

Radar Rainfall Analysis

October 2019 Summary Report



Improving our region's water quality

Prepared for 3 Rivers Wet Weather

November 25, 2019



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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.

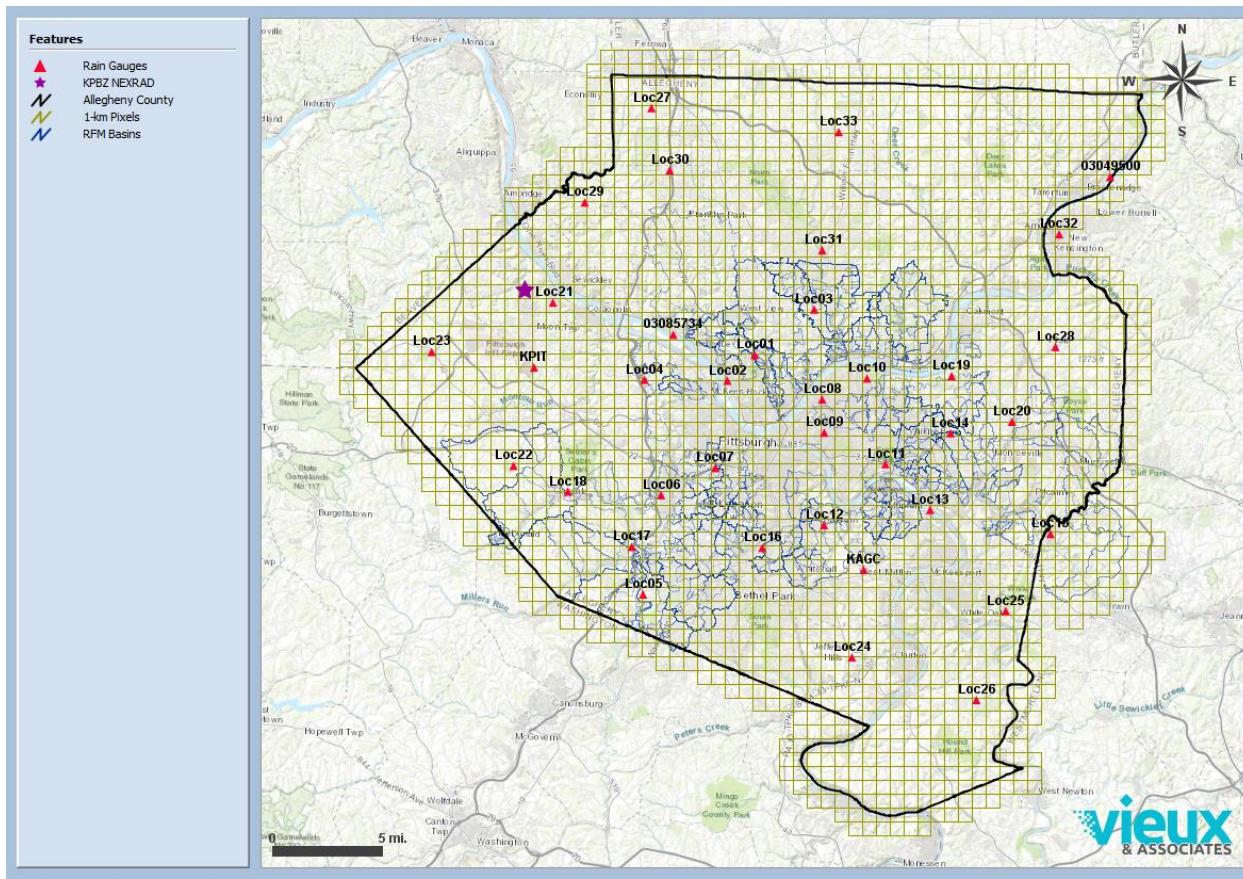


Figure 1. Spatial Distribution of the Rain Gauge Network, KPBZ NEXRAD, RFM Basins and 1-km² Pixels

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 2019-10-01 00:00 EDT to 2019-11-01 01:00 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 "Ryymm_" (i.e. R, year, month) prefix in front of the pixel ID.
- The comma-delimited text files contain a header row in the 1st row and time/data values beginning on the 2nd row.
- The time/data columns consist of Month, Day, Year, Hour, Minute, Rainfall and Source, where R represents EOM GARR quality.
- Time stamps are in EST/EDT.
- Data values represent 15-min accumulation (inches) at end of interval.
- The 1-km Pixel ID field that was used from the shapefile DBF is "PIXEL".

Basin CSV metadata:

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

Shapefile metadata:

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

Gauge-Adjusted Radar Rainfall (GARR)

Rainfall totals for October 2019 are shown in Figure 2. The rainfall amounts for the 2313 1-km² pixels range from 4.3 to 8.5 inches with a mean of 6.8 inches. The rainfall amounts for the 440 RFM basins range from 6.3 to 8.6 inches with a mean of 7.1 inches. The rainfall amounts for the 871 RFM sheds range from 6.1 to 8.6 inches with a mean of 7.2 inches.

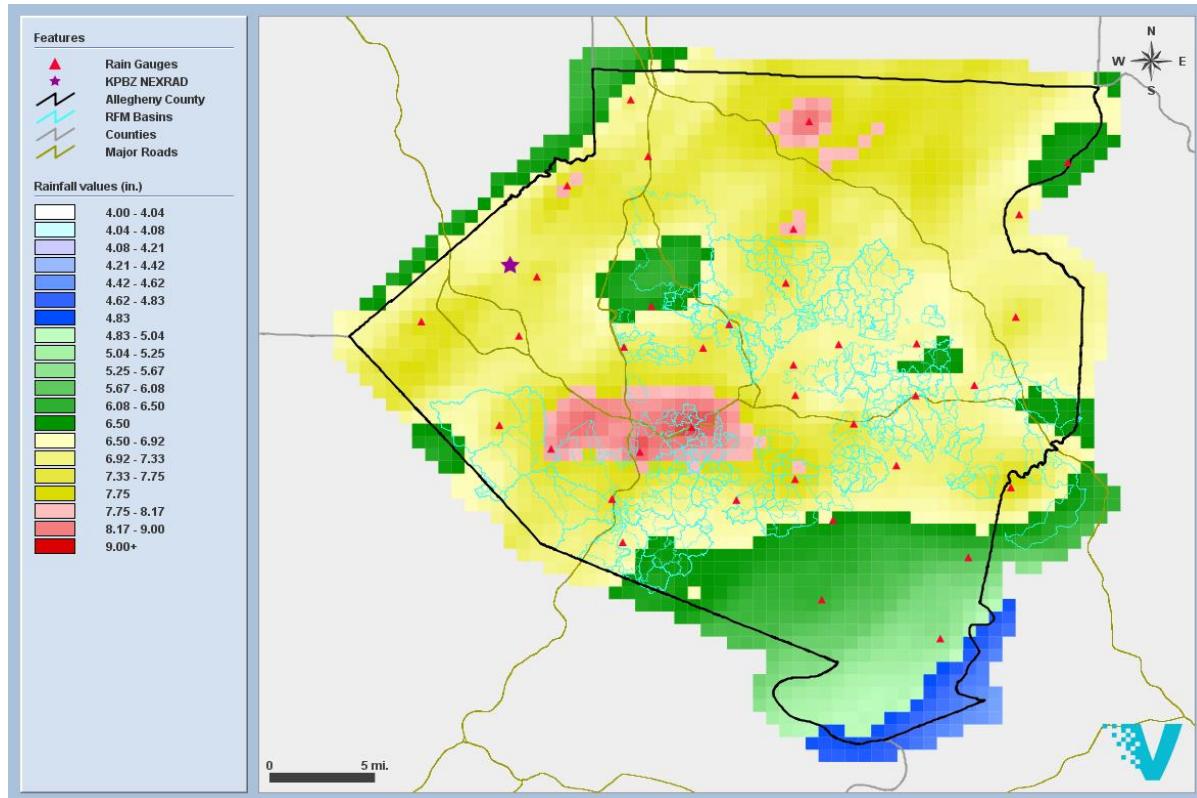


Figure 2. GARR Storm Total for October 2019

GARR was processed continuously at five-minute increments and covers the period from 2019-10-01 00:00 EDT to 2019-11-01 01:00 EDT. Seven rainfall events were identified as having met the storm definition during October 2019. The GARR statistics for each event are listed in Table 2. Seven of the events were split into multiple sub-event periods to improve gauge-adjustment of the radar, resulting in a total of fifty-three 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 seven 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 fifty-three 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	2019-10-03	2019-10-02 15:05	2019-10-03 01:00	7	0.045	1.283	19.3	0.8
E1b	KPBZ LII	2019-10-03	2019-10-03 01:05	2019-10-03 02:25	18	0.051	0.995	16.3	3.4
E1c	KPBZ LII	2019-10-03	2019-10-03 02:30	2019-10-03 04:25	18	0.062	0.842	19.7	2.7
E1d	KPBZ LII	2019-10-03	2019-10-03 04:30	2019-10-03 05:25	18	0.087	0.802	39.9	4.3
E1e	KPBZ LII	2019-10-03	2019-10-03 05:30	2019-10-03 08:00	18	0.074	1.014	27.6	5.3
E2a	KPBZ LII	2019-10-07	2019-10-06 07:05	2019-10-06 22:00	9	0.041	0.581	73.2	1.4
E2b	KPBZ LII	2019-10-07	2019-10-06 22:05	2019-10-06 23:00	13	0.042	1.074	11.3	2.7
E2c	KPBZ LII	2019-10-07	2019-10-06 23:05	2019-10-07 00:00	16	0.062	0.873	22.5	2.4
E2d	KPBZ LII	2019-10-07	2019-10-07 00:05	2019-10-07 01:00	33	0.207	1.156	17.1	1.4
E2e	KPBZ LII	2019-10-07	2019-10-07 01:05	2019-10-07 02:00	30	0.340	1.479	32.3	1.1
E2f	KPBZ LII	2019-10-07	2019-10-07 02:05	2019-10-07 03:00	32	0.245	1.425	29.2	1.4
E2g	KPBZ LII	2019-10-07	2019-10-07 03:05	2019-10-07 04:00	32	0.324	1.459	29.3	1.0
E2h	KPBZ LII	2019-10-07	2019-10-07 04:05	2019-10-07 06:15	33	0.166	1.558	35.4	1.2
E2i	KPBZ LII	2019-10-07	2019-10-07 06:20	2019-10-07 08:00	32	0.137	0.826	24.4	1.7
E2j	KPBZ LII	2019-10-07	2019-10-07 08:05	2019-10-07 10:00	12	0.036	0.811	26.0	2.0
E2k	KPBZ LII	2019-10-07	2019-10-07 10:05	2019-10-07 12:35	33	0.102	0.871	18.3	1.9
E2l	Gauge Only	2019-10-07	2019-10-07 12:40	2019-10-07 13:00	32	0.018	---	---	---

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E2m	KPBZ LII	2019-10-07	2019-10-07 13:05	2019-10-07 20:00	33	0.122	0.824	21.8	1.5
E3a	KPBZ LII	2019-10-16	2019-10-16 05:05	2019-10-16 07:30	21	0.117	1.037	13.8	2.7
E3b	KPBZ LII	2019-10-16	2019-10-16 07:35	2019-10-16 08:25	33	0.123	0.812	25.9	1.4
E3c	KPBZ LII	2019-10-16	2019-10-16 08:30	2019-10-16 09:20	34	0.144	1.388	25.7	2.4
E3d	KPBZ LII	2019-10-16	2019-10-16 09:25	2019-10-16 11:00	34	0.446	1.505	33.1	1.2
E3e	KPBZ LII	2019-10-16	2019-10-16 11:05	2019-10-16 15:00	35	0.171	1.428	29.1	1.6
E4a	KPBZ LII	2019-10-22	2019-10-22 01:05	2019-10-22 07:30	22	0.067	0.868	21.4	0.9
E4b	KPBZ LII	2019-10-22	2019-10-22 07:35	2019-10-22 08:05	8	0.022	0.664	50.7	2.9
E4c	KPBZ LII	2019-10-22	2019-10-22 08:10	2019-10-22 08:45	23	0.075	0.936	26.0	3.1
E4d	KPBZ LII	2019-10-22	2019-10-22 08:50	2019-10-22 09:20	32	0.143	1.023	16.5	1.8
E4e	KPBZ LII	2019-10-22	2019-10-22 09:25	2019-10-22 10:25	31	0.121	1.186	27.6	2.6
E4f	KPBZ LII	2019-10-22	2019-10-22 10:30	2019-10-22 11:00	6	0.034	0.546	86.1	0.9
E4g	KPBZ LII	2019-10-22	2019-10-22 11:05	2019-10-22 15:00	33	0.220	1.213	16.5	2.0
E5a	KPBZ LII	2019-10-27	2019-10-26 10:05	2019-10-26 18:30	25	0.080	0.782	29.6	4.0
E5b	KPBZ LII	2019-10-27	2019-10-26 18:35	2019-10-26 19:30	32	0.097	0.716	43.3	2.9
E5c	KPBZ LII	2019-10-27	2019-10-26 19:35	2019-10-26 20:10	22	0.064	0.761	35.2	1.8
E5d	KPBZ LII	2019-10-27	2019-10-26 20:15	2019-10-26 21:30	13	0.045	0.736	36.3	1.3
E5e	KPBZ LII	2019-10-27	2019-10-26 21:35	2019-10-27 03:00	32	0.106	1.299	22.3	2.7
E5f	KPBZ LII	2019-10-27	2019-10-27 03:05	2019-10-27 04:30	17	0.114	1.349	23.9	2.8

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E5g	KPBZ LII	2019-10-27	2019-10-27 04:35	2019-10-27 05:00	33	0.096	1.007	19.2	1.4
E5h	KPBZ LII	2019-10-27	2019-10-27 05:05	2019-10-27 08:00	33	0.193	2.253	54.9	1.2
E6a	KPBZ LII	2019-10-30	2019-10-30 14:05	2019-10-30 20:15	33	0.074	0.906	16.0	2.1
E6b	KPBZ LII	2019-10-30	2019-10-30 20:20	2019-10-30 21:25	32	0.137	1.055	17.8	1.6
E6c	KPBZ LII	2019-10-30	2019-10-30 21:30	2019-10-30 23:15	33	0.293	2.495	59.9	2.5
E6d	Gauge Only	2019-10-30	2019-10-30 23:20	2019-10-31 01:00	33	0.050	---	---	---
E6e	KPBZ LII	2019-10-30	2019-10-31 01:05	2019-10-31 01:50	31	0.102	0.880	17.9	2.6
E6f	KPBZ LII	2019-10-30	2019-10-31 01:55	2019-10-31 02:15	11	0.042	0.912	18.0	1.8
E6g	Gauge Only	2019-10-30	2019-10-31 02:20	2019-10-31 07:00	33	0.051	---	---	---
E7a	KPBZ LII	2019-10-31	2019-10-31 07:05	2019-10-31 10:45	33	0.116	0.797	31.0	2.5
E7b	KPBZ LII	2019-10-31	2019-10-31 10:50	2019-10-31 12:00	19	0.069	0.898	21.0	3.9
E7c	KPBZ LII	2019-10-31	2019-10-31 12:05	2019-10-31 13:00	6	0.035	1.473	31.4	0.3
E7d	KPBZ LII	2019-10-31	2019-10-31 13:05	2019-10-31 13:50	10	0.058	0.708	36.9	0.8
E7e	KPBZ LII	2019-10-31	2019-10-31 13:55	2019-10-31 15:20	32	0.493	1.372	24.6	1.0
E7f	KPBZ LII	2019-10-31	2019-10-31 15:25	2019-10-31 16:05	33	0.263	0.917	12.9	2.1
E7g	KPBZ LII	2019-10-31	2019-10-31 16:10	2019-10-31 18:00	9	0.049	1.255	19.4	1.3
E7h	KPBZ LII	2019-10-31	2019-10-31 18:05	2019-11-01 01:00	2	0.025	0.908	11.6	0.6

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 - I. CDPs are useful for visualizing rain gauge performance. Figure 3 shows the rainfall accumulation at the Bell Acres Munic Bldg (Loc29) gauge during the 2019-10-31 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.

