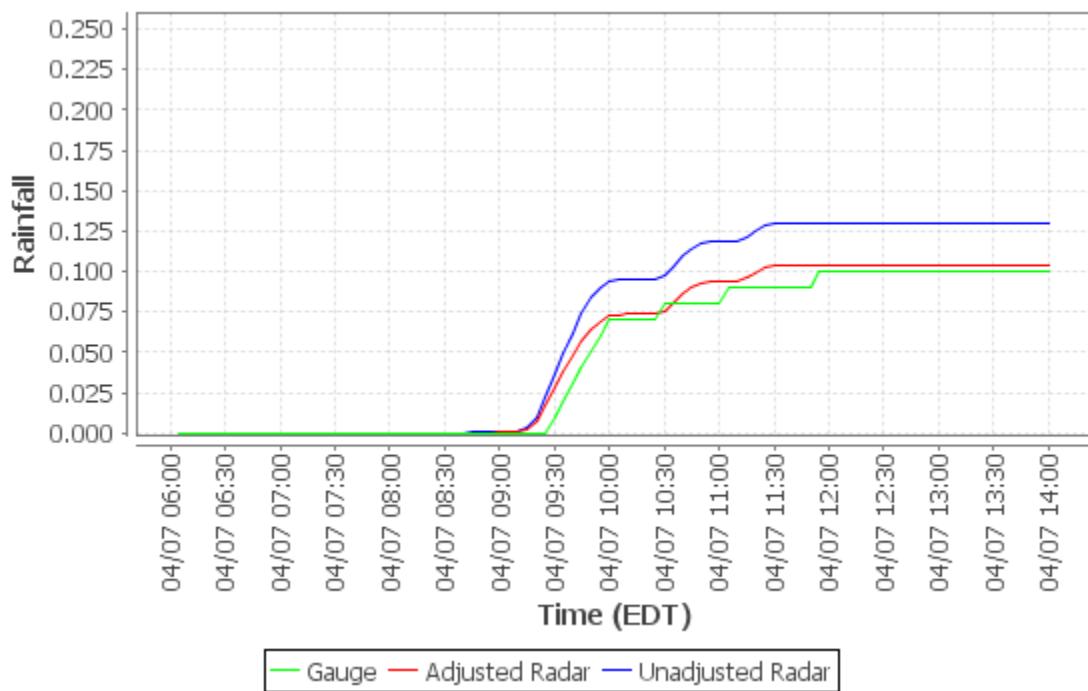
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



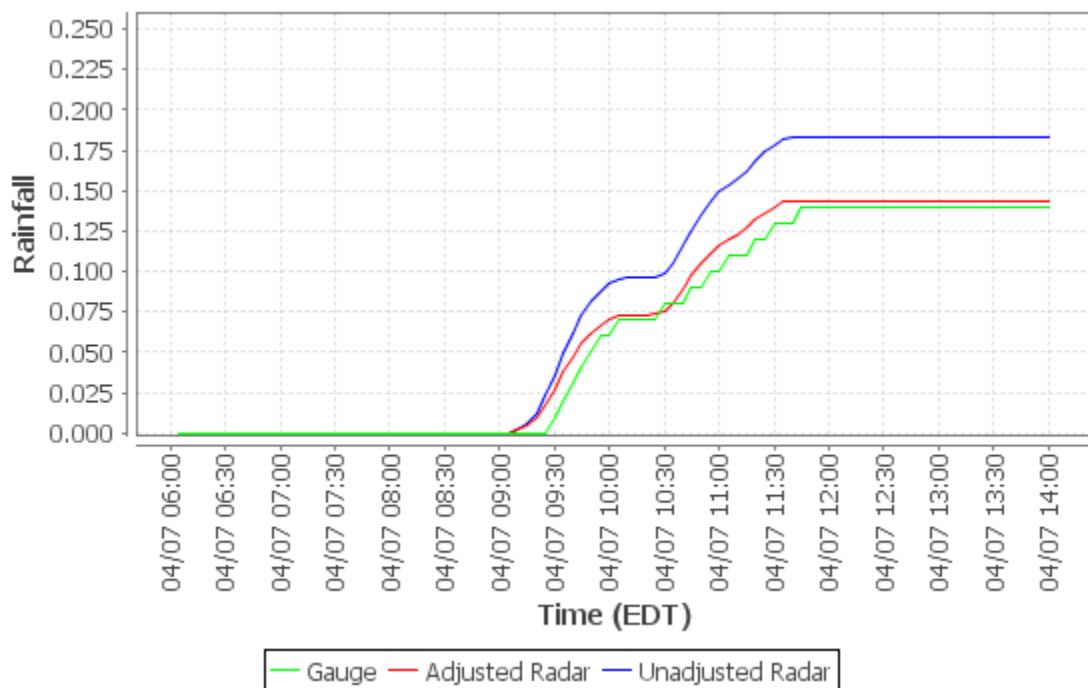
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



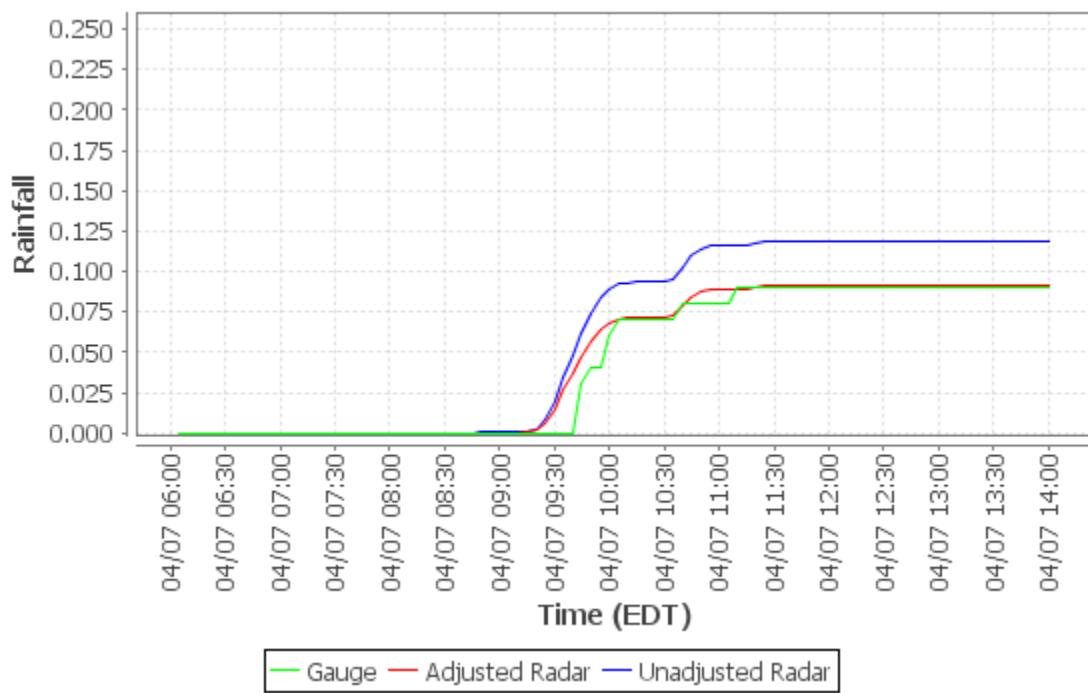
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



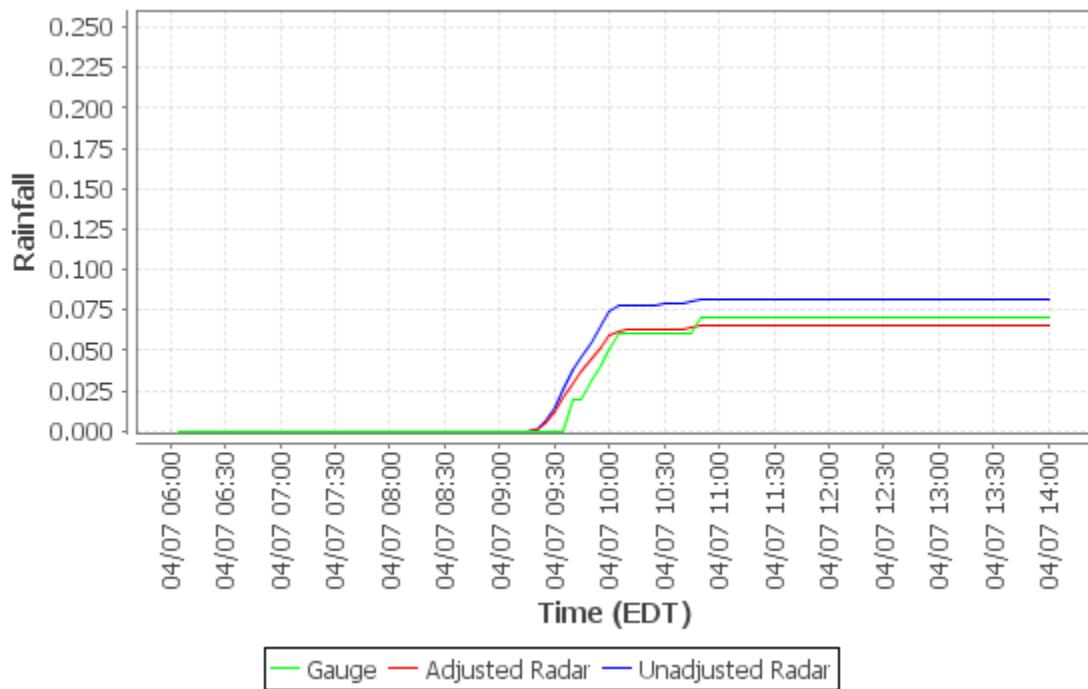
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



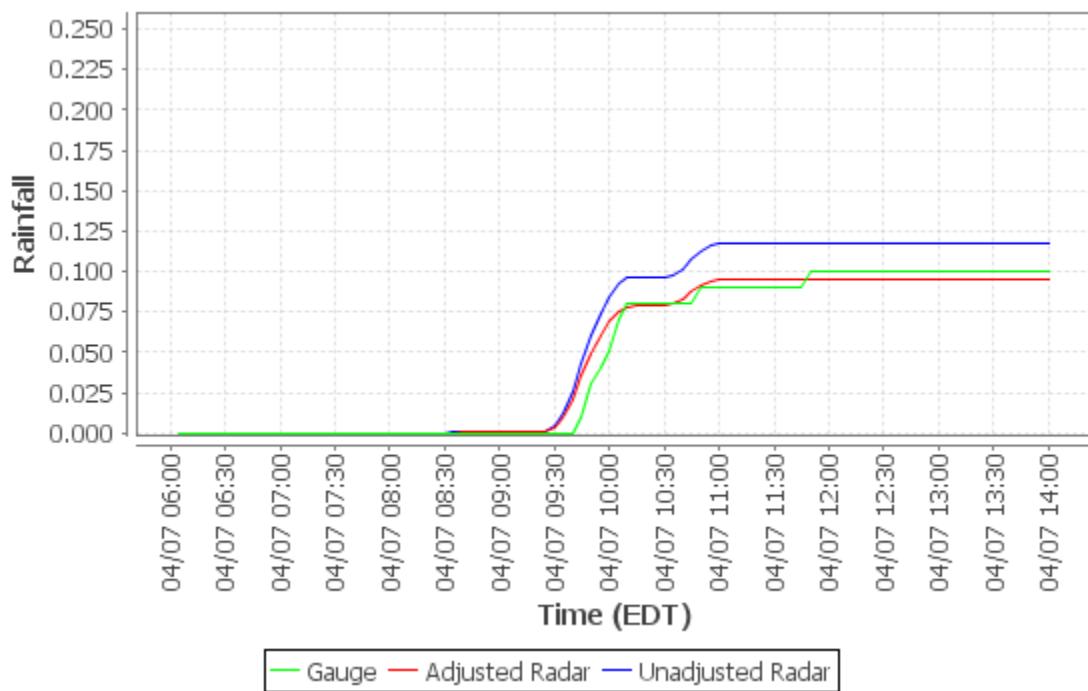
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



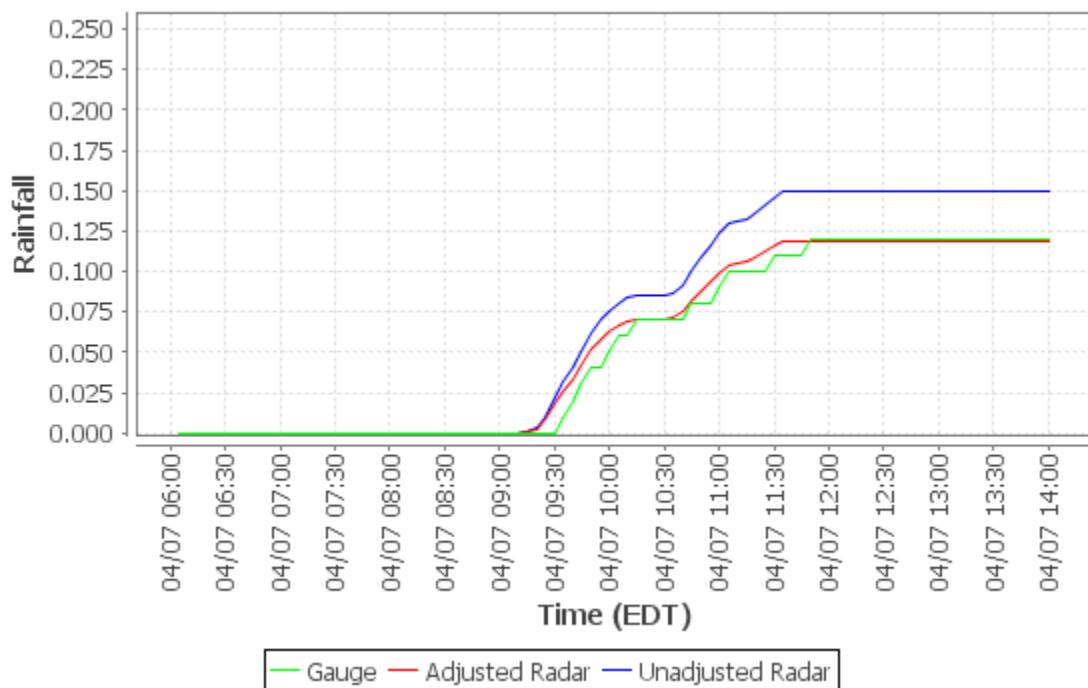
Cumulative Distribution Plot - Baldwin (Loc12)



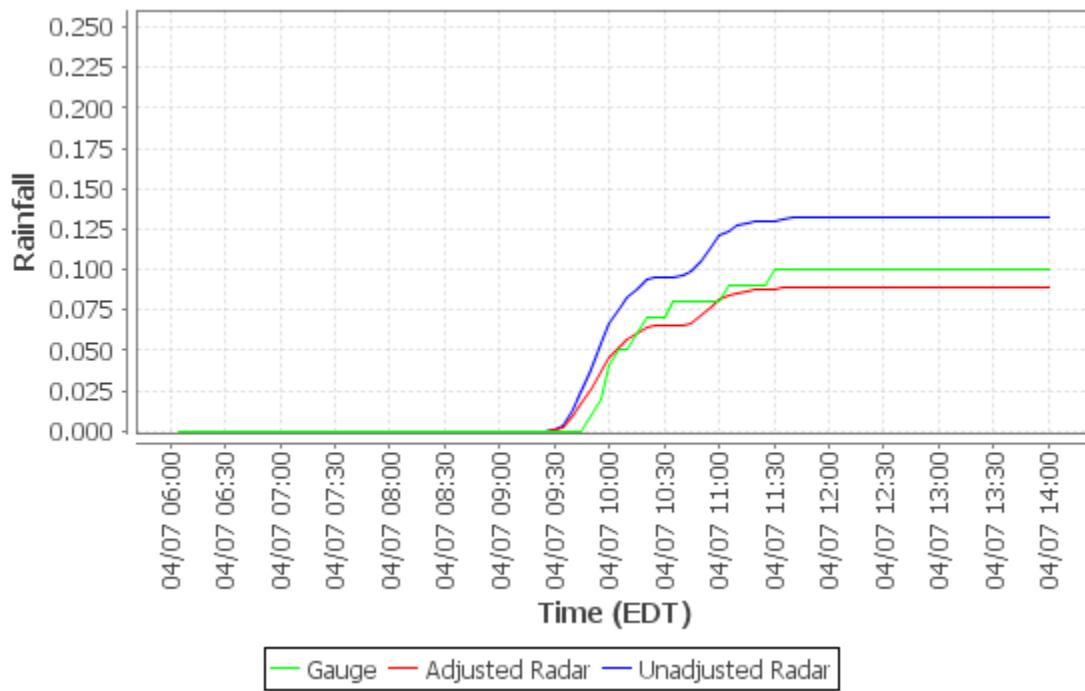
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



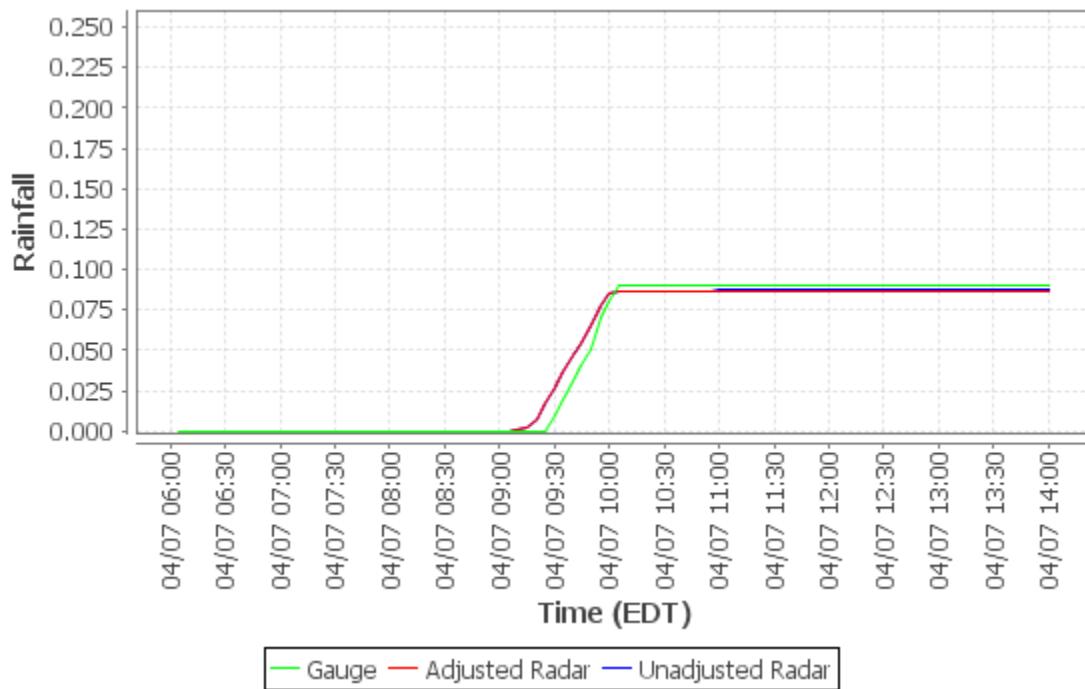
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



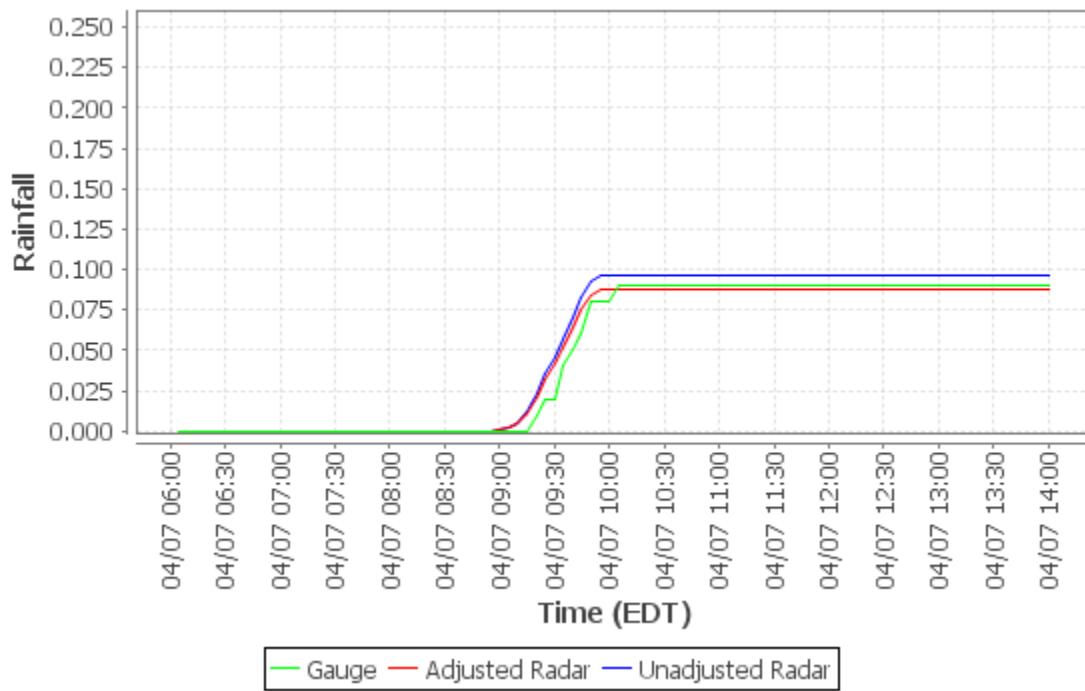
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



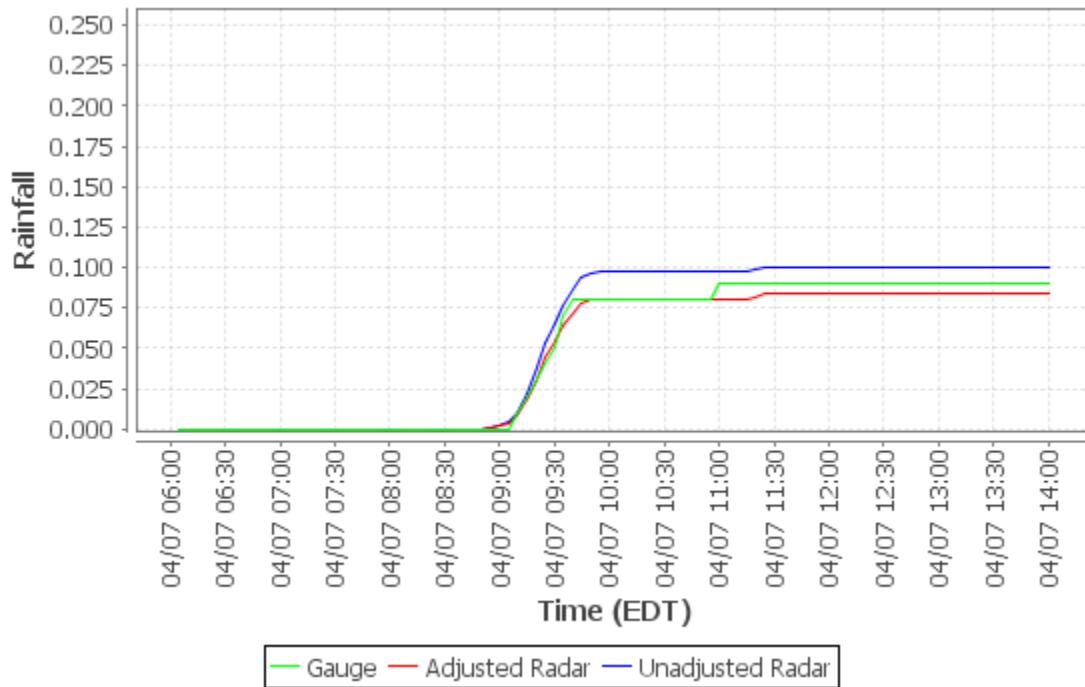
Cumulative Distribution Plot - Castle Shannon (Loc16)



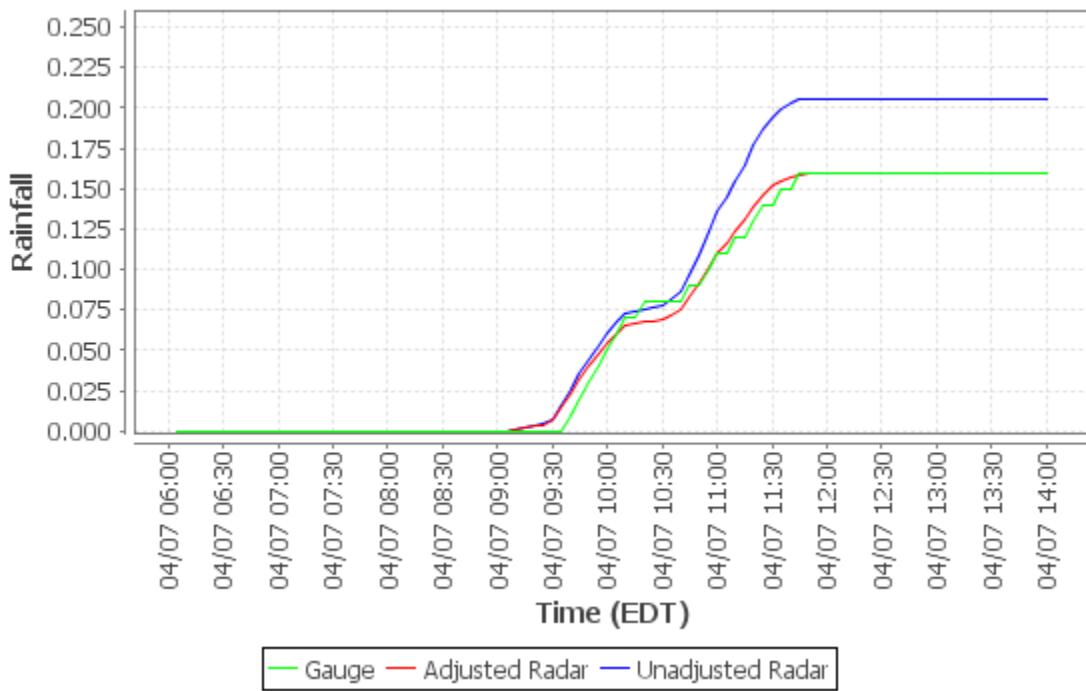
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



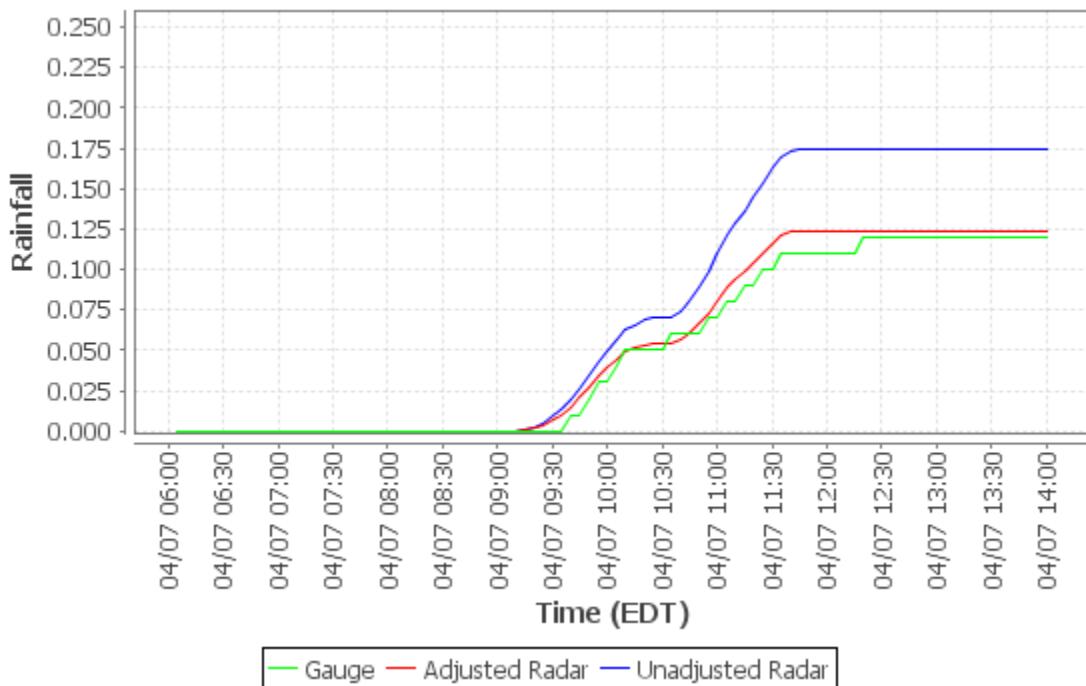
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



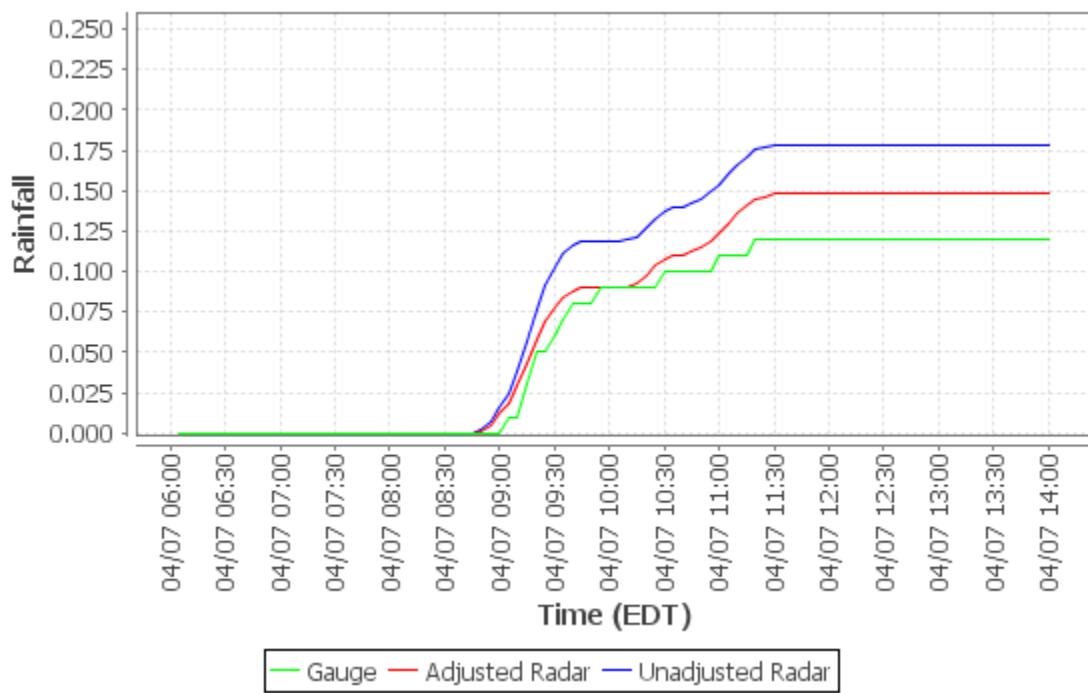
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



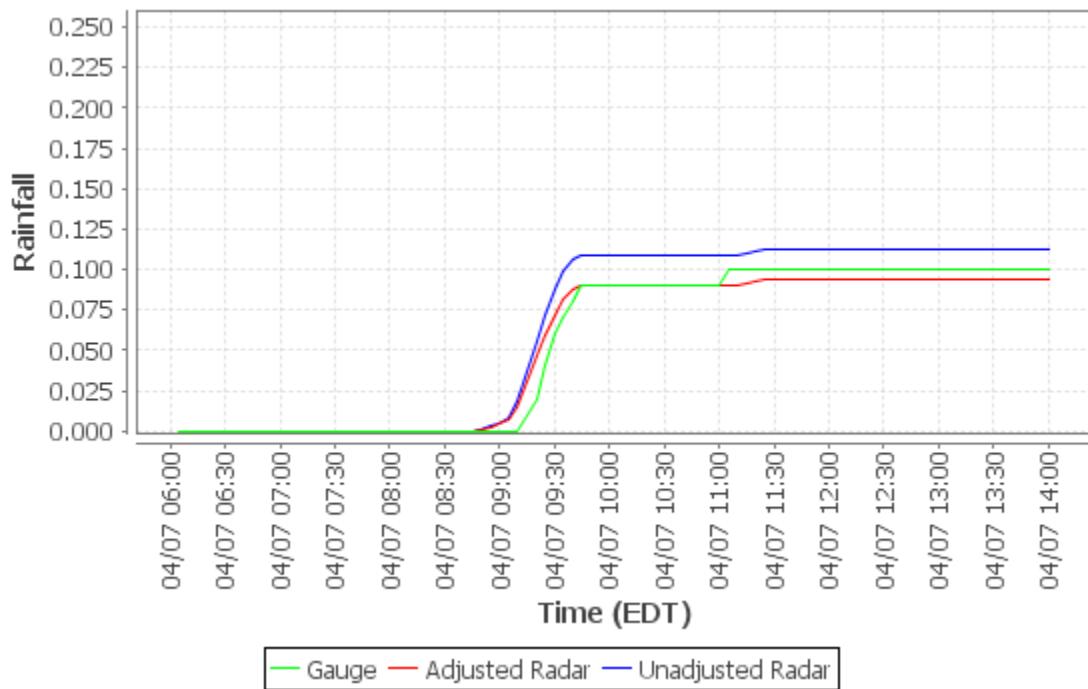
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



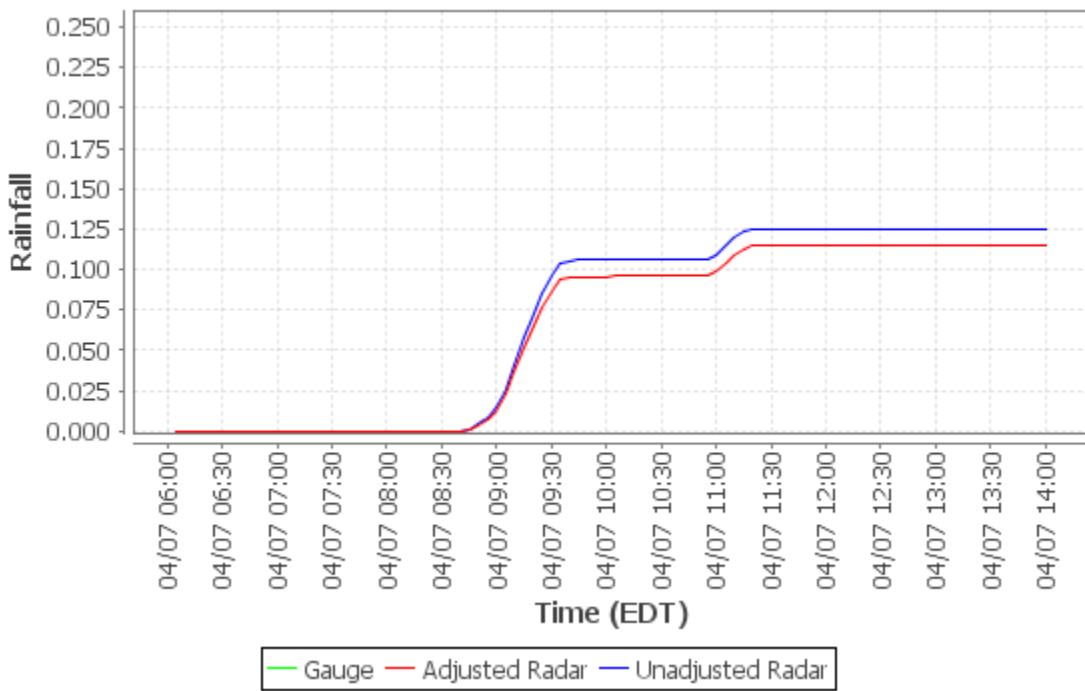
Cumulative Distribution Plot - Moon TWP (Loc21)



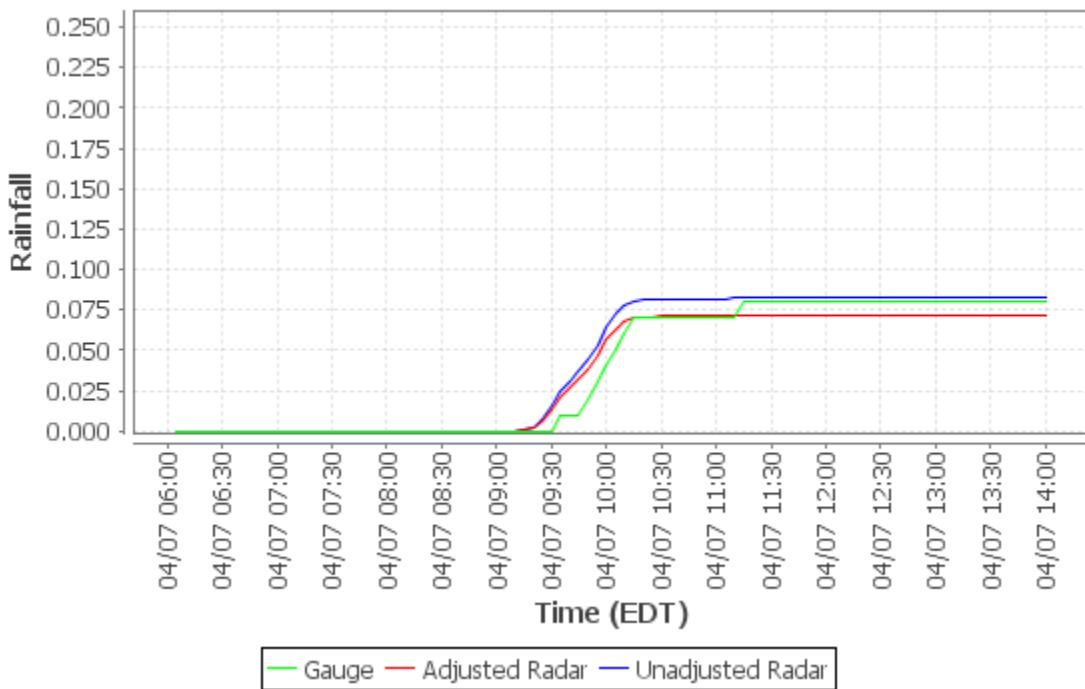
Cumulative Distribution Plot - North Fayette TWP (Loc22)



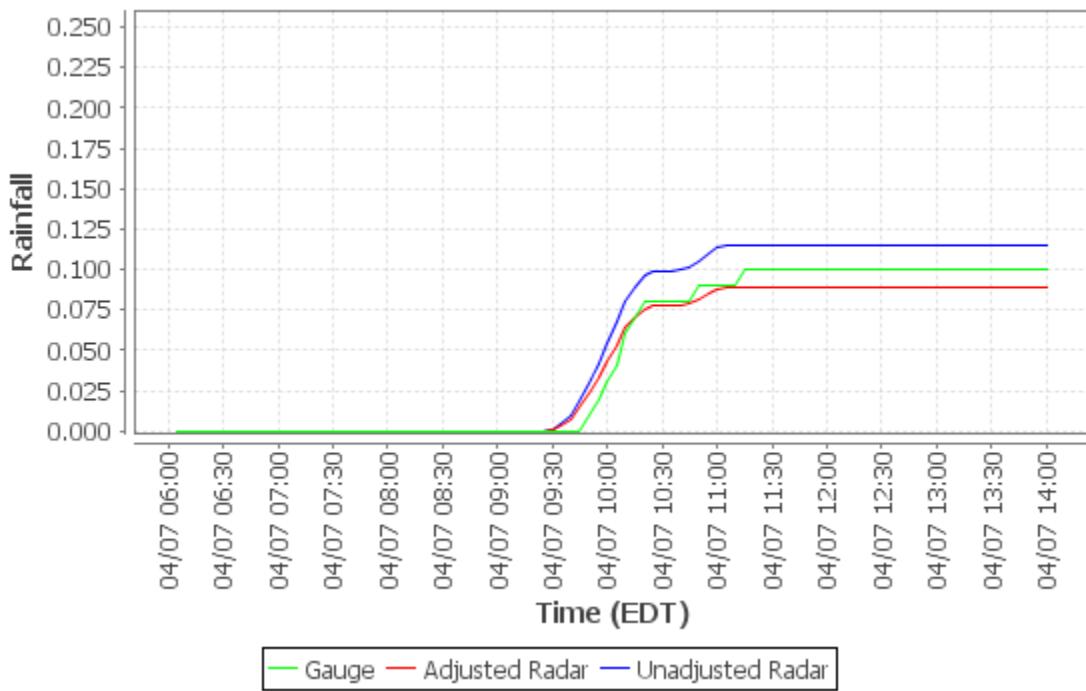
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



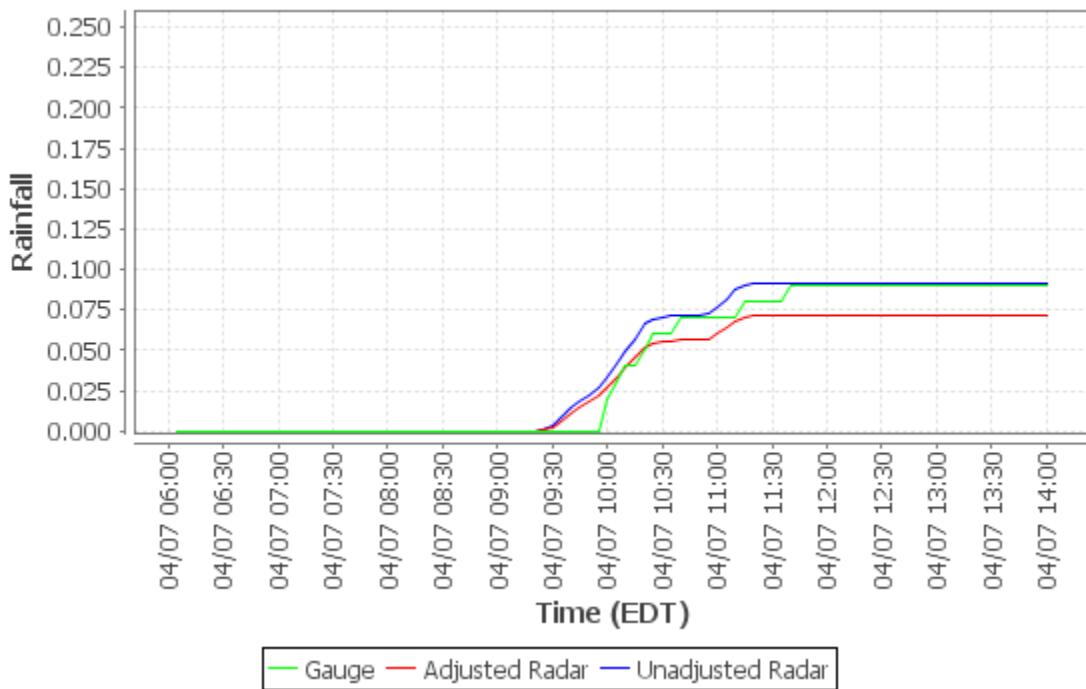
Cumulative Distribution Plot - Jefferson Hills (Loc24)



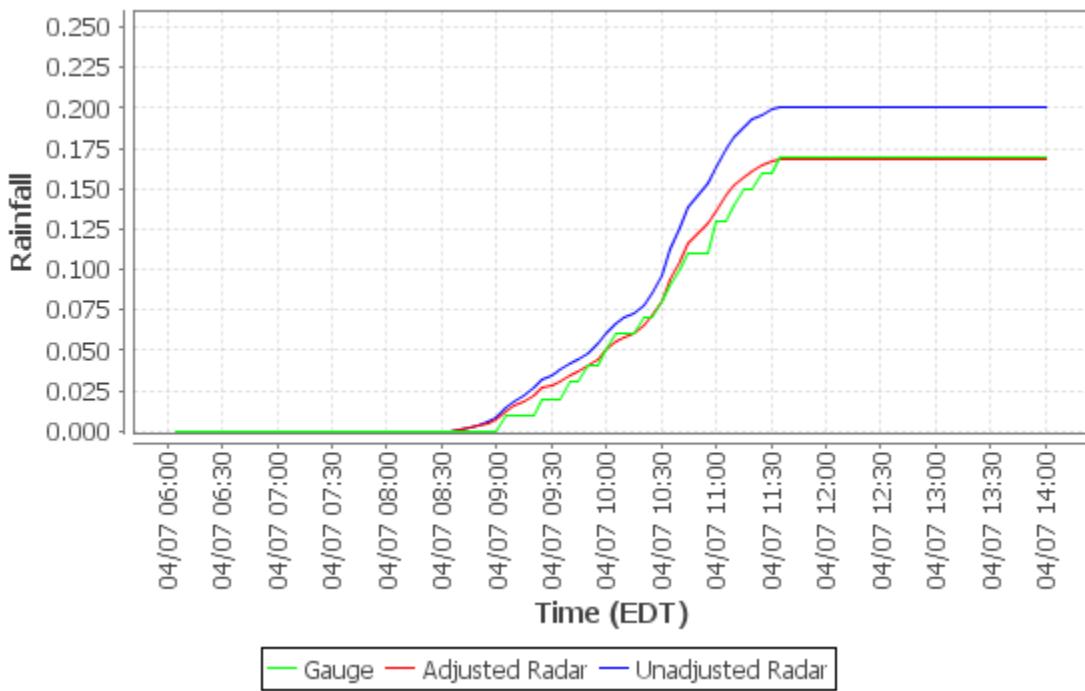
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



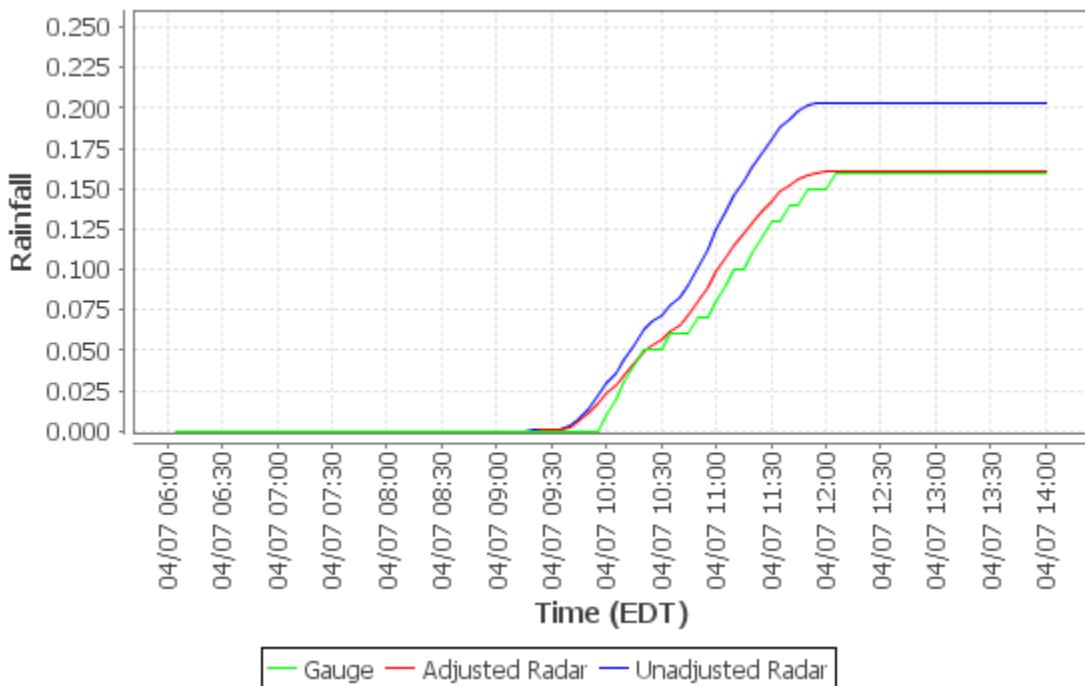
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



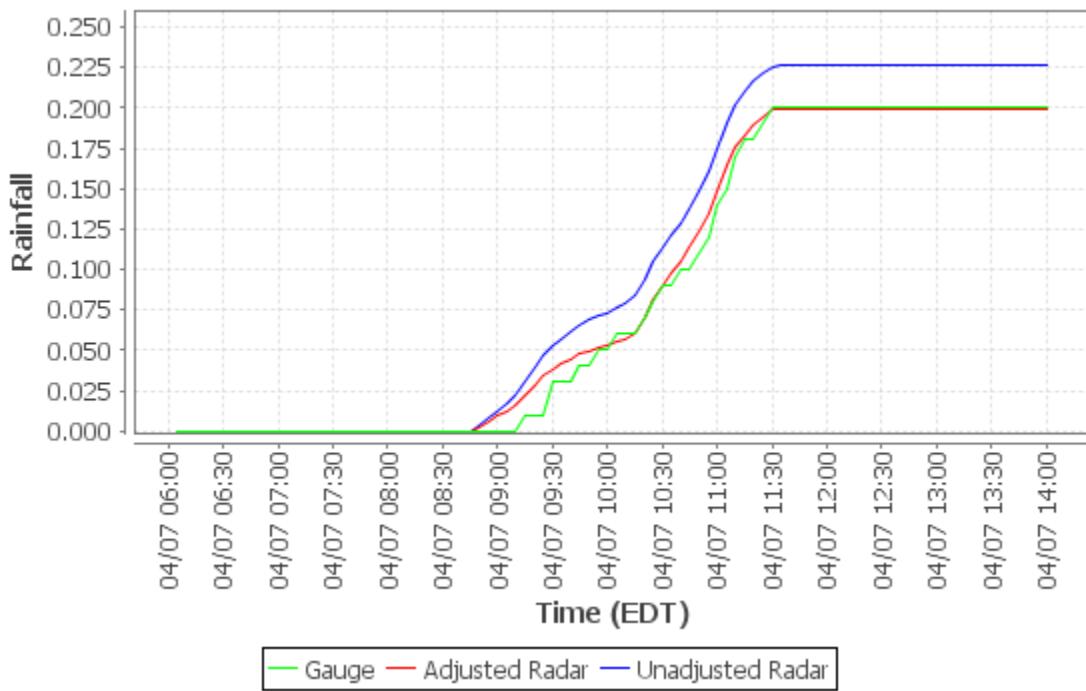
Cumulative Distribution Plot - Marshall TWP (Loc27)



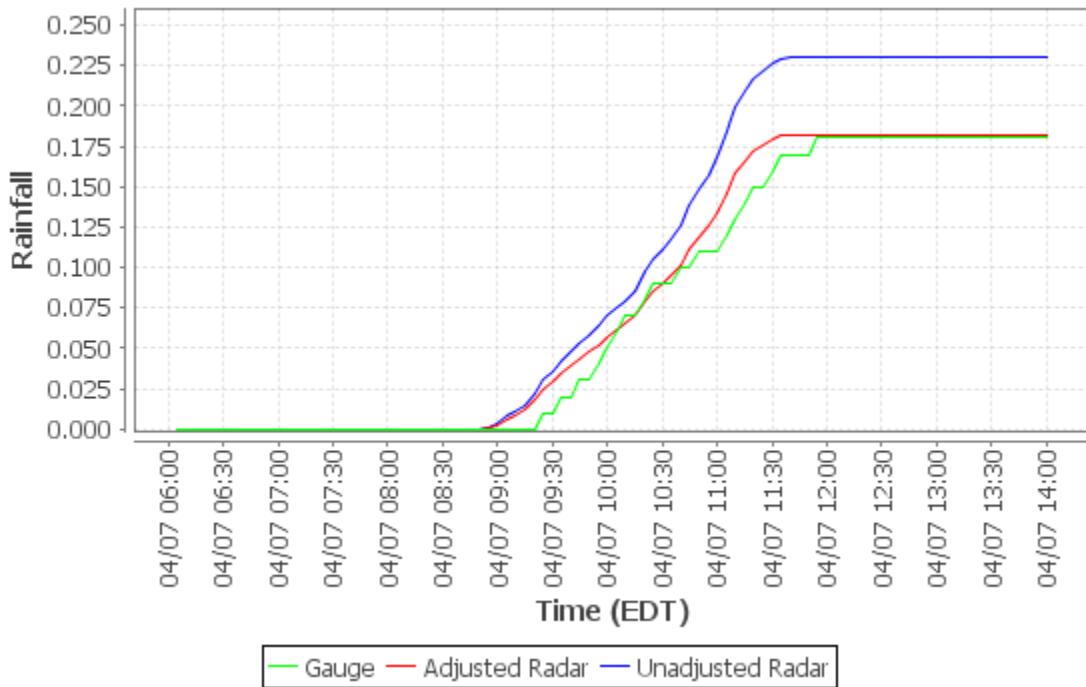
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



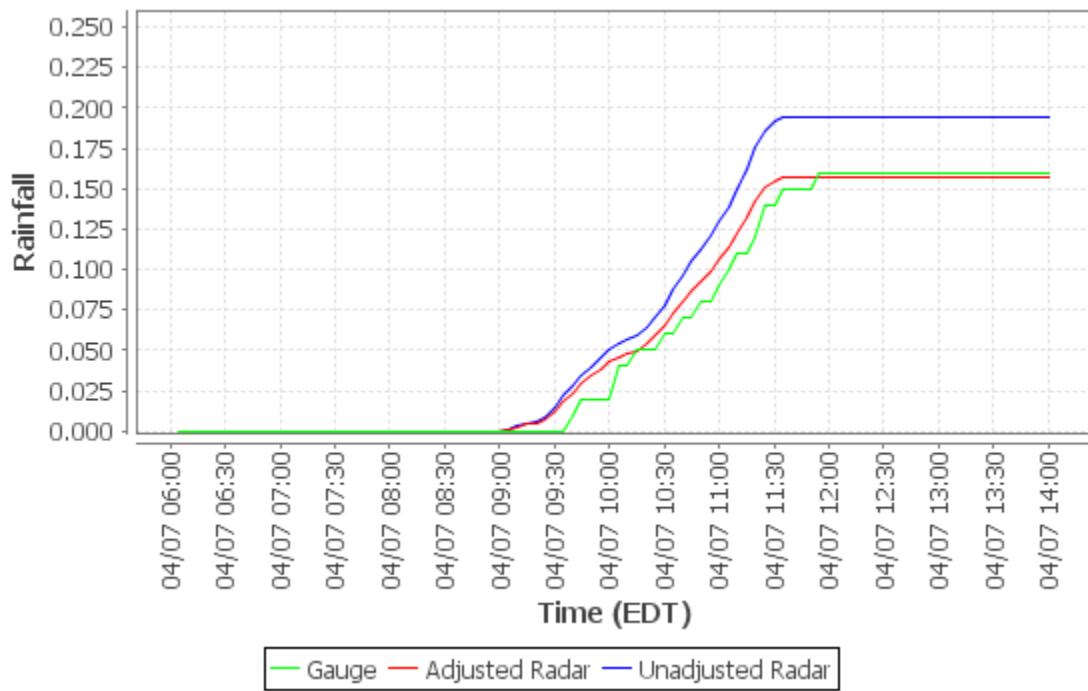
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



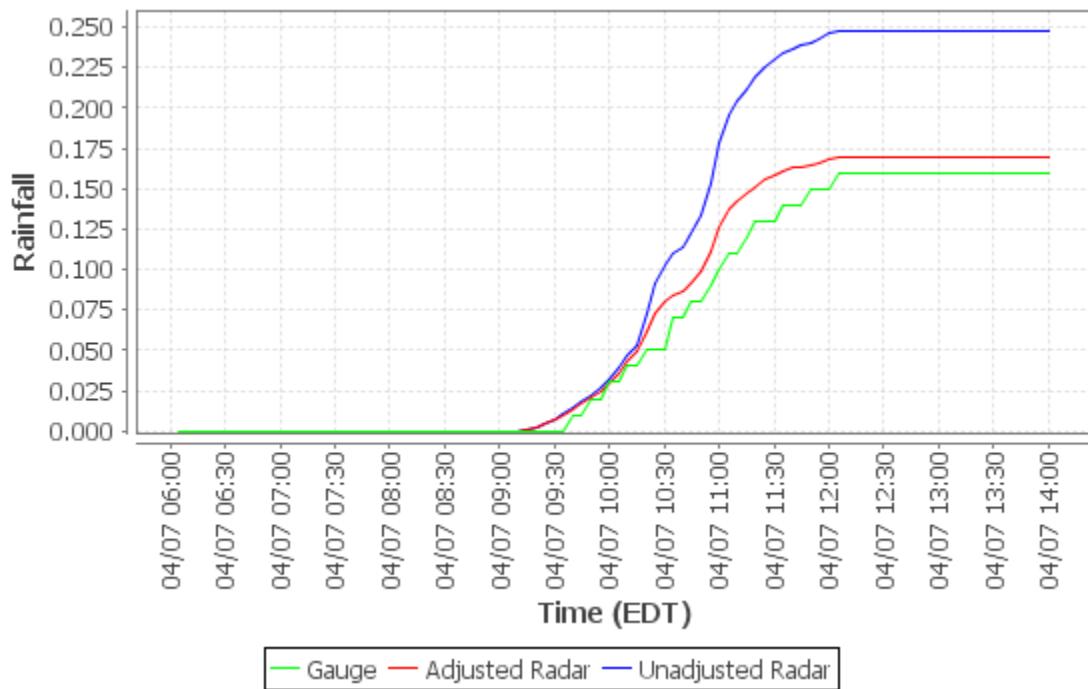
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



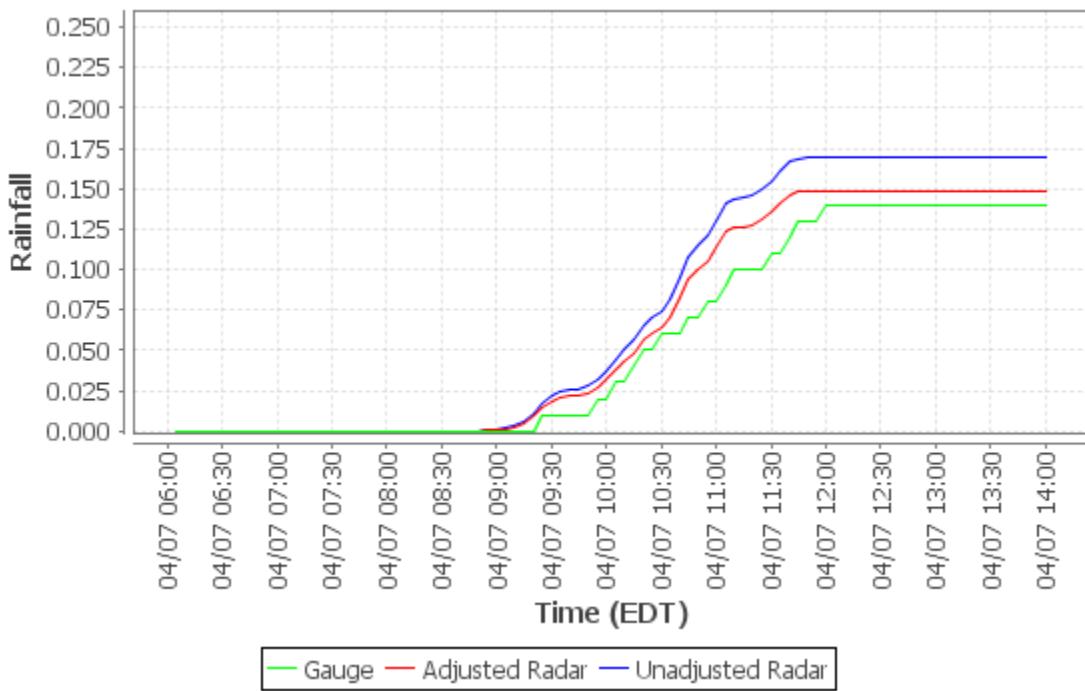
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



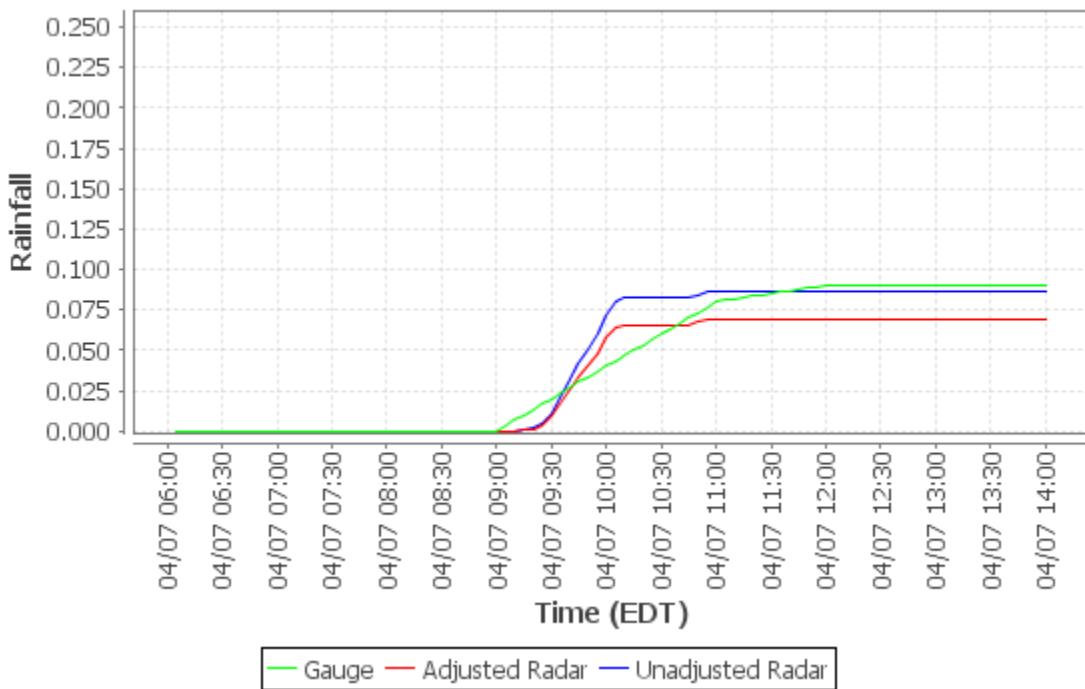
Cumulative Distribution Plot - Arnold (Loc32)



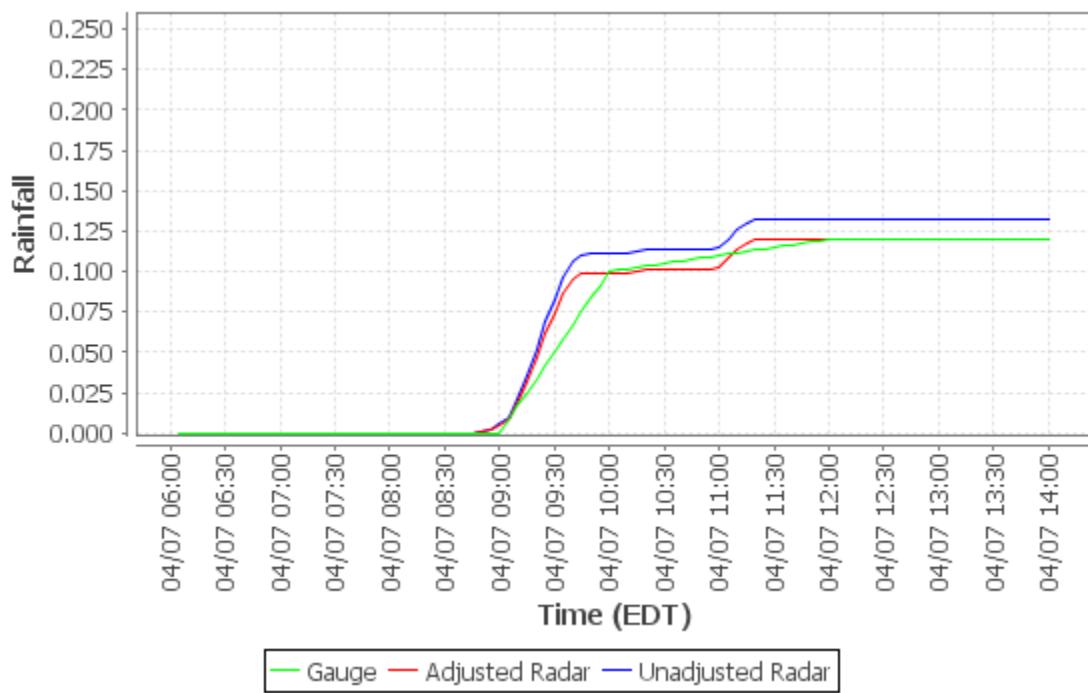
Cumulative Distribution Plot - Richland TWP (Loc33)



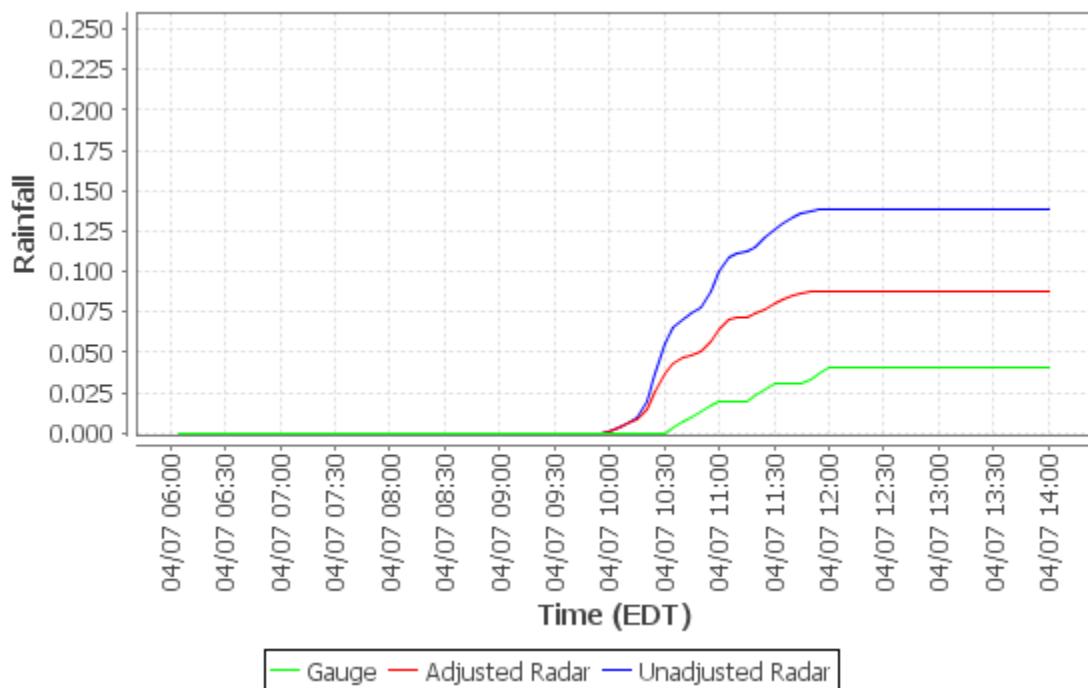
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



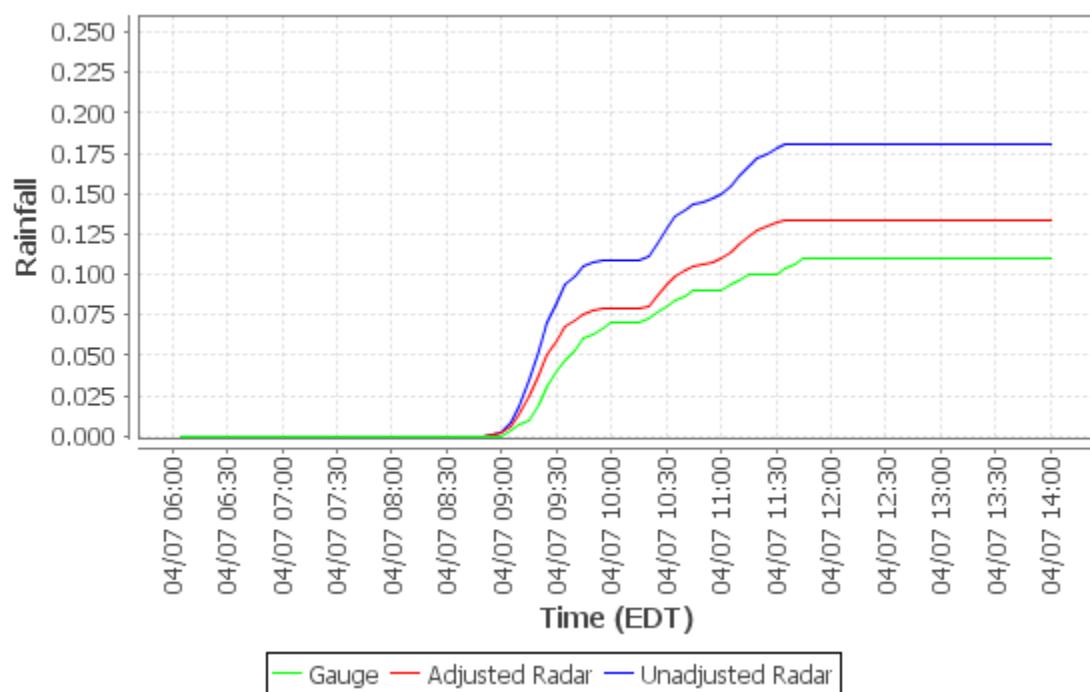
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

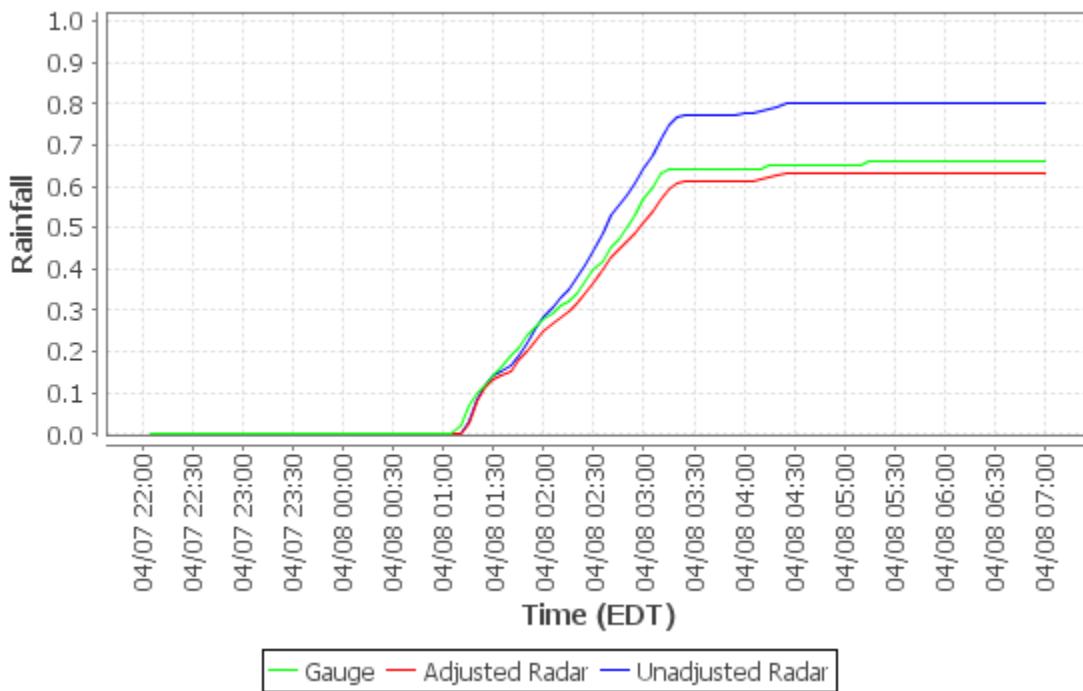


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

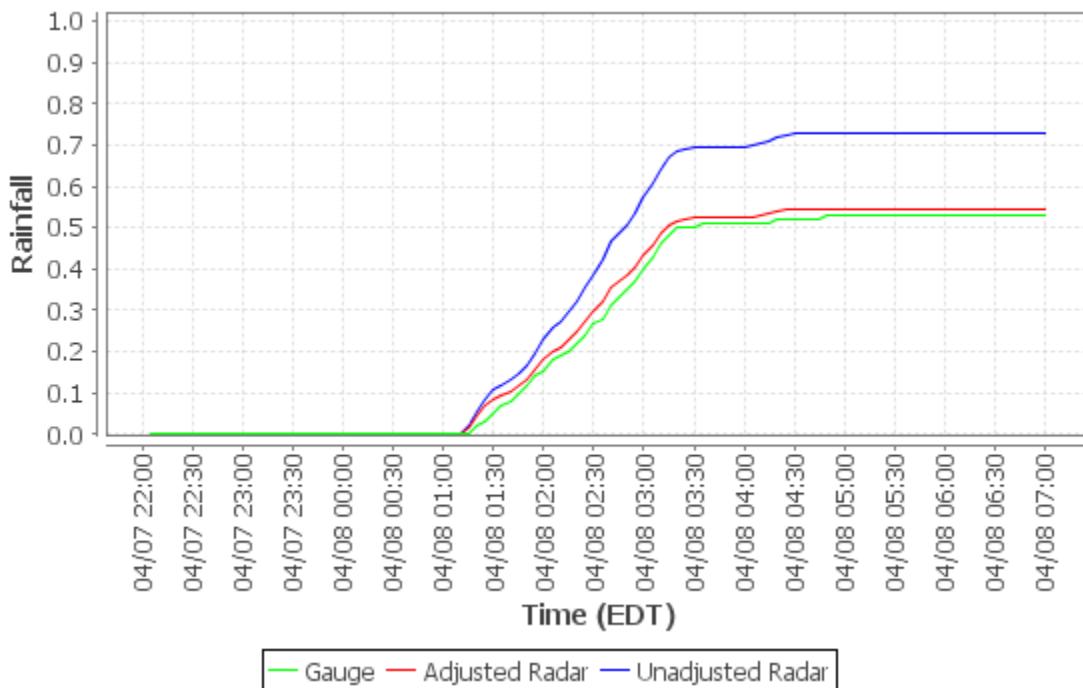


Appendix D - Event 2 (2020-04-08) CDPs

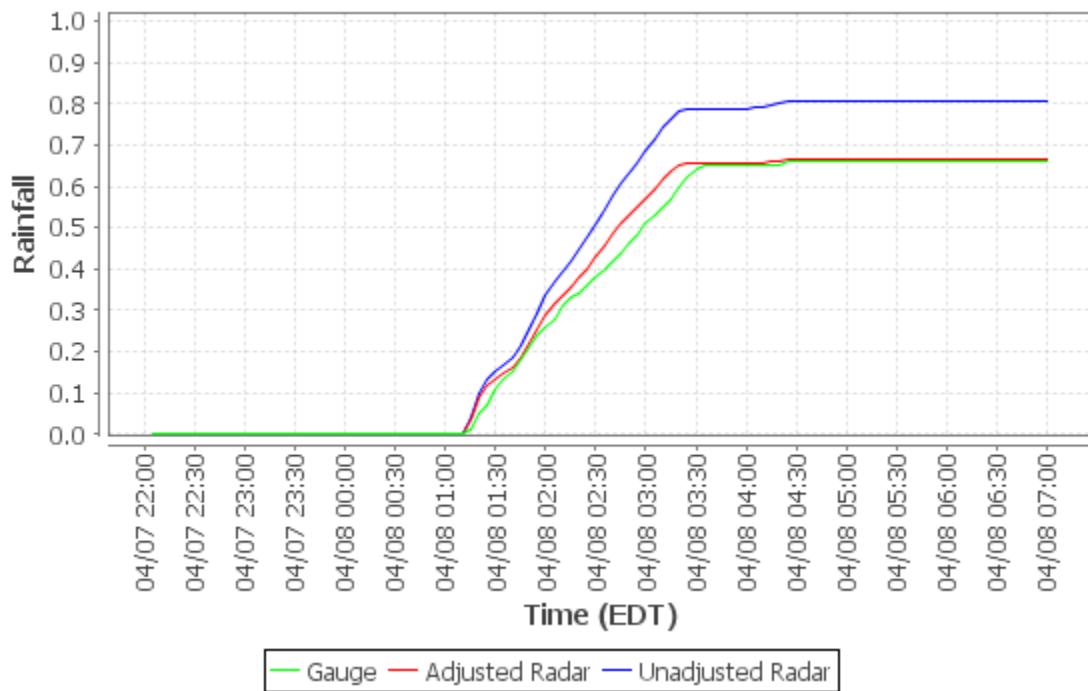
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



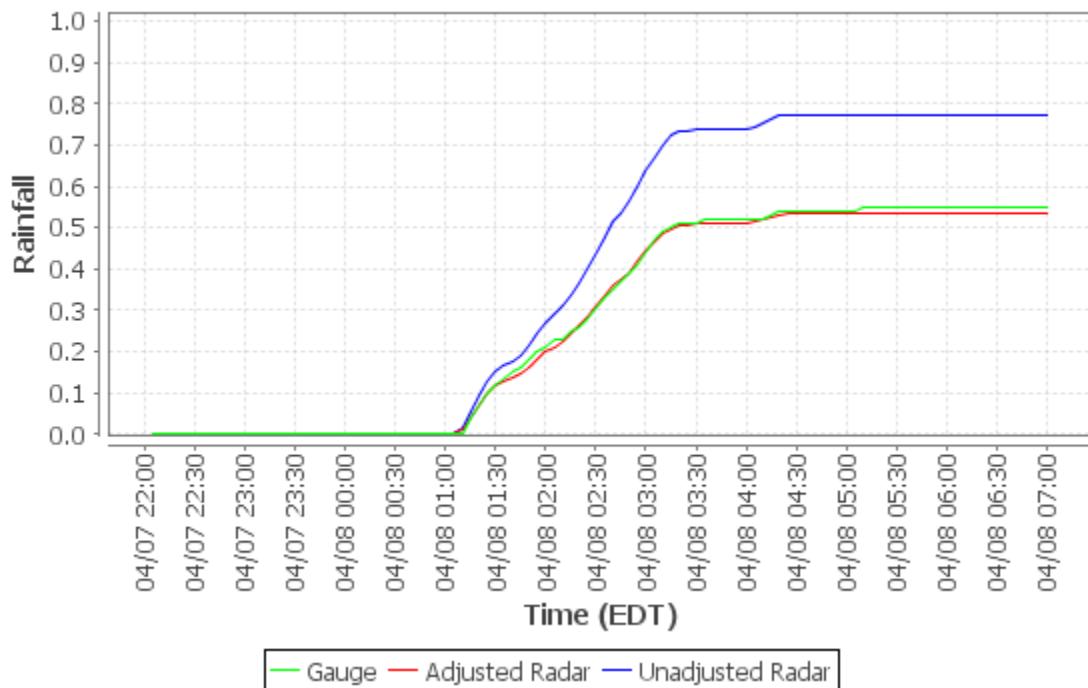
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



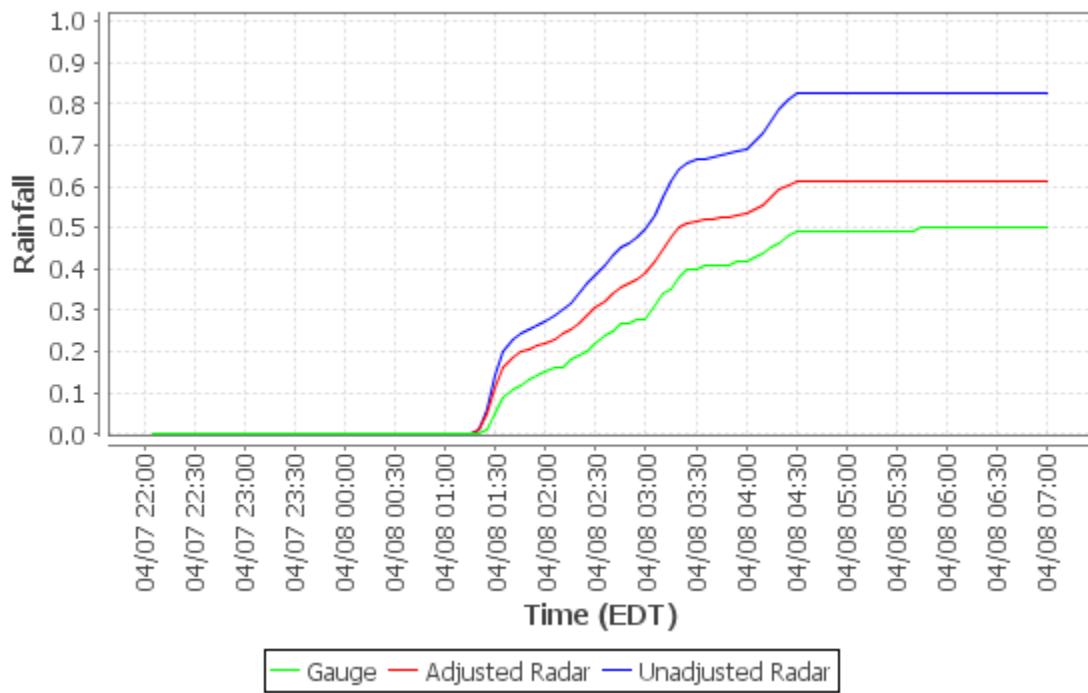
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



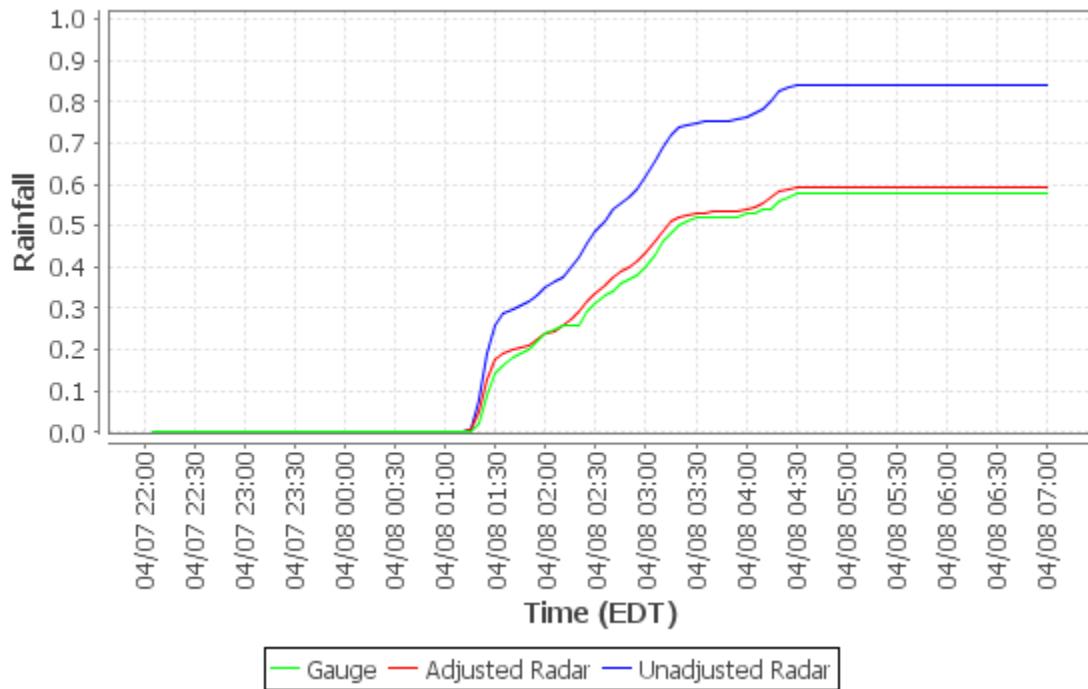
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



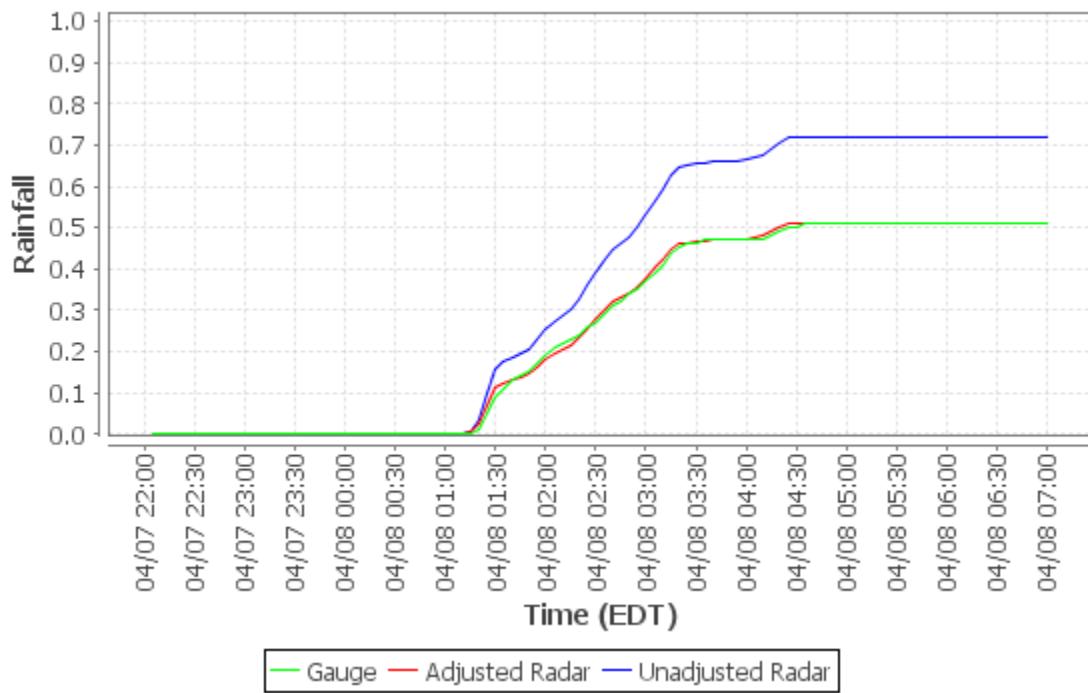
Cumulative Distribution Plot - Upper St. Clair (Loc05)



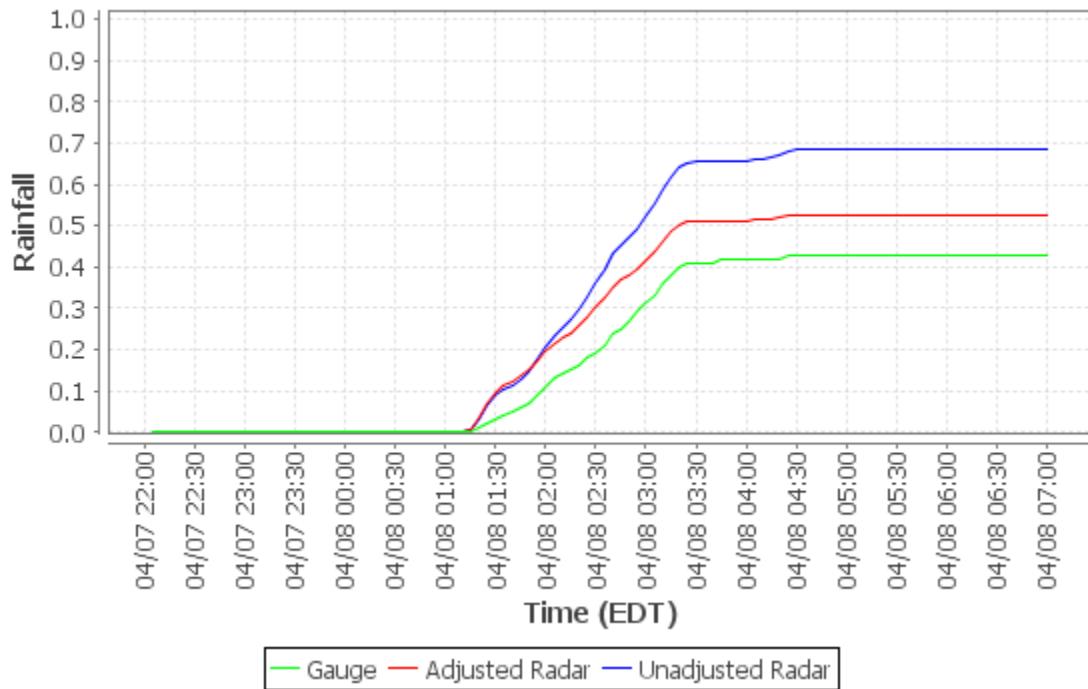
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



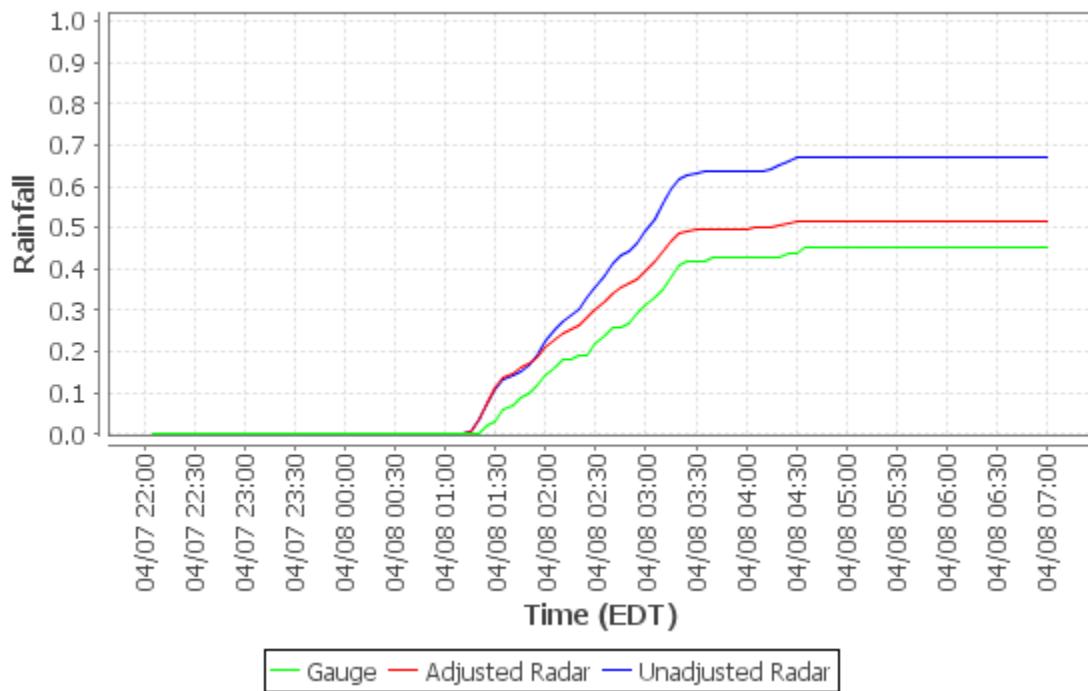
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



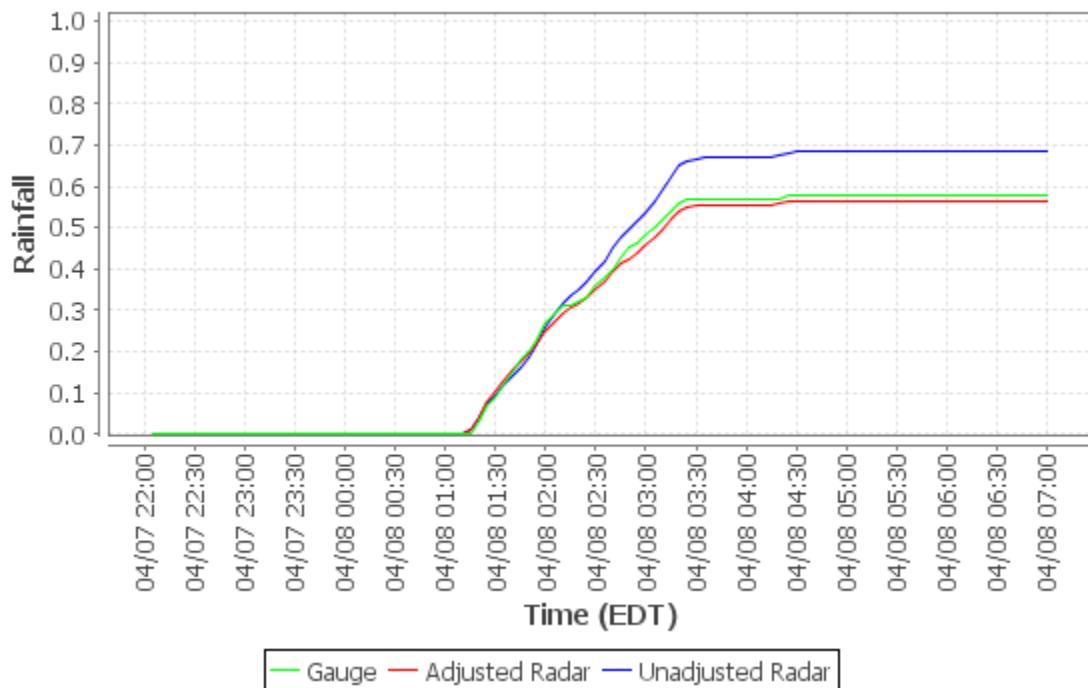
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



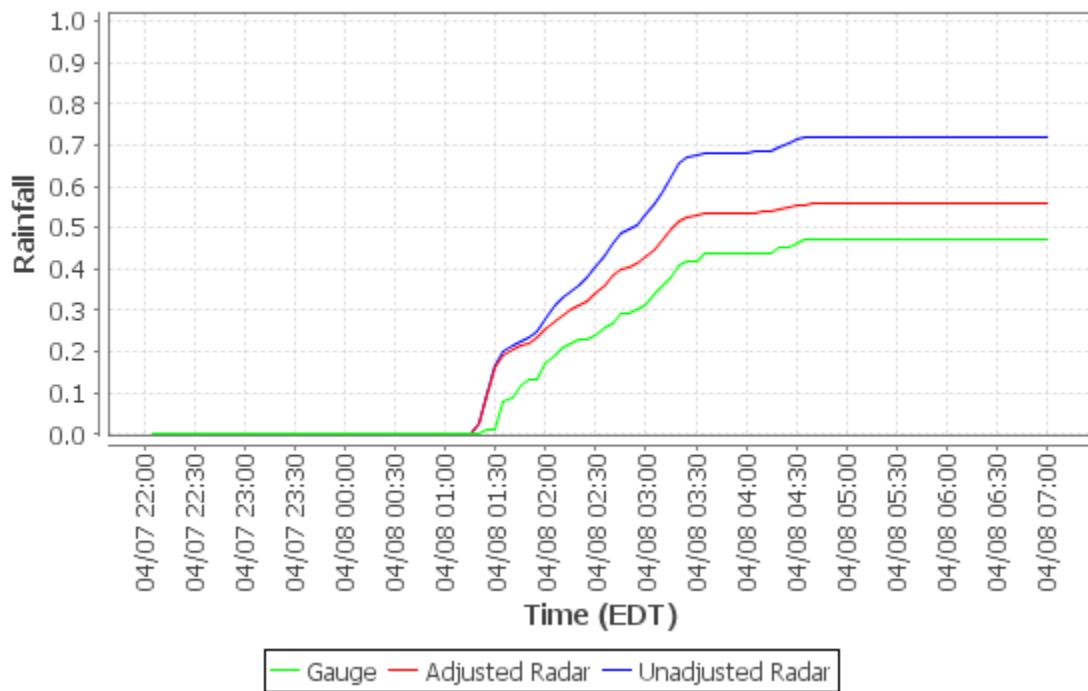
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



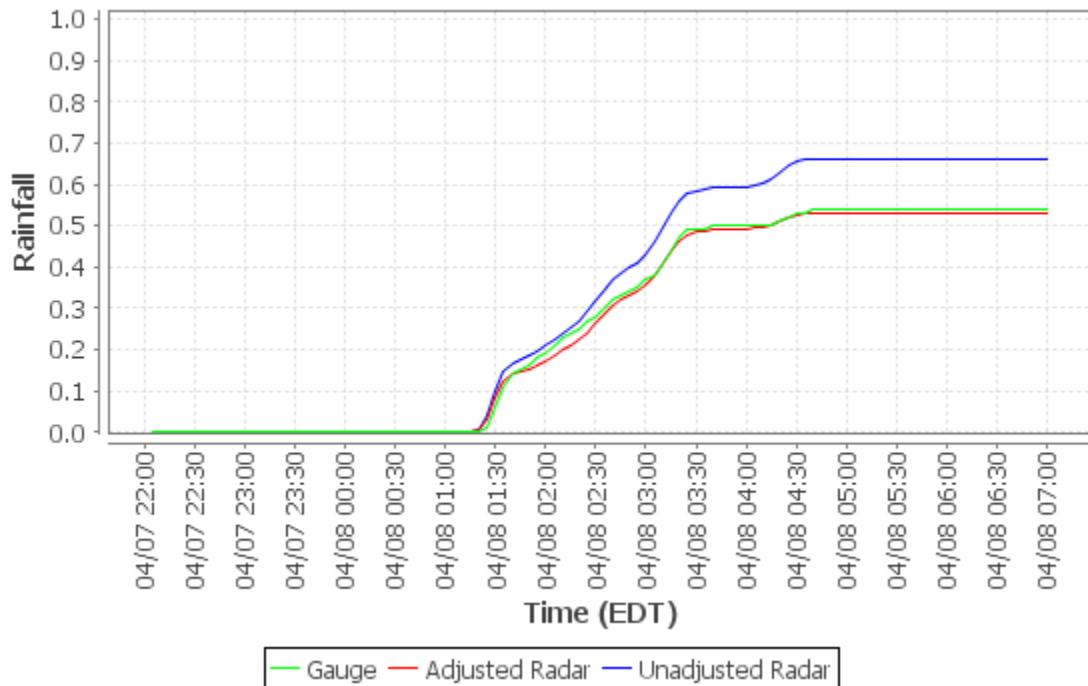
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



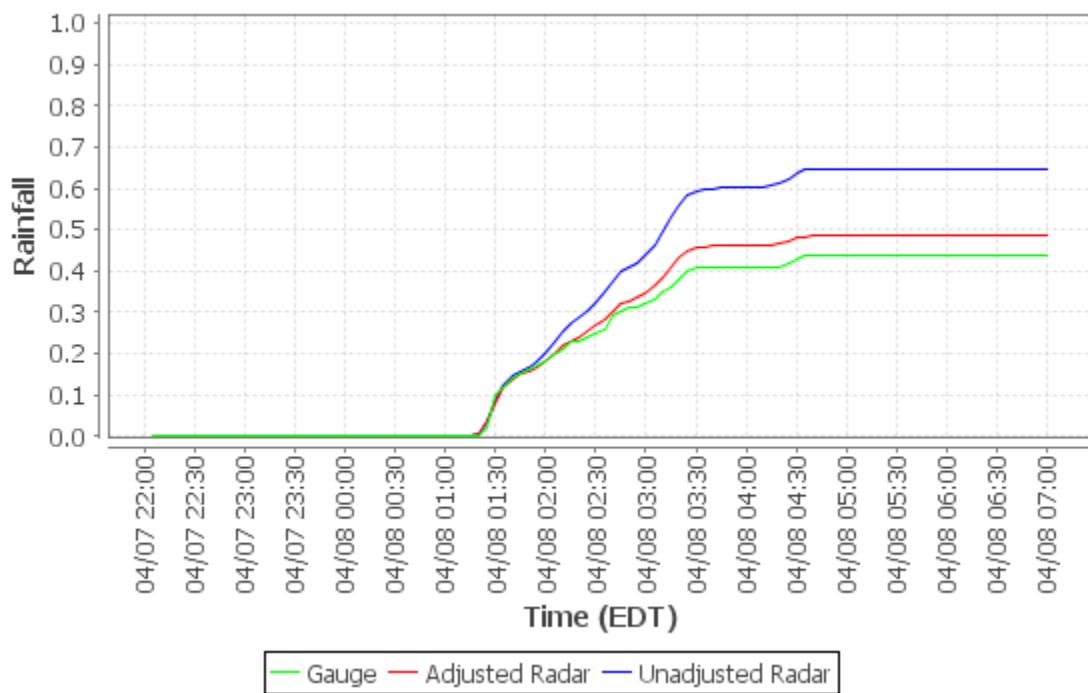
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



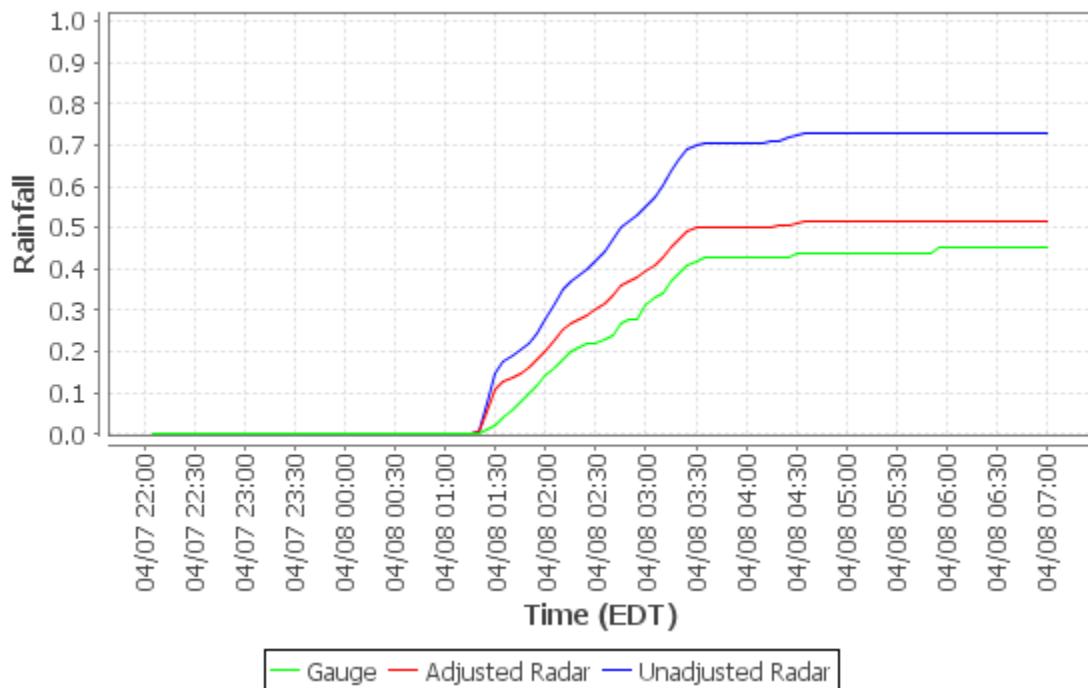
Cumulative Distribution Plot - Baldwin (Loc12)



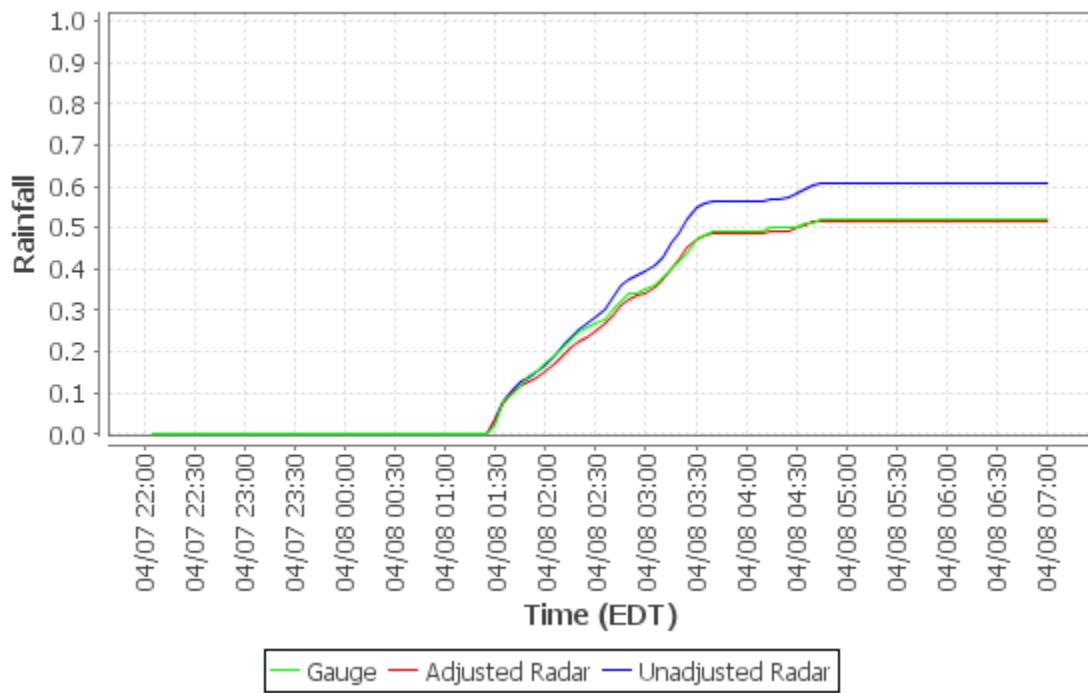
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



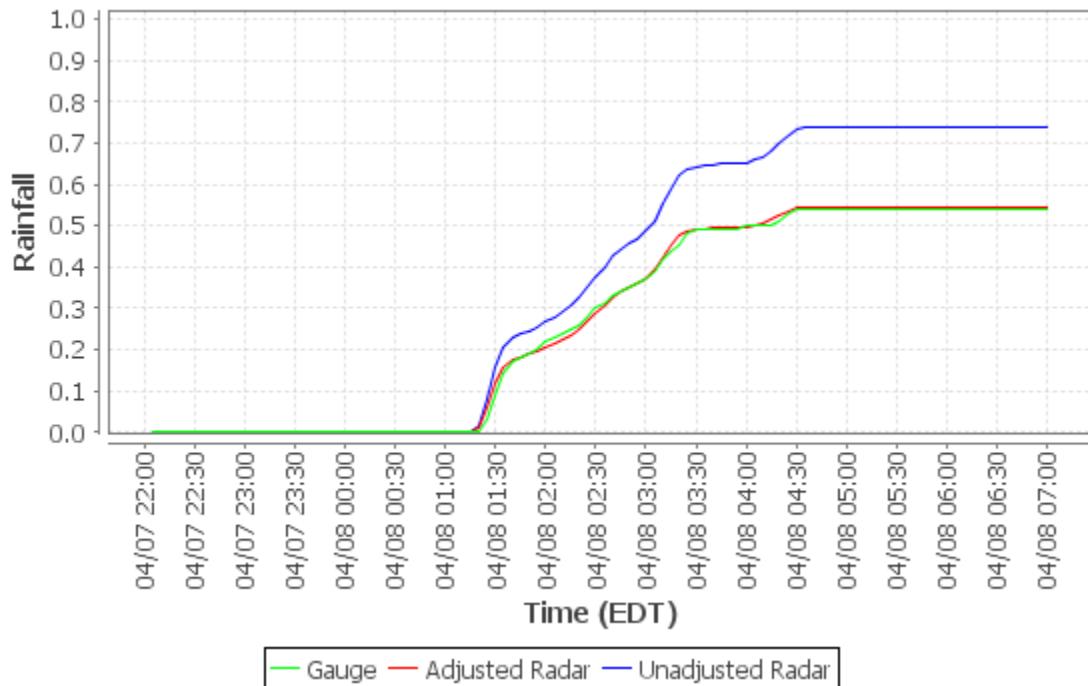
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



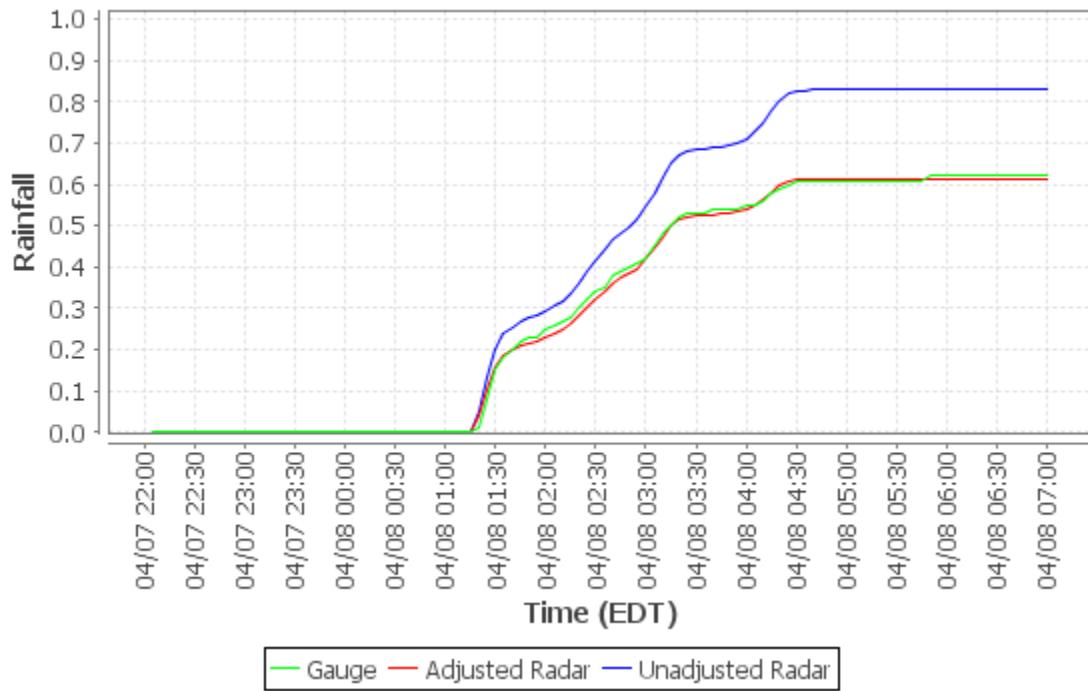
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



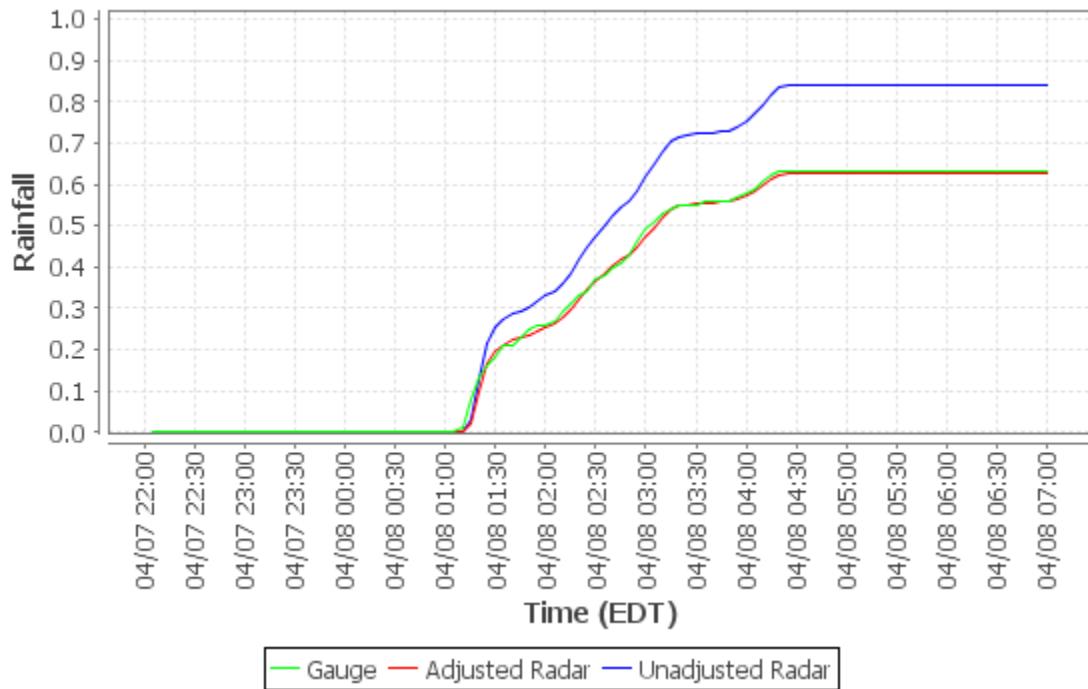
Cumulative Distribution Plot - Castle Shannon (Loc16)



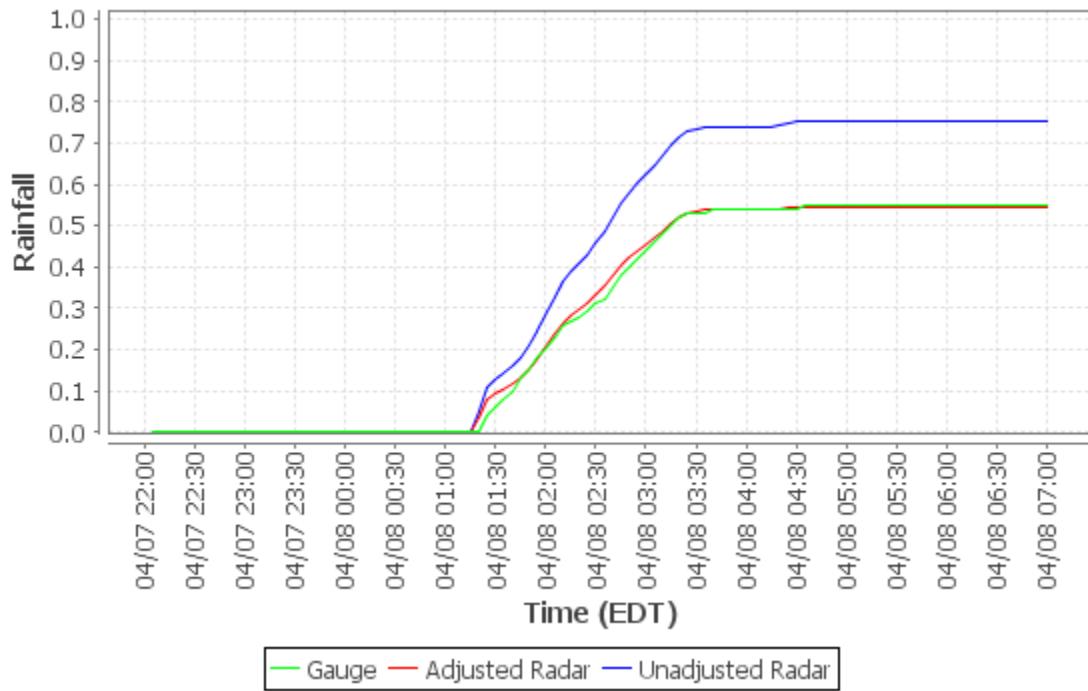
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



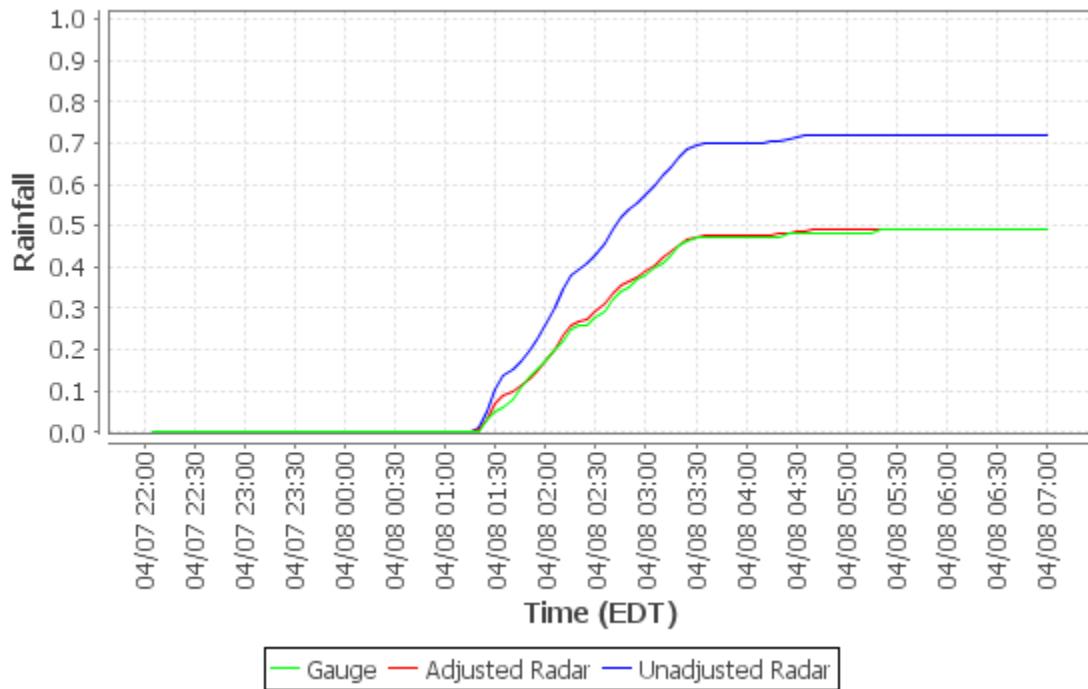
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



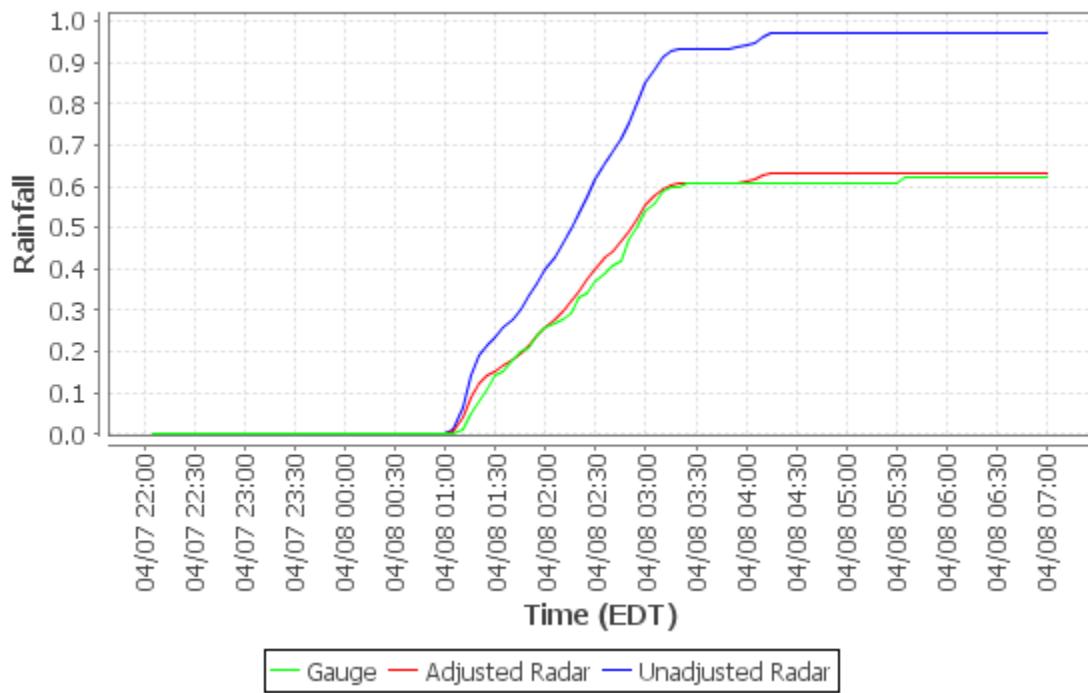
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



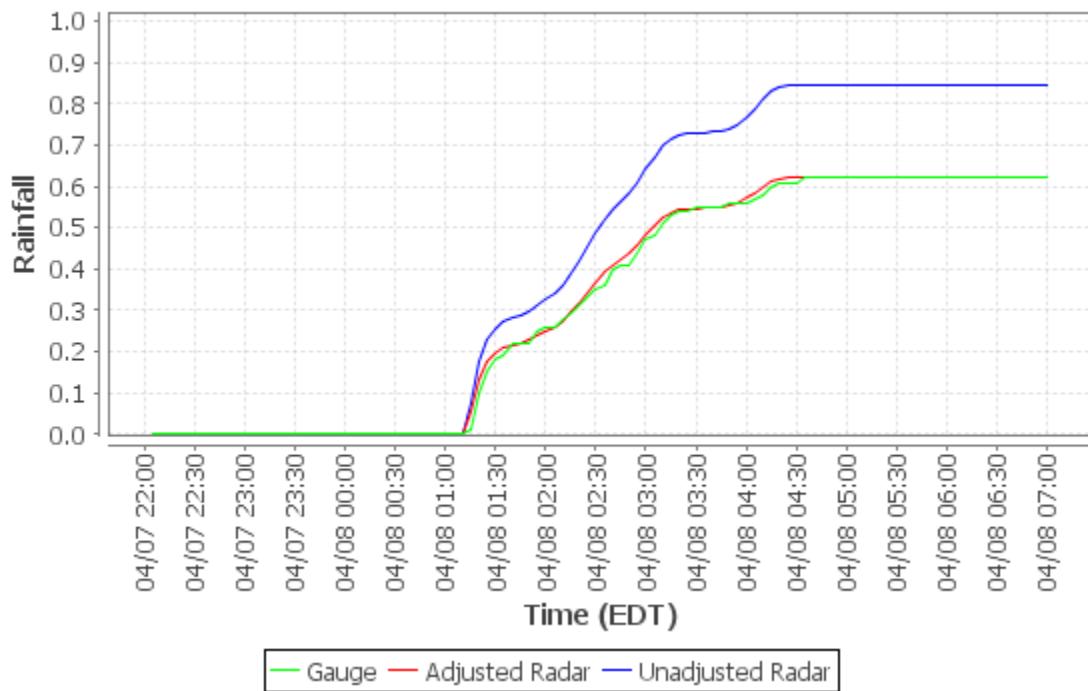
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



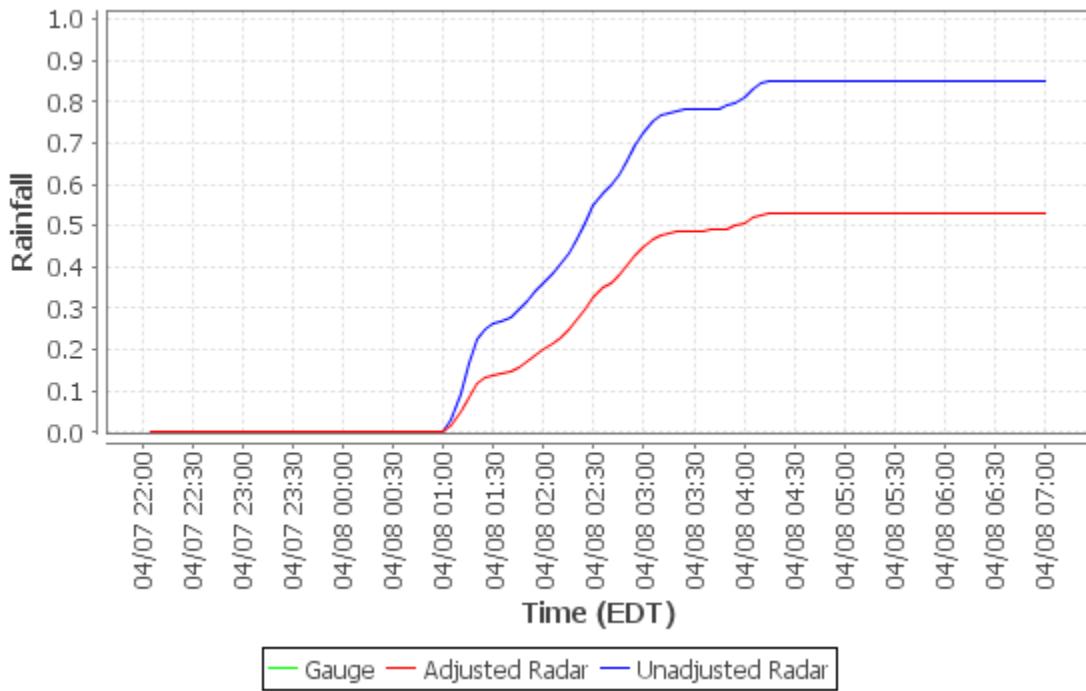
Cumulative Distribution Plot - Moon TWP (Loc21)



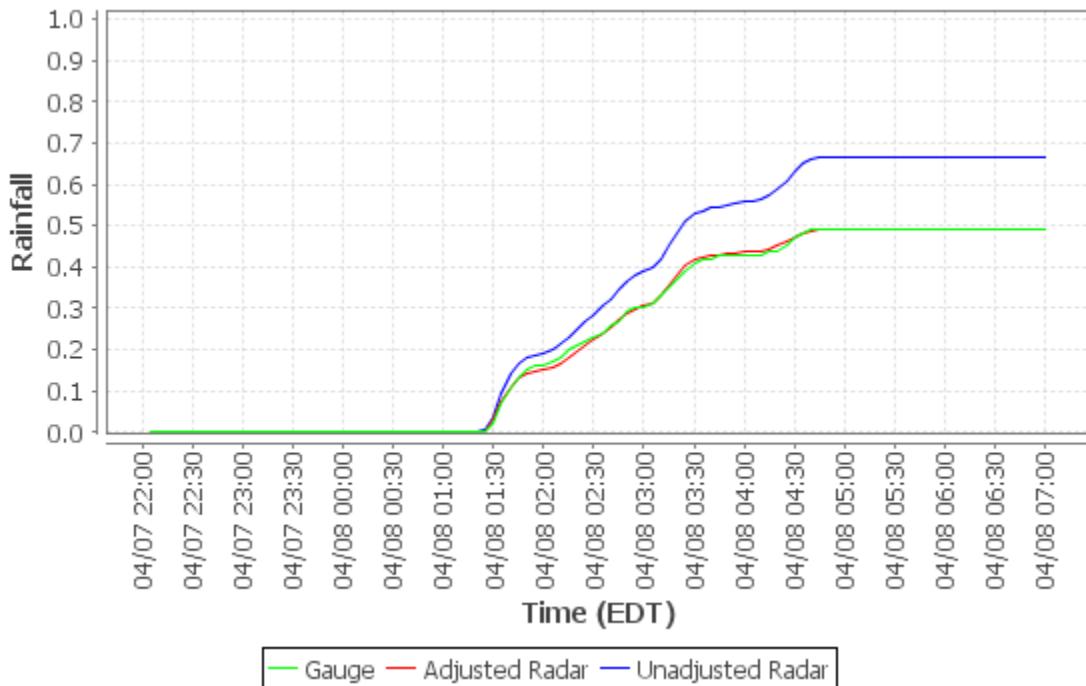
Cumulative Distribution Plot - North Fayette TWP (Loc22)



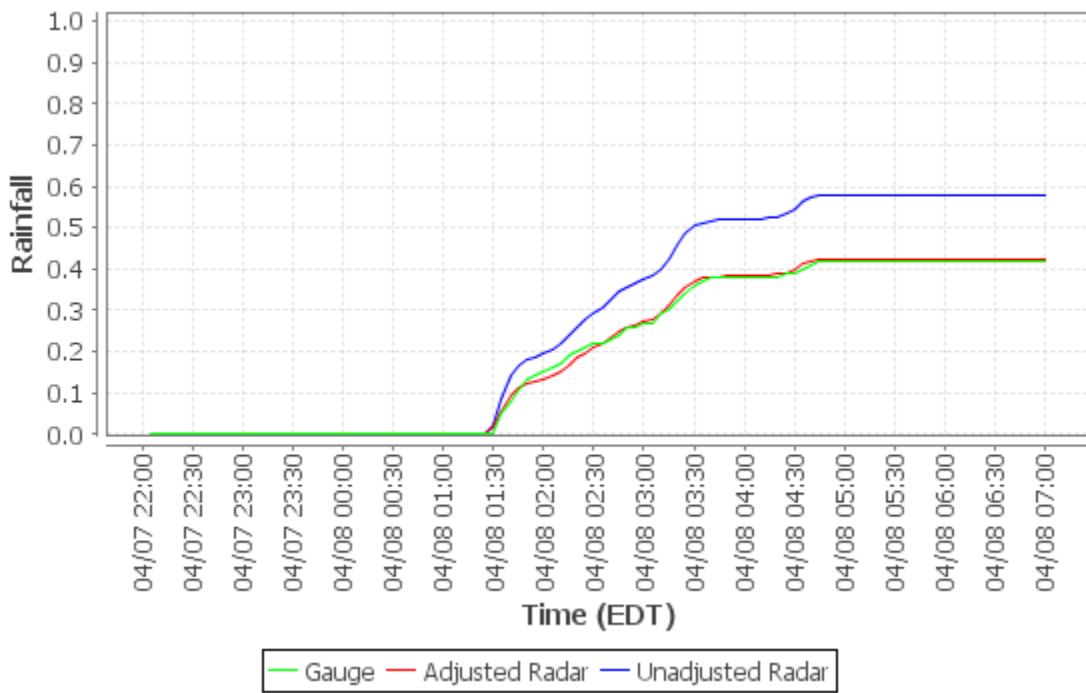
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



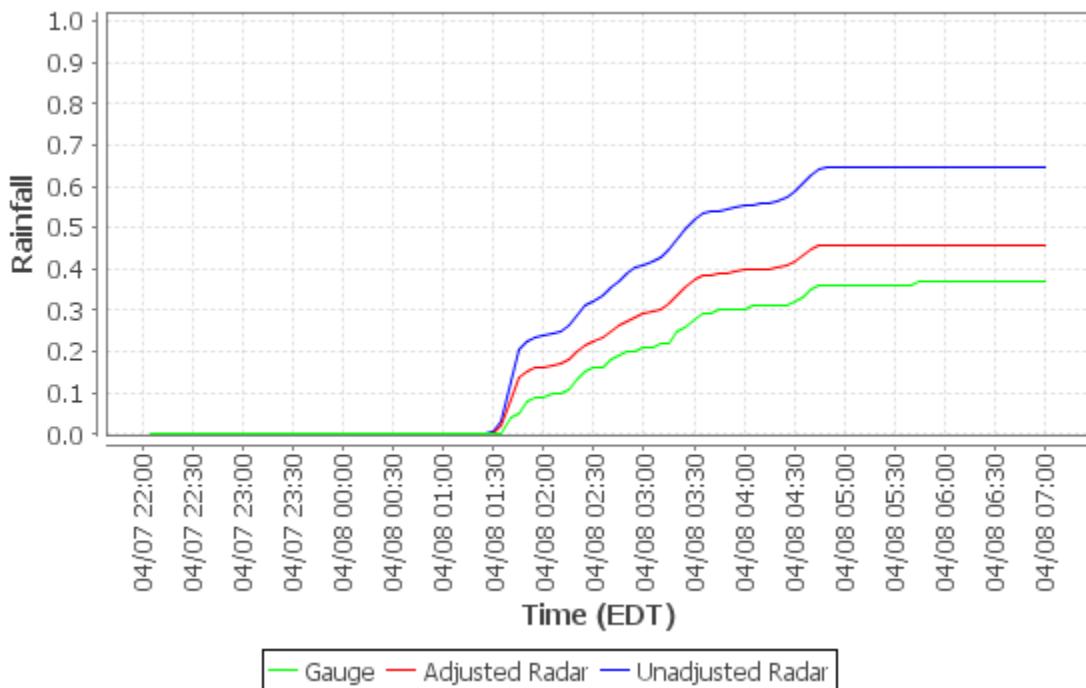
Cumulative Distribution Plot - Jefferson Hills (Loc24)



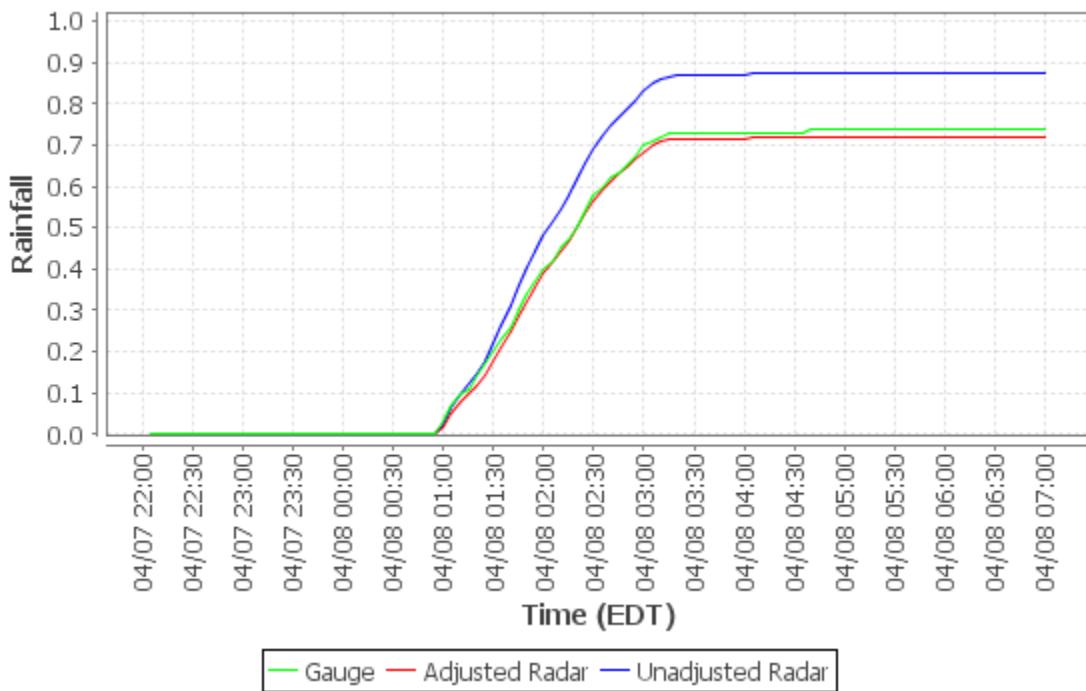
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



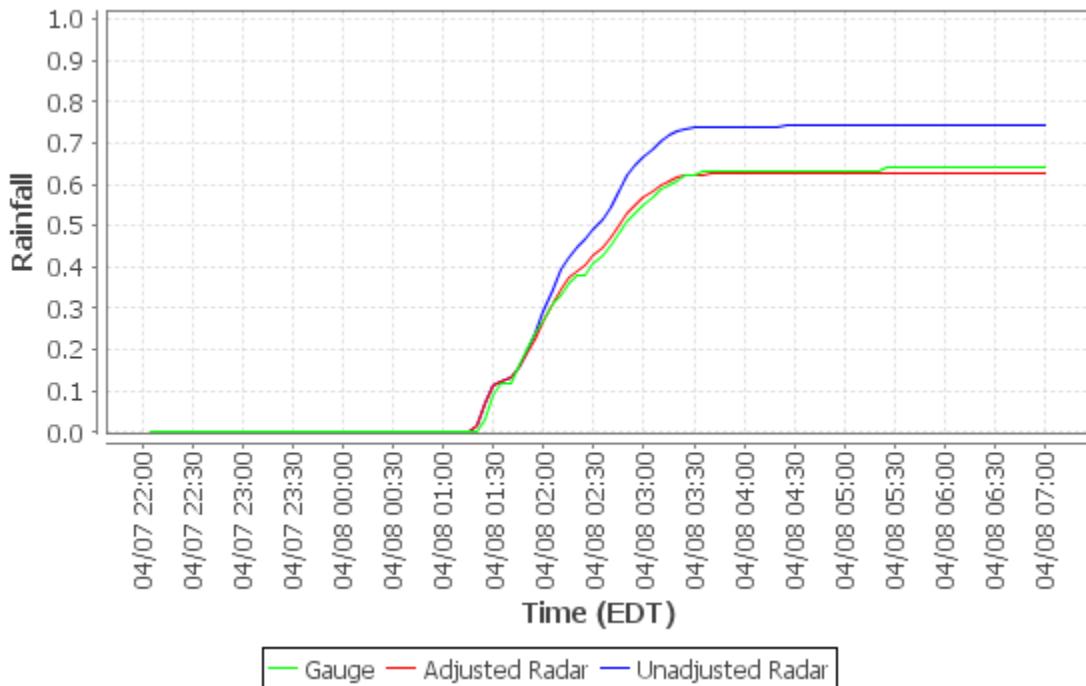
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



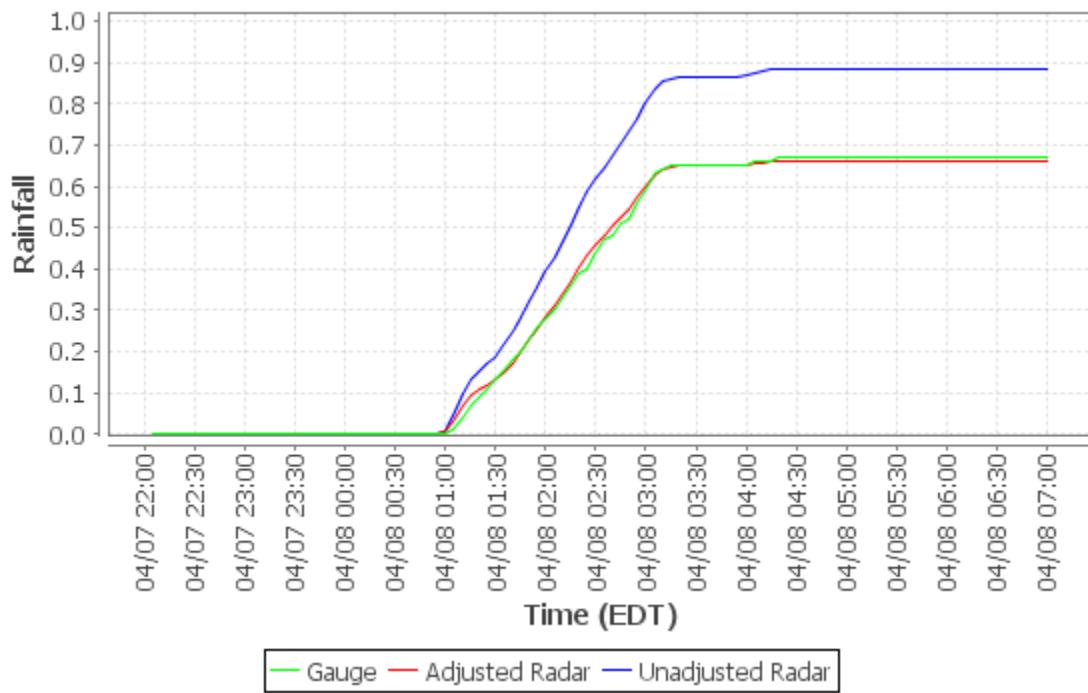
Cumulative Distribution Plot - Marshall TWP (Loc27)



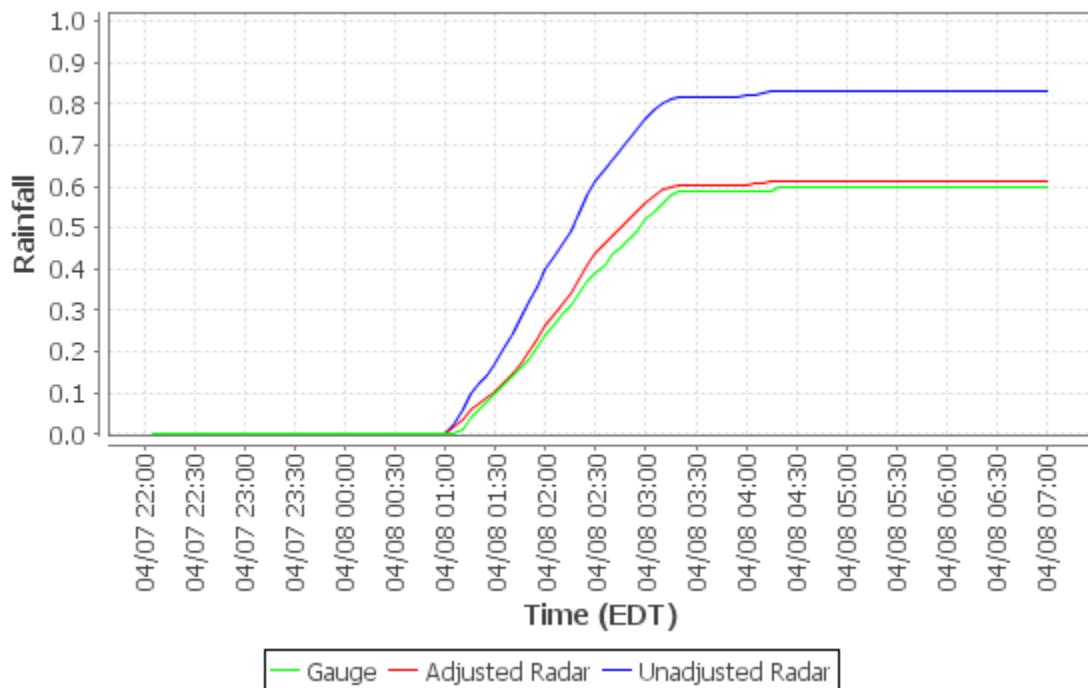
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



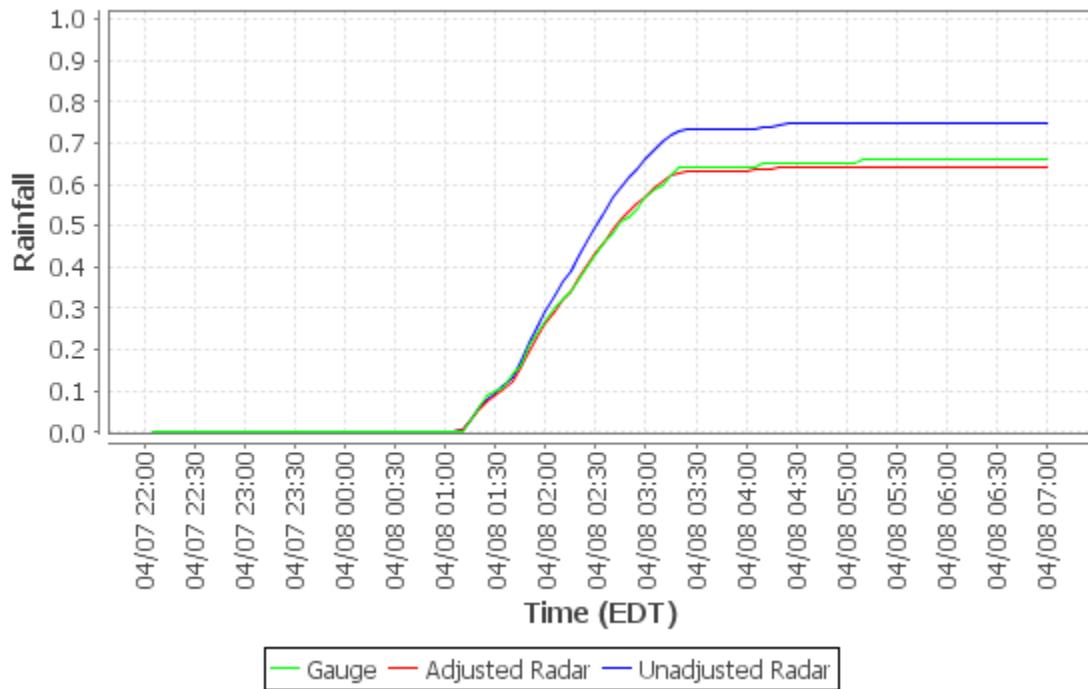
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



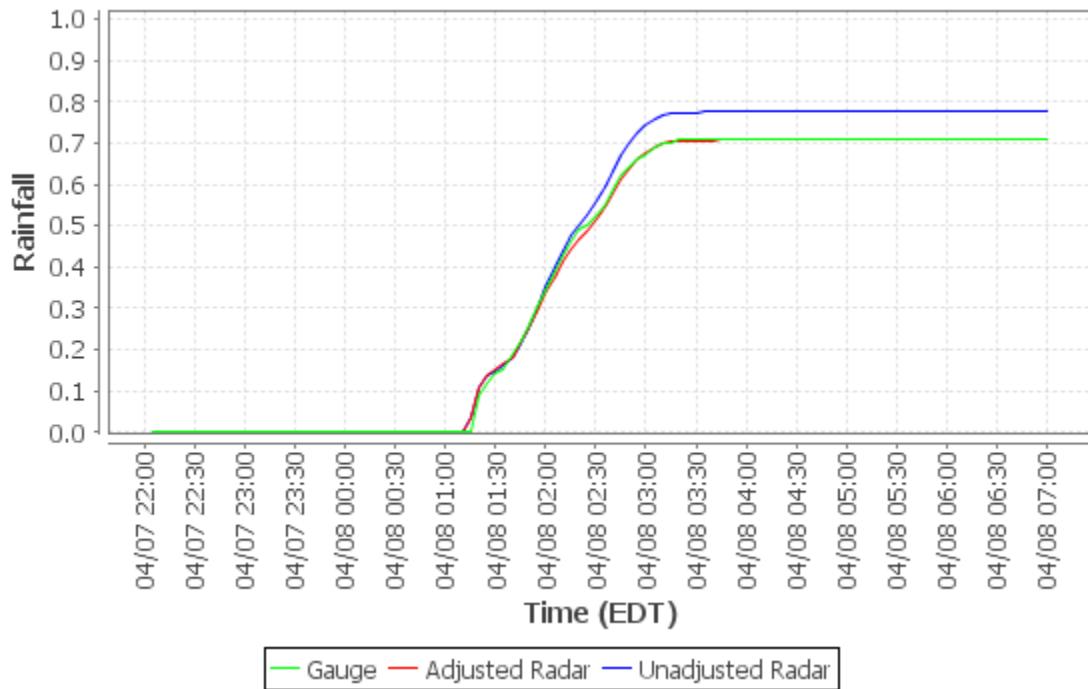
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



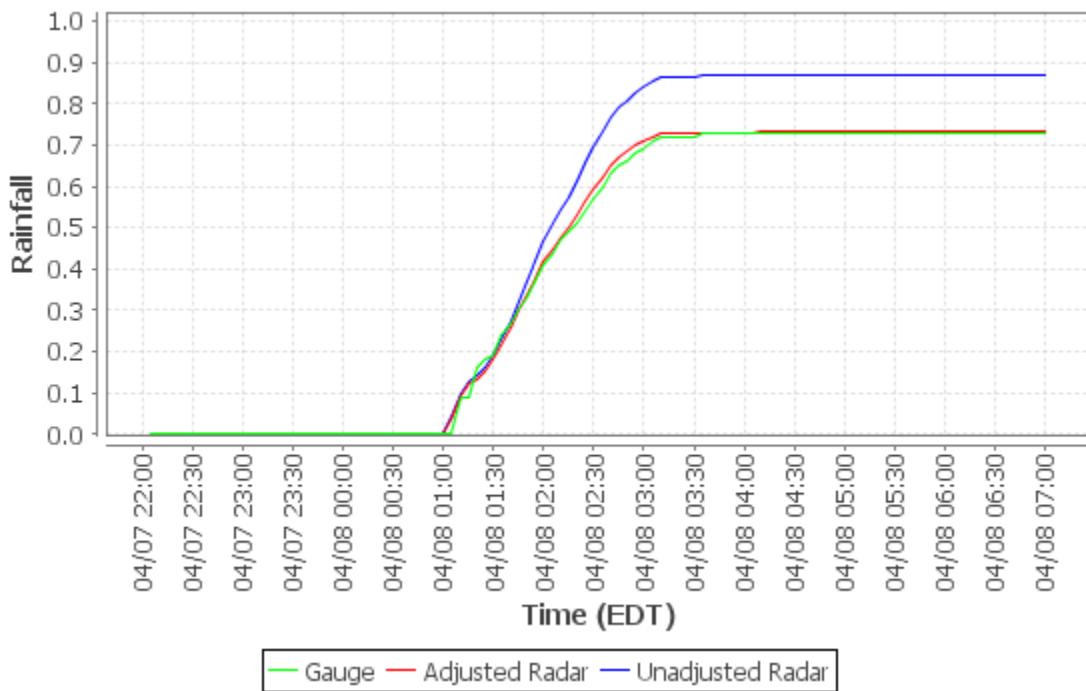
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



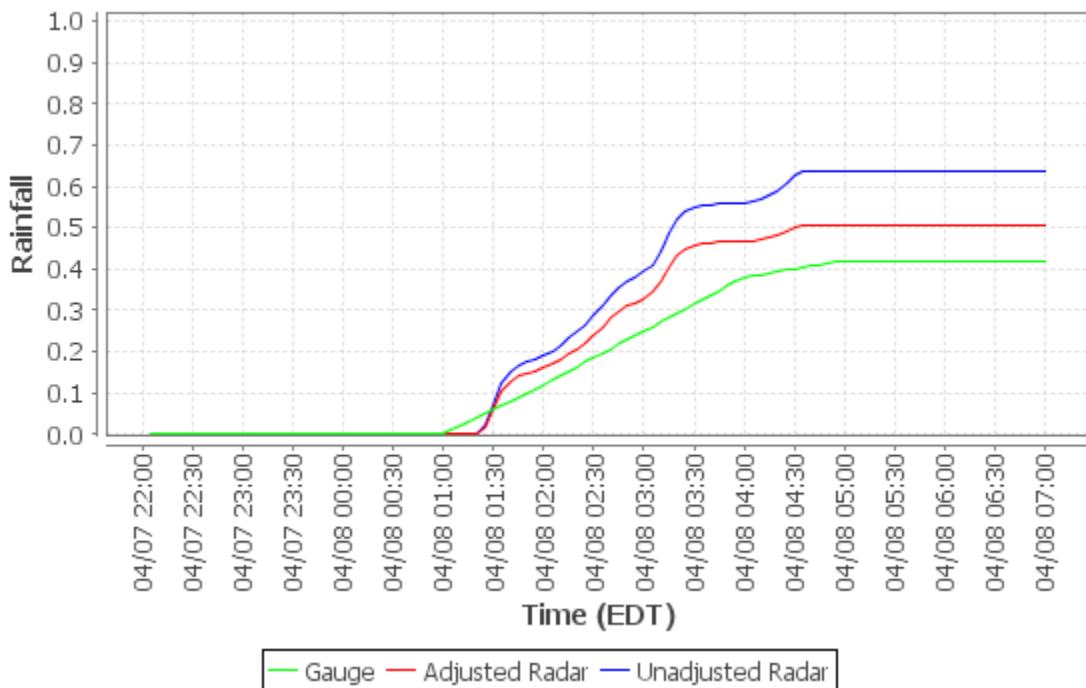
Cumulative Distribution Plot - Arnold (Loc32)



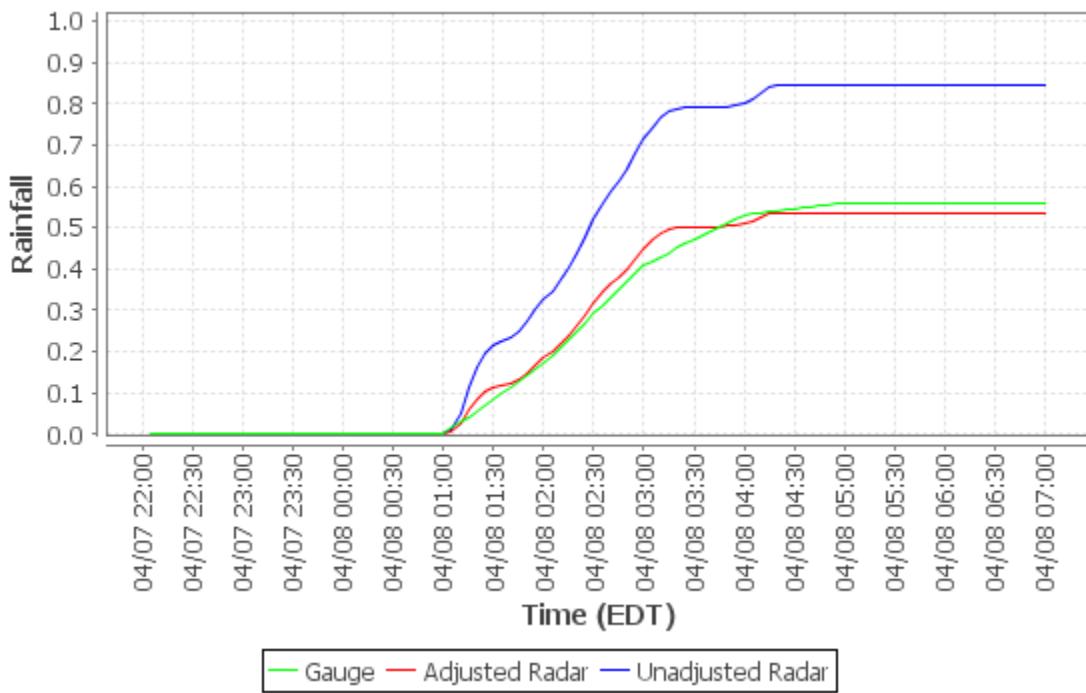
Cumulative Distribution Plot - Richland TWP (Loc33)



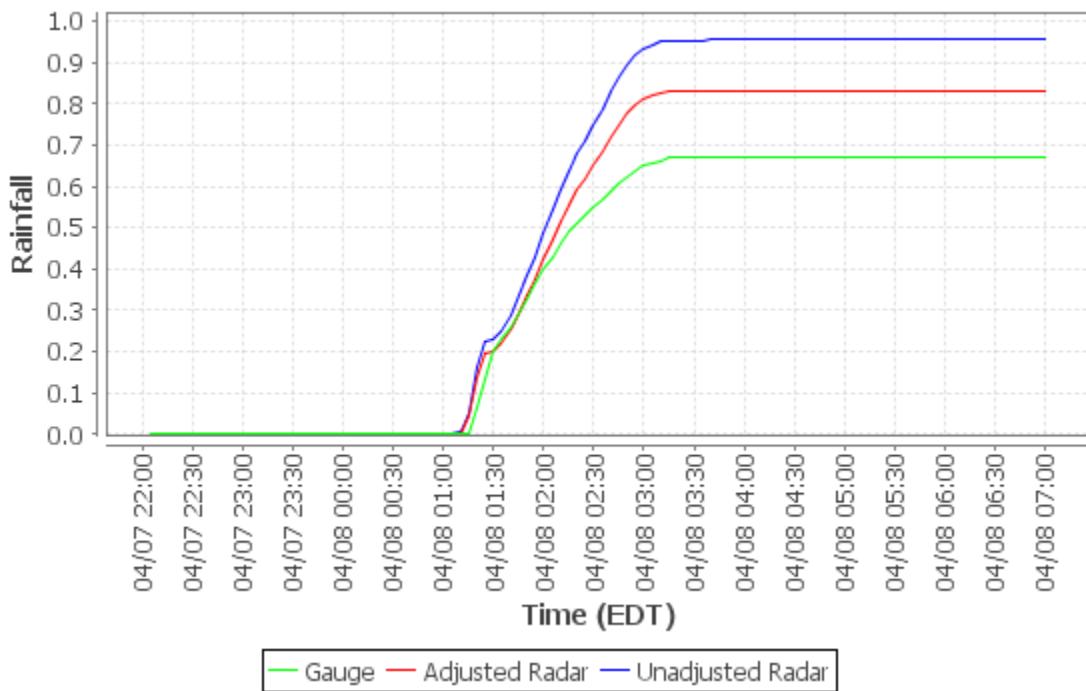
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



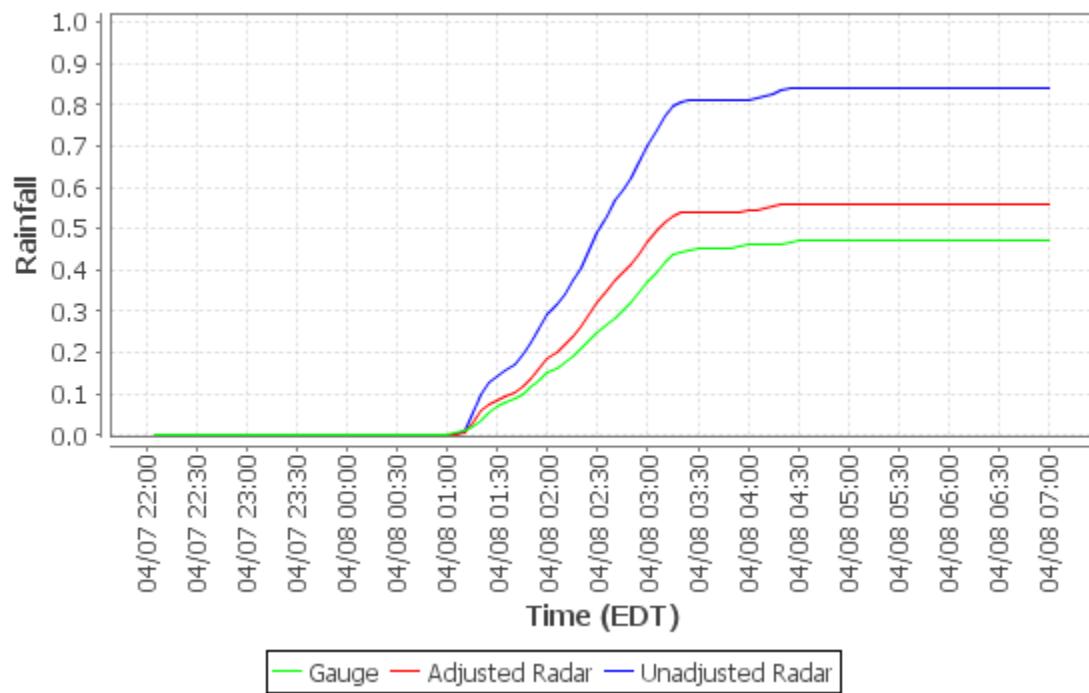
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

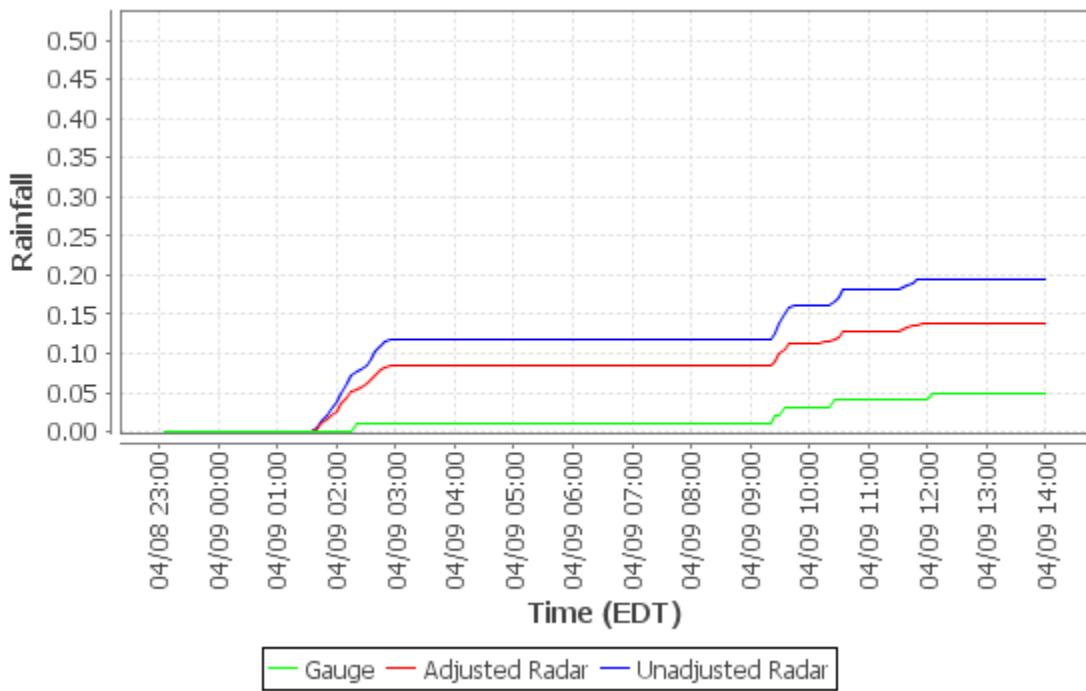


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

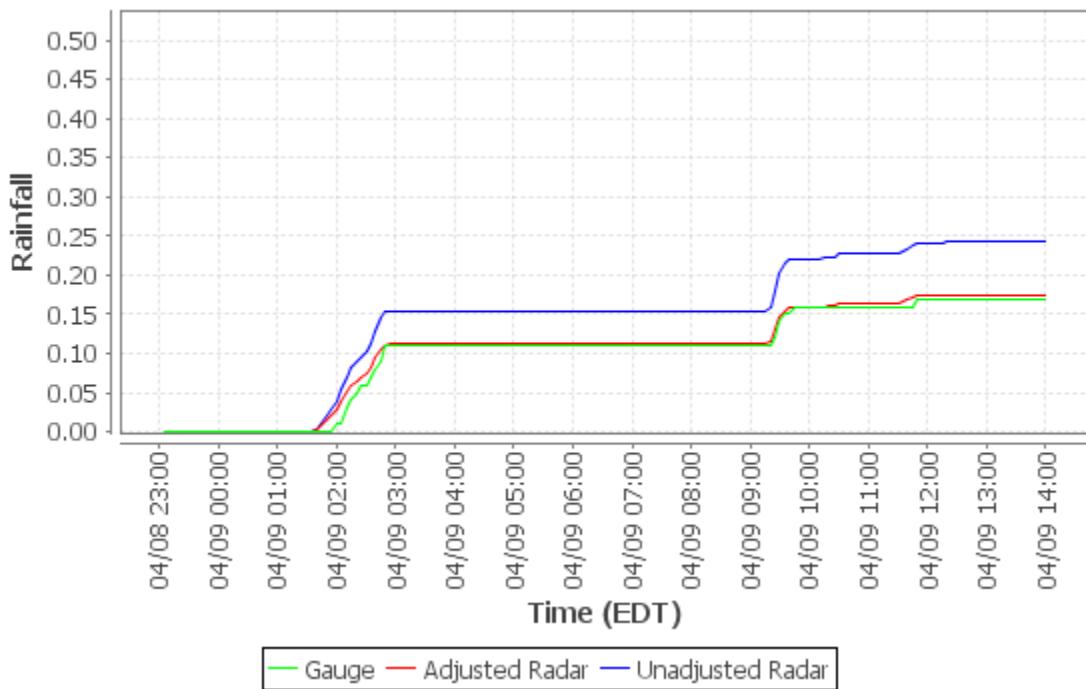


Appendix E - Event 3 (2020-04-09) CDPs

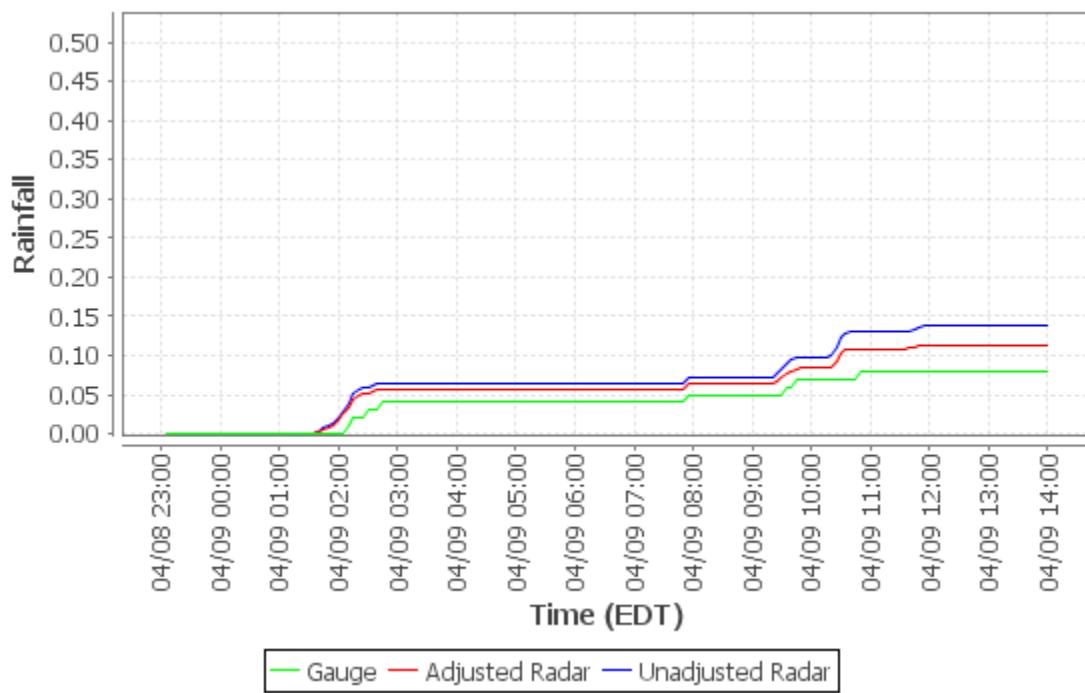
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



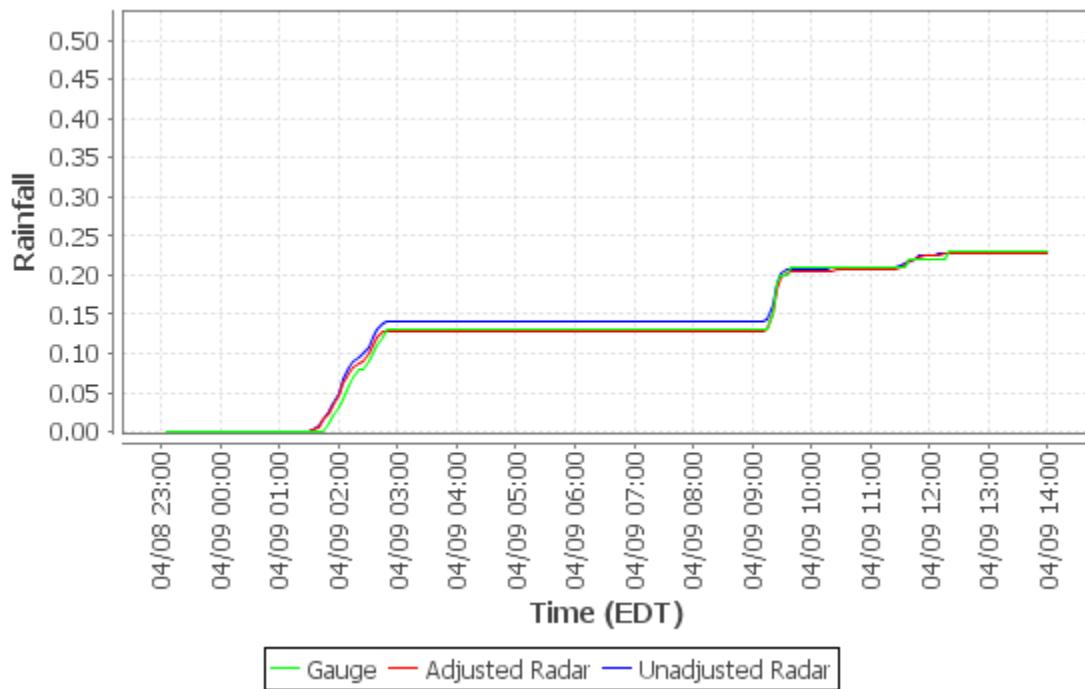
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



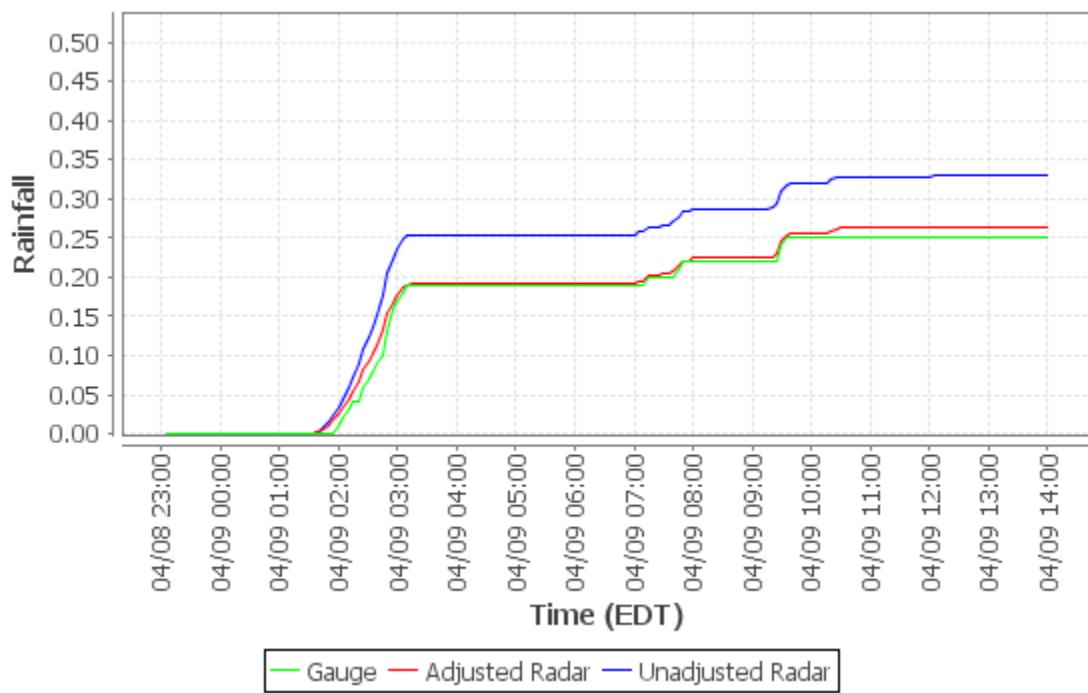
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



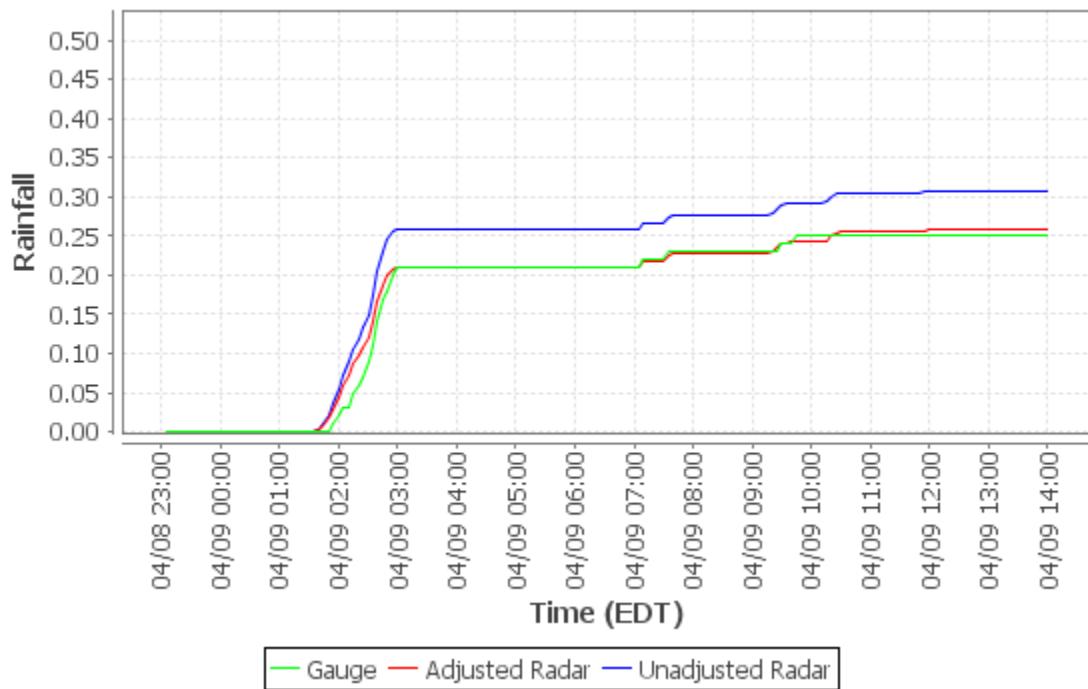
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