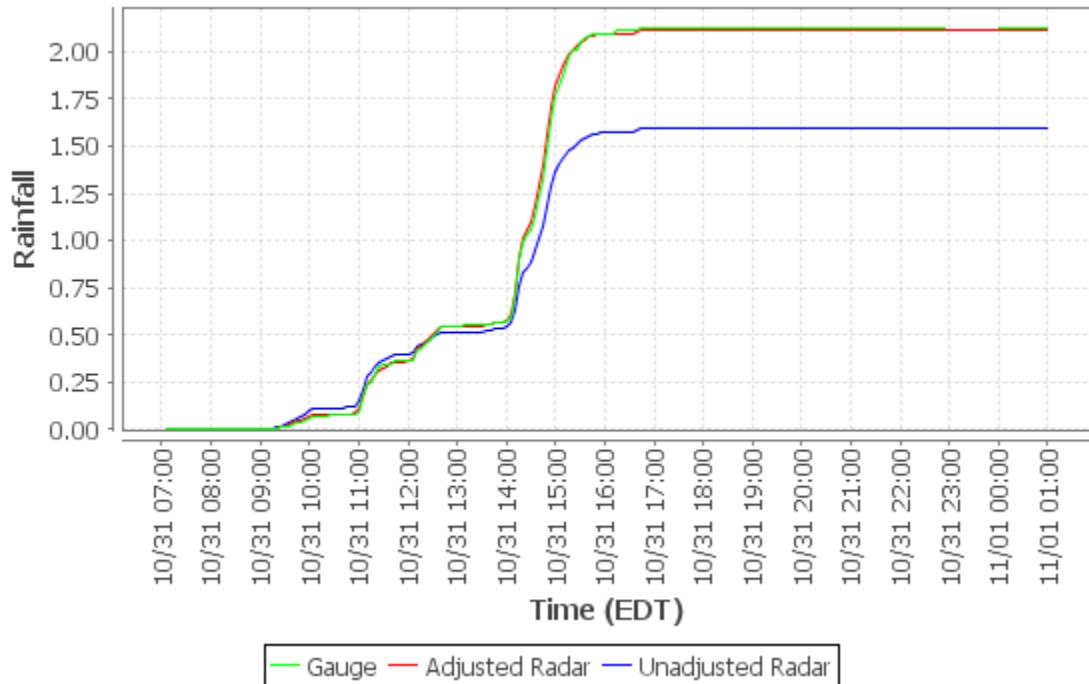


Figure 3. CDP Showing Rain Gauge Versus Unadjusted Radar Versus GARR

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: 2019-10-03

The analysis period was from 2019-10-02 15:00 EDT to 2019-10-03 08:00 EDT. The event was then split into five sub-event periods at 2019-10-03 01:00 EDT, 2019-10-03 02:25 EDT, 2019-10-03 04:25 EDT and 2019-10-03 05:25 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 - 10 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 - 8 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 9 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.0 - 1.2 inches with a mean of 0.3 inches. The GARR amounts for the 440 RFM basins range from 0.0 - 1.2 inches with a mean of 0.5 inches. The GARR amounts for the 871 RFM sheds range from 0.0 - 1.2 inches with a mean of 0.6 inches. Table 11 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	2019-10-03	2019-10-02 15:05	2019-10-03 01:00	7	0.045	1.283	19.3	0.8
E1b	KPBZ LII	2019-10-03	2019-10-03 01:05	2019-10-03 02:25	18	0.051	0.995	16.3	3.4
E1c	KPBZ LII	2019-10-03	2019-10-03 02:30	2019-10-03 04:25	18	0.062	0.842	19.7	2.7
E1d	KPBZ LII	2019-10-03	2019-10-03 04:30	2019-10-03 05:25	18	0.087	0.802	39.9	4.3
E1e	KPBZ LII	2019-10-03	2019-10-03 05:30	2019-10-03 08:00	18	0.074	1.014	27.6	5.3

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
Loc03	Shaler Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc27	Marshall TWP	0.26	0.18	0.26	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.08	0.10	0.00	0.0	
Loc30	McCandless Twn Hall	0.09	0.06	0.09	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.06	0.07	0.06	0.00	0.0	
Loc32	Arnold	0.07	0.07	0.07	0.00	0.0	
Loc33	Richland TWP	0.20	0.13	0.20	0.00	0.0	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
<u>KAGC</u>	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
<u>KPIT</u>	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
<u>Loc01</u>	PWSA-Montana St.	0.01	---	---	---	---	MSTT
<u>Loc02</u>	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
<u>Loc04</u>	Kennedy Twp PS	0.01	---	---	---	---	MSTT
<u>Loc05</u>	Upper St. Clair	0.00	---	---	---	---	MSTT
<u>Loc06</u>	Carnegie Transit Time	0.00	---	---	---	---	MSTT
<u>Loc07</u>	Greentree Munic Bldg	0.00	---	---	---	---	MSTT
<u>Loc08</u>	AC Health Dept Bldg	0.00	---	---	---	---	MSTT
<u>Loc09</u>	Univ of Pittsburgh	0.01	---	---	---	---	MSTT
<u>Loc10</u>	PWSA-Highland Park	ND	---	---	---	---	ND
<u>Loc11</u>	M-46 Access Shaft	0.01	---	---	---	---	MSTT
<u>Loc12</u>	Baldwin	0.01	---	---	---	---	MSTT
<u>Loc13</u>	M-59 Access Shaft	0.03	---	---	---	---	MSTT
<u>Loc14</u>	Churchill Munic Bldg	0.00	---	---	---	---	MSTT
<u>Loc15</u>	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
<u>Loc16</u>	Castle Shannon	0.03	---	---	---	---	MSTT
<u>Loc17</u>	Chartiers Pump Station	0.00	---	---	---	---	MSTT
<u>Loc18</u>	Oakdale Pump Station	0.00	---	---	---	---	MSTT
<u>Loc19</u>	Sandy Creek Eq Facility	0.02	---	---	---	---	MSTT
<u>Loc20</u>	Gascola Eq Facility	0.01	---	---	---	---	MSTT
<u>Loc21</u>	Moon TWP	0.00	---	---	---	---	MSTT
<u>Loc22</u>	North Fayette TWP	0.00	---	---	---	---	MSTT
<u>Loc23</u>	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
<u>Loc24</u>	Jefferson Hills	0.00	---	---	---	---	MSTT
<u>Loc25</u>	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
<u>Loc26</u>	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
<u>Loc28</u>	Plum Municipal Bldg	0.03	---	---	---	---	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
<u>Loc06</u>	Carnegie Transit Time	0.07	0.10	0.08	-0.01	-14.3	
<u>Loc08</u>	AC Health Dept Bldg	0.07	0.07	0.08	-0.01	-14.3	
<u>KPIT</u>	Greater Pittsburgh Int'l	0.12	0.08	0.12	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.05	0.06	0.05	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.06	0.06	0.06	0.00	0.0	
Loc03	Shaler Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.08	0.09	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.05	0.06	0.00	0.0	
Loc14	Churchill Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc16	Castle Shannon	0.05	0.06	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.12	0.13	0.12	0.00	0.0	
Loc22	North Fayette TWP	0.12	0.12	0.12	0.00	0.0	
Loc23	Clinton Munic Bldg	0.13	0.12	0.13	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.10	0.11	0.00	0.0	
Loc30	McCandless Twn Hall	0.08	0.09	0.08	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.10	0.12	0.10	0.00	0.0	
Loc33	Richland TWP	0.08	0.06	0.08	0.00	0.0	
Loc09	Univ of Pittsburgh	0.08	0.05	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.04	---	---	---	---	MSTT
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	0.06	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.06	---	---	---	---	MSTT
Loc32	Arnold	0.04	---	---	---	---	MSTT

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

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.09	0.12	0.10	-0.01	-11.1	
Loc02	ALCOSAN WWTP Lab	0.13	0.13	0.14	-0.01	-7.7	
Loc11	M-46 Access Shaft	0.27	0.38	0.29	-0.02	-7.4	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.06	0.06	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.11	0.13	0.11	0.00	0.0	
Loc01	PWSA-Montana St.	0.07	0.06	0.07	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.12	0.10	0.00	0.0	
Loc06	Carnegie Transit Time	0.09	0.14	0.09	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.13	0.12	0.00	0.0	
Loc12	Baldwin	0.13	0.16	0.13	0.00	0.0	
Loc13	M-59 Access Shaft	0.24	0.30	0.24	0.00	0.0	
Loc15	Trafford Maint Bldg	0.32	0.35	0.32	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.07	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.13	0.15	0.13	0.00	0.0	
Loc22	North Fayette TWP	0.08	0.11	0.08	0.00	0.0	
Loc23	Clinton Munic Bldg	0.14	0.16	0.14	0.00	0.0	
Loc07	Greentree Munic Bldg	0.32	0.41	0.31	0.01	3.1	
Loc09	Univ of Pittsburgh	0.21	0.21	0.20	0.01	4.8	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.04	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	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	0.04	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 9. Summary of Individual RG Pairs for Event 1d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.05	0.13	0.06	-0.01	-20.0	
Loc04	Kennedy Twp PS	0.15	0.21	0.18	-0.03	-20.0	
Loc07	Greentree Munic Bldg	0.36	0.54	0.38	-0.02	-5.6	
Loc13	M-59 Access Shaft	0.37	0.49	0.38	-0.01	-2.7	
Loc02	ALCOSAN WWTP Lab	0.18	0.18	0.18	0.00	0.0	
Loc08	AC Health Dept Bldg	0.13	0.15	0.13	0.00	0.0	
Loc09	Univ of Pittsburgh	0.26	0.31	0.26	0.00	0.0	
Loc14	Churchill Munic Bldg	0.21	0.25	0.21	0.00	0.0	
Loc15	Trafford Maint Bldg	0.27	0.35	0.27	0.00	0.0	
Loc16	Castle Shannon	0.05	0.12	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.19	0.26	0.19	0.00	0.0	
Loc21	Moon TWP	0.05	0.05	0.05	0.00	0.0	
Loc22	North Fayette TWP	0.31	0.39	0.31	0.00	0.0	
Loc23	Clinton Munic Bldg	0.27	0.22	0.27	0.00	0.0	
Loc06	Carnegie Transit Time	0.48	0.58	0.46	0.02	4.2	
Loc12	Baldwin	0.18	0.32	0.17	0.01	5.6	
Loc11	M-46 Access Shaft	0.49	0.48	0.45	0.04	8.2	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.08	0.06	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.13	---	---	---	---	U
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
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	0.01	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 10. Summary of Individual RG Pairs for Event 1e

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.13	0.11	0.15	-0.02	-15.4	
Loc06	Carnegie Transit Time	0.15	0.26	0.17	-0.02	-13.3	
KAGC	Pittsburgh Allegheny Cty	0.09	0.16	0.10	-0.01	-11.1	
Loc22	North Fayette TWP	0.09	0.12	0.10	-0.01	-11.1	
Loc13	M-59 Access Shaft	0.42	0.40	0.44	-0.02	-4.8	
KPIT	Greater Pittsburgh Int'l	0.10	0.10	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.10	0.06	0.10	0.00	0.0	
Loc04	Kennedy Twp PS	0.13	0.10	0.13	0.00	0.0	
Loc14	Churchill Munic Bldg	0.09	0.07	0.09	0.00	0.0	
Loc15	Trafford Maint Bldg	0.49	0.45	0.49	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.06	0.08	0.00	0.0	
Loc23	Clinton Munic Bldg	0.11	0.07	0.11	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.15	0.19	0.15	0.00	0.0	
Loc11	M-46 Access Shaft	0.25	0.18	0.24	0.01	4.0	
Loc12	Baldwin	0.44	0.50	0.42	0.02	4.5	
Loc07	Greentree Munic Bldg	0.36	0.34	0.34	0.02	5.6	
Loc08	AC Health Dept Bldg	0.09	0.05	0.08	0.01	11.1	
Loc18	Oakdale Pump Station	0.09	0.08	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

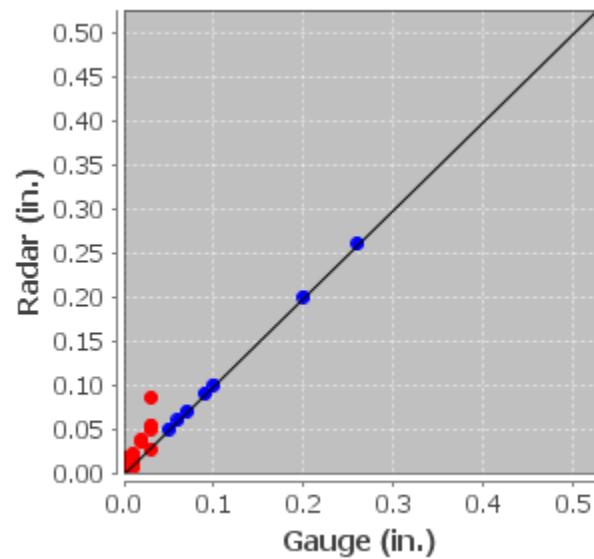


Figure 4. Scatter Plot of RG Pairs for Event 1a

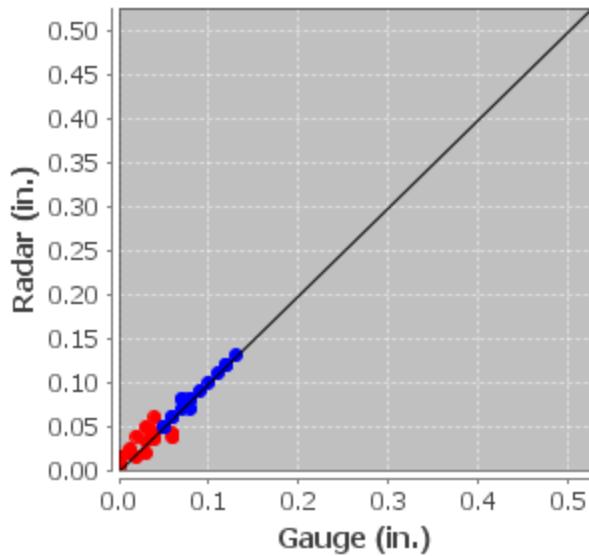


Figure 5. Scatter Plot of RG Pairs for Event 1b

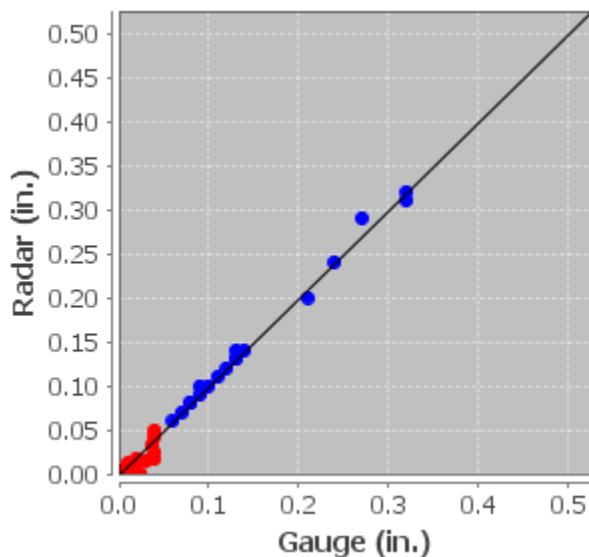


Figure 6. Scatter Plot of RG Pairs for Event 1c

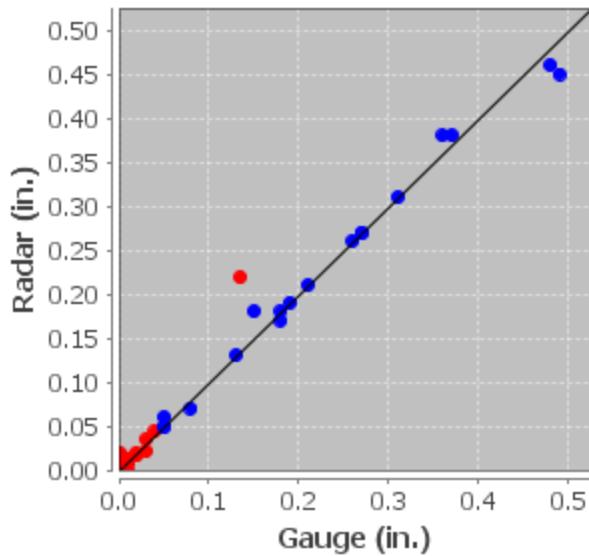


Figure 7. Scatter Plot of RG Pairs for Event 1d

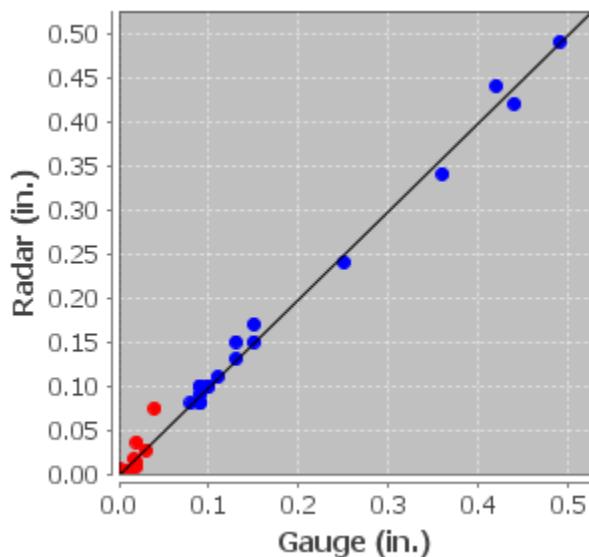


Figure 8. Scatter Plot of RG Pairs for Event 1e

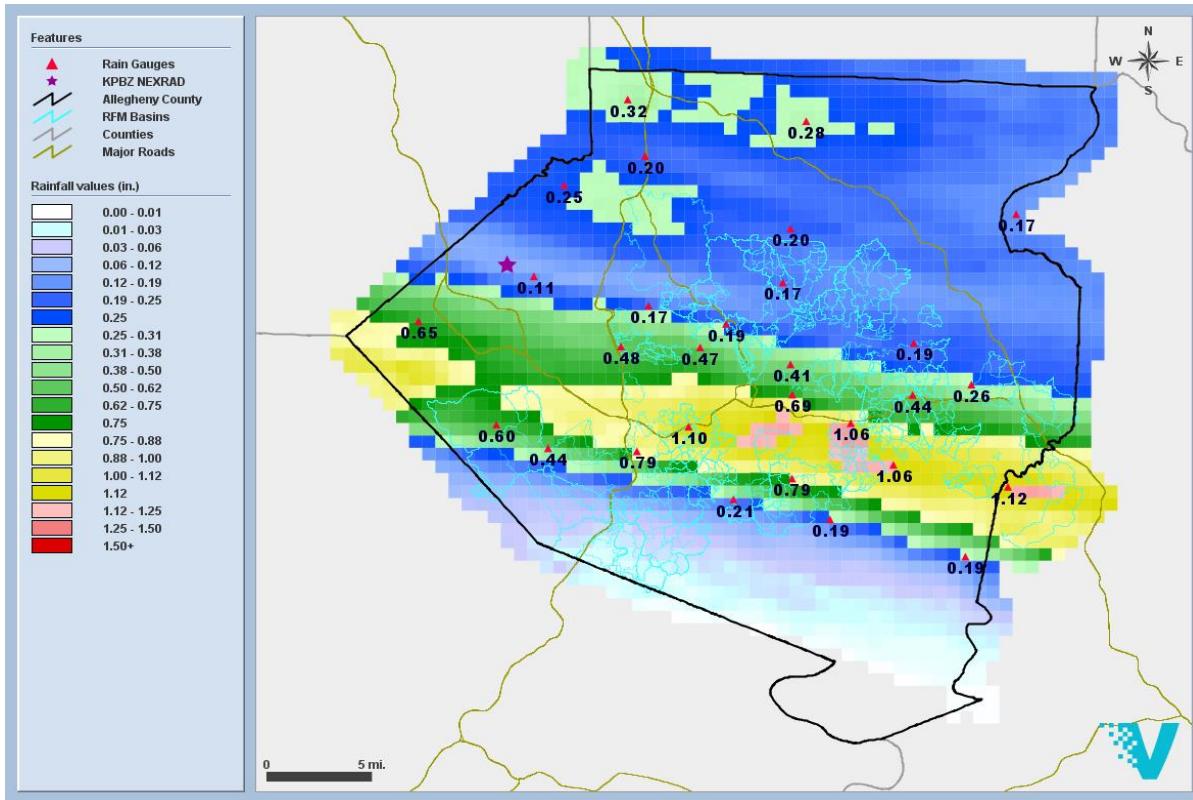


Figure 9. GARR Storm Total for Event 1

Table 11. Depth Duration Frequency Analyses for Event 1

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.371	121136	2019-10-03 04:45	<1 yr.
30 minutes	0.469	137143	2019-10-03 05:25	<1 yr.
1 hour	0.681	155144	2019-10-03 06:05	<1 yr.
2 hour	0.921	155144	2019-10-03 06:20	<1 yr.
3 hour	1.082	154142	2019-10-03 06:10	<1 yr.
6 hour	1.185	154142	2019-10-03 06:15	<1 yr.
12 hour	1.202	154141	2019-10-03 06:15	<1 yr.

Event 2: 2019-10-07

The analysis period was from 2019-10-06 07:00 EDT to 2019-10-07 20:00 EDT. The event was then split into thirteen sub-event periods at 2019-10-06 22:00 EDT, 2019-10-06 23:00 EDT, 2019-10-07 00:00 EDT, 2019-10-07 01:00 EDT, 2019-10-07 02:00 EDT, 2019-10-07 03:00 EDT, 2019-10-07 04:00 EDT, 2019-10-07 06:15 EDT, 2019-10-07 08:00 EDT, 2019-10-07 10:00 EDT, 2019-10-07 12:35 EDT and 2019-10-07 13:00 EDT to improve gauge adjustment of the radar. Gauge Only was used during Event 21 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 12 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 13 - 25 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 10 - 21 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 22 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 1.2 - 2.5 inches with a mean of 1.8 inches. The GARR amounts for the 440 RFM basins range from 1.6 - 2.5 inches with a mean of 2.1 inches. The GARR amounts for the 871 RFM sheds range from 1.6 - 2.5 inches with a mean of 2.1 inches. Table 26 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 12. 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	2019-10-07	2019-10-06 07:05	2019-10-06 22:00	9	0.041	0.581	73.2	1.4
E2b	KPBZ LII	2019-10-07	2019-10-06 22:05	2019-10-06 23:00	13	0.042	1.074	11.3	2.7
E2c	KPBZ LII	2019-10-07	2019-10-06 23:05	2019-10-07 00:00	16	0.062	0.873	22.5	2.4
E2d	KPBZ LII	2019-10-07	2019-10-07 00:05	2019-10-07 01:00	33	0.207	1.156	17.1	1.4
E2e	KPBZ LII	2019-10-07	2019-10-07 01:05	2019-10-07 02:00	30	0.340	1.479	32.3	1.1
E2f	KPBZ LII	2019-10-07	2019-10-07 02:05	2019-10-07 03:00	32	0.245	1.425	29.2	1.4
E2g	KPBZ LII	2019-10-07	2019-10-07 03:05	2019-10-07 04:00	32	0.324	1.459	29.3	1.0
E2h	KPBZ LII	2019-10-07	2019-10-07 04:05	2019-10-07 06:15	33	0.166	1.558	35.4	1.2
E2i	KPBZ LII	2019-10-07	2019-10-07 06:20	2019-10-07 08:00	32	0.137	0.826	24.4	1.7
E2j	KPBZ LII	2019-10-07	2019-10-07 08:05	2019-10-07 10:00	12	0.036	0.811	26.0	2.0

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E2k	KPBZ LII	2019-10-07	2019-10-07 10:05	2019-10-07 12:35	33	0.102	0.871	18.3	1.9
E2l	Gauge Only	2019-10-07	2019-10-07 12:40	2019-10-07 13:00	32	0.018	---	---	---
E2m	KPBZ LII	2019-10-07	2019-10-07 13:05	2019-10-07 20:00	33	0.122	0.824	21.8	1.5

Table 13. Summary of Individual RG Pairs for Event 2a

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.06	0.10	0.06	0.00	0.0	
Loc04	Kennedy Twp PS	0.05	0.06	0.05	0.00	0.0	
Loc09	Univ of Pittsburgh	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	
Loc27	Marshall TWP	0.07	0.11	0.07	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.12	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.05	0.08	0.05	0.00	0.0	
Loc32	Arnold	0.05	0.10	0.05	0.00	0.0	
Loc33	Richland TWP	0.07	0.11	0.07	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	Z
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.03	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.01	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.01	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.01	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
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	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.02	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.04	---	---	---	---	MSTT

Table 14. Summary of Individual RG Pairs for Event 2b

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.14	0.15	0.15	-0.01	-7.1	
Loc09	Univ of Pittsburgh	0.15	0.15	0.16	-0.01	-6.7	
Loc05	Upper St. Clair	0.08	0.09	0.08	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.06	0.07	0.00	0.0	
Loc12	Baldwin	0.19	0.15	0.19	0.00	0.0	
Loc13	M-59 Access Shaft	0.06	0.05	0.06	0.00	0.0	
Loc16	Castle Shannon	0.19	0.17	0.19	0.00	0.0	
Loc20	Gascola Eq Facility	0.18	0.16	0.18	0.00	0.0	
Loc23	Clinton Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc28	Plum Municipal Bldg	0.23	0.20	0.23	0.00	0.0	
Loc32	Arnold	0.09	0.10	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.19	0.17	0.18	0.01	5.3	
Loc19	Sandy Creek Eq Facility	0.19	0.17	0.18	0.01	5.3	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.07	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.00	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.00	---	---	---	---	MSTT
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
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	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 15. Summary of Individual RG Pairs for Event 2c

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	0.08	0.12	0.09	-0.01	-12.5	
03049500	Allegheny River at Natrona	0.15	0.16	0.15	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.13	0.15	0.13	0.00	0.0	
Loc01	PWSA-Montana St.	0.05	0.08	0.05	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.06	0.08	0.06	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.10	0.09	0.00	0.0	
Loc18	Oakdale Pump Station	0.05	0.06	0.05	0.00	0.0	
Loc21	Moon TWP	0.16	0.20	0.16	0.00	0.0	
Loc22	North Fayette TWP	0.10	0.13	0.10	0.00	0.0	
Loc23	Clinton Munic Bldg	0.13	0.15	0.13	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.24	0.24	0.24	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.28	0.29	0.28	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.06	0.08	0.06	0.00	0.0	
Loc32	Arnold	0.09	0.07	0.09	0.00	0.0	
Loc33	Richland TWP	0.09	0.11	0.09	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc11	M-46 Access Shaft	0.01	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.01	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.18	---	---	---	---	U

Table 16. Summary of Individual RG Pairs for Event 2d

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.23	0.22	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	
Loc22	North Fayette TWP	0.37	0.36	0.38	-0.01	-2.7	
KAGC	Pittsburgh Allegheny Cty	0.18	0.16	0.18	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
<u>KPIT</u>	Greater Pittsburgh Int'l	0.15	0.19	0.15	0.00	0.0	
<u>Loc02</u>	ALCOSAN WWTP Lab	0.41	0.35	0.41	0.00	0.0	
<u>Loc03</u>	Shaler Munic Bldg	0.21	0.20	0.21	0.00	0.0	
<u>Loc06</u>	Carnegie Transit Time	0.55	0.43	0.55	0.00	0.0	
<u>Loc07</u>	Greentree Munic Bldg	0.48	0.38	0.48	0.00	0.0	
<u>Loc13</u>	M-59 Access Shaft	0.12	0.09	0.12	0.00	0.0	
<u>Loc14</u>	Churchill Munic Bldg	0.09	0.06	0.09	0.00	0.0	
<u>Loc15</u>	Trafford Maint Bldg	0.42	0.33	0.42	0.00	0.0	
<u>Loc16</u>	Castle Shannon	0.29	0.23	0.29	0.00	0.0	
<u>Loc17</u>	Chartiers Pump Station	0.67	0.53	0.67	0.00	0.0	
<u>Loc19</u>	Sandy Creek Eq Facility	0.17	0.10	0.17	0.00	0.0	
<u>Loc20</u>	Gascola Eq Facility	0.08	0.06	0.08	0.00	0.0	
<u>Loc21</u>	Moon TWP	0.14	0.17	0.14	0.00	0.0	
<u>Loc23</u>	Clinton Munic Bldg	0.20	0.20	0.20	0.00	0.0	
<u>Loc24</u>	Jefferson Hills	0.15	0.20	0.15	0.00	0.0	
<u>Loc25</u>	White Oak Public Works Bldg	0.22	0.19	0.22	0.00	0.0	
<u>Loc26</u>	Elizabeth TWP Municipal Bldg	0.10	0.10	0.10	0.00	0.0	
<u>Loc27</u>	Marshall TWP	0.12	0.12	0.12	0.00	0.0	
<u>Loc29</u>	Bell Acres Munic Bldg	0.15	0.16	0.15	0.00	0.0	
<u>Loc30</u>	McCandless Twn Hall	0.12	0.12	0.12	0.00	0.0	
<u>Loc31</u>	Hampton Municipal Bldg	0.19	0.17	0.19	0.00	0.0	
<u>Loc32</u>	Arnold	0.09	0.05	0.09	0.00	0.0	
<u>Loc33</u>	Richland TWP	0.16	0.12	0.16	0.00	0.0	
<u>Loc18</u>	Oakdale Pump Station	0.59	0.51	0.58	0.01	1.7	
<u>Loc01</u>	PWSA-Montana St.	0.39	0.32	0.38	0.01	2.6	
<u>Loc04</u>	Kennedy Twp PS	0.39	0.34	0.38	0.01	2.6	
<u>Loc12</u>	Baldwin	0.33	0.25	0.32	0.01	3.0	
<u>Loc08</u>	AC Health Dept Bldg	0.29	0.25	0.28	0.01	3.4	
<u>Loc11</u>	M-46 Access Shaft	0.19	0.13	0.18	0.01	5.3	
<u>03049500</u>	Allegheny River at Natrona	0.06	---	---	---	---	MSTT
<u>Loc05</u>	Upper St. Clair	0.43	---	---	---	---	U
<u>Loc10</u>	PWSA-Highland Park	ND	---	---	---	---	ND
<u>Loc28</u>	Plum Municipal Bldg	0.04	---	---	---	---	MSTT

Table 17. Summary of Individual RG Pairs for Event 2e

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.28	0.23	0.30	-0.02	-7.1	
Loc22	North Fayette TWP	0.27	0.20	0.28	-0.01	-3.7	
Loc06	Carnegie Transit Time	0.41	0.29	0.42	-0.01	-2.4	
Loc11	M-46 Access Shaft	0.46	0.32	0.47	-0.01	-2.2	
KAGC	Pittsburgh Allegheny Cty	0.51	0.34	0.52	-0.01	-2.0	
Loc14	Churchill Munic Bldg	0.49	0.33	0.50	-0.01	-2.0	
KPIT	Greater Pittsburgh Int'l	0.22	0.14	0.22	0.00	0.0	
Loc01	PWSA-Montana St.	0.43	0.27	0.43	0.00	0.0	
Loc03	Shaler Munic Bldg	0.37	0.25	0.37	0.00	0.0	
Loc07	Greentree Munic Bldg	0.40	0.27	0.40	0.00	0.0	
Loc09	Univ of Pittsburgh	0.41	0.26	0.41	0.00	0.0	
Loc12	Baldwin	0.53	0.33	0.53	0.00	0.0	
Loc15	Trafford Maint Bldg	0.47	0.37	0.47	0.00	0.0	
Loc16	Castle Shannon	0.45	0.27	0.45	0.00	0.0	
Loc17	Chartiers Pump Station	0.45	0.31	0.45	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.38	0.24	0.38	0.00	0.0	
Loc20	Gascola Eq Facility	0.45	0.29	0.45	0.00	0.0	
Loc23	Clinton Munic Bldg	0.13	0.09	0.13	0.00	0.0	
Loc24	Jefferson Hills	0.64	0.44	0.64	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.40	0.28	0.40	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.40	0.29	0.40	0.00	0.0	
Loc27	Marshall TWP	0.29	0.17	0.29	0.00	0.0	
Loc28	Plum Municipal Bldg	0.41	0.29	0.41	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.22	0.14	0.22	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.46	0.32	0.46	0.00	0.0	
Loc32	Arnold	0.43	0.29	0.43	0.00	0.0	
Loc33	Richland TWP	0.26	0.22	0.26	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.44	0.28	0.43	0.01	2.3	
Loc04	Kennedy Twp PS	0.41	0.29	0.40	0.01	2.4	
Loc18	Oakdale Pump Station	0.30	0.17	0.29	0.01	3.3	
03049500	Allegheny River at Natrona	0.38	---	---	---	---	OMFB
Loc05	Upper St. Clair	0.34	---	---	---	---	U
Loc08	AC Health Dept Bldg	0.38	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.34	---	---	---	---	U

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.16	---	---	---	---	U
Loc30	McCandless Twn Hall	0.20	---	---	---	---	U

Table 18. Summary of Individual RG Pairs for Event 2f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.22	0.16	0.23	-0.01	-4.5	
Loc08	AC Health Dept Bldg	0.23	0.19	0.24	-0.01	-4.3	
Loc16	Castle Shannon	0.25	0.18	0.26	-0.01	-4.0	
Loc22	North Fayette TWP	0.30	0.25	0.31	-0.01	-3.3	
Loc17	Chartiers Pump Station	0.32	0.22	0.33	-0.01	-3.1	
03049500	Allegheny River at Natrona	0.26	0.18	0.26	0.00	0.0	
Loc01	PWSA-Montana St.	0.21	0.18	0.21	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.20	0.18	0.20	0.00	0.0	
Loc03	Shaler Munic Bldg	0.23	0.18	0.23	0.00	0.0	
Loc04	Kennedy Twp PS	0.20	0.19	0.20	0.00	0.0	
Loc07	Greentree Munic Bldg	0.29	0.20	0.29	0.00	0.0	
Loc13	M-59 Access Shaft	0.24	0.15	0.24	0.00	0.0	
Loc15	Trafford Maint Bldg	0.28	0.18	0.28	0.00	0.0	
Loc20	Gascola Eq Facility	0.32	0.22	0.32	0.00	0.0	
Loc21	Moon TWP	0.27	0.23	0.27	0.00	0.0	
Loc23	Clinton Munic Bldg	0.29	0.20	0.29	0.00	0.0	
Loc24	Jefferson Hills	0.28	0.17	0.28	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.25	0.15	0.25	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.19	0.12	0.19	0.00	0.0	
Loc27	Marshall TWP	0.25	0.17	0.25	0.00	0.0	
Loc28	Plum Municipal Bldg	0.40	0.25	0.40	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.23	0.16	0.23	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.26	0.20	0.26	0.00	0.0	
Loc32	Arnold	0.26	0.19	0.26	0.00	0.0	
Loc33	Richland TWP	0.27	0.20	0.27	0.00	0.0	
Loc06	Carnegie Transit Time	0.30	0.19	0.29	0.01	3.3	
Loc12	Baldwin	0.29	0.16	0.28	0.01	3.4	
KAGC	Pittsburgh Allegheny Cty	0.28	0.15	0.27	0.01	3.6	
Loc19	Sandy Creek Eq Facility	0.28	0.17	0.27	0.01	3.6	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.27	0.16	0.26	0.01	3.7	
Loc18	Oakdale Pump Station	0.27	0.19	0.26	0.01	3.7	
Loc09	Univ of Pittsburgh	0.26	0.19	0.25	0.01	3.8	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.17	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.16	---	---	---	---	U
Loc05	Upper St. Clair	0.21	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc30	McCandless Twn Hall	0.17	---	---	---	---	U

Table 19. Summary of Individual RG Pairs for Event 2g

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.31	0.23	0.32	-0.01	-3.2	
Loc01	PWSA-Montana St.	0.33	0.25	0.34	-0.01	-3.0	
Loc09	Univ of Pittsburgh	0.40	0.29	0.41	-0.01	-2.5	
Loc14	Churchill Munic Bldg	0.42	0.28	0.43	-0.01	-2.4	
Loc32	Arnold	0.47	0.33	0.48	-0.01	-2.1	
KAGC	Pittsburgh Allegheny Cty	0.49	0.29	0.49	0.00	0.0	
Loc06	Carnegie Transit Time	0.35	0.28	0.35	0.00	0.0	
Loc07	Greentree Munic Bldg	0.39	0.29	0.39	0.00	0.0	
Loc12	Baldwin	0.43	0.25	0.43	0.00	0.0	
Loc15	Trafford Maint Bldg	0.43	0.27	0.43	0.00	0.0	
Loc16	Castle Shannon	0.34	0.19	0.34	0.00	0.0	
Loc17	Chartiers Pump Station	0.30	0.24	0.30	0.00	0.0	
Loc20	Gascola Eq Facility	0.43	0.28	0.43	0.00	0.0	
Loc21	Moon TWP	0.23	0.19	0.23	0.00	0.0	
Loc22	North Fayette TWP	0.19	0.15	0.19	0.00	0.0	
Loc23	Clinton Munic Bldg	0.14	0.10	0.14	0.00	0.0	
Loc24	Jefferson Hills	0.44	0.27	0.44	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.36	0.19	0.36	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.27	0.15	0.27	0.00	0.0	
Loc27	Marshall TWP	0.12	0.12	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.47	0.33	0.47	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc29	Bell Acres Munic Bldg	0.17	0.15	0.17	0.00	0.0	
Loc30	McCandless Twn Hall	0.18	0.16	0.18	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.38	0.27	0.38	0.00	0.0	
Loc33	Richland TWP	0.33	0.22	0.33	0.00	0.0	
03049500	Allegheny River at Natrona	0.56	0.33	0.55	0.01	1.8	
Loc19	Sandy Creek Eq Facility	0.47	0.29	0.46	0.01	2.1	
Loc18	Oakdale Pump Station	0.45	0.33	0.44	0.01	2.2	
Loc11	M-46 Access Shaft	0.44	0.28	0.43	0.01	2.3	
Loc03	Shaler Munic Bldg	0.39	0.26	0.38	0.01	2.6	
Loc02	ALCOSAN WWTP Lab	0.37	0.27	0.36	0.01	2.7	
Loc04	Kennedy Twp PS	0.29	0.20	0.28	0.01	3.4	
KPIT	Greater Pittsburgh Int'l	0.31	---	---	---	---	O
Loc05	Upper St. Clair	0.17	---	---	---	---	U
Loc08	AC Health Dept Bldg	0.37	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.39	---	---	---	---	U