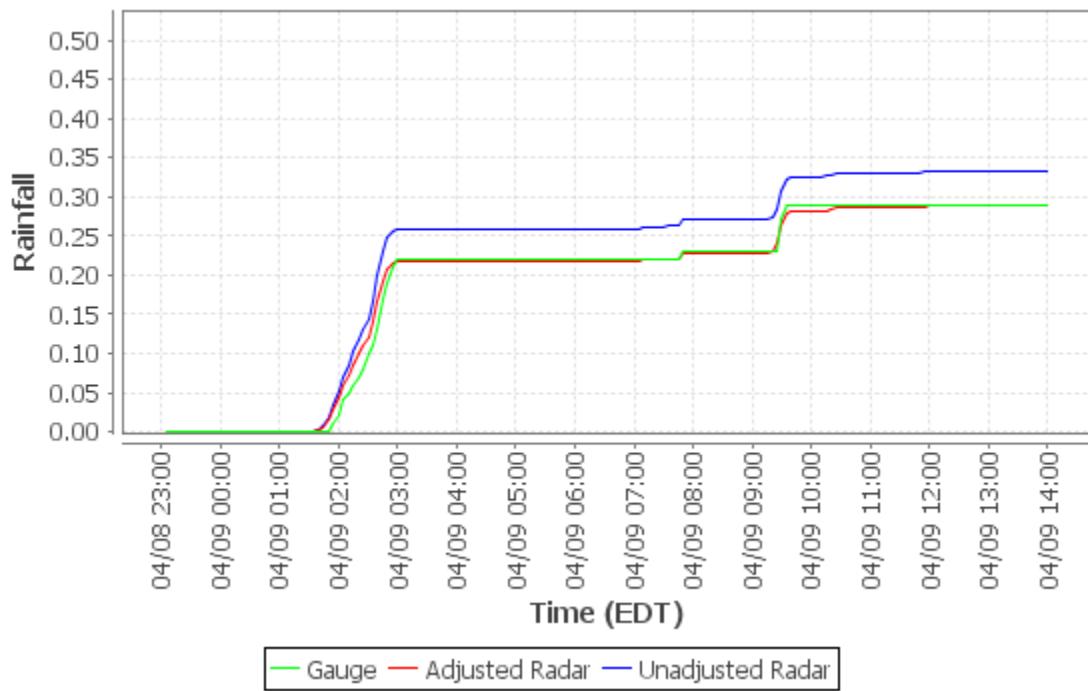
Cumulative Distribution Plot - Upper St. Clair (Loc05)



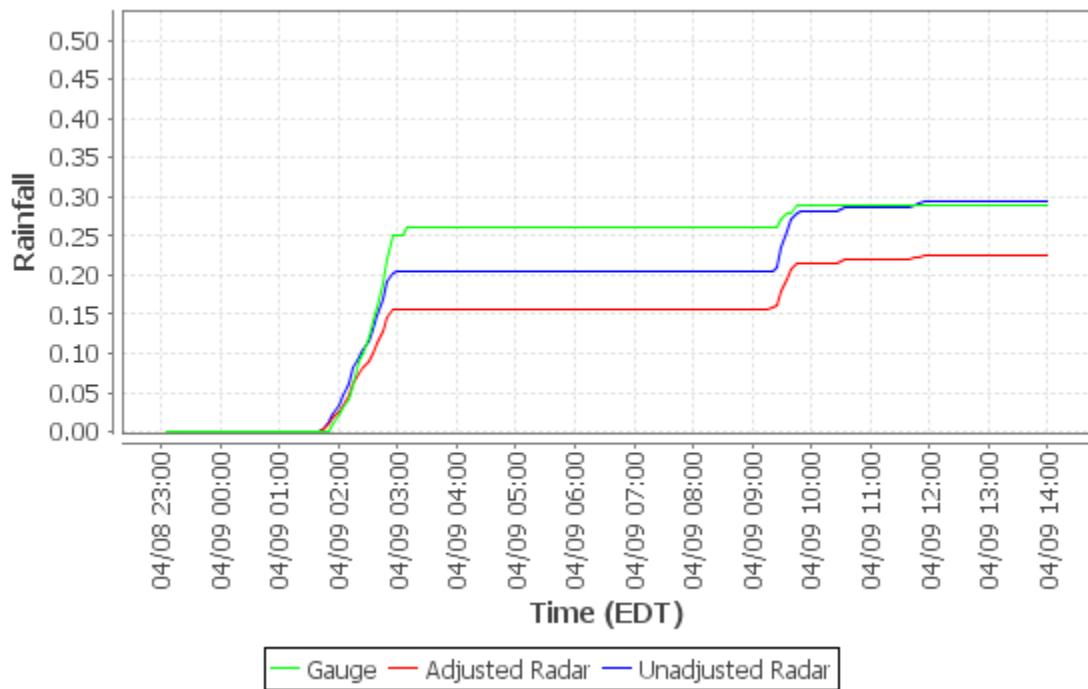
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



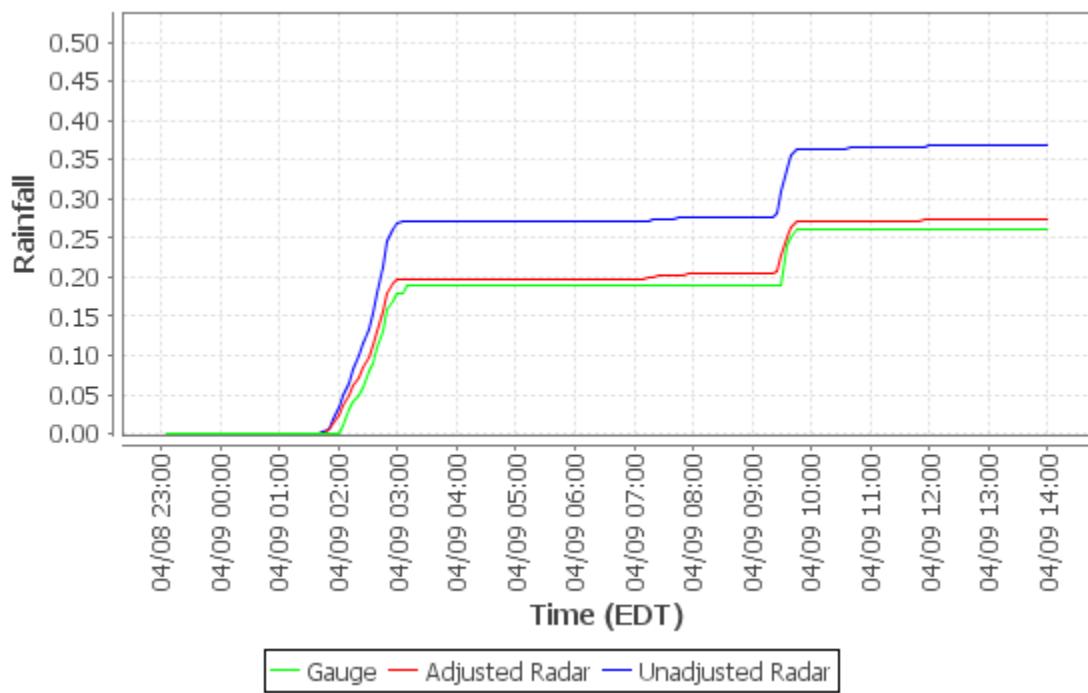
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



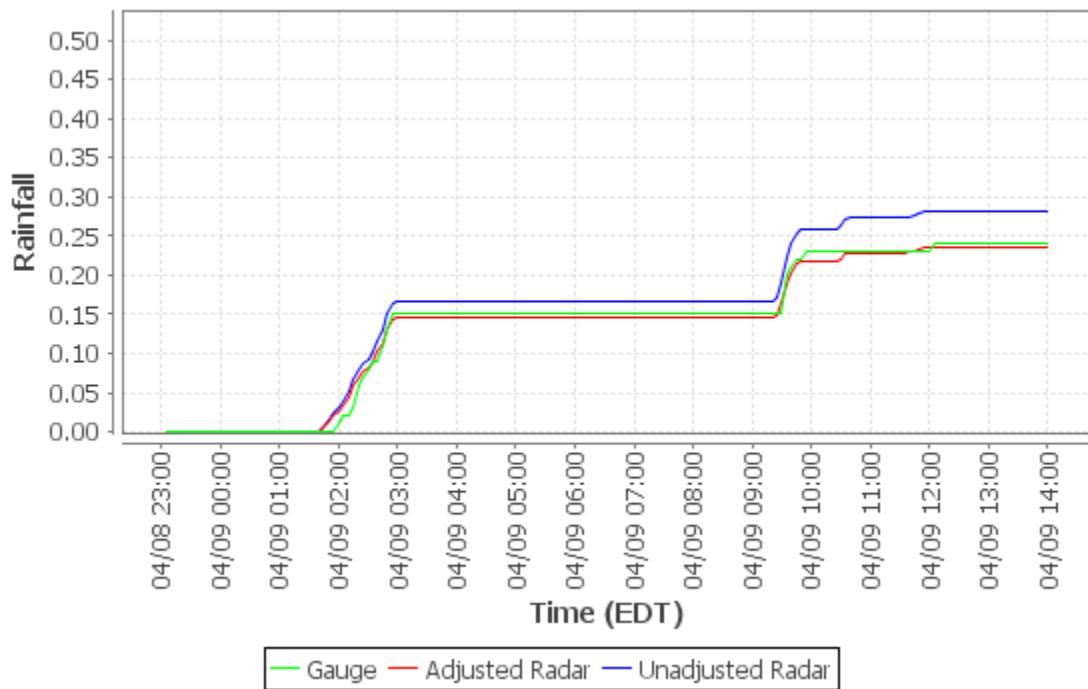
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



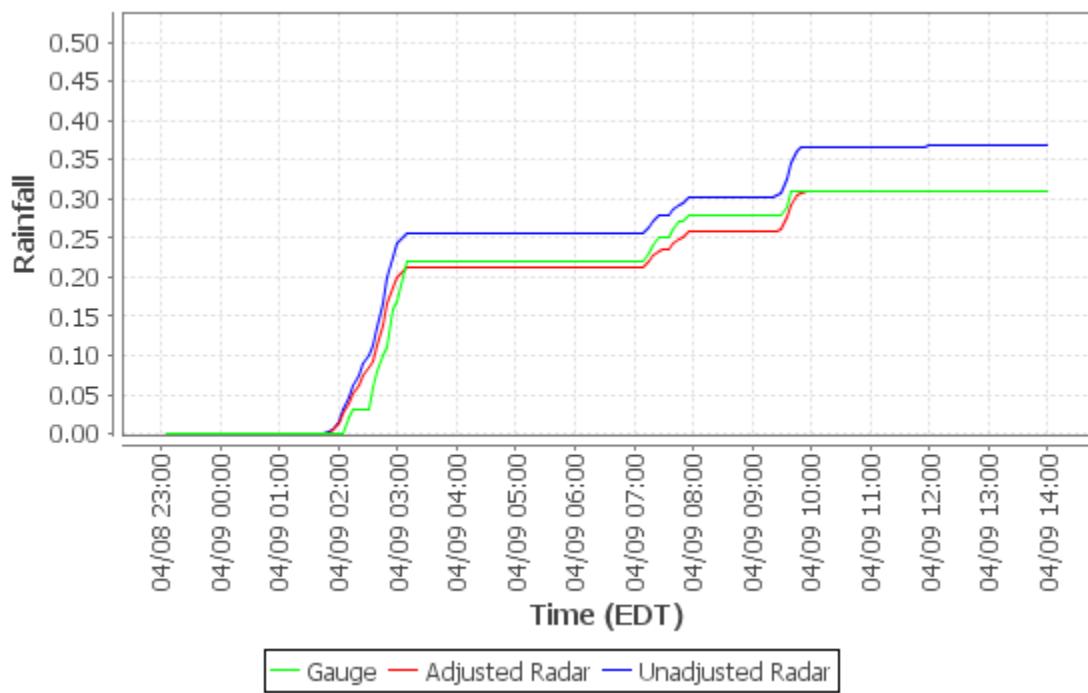
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



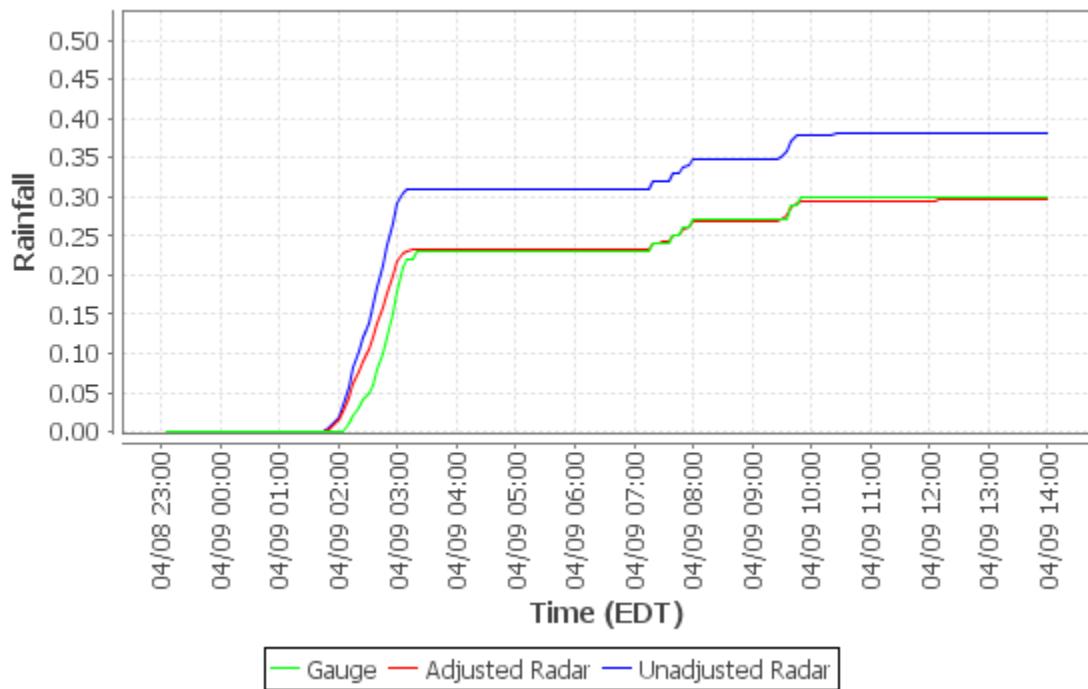
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



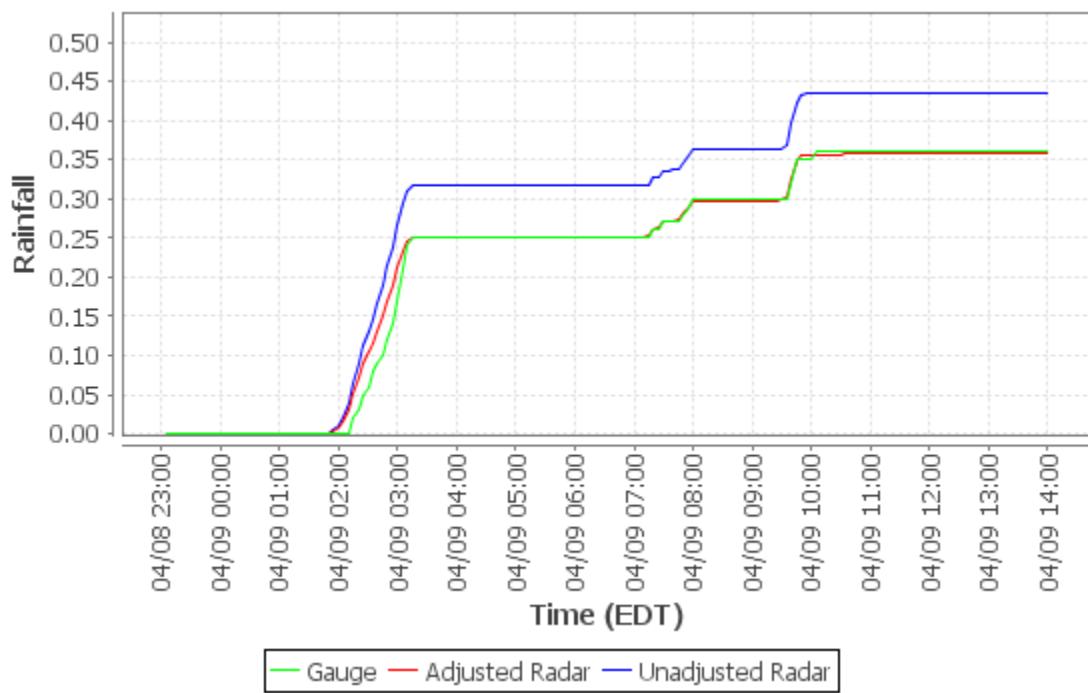
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



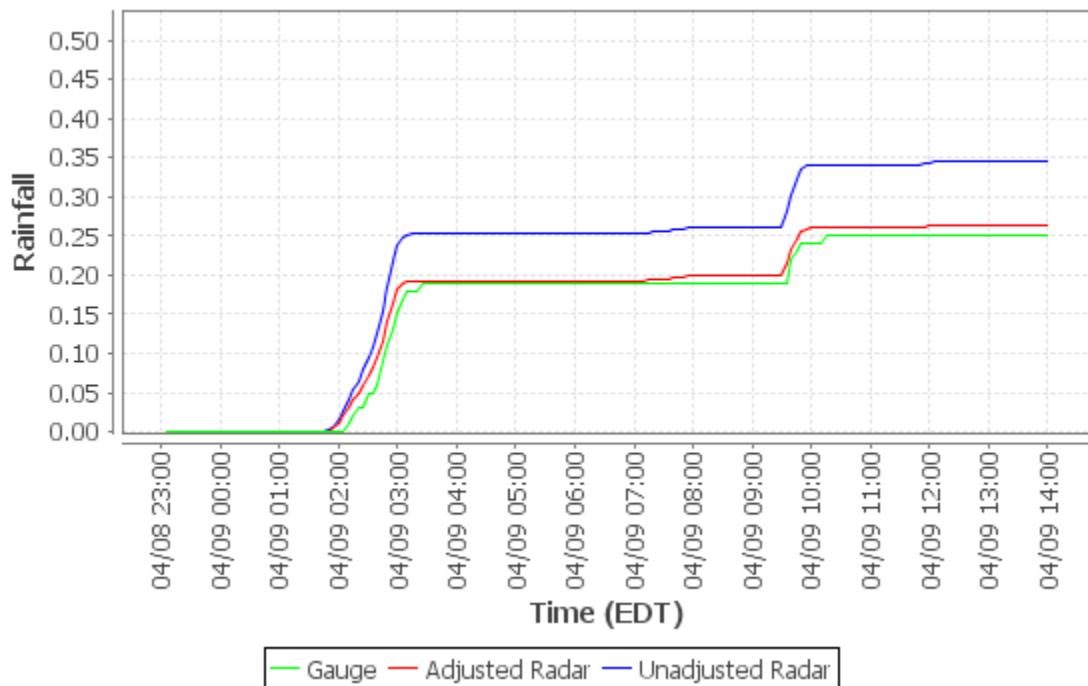
Cumulative Distribution Plot - Baldwin (Loc12)



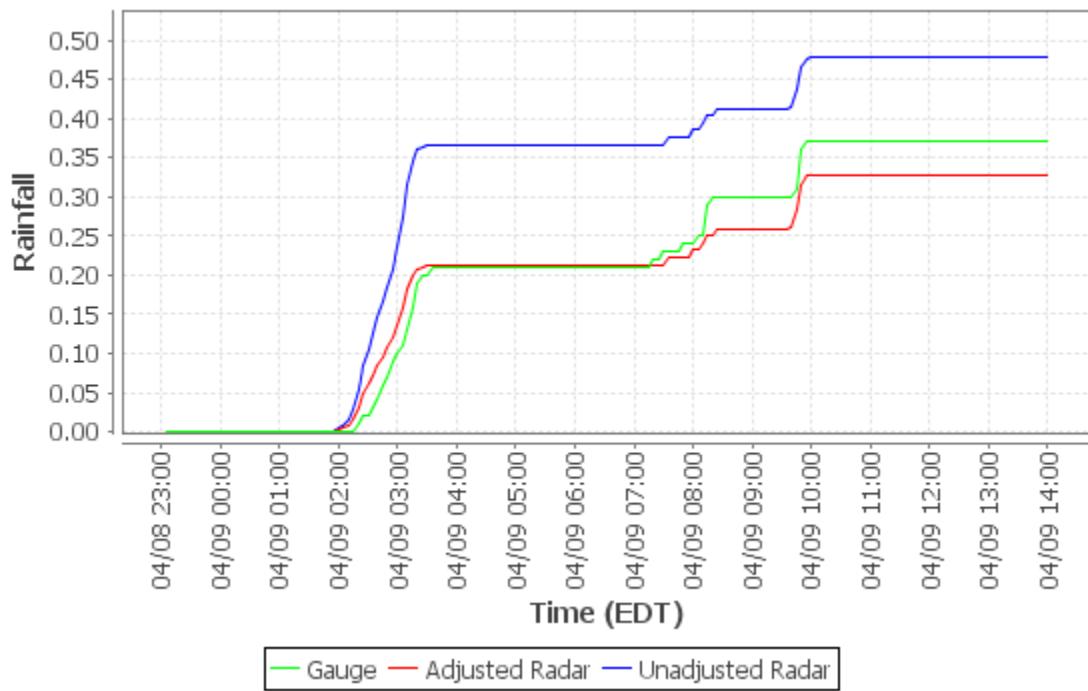
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



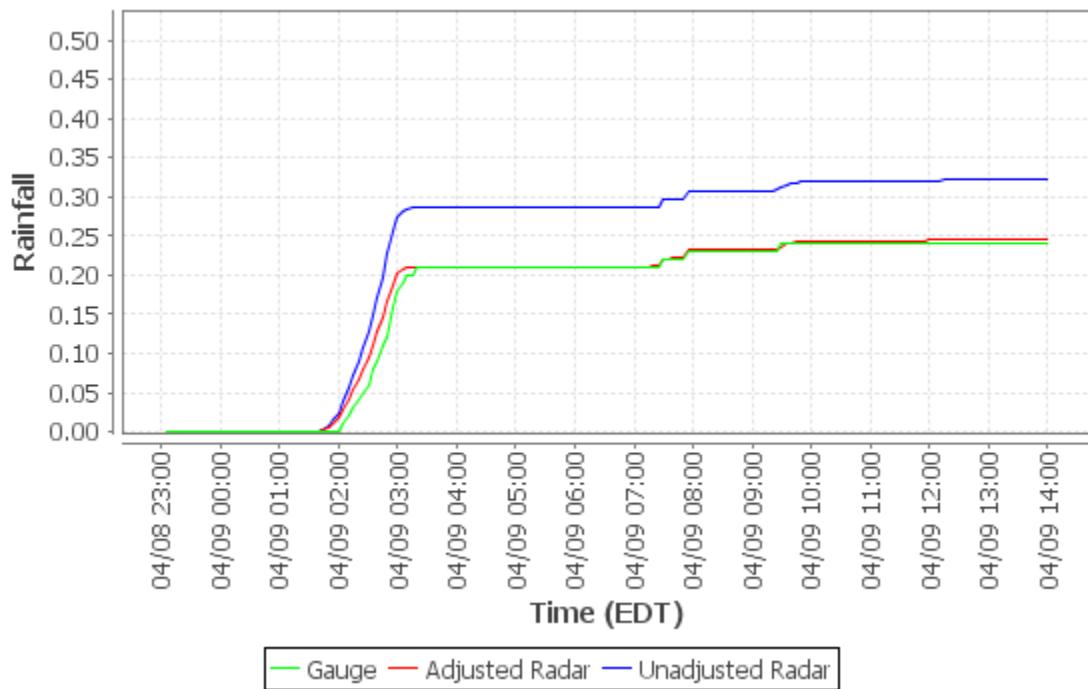
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



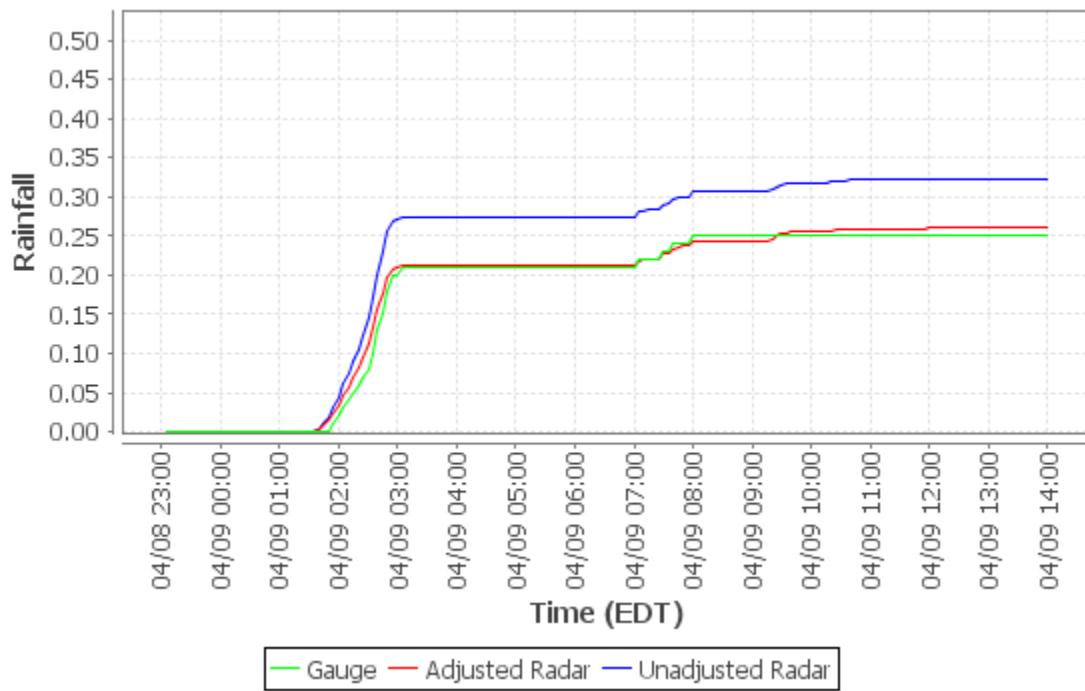
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



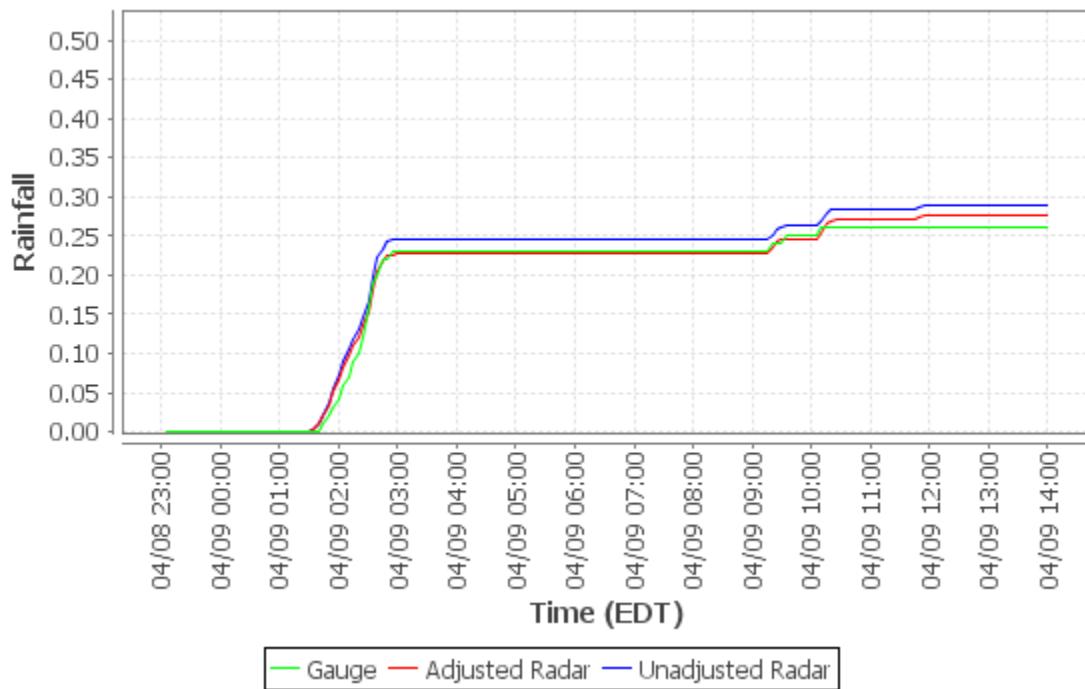
Cumulative Distribution Plot - Castle Shannon (Loc16)



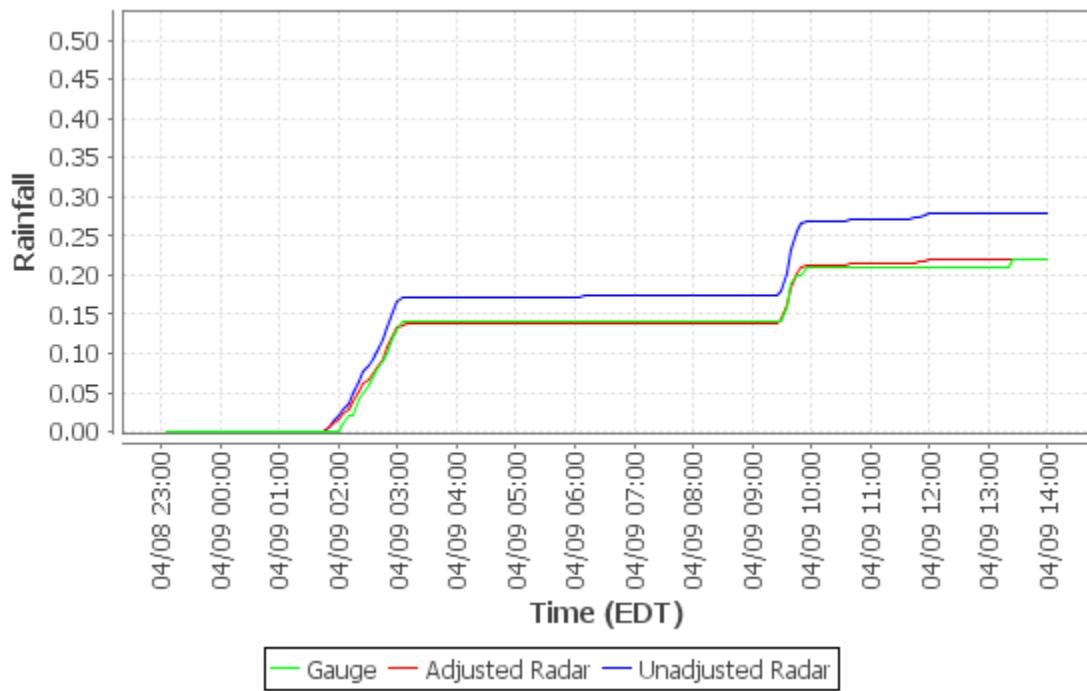
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



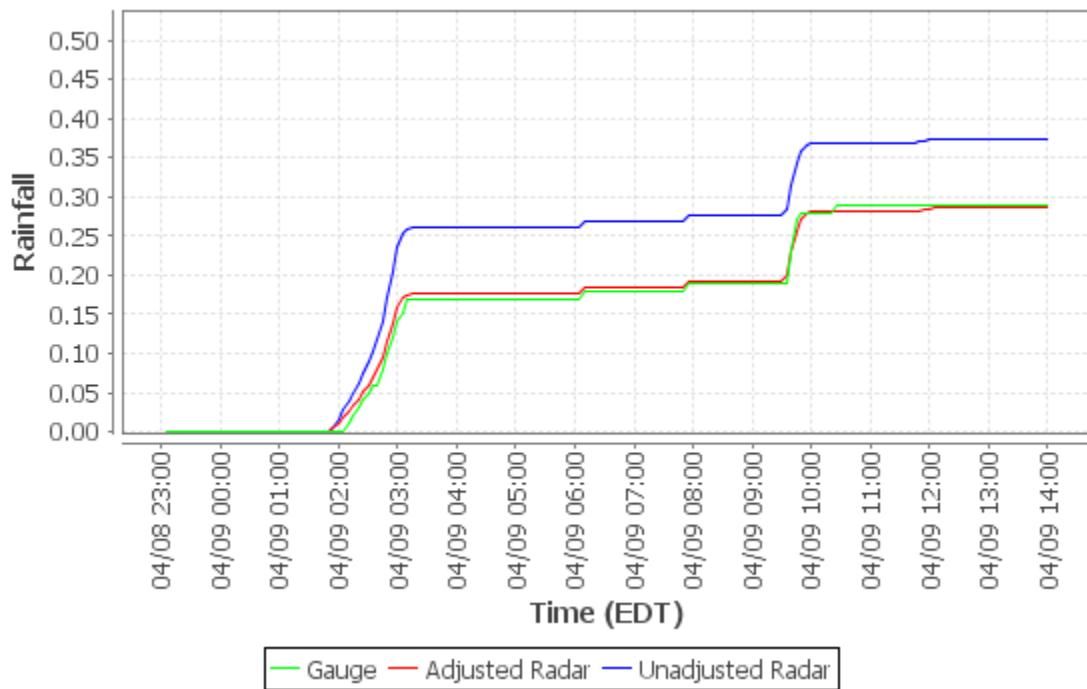
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



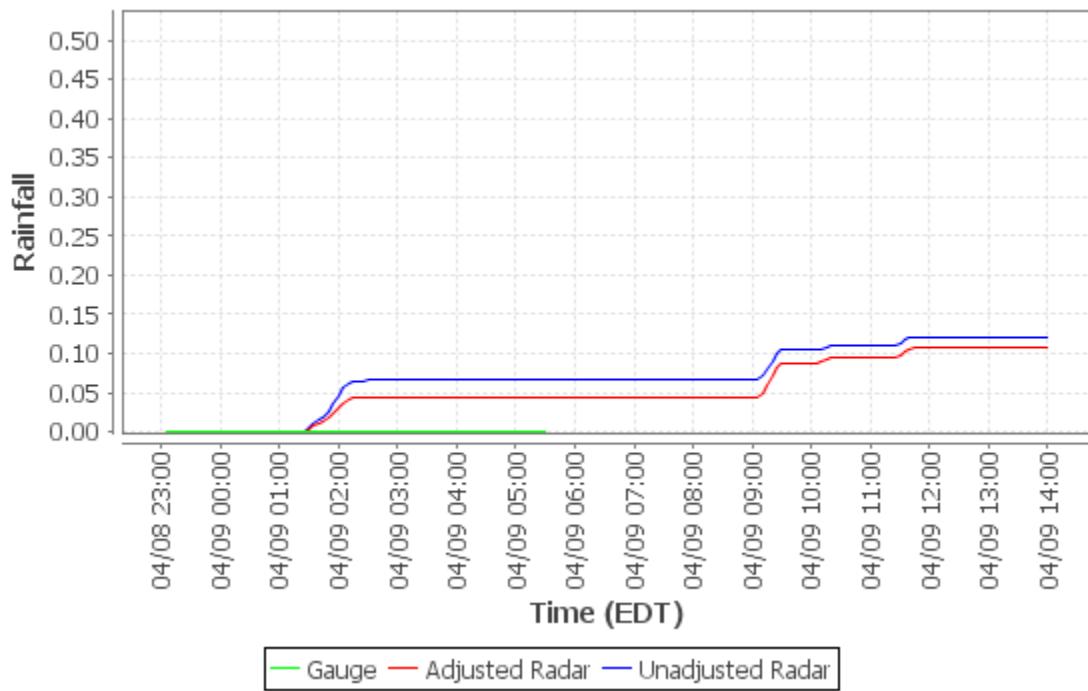
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



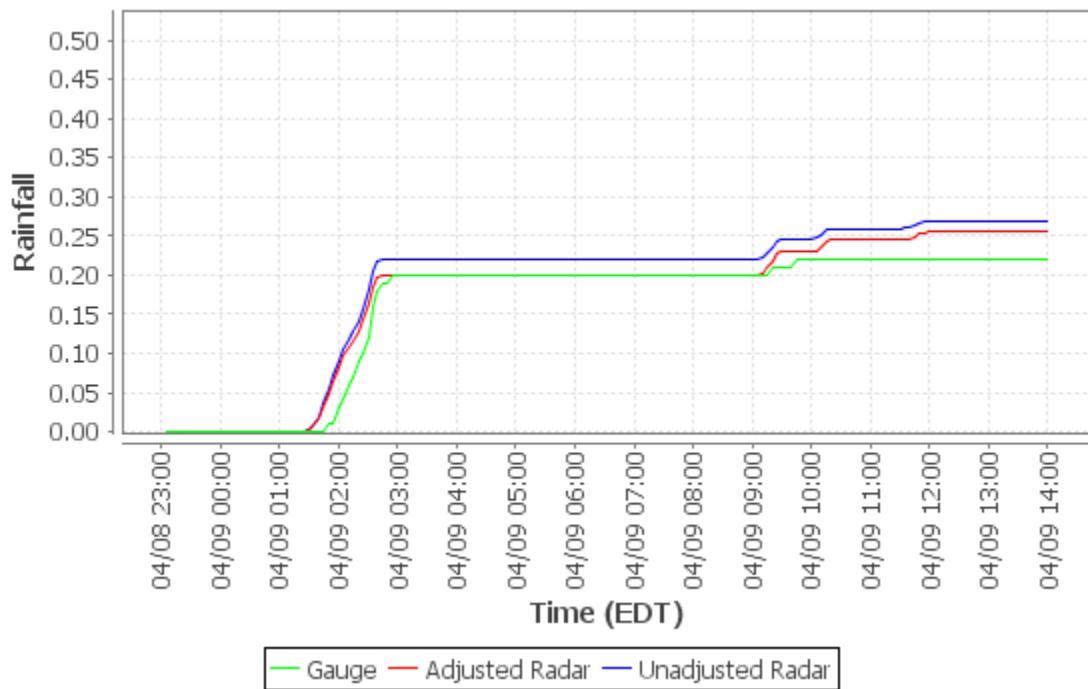
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



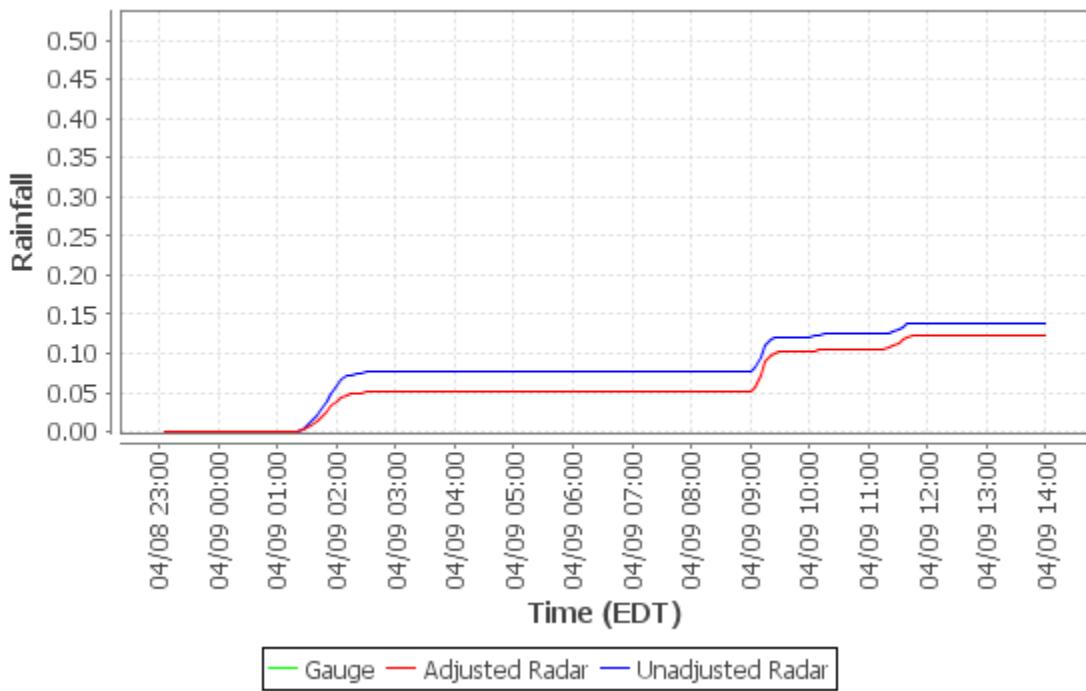
Cumulative Distribution Plot - Moon TWP (Loc21)



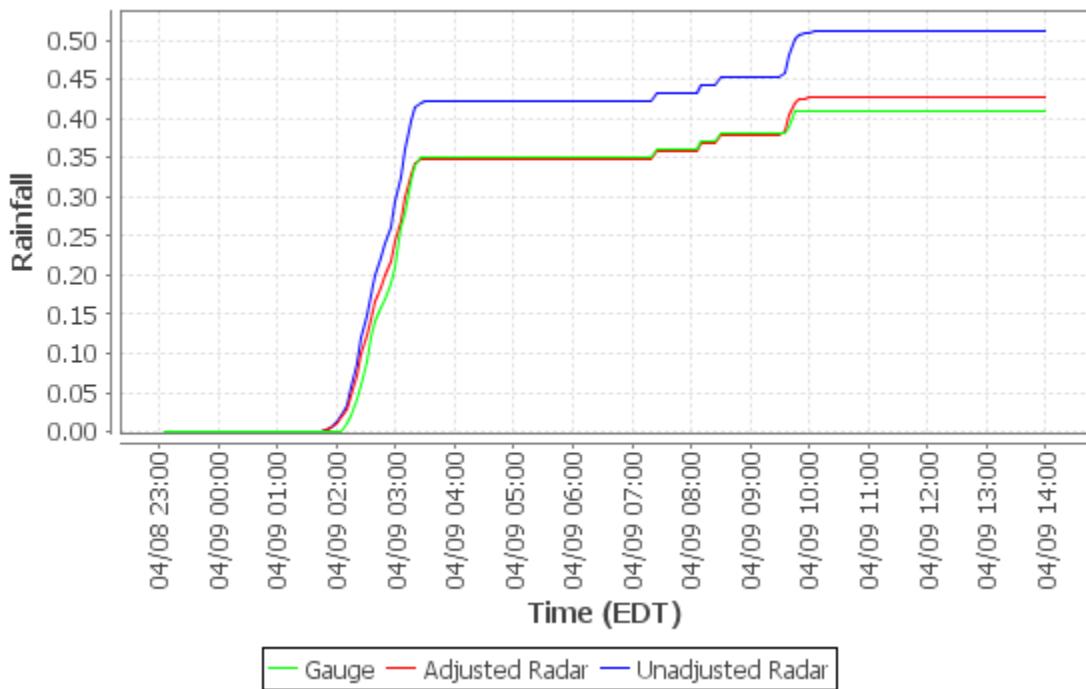
Cumulative Distribution Plot - North Fayette TWP (Loc22)



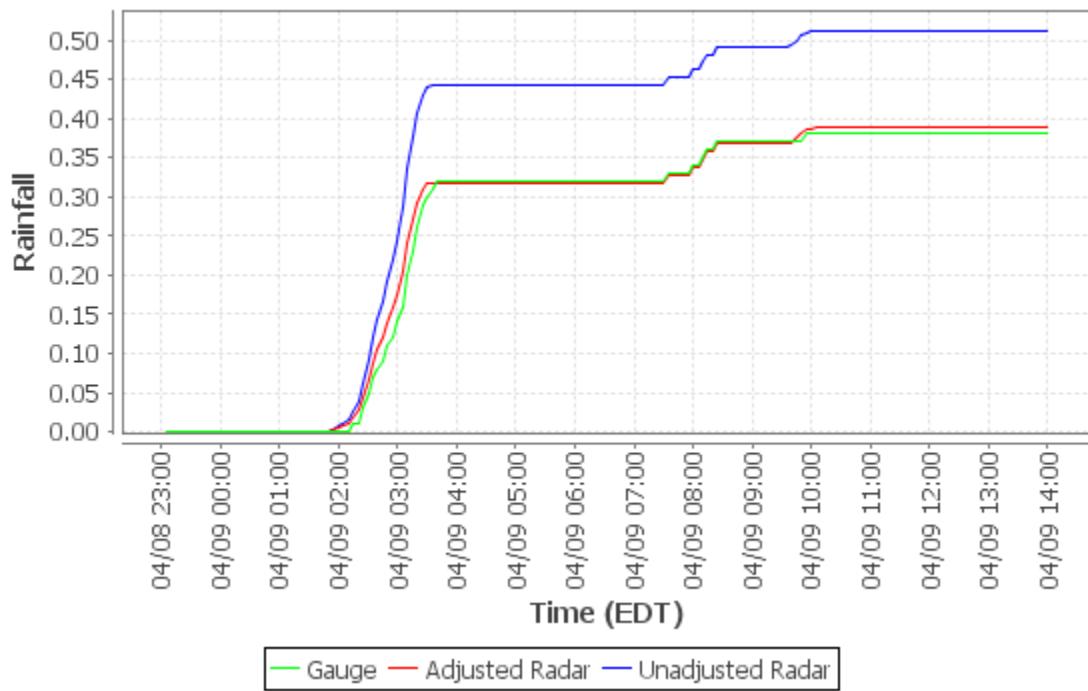
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



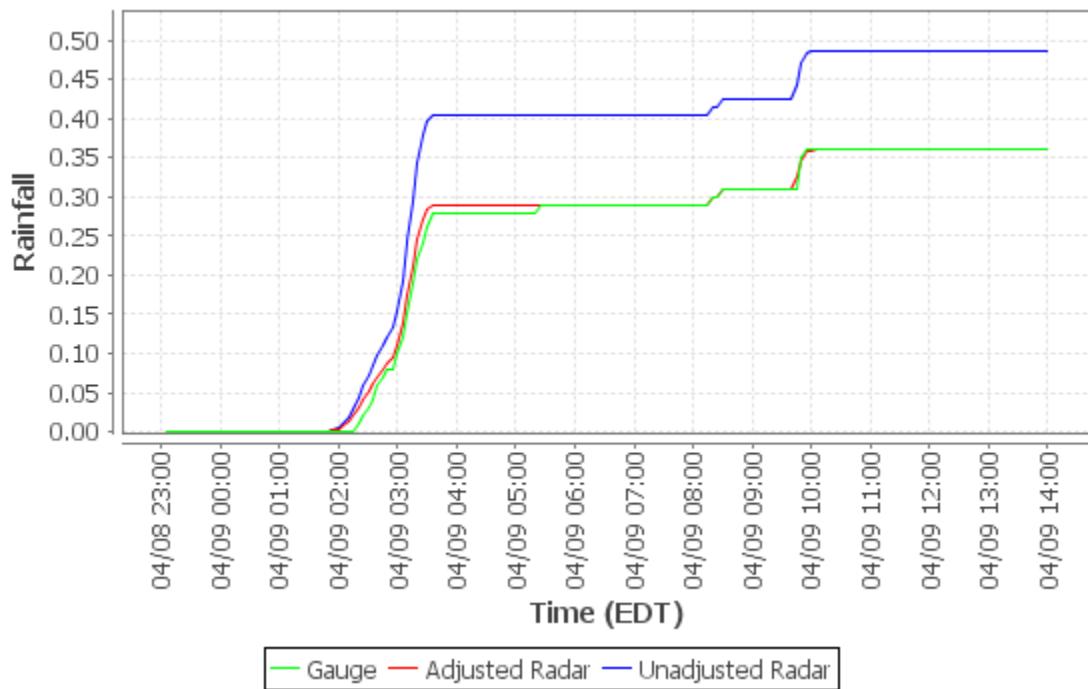
Cumulative Distribution Plot - Jefferson Hills (Loc24)



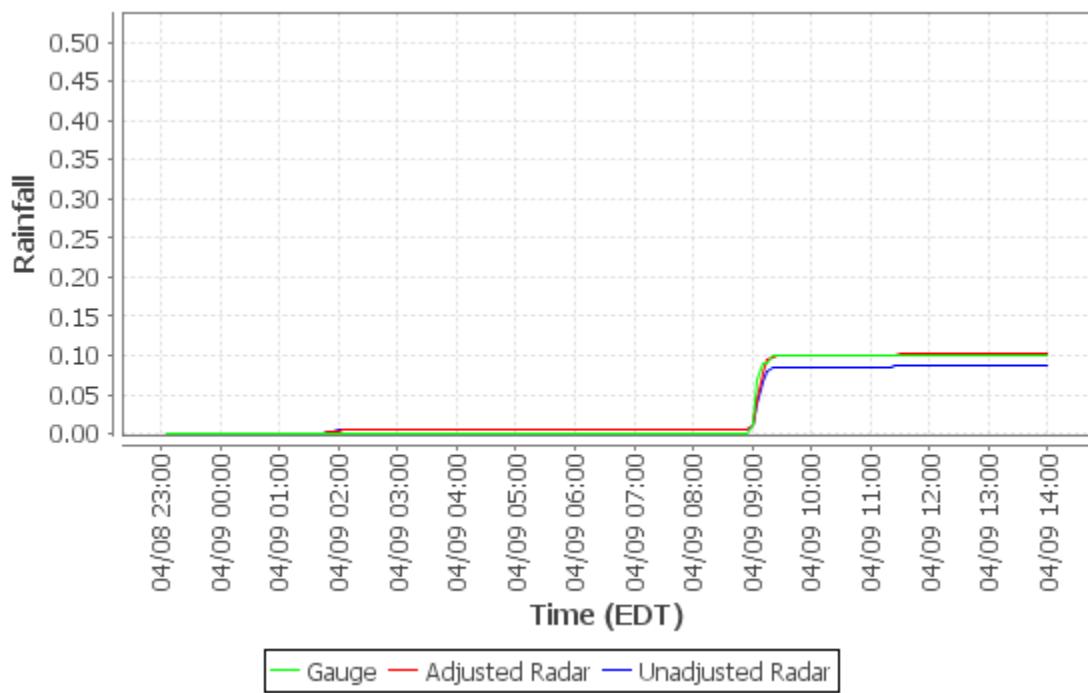
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



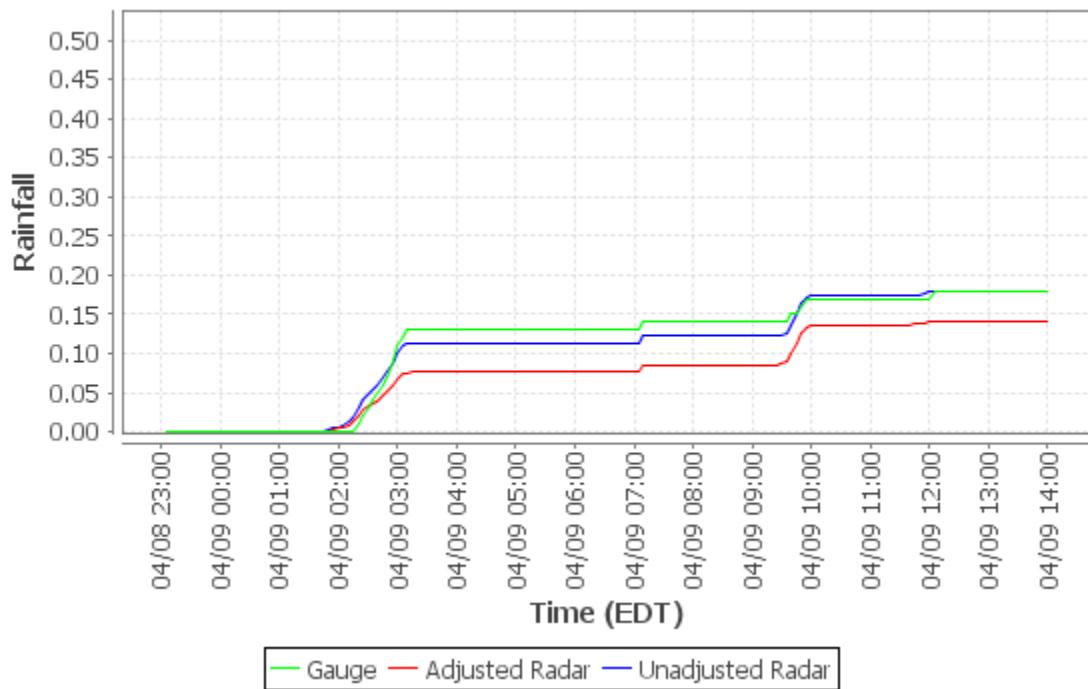
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



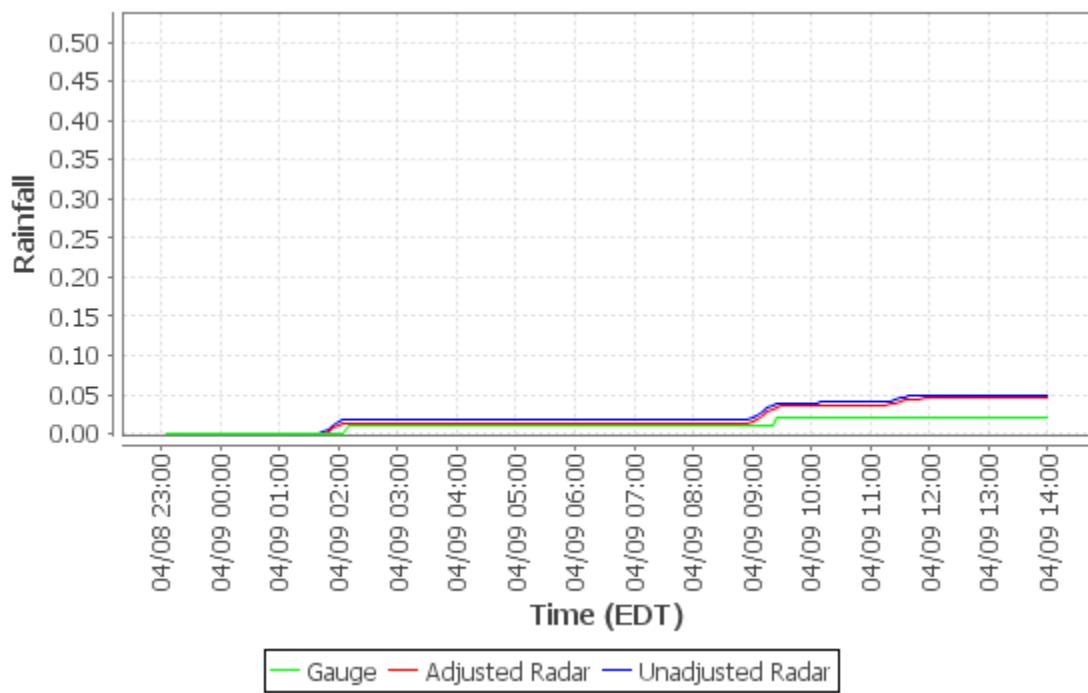
Cumulative Distribution Plot - Marshall TWP (Loc27)



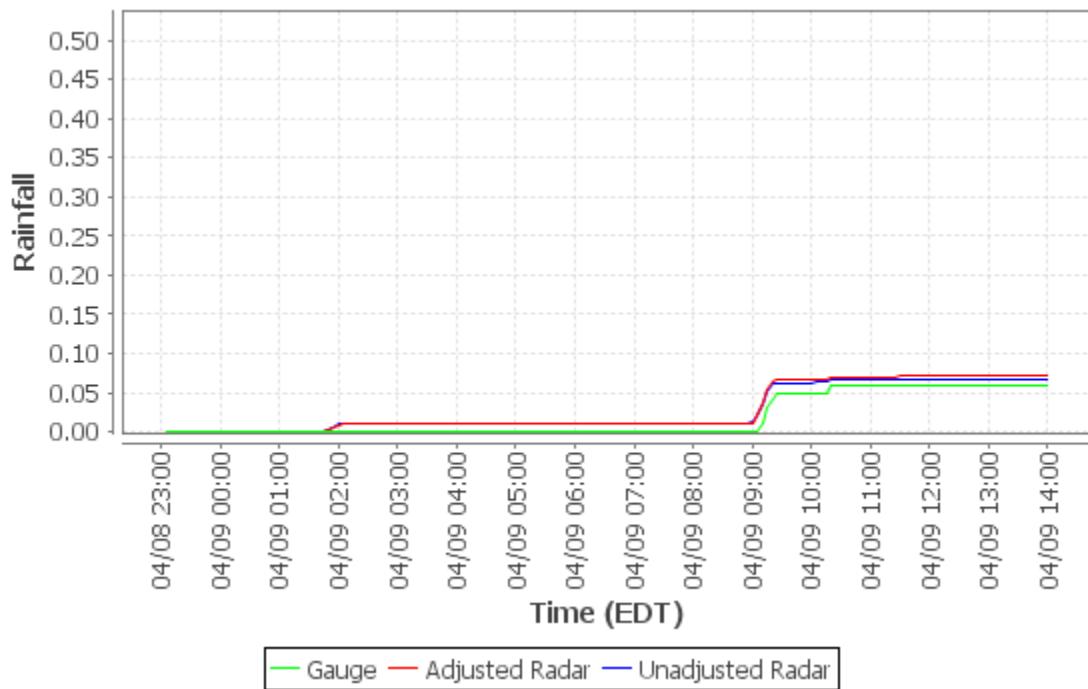
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



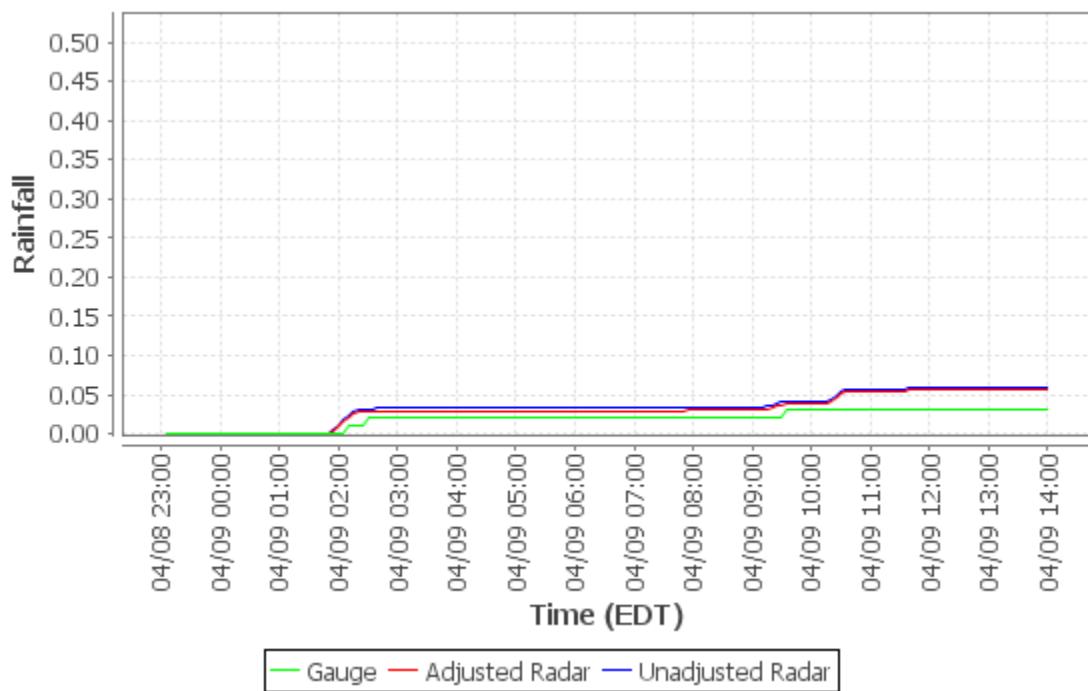
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



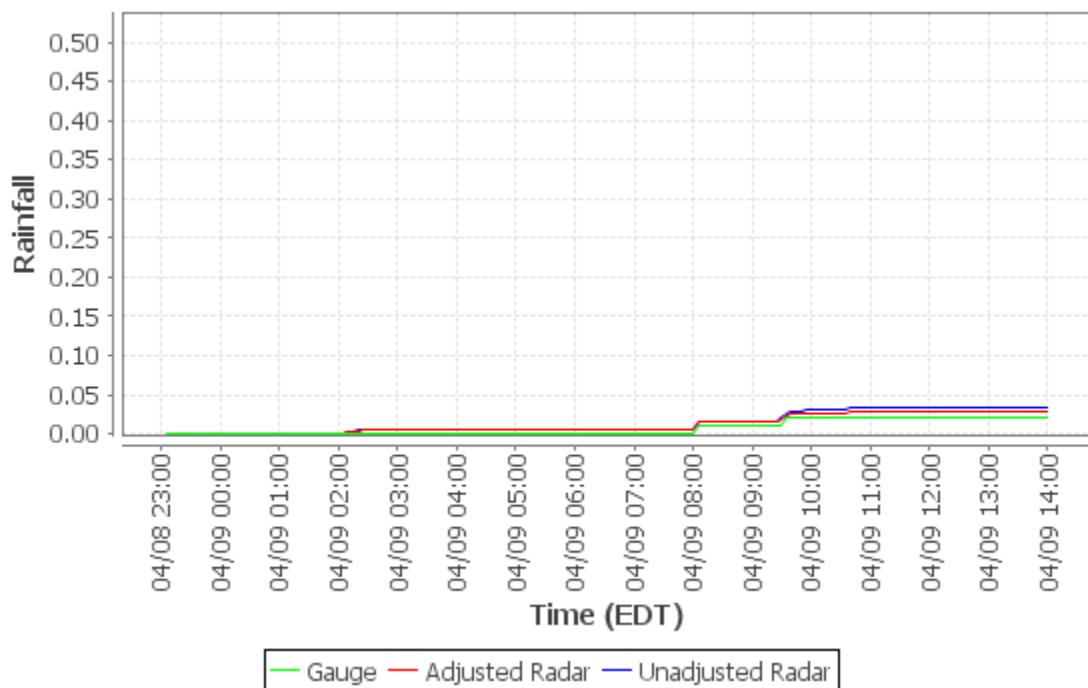
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



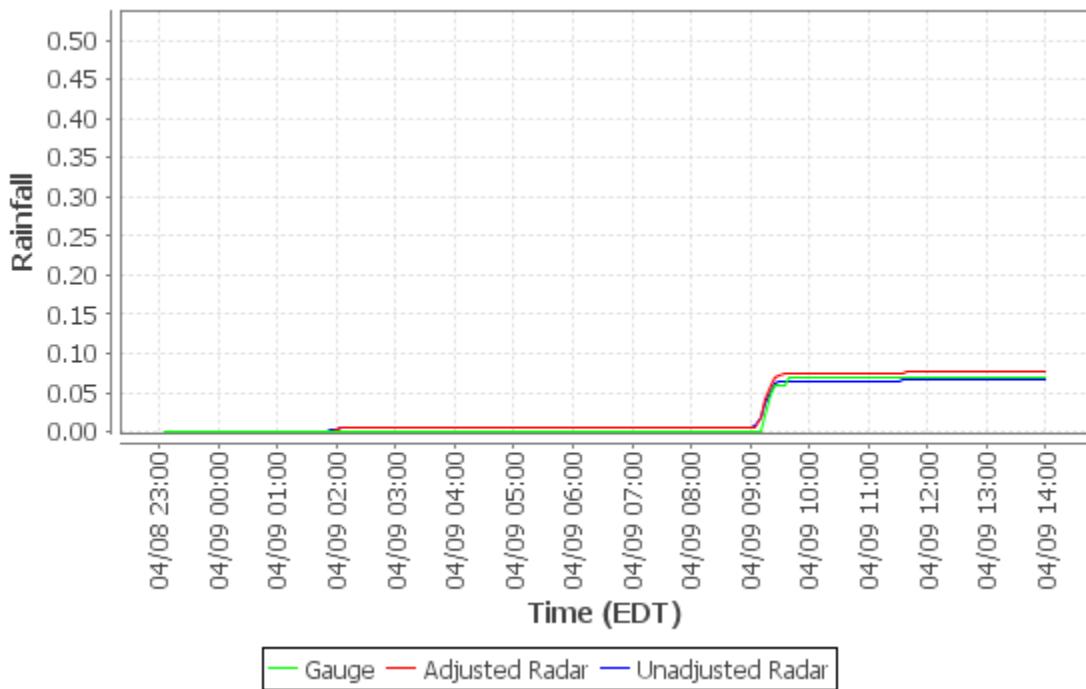
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



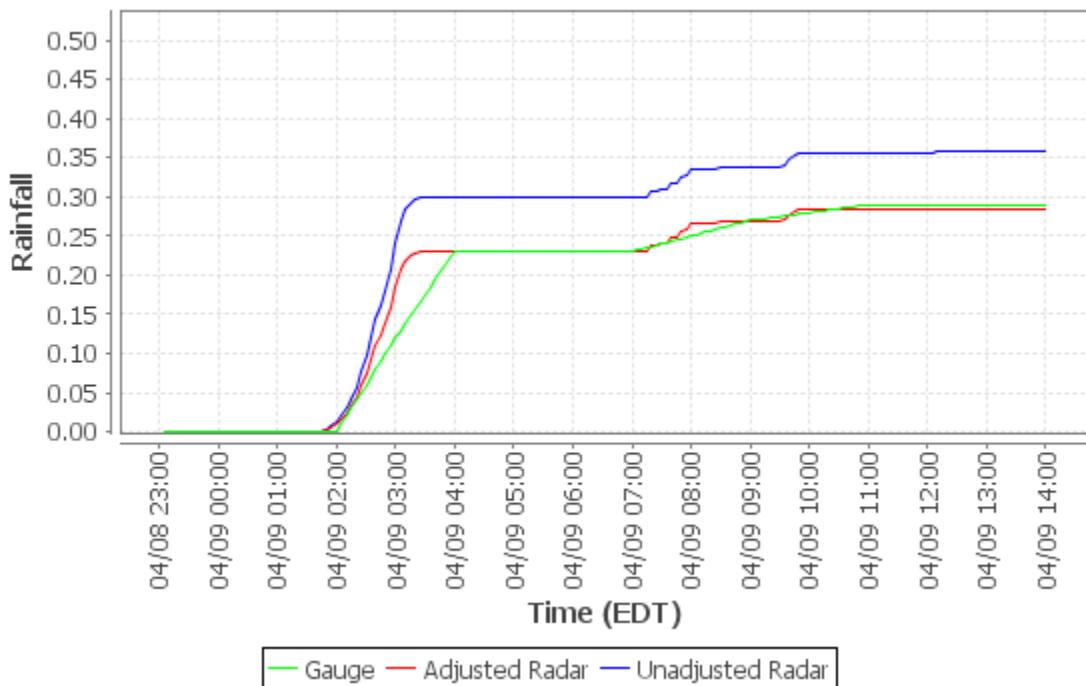
Cumulative Distribution Plot - Arnold (Loc32)



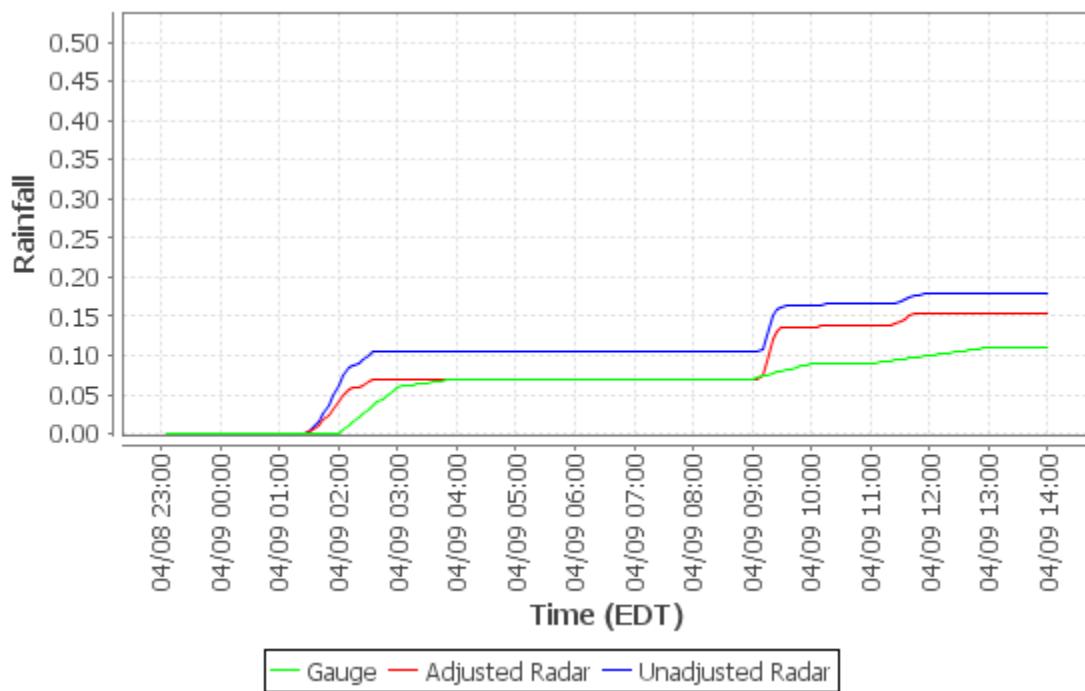
Cumulative Distribution Plot - Richland TWP (Loc33)



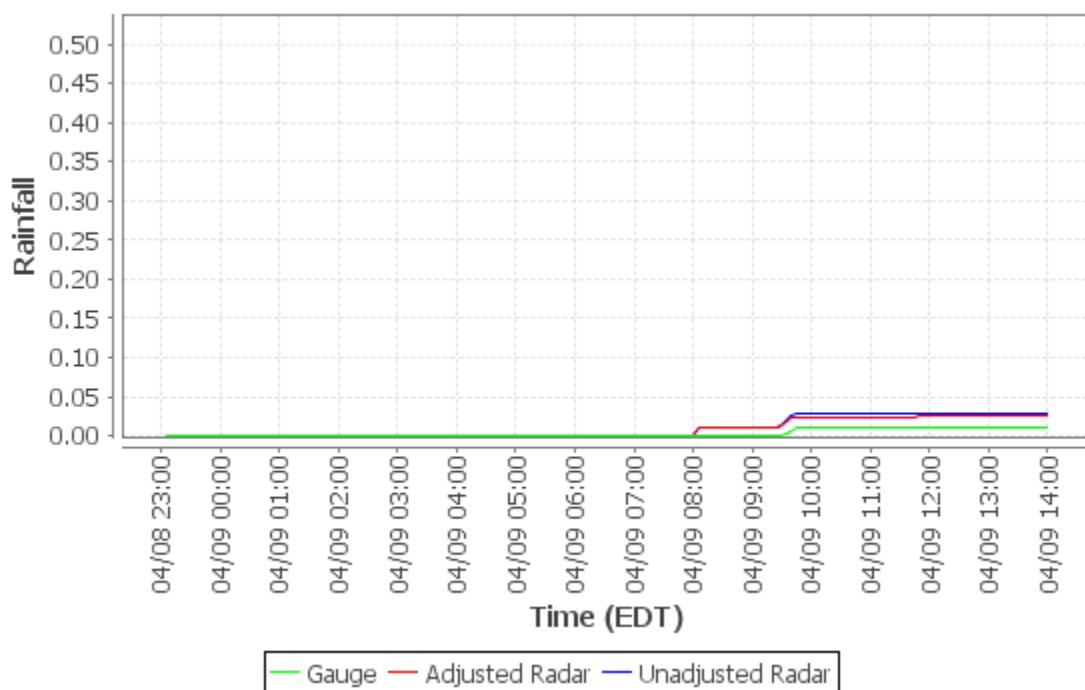
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



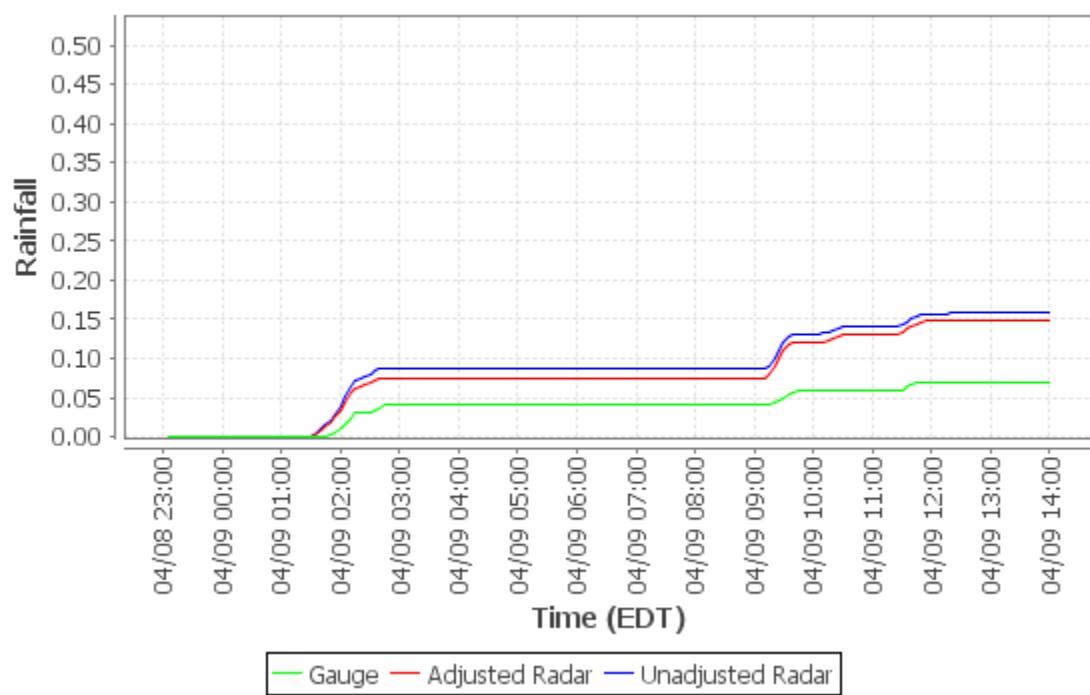
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

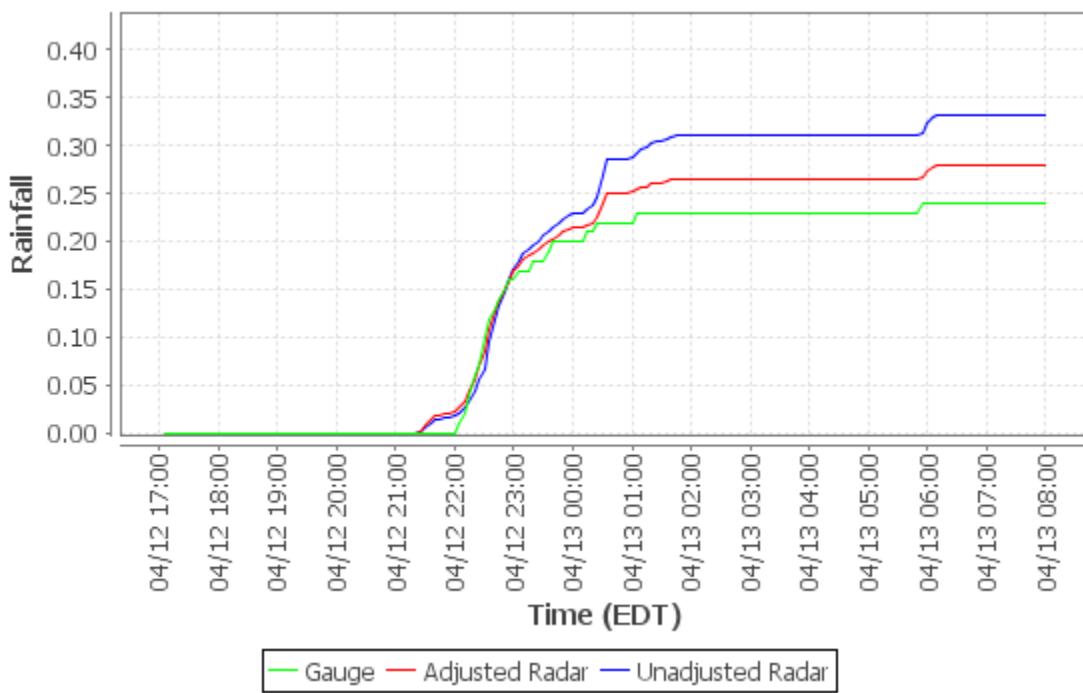


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

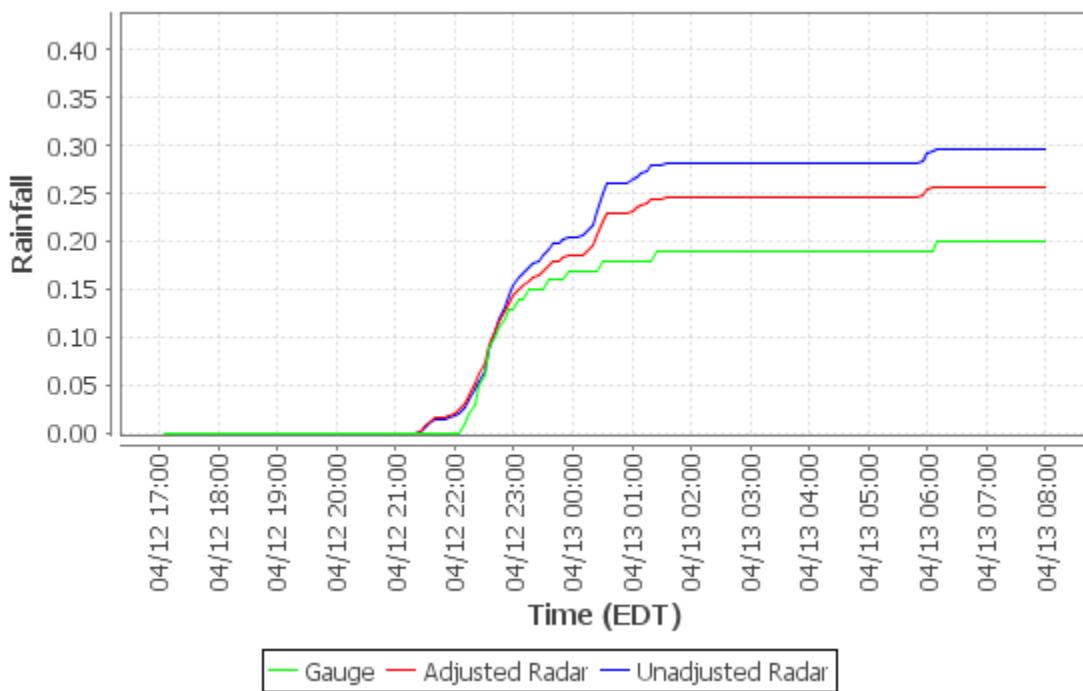


Appendix F - Event 4 (2020-04-12) CDPs

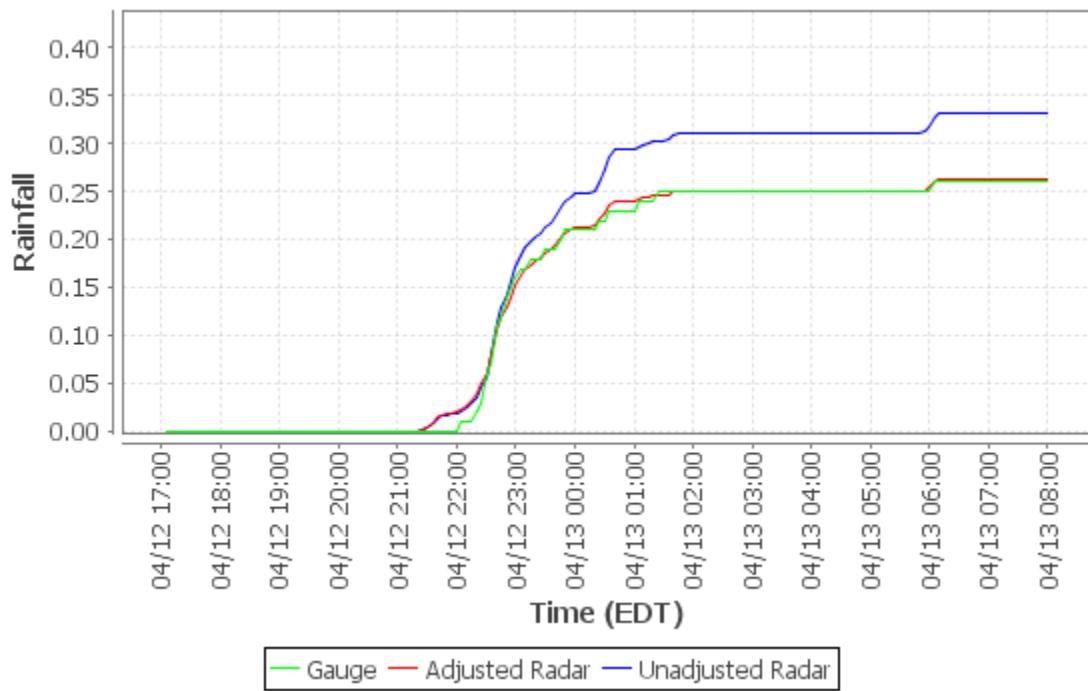
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



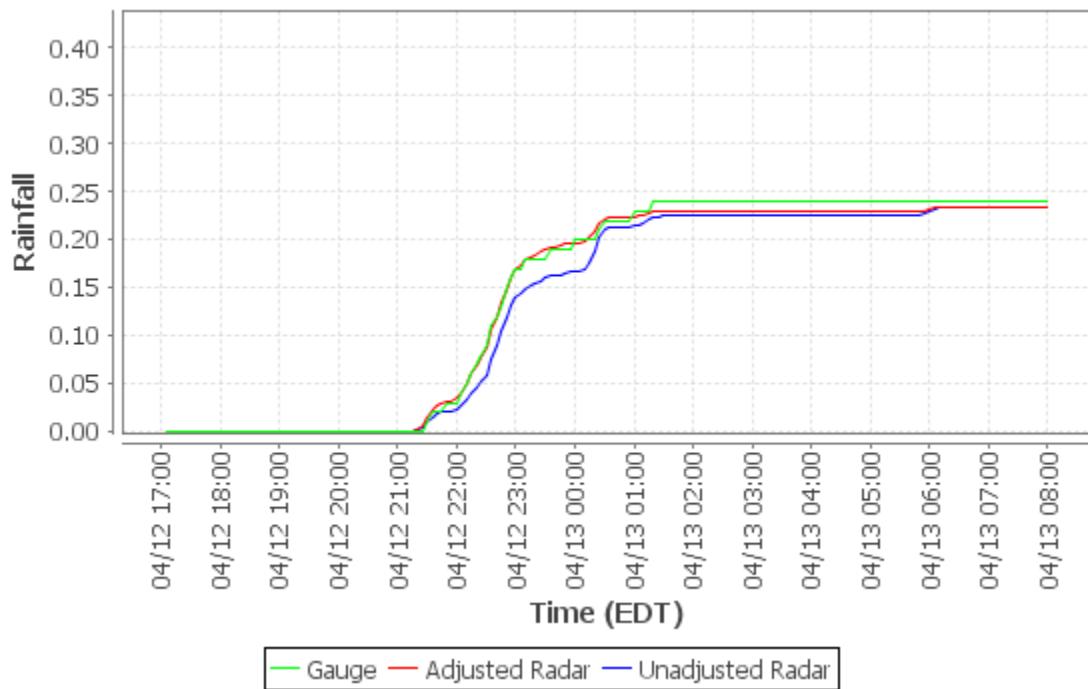
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



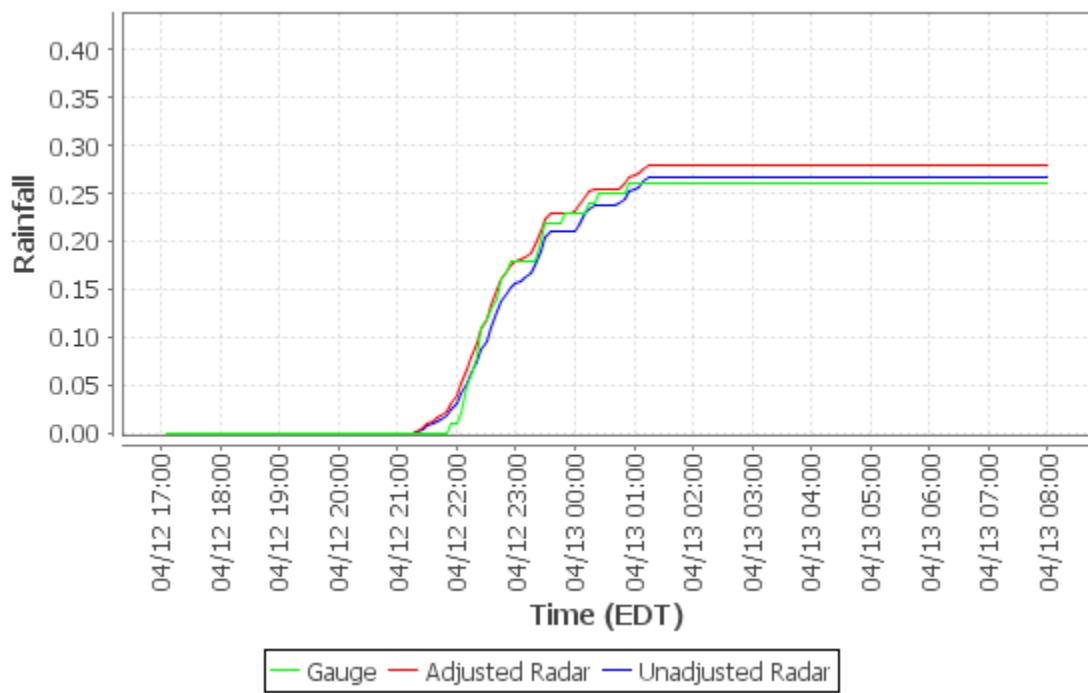
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