Table 20. Summary of Individual RG Pairs for Event 2h

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.13	0.10	0.14	-0.01	-7.7	
Loc22	North Fayette TWP	0.16	0.12	0.17	-0.01	-6.3	
03049500	Allegheny River at Natrona	0.18	0.10	0.18	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.17	0.11	0.17	0.00	0.0	
Loc01	PWSA-Montana St.	0.18	0.12	0.18	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.19	0.12	0.19	0.00	0.0	
Loc03	Shaler Munic Bldg	0.18	0.11	0.18	0.00	0.0	
Loc04	Kennedy Twp PS	0.18	0.13	0.18	0.00	0.0	
Loc06	Carnegie Transit Time	0.17	0.11	0.17	0.00	0.0	
Loc07	Greentree Munic Bldg	0.18	0.11	0.18	0.00	0.0	
Loc08	AC Health Dept Bldg	0.15	0.10	0.15	0.00	0.0	
Loc09	Univ of Pittsburgh	0.15	0.10	0.15	0.00	0.0	
Loc11	M-46 Access Shaft	0.14	0.10	0.14	0.00	0.0	
Loc12	Baldwin	0.15	0.10	0.15	0.00	0.0	
Loc15	Trafford Maint Bldg	0.13	0.10	0.13	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.17	0.10	0.17	0.00	0.0	
Loc17	Chartiers Pump Station	0.19	0.11	0.19	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.15	0.10	0.15	0.00	0.0	
Loc20	Gascola Eq Facility	0.15	0.10	0.15	0.00	0.0	
Loc21	Moon TWP	0.17	0.11	0.17	0.00	0.0	
Loc23	Clinton Munic Bldg	0.20	0.11	0.20	0.00	0.0	
Loc24	Jefferson Hills	0.16	0.10	0.16	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.14	0.10	0.14	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.13	0.09	0.13	0.00	0.0	
Loc27	Marshall TWP	0.14	0.07	0.14	0.00	0.0	
Loc28	Plum Municipal Bldg	0.16	0.10	0.16	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.10	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.17	0.10	0.17	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.20	0.12	0.20	0.00	0.0	
Loc32	Arnold	0.16	0.10	0.16	0.00	0.0	
Loc33	Richland TWP	0.20	0.13	0.20	0.00	0.0	
Loc18	Oakdale Pump Station	0.22	0.13	0.21	0.01	4.5	
KAGC	Pittsburgh Allegheny Cty	0.16	0.10	0.15	0.01	6.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.15	---	---	---	---	U
Loc05	Upper St. Clair	0.14	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.10	---	---	---	---	U

Table 21. Summary of Individual RG Pairs for Event 2i

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.13	0.21	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.12	0.07	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.19	0.22	0.19	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.10	0.11	0.10	0.00	0.0	
Loc01	PWSA-Montana St.	0.10	0.14	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.10	0.14	0.10	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.13	0.10	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.09	0.12	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.11	0.16	0.11	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.18	0.14	0.00	0.0	
Loc08	AC Health Dept Bldg	0.13	0.19	0.13	0.00	0.0	
Loc11	M-46 Access Shaft	0.18	0.23	0.18	0.00	0.0	
Loc12	Baldwin	0.20	0.25	0.20	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.21	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.21	0.22	0.21	0.00	0.0	
Loc16	Castle Shannon	0.19	0.25	0.19	0.00	0.0	
Loc17	Chartiers Pump Station	0.13	0.18	0.13	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.15	0.13	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.17	0.20	0.17	0.00	0.0	
Loc20	Gascola Eq Facility	0.18	0.21	0.18	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	
Loc23	Clinton Munic Bldg	0.10	0.11	0.10	0.00	0.0	
Loc24	Jefferson Hills	0.24	0.24	0.24	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.17	0.21	0.17	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.19	0.23	0.19	0.00	0.0	
Loc27	Marshall TWP	0.07	0.06	0.07	0.00	0.0	
Loc28	Plum Municipal Bldg	0.21	0.20	0.21	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.09	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.07	0.08	0.07	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.10	0.11	0.10	0.00	0.0	
Loc32	Arnold	0.15	0.14	0.15	0.00	0.0	
03049500	Allegheny River at Natrona	0.10	---	---	---	---	U
Loc05	Upper St. Clair	0.11	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.14	---	---	---	---	U
Loc33	Richland TWP	0.12	---	---	---	---	O

Table 22. Summary of Individual RG Pairs for Event 2j

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.05	0.07	0.05	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc11	M-46 Access Shaft	0.05	0.07	0.05	0.00	0.0	
Loc14	Churchill Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc15	Trafford Maint Bldg	0.07	0.09	0.07	0.00	0.0	
Loc16	Castle Shannon	0.06	0.07	0.06	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.07	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.05	0.06	0.05	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.06	0.08	0.06	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.08	0.05	0.00	0.0	
Loc28	Plum Municipal Bldg	0.05	0.05	0.05	0.00	0.0	
Loc12	Baldwin	0.07	0.06	0.06	0.01	14.3	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.04	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.04	---	---	---	---	U
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.02	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.01	---	---	---	---	MSTT
Loc27	Marshall TWP	0.01	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.02	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.04	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.04	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 23. Summary of Individual RG Pairs for Event 2k

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.10	0.13	0.11	-0.01	-10.0	
Loc09	Univ of Pittsburgh	0.10	0.13	0.11	-0.01	-10.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	0.12	0.09	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.12	0.15	0.12	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.10	0.08	0.00	0.0	
Loc03	Shaler Munic Bldg	0.12	0.13	0.12	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.12	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.12	0.12	0.12	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.13	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.14	0.11	0.00	0.0	
Loc12	Baldwin	0.13	0.15	0.13	0.00	0.0	
Loc14	Churchill Munic Bldg	0.11	0.13	0.11	0.00	0.0	
Loc15	Trafford Maint Bldg	0.11	0.14	0.11	0.00	0.0	
Loc16	Castle Shannon	0.13	0.15	0.13	0.00	0.0	
Loc17	Chartiers Pump Station	0.13	0.12	0.13	0.00	0.0	
Loc18	Oakdale Pump Station	0.12	0.11	0.12	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.10	0.12	0.10	0.00	0.0	
Loc20	Gascola Eq Facility	0.10	0.13	0.10	0.00	0.0	
Loc21	Moon TWP	0.08	0.08	0.08	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.10	0.09	0.00	0.0	
Loc23	Clinton Munic Bldg	0.08	0.07	0.08	0.00	0.0	
Loc24	Jefferson Hills	0.09	0.12	0.09	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.09	0.13	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.09	0.13	0.09	0.00	0.0	
Loc27	Marshall TWP	0.06	0.05	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.10	0.12	0.10	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.08	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.08	0.09	0.08	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc31	Hampton Municipal Bldg	0.10	0.12	0.10	0.00	0.0	
Loc32	Arnold	0.12	0.13	0.12	0.00	0.0	
Loc33	Richland TWP	0.11	0.09	0.11	0.00	0.0	
Loc01	PWSA-Montana St.	0.12	0.13	0.11	0.01	8.3	
Loc08	AC Health Dept Bldg	0.12	0.14	0.11	0.01	8.3	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
Loc05	Upper St. Clair	0.10	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.08	---	---	---	---	U

Table 24. Summary of Individual RG Pairs for Event 2l

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.00	---	---	---	---	
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	
Loc27	Marshall TWP	0.01	---	---	---	---	
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	
Loc30	McCandless Twn Hall	0.01	---	---	---	---	
Loc33	Richland TWP	0.01	---	---	---	---	
Loc04	Kennedy Twp PS	0.02	---	---	---	---	
Loc06	Carnegie Transit Time	0.02	---	---	---	---	
Loc08	AC Health Dept Bldg	0.02	---	---	---	---	
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	
Loc11	M-46 Access Shaft	0.02	---	---	---	---	
Loc13	M-59 Access Shaft	0.02	---	---	---	---	
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	
Loc17	Chartiers Pump Station	0.02	---	---	---	---	
Loc18	Oakdale Pump Station	0.02	---	---	---	---	
Loc20	Gascola Eq Facility	0.02	---	---	---	---	
Loc22	North Fayette TWP	0.02	---	---	---	---	
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	
Loc24	Jefferson Hills	0.02	---	---	---	---	
Loc25	White Oak Public Works Bldg	0.02	---	---	---	---	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	
Loc31	Hampton Municipal Bldg	0.02	---	---	---	---	
Loc32	Arnold	0.02	---	---	---	---	
Loc01	PWSA-Montana St.	0.03	---	---	---	---	
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	
Loc05	Upper St. Clair	0.03	---	---	---	---	
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	
Loc12	Baldwin	0.03	---	---	---	---	
Loc16	Castle Shannon	0.03	---	---	---	---	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	T
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	T
KAGC	Pittsburgh Allegheny Cty	0.02	---	---	---	---	T
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	T
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND

Table 25. Summary of Individual RG Pairs for Event 2m

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.09	0.13	0.10	-0.01	-11.1	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	0.11	0.09	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.18	0.23	0.18	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.08	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.11	0.13	0.11	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.13	0.11	0.00	0.0	
Loc03	Shaler Munic Bldg	0.11	0.12	0.11	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.12	0.11	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.14	0.12	0.00	0.0	
Loc08	AC Health Dept Bldg	0.10	0.15	0.10	0.00	0.0	
Loc09	Univ of Pittsburgh	0.09	0.15	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.13	0.16	0.13	0.00	0.0	
Loc12	Baldwin	0.15	0.16	0.15	0.00	0.0	
Loc14	Churchill Munic Bldg	0.13	0.17	0.13	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc15	Trafford Maint Bldg	0.19	0.24	0.19	0.00	0.0	
Loc16	Castle Shannon	0.15	0.16	0.15	0.00	0.0	
Loc17	Chartiers Pump Station	0.12	0.14	0.12	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.12	0.15	0.12	0.00	0.0	
Loc20	Gascola Eq Facility	0.15	0.20	0.15	0.00	0.0	
Loc21	Moon TWP	0.07	0.06	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.11	0.09	0.00	0.0	
Loc23	Clinton Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.20	0.25	0.20	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.17	0.25	0.17	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.18	0.26	0.18	0.00	0.0	
Loc27	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.13	0.17	0.13	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.06	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.07	0.07	0.07	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.10	0.10	0.10	0.00	0.0	
Loc32	Arnold	0.10	0.13	0.10	0.00	0.0	
Loc33	Richland TWP	0.12	0.09	0.12	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.13	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.07	---	---	---	---	U
Loc05	Upper St. Clair	0.09	---	---	---	---	U
Loc10	PWSA-Highland Park	ND	---	---	---	---	ND
Loc13	M-59 Access Shaft	0.11	---	---	---	---	U

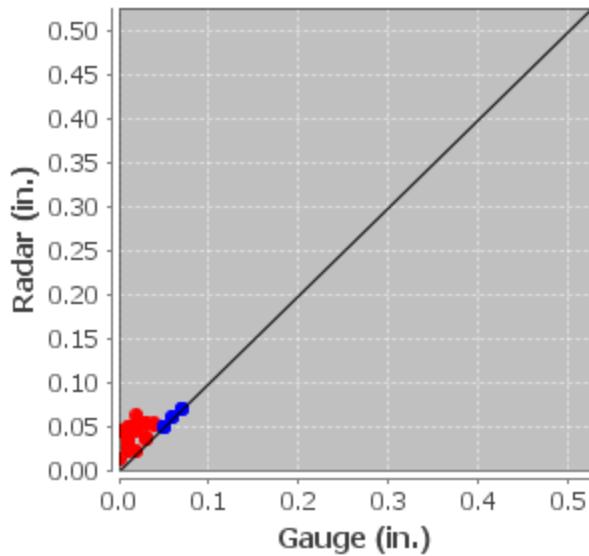


Figure 10. Scatter Plot of RG Pairs for Event 2a

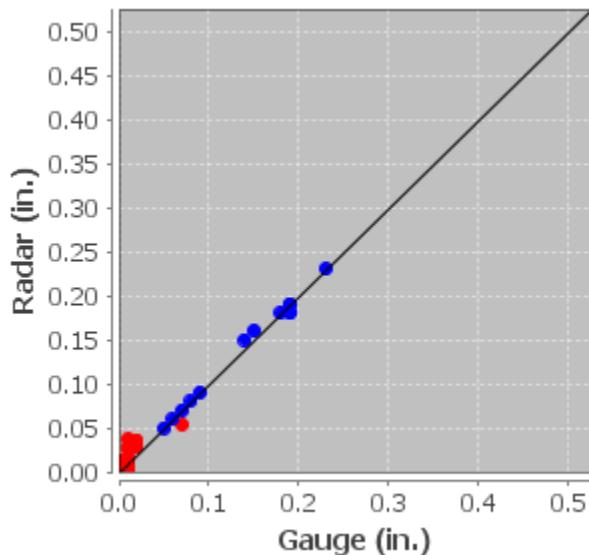


Figure 11. Scatter Plot of RG Pairs for Event 2b

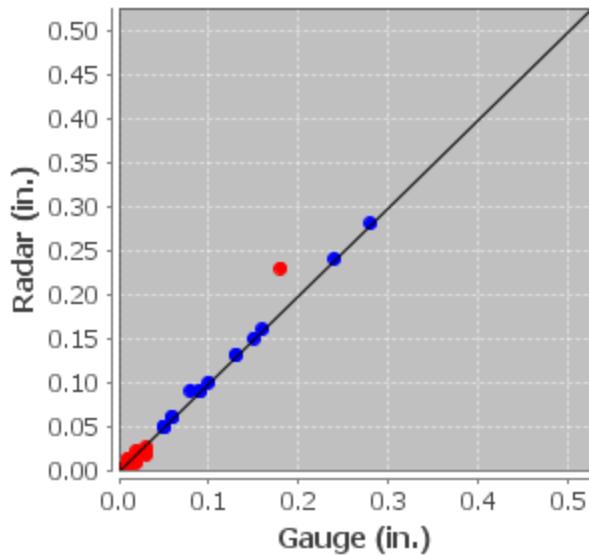


Figure 12. Scatter Plot of RG Pairs for Event 2c

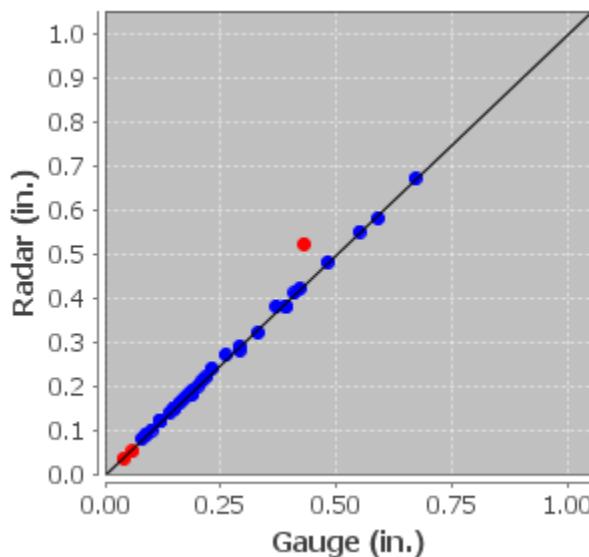


Figure 13. Scatter Plot of RG Pairs for Event 2d

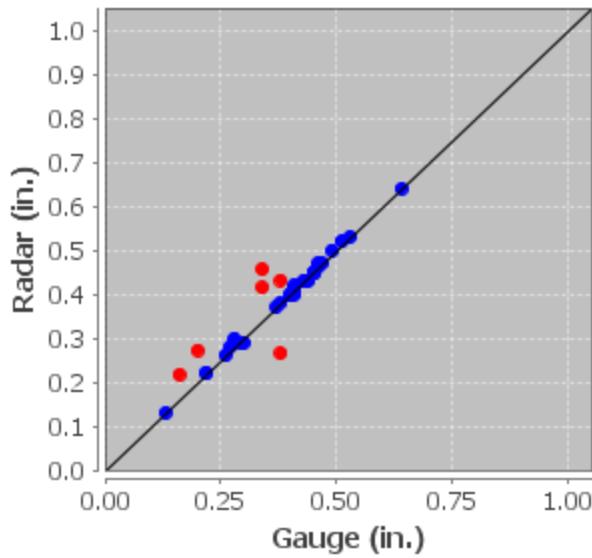


Figure 14. Scatter Plot of RG Pairs for Event 2e

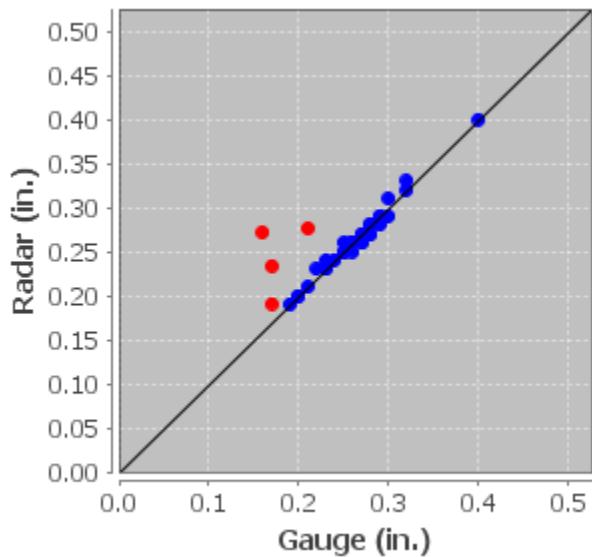


Figure 15. Scatter Plot of RG Pairs for Event 2f

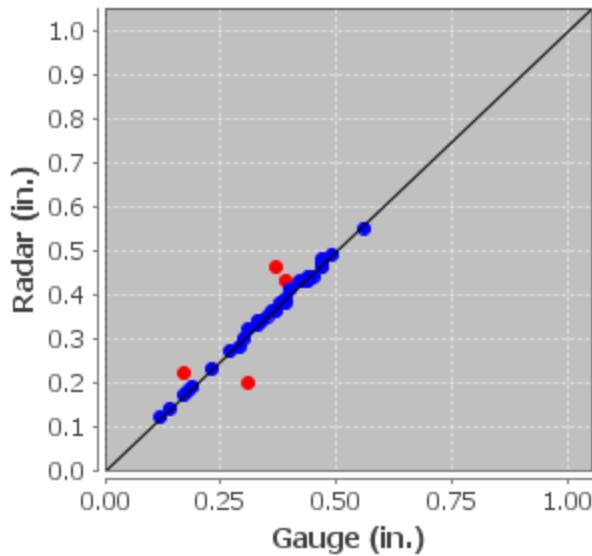


Figure 16. Scatter Plot of RG Pairs for Event 2g

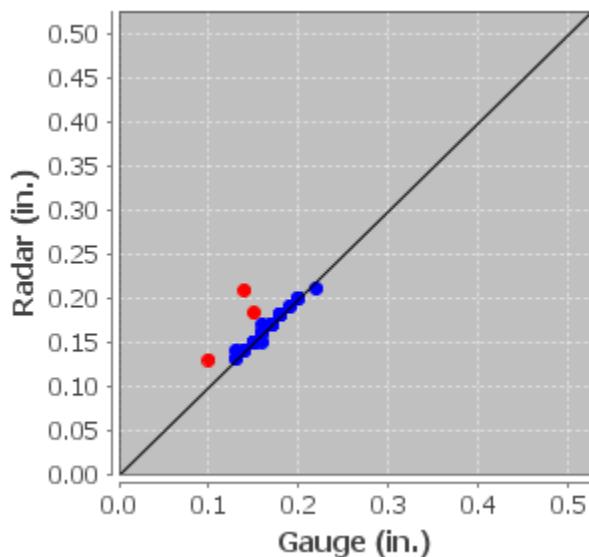


Figure 17. Scatter Plot of RG Pairs for Event 2h

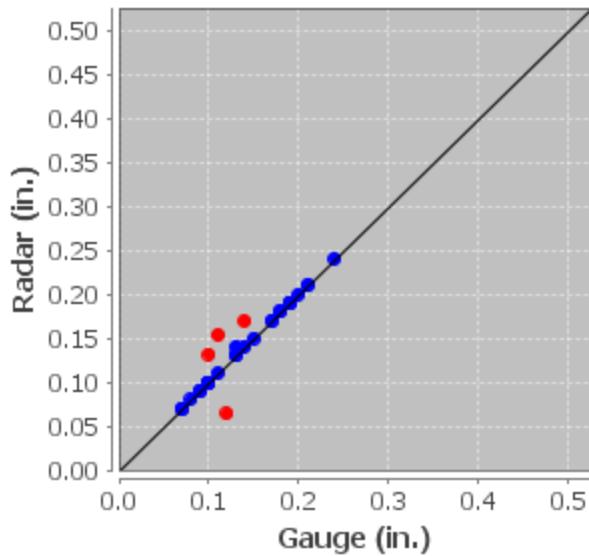


Figure 18. Scatter Plot of RG Pairs for Event 2i

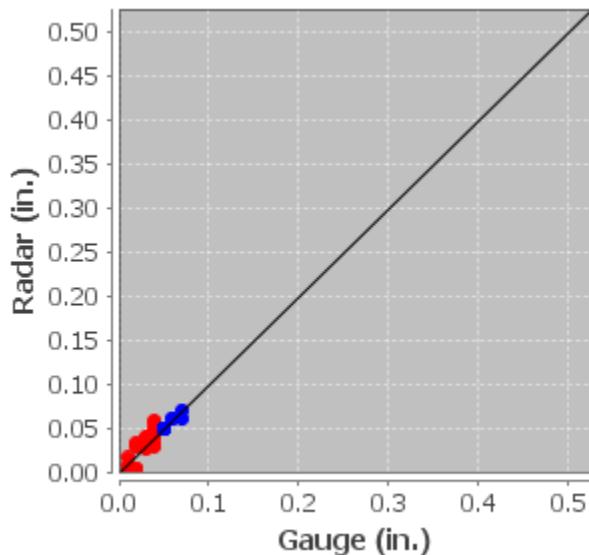


Figure 19. Scatter Plot of RG Pairs for Event 2j

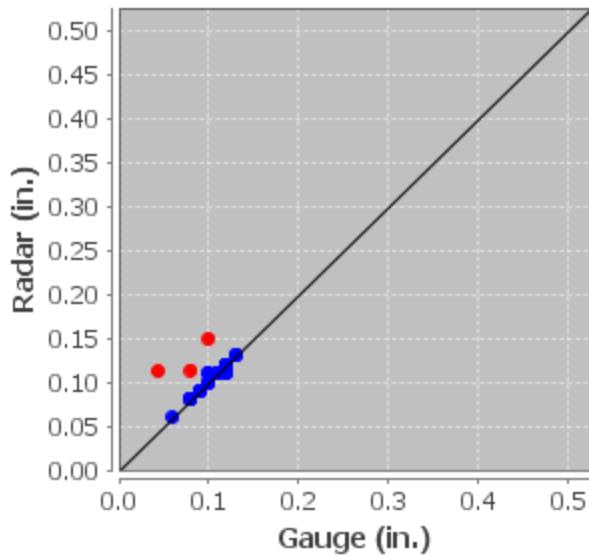


Figure 20. Scatter Plot of RG Pairs for Event 2k

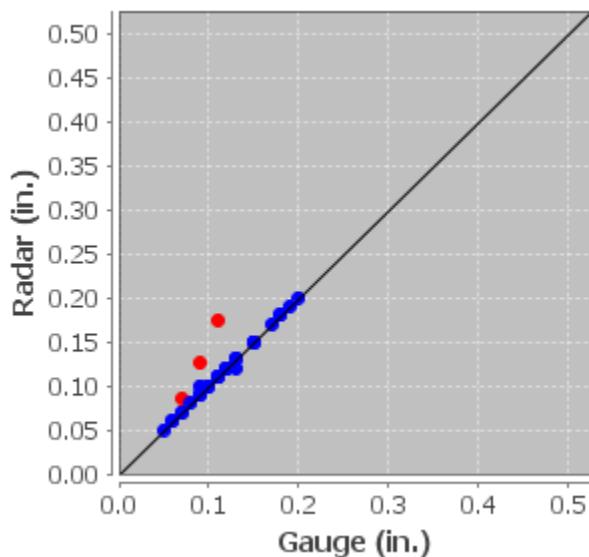


Figure 21. Scatter Plot of RG Pairs for Event 2m

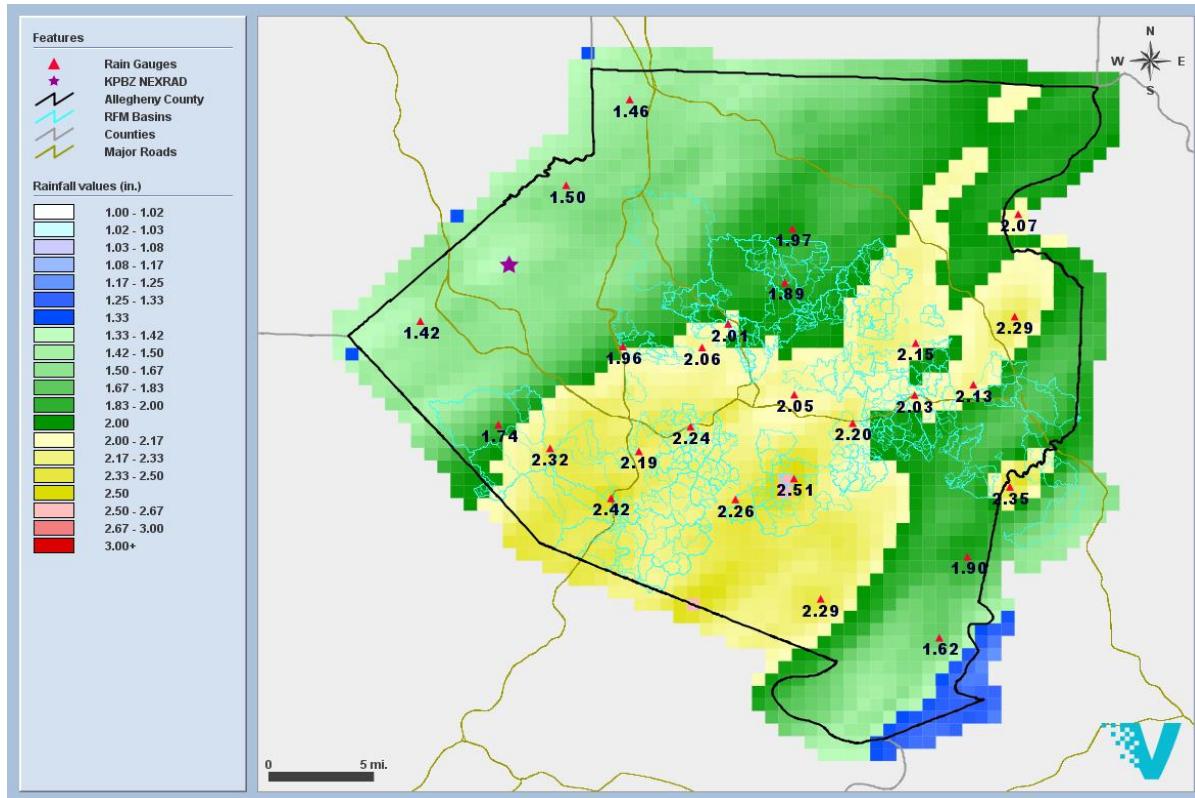


Figure 22. GARR Storm Total for Event 2

Table 26. Depth Duration Frequency Analyses for Event 2

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.366	143154	2019-10-07 01:15	<1 yr.
30 minutes	0.526	143154	2019-10-07 01:25	<1 yr.
1 hour	0.782	136139	2019-10-07 01:15	<1 yr.
2 hour	1.171	136146	2019-10-07 02:10	1 yr.
3 hour	1.518	136146	2019-10-07 03:15	2 yr.
6 hour	1.944	136146	2019-10-07 06:00	2 yr.
12 hour	2.238	136146	2019-10-07 11:55	2 yr.
24 hour	2.520	149145	2019-10-07 17:15	2 yr.

Event 3: 2019-10-16

The analysis period was from 2019-10-16 05:00 EDT to 2019-10-16 15:00 EDT. The event was then split into five sub-event periods at 2019-10-16 07:30 EDT, 2019-10-16 08:25 EDT, 2019-10-16 09:20 EDT and 2019-10-16 11:00 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 27 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 28 - 32 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 23 - 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 0.7 - 1.4 inches with a mean of 1.0 inches. The GARR amounts for the 440 RFM basins range from 0.7 - 1.3 inches with a mean of 1.0 inches. The GARR amounts for the 871 RFM sheds range from 0.7 - 1.4 inches with a mean of 1.0 inches. Table 33 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 27. 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	2019-10-16	2019-10-16 05:05	2019-10-16 07:30	21	0.117	1.037	13.8	2.7
E3b	KPBZ LII	2019-10-16	2019-10-16 07:35	2019-10-16 08:25	33	0.123	0.812	25.9	1.4
E3c	KPBZ LII	2019-10-16	2019-10-16 08:30	2019-10-16 09:20	34	0.144	1.388	25.7	2.4
E3d	KPBZ LII	2019-10-16	2019-10-16 09:25	2019-10-16 11:00	34	0.446	1.505	33.1	1.2
E3e	KPBZ LII	2019-10-16	2019-10-16 11:05	2019-10-16 15:00	35	0.171	1.428	29.1	1.6

Table 28. Summary of Individual RG Pairs for Event 3a

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.12	0.17	0.13	-0.01	-8.3	
Loc06	Carnegie Transit Time	0.13	0.14	0.14	-0.01	-7.7	
Loc31	Hampton Municipal Bldg	0.27	0.28	0.28	-0.01	-3.7	
Loc04	Kennedy Twp PS	0.12	0.13	0.12	0.00	0.0	
Loc08	AC Health Dept Bldg	0.10	0.11	0.10	0.00	0.0	
Loc09	Univ of Pittsburgh	0.06	0.08	0.06	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.07	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	0.07	0.09	0.07	0.00	0.0	
Loc17	Chartiers Pump Station	0.19	0.18	0.19	0.00	0.0	
Loc18	Oakdale Pump Station	0.16	0.14	0.16	0.00	0.0	
Loc21	Moon TWP	0.26	0.22	0.26	0.00	0.0	
Loc22	North Fayette TWP	0.16	0.13	0.16	0.00	0.0	
Loc23	Clinton Munic Bldg	0.22	0.23	0.22	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.07	0.08	0.00	0.0	
Loc27	Marshall TWP	0.19	0.16	0.19	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.32	0.27	0.32	0.00	0.0	
Loc30	McCandless Twn Hall	0.20	0.18	0.20	0.00	0.0	
Loc33	Richland TWP	0.21	0.22	0.21	0.00	0.0	
Loc03	Shaler Munic Bldg	0.18	0.16	0.17	0.01	5.6	
Loc07	Greentree Munic Bldg	0.16	0.15	0.15	0.01	6.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.14	0.12	0.13	0.01	7.1	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	Z
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.17	---	---	---	---	U
Loc01	PWSA-Montana St.	0.10	---	---	---	---	U
Loc05	Upper St. Clair	0.07	---	---	---	---	U
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.04	---	---	---	---	MSTT

Table 29. Summary of Individual RG Pairs for Event 3b

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.08	0.12	0.09	-0.01	-12.5	
Loc03	Shaler Munic Bldg	0.13	0.22	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	0.18	0.11	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.09	0.11	0.09	0.00	0.0	
Loc01	PWSA-Montana St.	0.15	0.22	0.15	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.14	0.21	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.19	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.15	0.21	0.15	0.00	0.0	
Loc07	Greentree Munic Bldg	0.15	0.21	0.15	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.16	0.12	0.00	0.0	
Loc09	Univ of Pittsburgh	0.10	0.13	0.10	0.00	0.0	
Loc10	PWSA-Highland Park	0.10	0.13	0.10	0.00	0.0	
Loc11	M-46 Access Shaft	0.09	0.11	0.09	0.00	0.0	
Loc12	Baldwin	0.10	0.12	0.10	0.00	0.0	
Loc13	M-59 Access Shaft	0.11	0.12	0.11	0.00	0.0	
Loc14	Churchill Munic Bldg	0.10	0.13	0.10	0.00	0.0	
Loc15	Trafford Maint Bldg	0.13	0.12	0.13	0.00	0.0	
Loc16	Castle Shannon	0.12	0.14	0.12	0.00	0.0	
Loc17	Chartiers Pump Station	0.16	0.20	0.16	0.00	0.0	
Loc18	Oakdale Pump Station	0.17	0.19	0.17	0.00	0.0	
Loc21	Moon TWP	0.10	0.11	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.12	0.14	0.12	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.13	0.11	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.09	0.10	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.09	0.08	0.09	0.00	0.0	
Loc27	Marshall TWP	0.14	0.13	0.14	0.00	0.0	
Loc28	Plum Municipal Bldg	0.17	0.16	0.17	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.11	0.11	0.11	0.00	0.0	
Loc30	McCandless Twn Hall	0.13	0.14	0.13	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.16	0.22	0.16	0.00	0.0	
Loc32	Arnold	0.16	0.15	0.16	0.00	0.0	
Loc33	Richland TWP	0.14	0.19	0.14	0.00	0.0	
Loc20	Gascola Eq Facility	0.17	0.17	0.16	0.01	5.9	
03049500	Allegheny River at Natrona	0.12	---	---	---	---	U
KPIP	Greater Pittsburgh Int'l	0.15	---	---	---	---	O

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.09	---	---	---	---	U
Loc23	Clinton Munic Bldg	0.08	---	---	---	---	OMFB