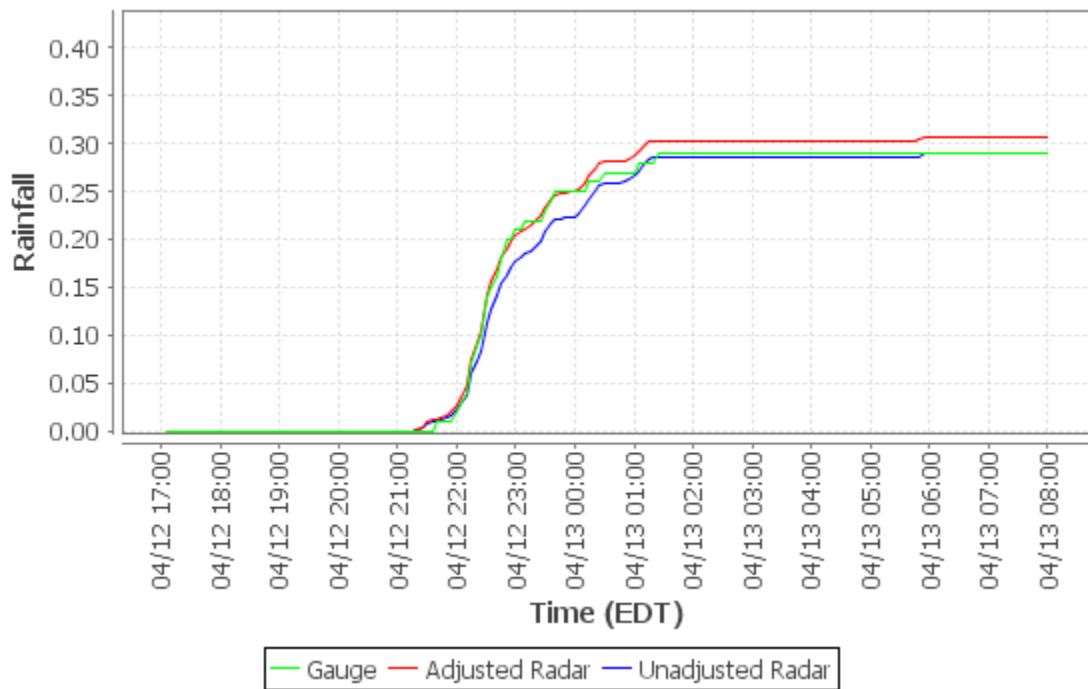
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



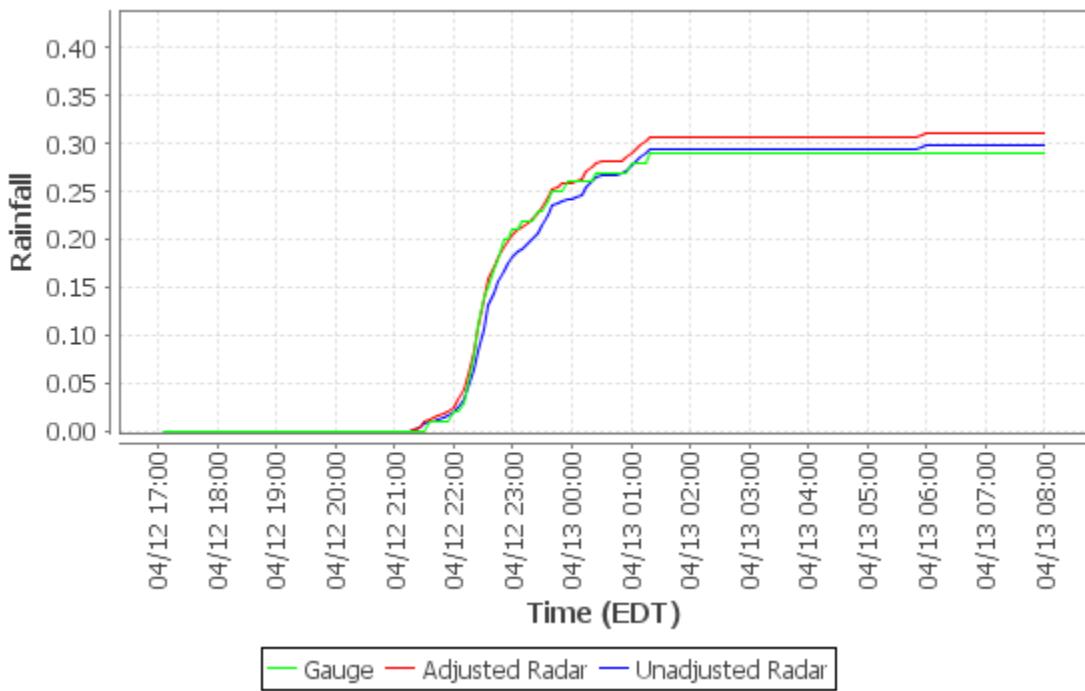
Cumulative Distribution Plot - Upper St. Clair (Loc05)



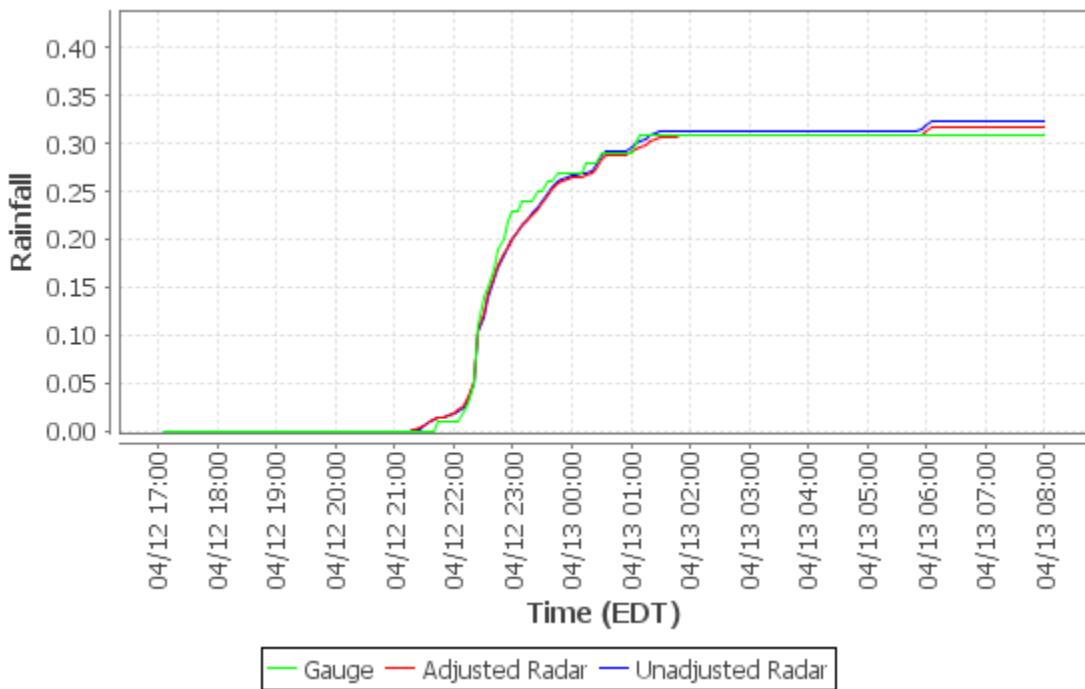
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



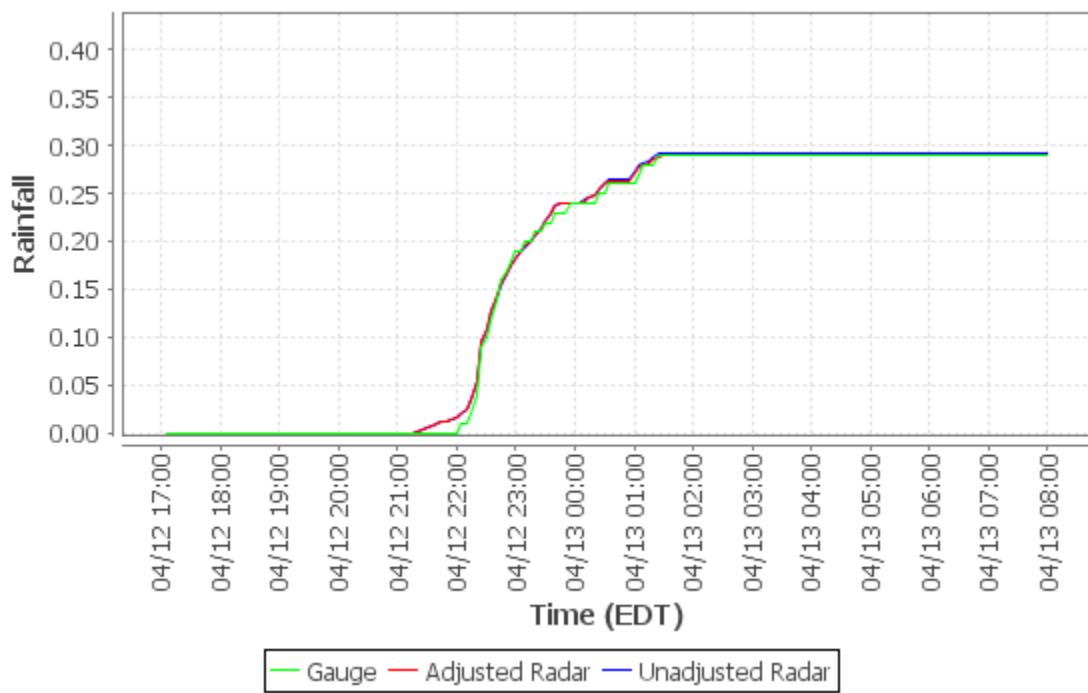
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



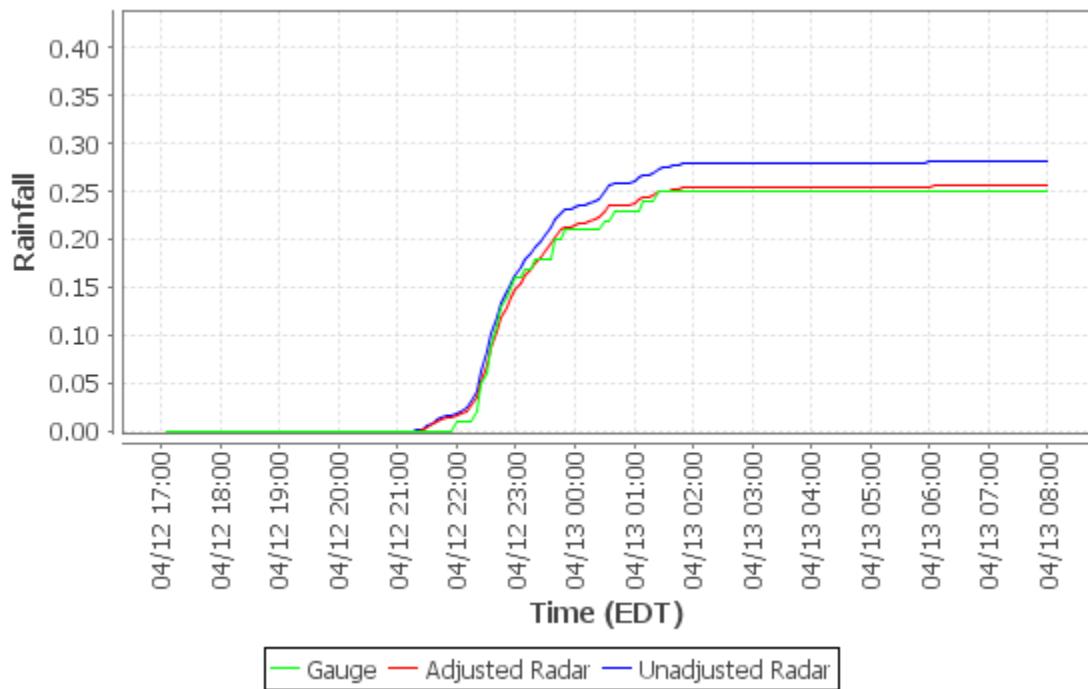
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



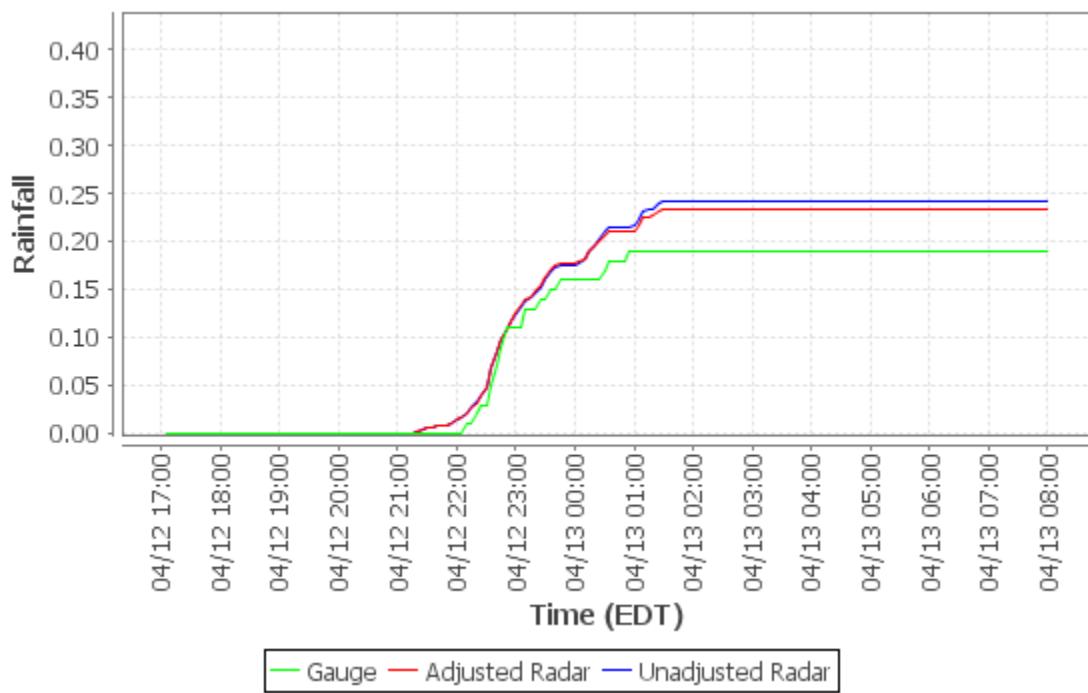
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



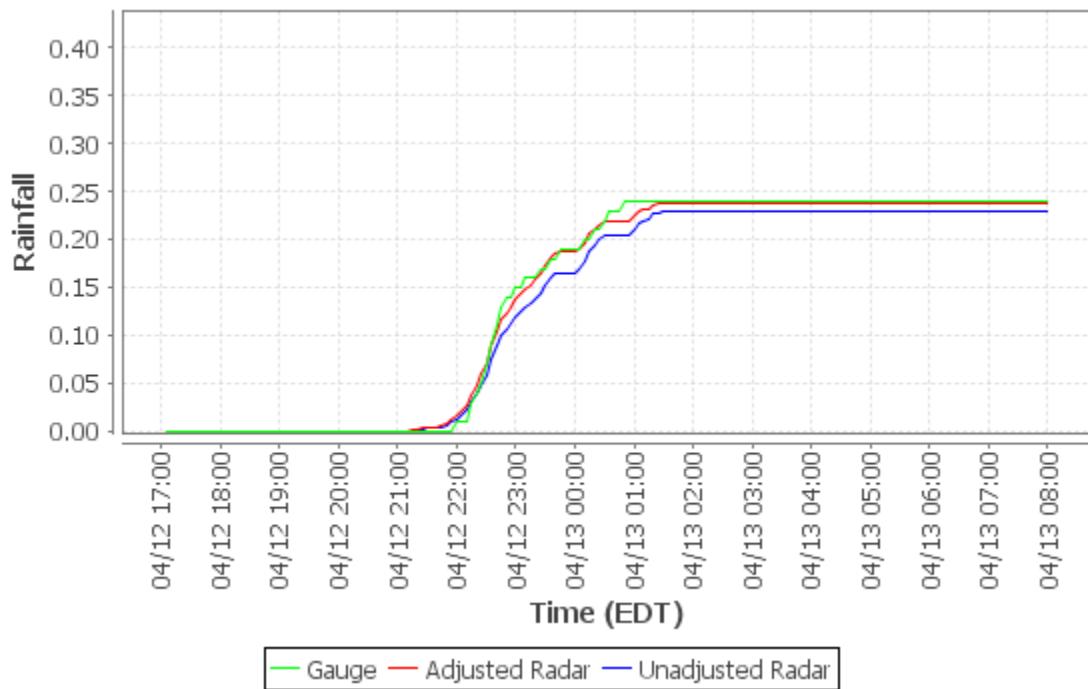
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



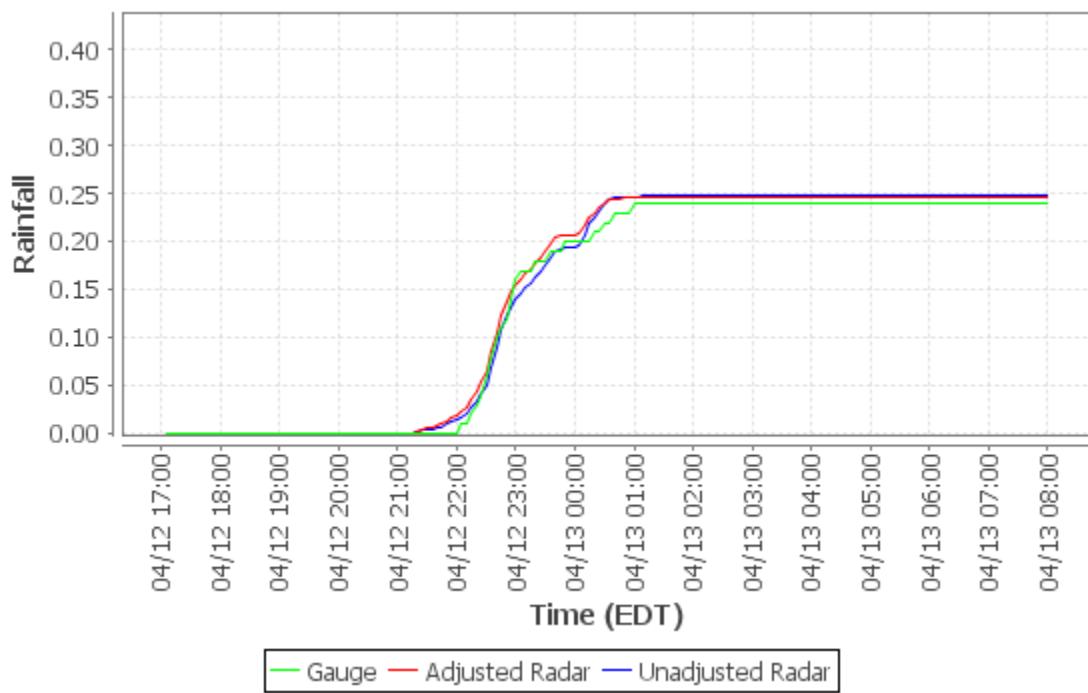
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



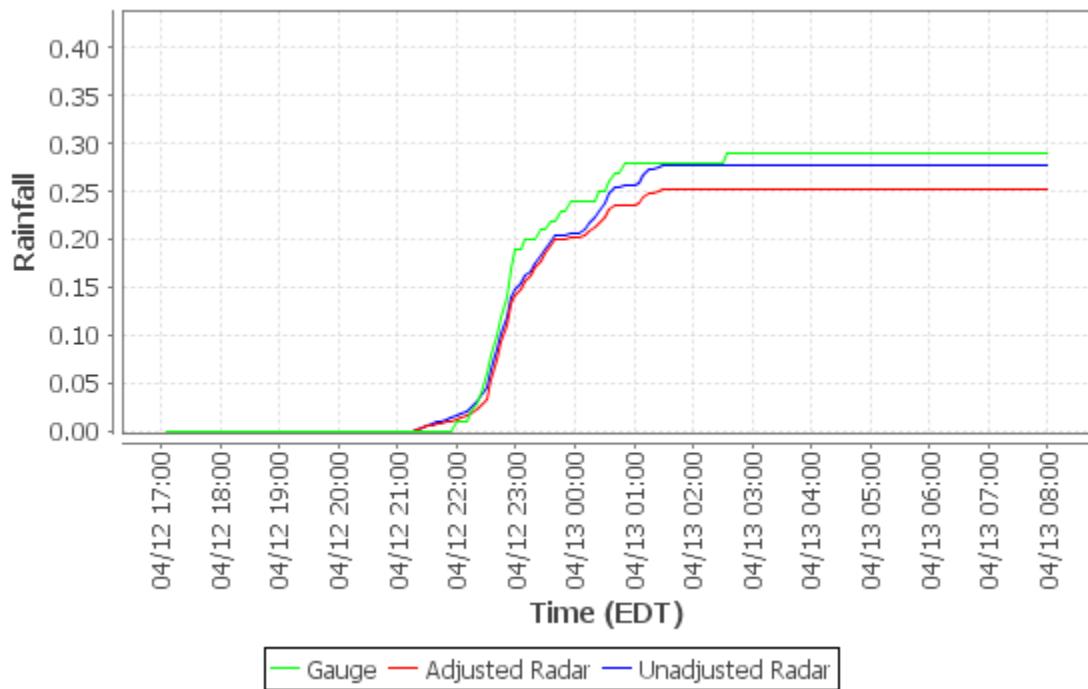
Cumulative Distribution Plot - Baldwin (Loc12)



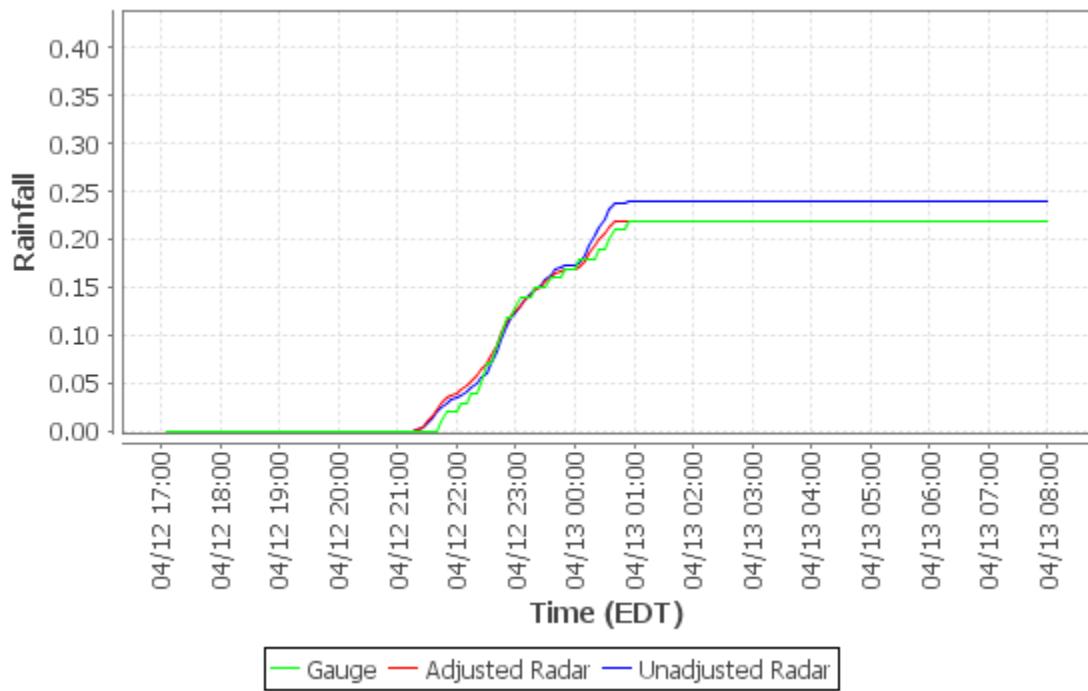
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



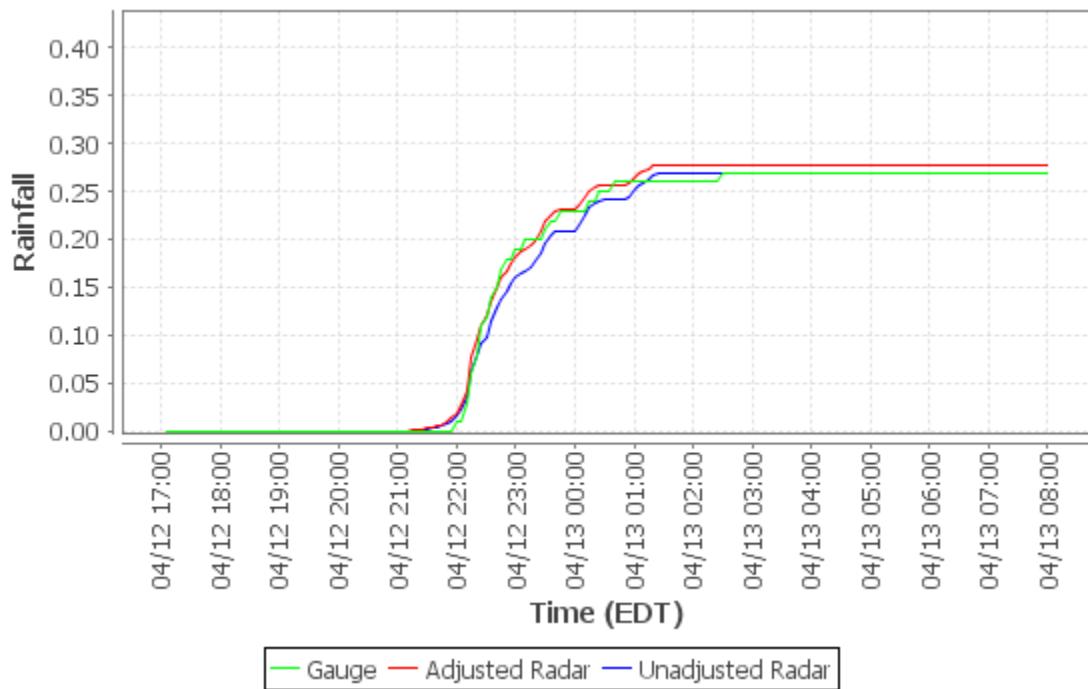
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



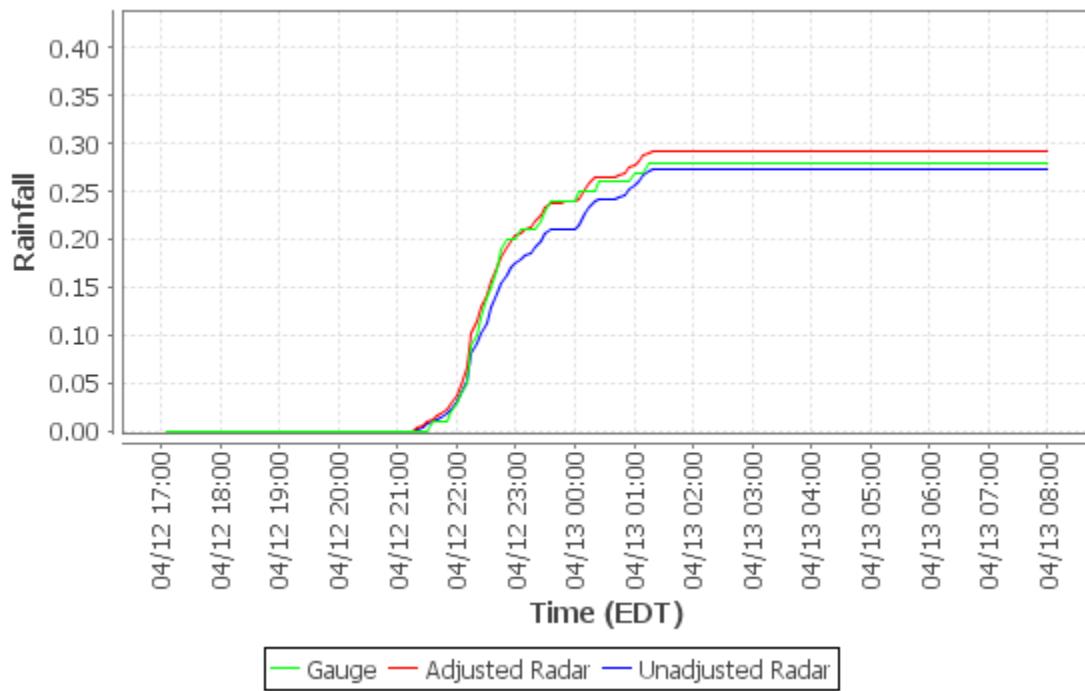
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



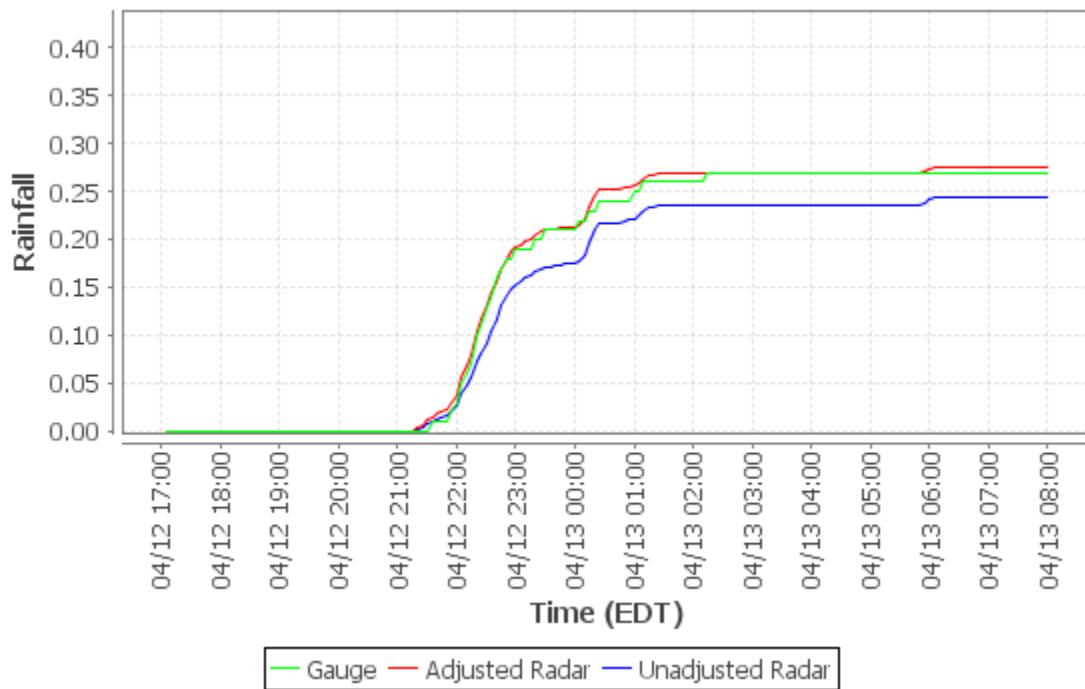
Cumulative Distribution Plot - Castle Shannon (Loc16)



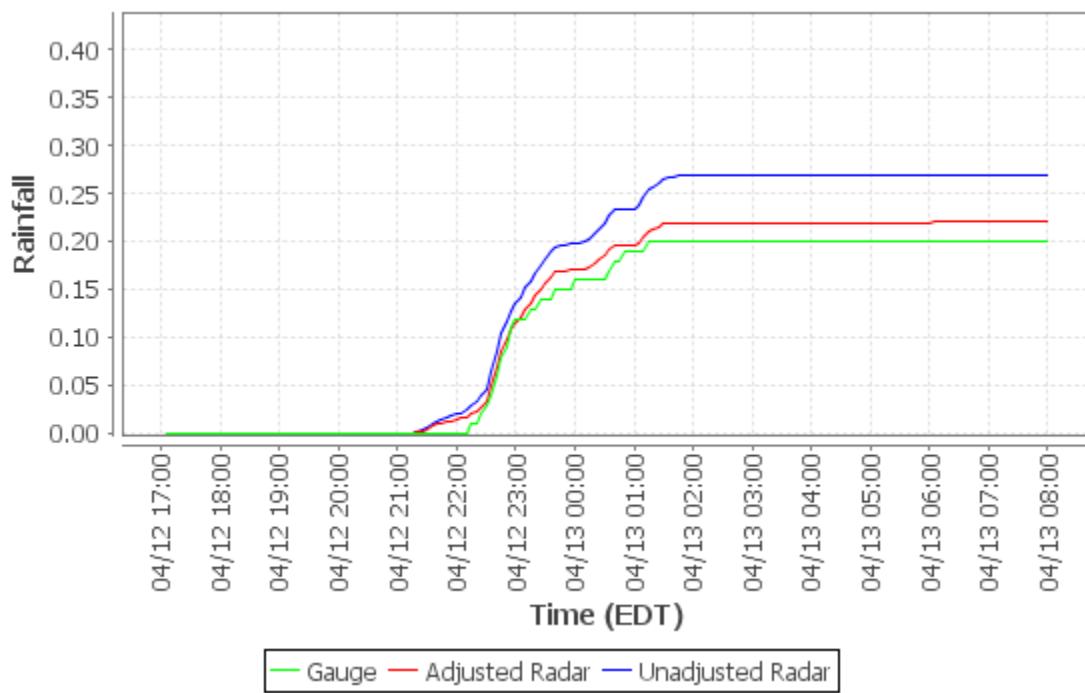
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



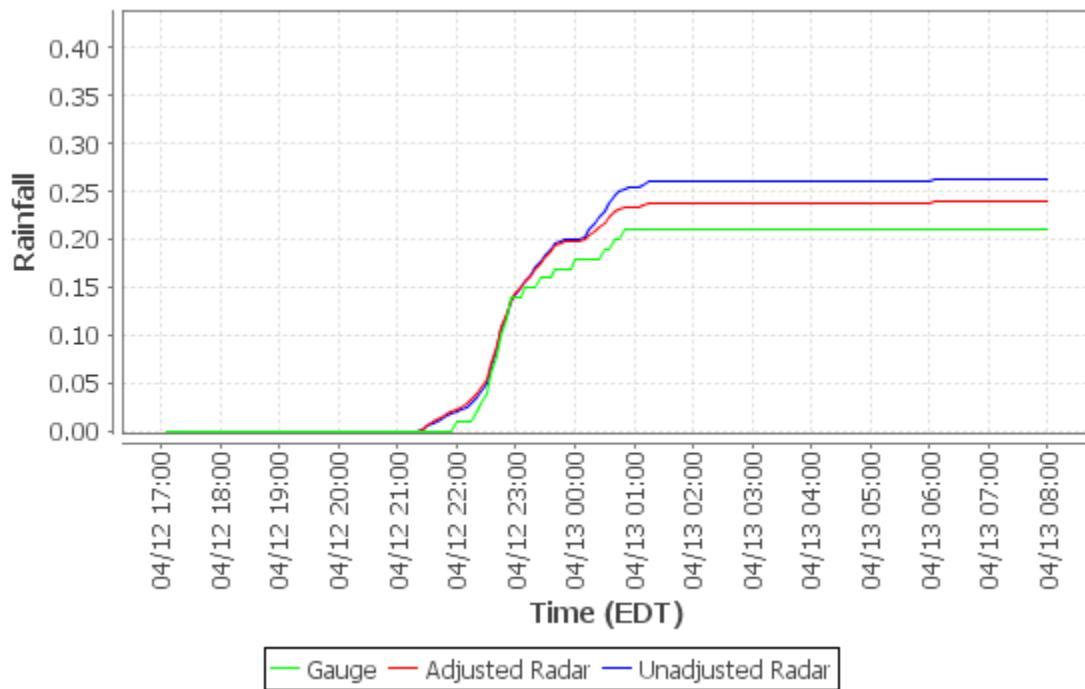
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



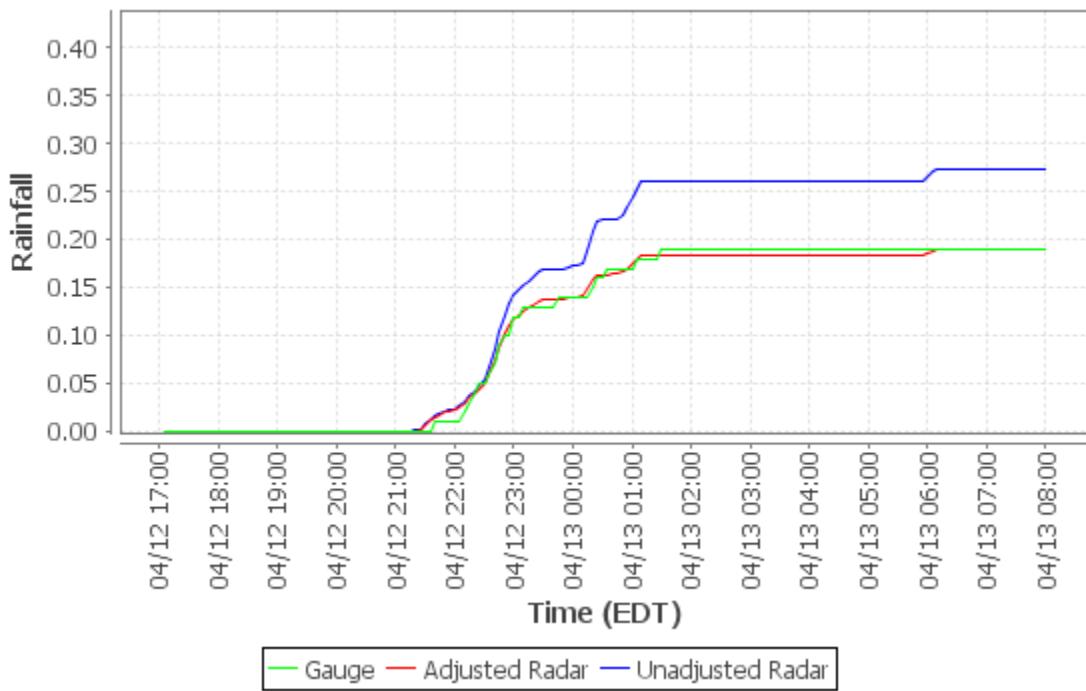
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



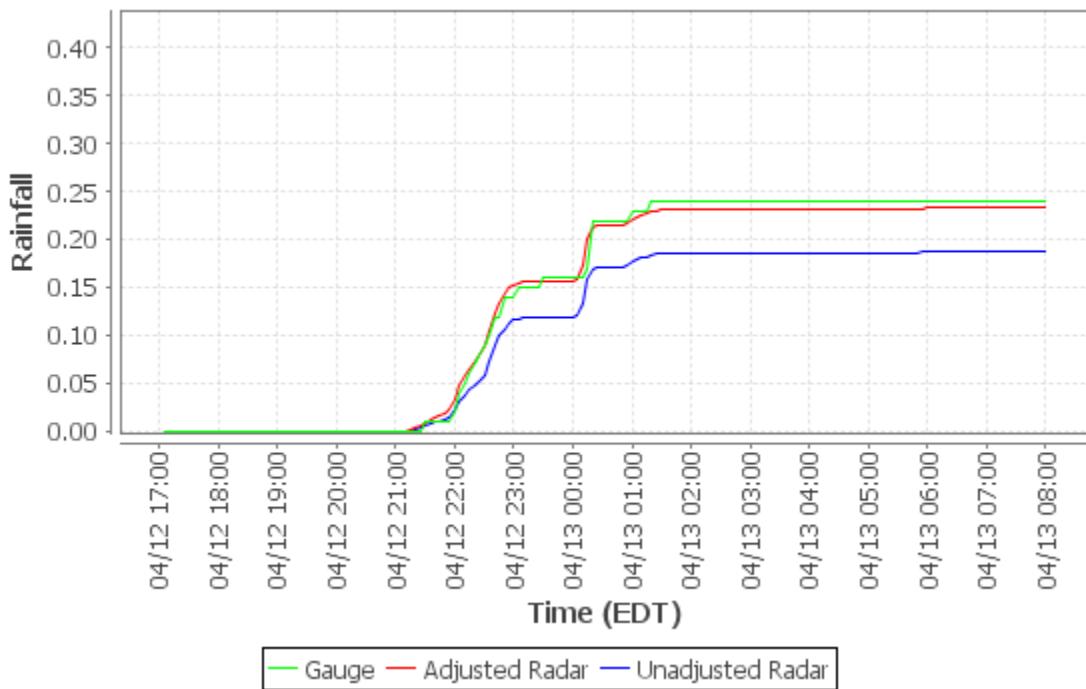
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



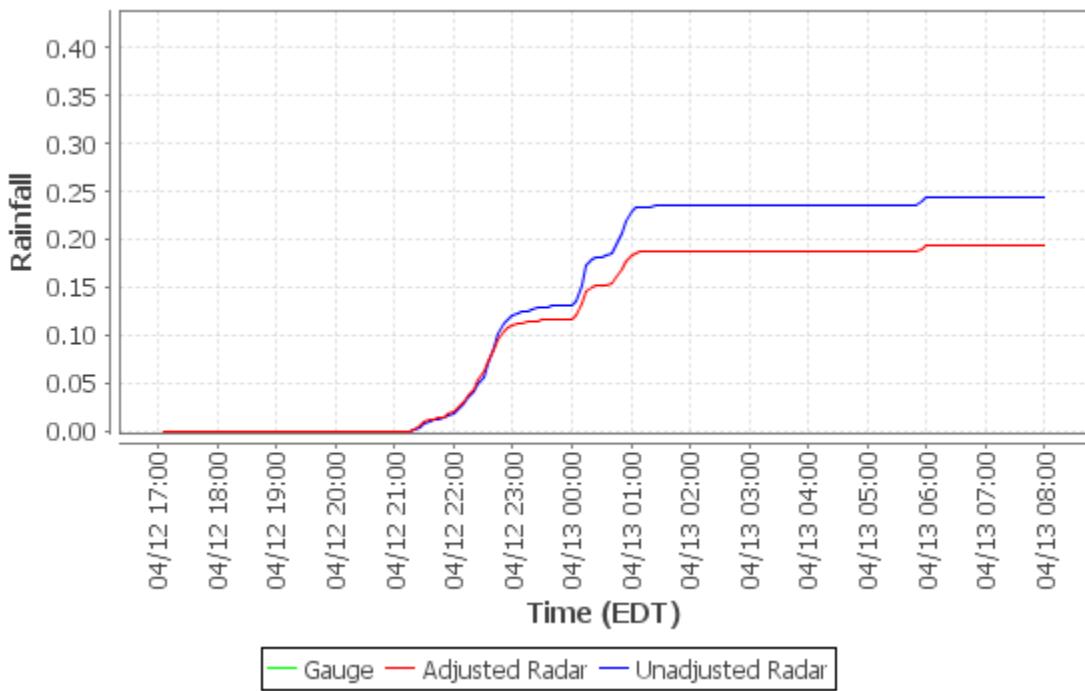
Cumulative Distribution Plot - Moon TWP (Loc21)



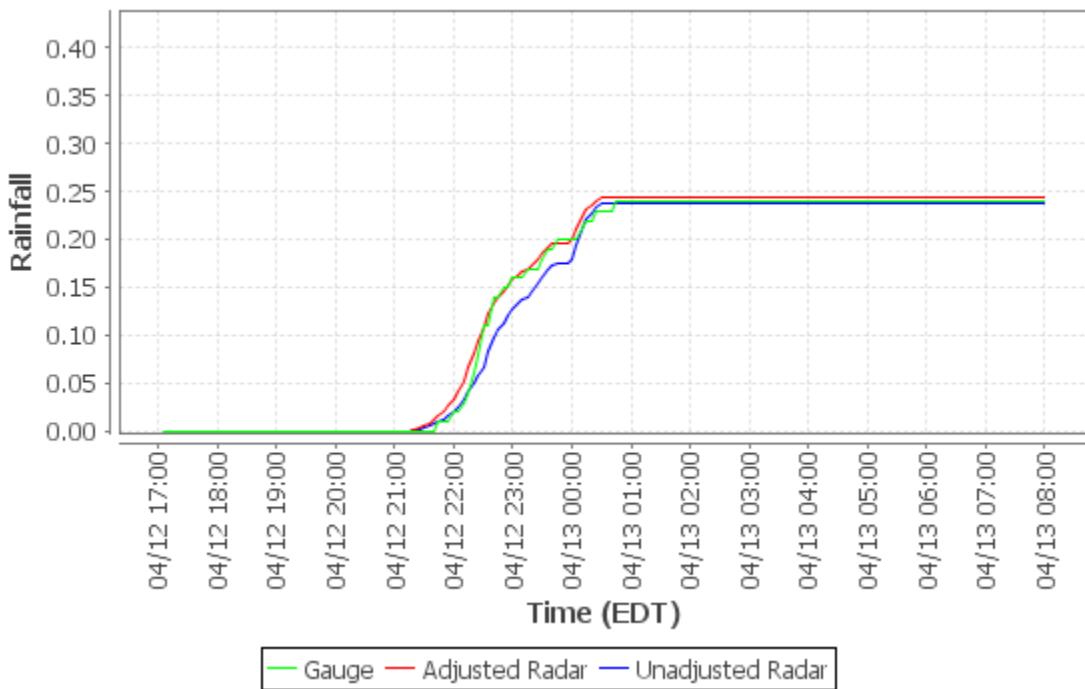
Cumulative Distribution Plot - North Fayette TWP (Loc22)



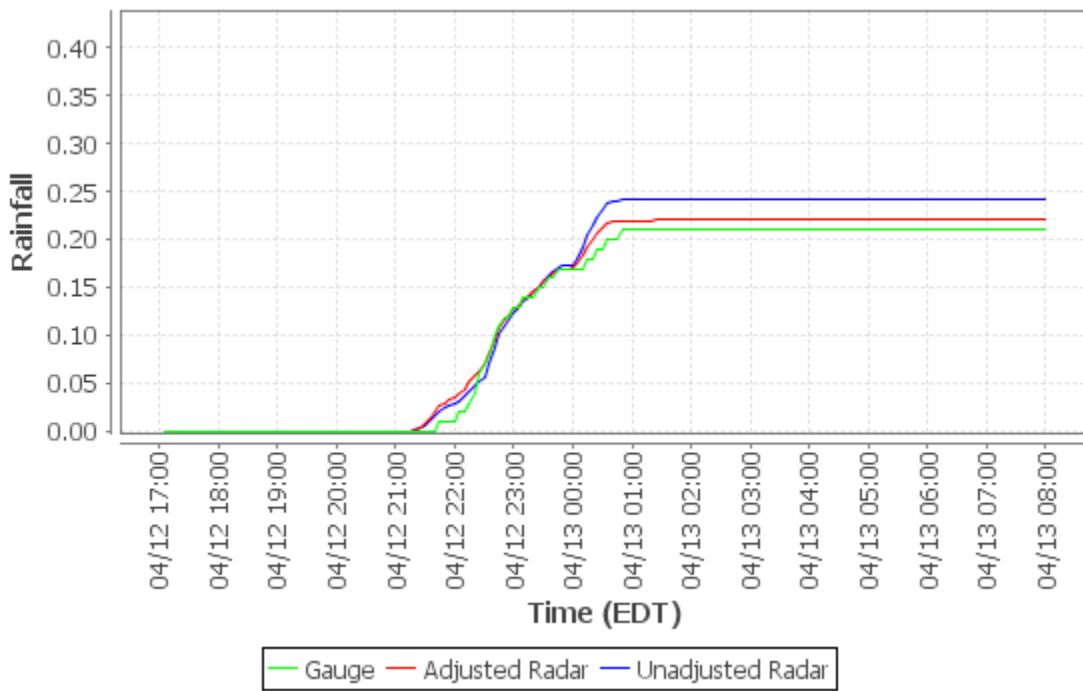
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



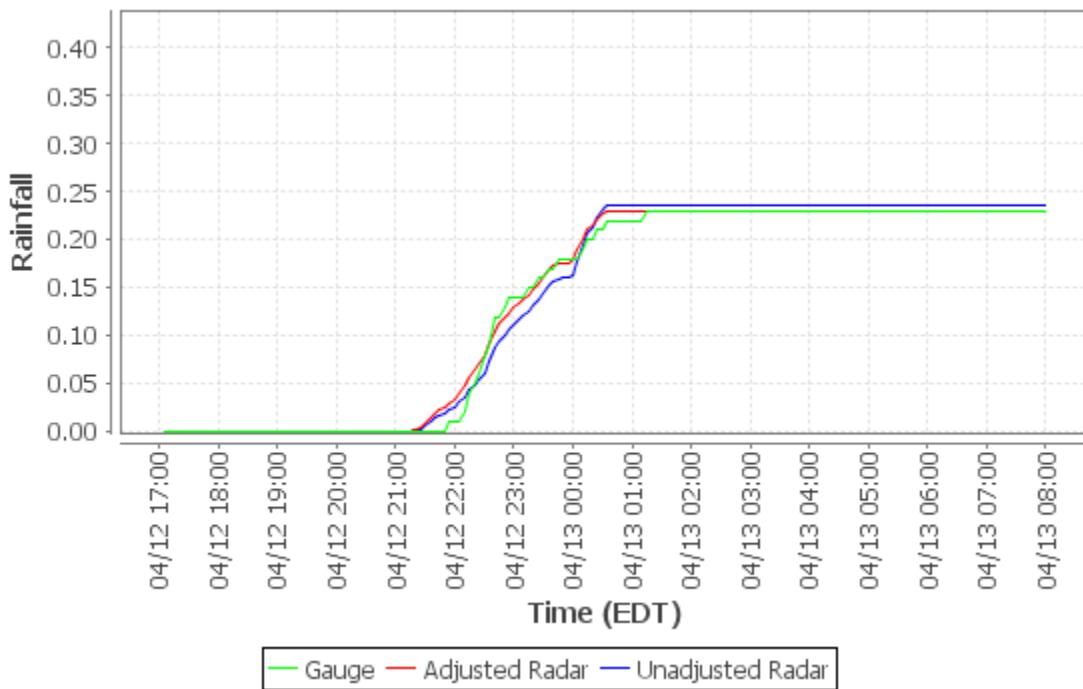
Cumulative Distribution Plot - Jefferson Hills (Loc24)



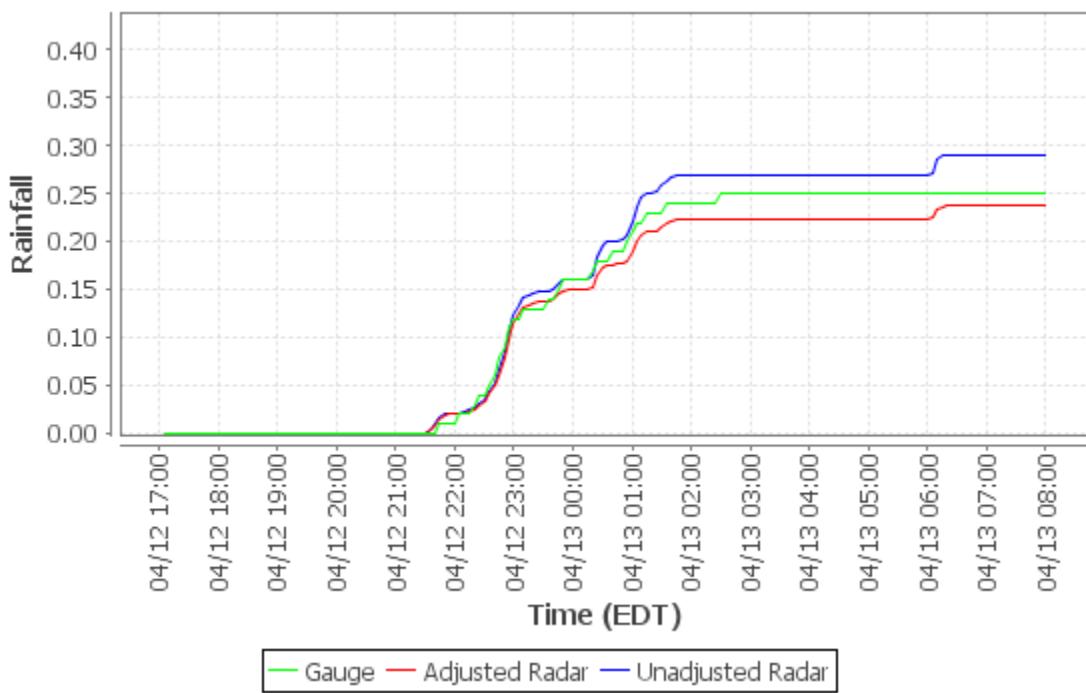
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



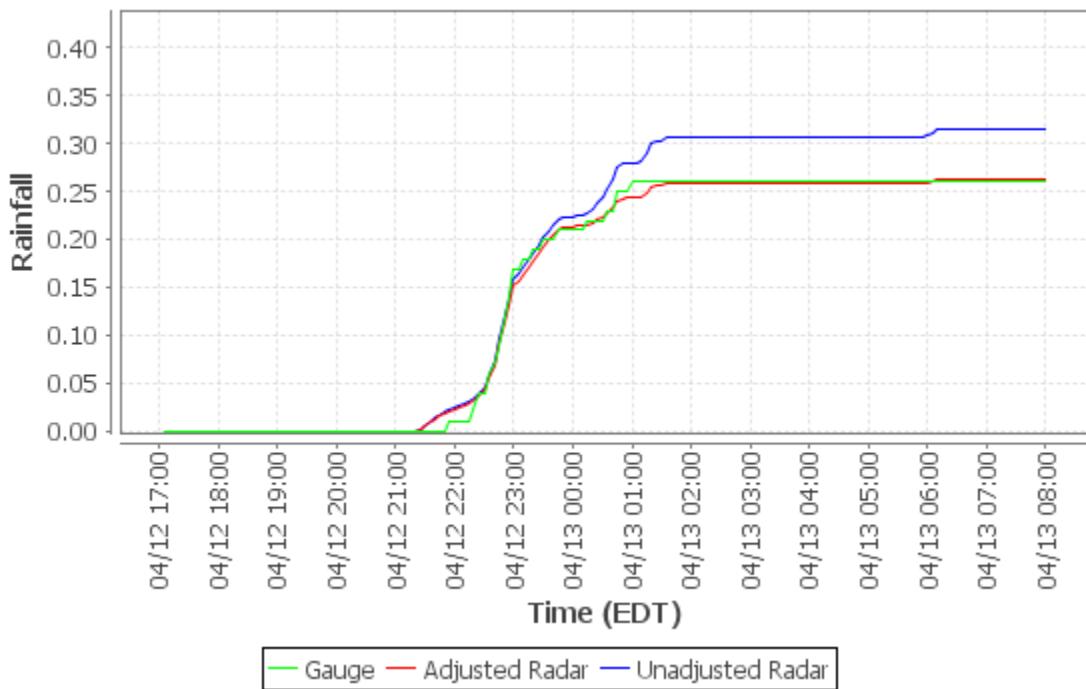
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



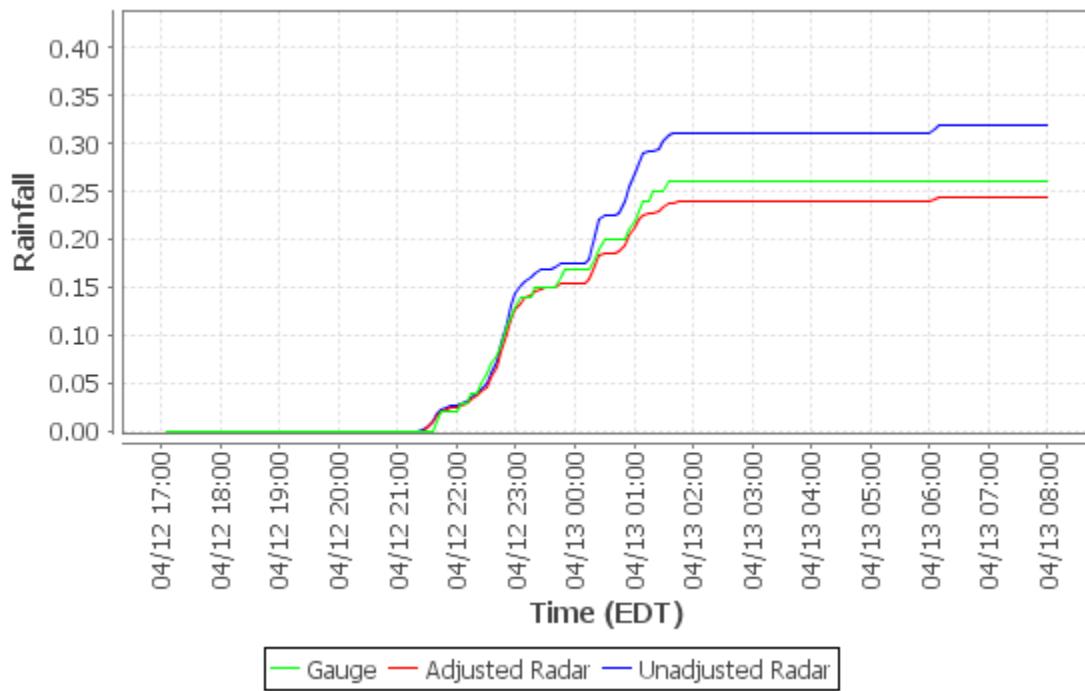
Cumulative Distribution Plot - Marshall TWP (Loc27)



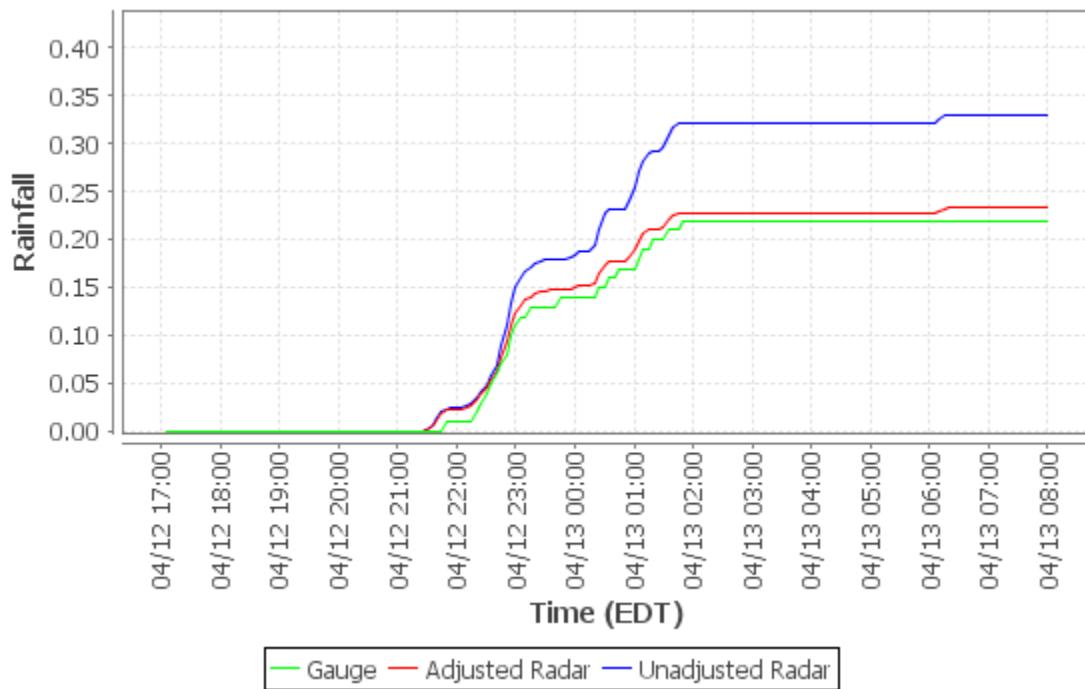
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



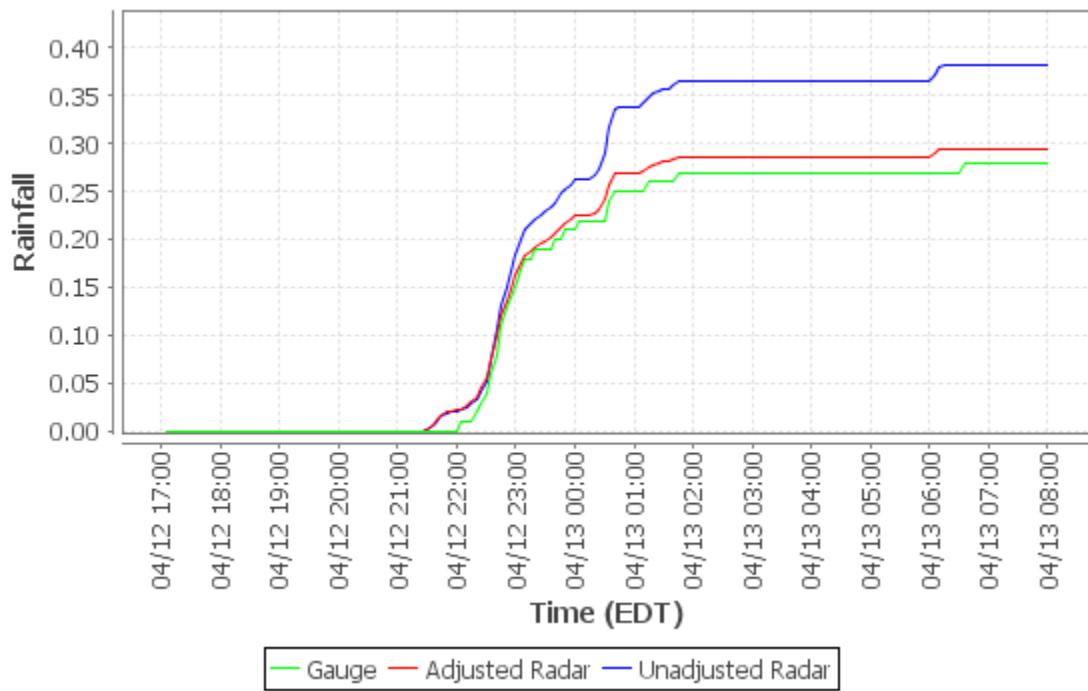
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



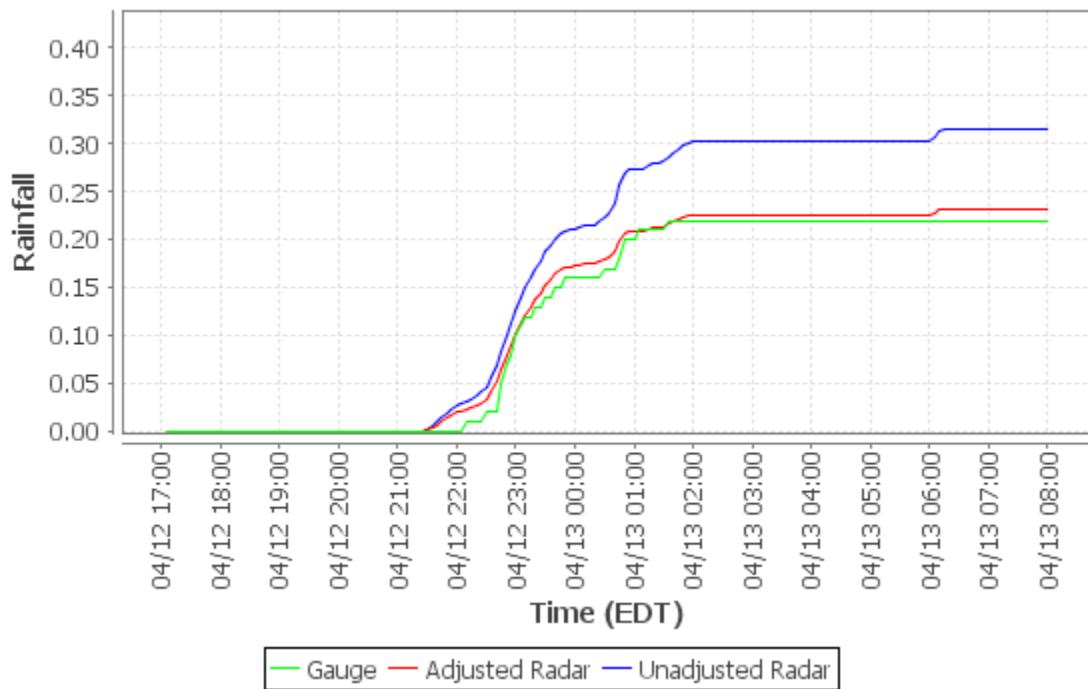
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



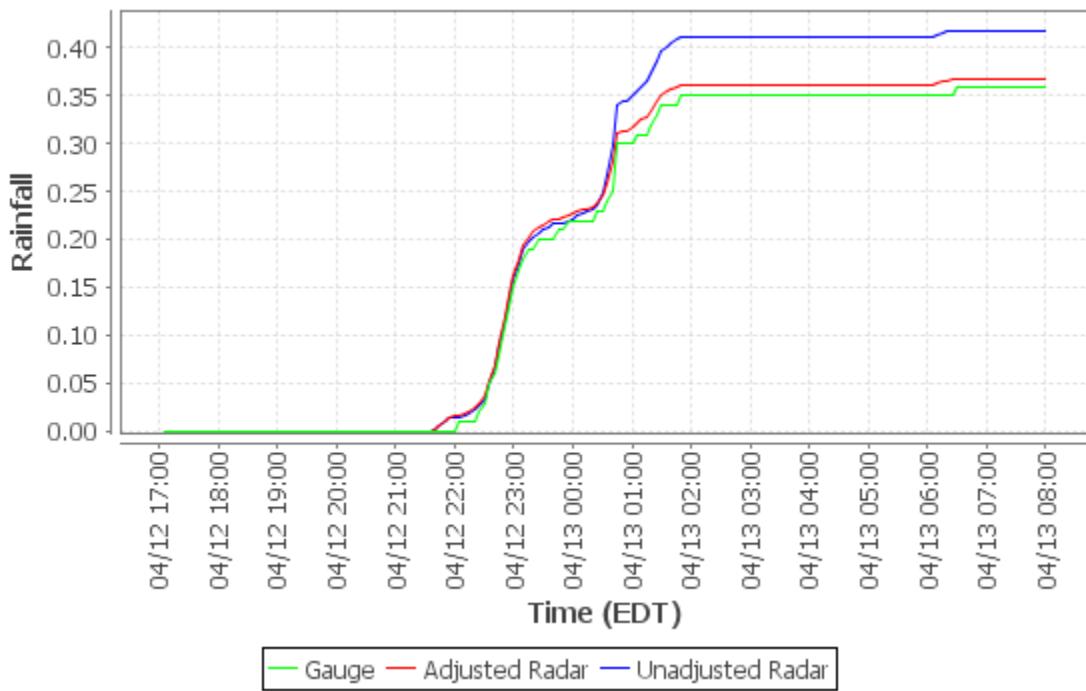
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



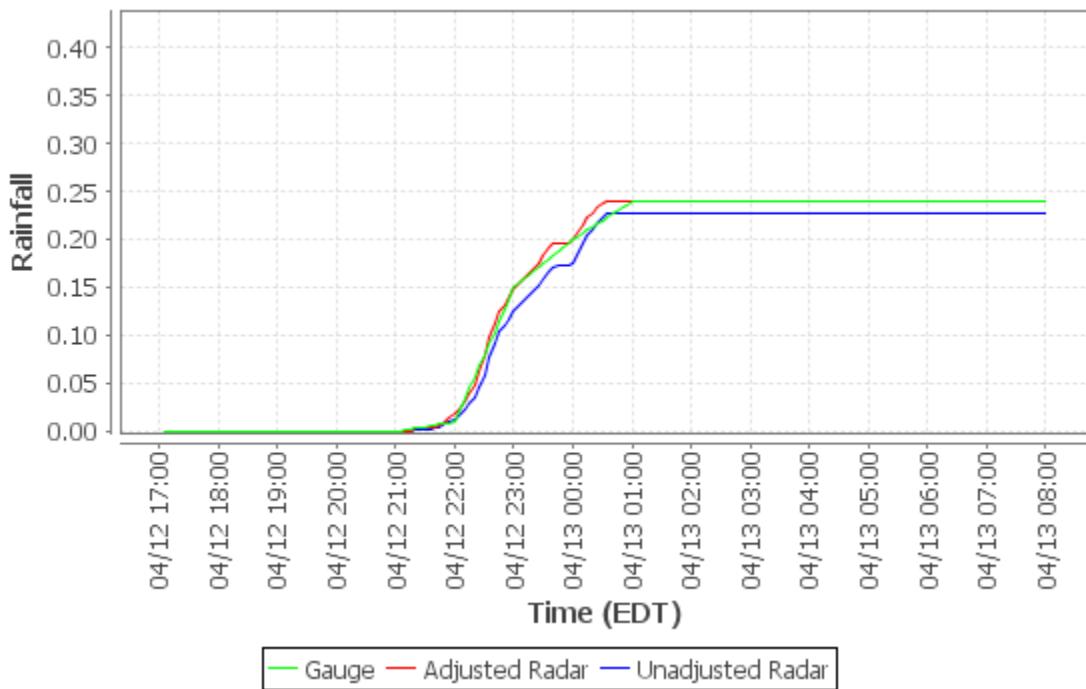
Cumulative Distribution Plot - Arnold (Loc32)



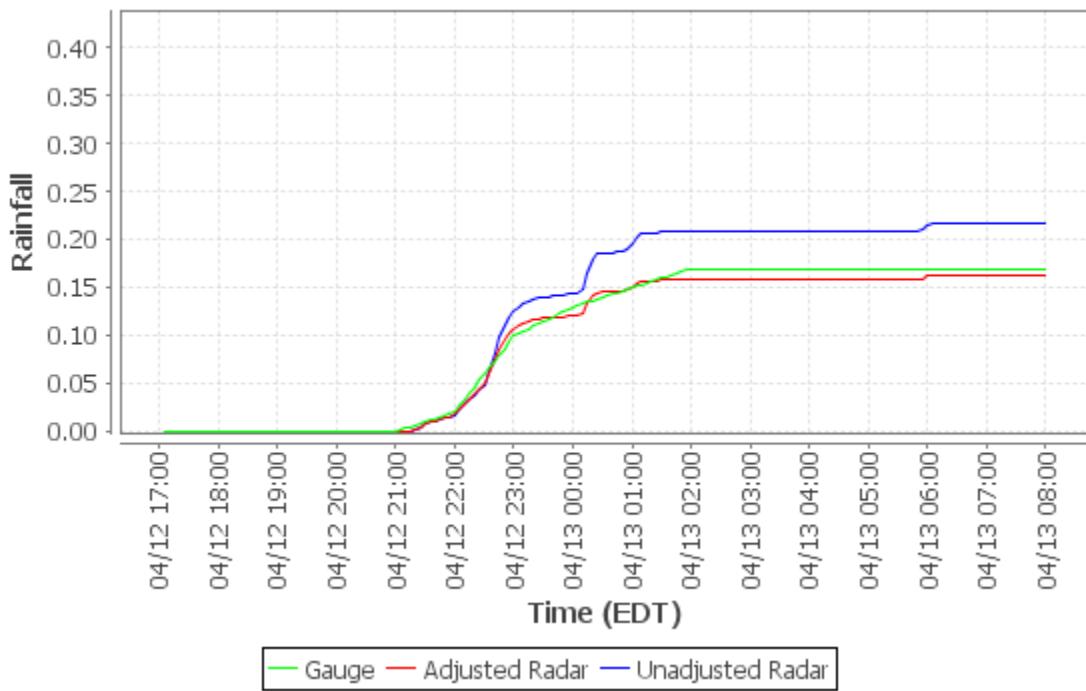
Cumulative Distribution Plot - Richland TWP (Loc33)



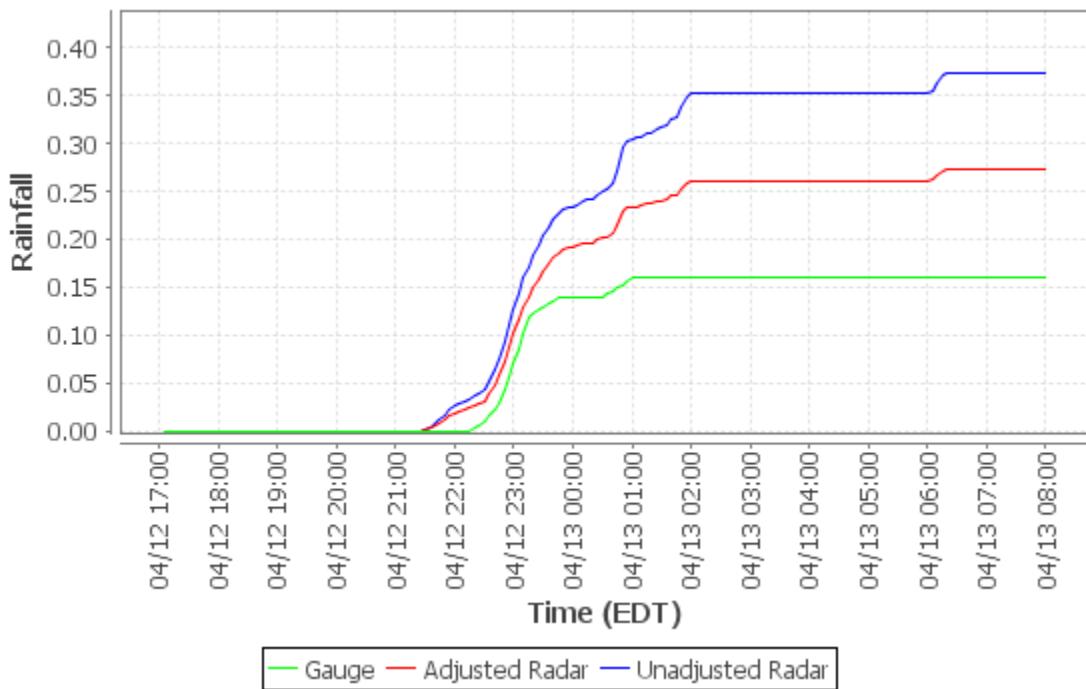
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



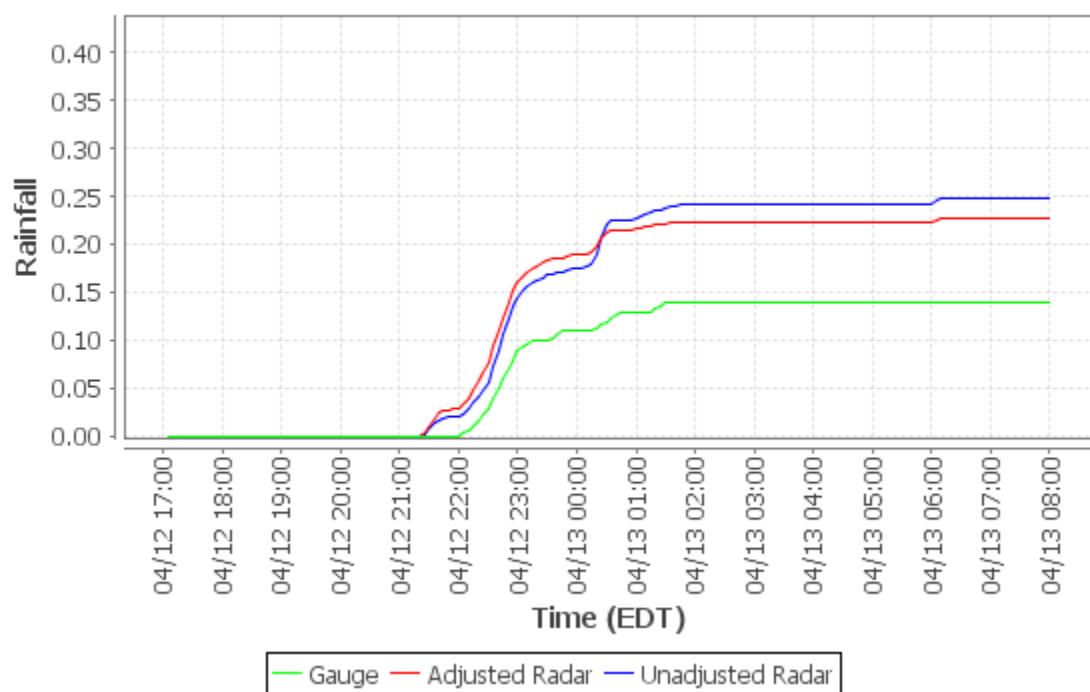
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

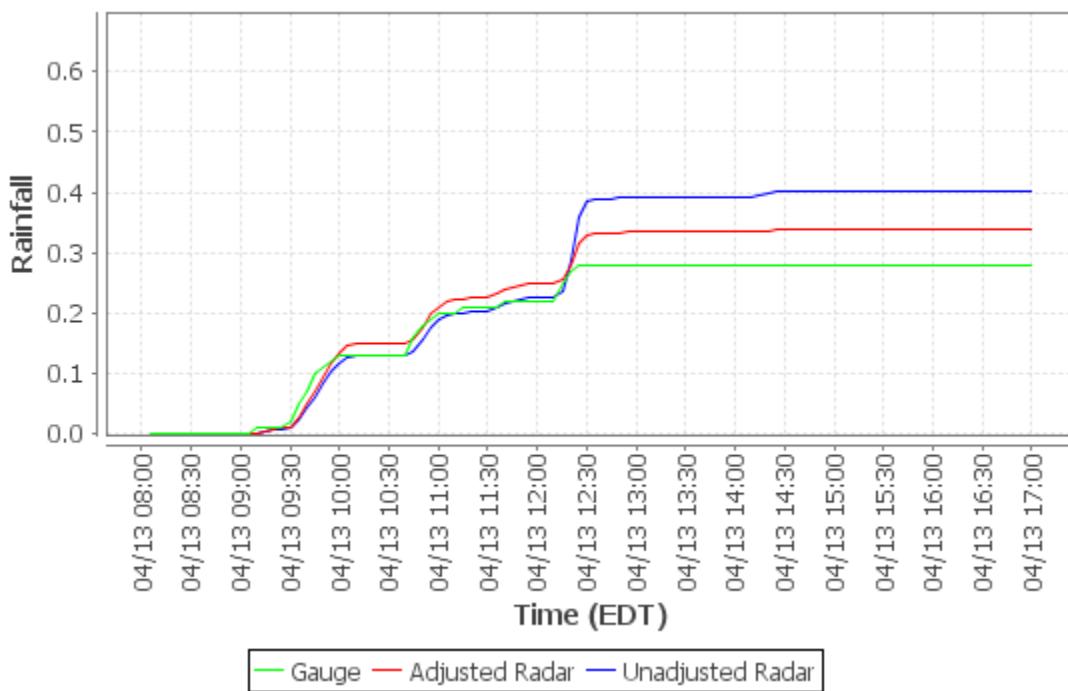


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

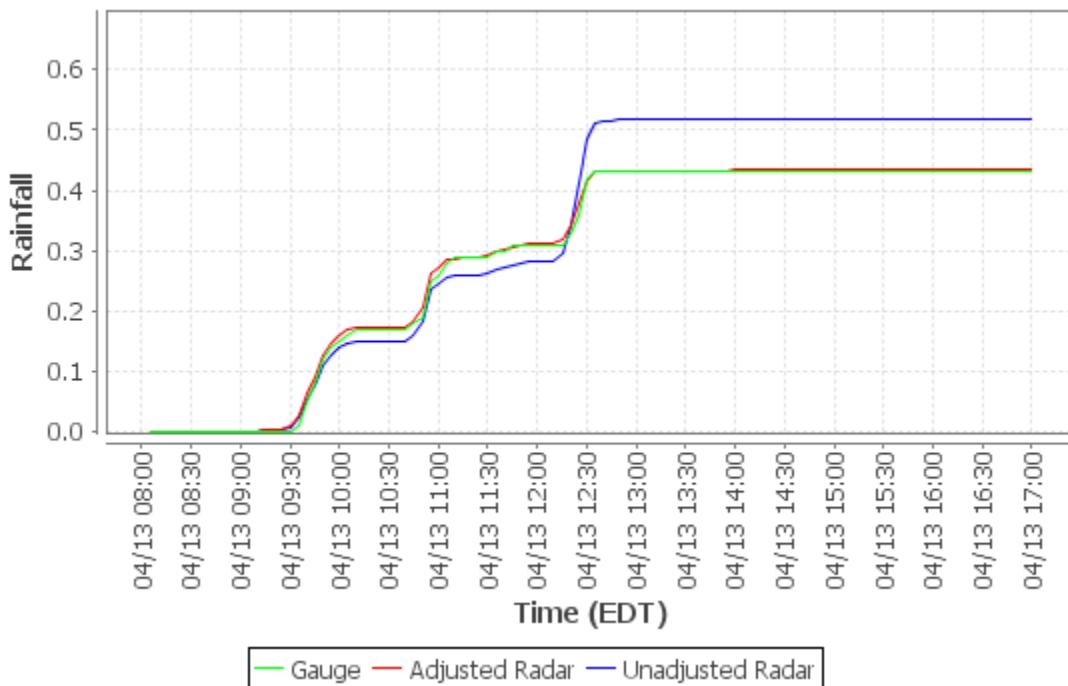


Appendix G - Event 5 (2020-04-13) CDPs

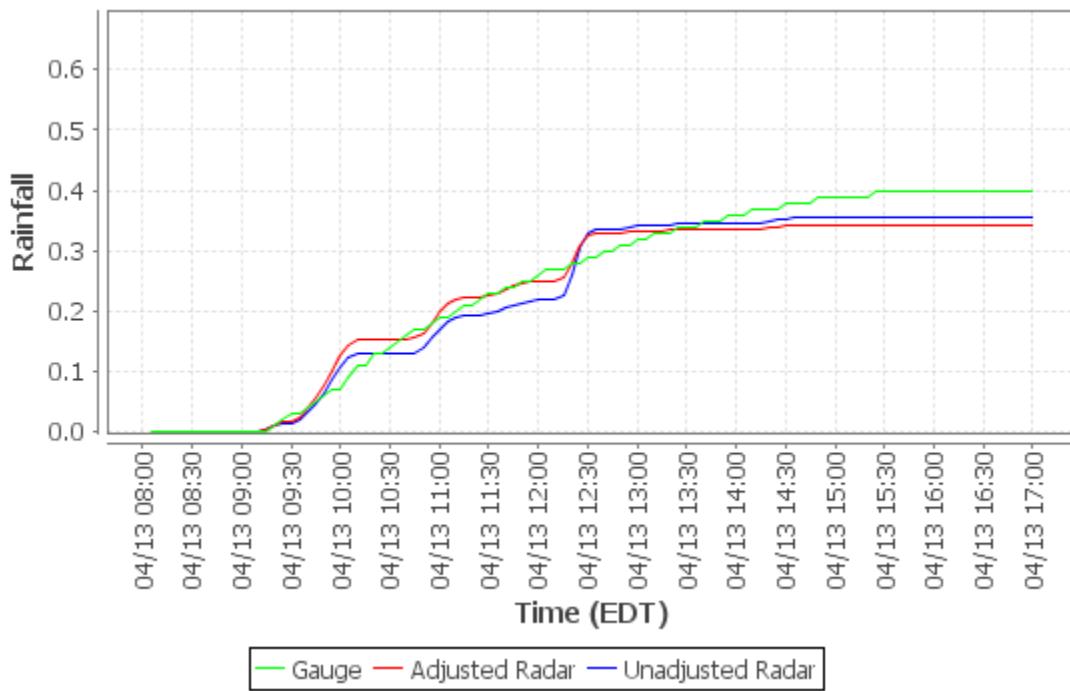
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



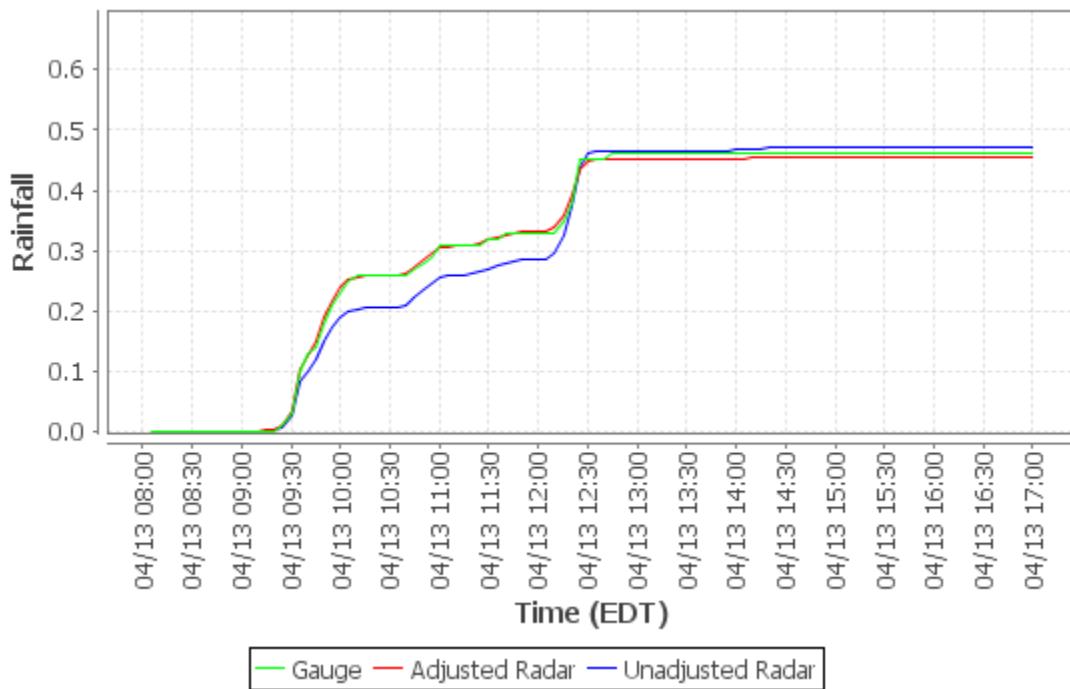
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