Table 30. Summary of Individual RG Pairs for Event 3c

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.09	0.10	0.10	-0.01	-11.1	
KAGC	Pittsburgh Allegheny Cty	0.11	0.10	0.12	-0.01	-9.1	
Loc20	Gascola Eq Facility	0.11	0.09	0.12	-0.01	-9.1	
Loc17	Chartiers Pump Station	0.15	0.11	0.16	-0.01	-6.7	
Loc22	North Fayette TWP	0.44	0.32	0.46	-0.02	-4.5	
03049500	Allegheny River at Natrona	0.10	0.08	0.10	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.16	0.13	0.16	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.10	0.11	0.00	0.0	
Loc03	Shaler Munic Bldg	0.08	0.08	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.17	0.13	0.17	0.00	0.0	
Loc07	Greentree Munic Bldg	0.11	0.08	0.11	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.06	0.07	0.00	0.0	
Loc09	Univ of Pittsburgh	0.08	0.06	0.08	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.05	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.10	0.07	0.10	0.00	0.0	
Loc13	M-59 Access Shaft	0.12	0.10	0.12	0.00	0.0	
Loc15	Trafford Maint Bldg	0.12	0.11	0.12	0.00	0.0	
Loc16	Castle Shannon	0.10	0.07	0.10	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.11	0.07	0.11	0.00	0.0	
Loc21	Moon TWP	0.29	0.16	0.29	0.00	0.0	
Loc23	Clinton Munic Bldg	0.14	0.08	0.14	0.00	0.0	
Loc24	Jefferson Hills	0.13	0.11	0.13	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.10	0.08	0.10	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.11	0.07	0.11	0.00	0.0	
Loc27	Marshall TWP	0.24	0.16	0.24	0.00	0.0	
Loc28	Plum Municipal Bldg	0.12	0.08	0.12	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.21	0.12	0.21	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.09	0.11	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.10	0.07	0.10	0.00	0.0	
Loc33	Richland TWP	0.13	0.10	0.13	0.00	0.0	
Loc18	Oakdale Pump Station	0.26	0.15	0.25	0.01	3.8	
Loc06	Carnegie Transit Time	0.17	0.11	0.16	0.01	5.9	
Loc14	Churchill Munic Bldg	0.13	0.08	0.12	0.01	7.7	
Loc12	Baldwin	0.12	0.07	0.11	0.01	8.3	
KPIT	Greater Pittsburgh Int'l	0.21	---	---	---	---	U
Loc05	Upper St. Clair	0.10	---	---	---	---	U
Loc30	McCandless Twn Hall	0.20	---	---	---	---	U

Table 31. Summary of Individual RG Pairs for Event 3d

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.44	0.35	0.46	-0.02	-4.5	
Loc12	Baldwin	0.37	0.28	0.38	-0.01	-2.7	
Loc08	AC Health Dept Bldg	0.38	0.31	0.39	-0.01	-2.6	
Loc22	North Fayette TWP	0.41	0.29	0.42	-0.01	-2.4	
Loc03	Shaler Munic Bldg	0.49	0.35	0.50	-0.01	-2.0	
Loc30	McCandless Twn Hall	0.58	0.40	0.59	-0.01	-1.7	
Loc06	Carnegie Transit Time	0.75	0.51	0.76	-0.01	-1.3	
KPIT	Greater Pittsburgh Int'l	0.52	0.32	0.52	0.00	0.0	
Loc01	PWSA-Montana St.	0.57	0.39	0.57	0.00	0.0	
Loc04	Kennedy Twp PS	0.47	0.34	0.47	0.00	0.0	
Loc09	Univ of Pittsburgh	0.39	0.31	0.39	0.00	0.0	
Loc10	PWSA-Highland Park	0.42	0.31	0.42	0.00	0.0	
Loc11	M-46 Access Shaft	0.35	0.25	0.35	0.00	0.0	
Loc15	Trafford Maint Bldg	0.42	0.31	0.42	0.00	0.0	
Loc16	Castle Shannon	0.41	0.28	0.41	0.00	0.0	
Loc17	Chartiers Pump Station	0.61	0.41	0.61	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.38	0.24	0.38	0.00	0.0	
Loc20	Gascola Eq Facility	0.36	0.22	0.36	0.00	0.0	
Loc21	Moon TWP	0.55	0.33	0.55	0.00	0.0	
Loc23	Clinton Munic Bldg	0.53	0.27	0.53	0.00	0.0	
Loc24	Jefferson Hills	0.40	0.24	0.40	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc25	White Oak Public Works Bldg	0.35	0.26	0.35	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.39	0.28	0.39	0.00	0.0	
Loc28	Plum Municipal Bldg	0.40	0.22	0.40	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.55	0.34	0.55	0.00	0.0	
Loc32	Arnold	0.36	0.25	0.36	0.00	0.0	
Loc33	Richland TWP	0.57	0.34	0.57	0.00	0.0	
Loc07	Greentree Munic Bldg	0.67	0.44	0.66	0.01	1.5	
Loc02	ALCOSAN WWTP Lab	0.59	0.40	0.58	0.01	1.7	
Loc27	Marshall TWP	0.58	0.35	0.57	0.01	1.7	
KAGC	Pittsburgh Allegheny Cty	0.38	0.24	0.37	0.01	2.6	
Loc14	Churchill Munic Bldg	0.37	0.22	0.36	0.01	2.7	
Loc31	Hampton Municipal Bldg	0.63	0.37	0.61	0.02	3.2	
Loc18	Oakdale Pump Station	0.54	0.33	0.52	0.02	3.7	
03049500	Allegheny River at Natrona	0.30	---	---	---	---	U
Loc05	Upper St. Clair	0.39	---	---	---	---	U
Loc13	M-59 Access Shaft	0.29	---	---	---	---	U

Table 32. Summary of Individual RG Pairs for Event 3e

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.17	0.12	0.18	-0.01	-5.9	
03049500	Allegheny River at Natrona	0.22	0.19	0.22	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.10	0.10	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.18	0.11	0.18	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.12	0.07	0.12	0.00	0.0	
Loc01	PWSA-Montana St.	0.13	0.11	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.12	0.10	0.12	0.00	0.0	
Loc03	Shaler Munic Bldg	0.15	0.11	0.15	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.10	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.14	0.09	0.14	0.00	0.0	
Loc07	Greentree Munic Bldg	0.15	0.10	0.15	0.00	0.0	
Loc09	Univ of Pittsburgh	0.17	0.11	0.17	0.00	0.0	
Loc11	M-46 Access Shaft	0.17	0.11	0.17	0.00	0.0	
Loc12	Baldwin	0.16	0.09	0.16	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.19	0.12	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.25	0.18	0.25	0.00	0.0	
Loc16	Castle Shannon	0.16	0.09	0.16	0.00	0.0	
Loc17	Chartiers Pump Station	0.15	0.09	0.15	0.00	0.0	
Loc18	Oakdale Pump Station	0.13	0.09	0.13	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.18	0.13	0.18	0.00	0.0	
Loc20	Gascola Eq Facility	0.20	0.14	0.20	0.00	0.0	
Loc21	Moon TWP	0.10	0.09	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.07	0.09	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.07	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.19	0.12	0.19	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.19	0.16	0.19	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.24	0.17	0.24	0.00	0.0	
Loc27	Marshall TWP	0.15	0.09	0.15	0.00	0.0	
Loc28	Plum Municipal Bldg	0.27	0.16	0.27	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.09	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.13	0.10	0.13	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.18	0.11	0.18	0.00	0.0	
Loc32	Arnold	0.21	0.16	0.21	0.00	0.0	
Loc33	Richland TWP	0.18	0.12	0.18	0.00	0.0	
Loc10	PWSA-Highland Park	0.19	0.12	0.18	0.01	5.3	
Loc05	Upper St. Clair	0.10	---	---	---	---	U
Loc13	M-59 Access Shaft	0.13	---	---	---	---	U

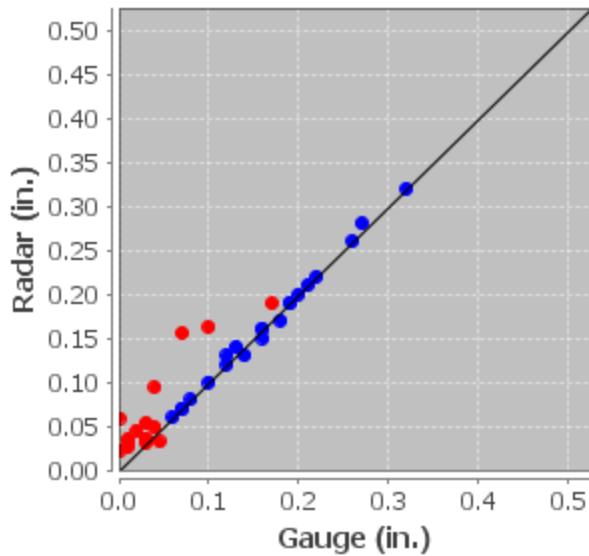


Figure 23. Scatter Plot of RG Pairs for Event 3a

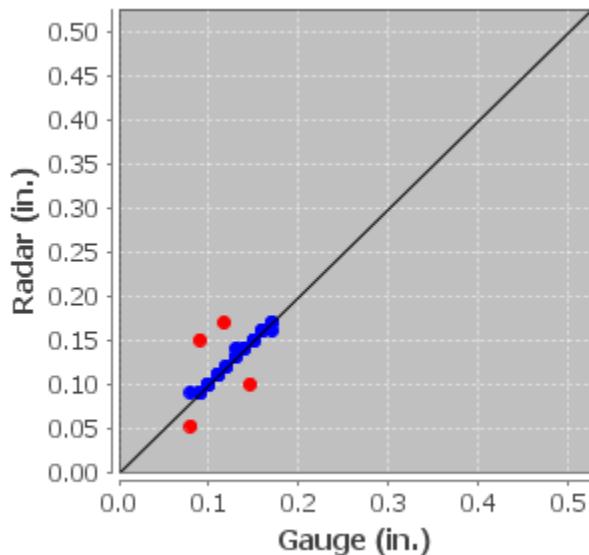


Figure 24. Scatter Plot of RG Pairs for Event 3b

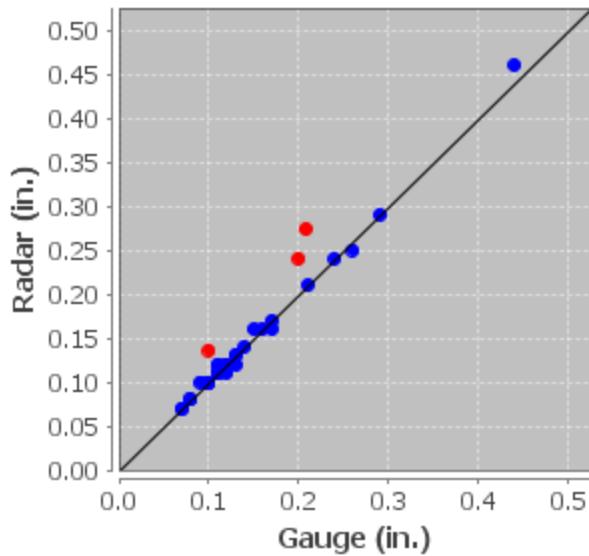


Figure 25. Scatter Plot of RG Pairs for Event 3c

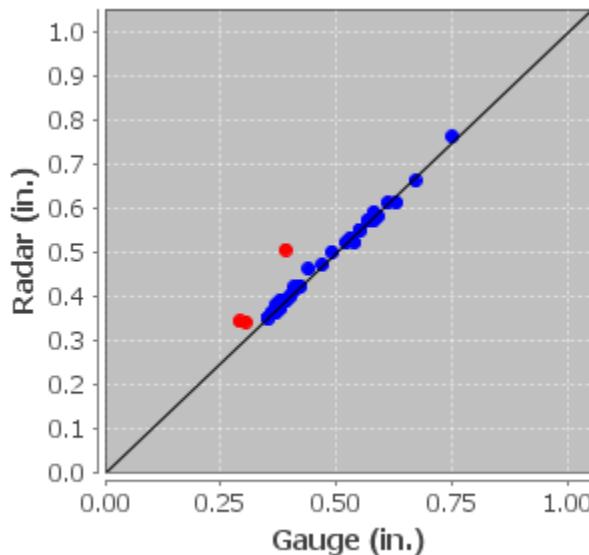


Figure 26. Scatter Plot of RG Pairs for Event 3d

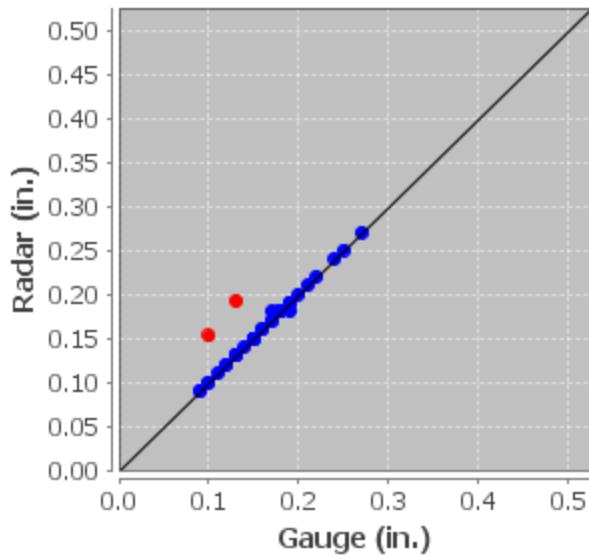


Figure 27. Scatter Plot of RG Pairs for Event 3e

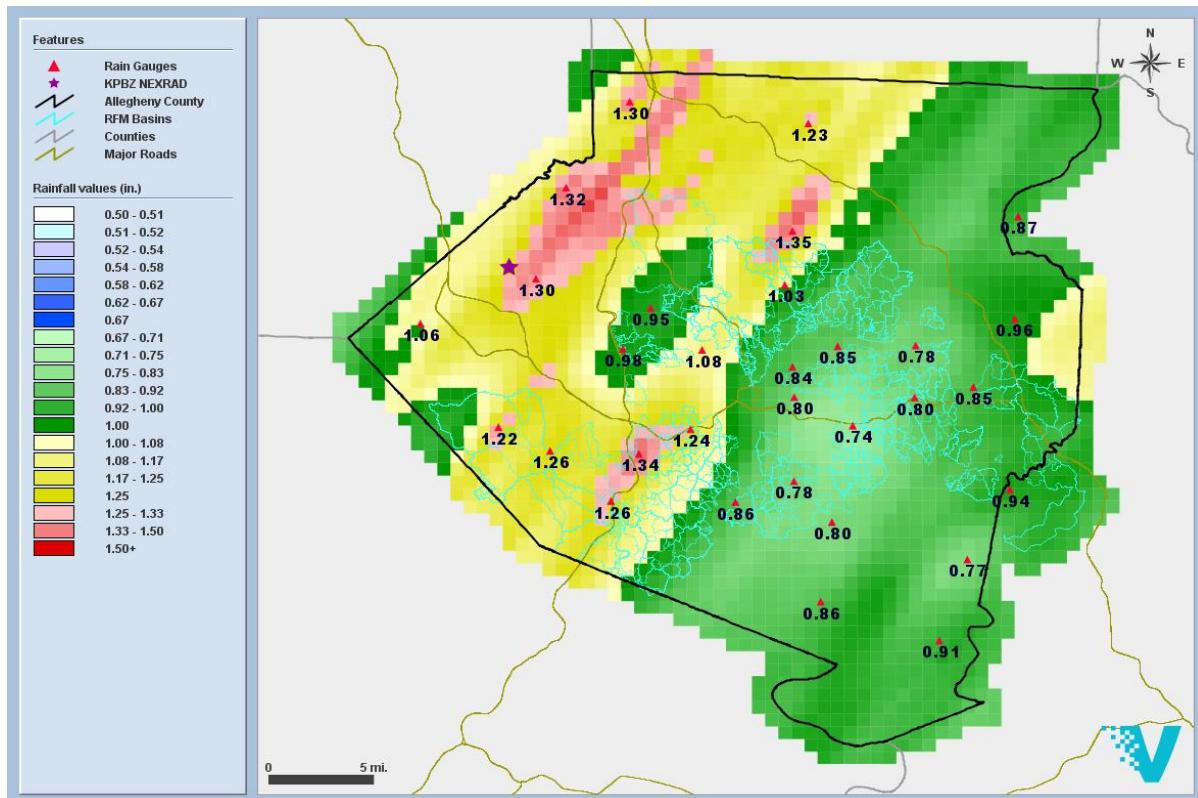


Figure 28. GARR Storm Total for Event 3

Table 33. Depth Duration Frequency Analyses for Event 3

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.305	139119	2019-10-16 09:50	<1 yr.
30 minutes	0.413	141141	2019-10-16 10:20	<1 yr.
1 hour	0.640	138143	2019-10-16 10:20	<1 yr.
2 hour	0.852	138142	2019-10-16 10:40	<1 yr.
3 hour	1.007	138142	2019-10-16 10:45	<1 yr.
6 hour	1.417	134123	2019-10-16 12:15	1 yr.