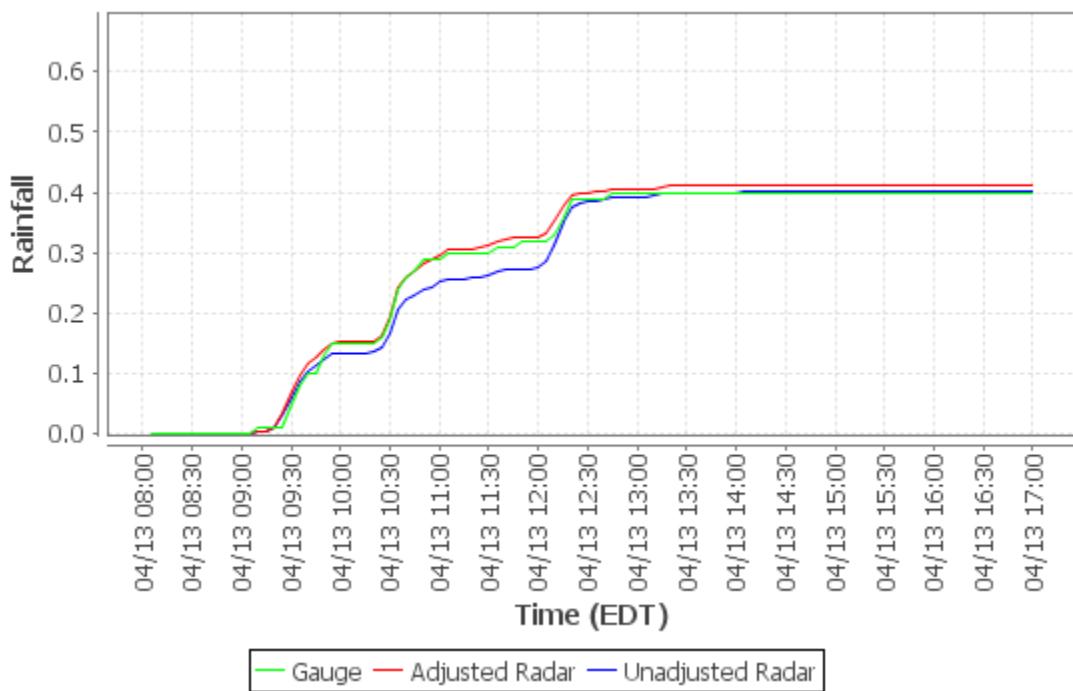
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



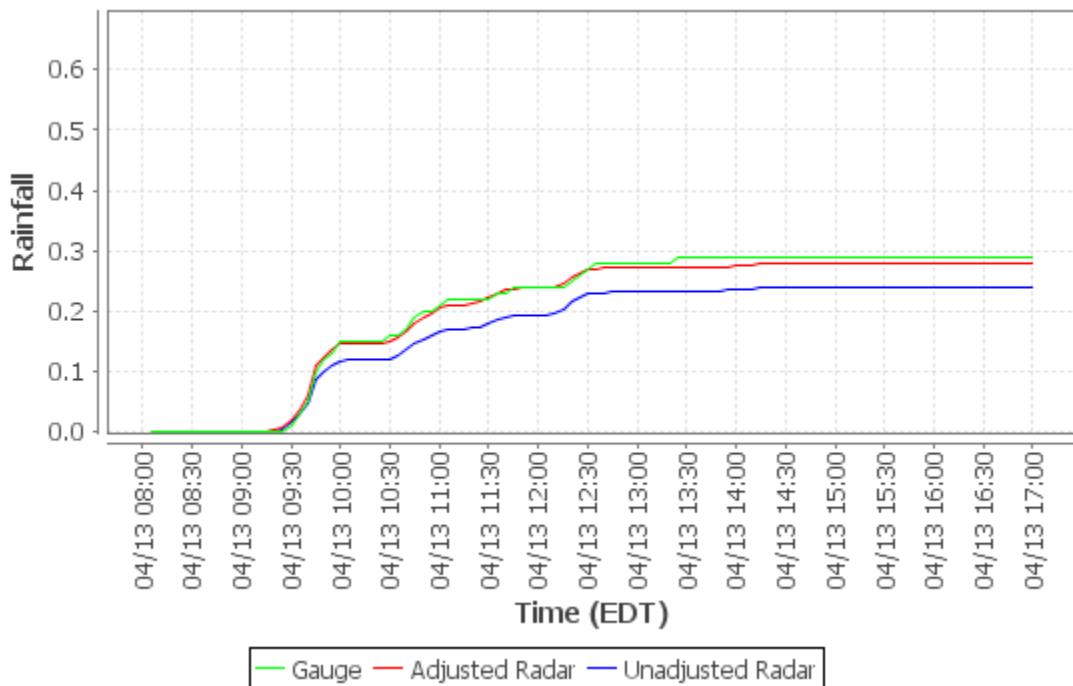
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



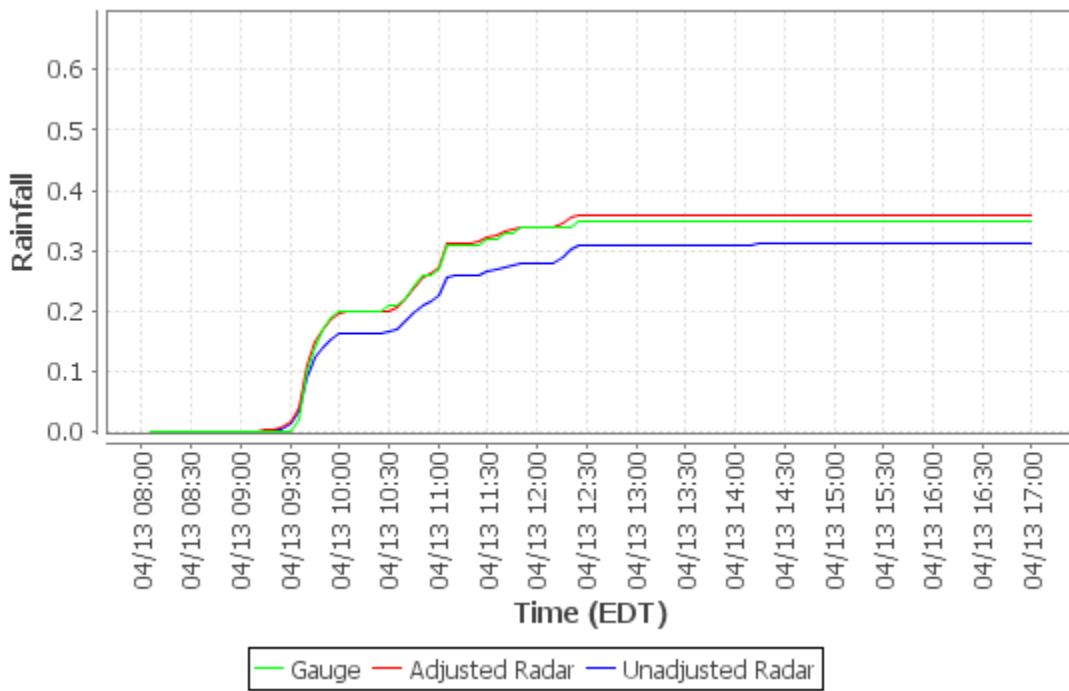
Cumulative Distribution Plot - Upper St. Clair (Loc05)



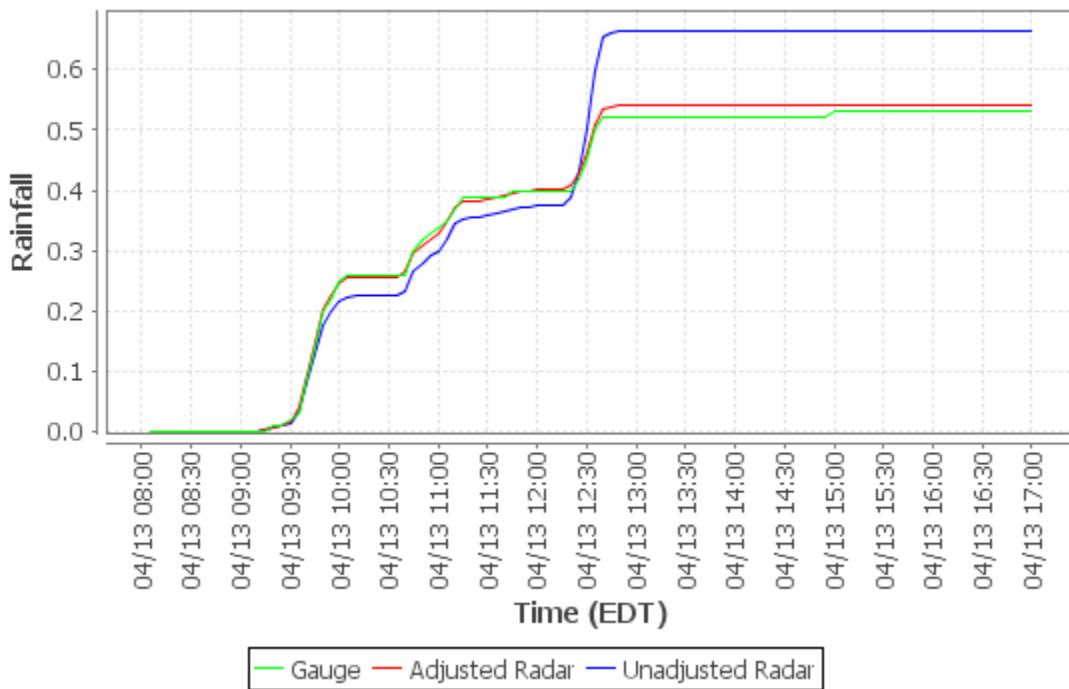
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



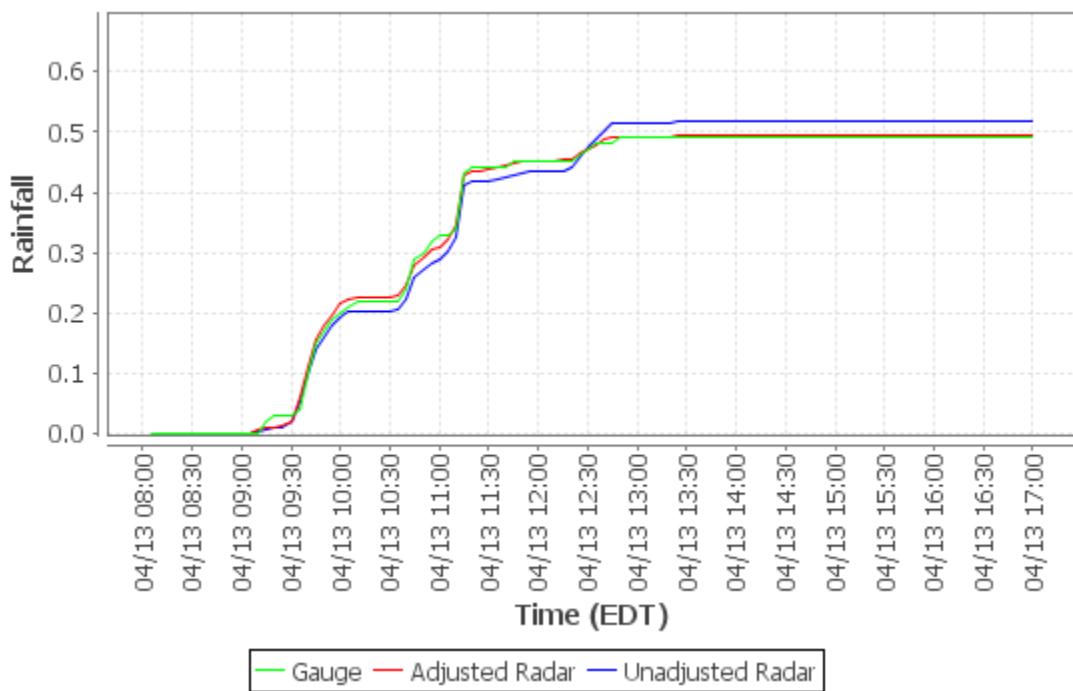
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



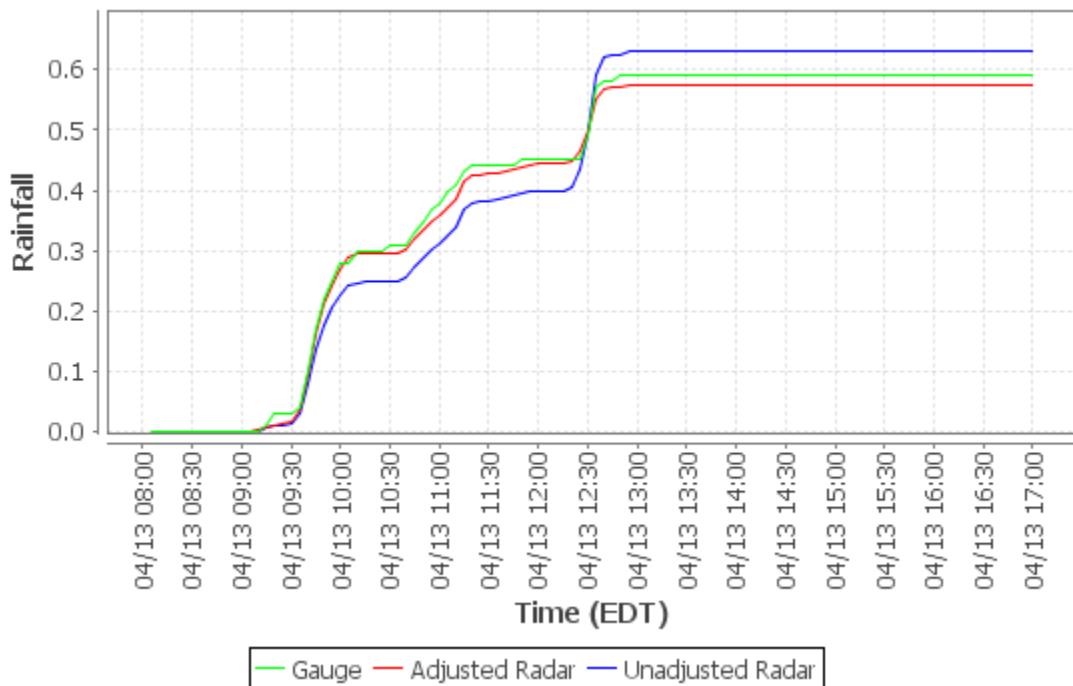
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



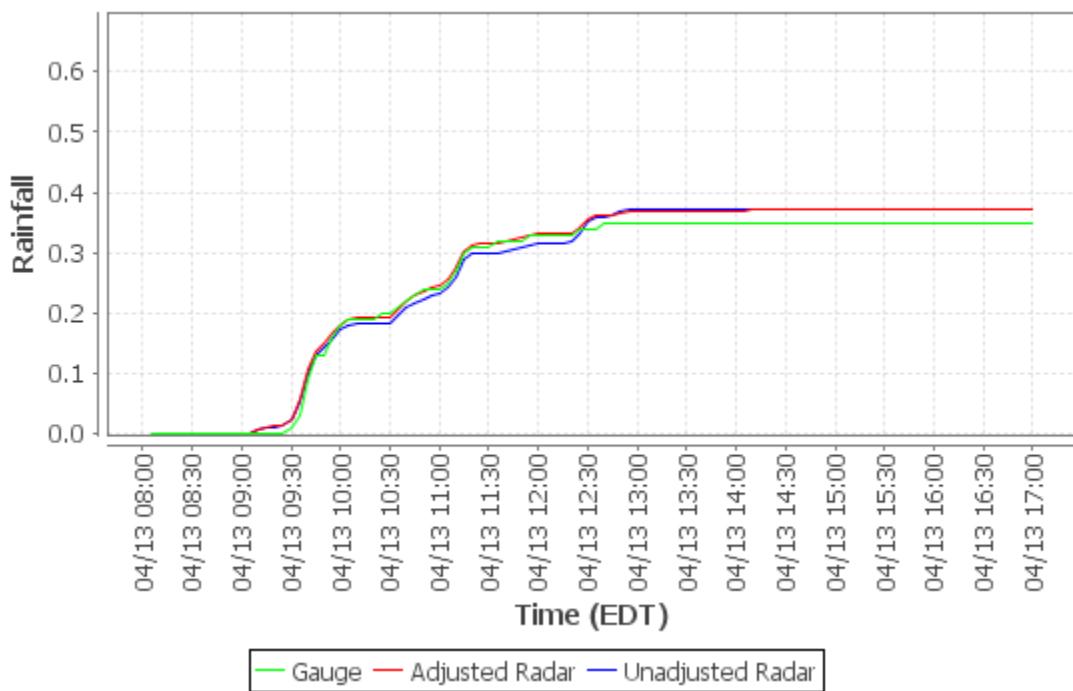
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



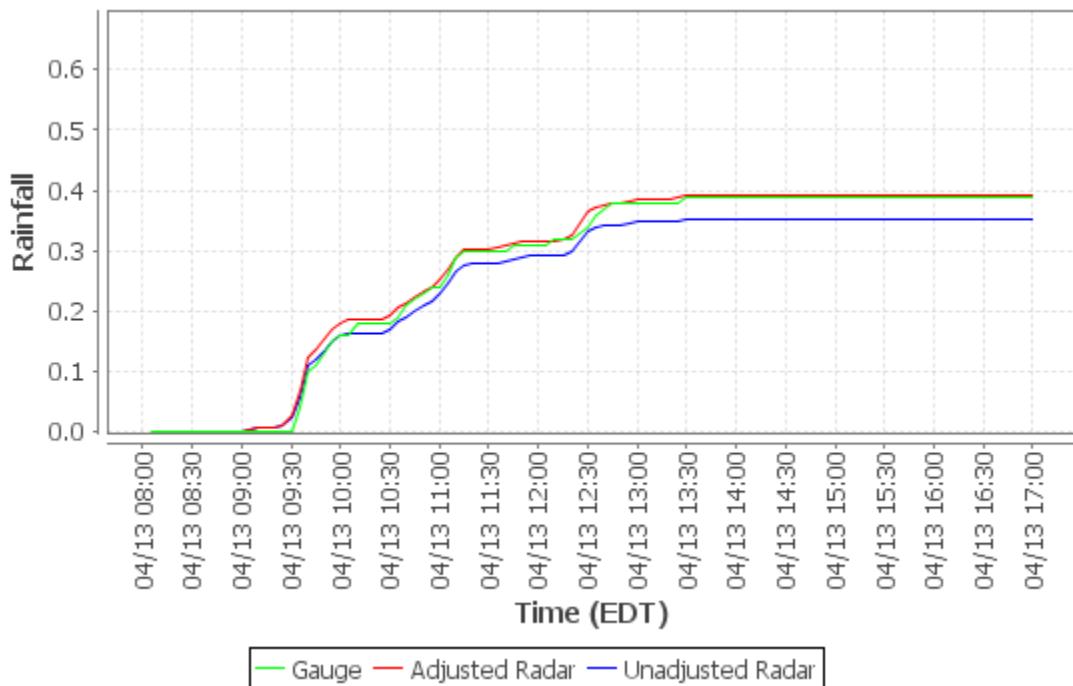
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



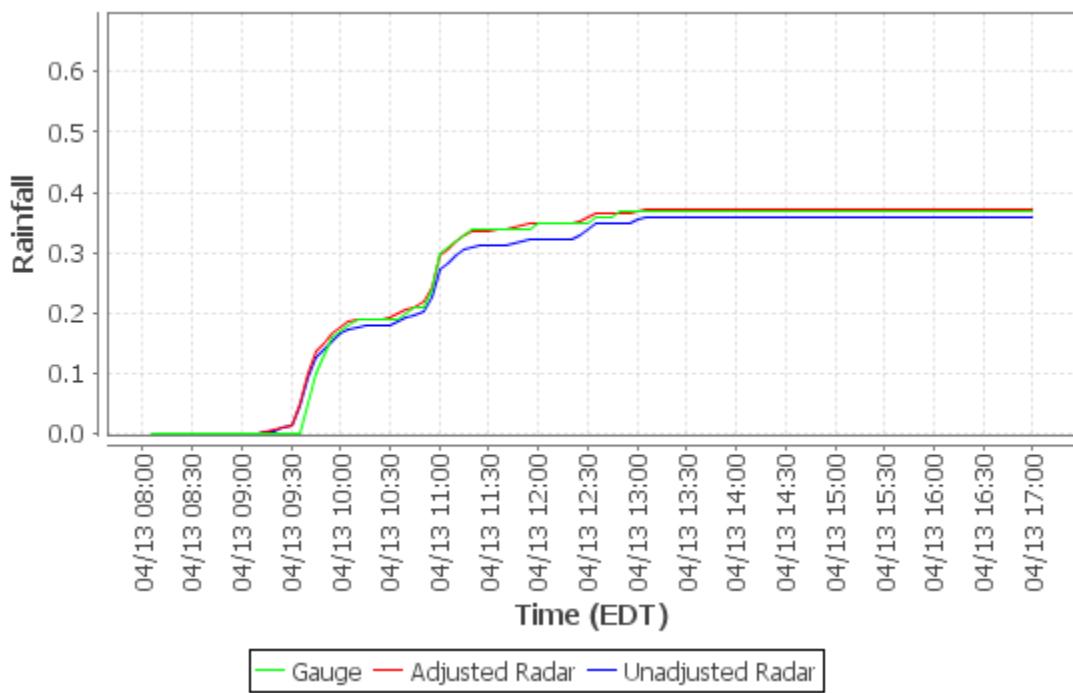
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



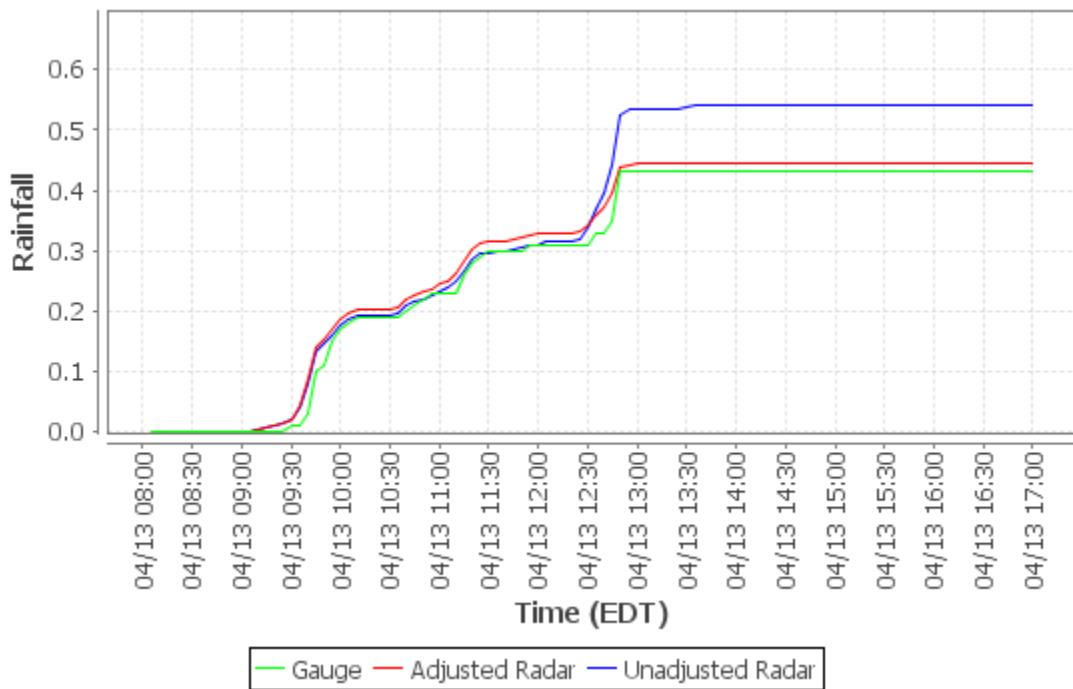
Cumulative Distribution Plot - Baldwin (Loc12)



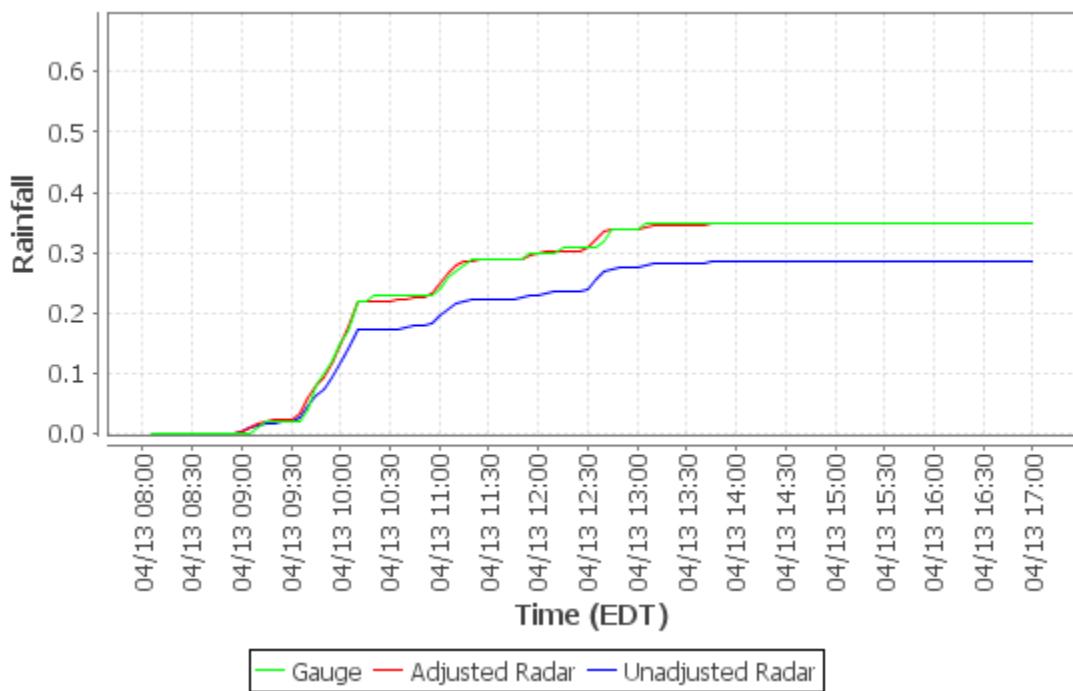
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



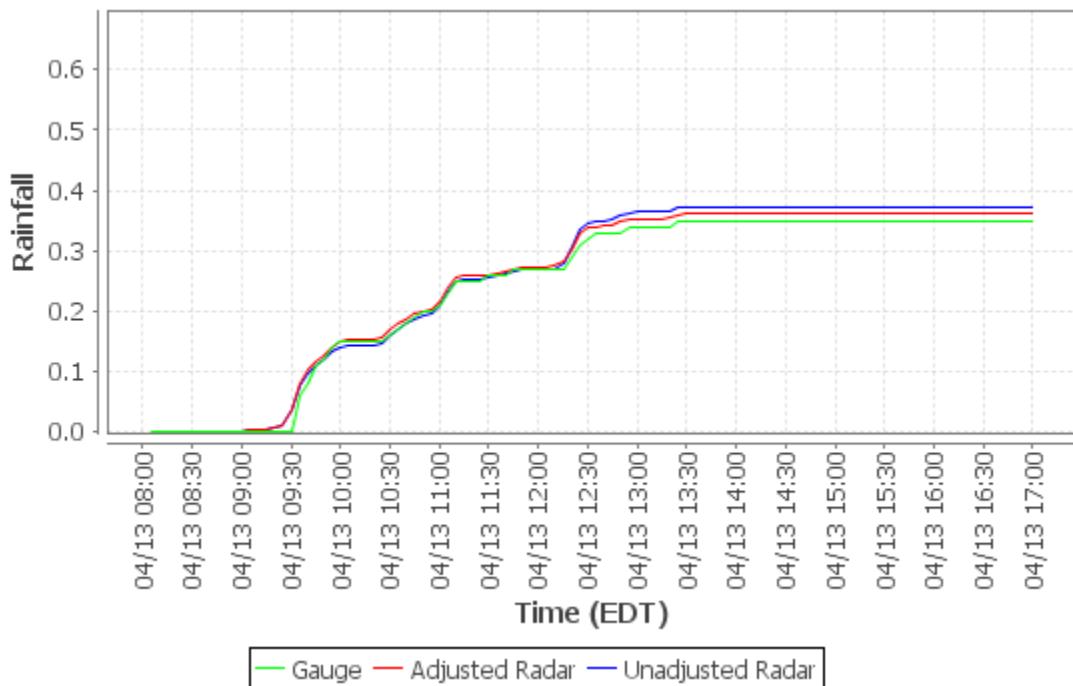
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



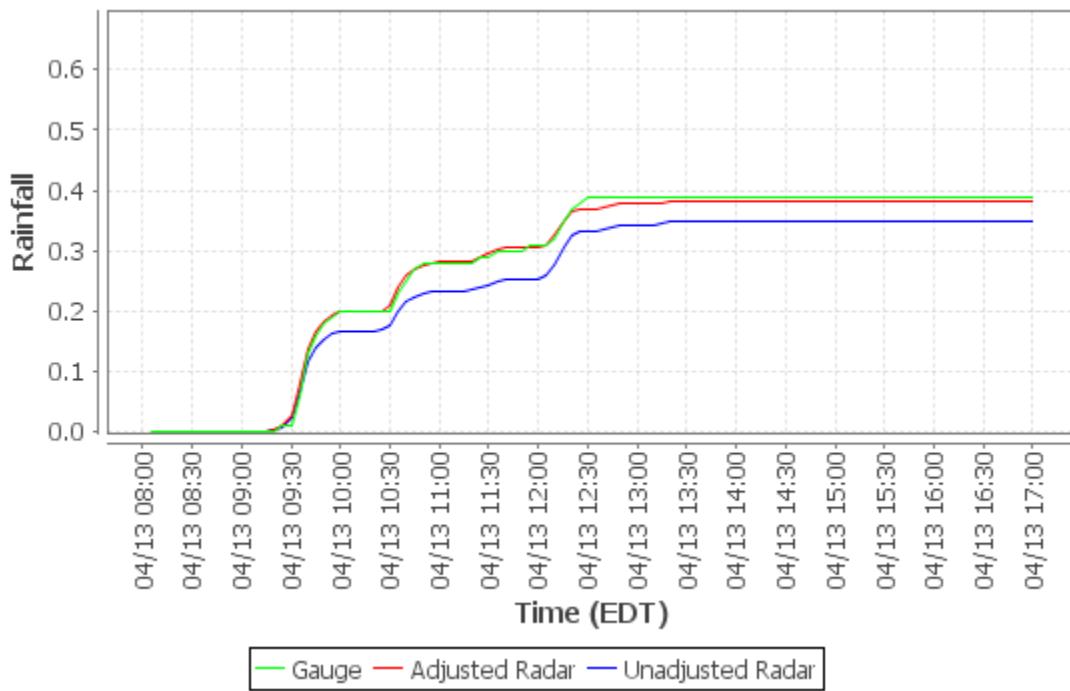
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



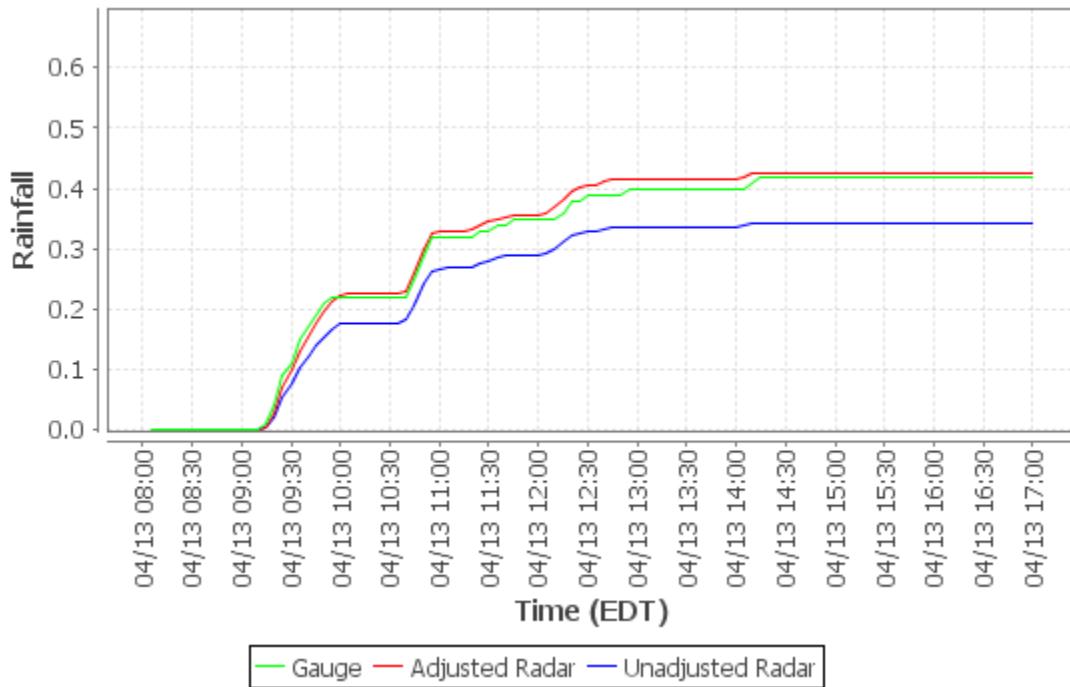
Cumulative Distribution Plot - Castle Shannon (Loc16)



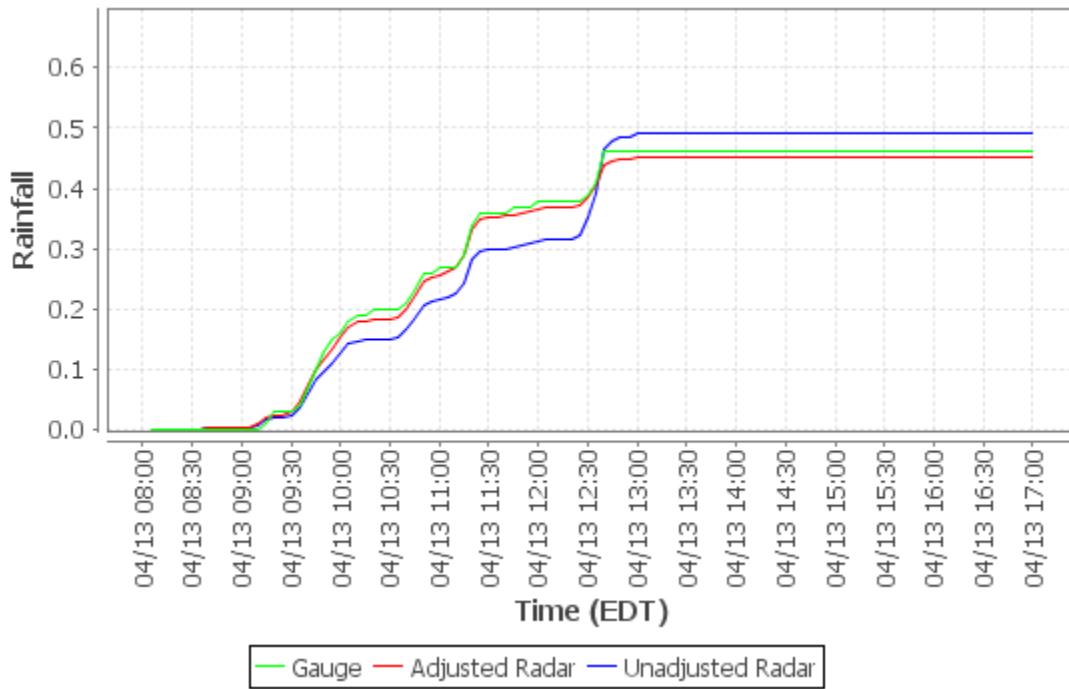
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



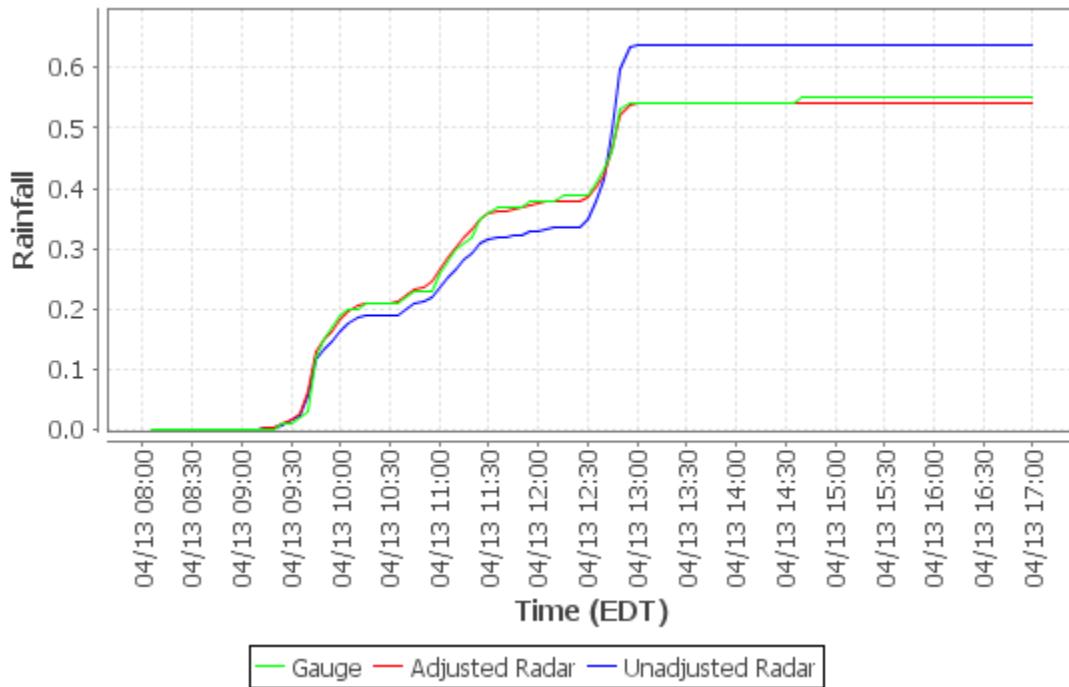
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



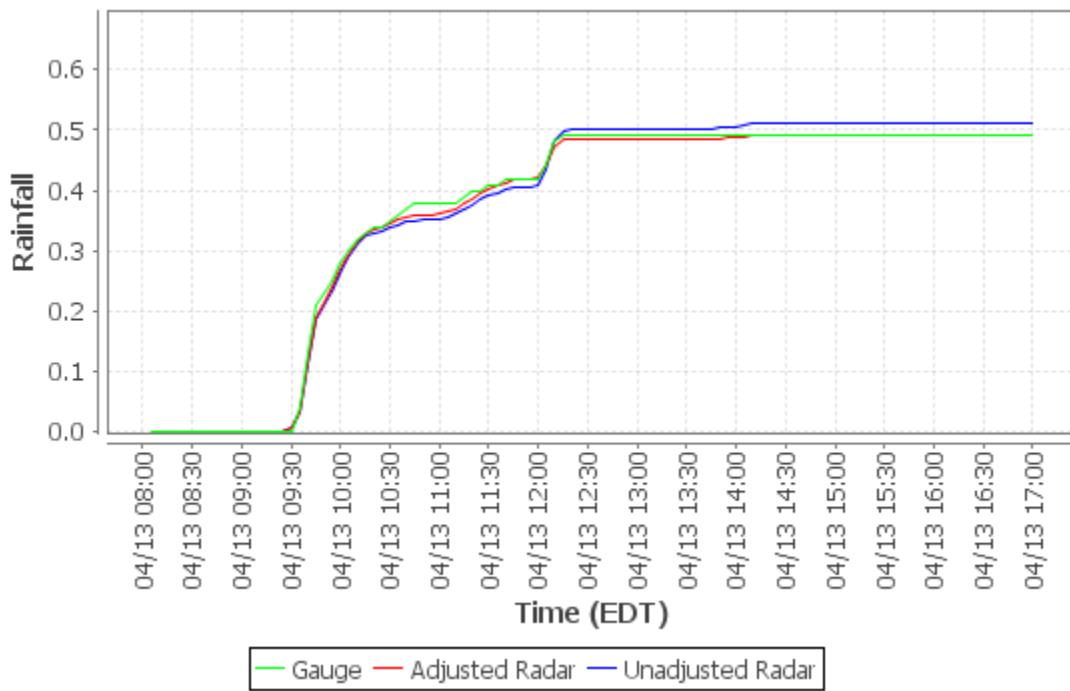
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



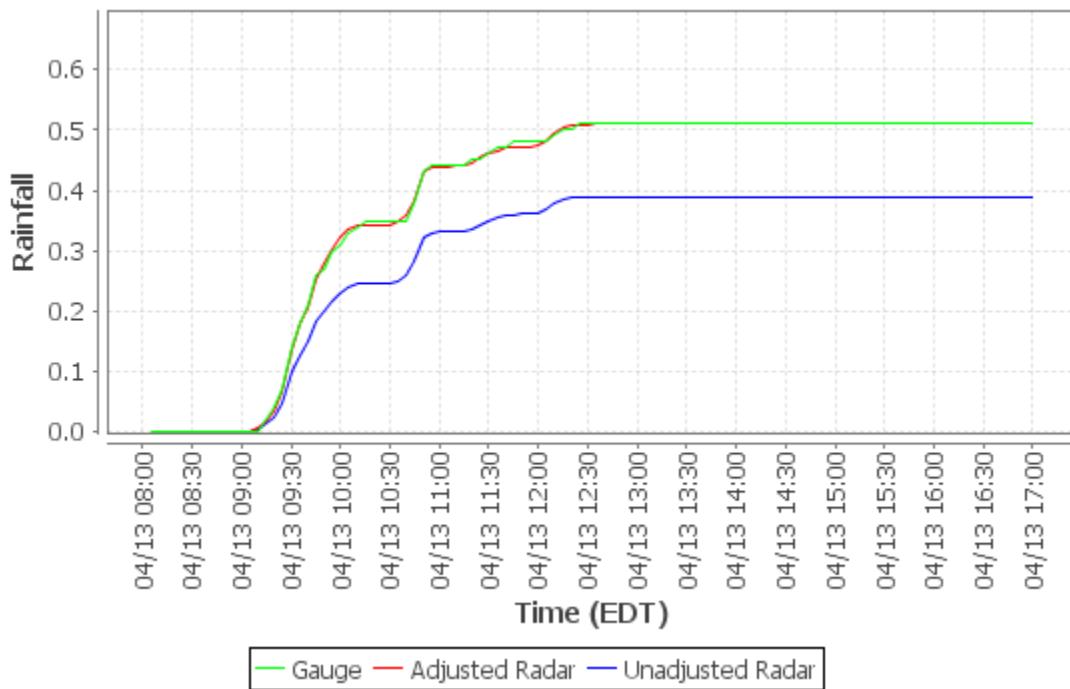
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



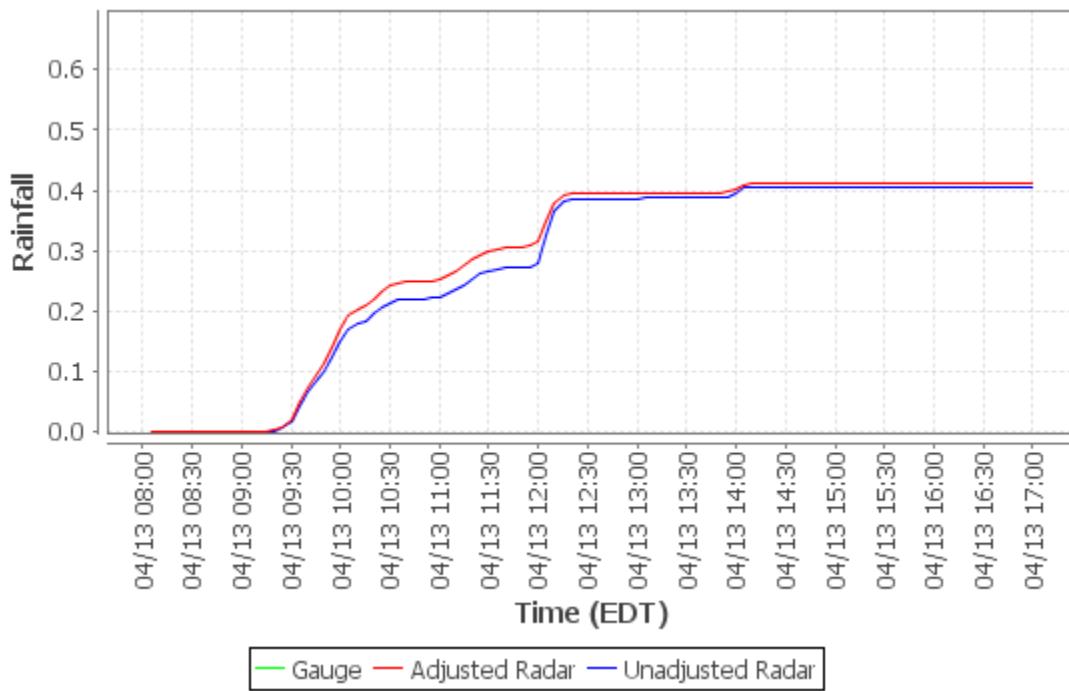
Cumulative Distribution Plot - Moon TWP (Loc21)



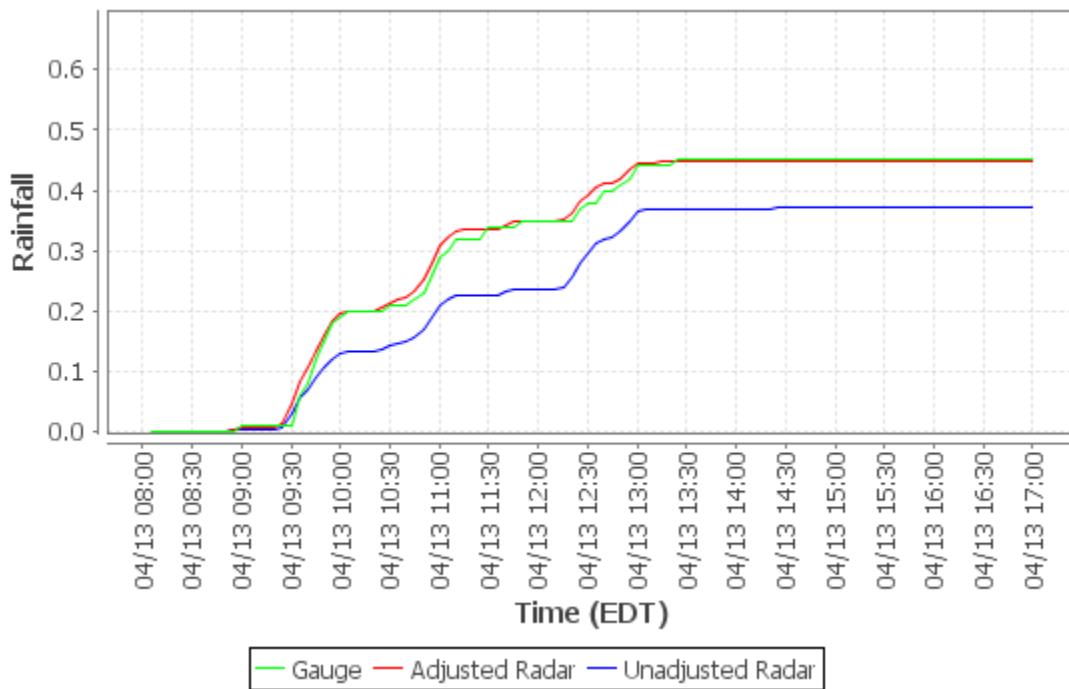
Cumulative Distribution Plot - North Fayette TWP (Loc22)



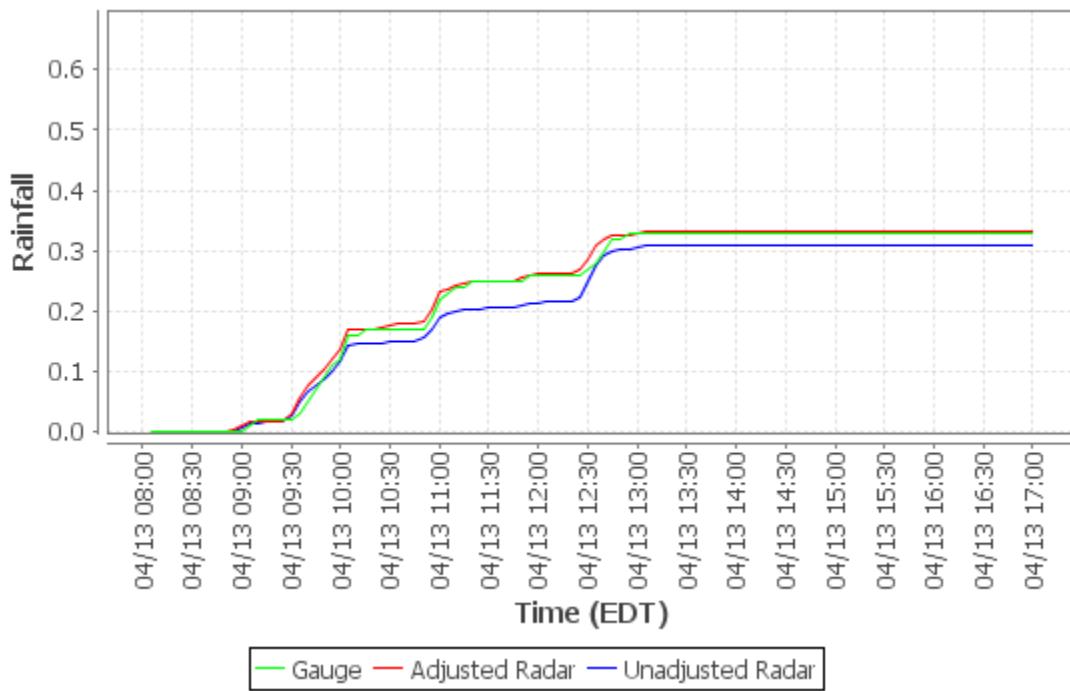
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



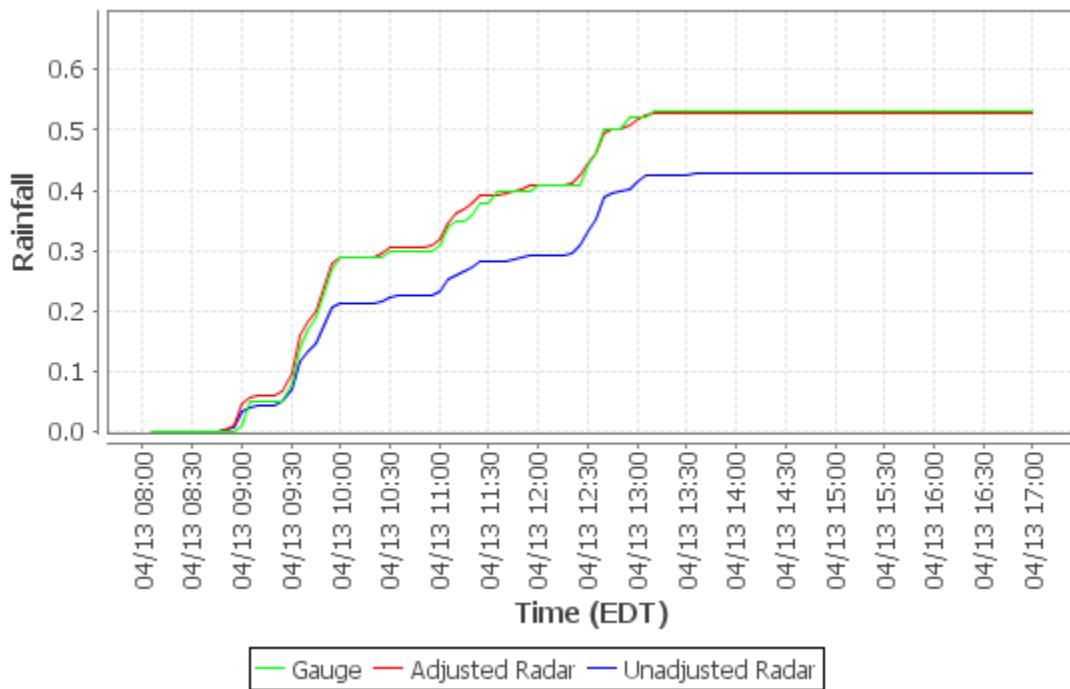
Cumulative Distribution Plot - Jefferson Hills (Loc24)



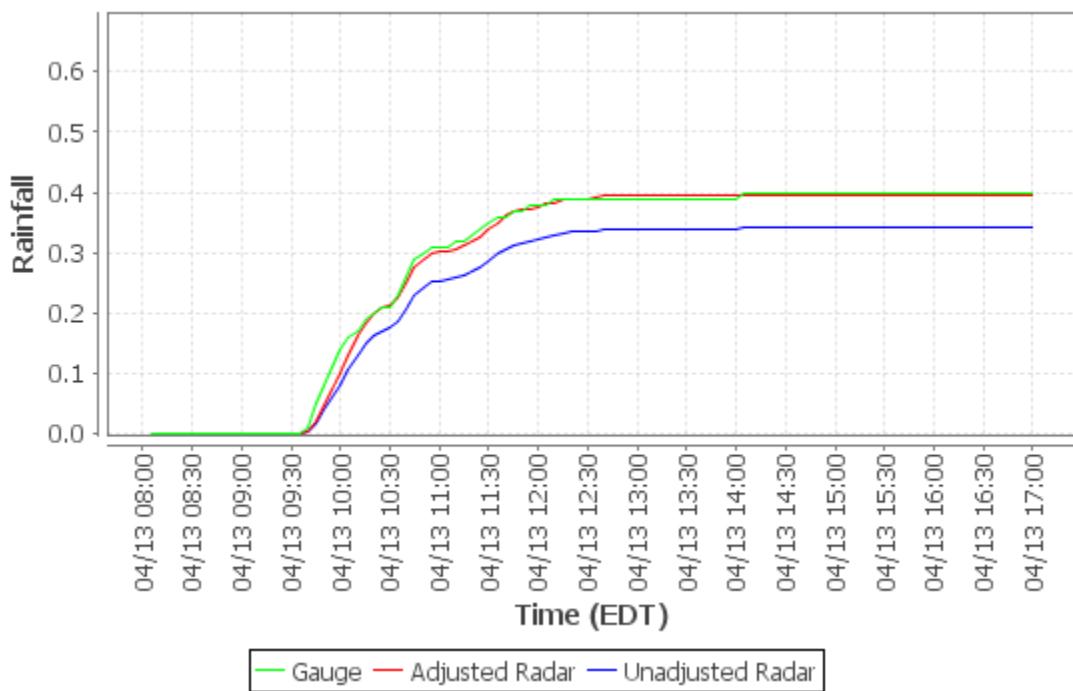
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



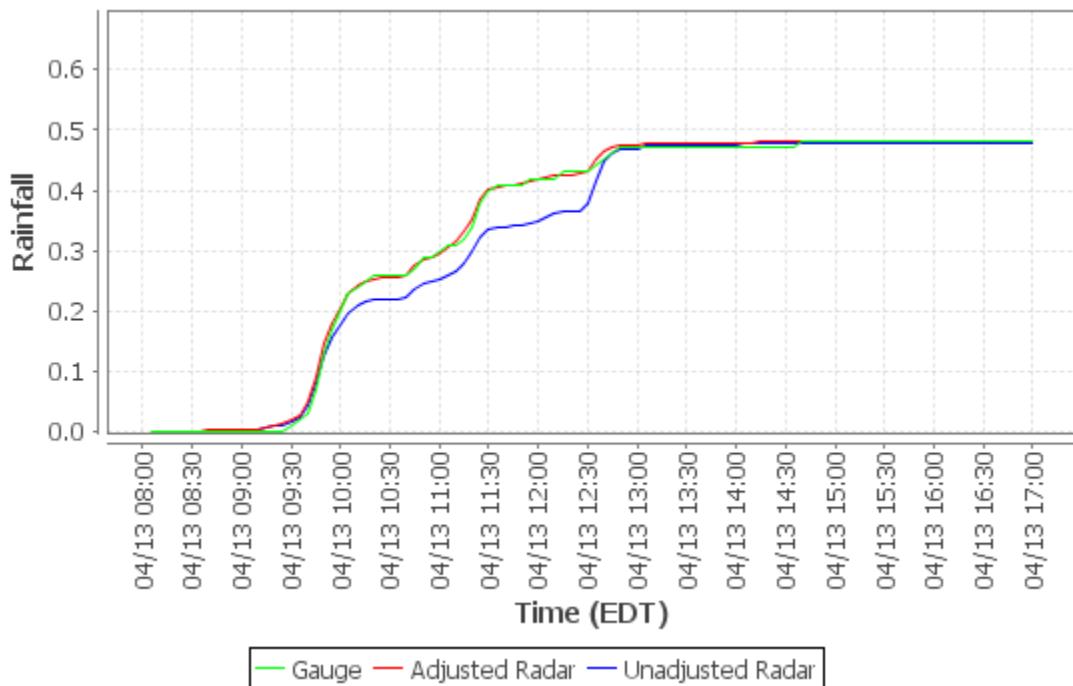
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



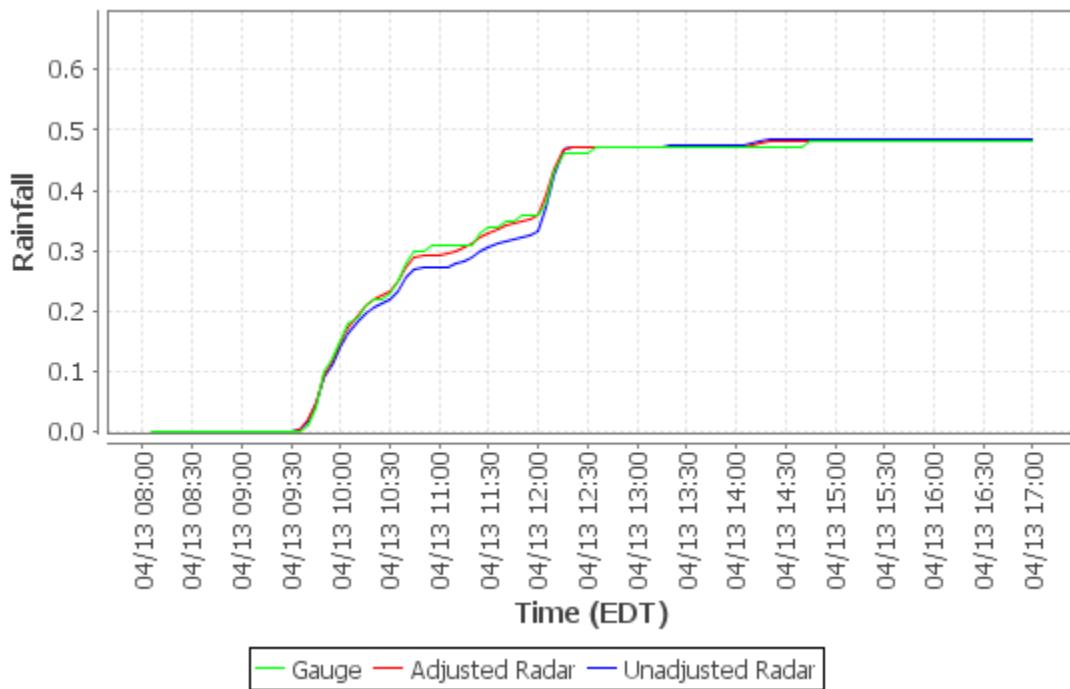
Cumulative Distribution Plot - Marshall TWP (Loc27)



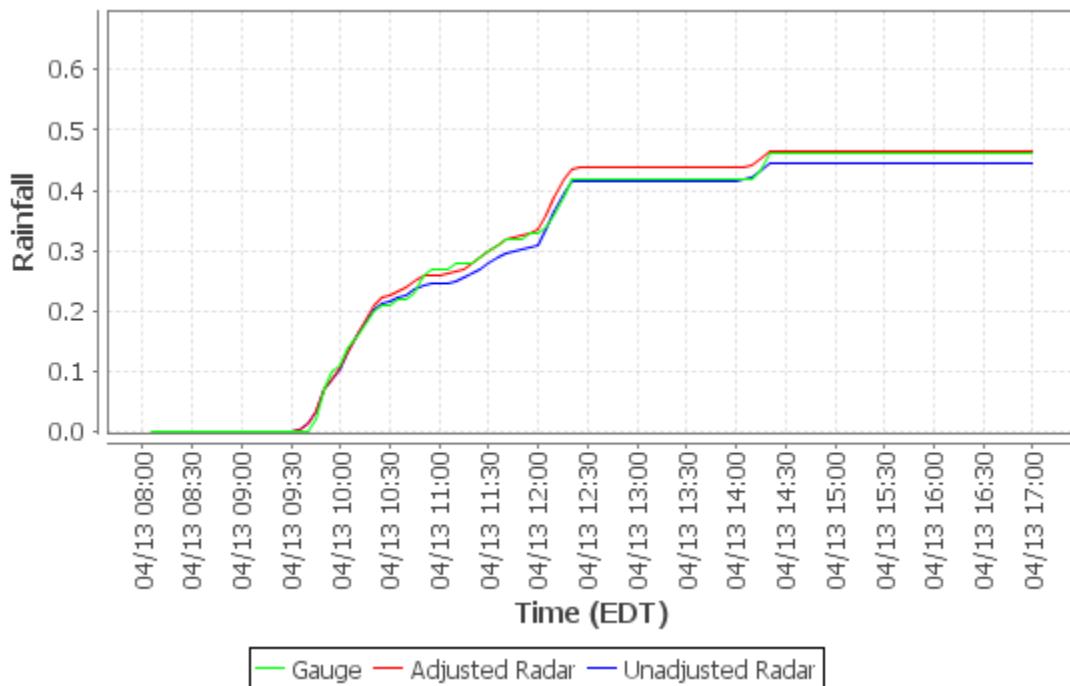
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



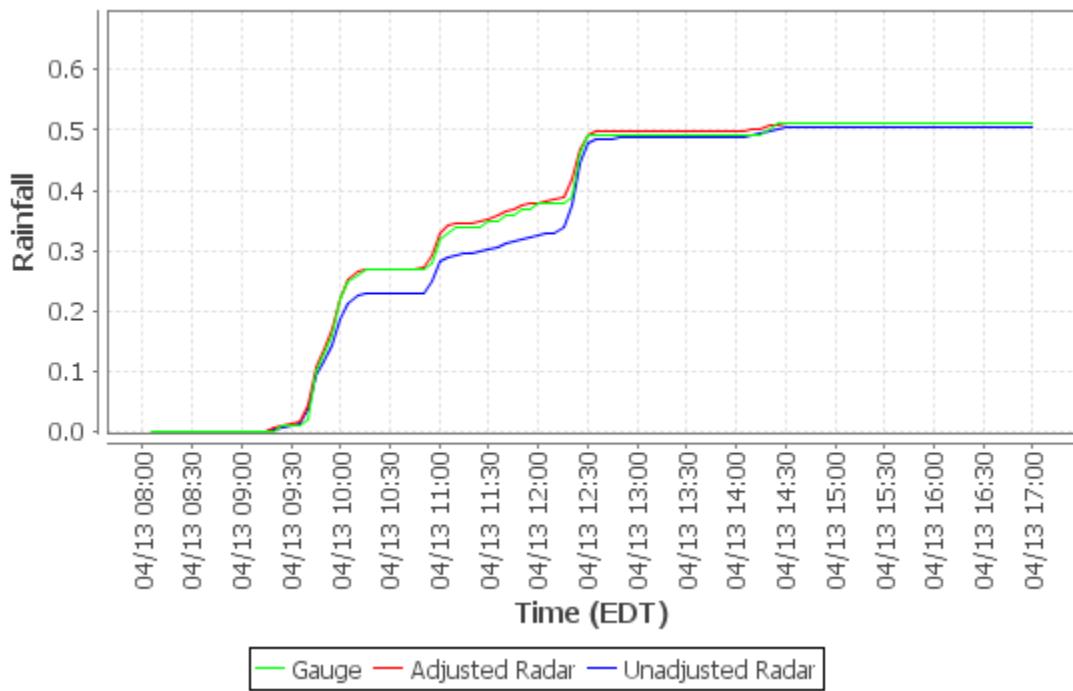
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



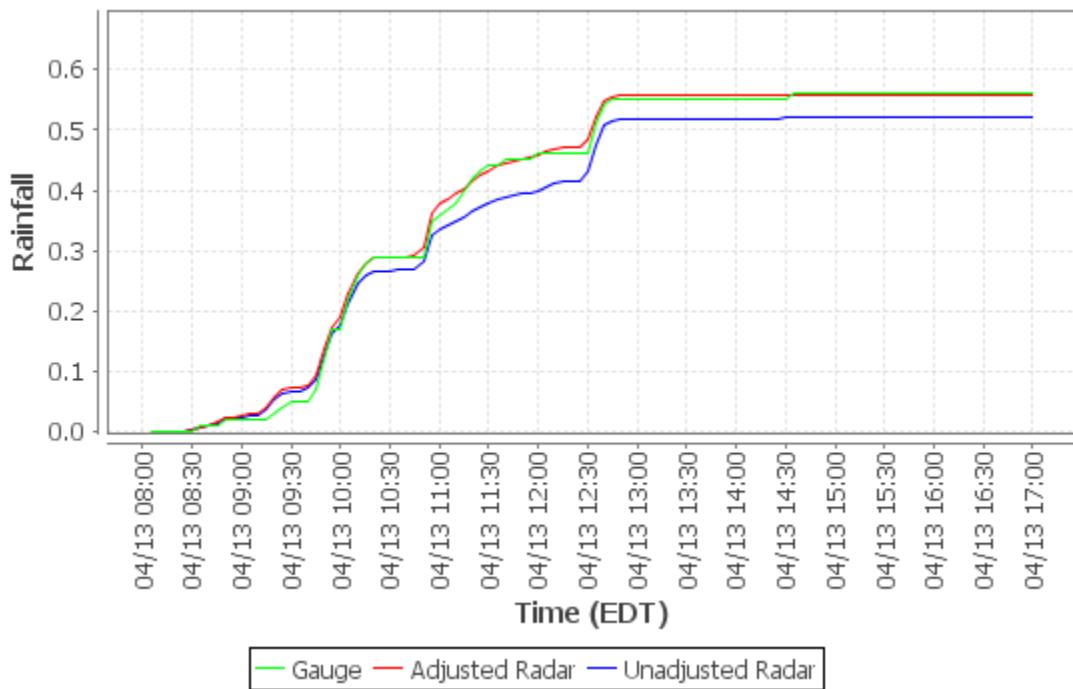
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



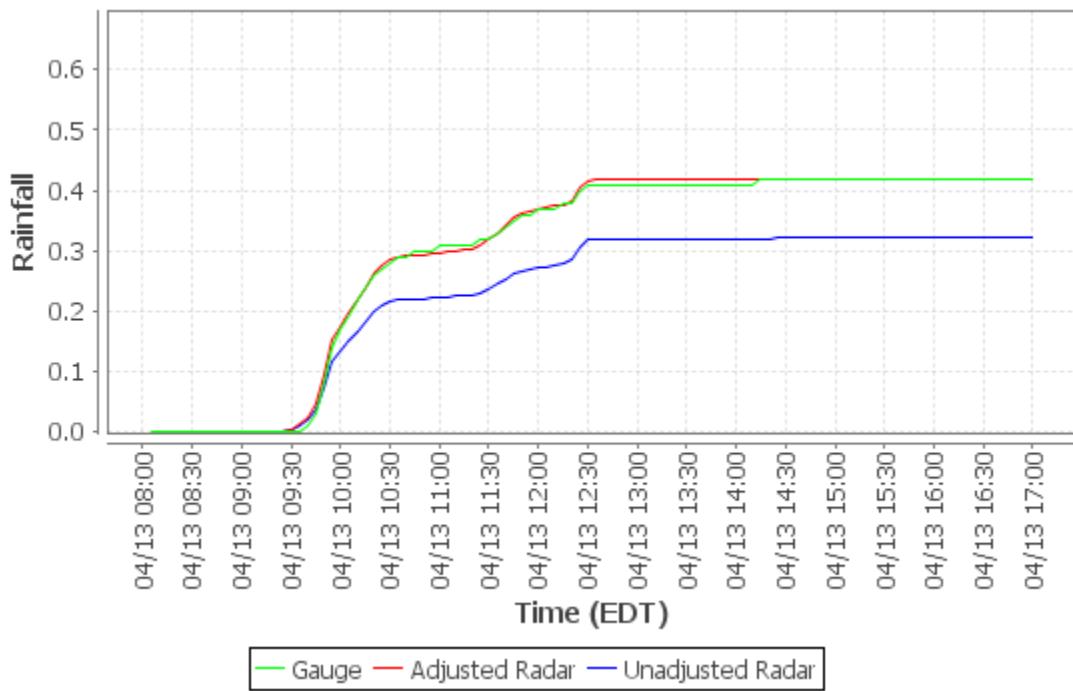
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



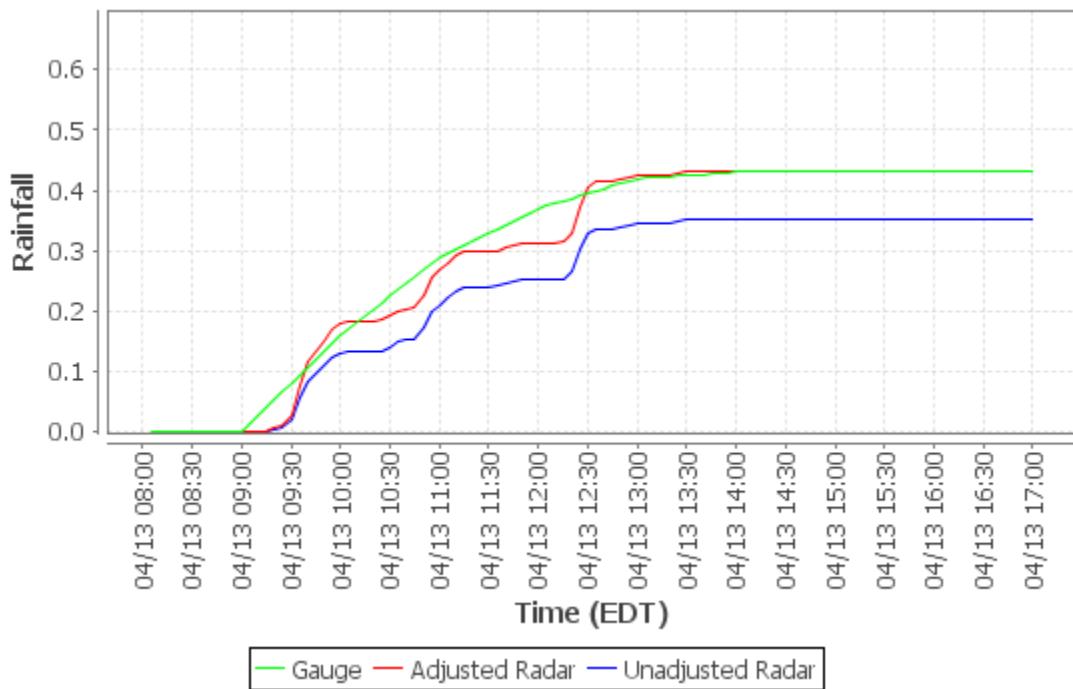
Cumulative Distribution Plot - Arnold (Loc32)



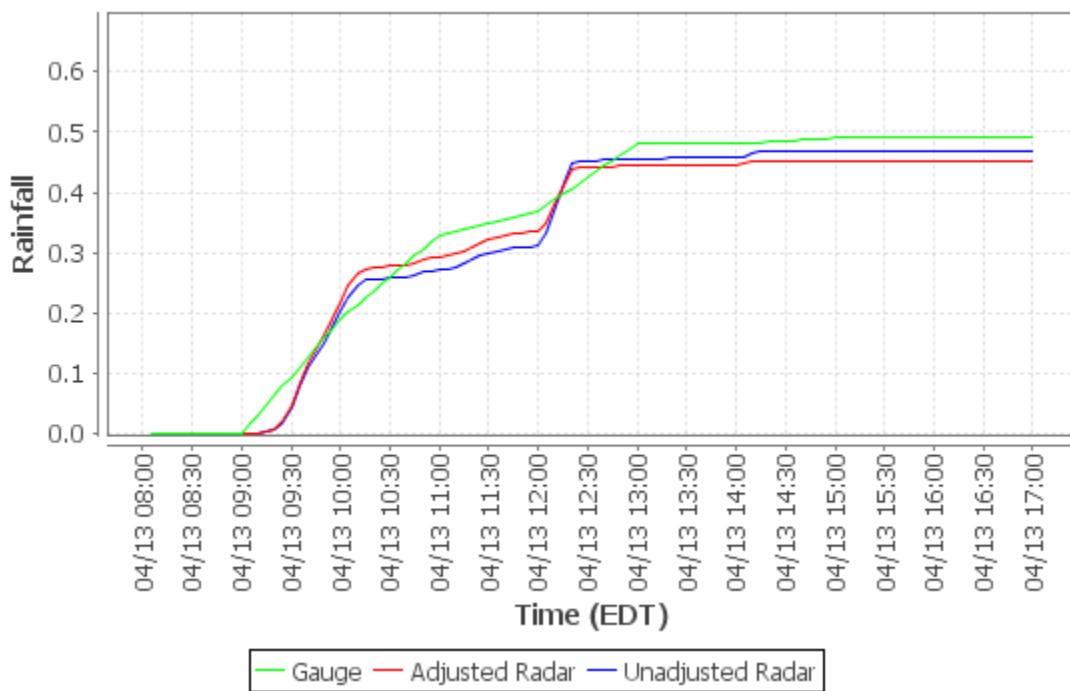
Cumulative Distribution Plot - Richland TWP (Loc33)



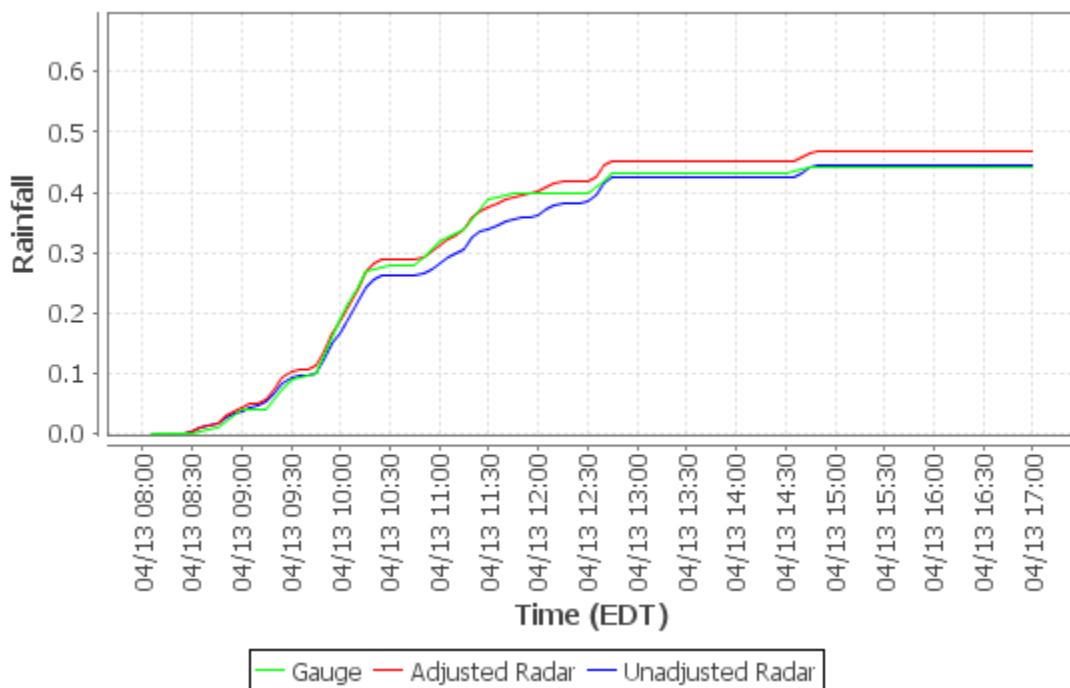
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



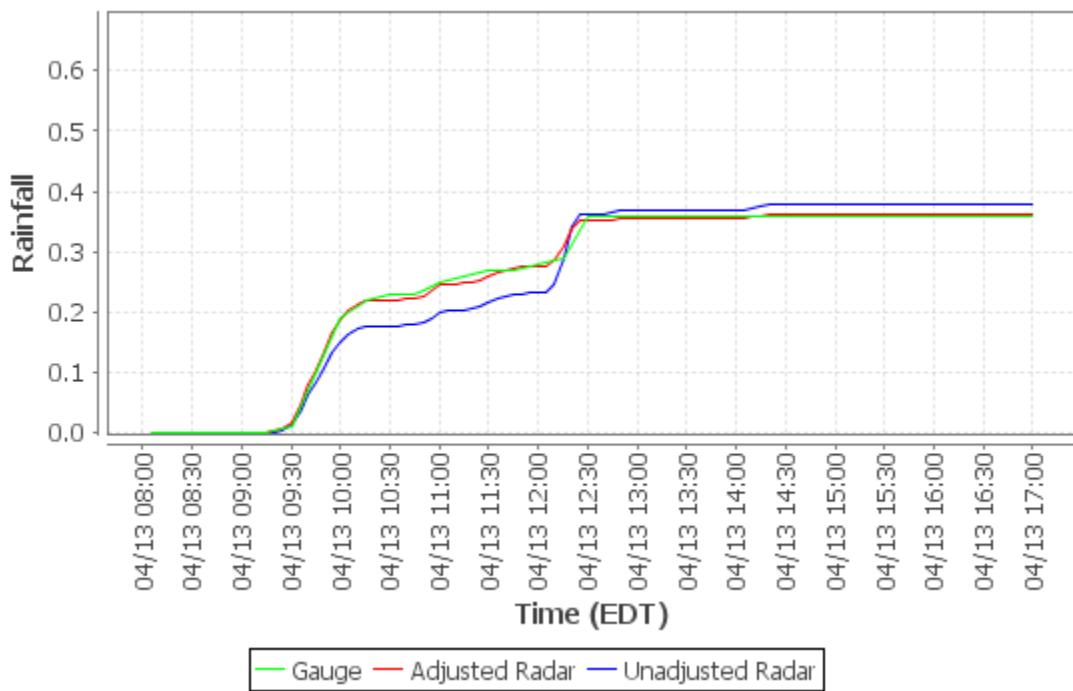
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

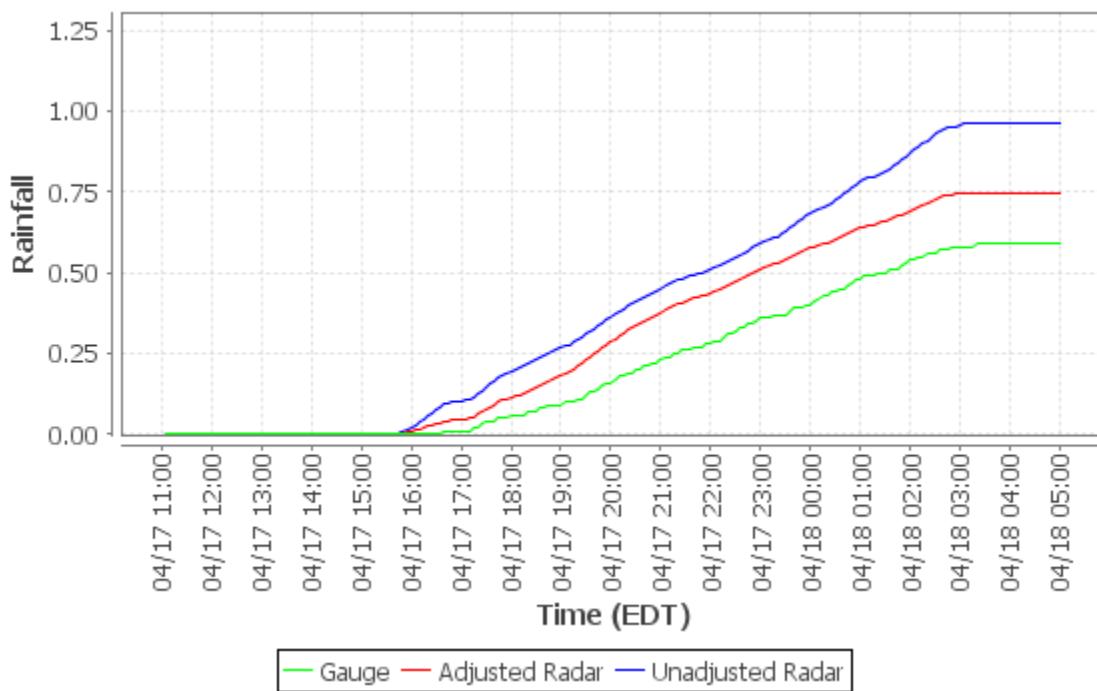


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

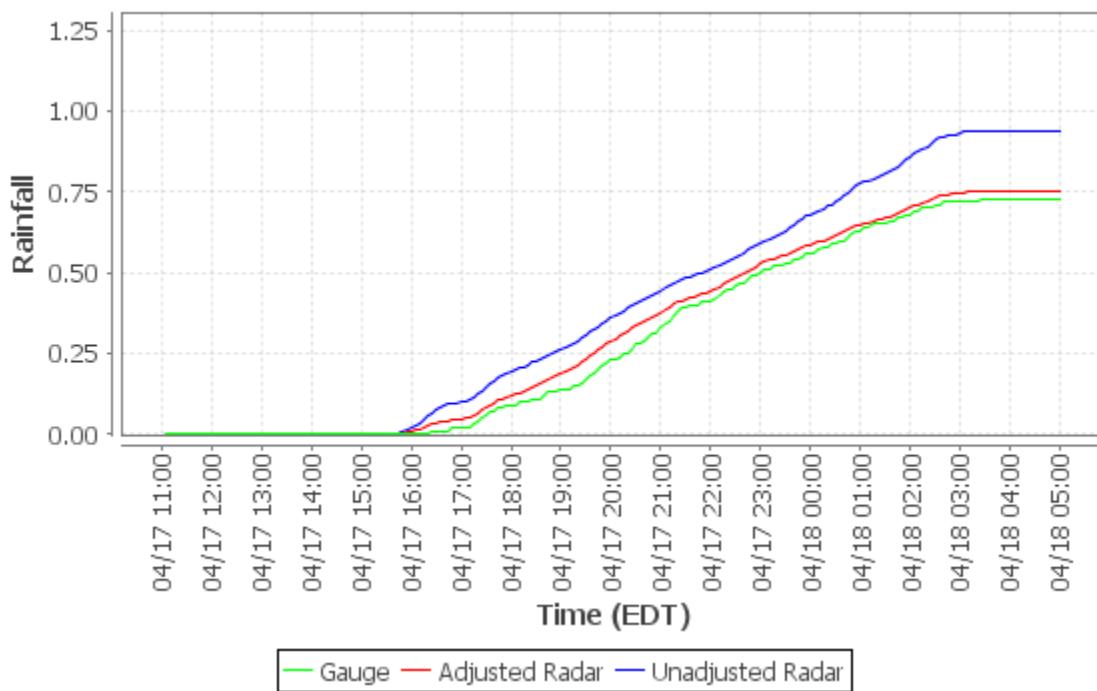


Appendix H - Event 6 (2020-04-17) CDPs

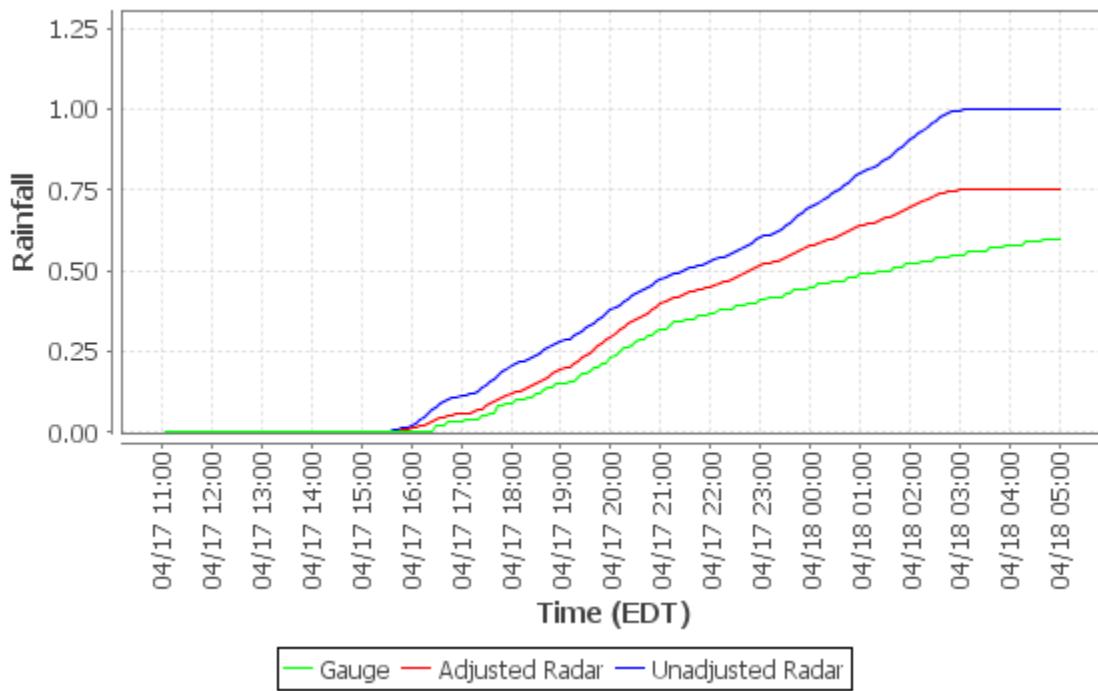
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



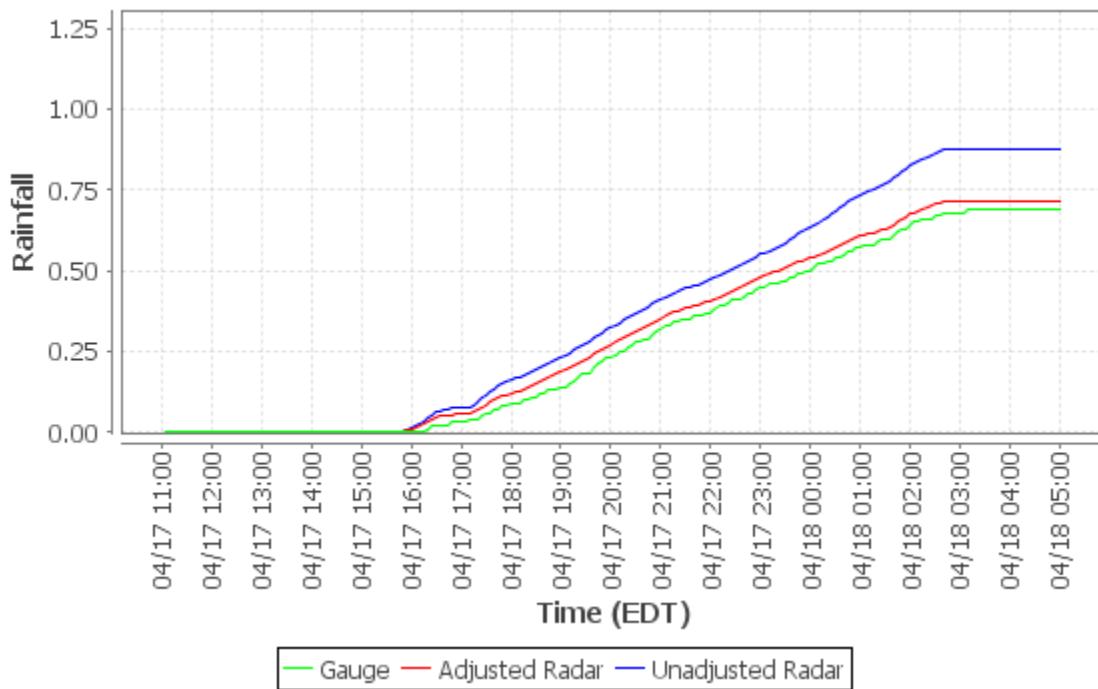
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



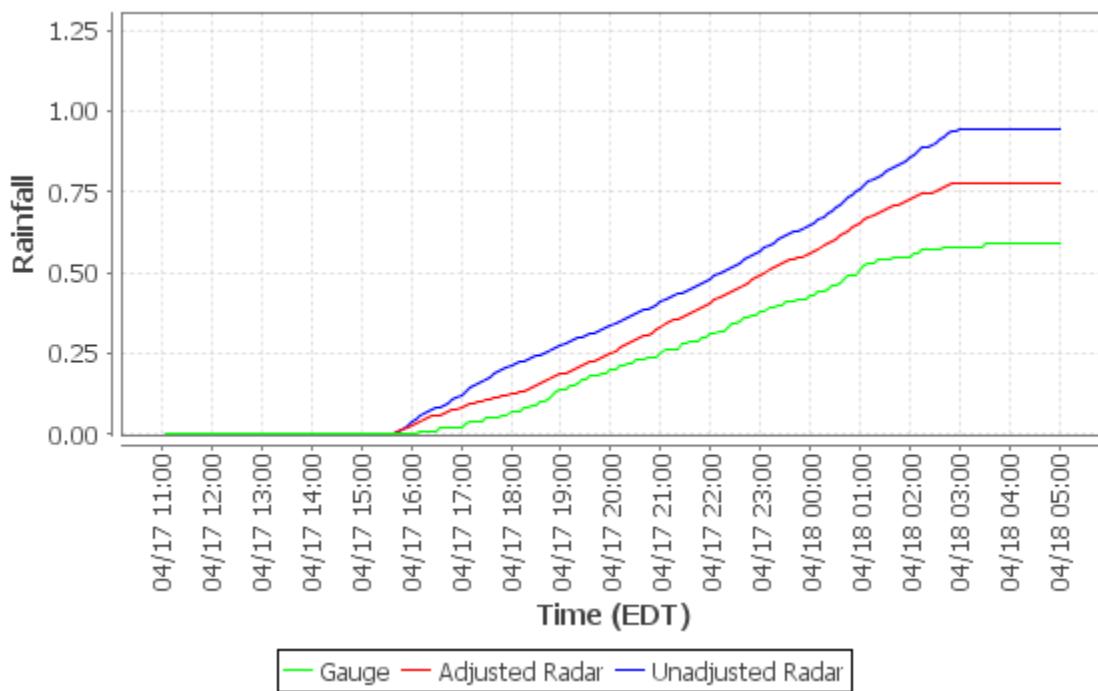
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



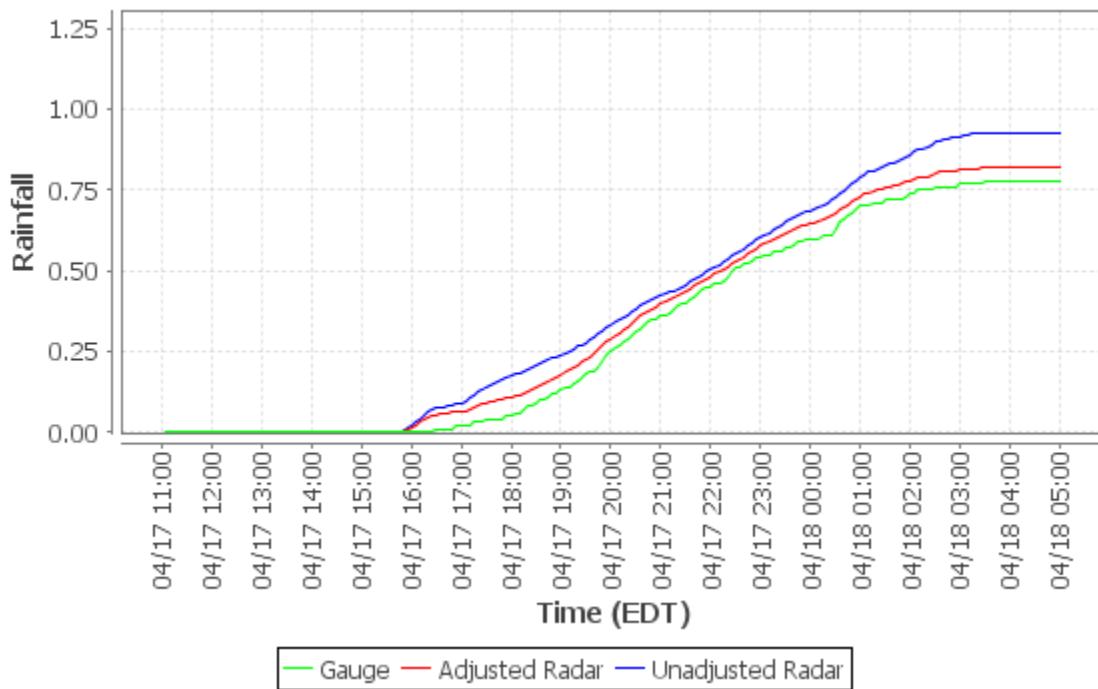
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



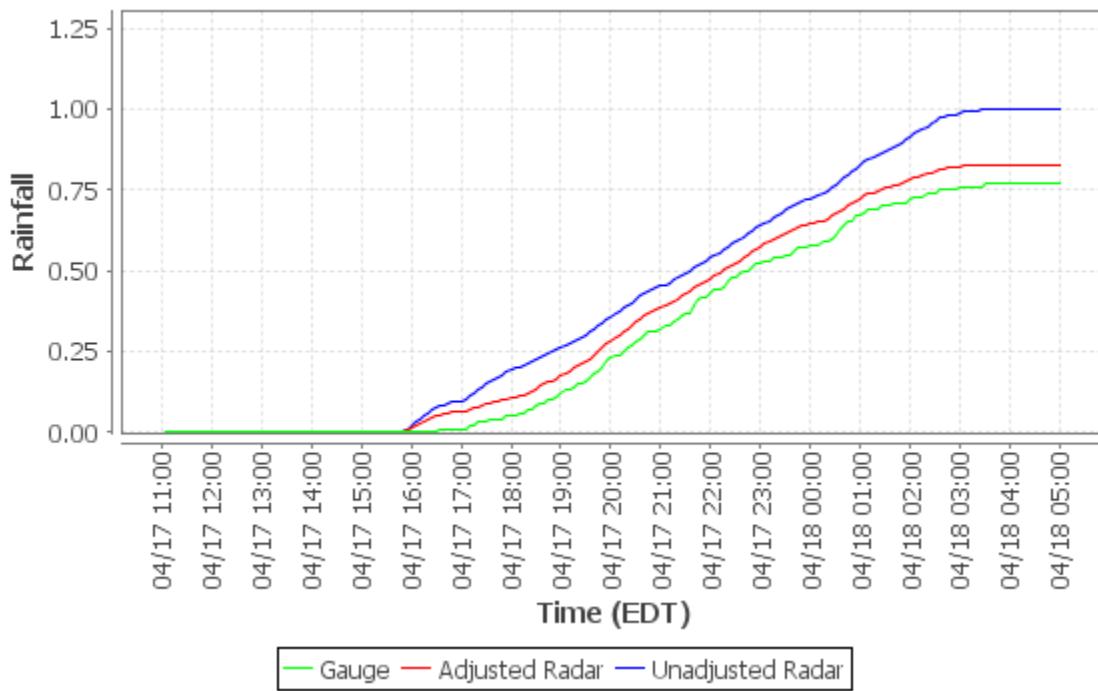
Cumulative Distribution Plot - Upper St. Clair (Loc05)



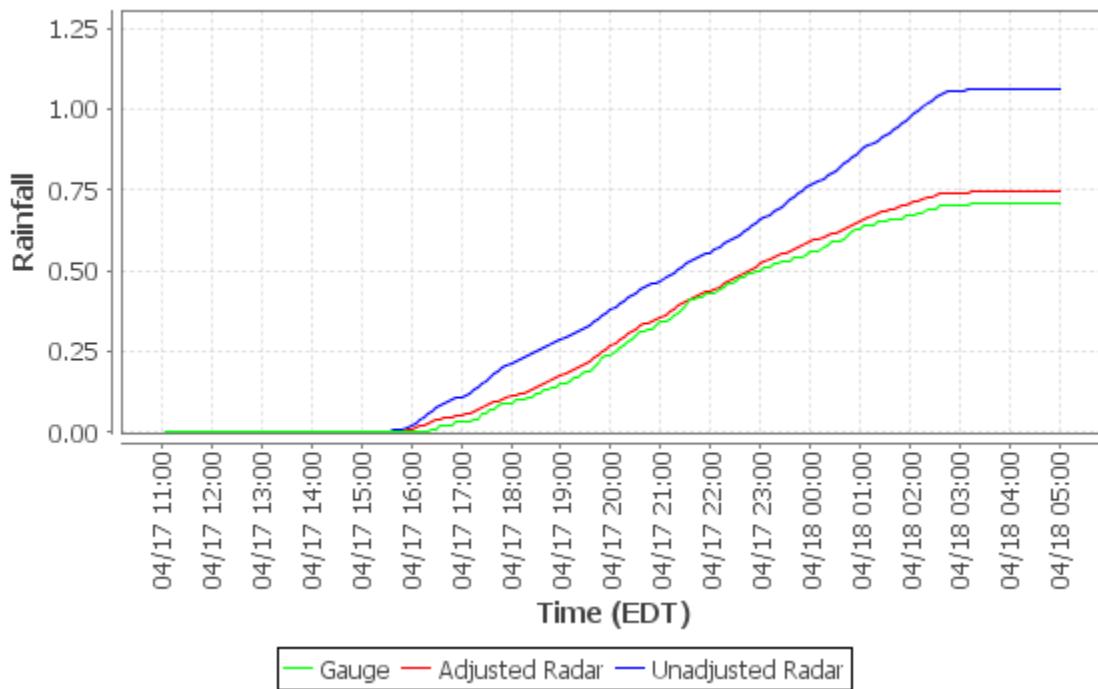
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



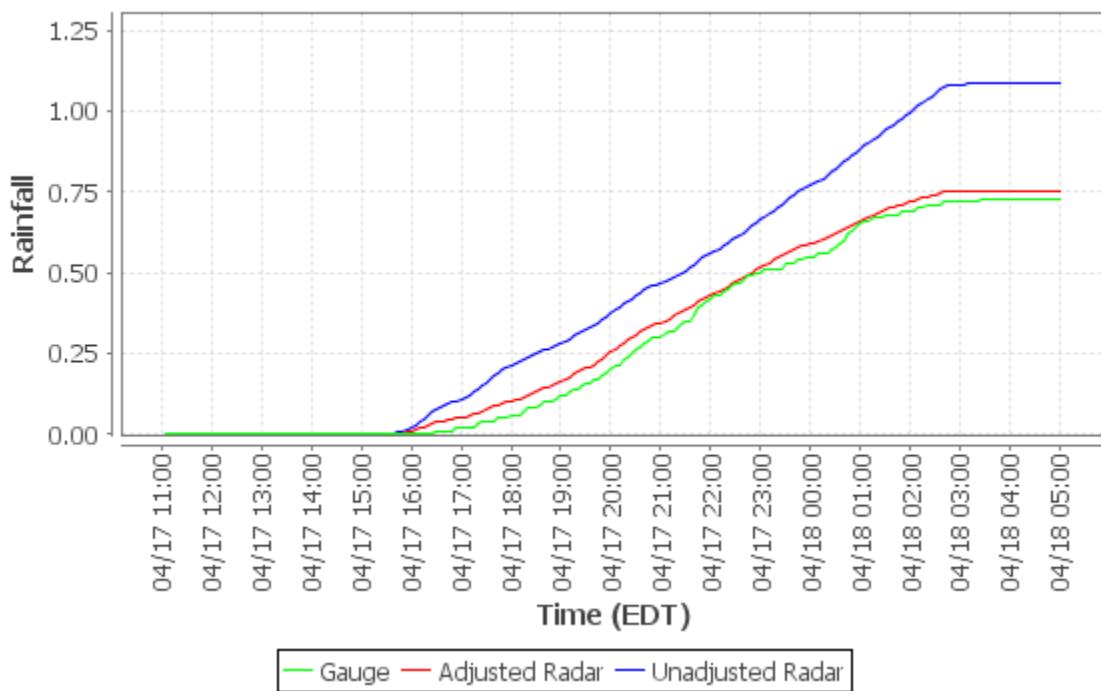
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



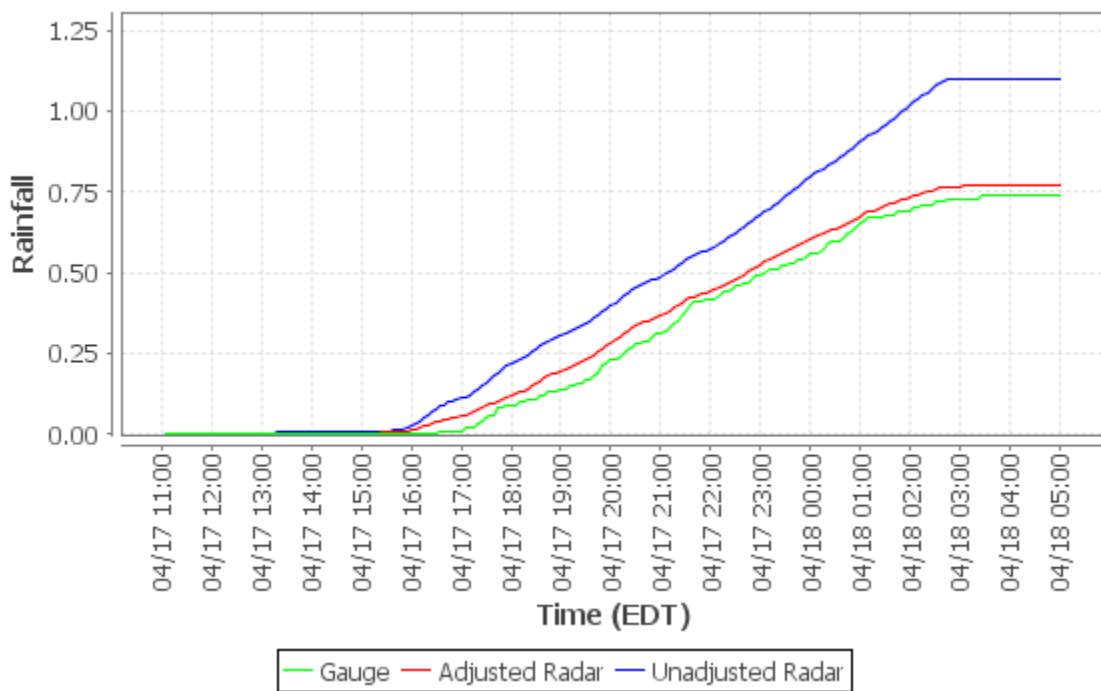
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



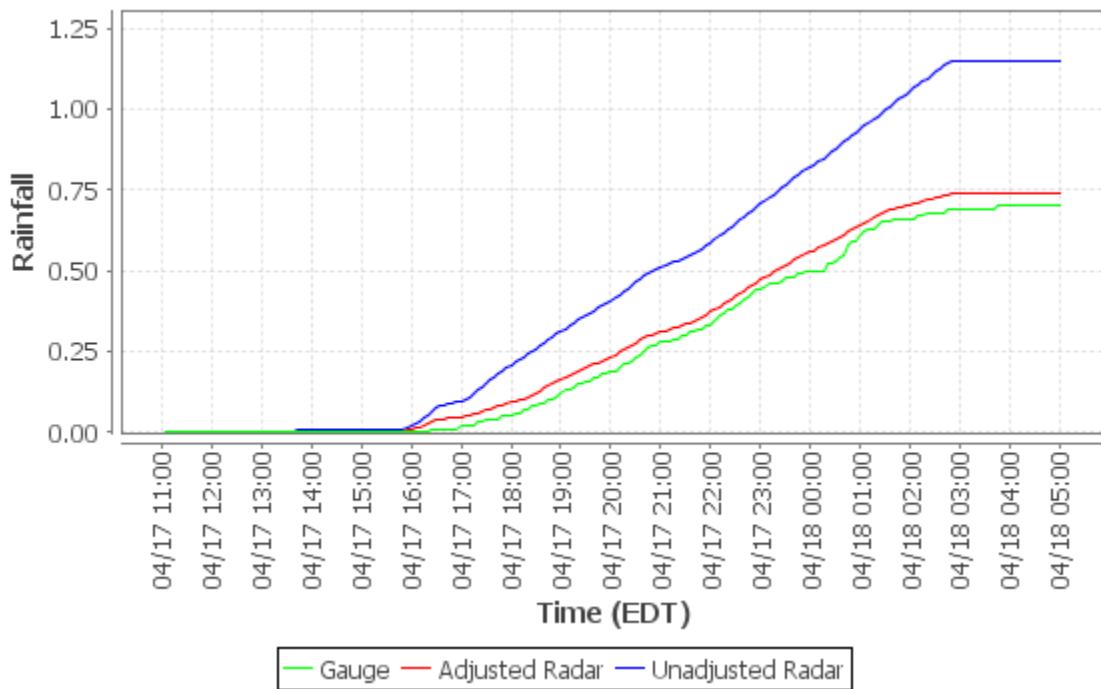
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



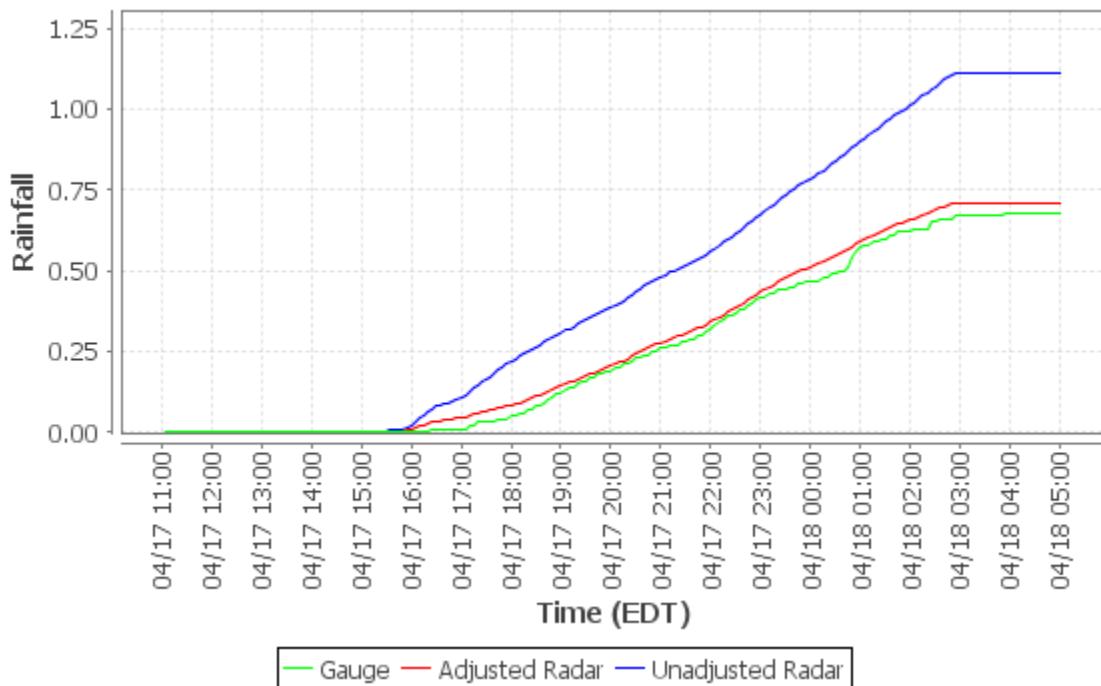
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



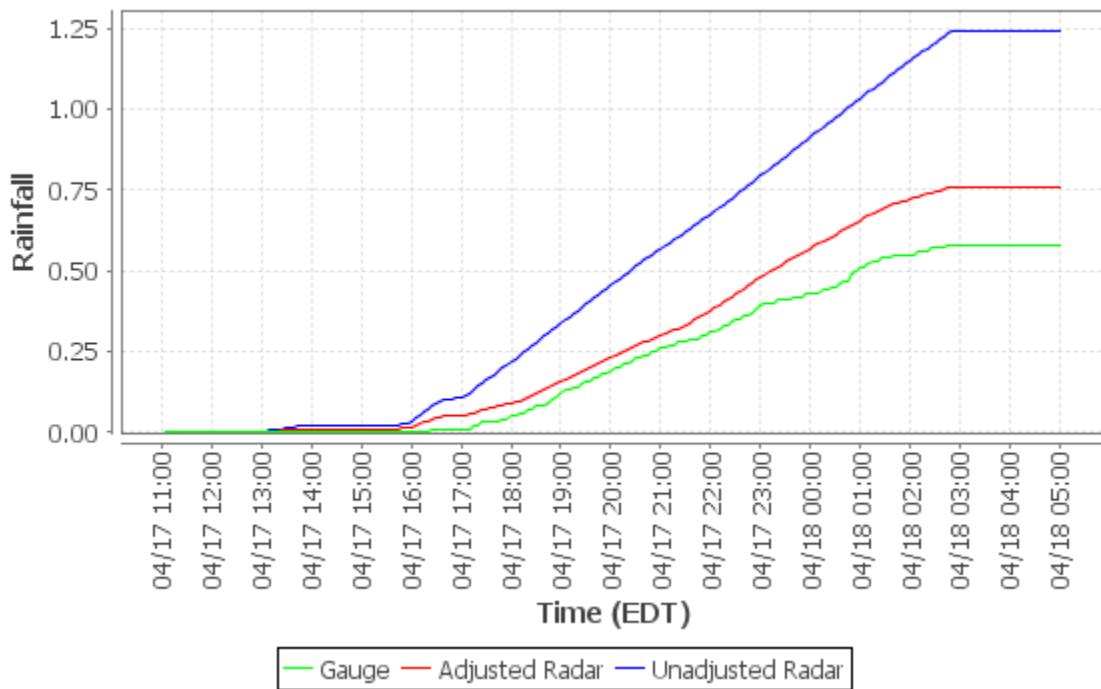
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



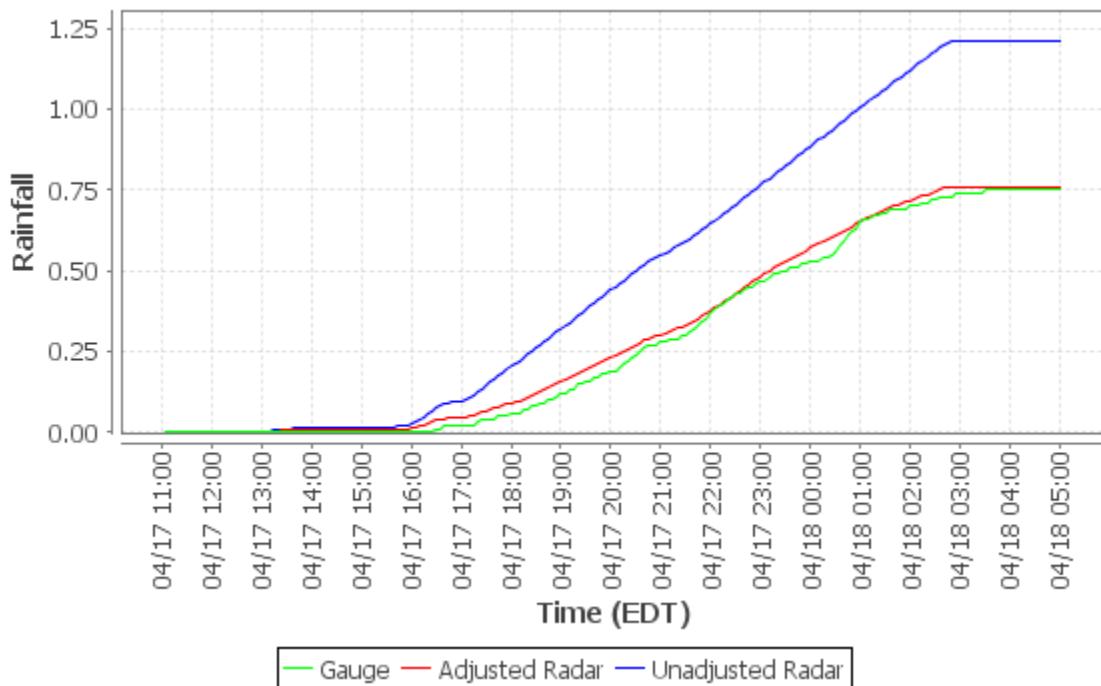
Cumulative Distribution Plot - Baldwin (Loc12)



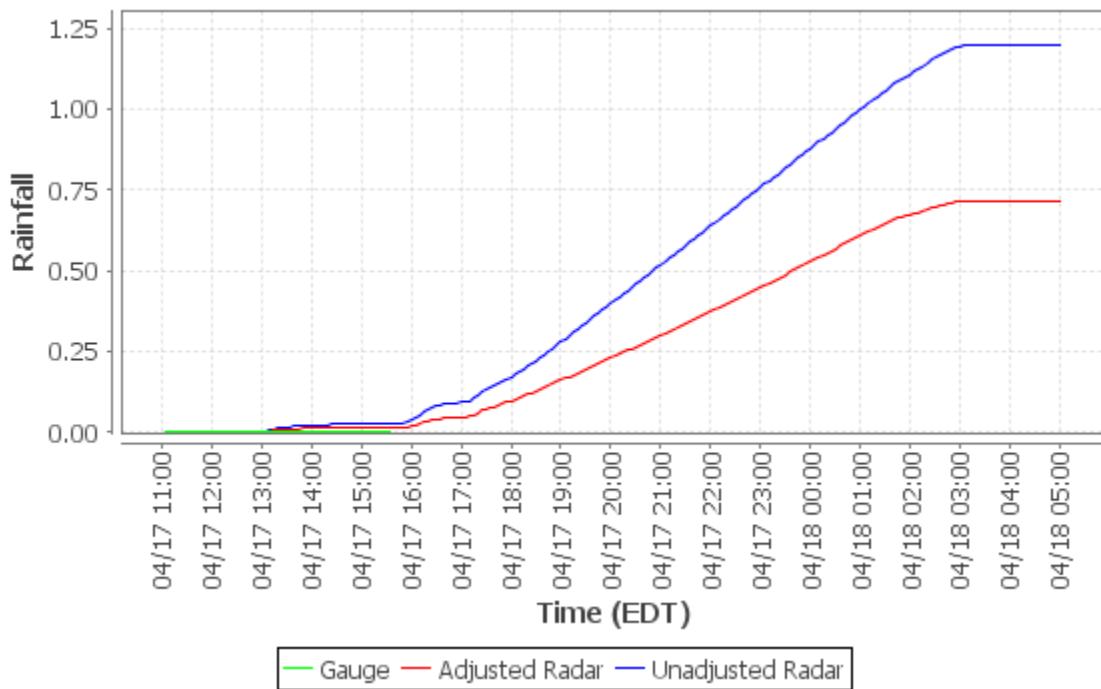
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



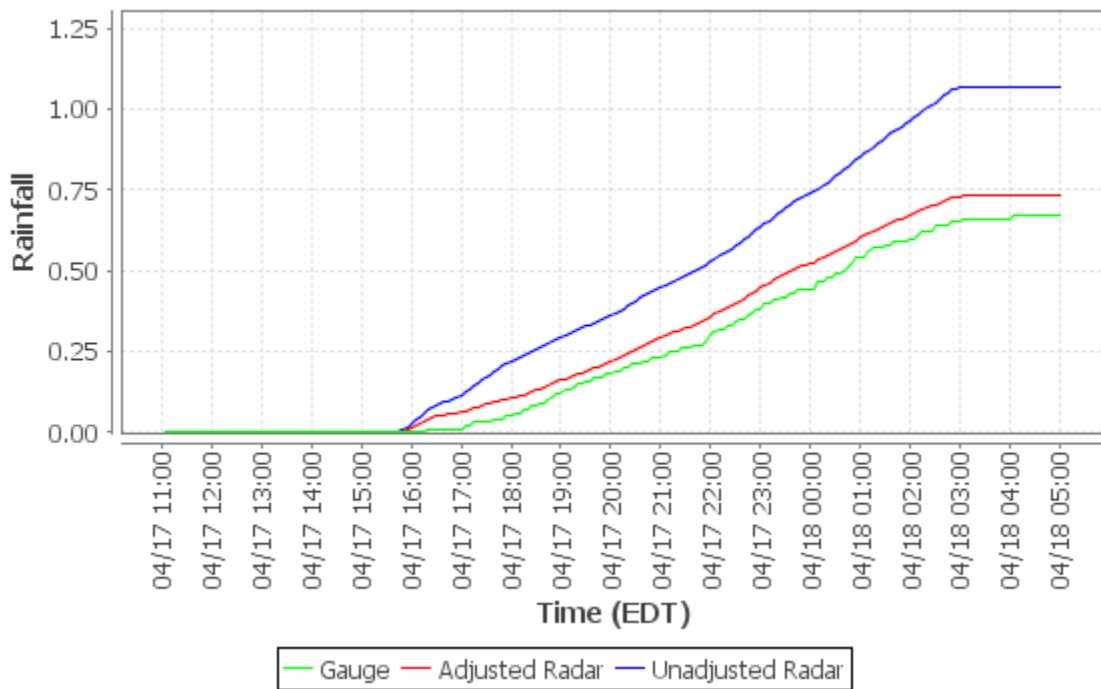
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



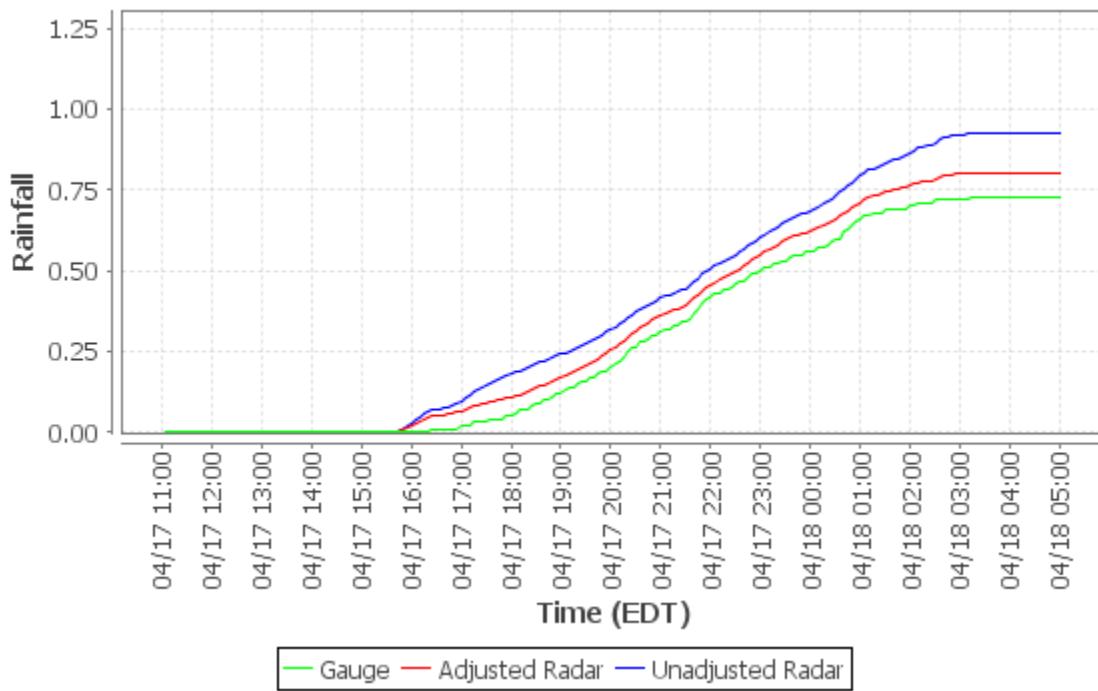
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



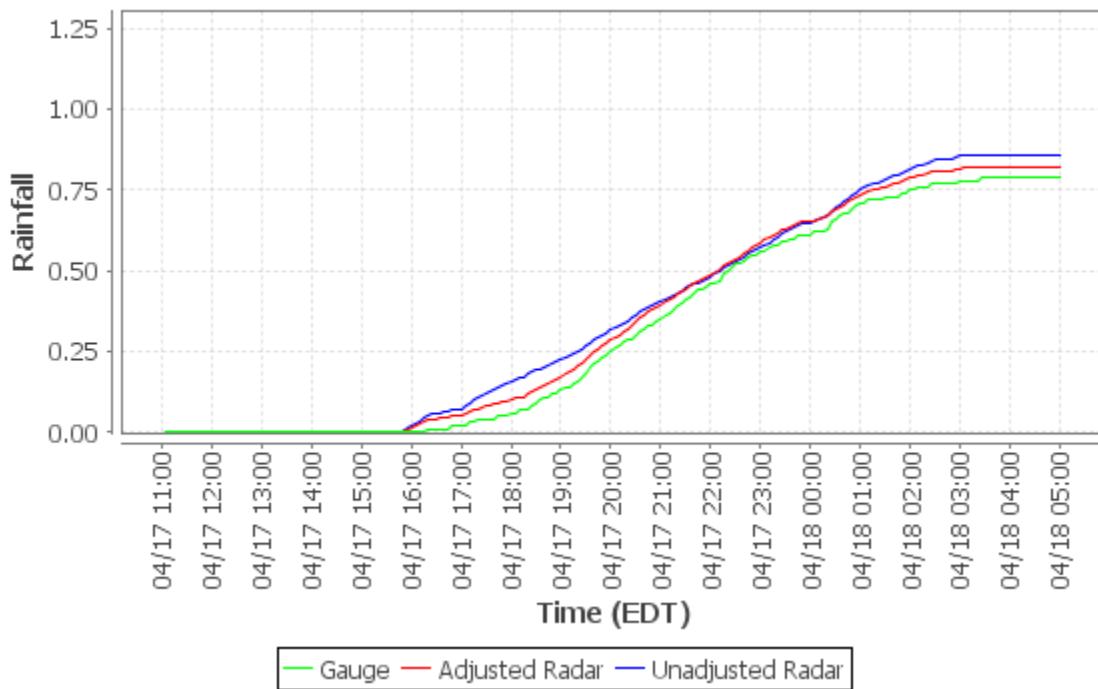
Cumulative Distribution Plot - Castle Shannon (Loc16)



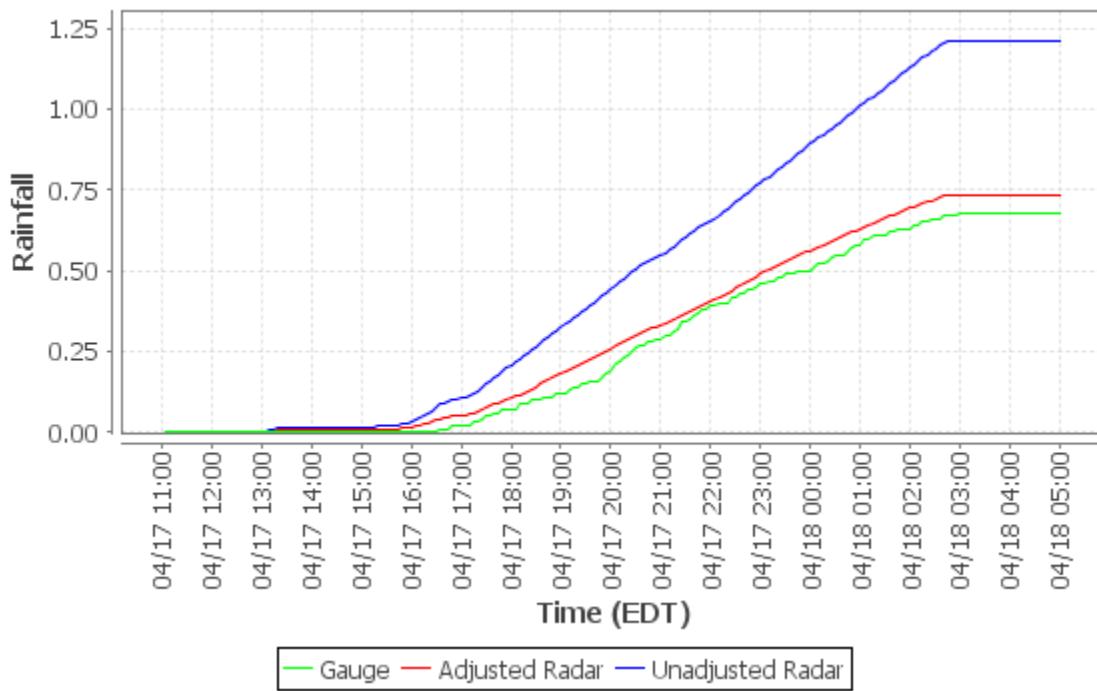
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



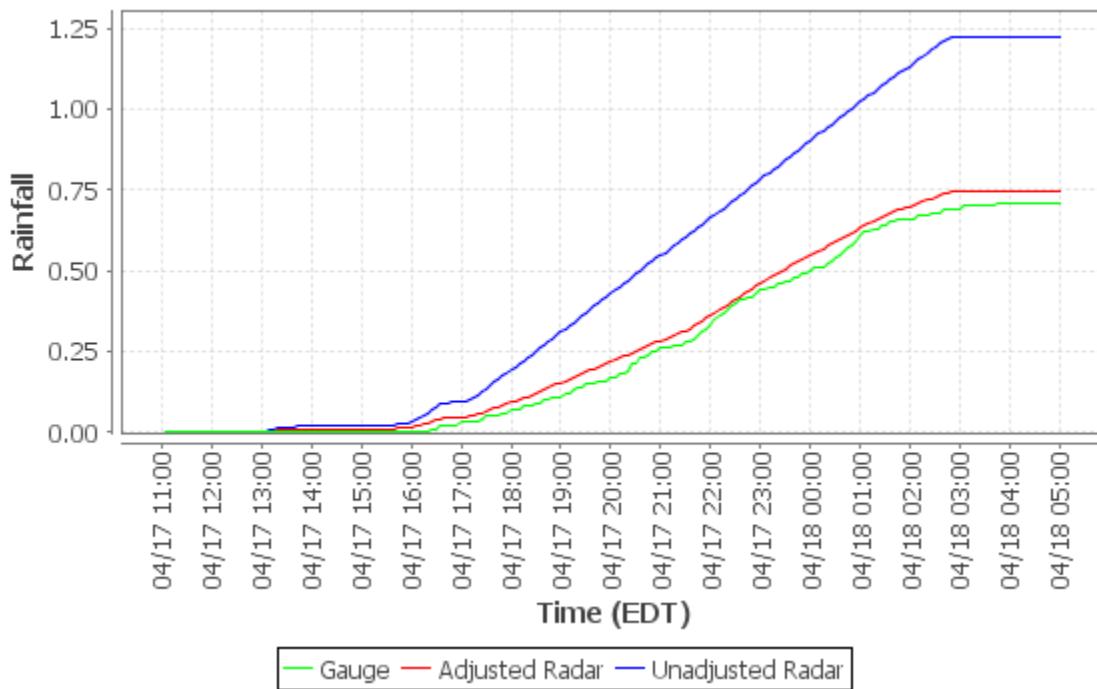
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



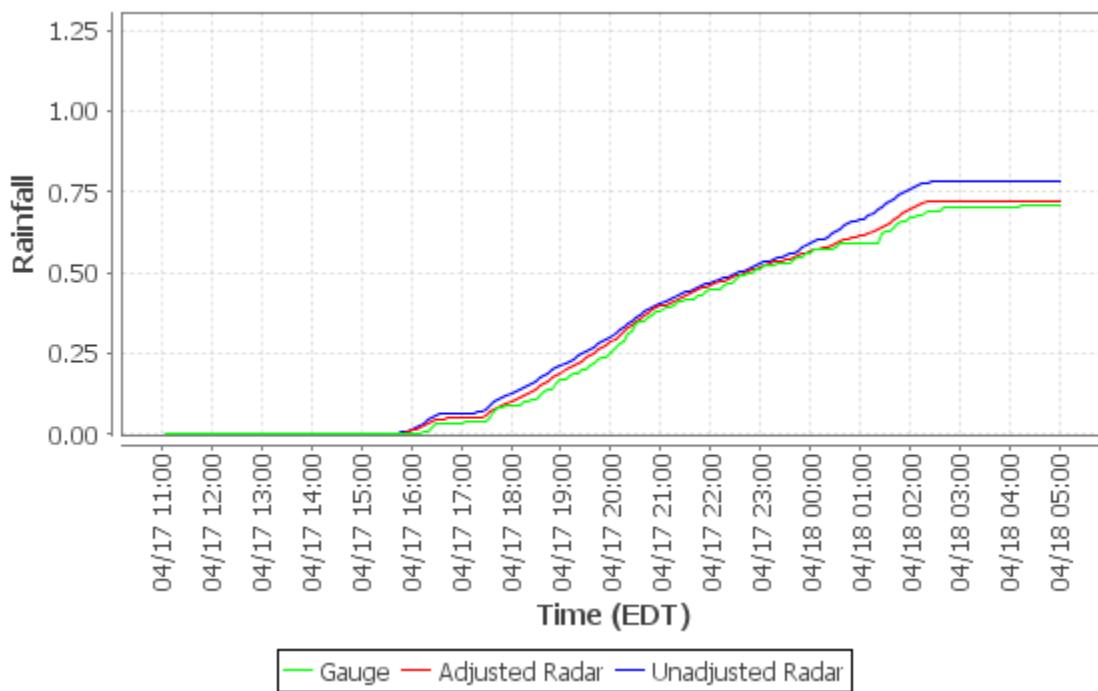
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



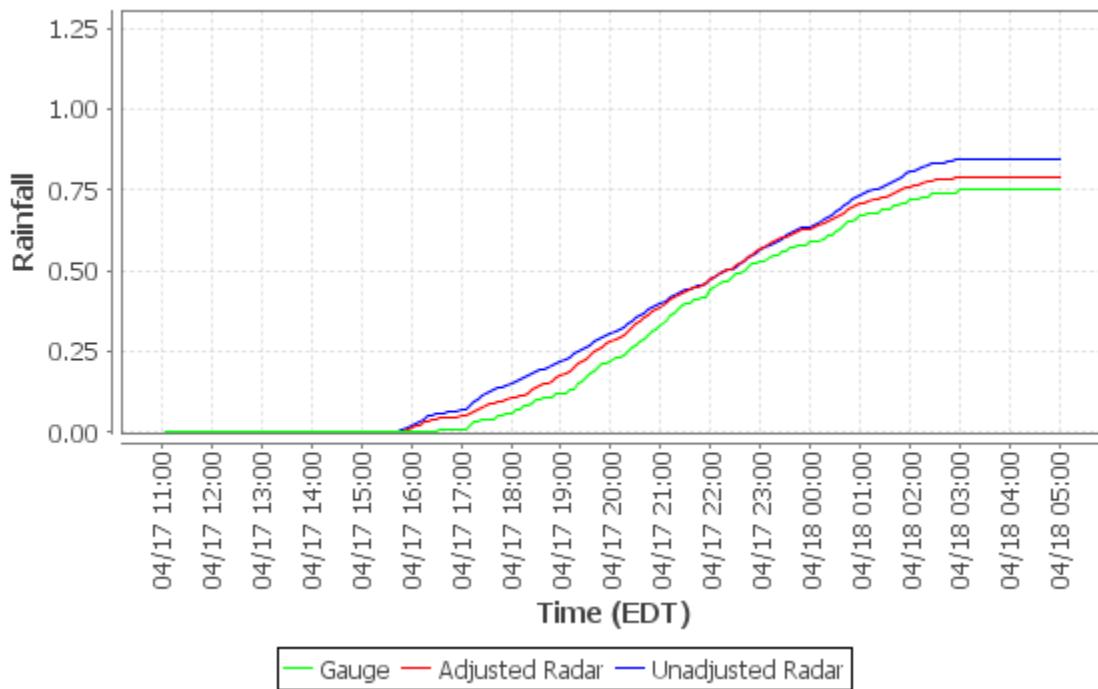
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



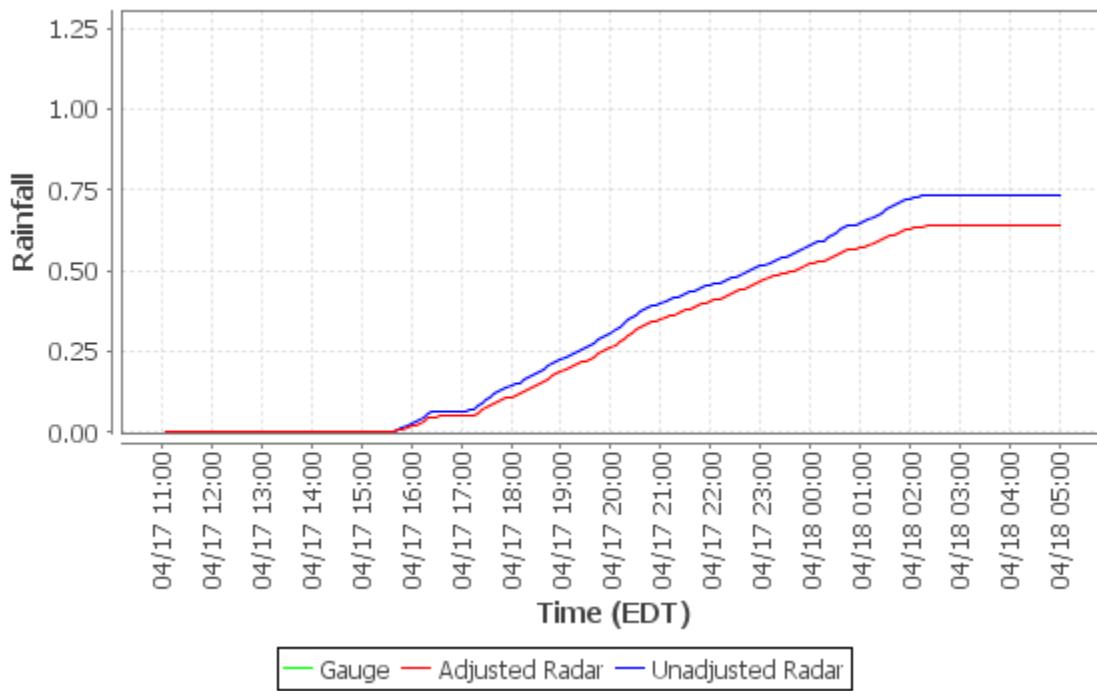
Cumulative Distribution Plot - Moon TWP (Loc21)



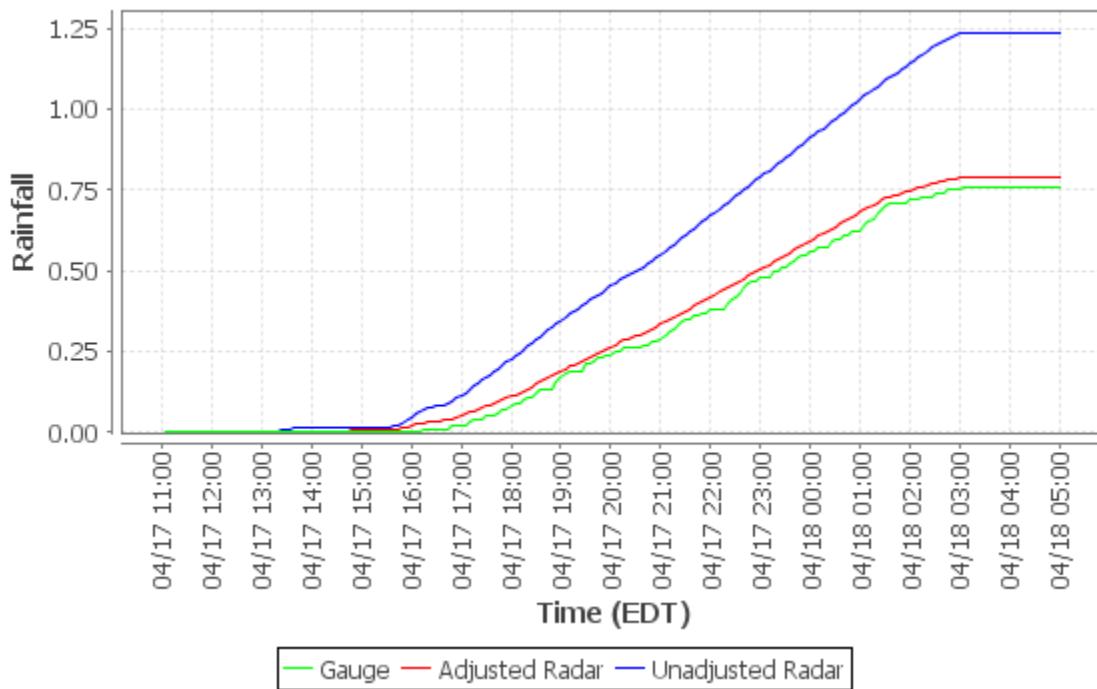
Cumulative Distribution Plot - North Fayette TWP (Loc22)



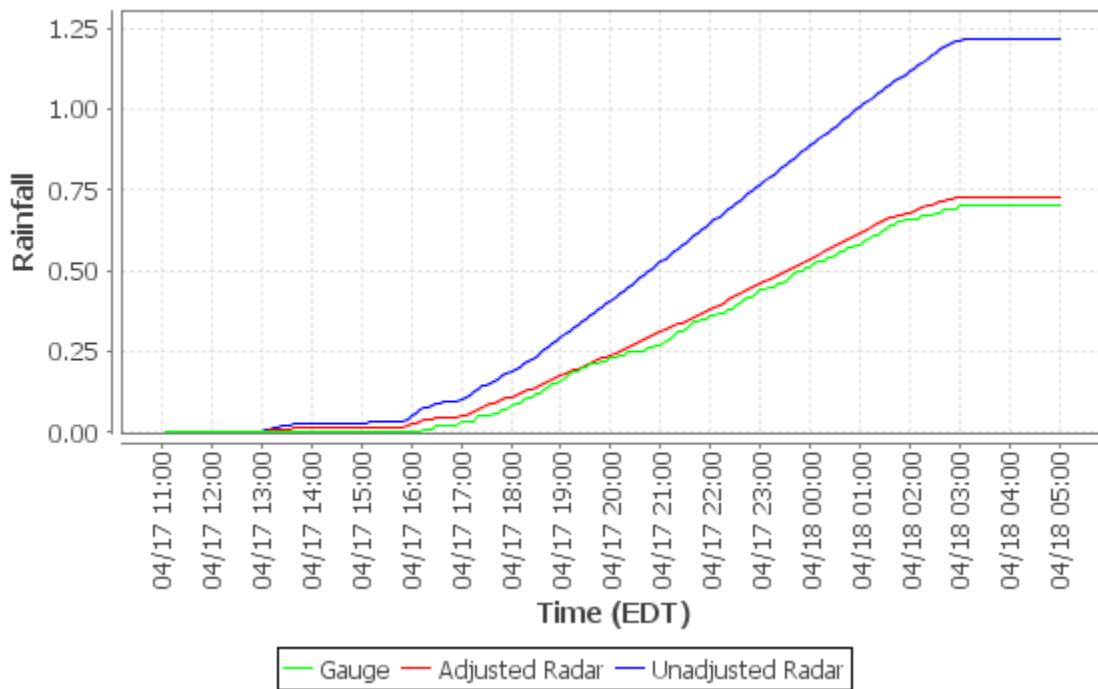
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



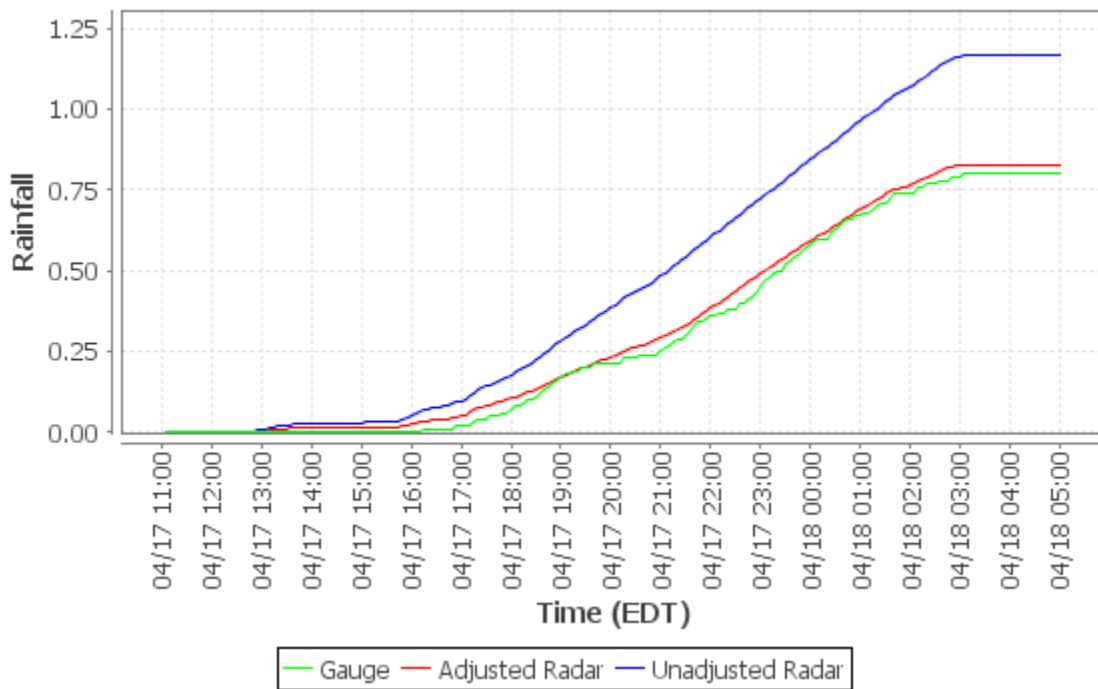
Cumulative Distribution Plot - Jefferson Hills (Loc24)



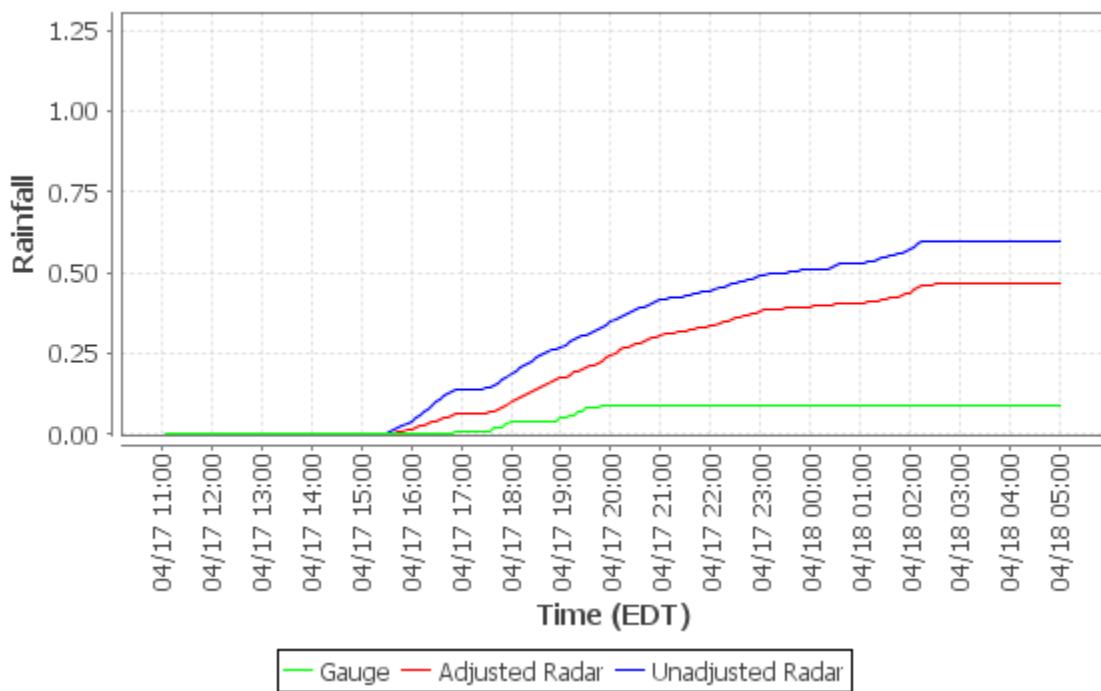
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



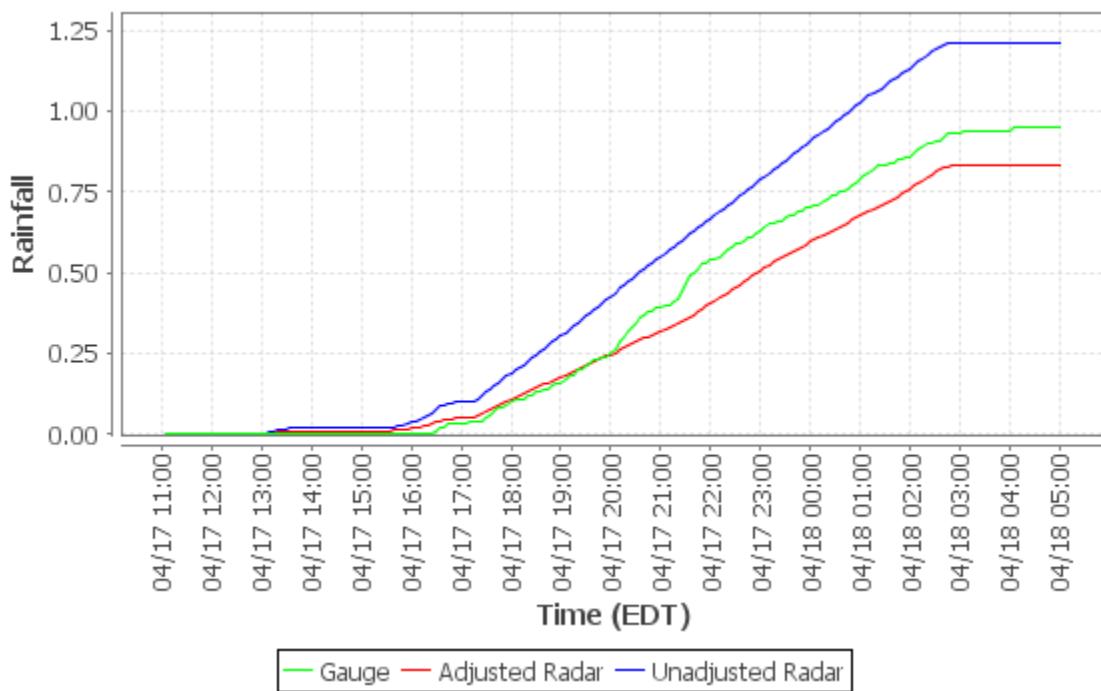
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



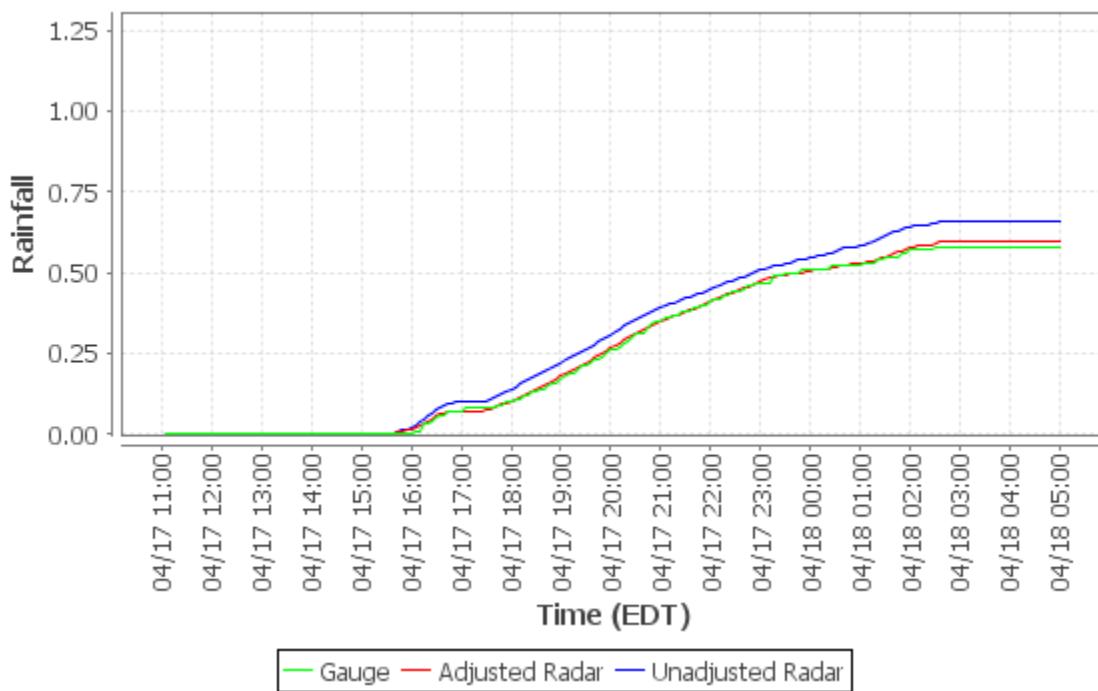
Cumulative Distribution Plot - Marshall TWP (Loc27)



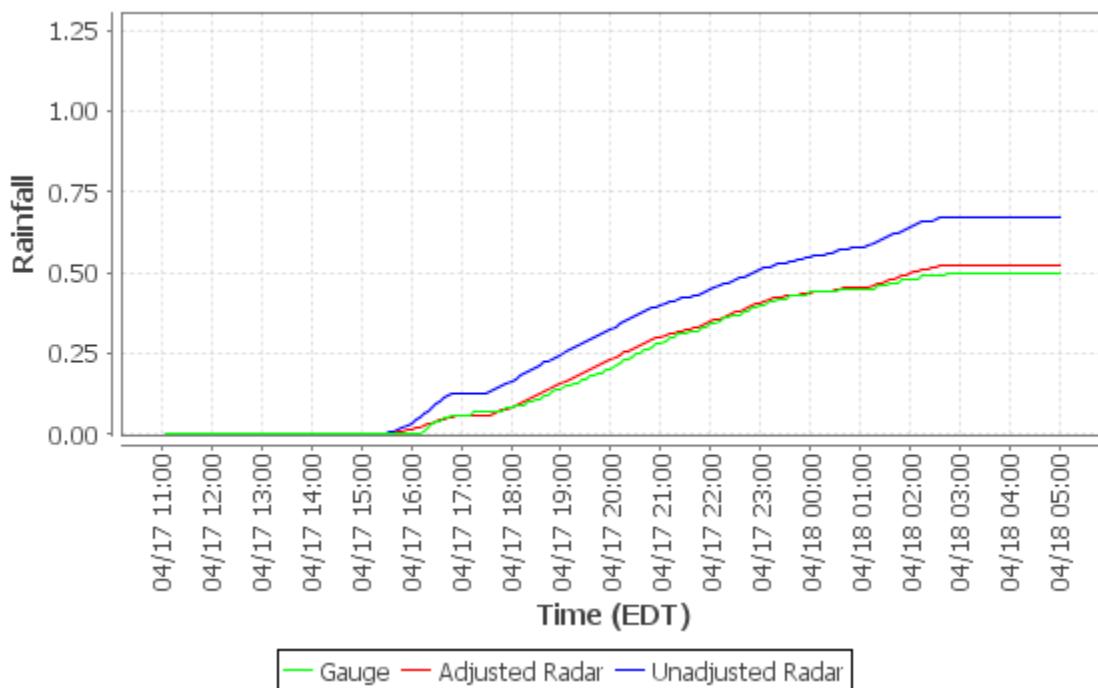
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



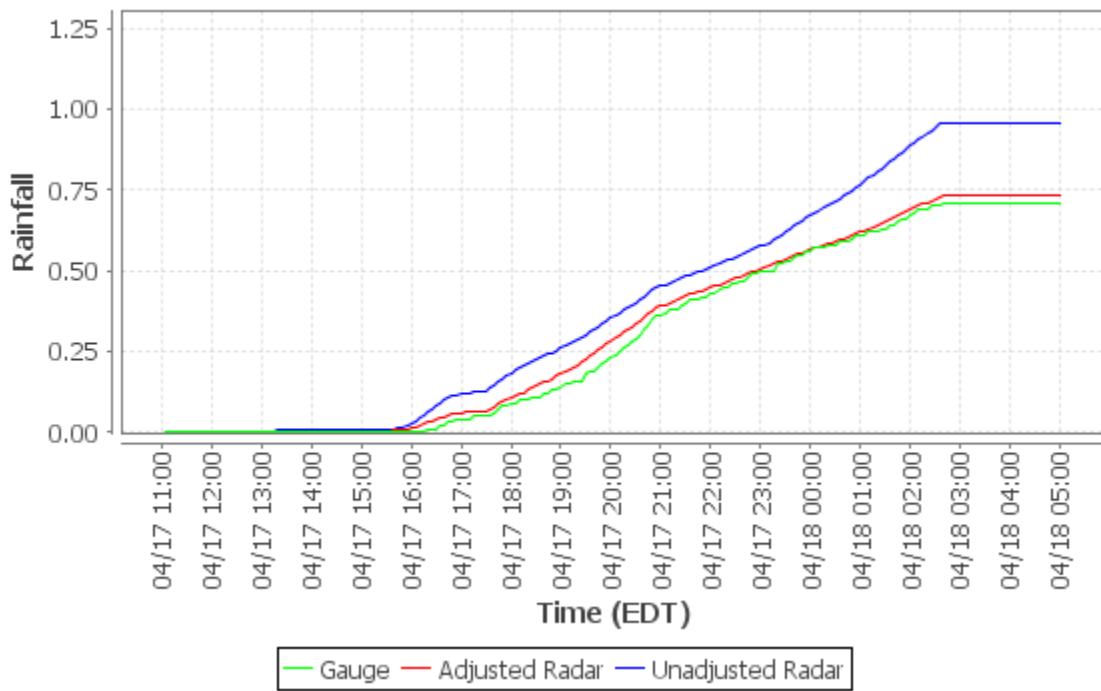
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



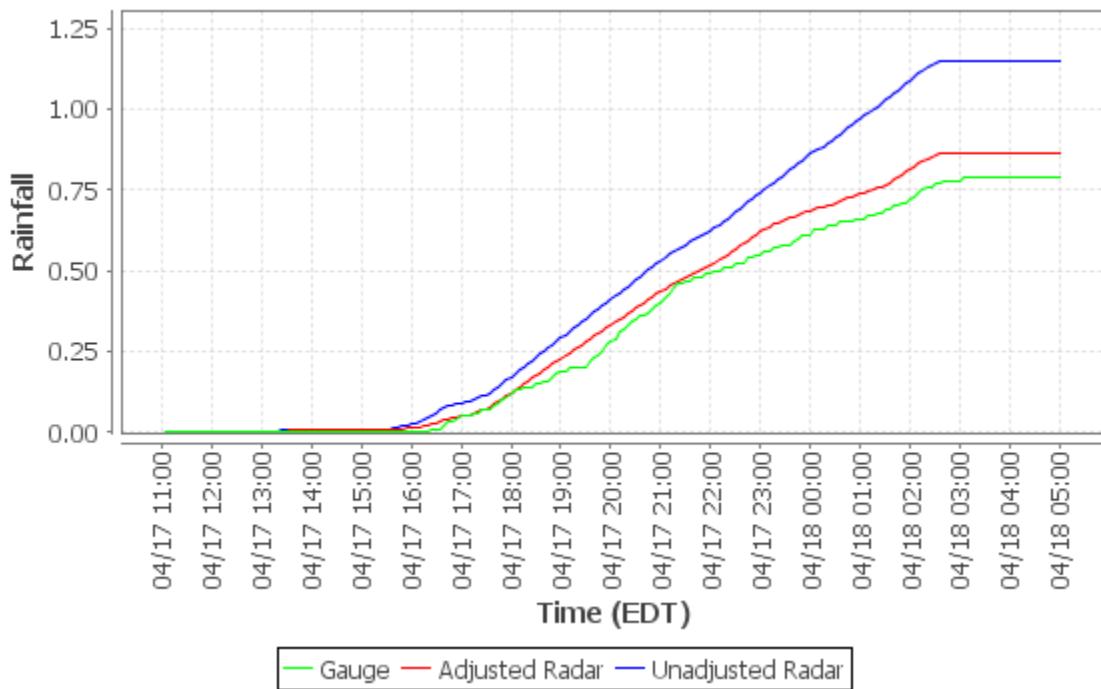
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



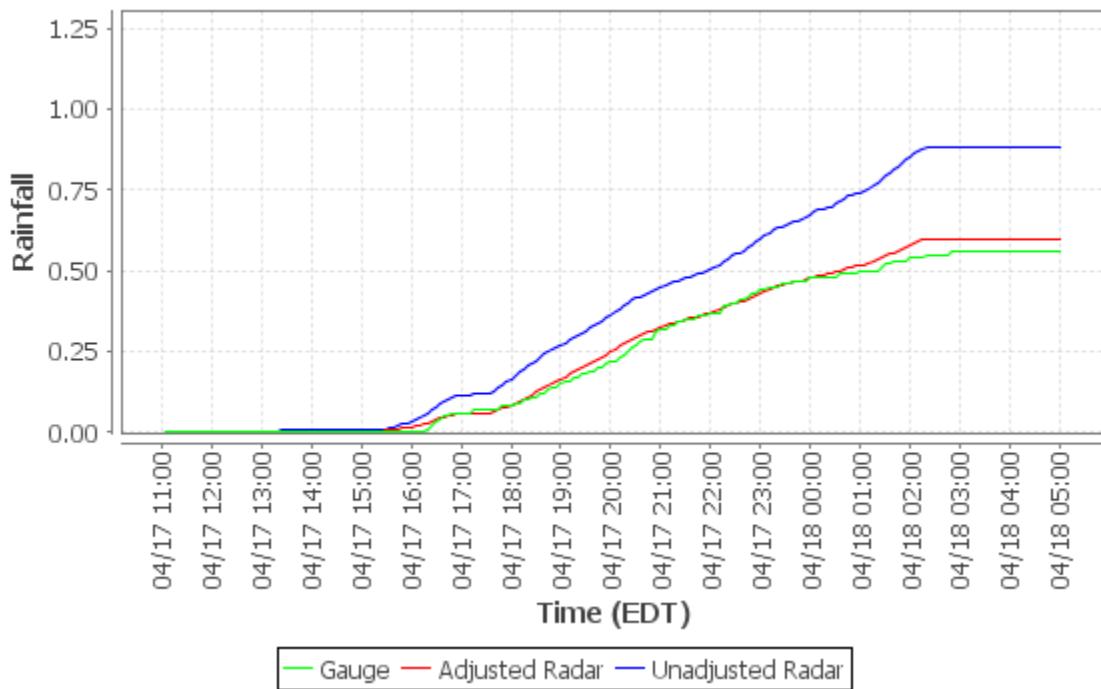
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



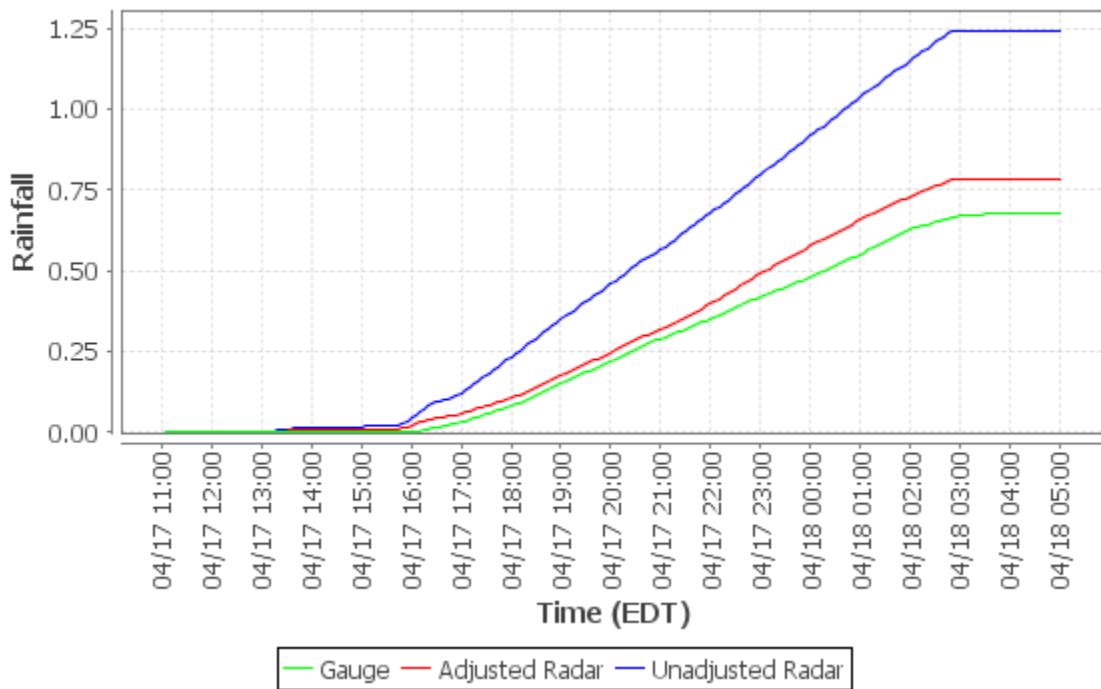
Cumulative Distribution Plot - Arnold (Loc32)



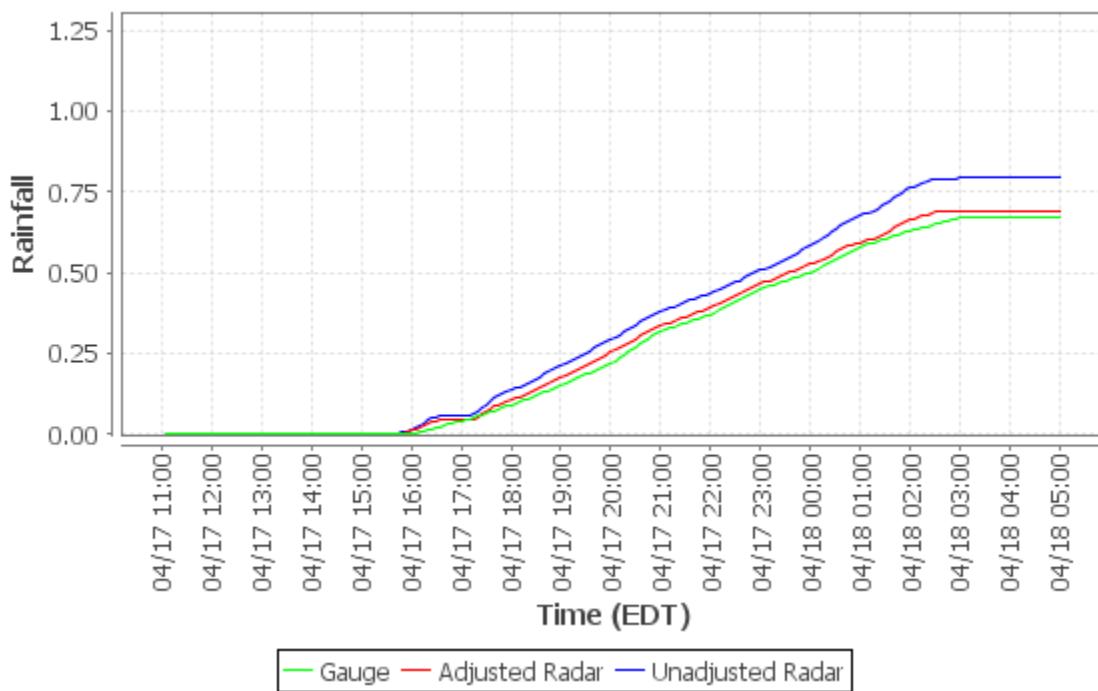
Cumulative Distribution Plot - Richland TWP (Loc33)



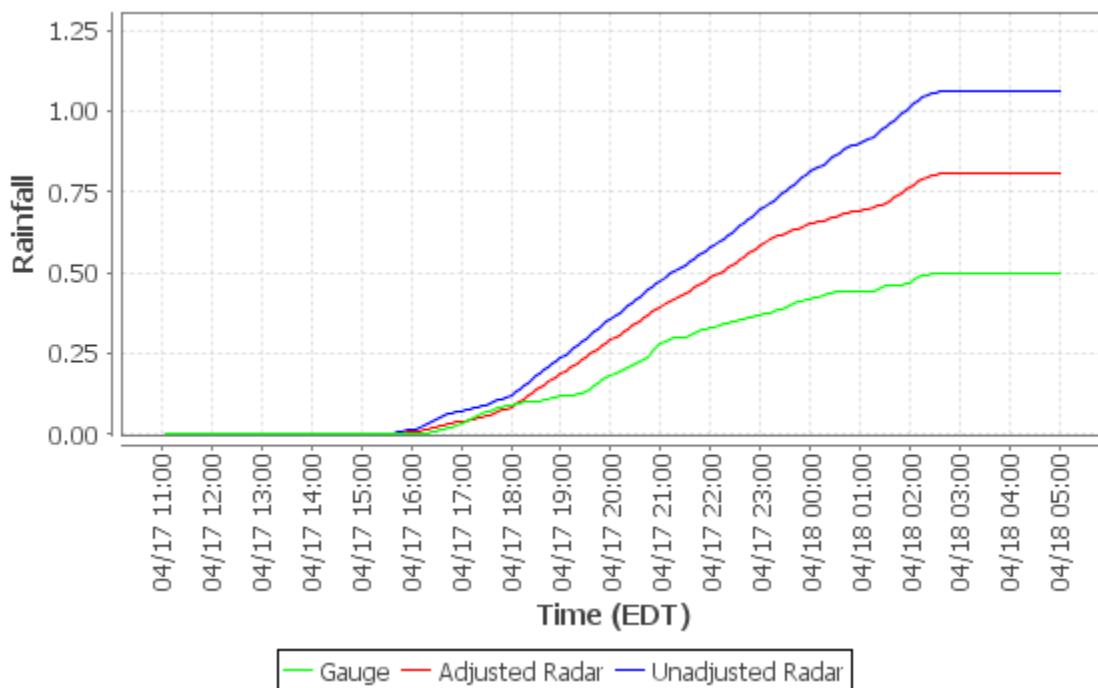
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



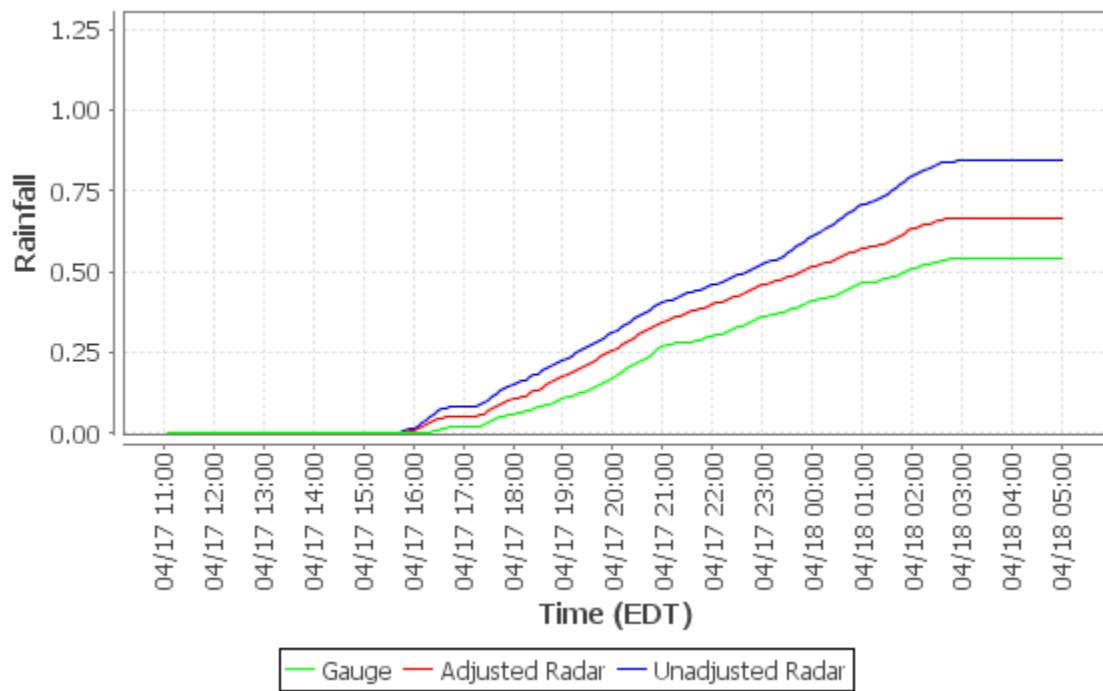
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

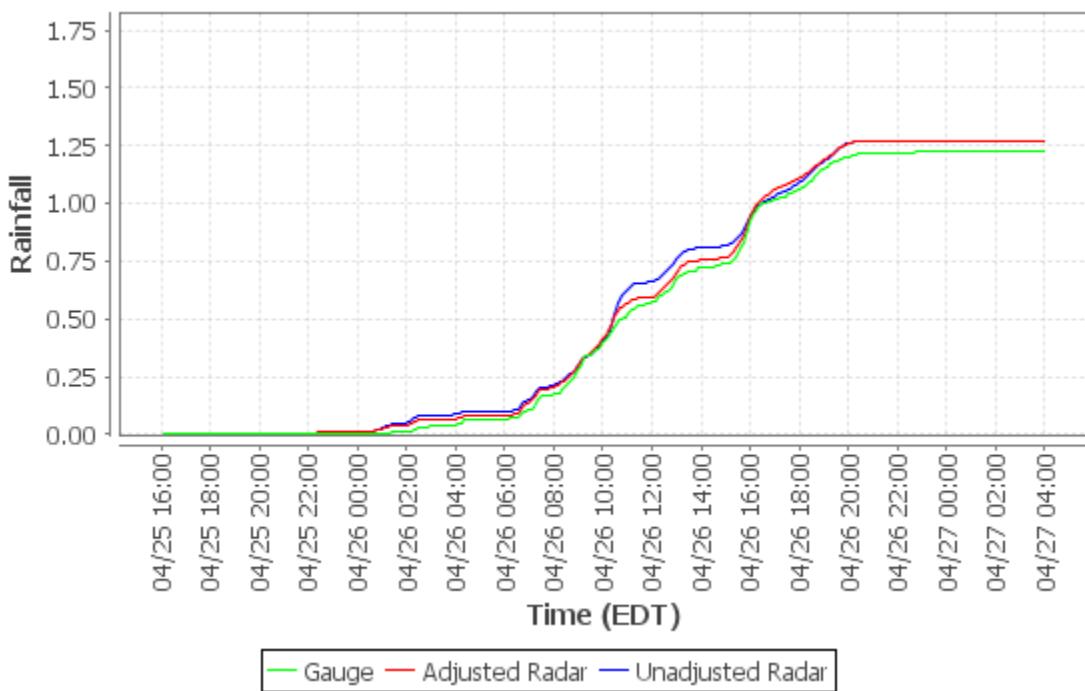


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

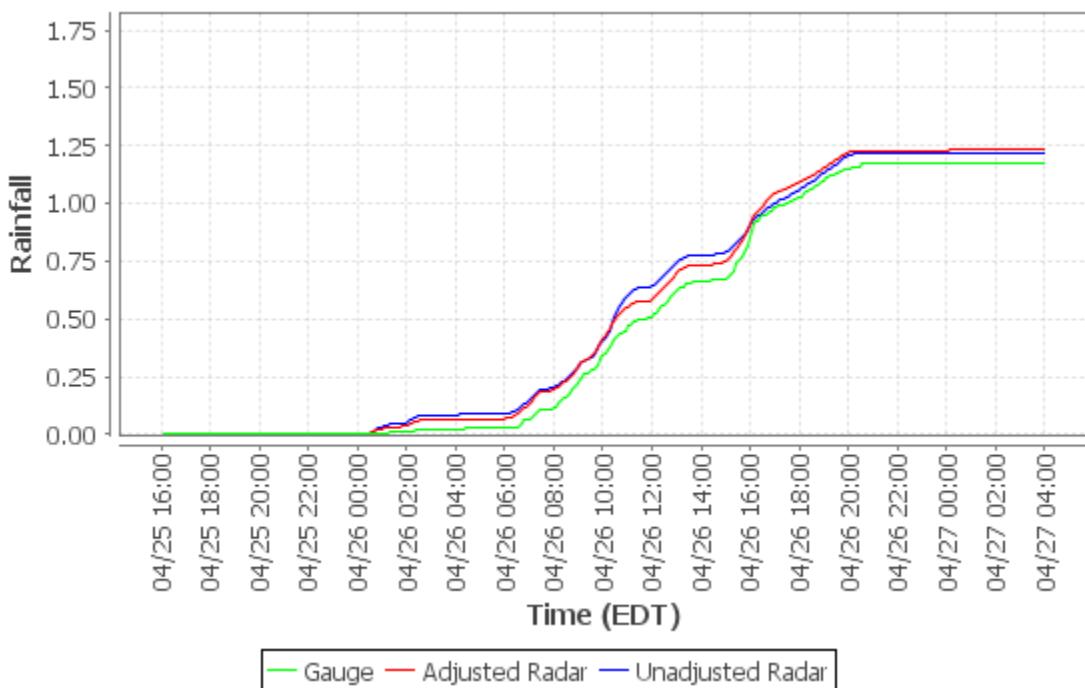


Appendix I - Event 7 (2020-04-26) CDPs

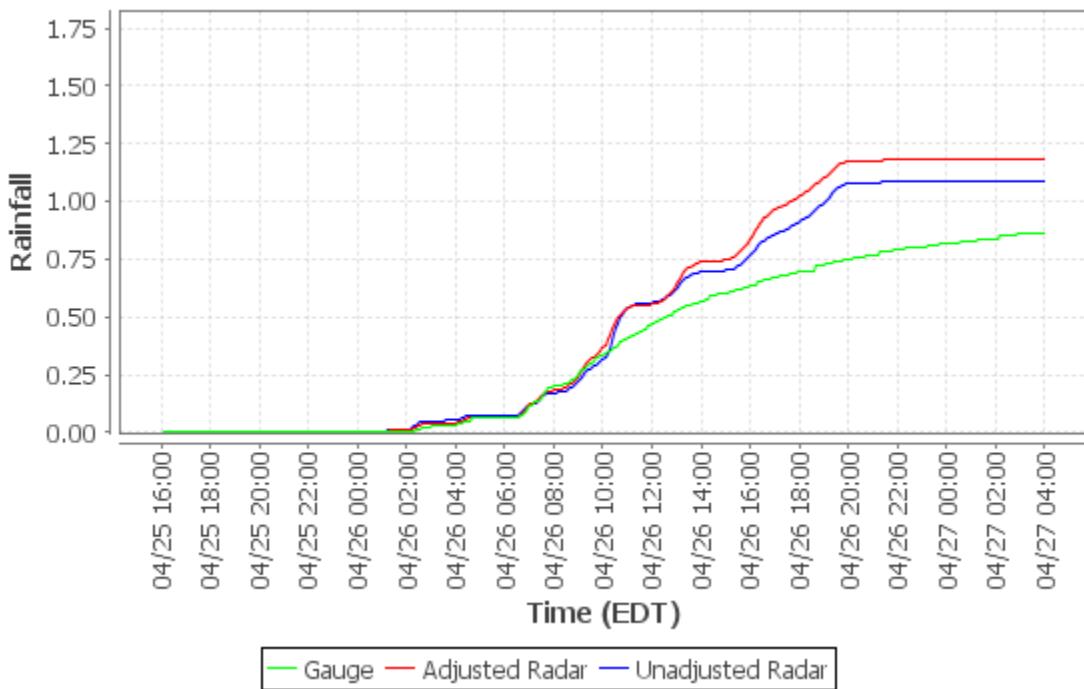
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