Event 4: 2019-10-22

The analysis period was from 2019-10-22 01:00 EDT to 2019-10-22 15:00 EDT. The event was then split into seven sub-event periods at 2019-10-22 07:30 EDT, 2019-10-22 08:05 EDT, 2019-10-22 08:45 EDT, 2019-10-22 09:20 EDT, 2019-10-22 10:25 EDT and 2019-10-22 11:00 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 34 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 35 - 41 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 - 35 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 36 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.5 - 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 0.7 inches. The GARR amounts for the 871 RFM sheds range from 0.6 - 0.9 inches with a mean of 0.7 inches. Table 42 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 34. 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	2019-10-22	2019-10-22 01:05	2019-10-22 07:30	22	0.067	0.868	21.4	0.9
E4b	KPBZ LII	2019-10-22	2019-10-22 07:35	2019-10-22 08:05	8	0.022	0.664	50.7	2.9

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E4c	KPBZ LII	2019-10-22	2019-10-22 08:10	2019-10-22 08:45	23	0.075	0.936	26.0	3.1
E4d	KPBZ LII	2019-10-22	2019-10-22 08:50	2019-10-22 09:20	32	0.143	1.023	16.5	1.8
E4e	KPBZ LII	2019-10-22	2019-10-22 09:25	2019-10-22 10:25	31	0.121	1.186	27.6	2.6
E4f	KPBZ LII	2019-10-22	2019-10-22 10:30	2019-10-22 11:00	6	0.034	0.546	86.1	0.9
E4g	KPBZ LII	2019-10-22	2019-10-22 11:05	2019-10-22 15:00	33	0.220	1.213	16.5	2.0

Table 35. Summary of Individual RG Pairs for Event 4a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
<u>KAGC</u>	Pittsburgh Allegheny Cty	0.06	0.06	0.06	0.00	0.0	
<u>KPIT</u>	Greater Pittsburgh Int'l	0.06	0.09	0.06	0.00	0.0	
<u>Loc01</u>	PWSA-Montana St.	0.05	0.07	0.05	0.00	0.0	
<u>Loc04</u>	Kennedy Twp PS	0.07	0.08	0.07	0.00	0.0	
<u>Loc07</u>	Greentree Munic Bldg	0.08	0.07	0.08	0.00	0.0	
<u>Loc10</u>	PWSA-Highland Park	0.06	0.06	0.06	0.00	0.0	
<u>Loc12</u>	Baldwin	0.05	0.05	0.05	0.00	0.0	
<u>Loc15</u>	Trafford Maint Bldg	0.06	0.08	0.06	0.00	0.0	
<u>Loc17</u>	Chartiers Pump Station	0.05	0.05	0.05	0.00	0.0	
<u>Loc18</u>	Oakdale Pump Station	0.08	0.07	0.08	0.00	0.0	
<u>Loc20</u>	Gascola Eq Facility	0.07	0.08	0.07	0.00	0.0	
<u>Loc21</u>	Moon TWP	0.06	0.10	0.06	0.00	0.0	
<u>Loc22</u>	North Fayette TWP	0.06	0.07	0.06	0.00	0.0	
<u>Loc23</u>	Clinton Munic Bldg	0.08	0.09	0.08	0.00	0.0	
<u>Loc25</u>	White Oak Public Works Bldg	0.05	0.07	0.05	0.00	0.0	
<u>Loc26</u>	Elizabeth TWP Municipal Bldg	0.05	0.07	0.05	0.00	0.0	
<u>Loc27</u>	Marshall TWP	0.10	0.11	0.10	0.00	0.0	
<u>Loc28</u>	Plum Municipal Bldg	0.08	0.09	0.08	0.00	0.0	
<u>Loc29</u>	Bell Acres Munic Bldg	0.08	0.12	0.08	0.00	0.0	
<u>Loc30</u>	McCandless Twn Hall	0.08	0.10	0.08	0.00	0.0	
<u>Loc31</u>	Hampton Municipal Bldg	0.08	0.10	0.08	0.00	0.0	
<u>Loc33</u>	Richland TWP	0.11	0.10	0.11	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
03049500	Allegheny River at Natrona	0.01	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	ND
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.03	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.06	---	---	---	---	MSTT
Loc16	Castle Shannon	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.05	---	---	---	---	MSTT

Table 36. Summary of Individual RG Pairs for Event 4b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.05	0.11	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.05	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.06	0.05	0.06	0.00	0.0	
Loc21	Moon TWP	0.08	0.13	0.08	0.00	0.0	
Loc22	North Fayette TWP	0.05	0.07	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.20	0.09	0.00	0.0	
Loc27	Marshall TWP	0.06	0.08	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.13	0.10	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	U
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.01	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 37. Summary of Individual RG Pairs for Event 4c

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.09	0.11	0.10	-0.01	-11.1	
Loc04	Kennedy Twp PS	0.10	0.16	0.11	-0.01	-10.0	
Loc01	PWSA-Montana St.	0.12	0.15	0.13	-0.01	-8.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.13	0.17	0.13	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.09	0.12	0.09	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.09	0.12	0.00	0.0	
Loc09	Univ of Pittsburgh	0.11	0.08	0.11	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc10	PWSA-Highland Park	0.10	0.07	0.10	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.05	0.06	0.00	0.0	
Loc12	Baldwin	0.10	0.08	0.10	0.00	0.0	
Loc16	Castle Shannon	0.13	0.09	0.13	0.00	0.0	
Loc18	Oakdale Pump Station	0.11	0.11	0.11	0.00	0.0	
Loc21	Moon TWP	0.10	0.14	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.12	0.12	0.12	0.00	0.0	
Loc23	Clinton Munic Bldg	0.10	0.14	0.10	0.00	0.0	
Loc27	Marshall TWP	0.12	0.18	0.12	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.20	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.15	0.20	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.12	0.13	0.00	0.0	
Loc33	Richland TWP	0.12	0.10	0.12	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.15	0.14	0.14	0.01	6.7	
Loc07	Greentree Munic Bldg	0.15	0.12	0.14	0.01	6.7	
Loc17	Chartiers Pump Station	0.12	0.10	0.11	0.01	8.3	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.05	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND
Loc05	Upper St. Clair	0.09	---	---	---	---	U
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT

Table 38. Summary of Individual RG Pairs for Event 4d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.13	0.14	0.15	-0.02	-15.4	
Loc06	Carnegie Transit Time	0.13	0.14	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.15	0.19	0.15	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.09	0.09	0.09	0.00	0.0	
Loc01	PWSA-Montana St.	0.15	0.16	0.15	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.14	0.14	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.14	0.18	0.14	0.00	0.0	
Loc07	Greentree Munic Bldg	0.15	0.14	0.15	0.00	0.0	
Loc08	AC Health Dept Bldg	0.16	0.16	0.16	0.00	0.0	
Loc09	Univ of Pittsburgh	0.14	0.14	0.14	0.00	0.0	
Loc10	PWSA-Highland Park	0.14	0.13	0.14	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.10	0.11	0.00	0.0	
Loc12	Baldwin	0.08	0.07	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.09	0.07	0.09	0.00	0.0	
Loc14	Churchill Munic Bldg	0.20	0.15	0.20	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.06	0.05	0.00	0.0	
Loc16	Castle Shannon	0.12	0.09	0.12	0.00	0.0	
Loc17	Chartiers Pump Station	0.15	0.14	0.15	0.00	0.0	
Loc18	Oakdale Pump Station	0.17	0.18	0.17	0.00	0.0	
Loc21	Moon TWP	0.21	0.25	0.21	0.00	0.0	
Loc23	Clinton Munic Bldg	0.19	0.22	0.19	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.05	0.08	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.05	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.06	0.05	0.06	0.00	0.0	
Loc27	Marshall TWP	0.18	0.21	0.18	0.00	0.0	
Loc28	Plum Municipal Bldg	0.11	0.06	0.11	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.22	0.27	0.22	0.00	0.0	
Loc30	McCandless Twn Hall	0.18	0.21	0.18	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.21	0.16	0.21	0.00	0.0	
Loc32	Arnold	0.08	0.06	0.08	0.00	0.0	
Loc33	Richland TWP	0.25	0.23	0.25	0.00	0.0	
Loc20	Gascola Eq Facility	0.12	0.07	0.11	0.01	8.3	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.10	---	---	---	---	U
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.10	---	---	---	---	U
Loc22	North Fayette TWP	0.13	---	---	---	---	U

Table 39. Summary of Individual RG Pairs for Event 4e

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.09	0.10	0.10	-0.01	-11.1	
Loc19	Sandy Creek Eq Facility	0.13	0.11	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.09	0.07	0.00	0.0	
Loc01	PWSA-Montana St.	0.08	0.09	0.08	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.08	0.09	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.06	0.08	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.10	0.12	0.00	0.0	
Loc10	PWSA-Highland Park	0.09	0.09	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.12	0.09	0.12	0.00	0.0	
Loc12	Baldwin	0.13	0.10	0.13	0.00	0.0	
Loc14	Churchill Munic Bldg	0.13	0.08	0.13	0.00	0.0	
Loc15	Trafford Maint Bldg	0.17	0.11	0.17	0.00	0.0	
Loc16	Castle Shannon	0.14	0.09	0.14	0.00	0.0	
Loc17	Chartiers Pump Station	0.10	0.08	0.10	0.00	0.0	
Loc18	Oakdale Pump Station	0.08	0.07	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.14	0.08	0.14	0.00	0.0	
Loc21	Moon TWP	0.07	0.09	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.05	0.06	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.10	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.07	0.11	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.15	0.11	0.15	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.19	0.10	0.19	0.00	0.0	
Loc27	Marshall TWP	0.08	0.10	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.19	0.11	0.19	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.07	0.11	0.07	0.00	0.0	
Loc30	McCandless Twn Hall	0.06	0.10	0.06	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.08	0.11	0.00	0.0	
Loc32	Arnold	0.20	0.12	0.20	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc33	Richland TWP	0.10	0.10	0.10	0.00	0.0	
Loc06	Carnegie Transit Time	0.12	0.08	0.11	0.01	8.3	
Loc09	Univ of Pittsburgh	0.12	0.10	0.11	0.01	8.3	
03049500	Allegheny River at Natrona	0.15	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.16	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.14	---	---	---	---	O
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND
Loc05	Upper St. Clair	0.09	---	---	---	---	U
Loc13	M-59 Access Shaft	0.09	---	---	---	---	U

Table 40. Summary of Individual RG Pairs for Event 4f

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.05	0.12	0.05	0.00	0.0	
Loc06	Carnegie Transit Time	0.05	0.10	0.05	0.00	0.0	
Loc07	Greentree Munic Bldg	0.08	0.14	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.12	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.07	0.11	0.07	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.05	0.06	0.05	0.00	0.0	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
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	0.02	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.02	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.04	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.01	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.04	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.04	---	---	---	---	MSTT
Loc27	Marshall TWP	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.02	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.02	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 41. Summary of Individual RG Pairs for Event 4g

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.11	0.11	0.12	-0.01	-9.1	
Loc17	Chartiers Pump Station	0.15	0.12	0.16	-0.01	-6.7	
Loc07	Greentree Munic Bldg	0.23	0.18	0.24	-0.01	-4.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.11	0.10	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.29	0.22	0.29	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.07	0.07	0.07	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.15	0.15	0.15	0.00	0.0	
Loc04	Kennedy Twp PS	0.11	0.10	0.11	0.00	0.0	
Loc08	AC Health Dept Bldg	0.25	0.23	0.25	0.00	0.0	
Loc09	Univ of Pittsburgh	0.23	0.21	0.23	0.00	0.0	
Loc10	PWSA-Highland Park	0.26	0.22	0.26	0.00	0.0	
Loc11	M-46 Access Shaft	0.25	0.20	0.25	0.00	0.0	
Loc12	Baldwin	0.27	0.19	0.27	0.00	0.0	
Loc13	M-59 Access Shaft	0.30	0.24	0.30	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc15	Trafford Maint Bldg	0.33	0.30	0.33	0.00	0.0	
Loc16	Castle Shannon	0.26	0.19	0.26	0.00	0.0	
Loc18	Oakdale Pump Station	0.10	0.08	0.10	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.25	0.21	0.25	0.00	0.0	
Loc20	Gascola Eq Facility	0.33	0.26	0.33	0.00	0.0	
Loc21	Moon TWP	0.07	0.06	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.08	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.29	0.22	0.29	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.32	0.29	0.32	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.33	0.28	0.33	0.00	0.0	
Loc27	Marshall TWP	0.08	0.05	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.36	0.25	0.36	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.21	0.19	0.21	0.00	0.0	
Loc32	Arnold	0.31	0.23	0.31	0.00	0.0	
Loc33	Richland TWP	0.21	0.18	0.21	0.00	0.0	
Loc14	Churchill Munic Bldg	0.29	0.22	0.28	0.01	3.4	
Loc06	Carnegie Transit Time	0.20	0.13	0.19	0.01	5.0	
Loc01	PWSA-Montana St.	0.18	0.16	0.17	0.01	5.6	
03049500	Allegheny River at Natrona	0.28	---	---	---	---	U
Loc03	Shaler Munic Bldg	ND	---	---	---	---	ND
Loc05	Upper St. Clair	0.13	---	---	---	---	U
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	MSTT