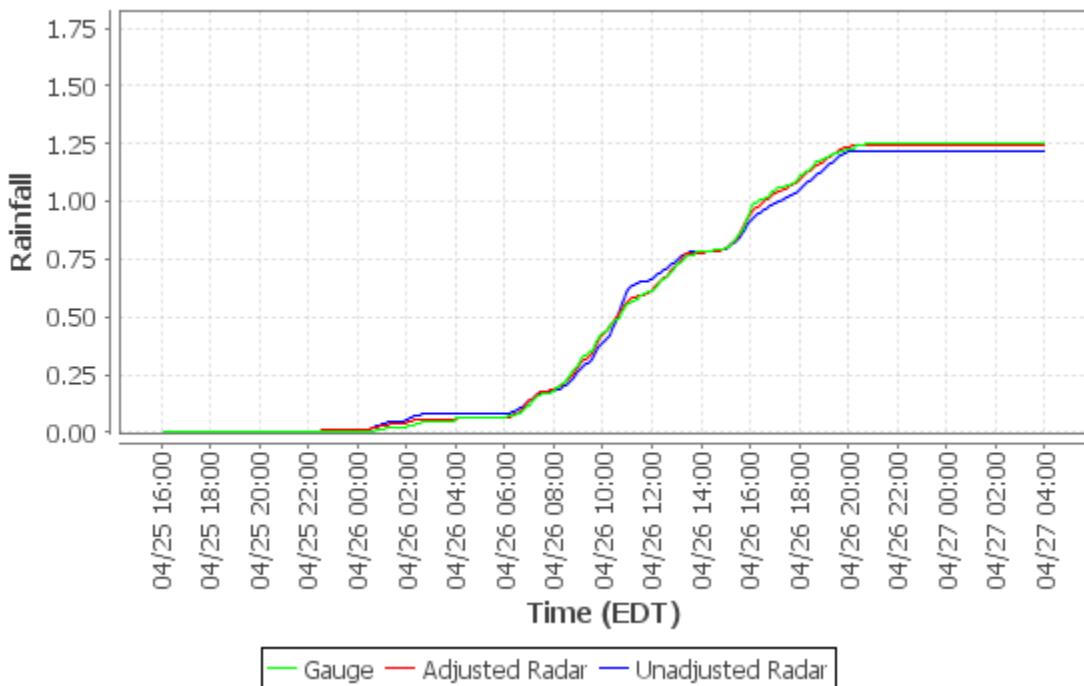
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



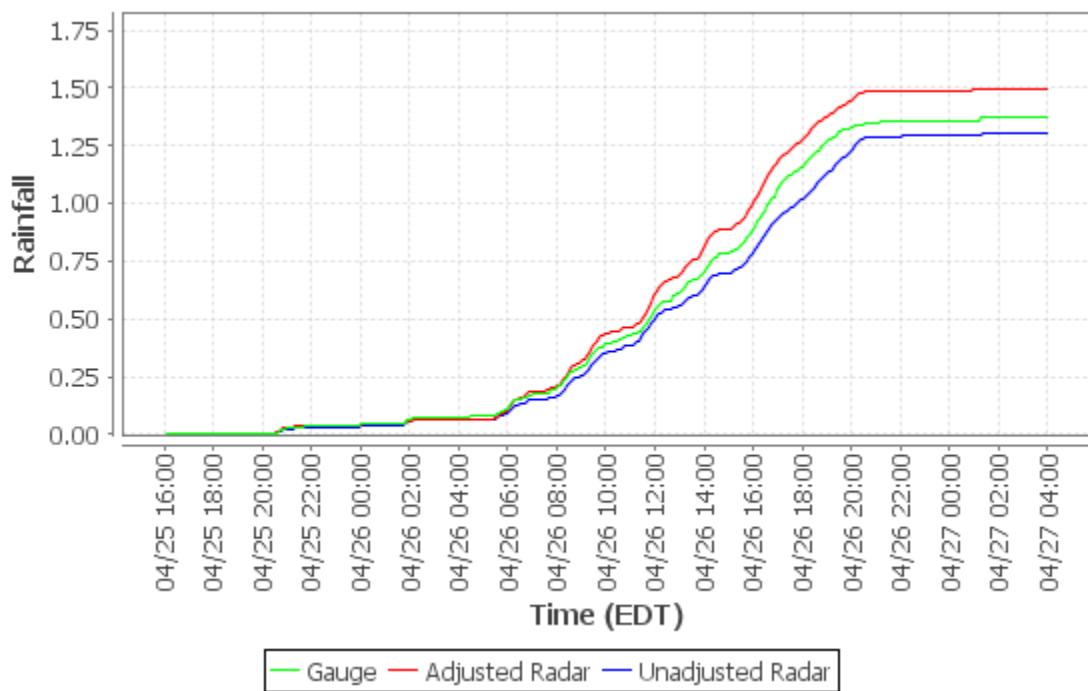
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



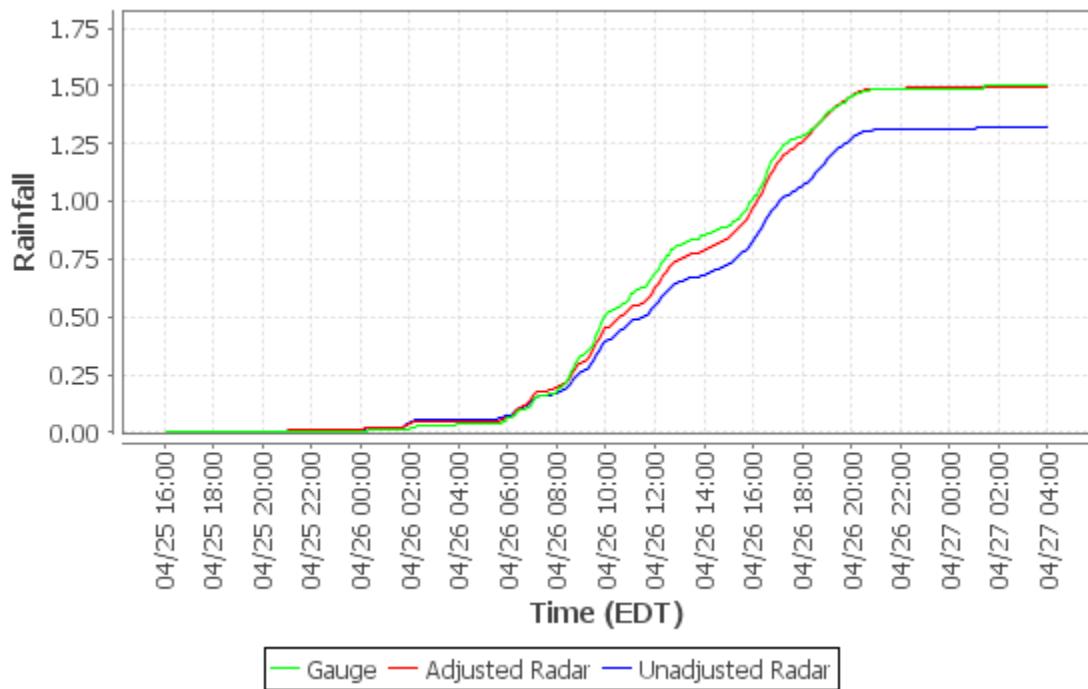
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



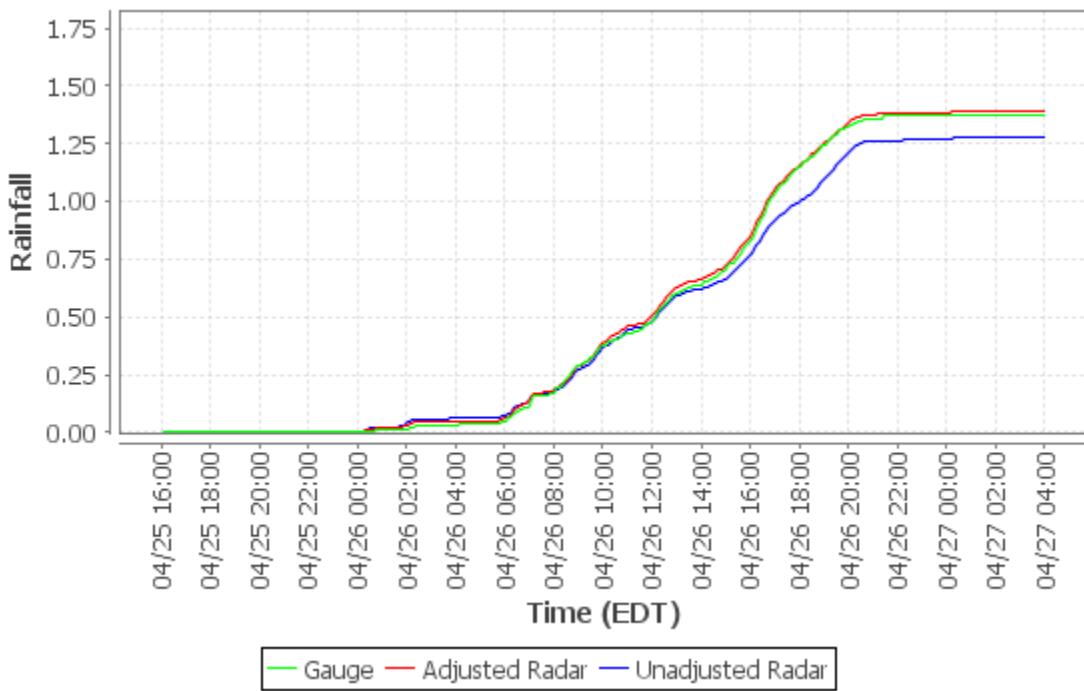
Cumulative Distribution Plot - Upper St. Clair (Loc05)



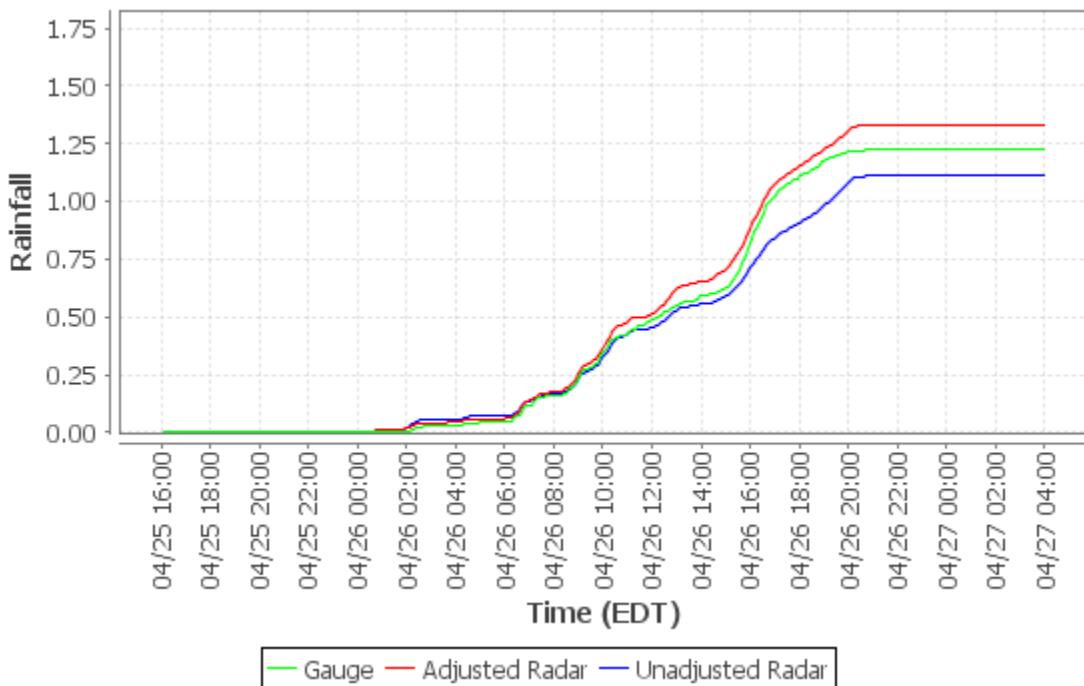
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



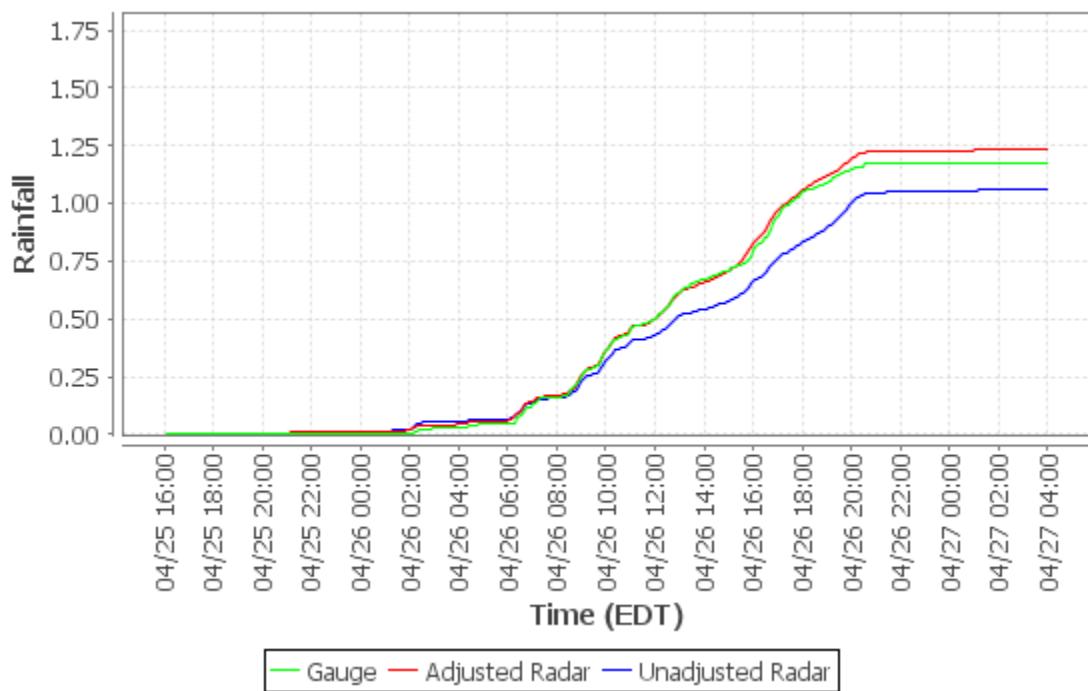
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



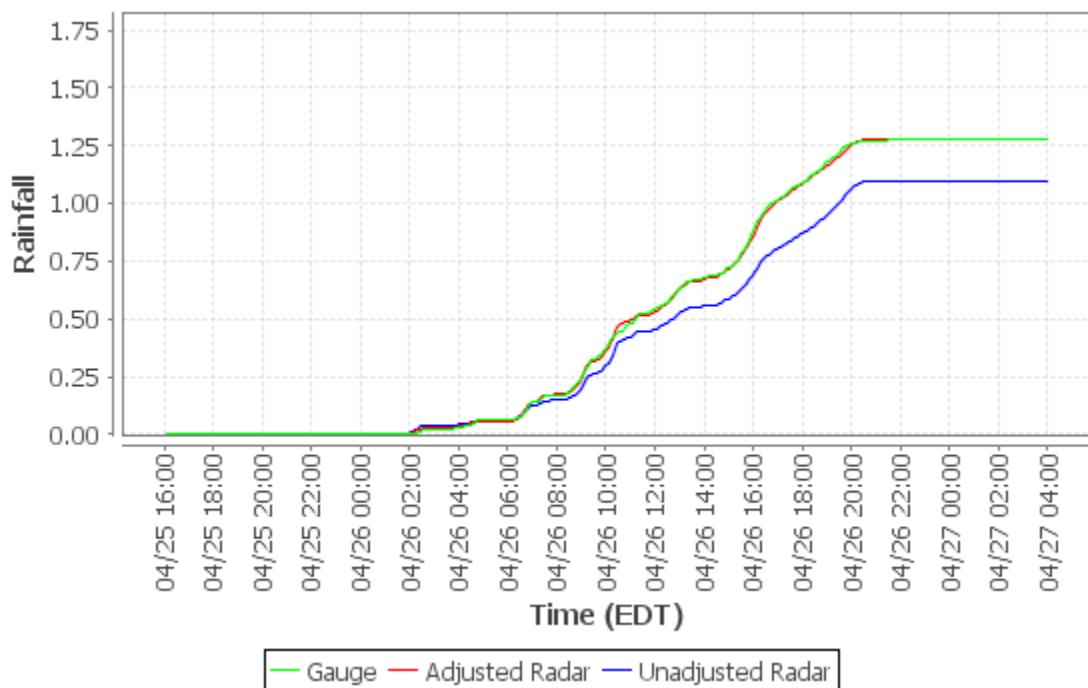
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



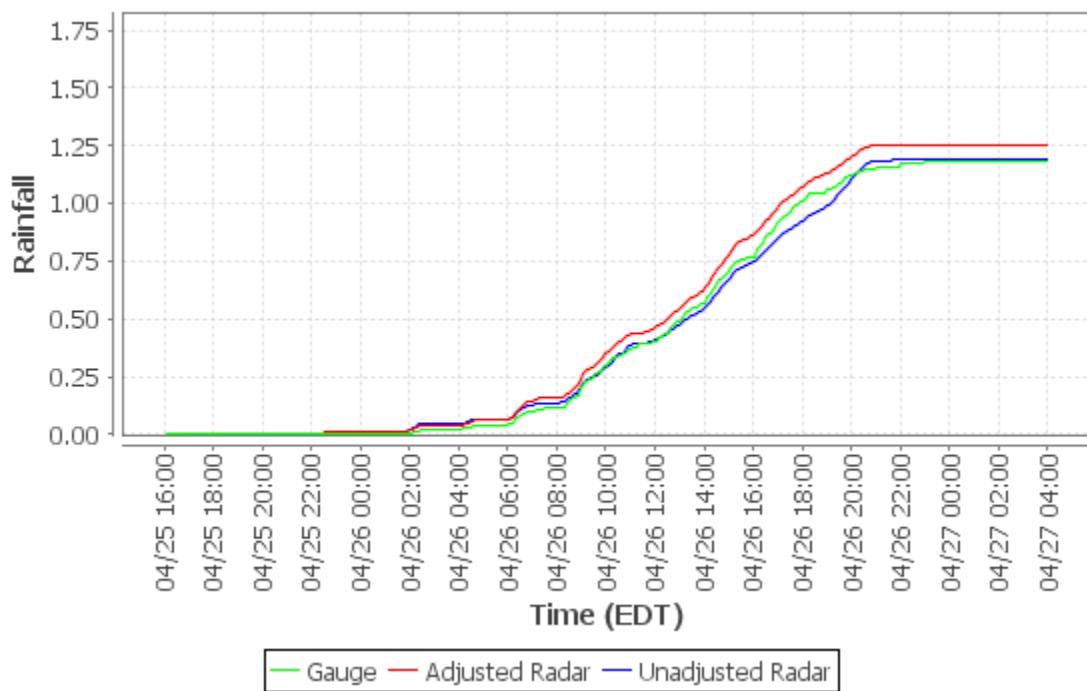
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



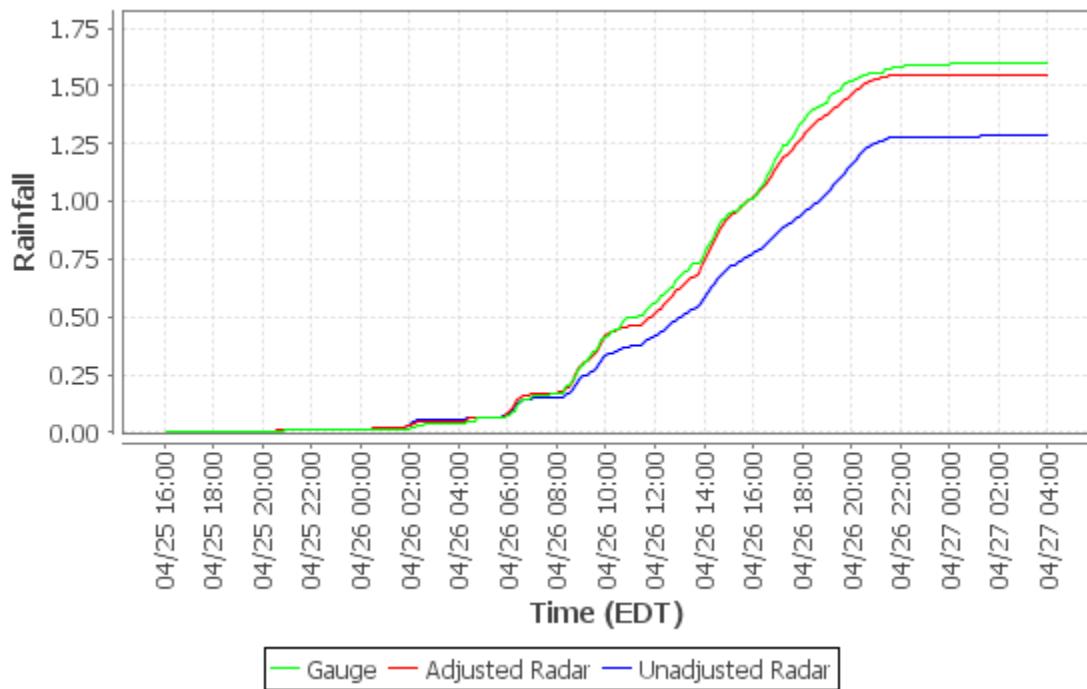
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



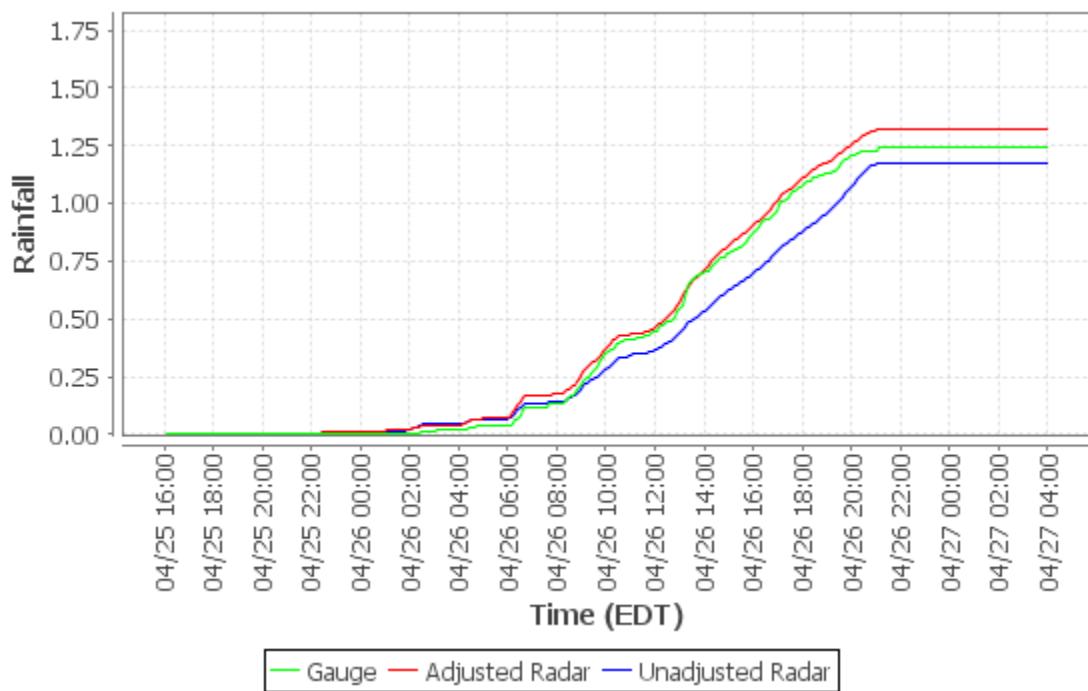
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



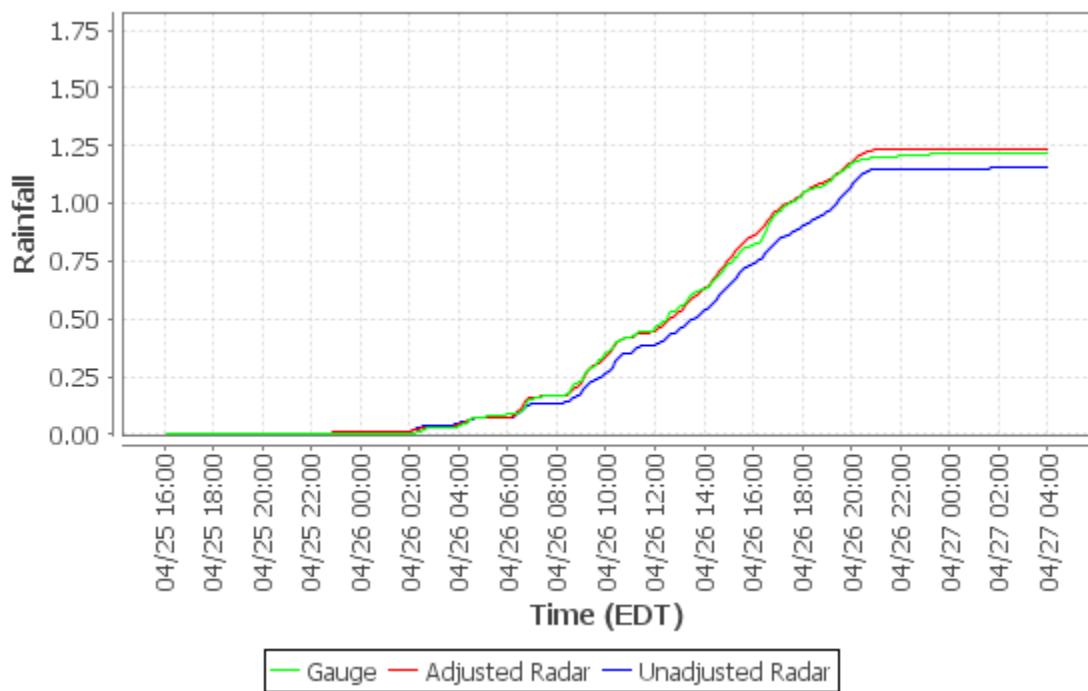
Cumulative Distribution Plot - Baldwin (Loc12)



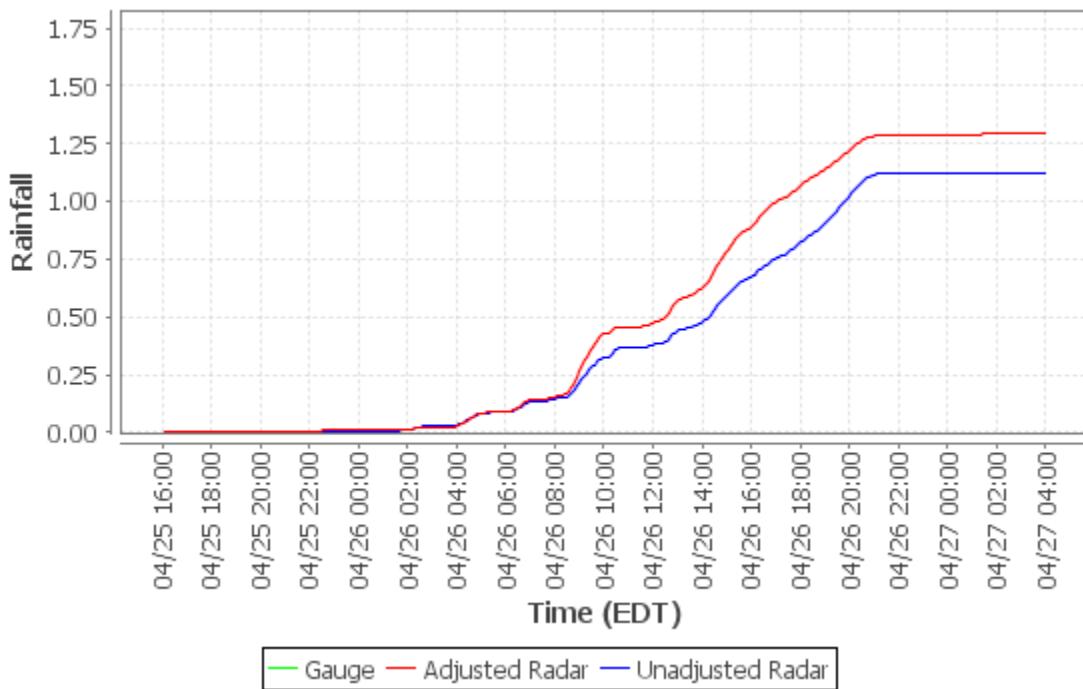
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



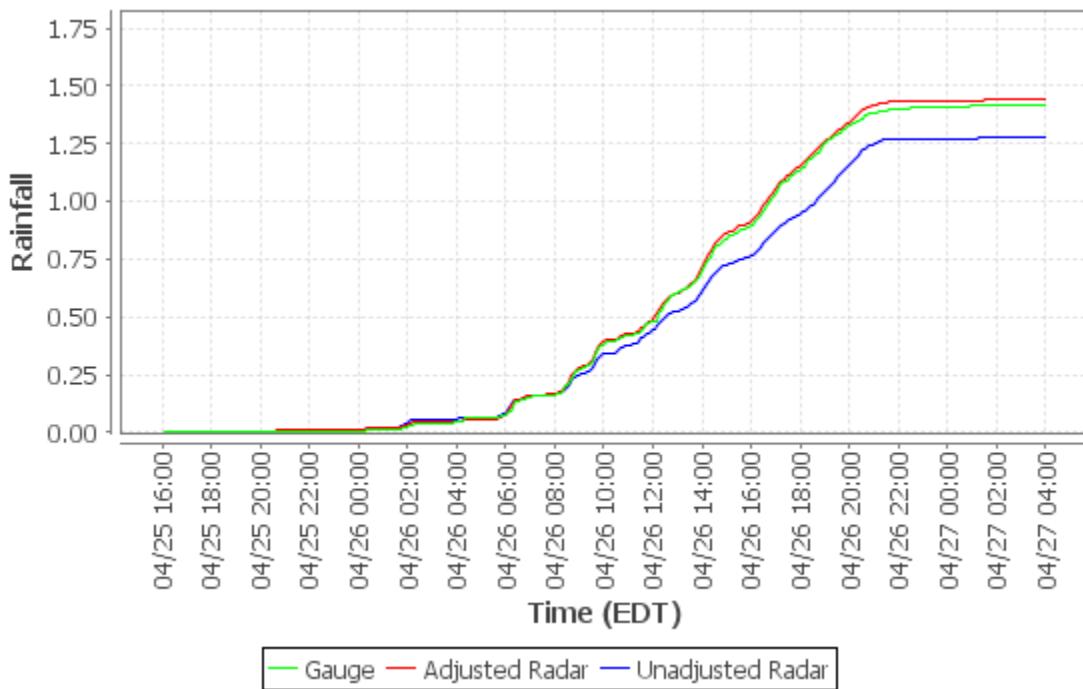
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



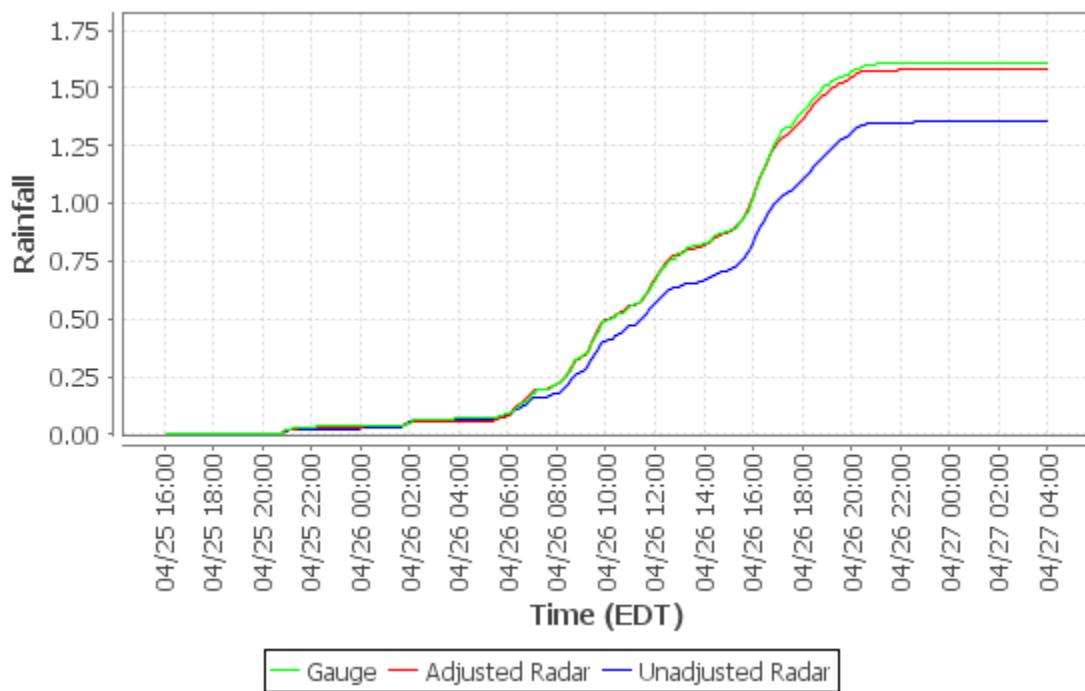
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



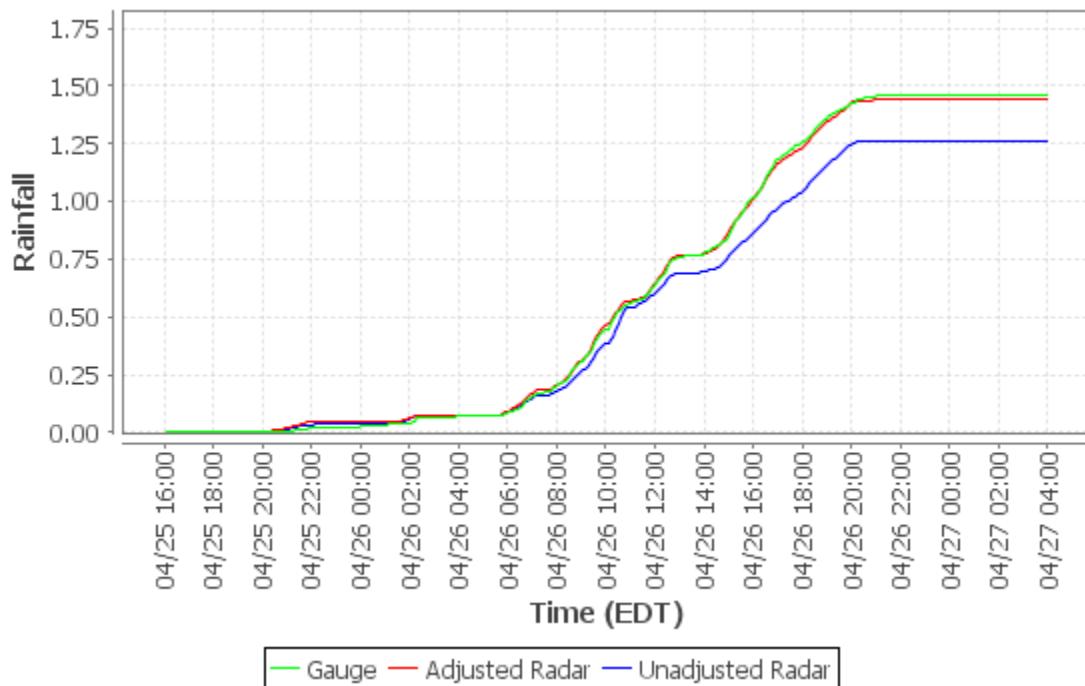
Cumulative Distribution Plot - Castle Shannon (Loc16)



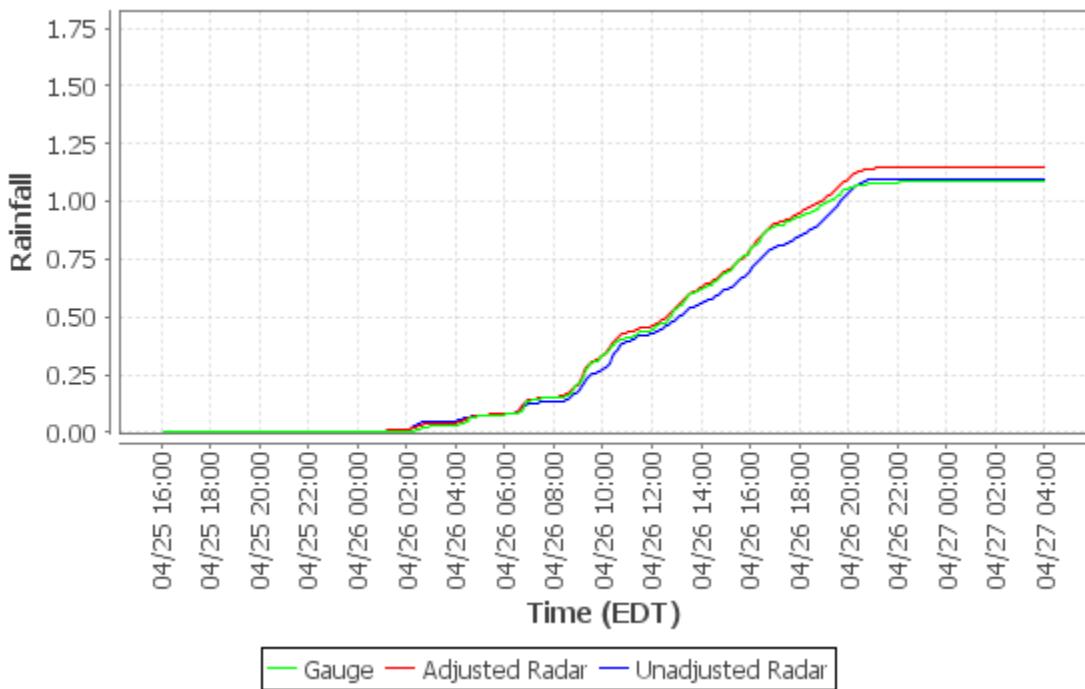
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



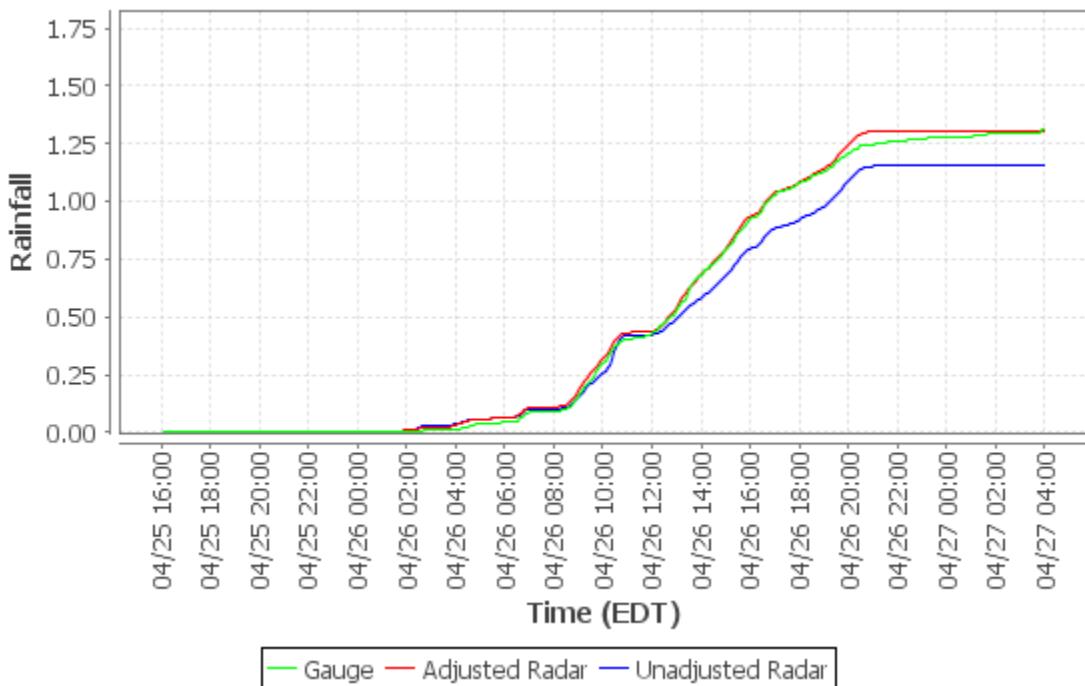
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



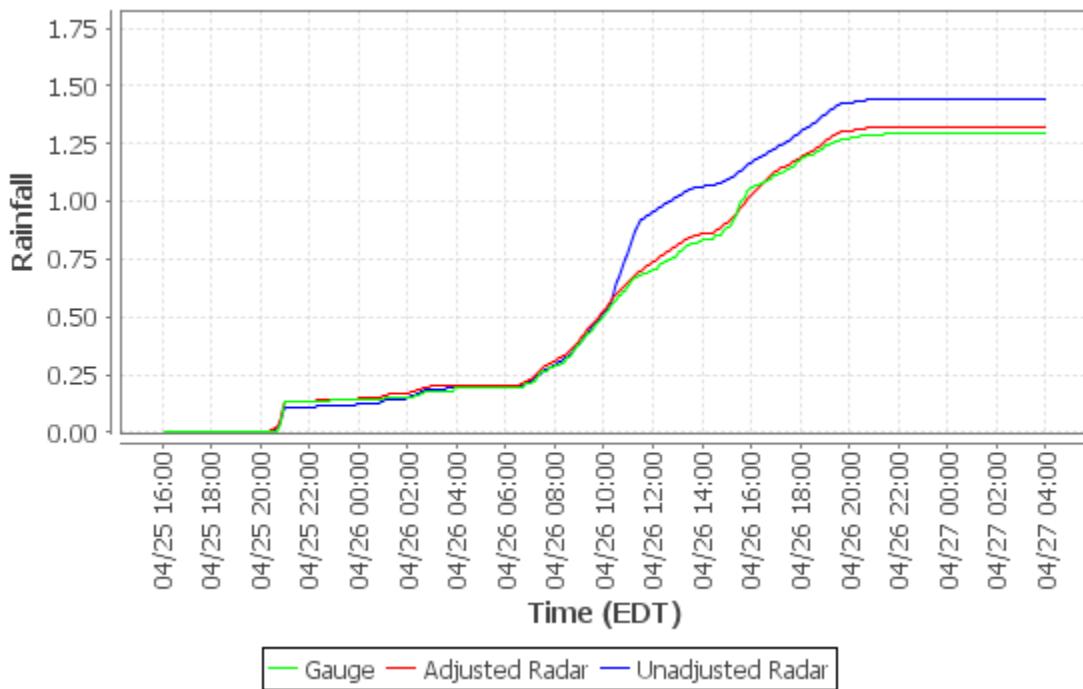
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



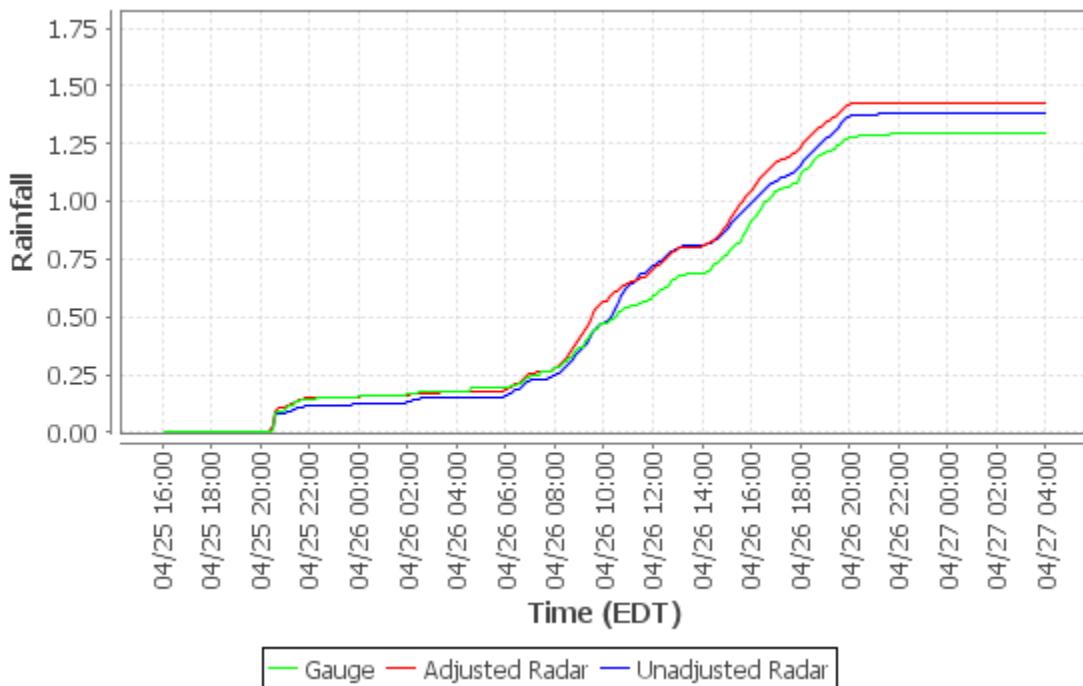
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



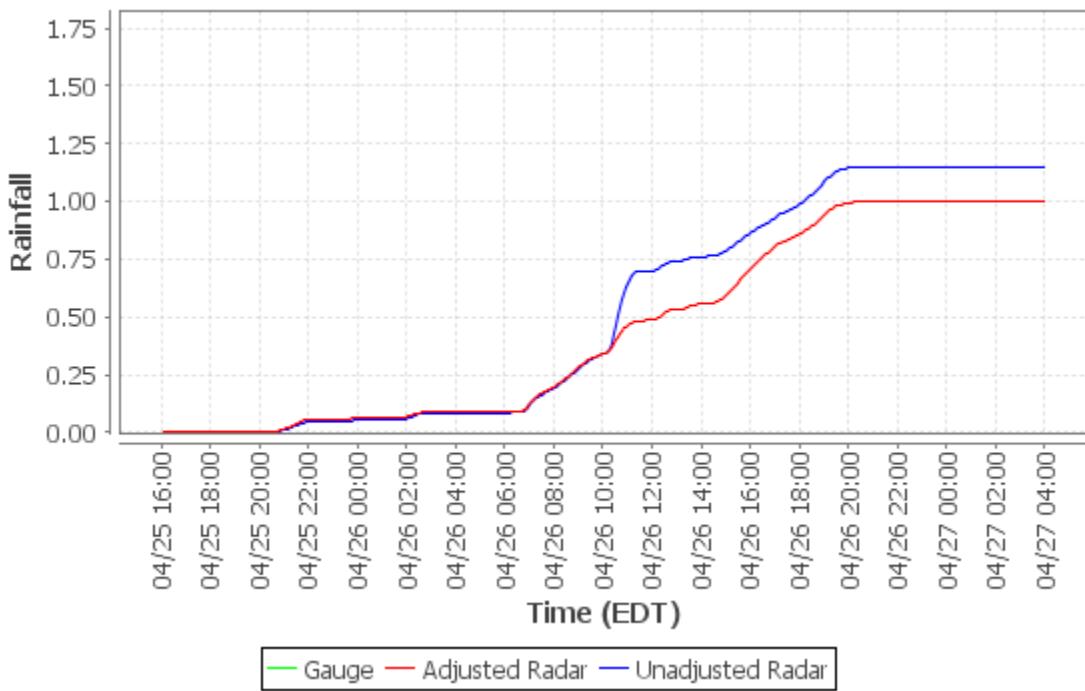
Cumulative Distribution Plot - Moon TWP (Loc21)



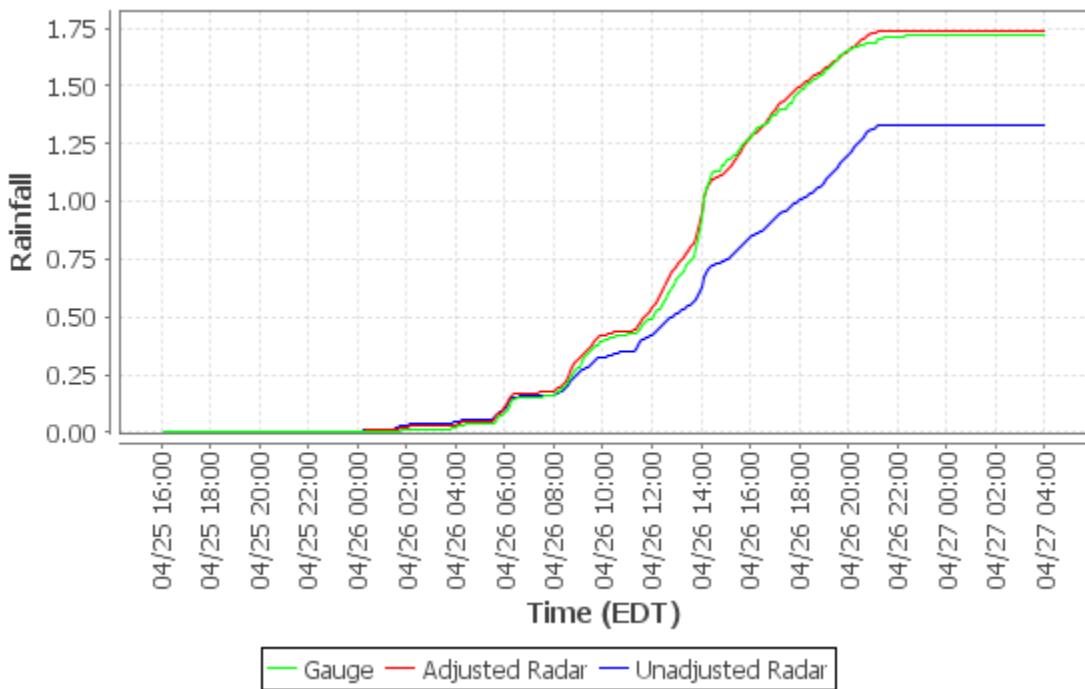
Cumulative Distribution Plot - North Fayette TWP (Loc22)



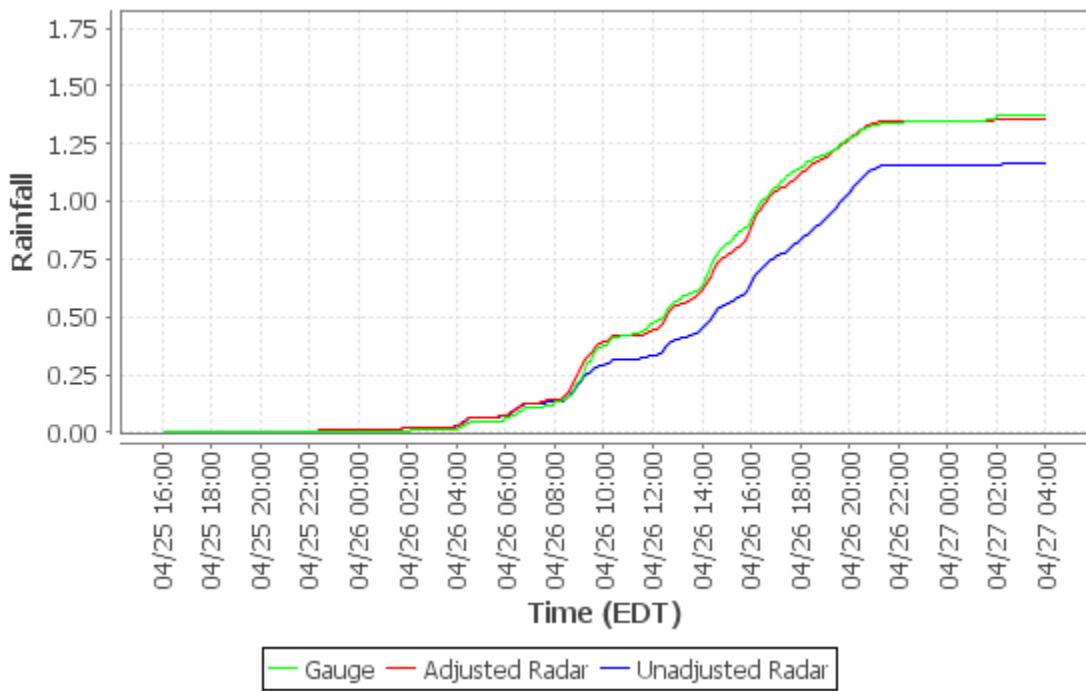
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



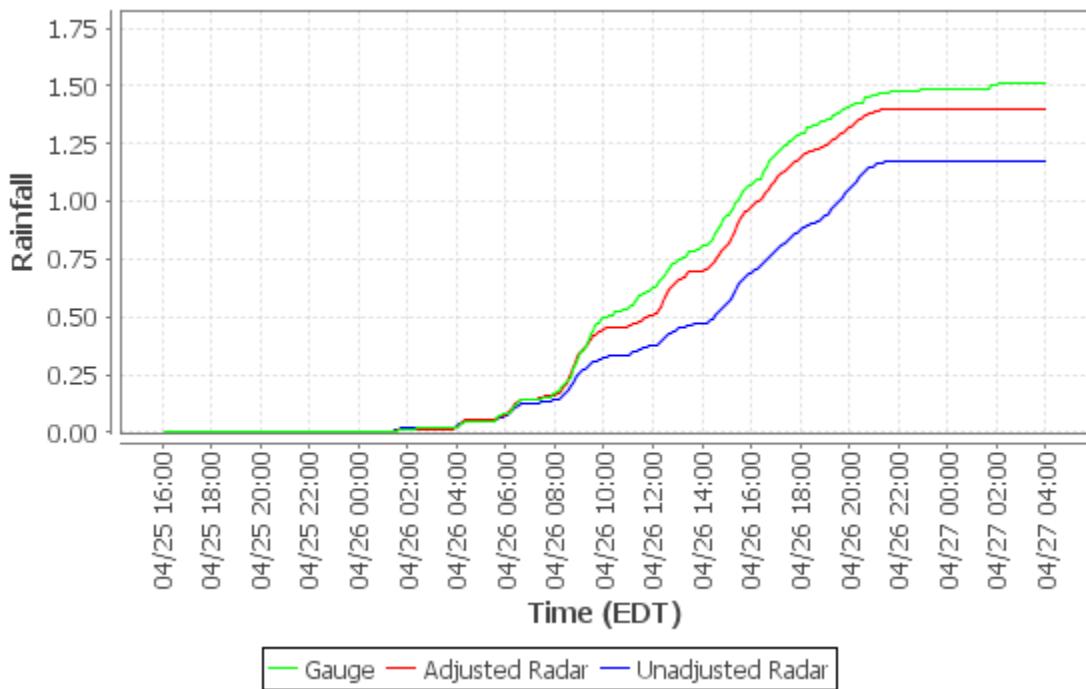
Cumulative Distribution Plot - Jefferson Hills (Loc24)



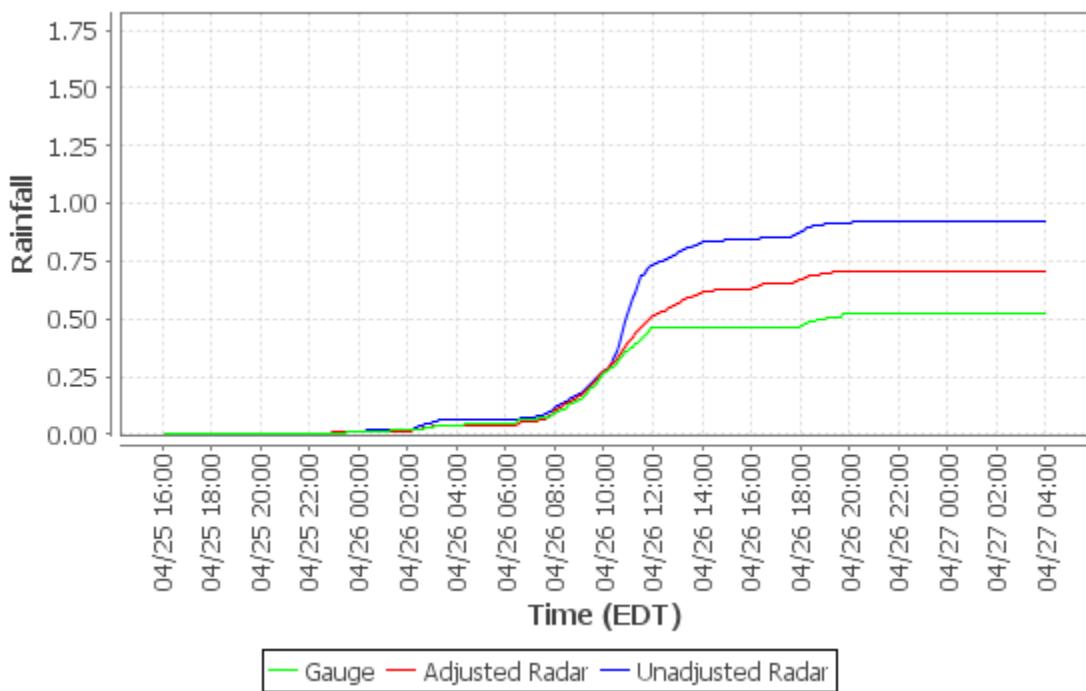
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



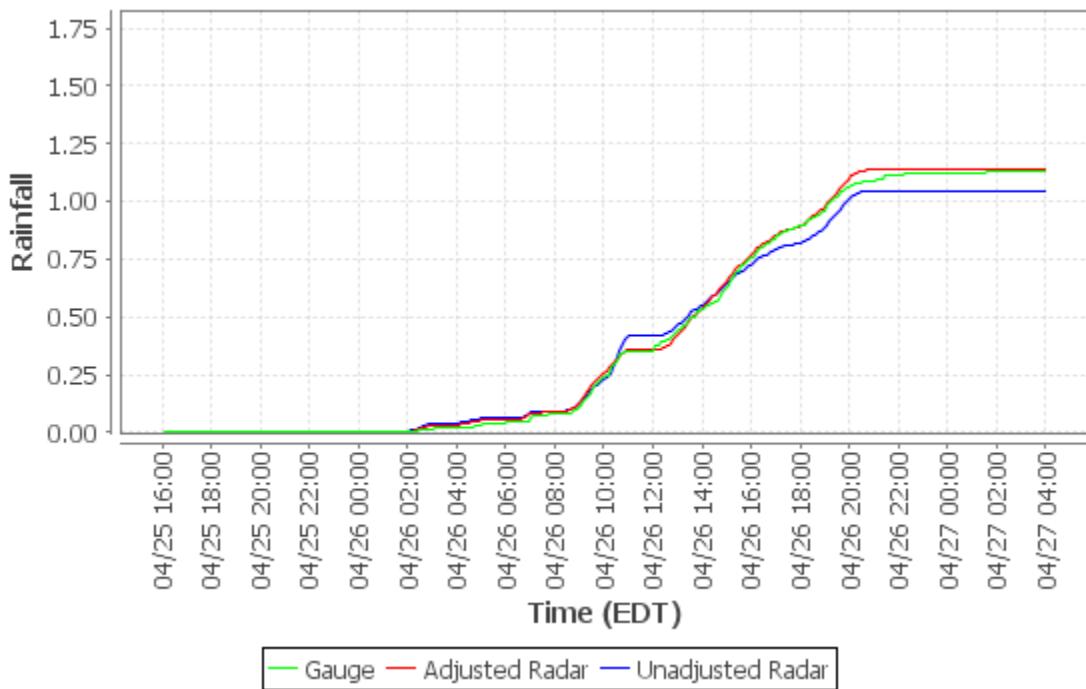
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



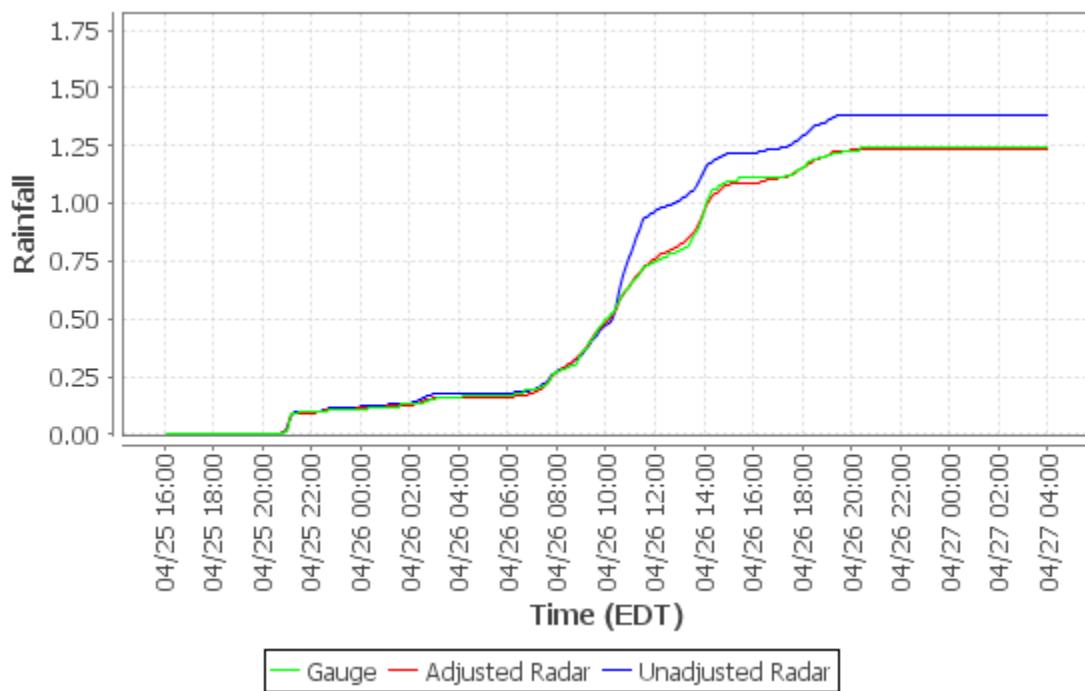
Cumulative Distribution Plot - Marshall TWP (Loc27)



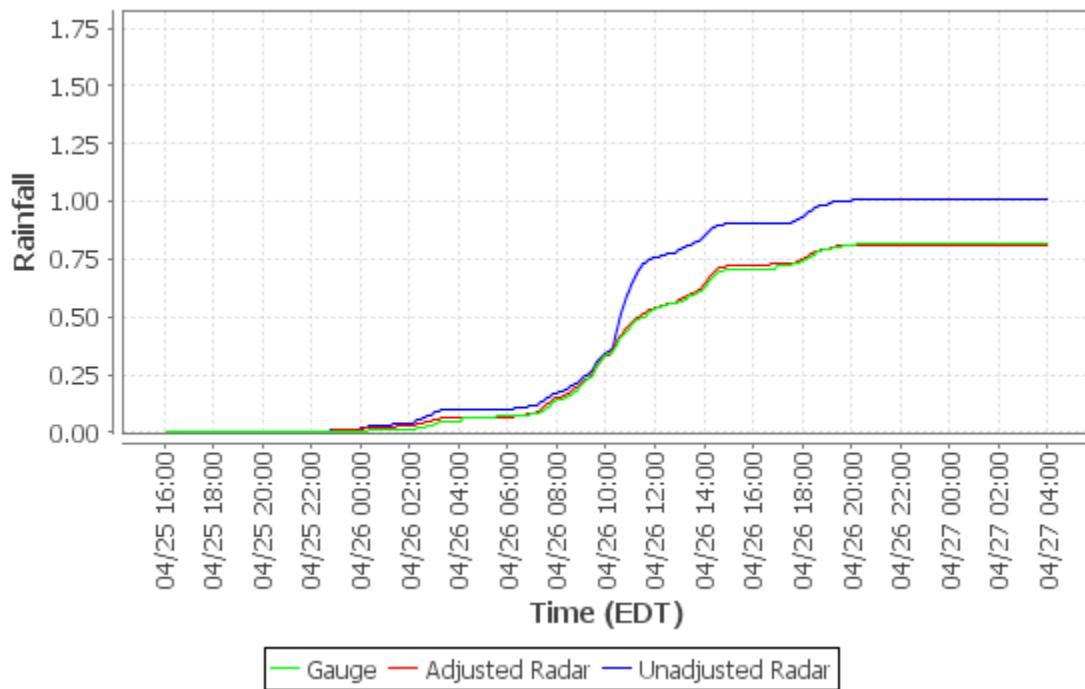
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



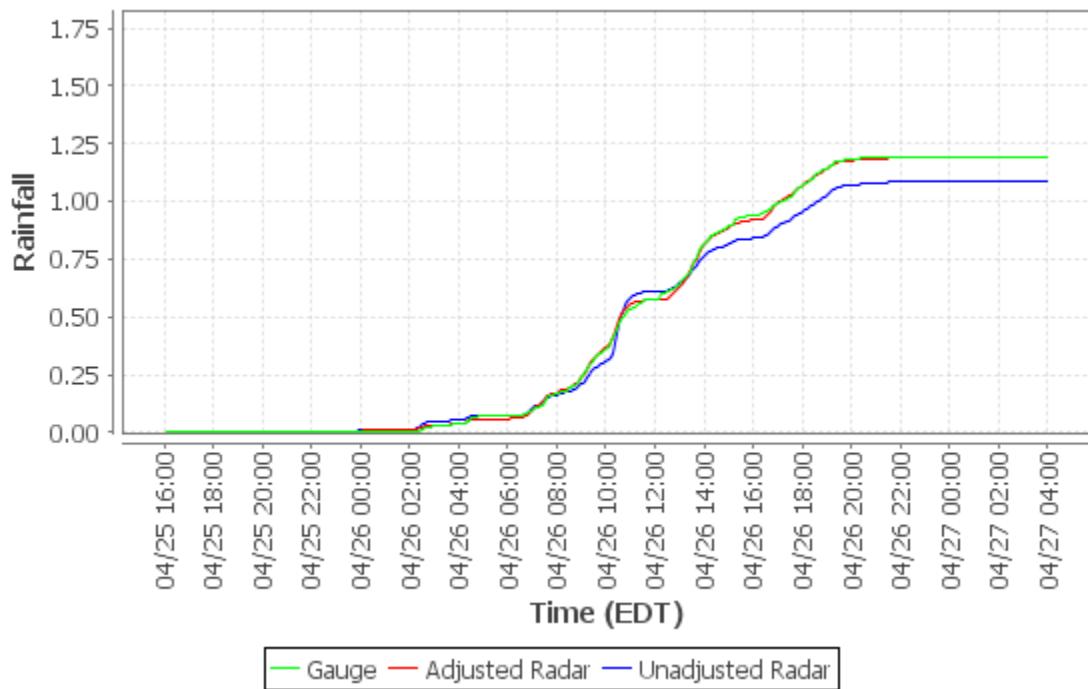
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



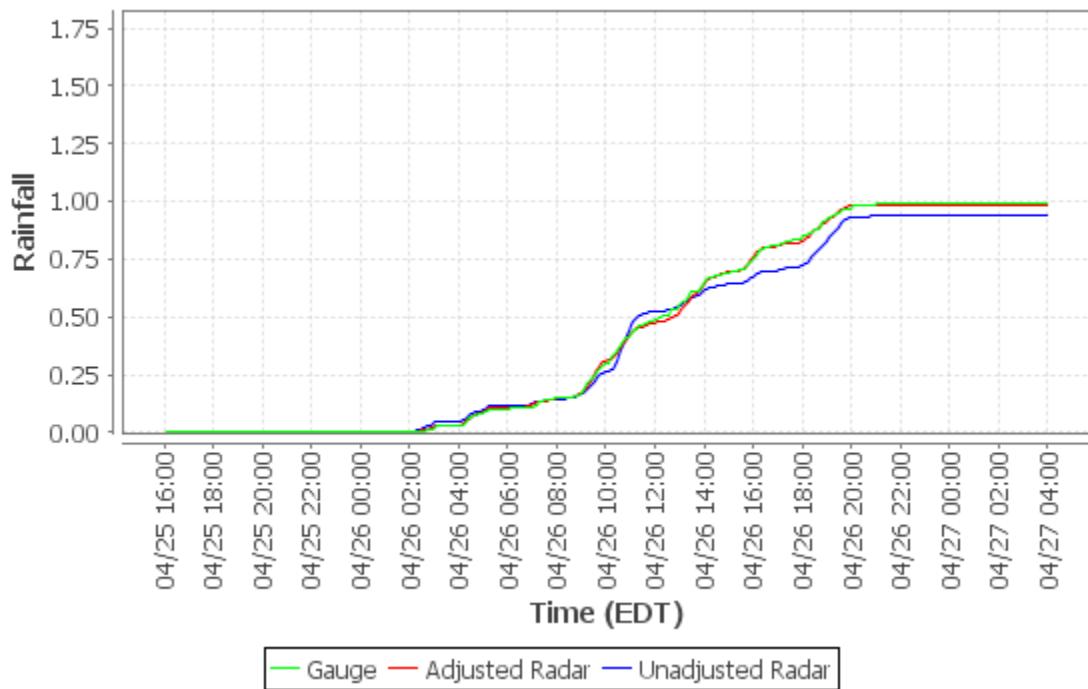
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



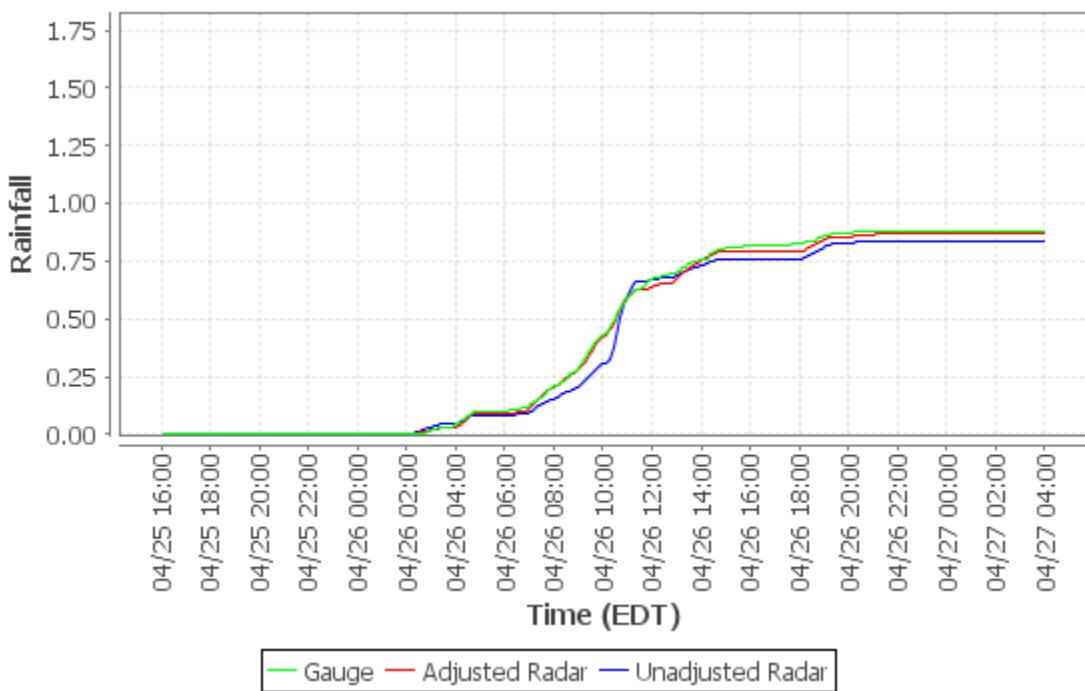
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



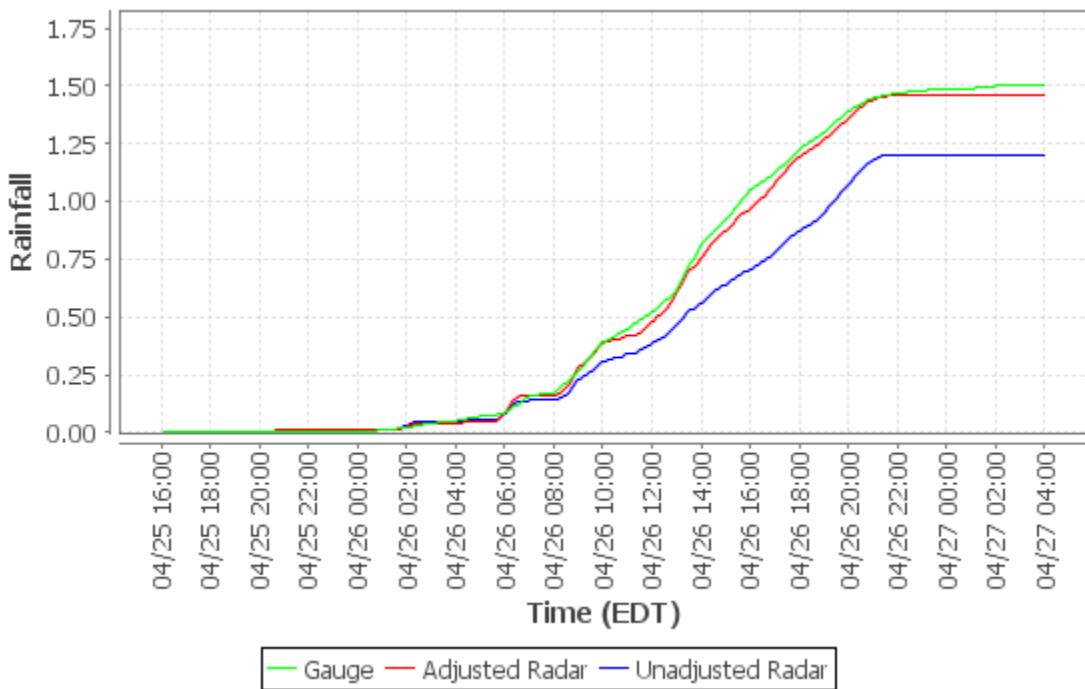
Cumulative Distribution Plot - Arnold (Loc32)



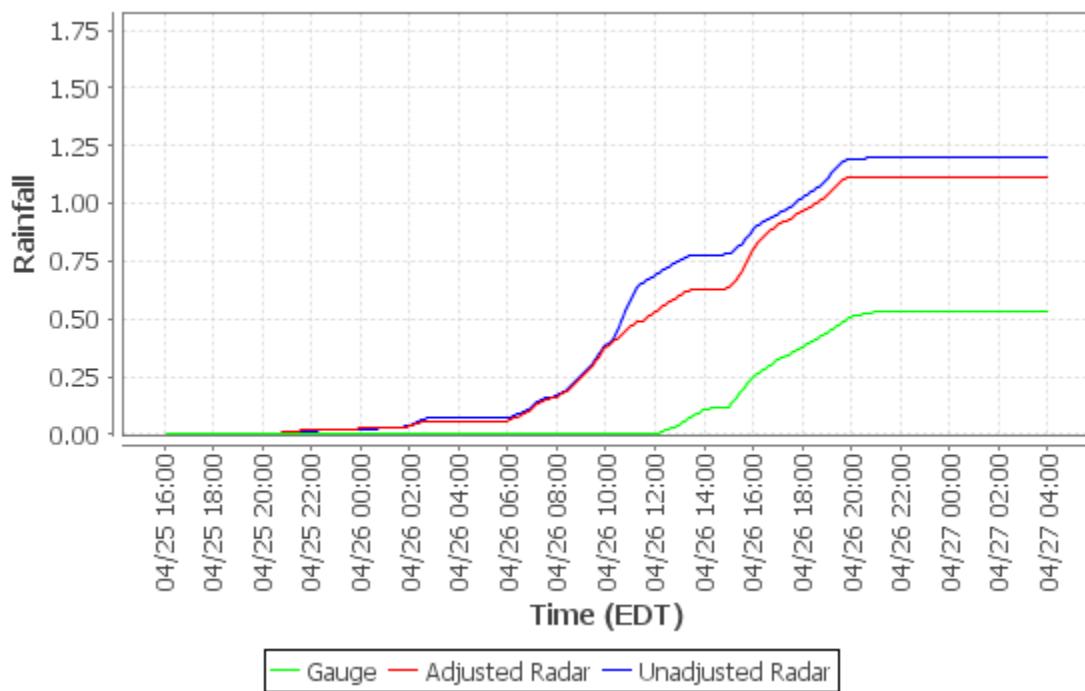
Cumulative Distribution Plot - Richland TWP (Loc33)



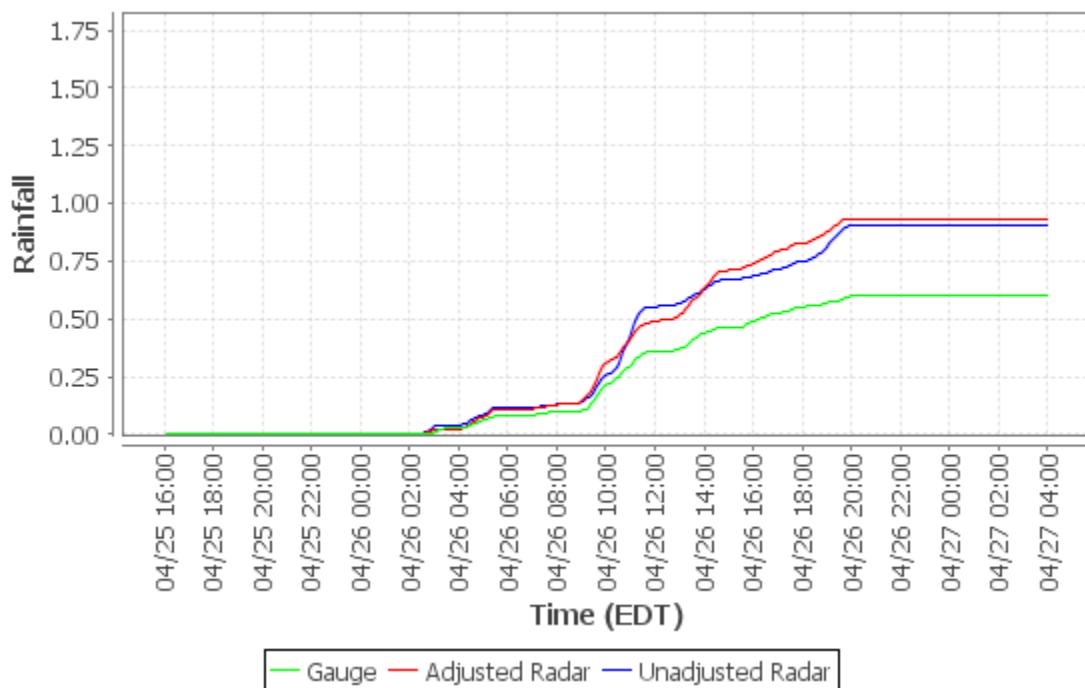
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



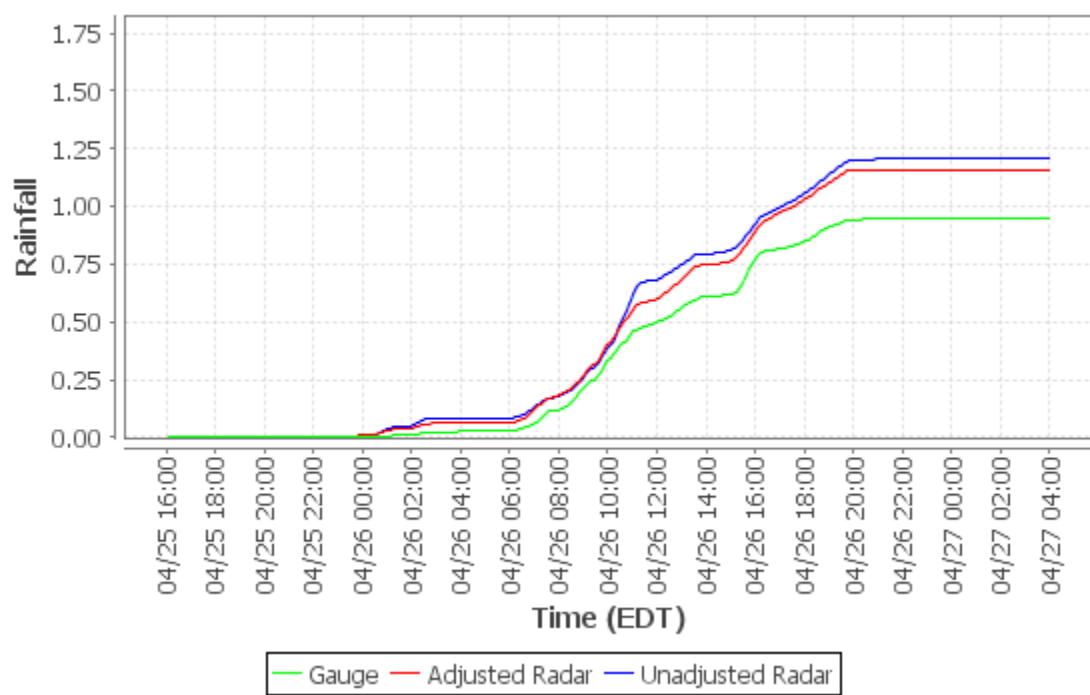
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

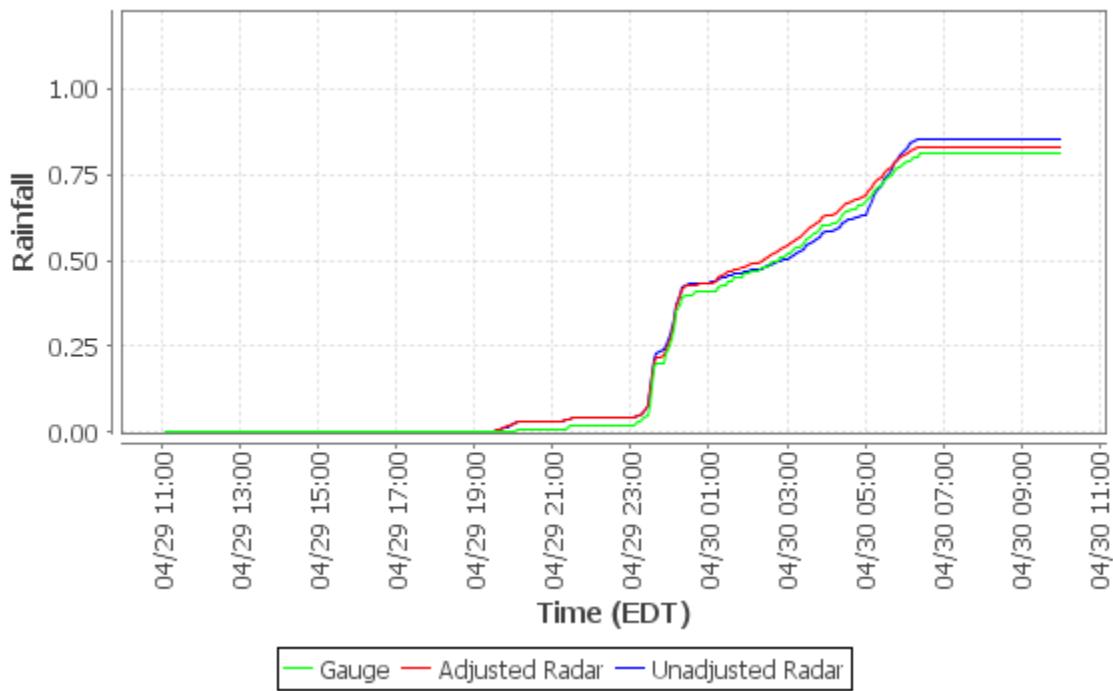


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

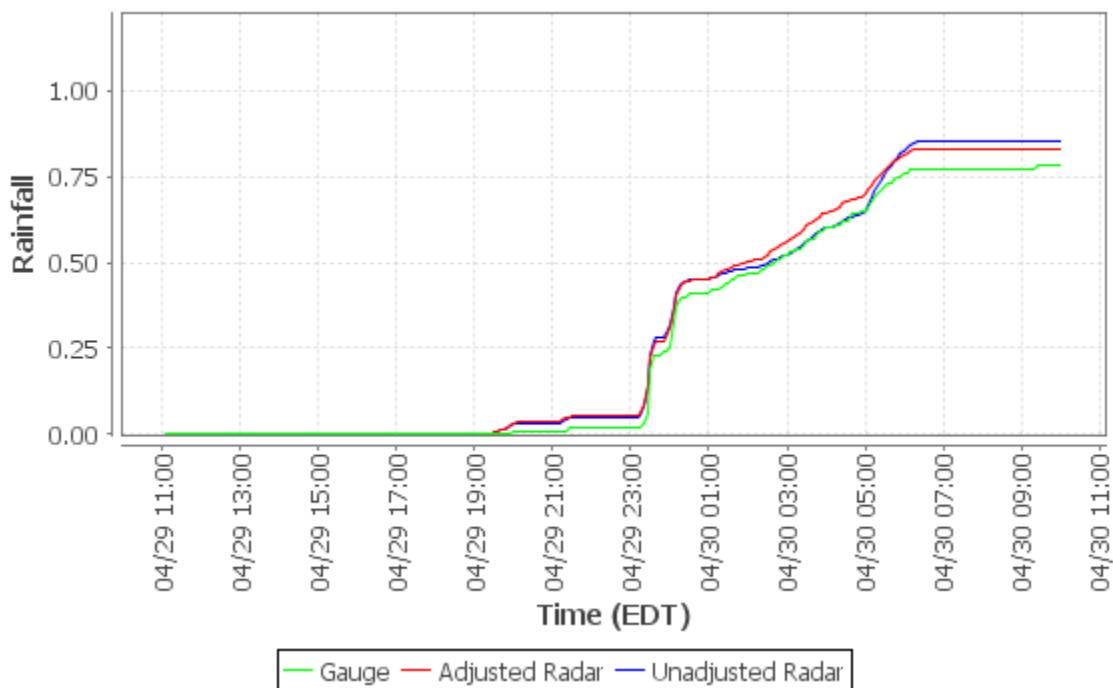


Appendix J - Event 8 (2020-04-30) CDPs

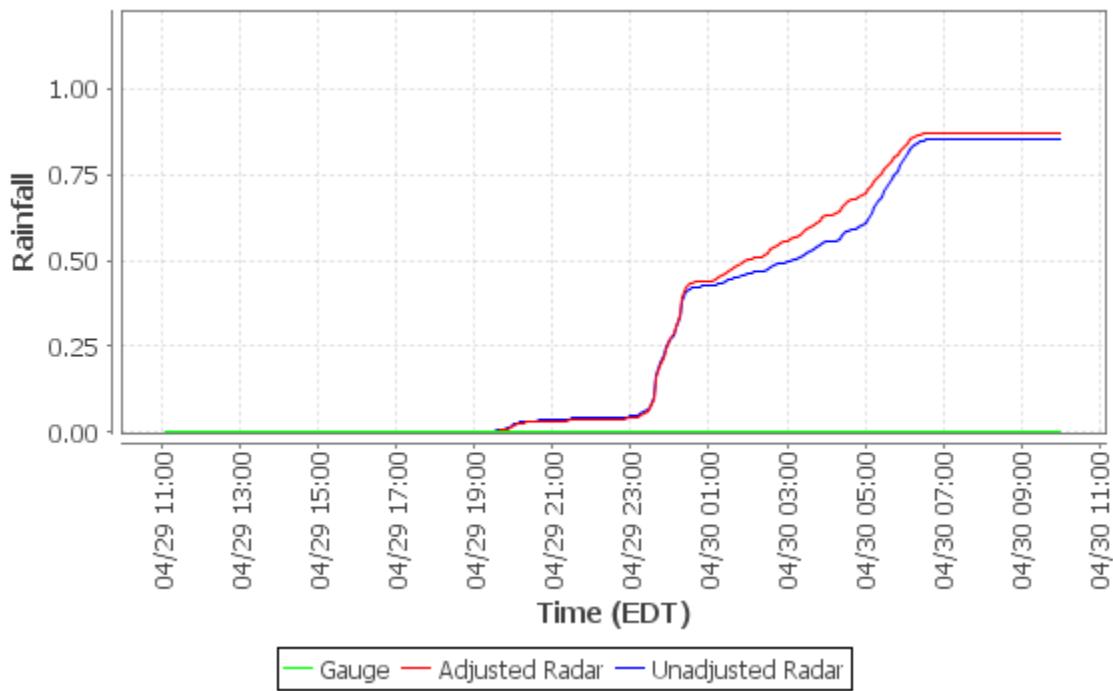
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



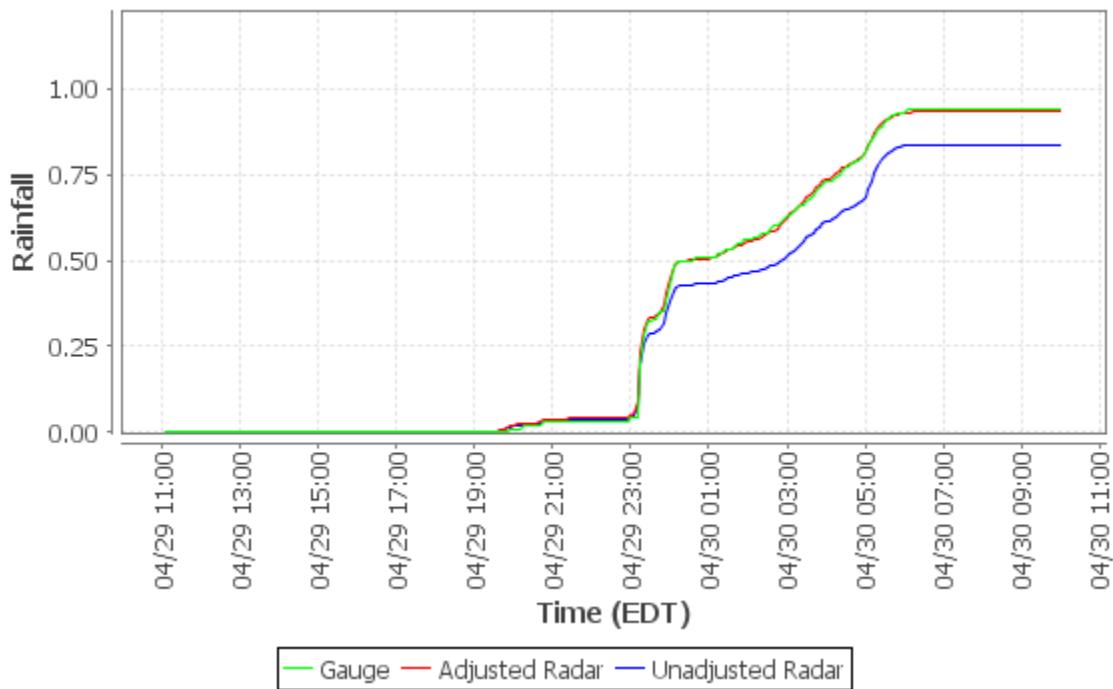
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



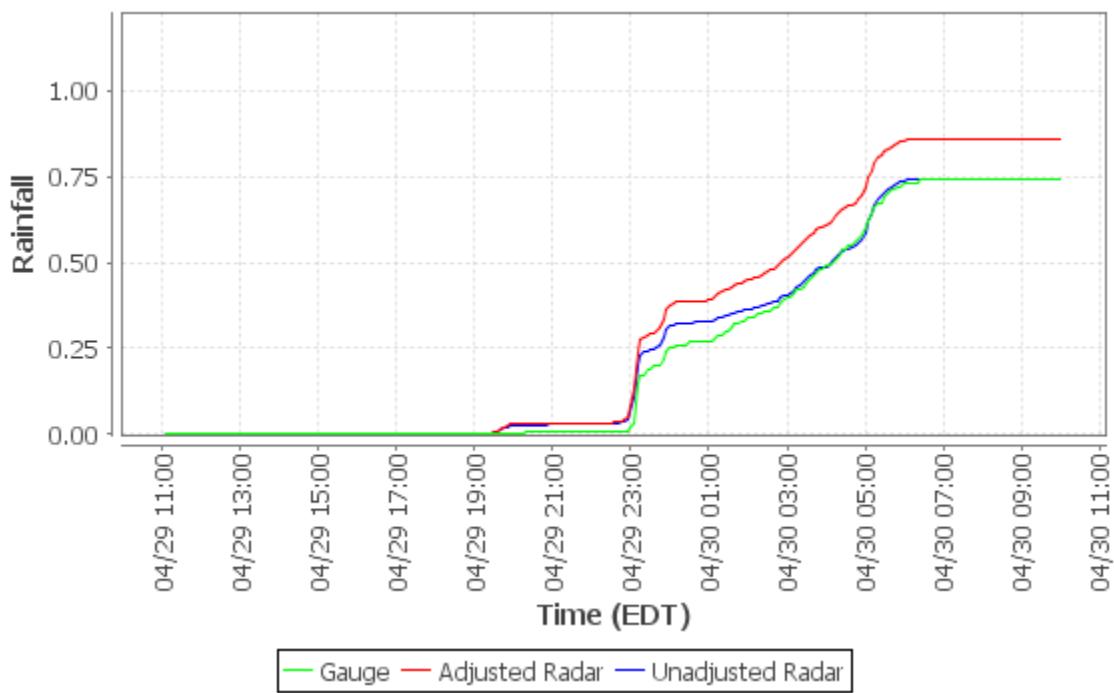
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



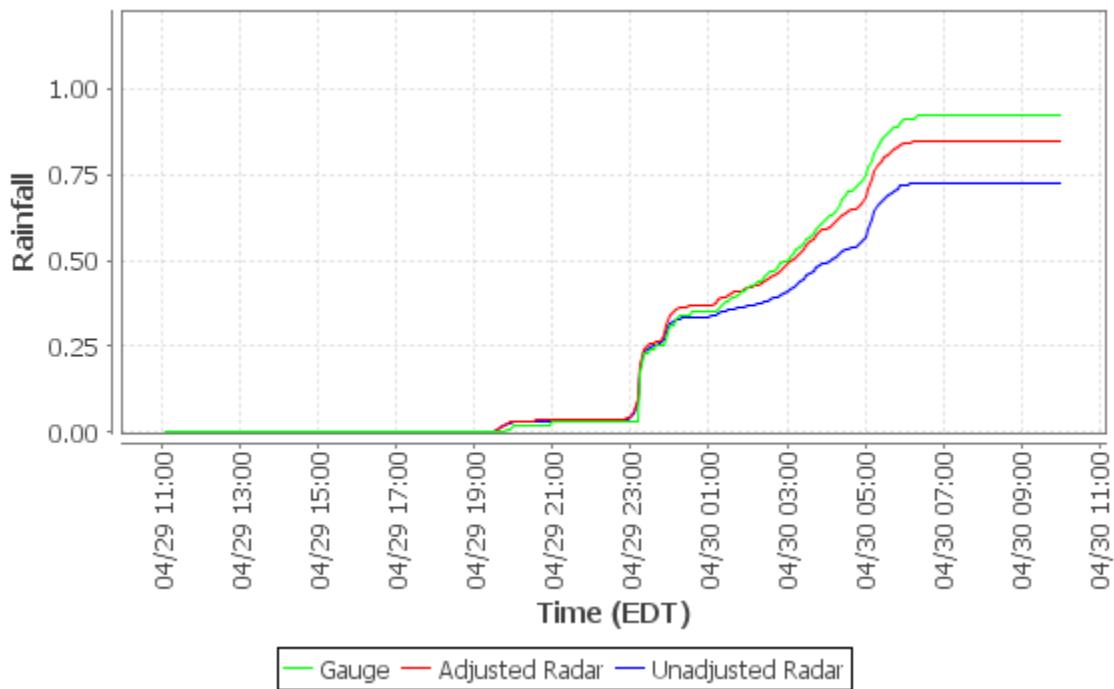
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



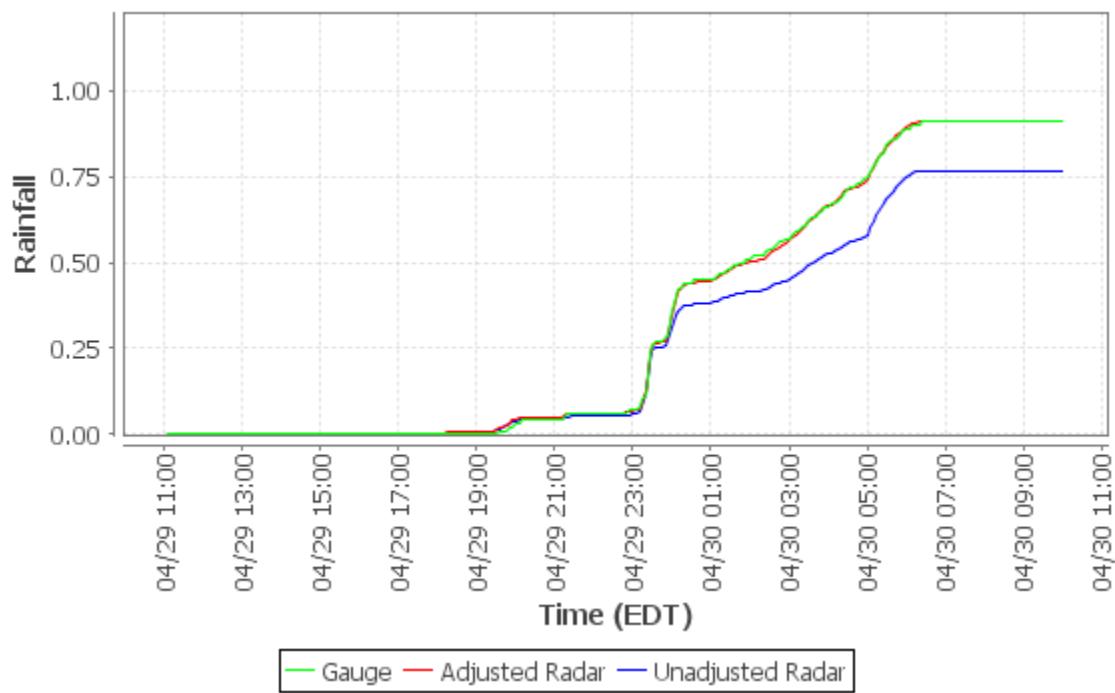
Cumulative Distribution Plot - Upper St. Clair (Loc05)



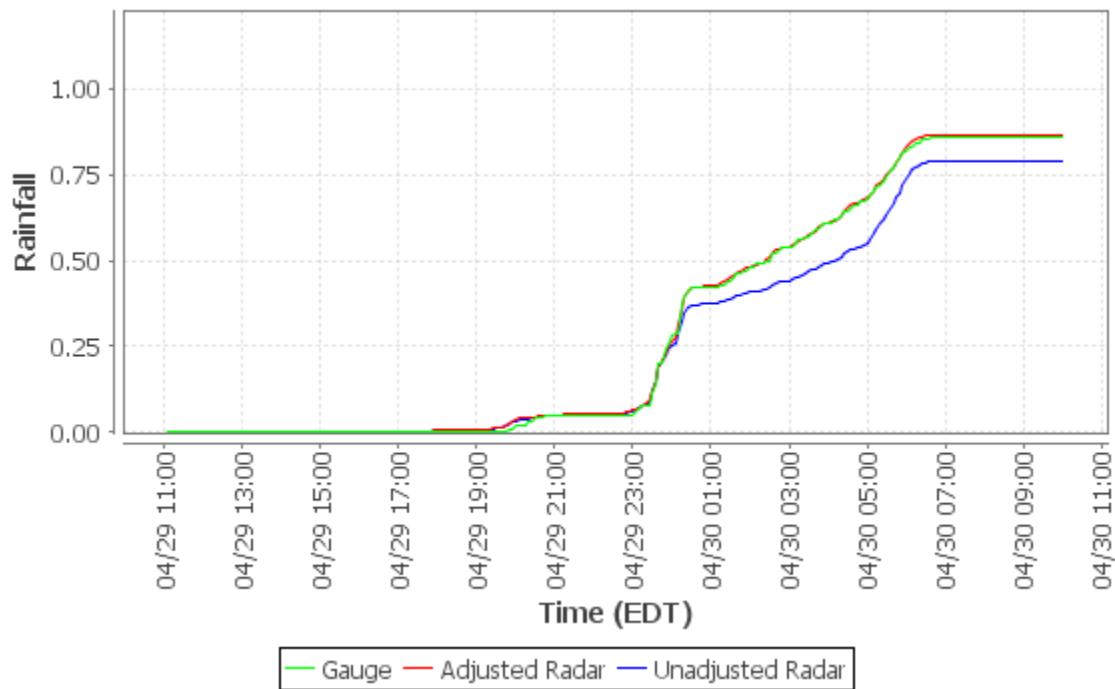
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



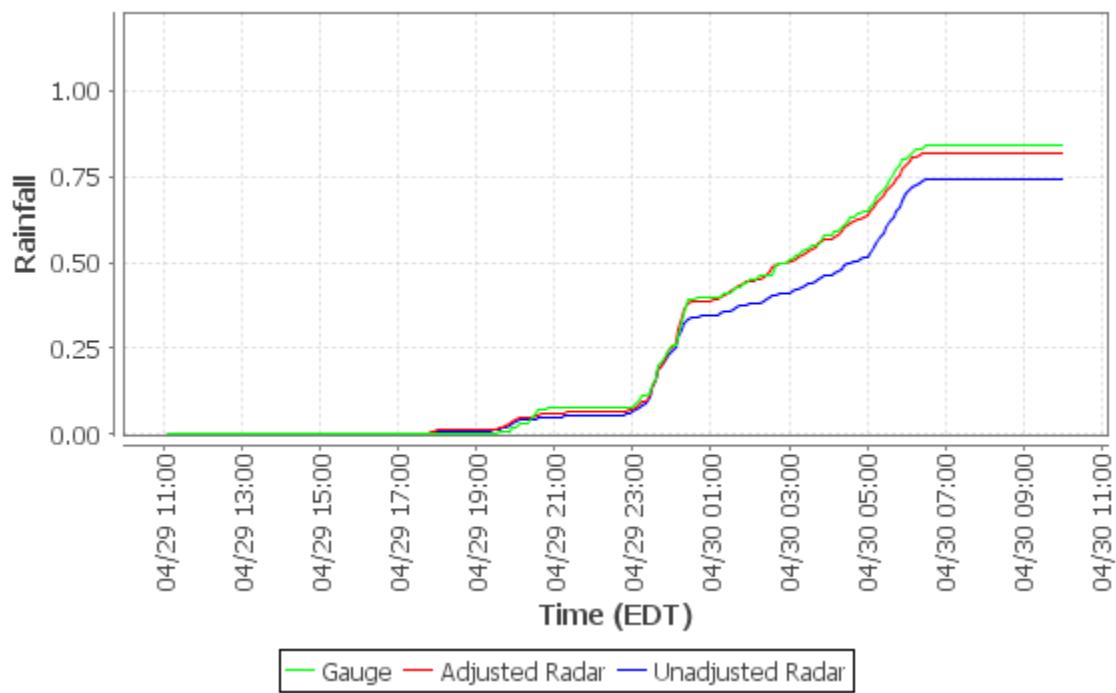
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



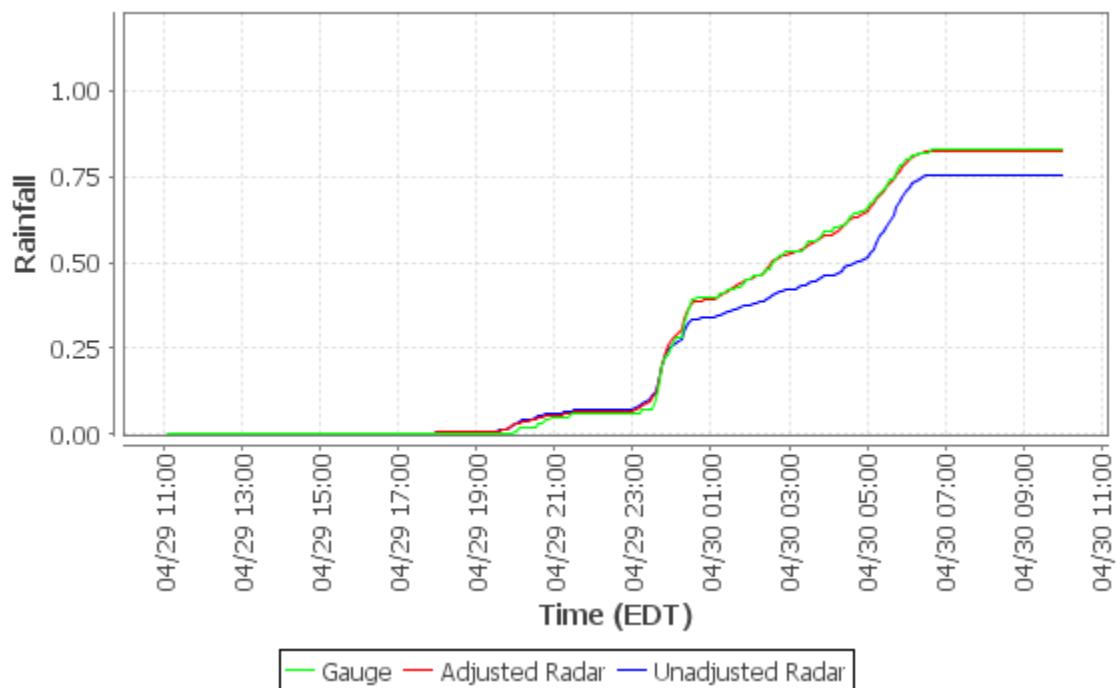
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



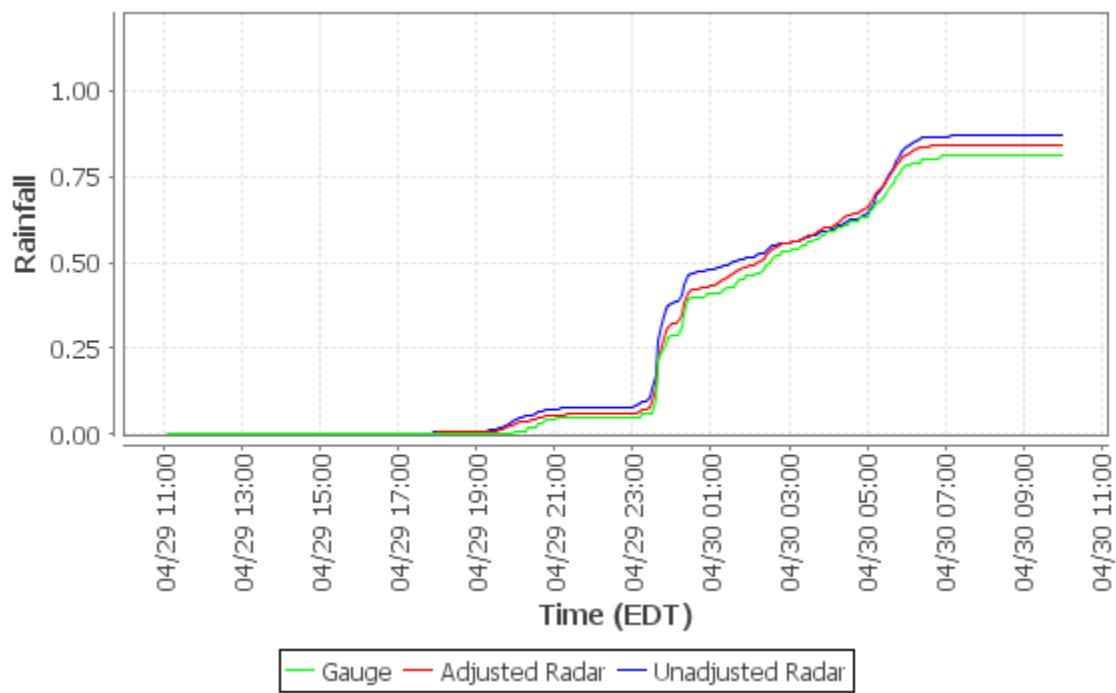
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



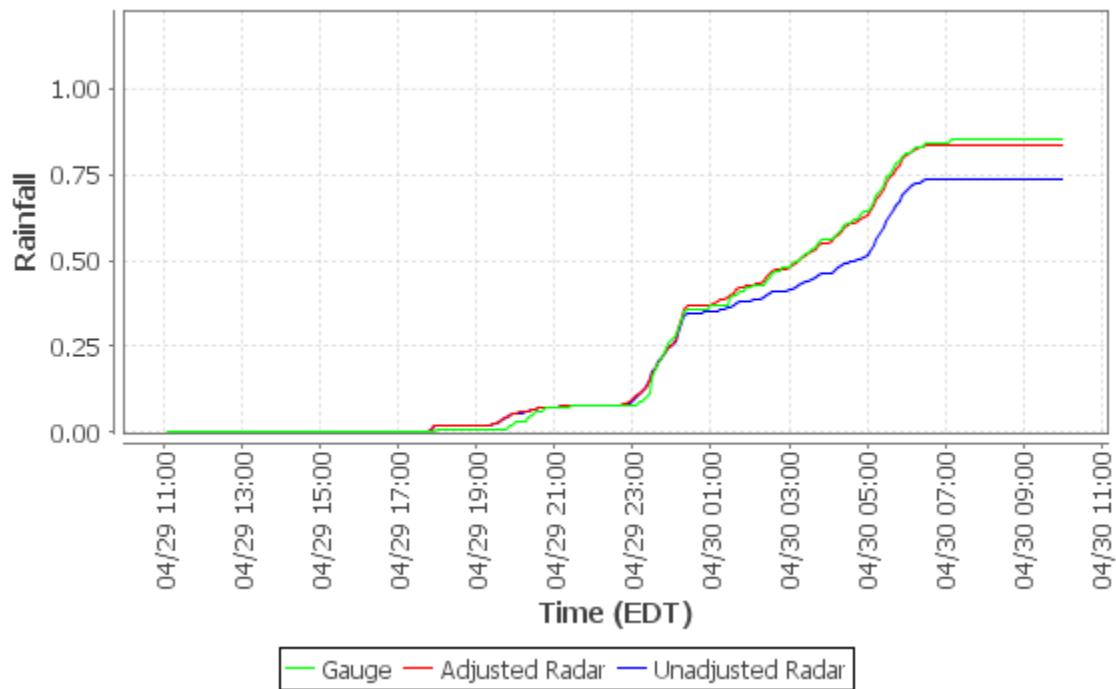
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



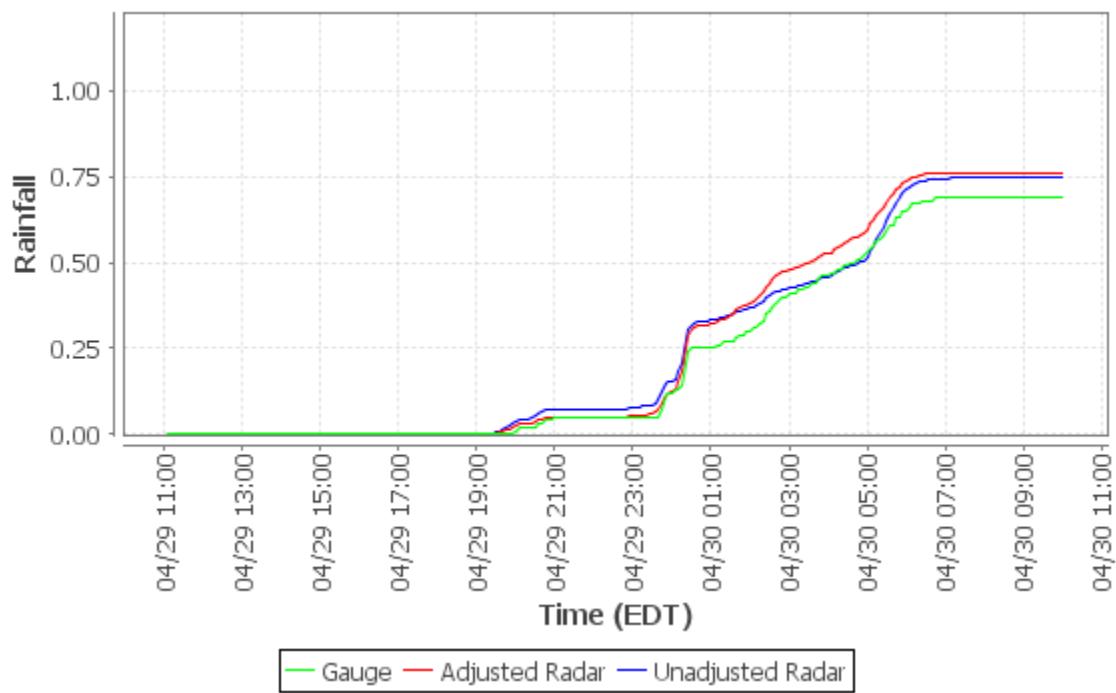
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



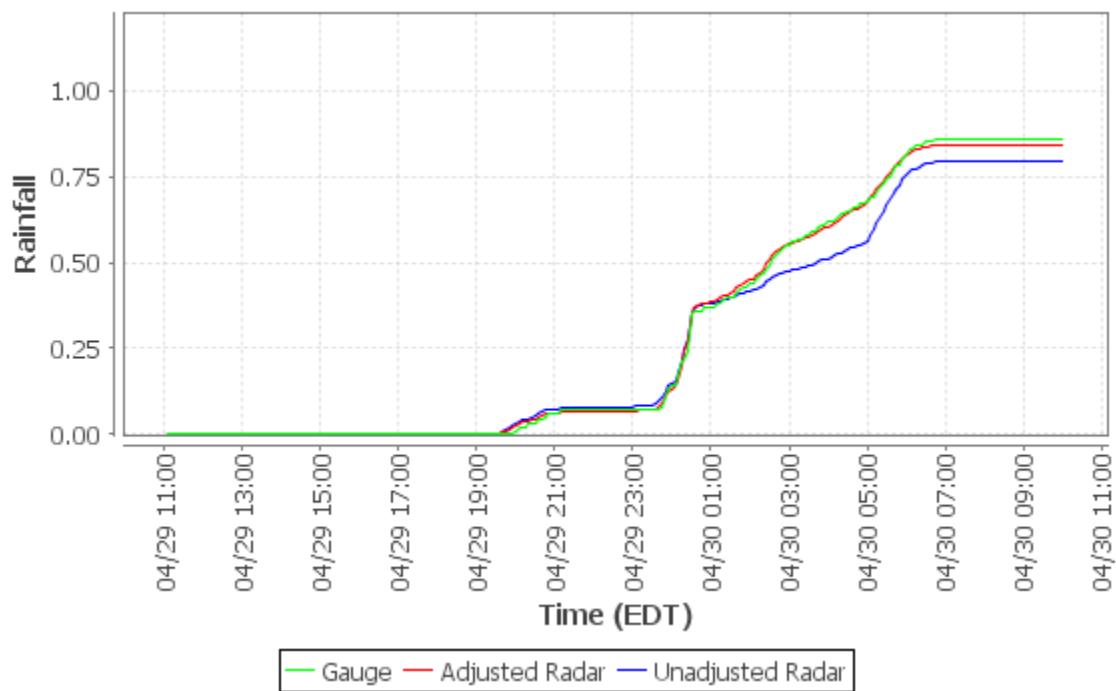
Cumulative Distribution Plot - Baldwin (Loc12)



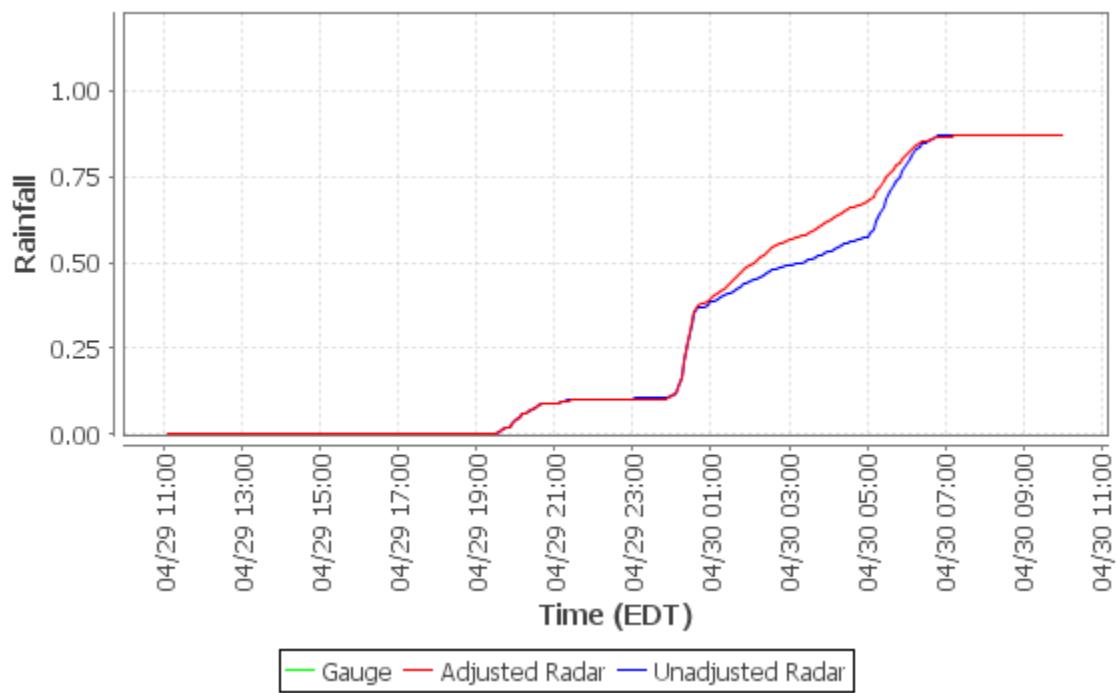
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



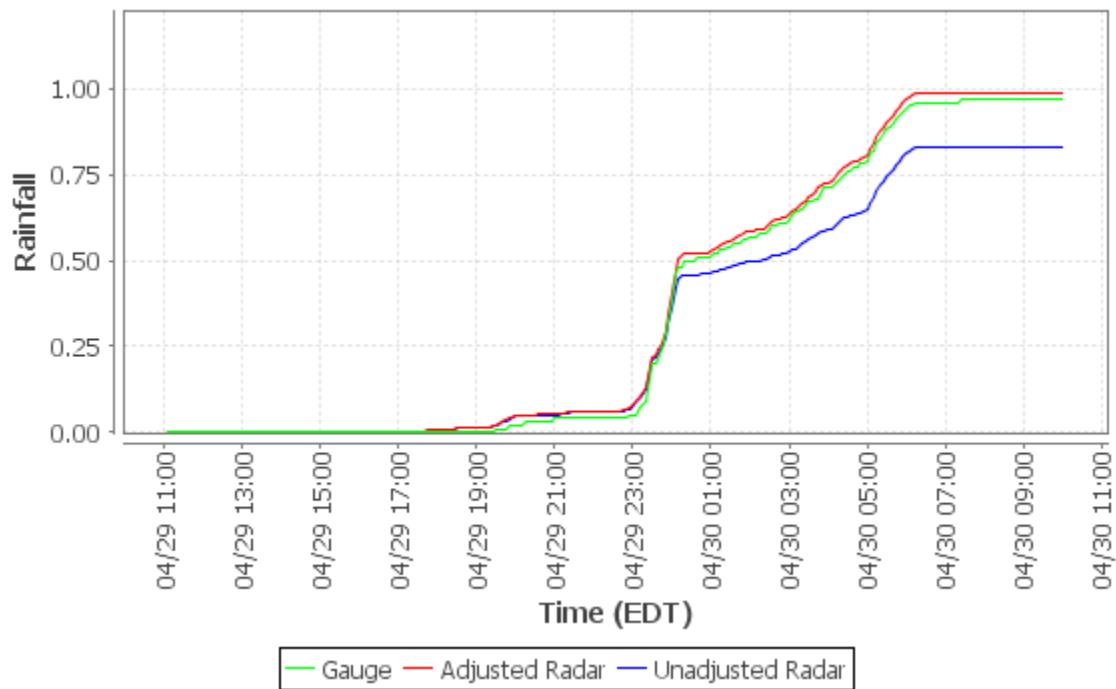
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



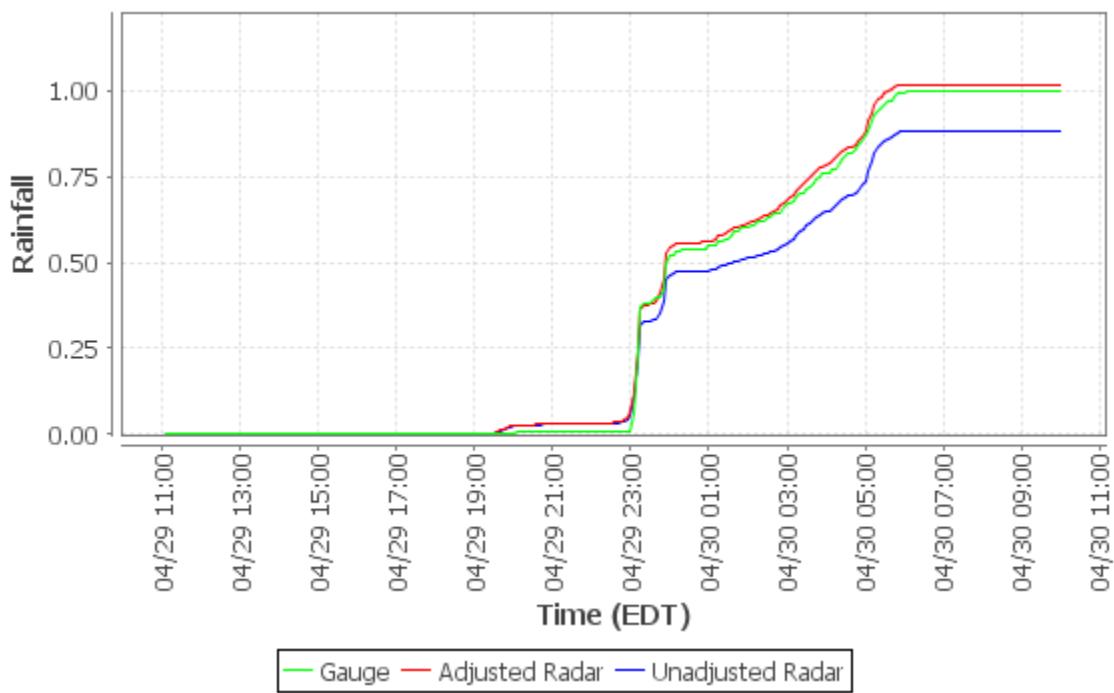
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



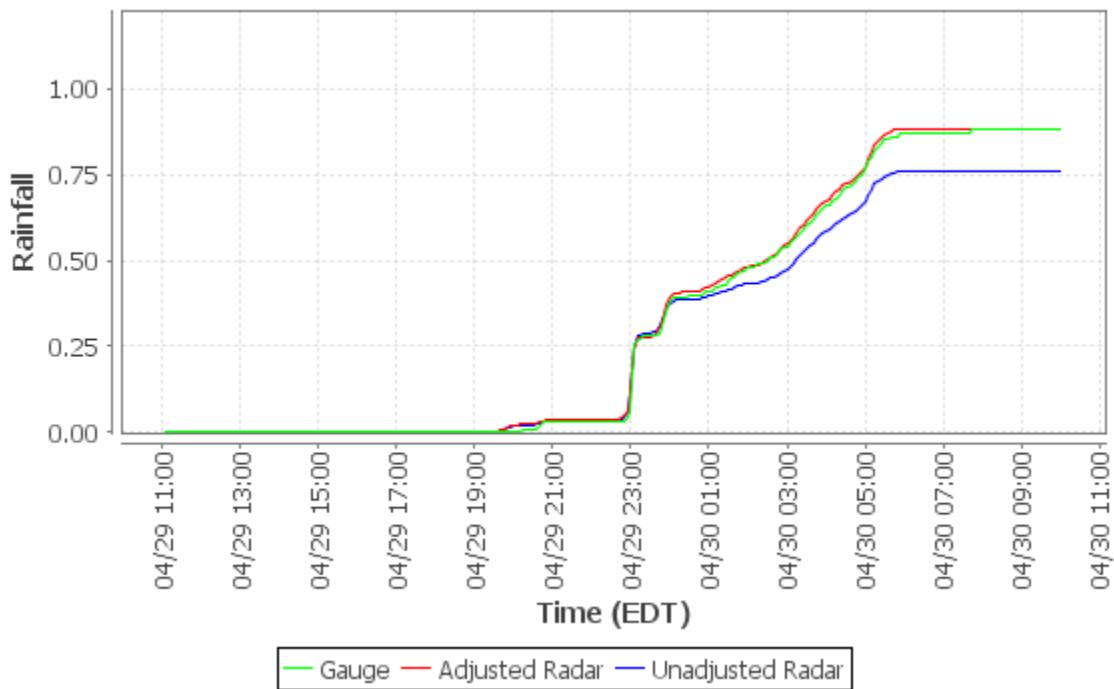
Cumulative Distribution Plot - Castle Shannon (Loc16)



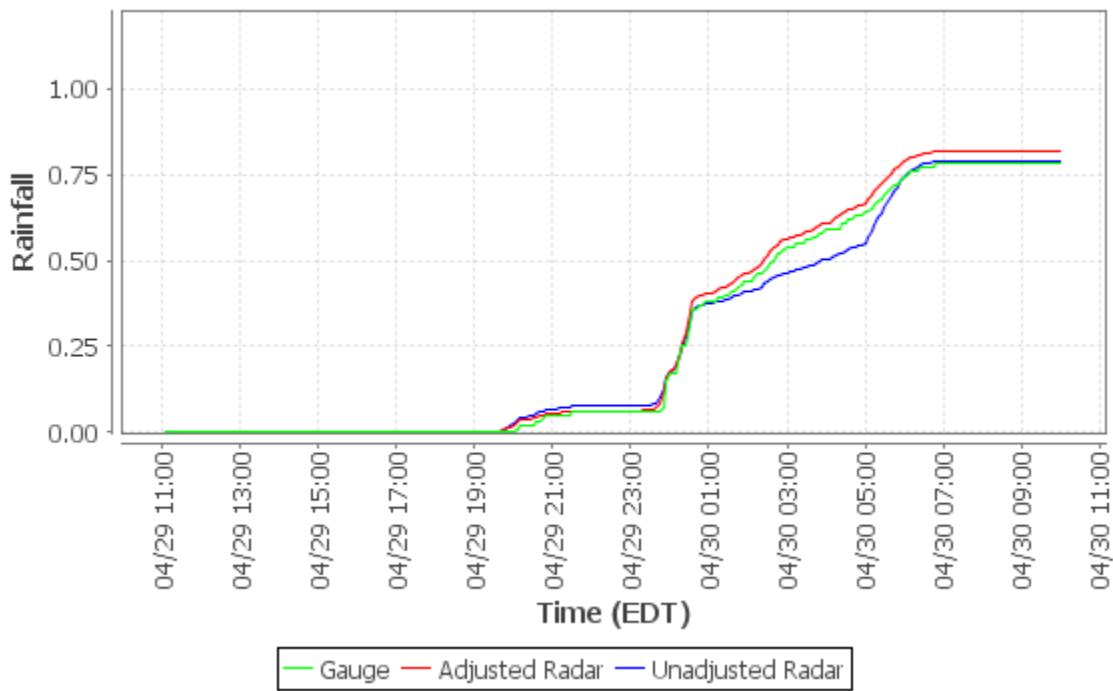
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



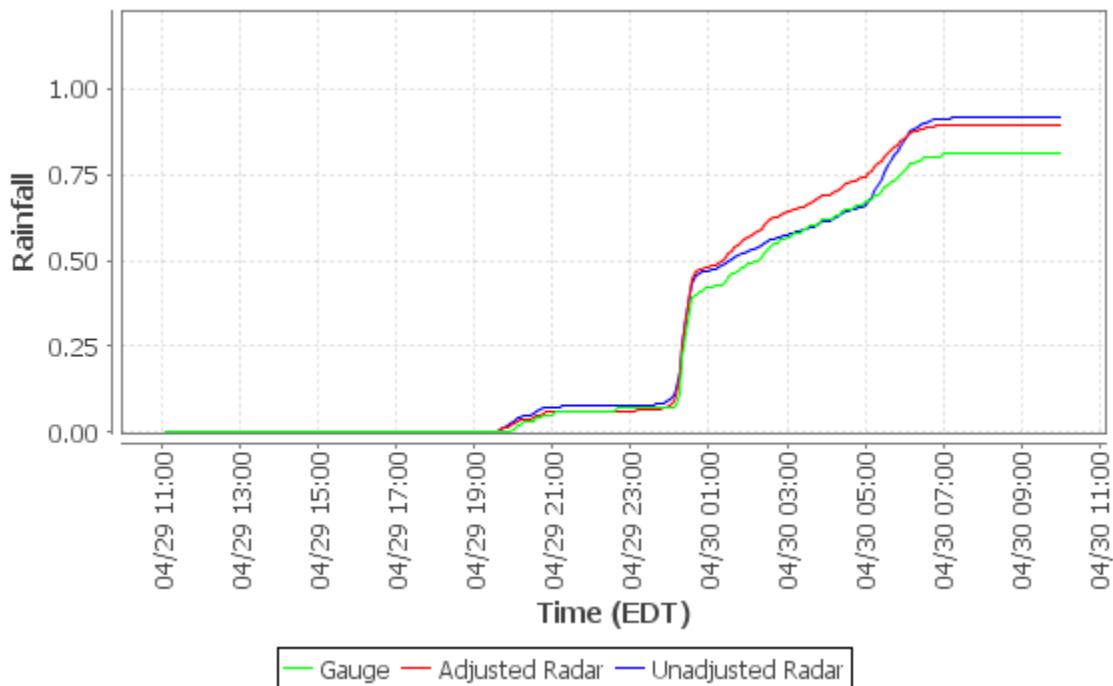
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



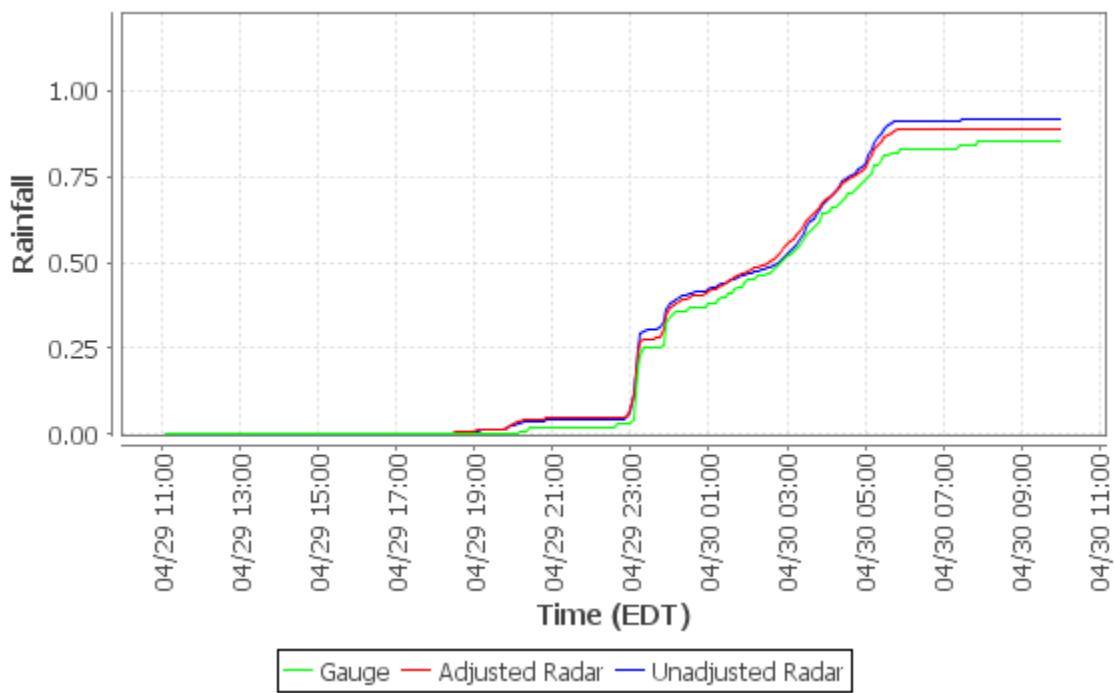
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



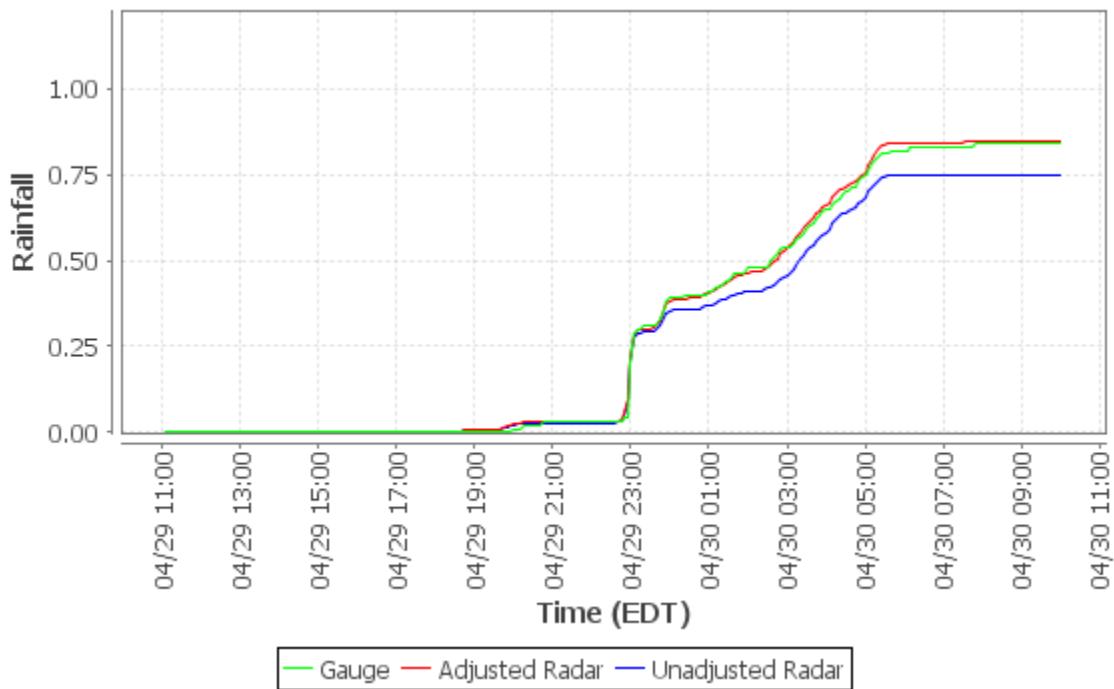
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



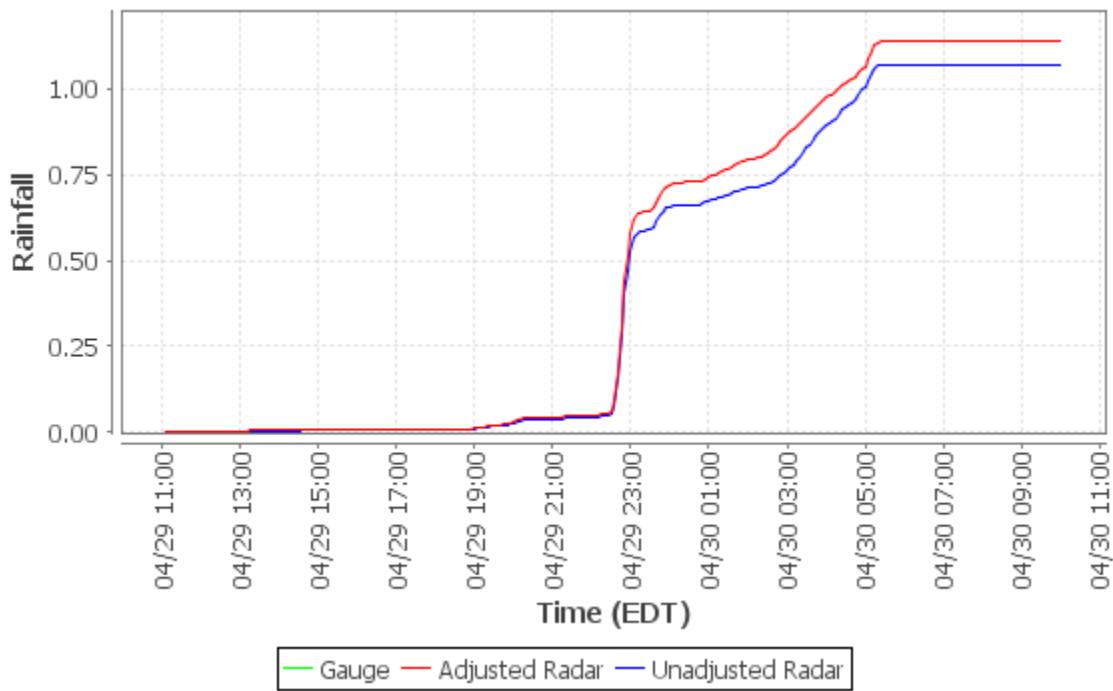
Cumulative Distribution Plot - Moon TWP (Loc21)



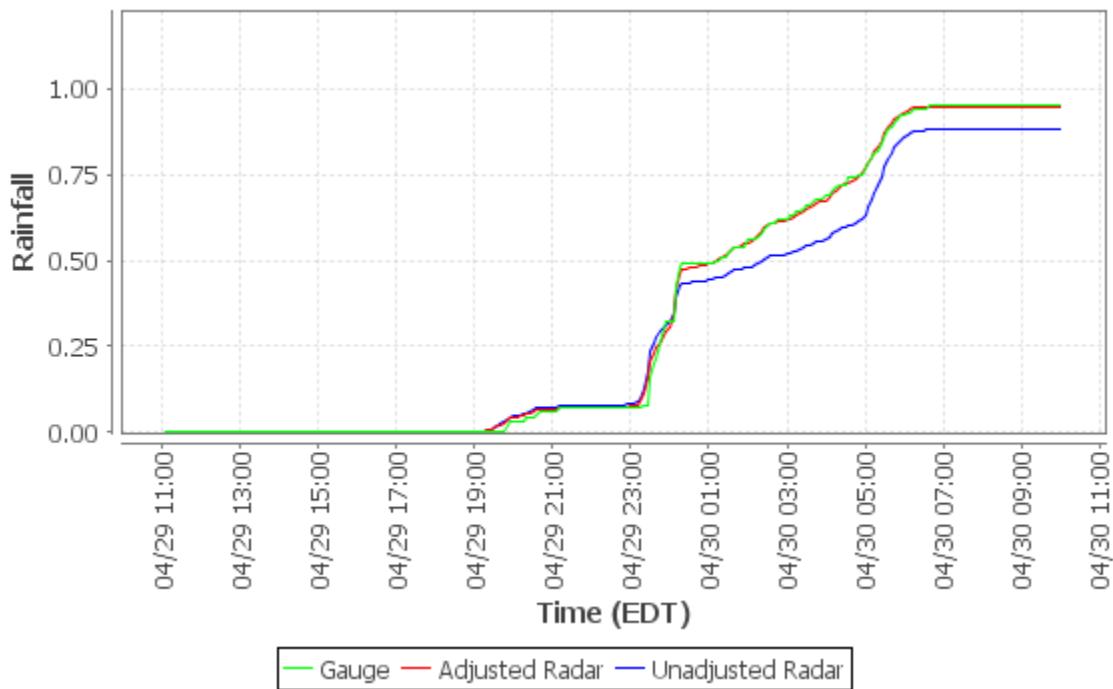
Cumulative Distribution Plot - North Fayette TWP (Loc22)



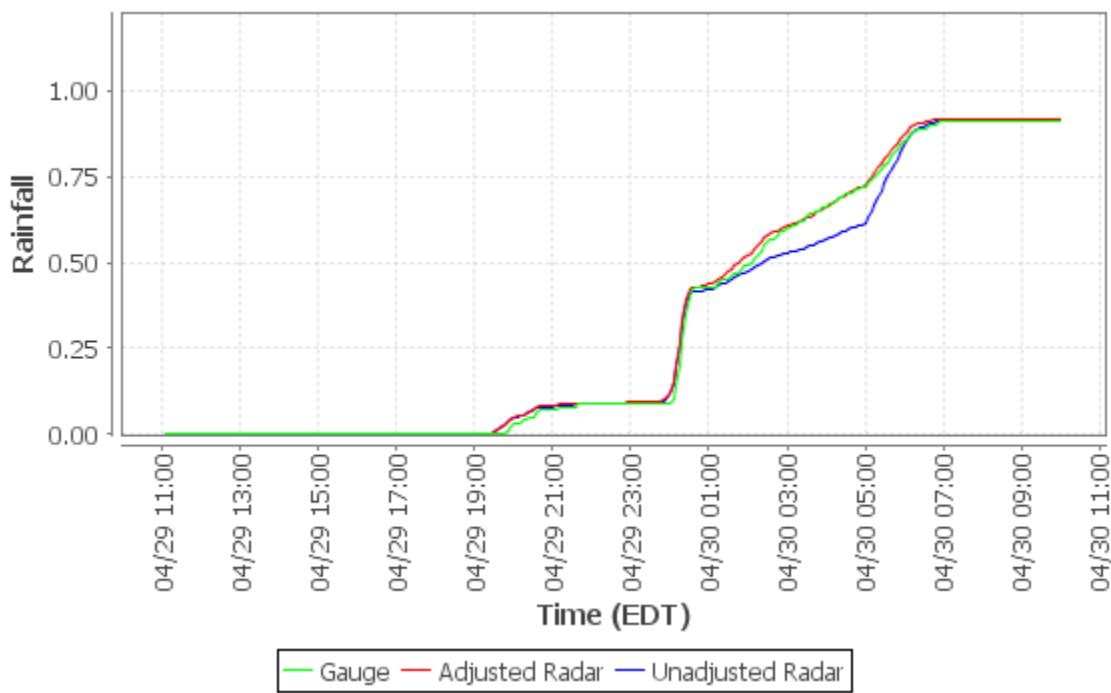
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



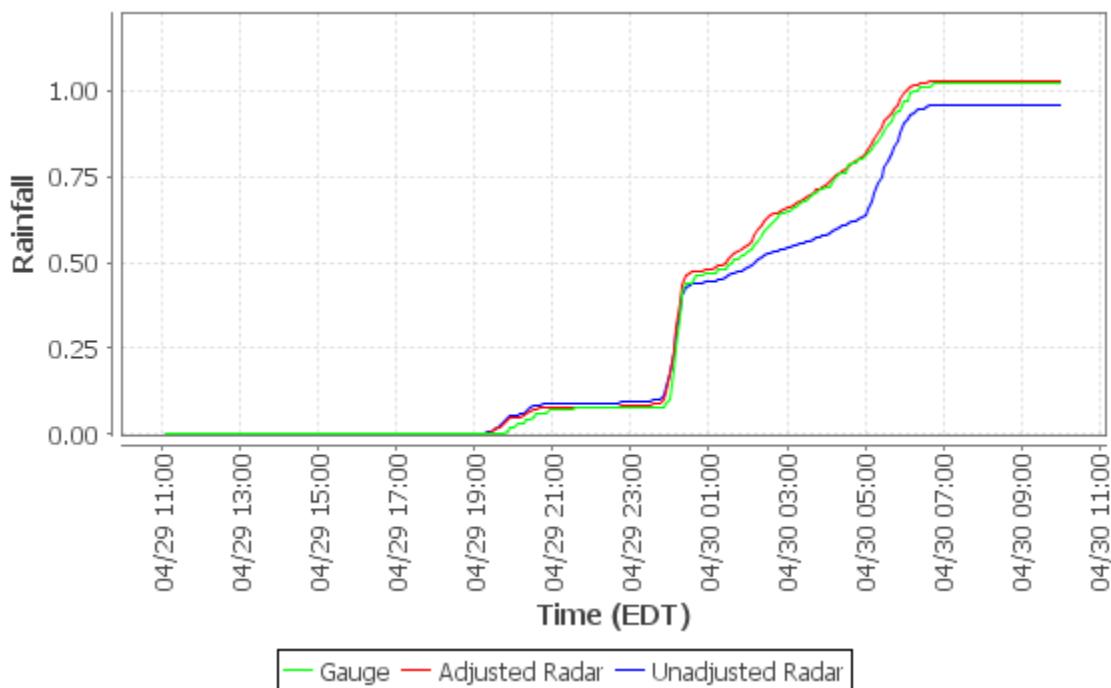
Cumulative Distribution Plot - Jefferson Hills (Loc24)



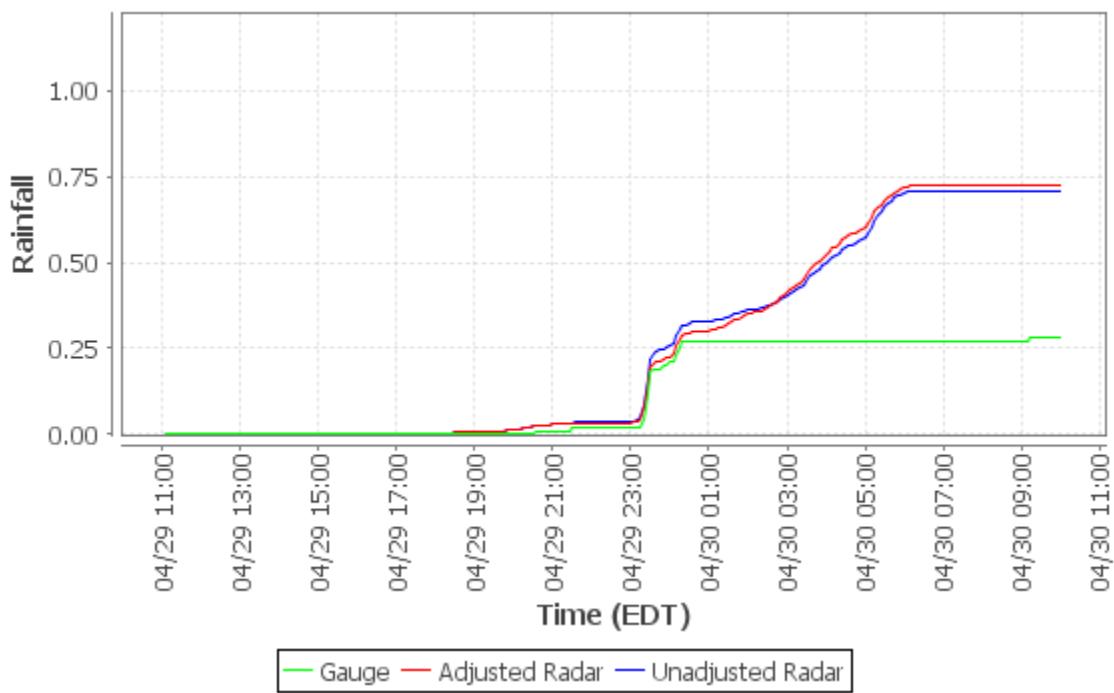
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



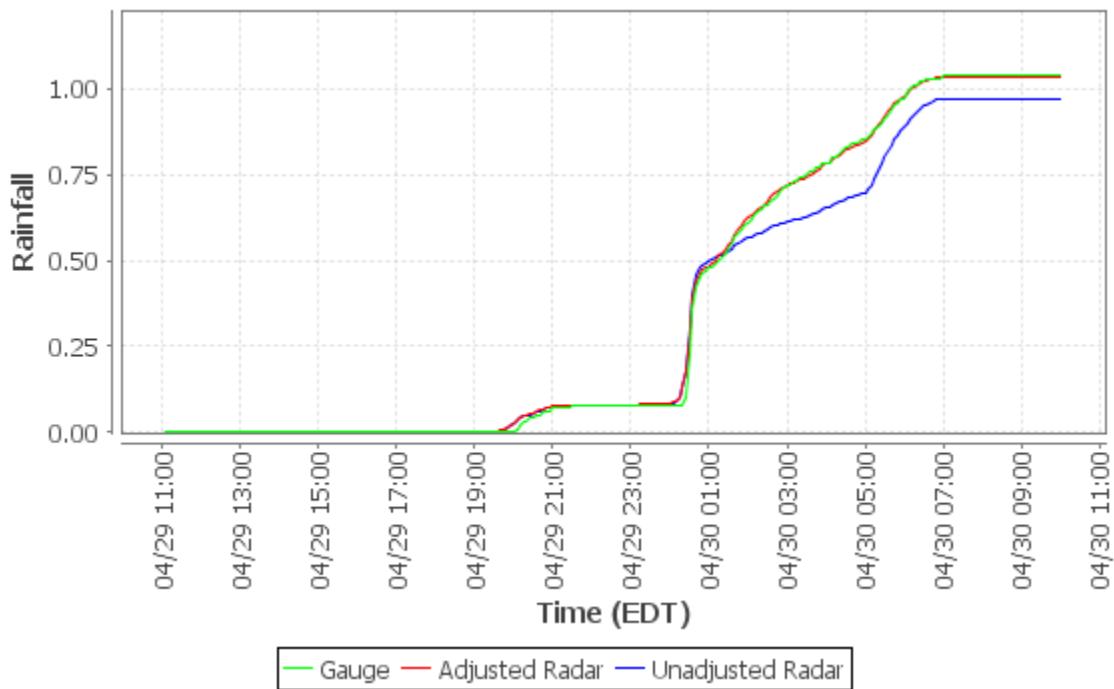
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



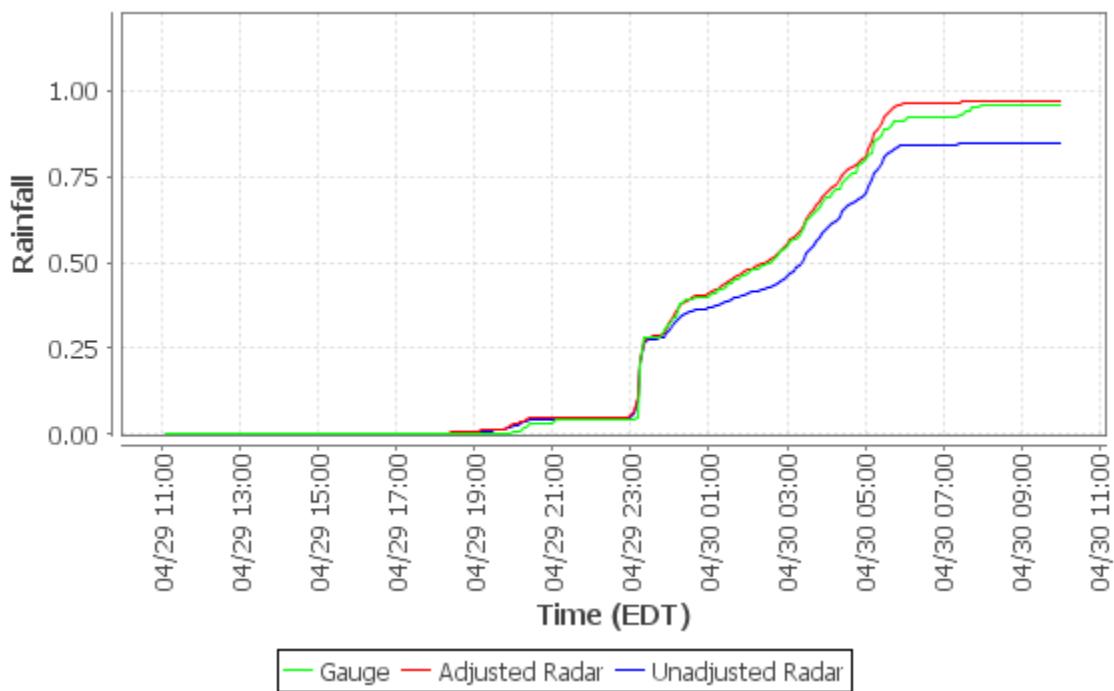
Cumulative Distribution Plot - Marshall TWP (Loc27)



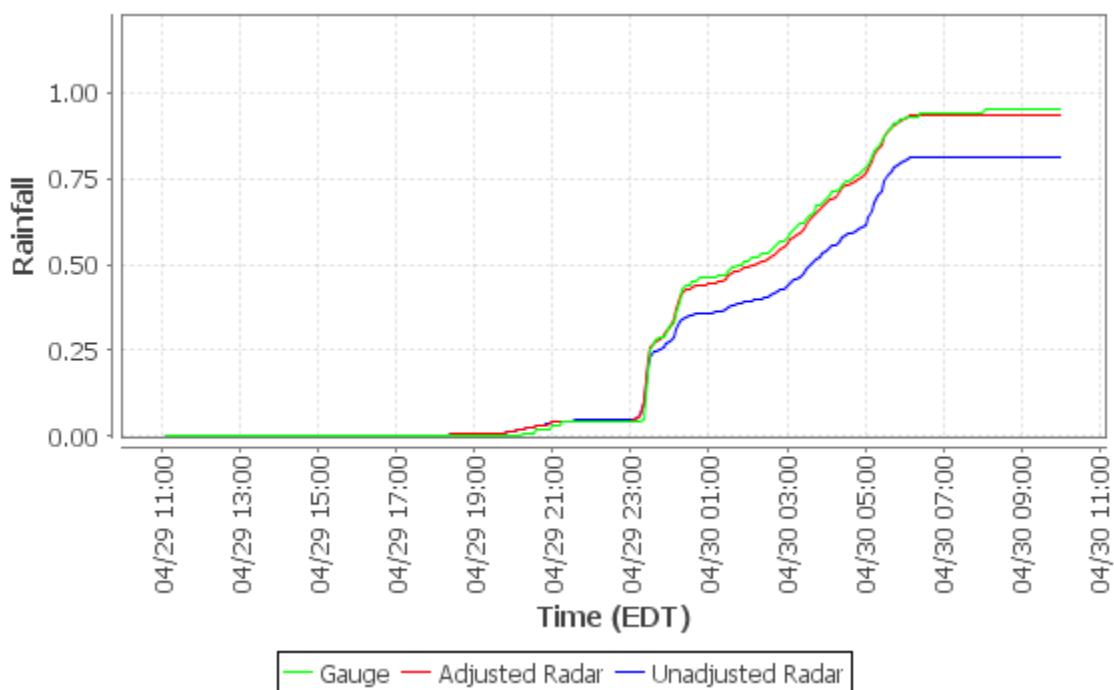
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



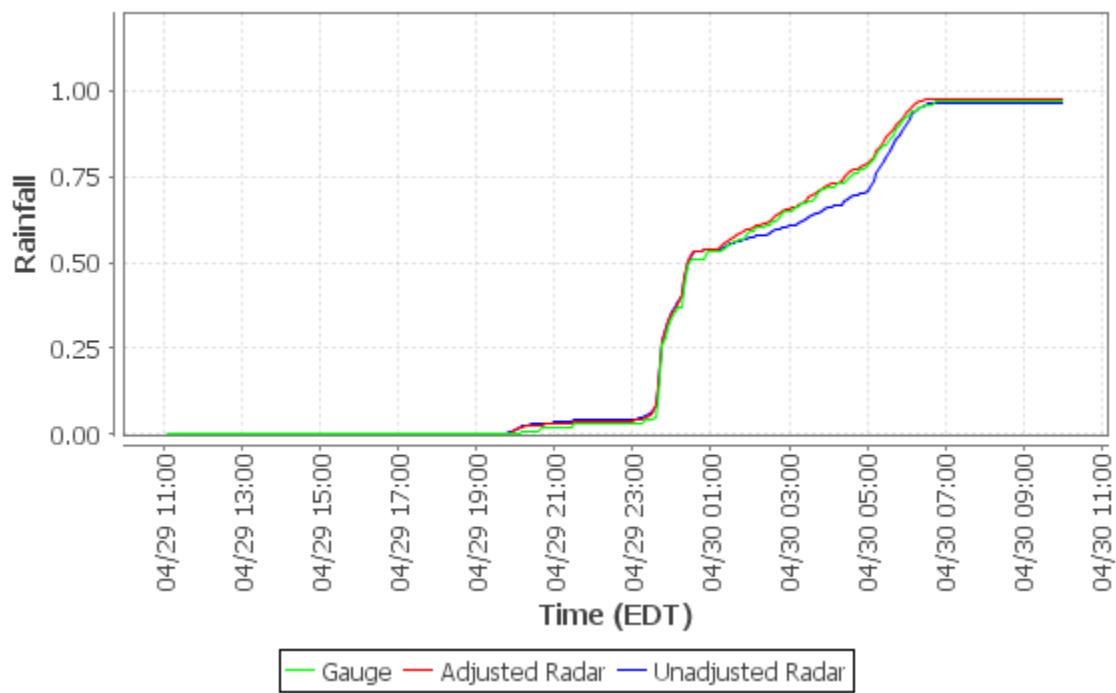
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



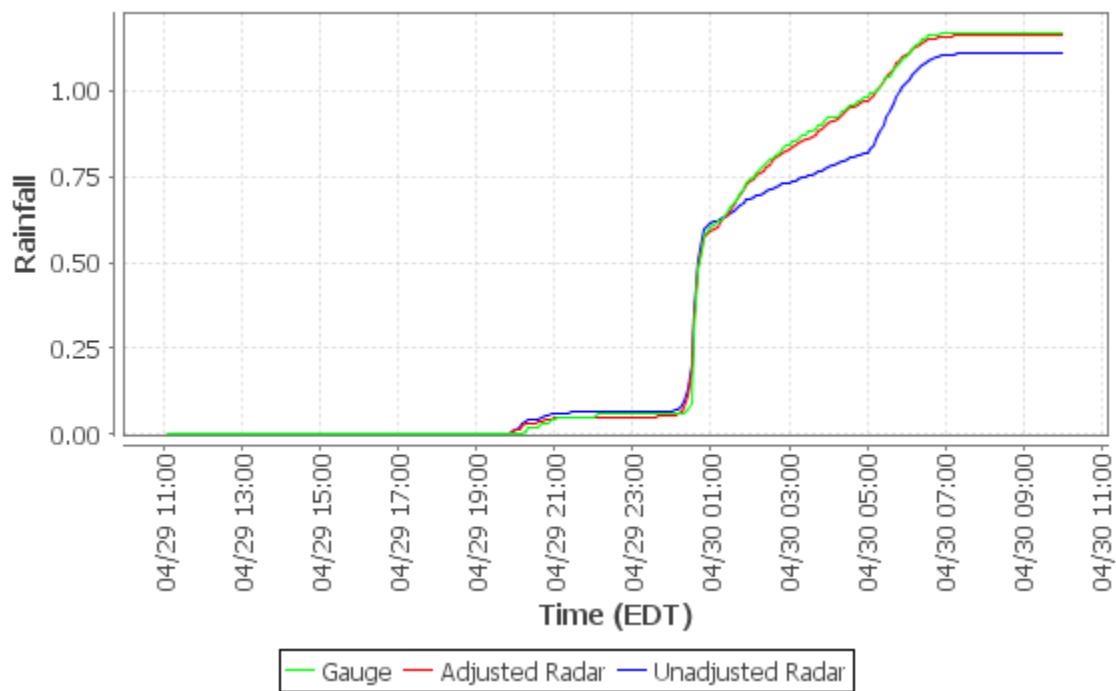
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



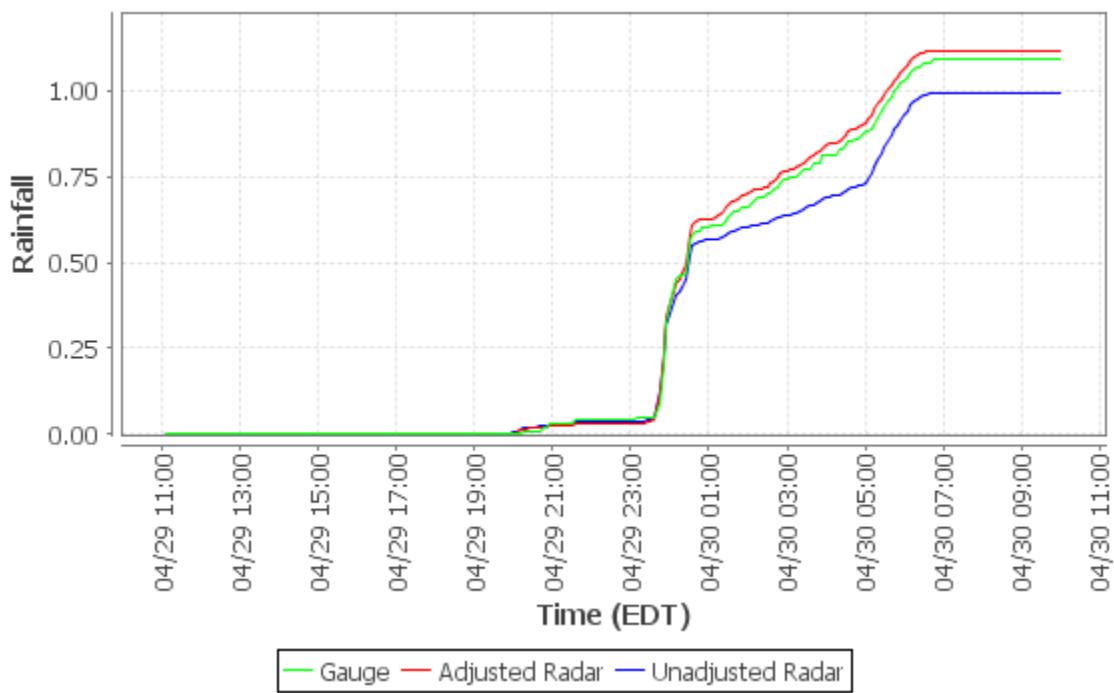
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



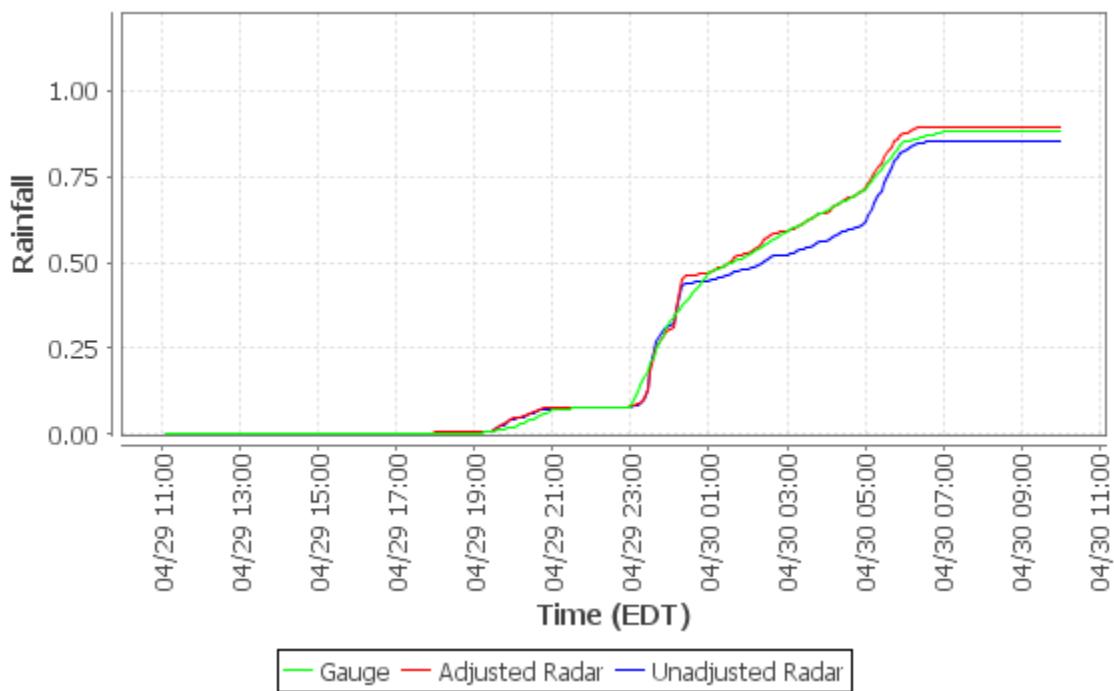
Cumulative Distribution Plot - Arnold (Loc32)



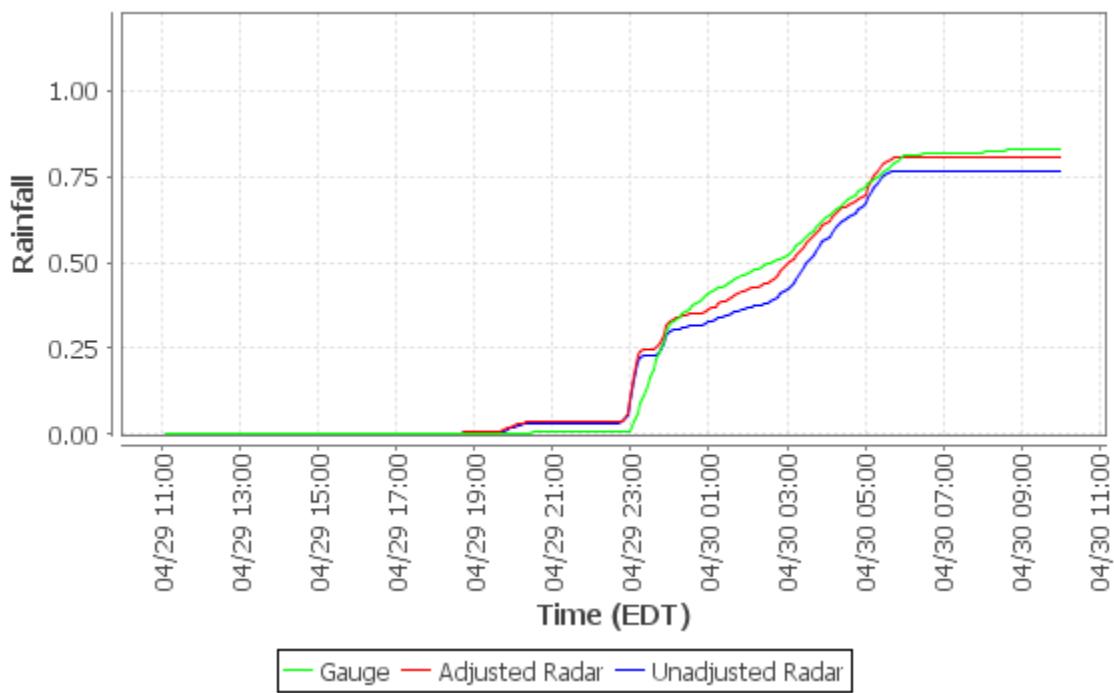
Cumulative Distribution Plot - Richland TWP (Loc33)



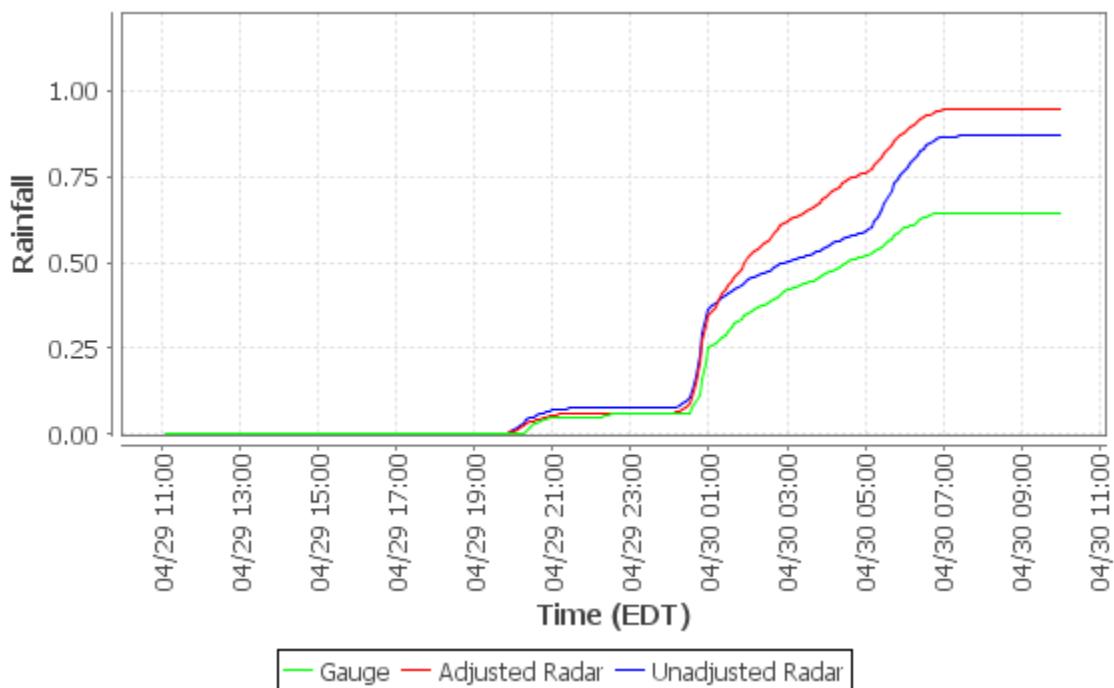
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



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