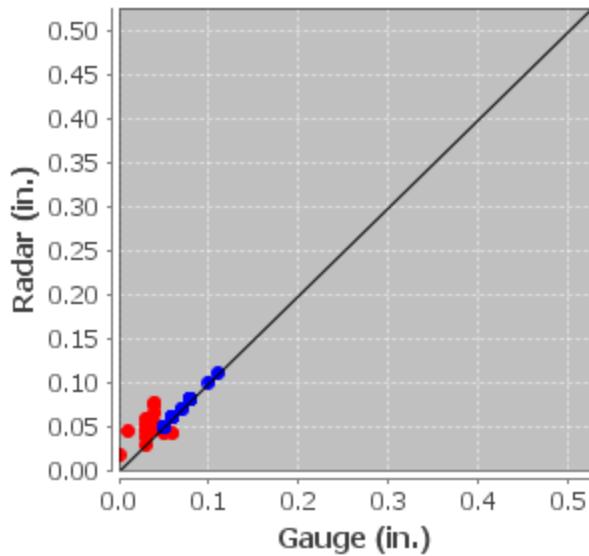


Figure 29. Scatter Plot of RG Pairs for Event 4a

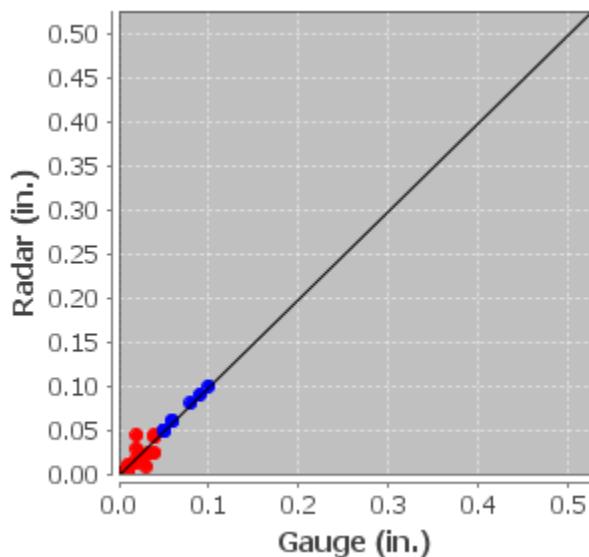


Figure 30. Scatter Plot of RG Pairs for Event 4b

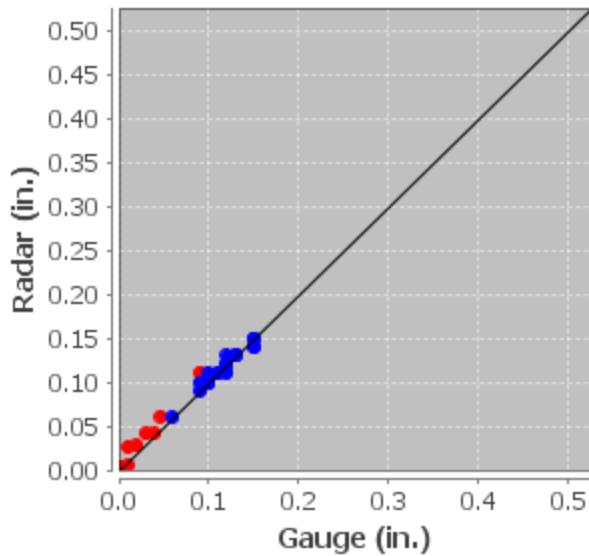


Figure 31. Scatter Plot of RG Pairs for Event 4c

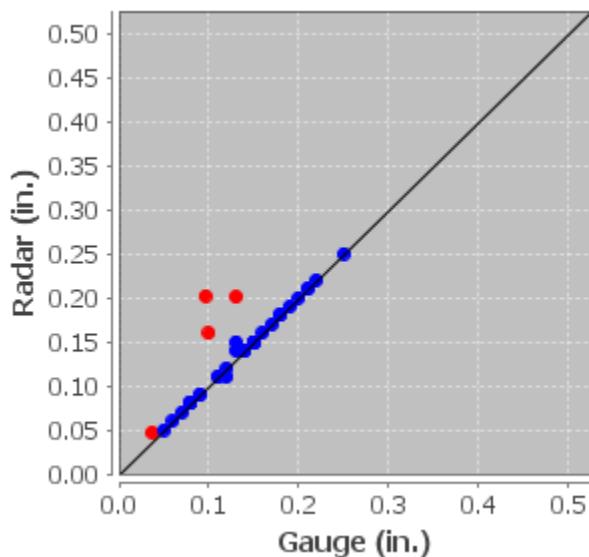


Figure 32. Scatter Plot of RG Pairs for Event 4d

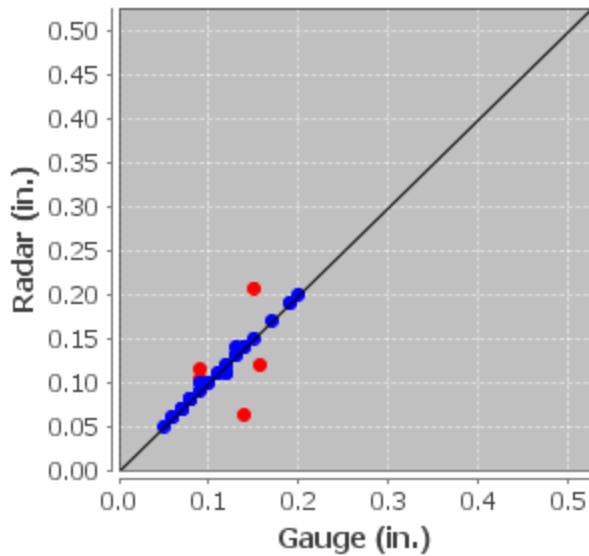


Figure 33. Scatter Plot of RG Pairs for Event 4e

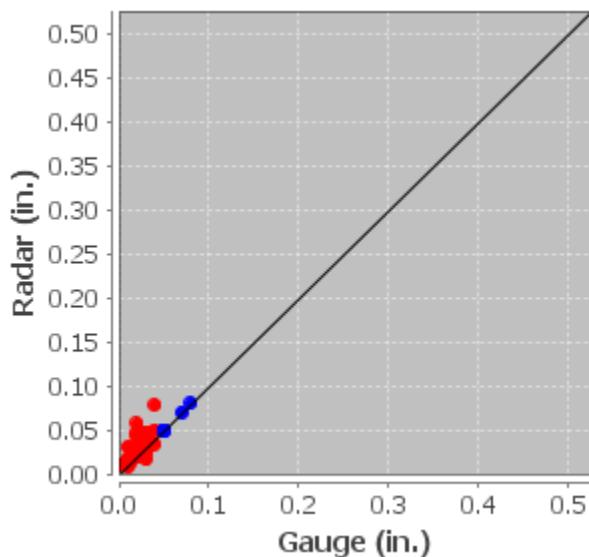


Figure 34. Scatter Plot of RG Pairs for Event 4f

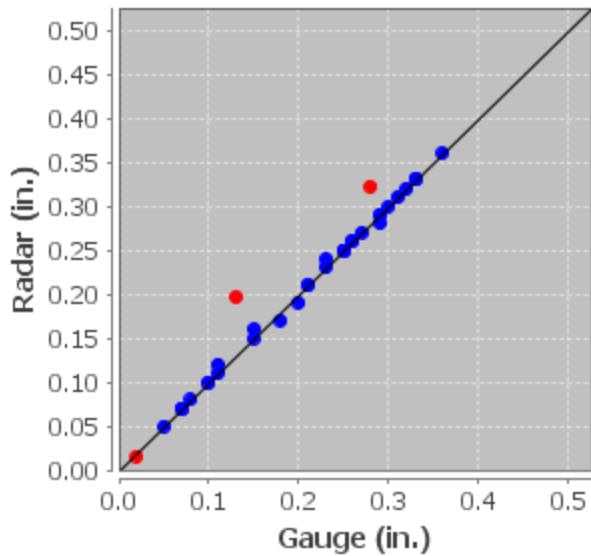


Figure 35. Scatter Plot of RG Pairs for Event 4g

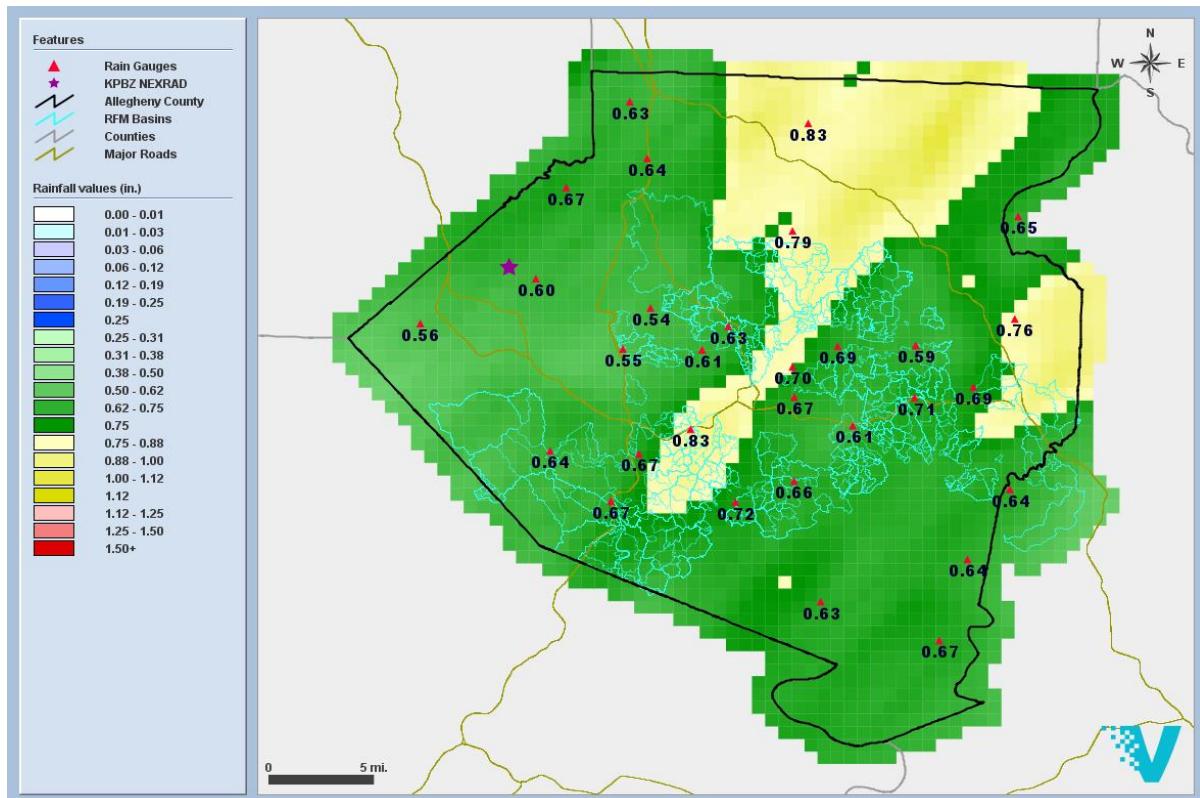


Figure 36. GARR Storm Total for Event 4

Table 42. Depth Duration Frequency Analyses for Event 4

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.300	161117	2019-10-22 09:25	<1 yr.
30 minutes	0.358	161117	2019-10-22 09:35	<1 yr.
1 hour	0.446	147116	2019-10-22 09:20	<1 yr.
2 hour	0.535	147116	2019-10-22 10:05	<1 yr.
3 hour	0.695	161117	2019-10-22 12:05	<1 yr.
6 hour	0.909	161118	2019-10-22 13:20	<1 yr.
12 hour	1.011	161117	2019-10-22 13:20	<1 yr.

Event 5: 2019-10-27

The analysis period was from 2019-10-26 10:00 EDT to 2019-10-27 08:00 EDT. The event was then split into eight sub-event periods at 2019-10-26 18:30 EDT, 2019-10-26 19:30 EDT, 2019-10-26 20:10 EDT, 2019-10-26 21:30 EDT, 2019-10-27 03:00 EDT, 2019-10-27 04:30 EDT and 2019-10-27 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 43 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 44 - 51 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 37 - 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 0.5 - 1.2 inches with a mean of 0.8 inches. The GARR amounts for the 440 RFM basins range from 0.5 - 1.0 inches with a mean of 0.8 inches. The GARR amounts for the 871 RFM sheds range from 0.5 - 1.0 inches with a mean of 0.8 inches. Table 52 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 43. 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	2019-10-27	2019-10-26 10:05	2019-10-26 18:30	25	0.080	0.782	29.6	4.0
E5b	KPBZ LII	2019-10-27	2019-10-26 18:35	2019-10-26 19:30	32	0.097	0.716	43.3	2.9
E5c	KPBZ LII	2019-10-27	2019-10-26 19:35	2019-10-26 20:10	22	0.064	0.761	35.2	1.8
E5d	KPBZ LII	2019-10-27	2019-10-26 20:15	2019-10-26 21:30	13	0.045	0.736	36.3	1.3
E5e	KPBZ LII	2019-10-27	2019-10-26 21:35	2019-10-27 03:00	32	0.106	1.299	22.3	2.7
E5f	KPBZ LII	2019-10-27	2019-10-27 03:05	2019-10-27 04:30	17	0.114	1.349	23.9	2.8
E5g	KPBZ LII	2019-10-27	2019-10-27 04:35	2019-10-27 05:00	33	0.096	1.007	19.2	1.4
E5h	KPBZ LII	2019-10-27	2019-10-27 05:05	2019-10-27 08:00	33	0.193	2.253	54.9	1.2

Table 44. Summary of Individual RG Pairs for Event 5a

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	0.06	0.11	0.07	-0.01	-16.7	
Loc21	Moon TWP	0.12	0.19	0.13	-0.01	-8.3	
KPIT	Greater Pittsburgh Int'l	0.13	0.15	0.13	0.00	0.0	
Loc01	PWSA-Montana St.	0.07	0.08	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.08	0.05	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.06	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.06	0.09	0.06	0.00	0.0	
Loc10	PWSA-Highland Park	0.08	0.09	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.05	0.06	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.06	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.07	0.09	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	0.07	0.09	0.07	0.00	0.0	
Loc22	North Fayette 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
Loc23	Clinton Munic Bldg	0.16	0.19	0.16	0.00	0.0	
Loc27	Marshall TWP	0.18	0.21	0.18	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.19	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.14	0.19	0.14	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
Loc32	Arnold	0.08	0.11	0.08	0.00	0.0	
Loc33	Richland TWP	0.13	0.18	0.13	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.10	0.09	0.01	10.0	
Loc14	Churchill Munic Bldg	0.08	0.07	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.09	---	---	---	---	O
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	U
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc16	Castle Shannon	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT

Table 45. Summary of Individual RG Pairs for Event 5b

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.10	0.21	0.11	-0.01	-10.0	
Loc02	ALCOSAN WWTP Lab	0.12	0.16	0.13	-0.01	-8.3	
Loc12	Baldwin	0.13	0.22	0.14	-0.01	-7.7	
Loc17	Chartiers Pump Station	0.13	0.17	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.08	0.10	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.05	0.08	0.05	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.14	0.10	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.11	0.09	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
<u>Loc06</u>	Carnegie Transit Time	0.15	0.17	0.15	0.00	0.0	
<u>Loc07</u>	Greentree Munic Bldg	0.15	0.18	0.15	0.00	0.0	
<u>Loc08</u>	AC Health Dept Bldg	0.16	0.22	0.16	0.00	0.0	
<u>Loc09</u>	Univ of Pittsburgh	0.17	0.23	0.17	0.00	0.0	
<u>Loc13</u>	M-59 Access Shaft	0.09	0.17	0.09	0.00	0.0	
<u>Loc15</u>	Trafford Maint Bldg	0.13	0.18	0.13	0.00	0.0	
<u>Loc19</u>	Sandy Creek Eq Facility	0.10	0.18	0.10	0.00	0.0	
<u>Loc20</u>	Gascola Eq Facility	0.08	0.16	0.08	0.00	0.0	
<u>Loc21</u>	Moon TWP	0.07	0.08	0.07	0.00	0.0	
<u>Loc22</u>	North Fayette TWP	0.08	0.10	0.08	0.00	0.0	
<u>Loc23</u>	Clinton Munic Bldg	0.06	0.08	0.06	0.00	0.0	
<u>Loc24</u>	Jefferson Hills	0.11	0.18	0.11	0.00	0.0	
<u>Loc25</u>	White Oak Public Works Bldg	0.14	0.21	0.14	0.00	0.0	
<u>Loc26</u>	Elizabeth TWP Municipal Bldg	0.17	0.19	0.17	0.00	0.0	
<u>Loc28</u>	Plum Municipal Bldg	0.07	0.13	0.07	0.00	0.0	
<u>Loc29</u>	Bell Acres Munic Bldg	0.06	0.07	0.06	0.00	0.0	
<u>Loc30</u>	McCandless Twn Hall	0.05	0.06	0.05	0.00	0.0	
<u>Loc31</u>	Hampton Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
<u>Loc32</u>	Arnold	0.07	0.14	0.07	0.00	0.0	
<u>Loc10</u>	PWSA-Highland Park	0.19	0.24	0.18	0.01	5.3	
<u>Loc16</u>	Castle Shannon	0.18	0.21	0.17	0.01	5.6	
<u>Loc01</u>	PWSA-Montana St.	0.14	0.15	0.13	0.01	7.1	
<u>Loc18</u>	Oakdale Pump Station	0.13	0.12	0.12	0.01	7.7	
<u>Loc14</u>	Churchill Munic Bldg	0.11	0.17	0.10	0.01	9.1	
<u>03049500</u>	Allegheny River at Natrona	0.01	---	---	---	---	U
<u>KAGC</u>	Pittsburgh Allegheny Cty	0.07	---	---	---	---	U
<u>Loc05</u>	Upper St. Clair	0.08	---	---	---	---	U
<u>Loc27</u>	Marshall TWP	0.03	---	---	---	---	MSTT
<u>Loc33</u>	Richland TWP	0.05	---	---	---	---	MSTT

Table 46. Summary of Individual RG Pairs for Event 5c

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.10	0.07	-0.01	-16.7	
Loc02	ALCOSAN WWTP Lab	0.06	0.10	0.07	-0.01	-16.7	
KAGC	Pittsburgh Allegheny Cty	0.06	0.06	0.06	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.05	0.08	0.05	0.00	0.0	
Loc01	PWSA-Montana St.	0.08	0.11	0.08	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.11	0.09	0.00	0.0	
Loc04	Kennedy Twp PS	0.07	0.09	0.07	0.00	0.0	
Loc06	Carnegie Transit Time	0.05	0.07	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.07	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.05	0.07	0.05	0.00	0.0	
Loc12	Baldwin	0.05	0.06	0.05	0.00	0.0	
Loc13	M-59 Access Shaft	0.06	0.07	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.05	0.07	0.05	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.08	0.05	0.00	0.0	
Loc21	Moon TWP	0.06	0.08	0.06	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.09	0.09	0.00	0.0	
Loc28	Plum Municipal Bldg	0.06	0.10	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc30	McCandless Twn Hall	0.06	0.07	0.06	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.14	0.11	0.00	0.0	
Loc32	Arnold	0.09	0.14	0.09	0.00	0.0	
Loc33	Richland TWP	0.14	0.13	0.14	0.00	0.0	
03049500	Allegheny River at Natrona	0.08	---	---	---	---	U
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.04	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.04	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc26	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	MSTT
Loc27	Marshall TWP	0.07	---	---	---	---	OMFB

Table 47. Summary of Individual RG Pairs for Event 5d

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc18	Oakdale Pump Station	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.02	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.04	---	---	---	---	MSTT

Table 48. Summary of Individual RG Pairs for Event 5e

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.08	0.07	0.09	-0.01	-12.5	
Loc09	Univ of Pittsburgh	0.11	0.11	0.12	-0.01	-9.1	
03049500	Allegheny River at Natrona	0.16	0.10	0.16	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.06	0.06	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.12	0.10	0.12	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.10	0.08	0.10	0.00	0.0	
Loc01	PWSA-Montana St.	0.09	0.06	0.09	0.00	0.0	
Loc04	Kennedy Twp PS	0.08	0.06	0.08	0.00	0.0	
Loc07	Greentree Munic Bldg	0.12	0.09	0.12	0.00	0.0	
Loc08	AC Health Dept Bldg	0.12	0.10	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.11	0.11	0.00	0.0	
Loc12	Baldwin	0.11	0.09	0.11	0.00	0.0	
Loc14	Churchill Munic Bldg	0.13	0.11	0.13	0.00	0.0	
Loc15	Trafford Maint Bldg	0.07	0.08	0.07	0.00	0.0	
Loc16	Castle Shannon	0.11	0.09	0.11	0.00	0.0	
Loc17	Chartiers Pump Station	0.11	0.09	0.11	0.00	0.0	
Loc18	Oakdale Pump Station	0.07	0.06	0.07	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.15	0.12	0.15	0.00	0.0	
Loc20	Gascola Eq Facility	0.11	0.10	0.11	0.00	0.0	
Loc21	Moon TWP	0.13	0.09	0.13	0.00	0.0	
Loc23	Clinton Munic Bldg	0.11	0.07	0.11	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc25	White Oak Public Works Bldg	0.09	0.07	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.08	0.08	0.00	0.0	
Loc27	Marshall TWP	0.12	0.07	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.12	0.13	0.12	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.07	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.11	0.08	0.11	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.10	0.06	0.10	0.00	0.0	
Loc32	Arnold	0.15	0.11	0.15	0.00	0.0	
Loc33	Richland TWP	0.15	0.09	0.15	0.00	0.0	
Loc06	Carnegie Transit Time	0.12	0.08	0.11	0.01	8.3	
Loc10	PWSA-Highland Park	0.17	0.10	0.15	0.02	11.8	
Loc02	ALCOSAN WWTP Lab	0.06	---	---	---	---	U
Loc05	Upper St. Clair	0.07	---	---	---	---	U
Loc13	M-59 Access Shaft	0.09	---	---	---	---	U
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.05	---	---	---	---	U

Table 49. Summary of Individual RG Pairs for Event 5f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.17	0.16	0.19	-0.02	-11.8	
Loc07	Greentree Munic Bldg	0.11	0.09	0.12	-0.01	-9.1	
Loc17	Chartiers Pump Station	0.16	0.15	0.17	-0.01	-6.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.19	0.13	0.19	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.05	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.34	0.25	0.34	0.00	0.0	
Loc21	Moon TWP	0.22	0.15	0.22	0.00	0.0	
Loc22	North Fayette TWP	0.23	0.15	0.23	0.00	0.0	
Loc23	Clinton Munic Bldg	0.27	0.18	0.27	0.00	0.0	
Loc27	Marshall TWP	0.19	0.15	0.19	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.26	0.20	0.26	0.00	0.0	
Loc30	McCandless Twn Hall	0.18	0.13	0.18	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.18	0.16	0.18	0.00	0.0	
Loc33	Richland TWP	0.25	0.14	0.25	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.27	0.17	0.26	0.01	3.7	
Loc01	PWSA-Montana St.	0.20	0.16	0.19	0.01	5.0	
Loc06	Carnegie Transit Time	0.20	0.13	0.18	0.02	10.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.14	---	---	---	---	U
Loc03	Shaler Munic Bldg	0.11	---	---	---	---	U
Loc05	Upper St. Clair	0.07	---	---	---	---	U
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.01	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT

Table 50. Summary of Individual RG Pairs for Event 5g

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	0.08	0.09	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.10	0.10	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.10	0.11	0.10	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.10	0.10	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.10	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.11	0.10	0.11	0.00	0.0	
Loc07	Greentree Munic Bldg	0.10	0.10	0.10	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.08	0.10	0.08	0.00	0.0	
Loc09	Univ of Pittsburgh	0.08	0.10	0.08	0.00	0.0	
Loc10	PWSA-Highland Park	0.09	0.10	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.10	0.07	0.00	0.0	
Loc12	Baldwin	0.09	0.10	0.09	0.00	0.0	
Loc13	M-59 Access Shaft	0.07	0.09	0.07	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.10	0.07	0.00	0.0	
Loc15	Trafford Maint Bldg	0.08	0.09	0.08	0.00	0.0	
Loc16	Castle Shannon	0.08	0.09	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.12	0.10	0.12	0.00	0.0	
Loc18	Oakdale Pump Station	0.15	0.12	0.15	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.10	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.06	0.09	0.06	0.00	0.0	
Loc21	Moon TWP	0.13	0.09	0.13	0.00	0.0	
Loc22	North Fayette TWP	0.12	0.11	0.12	0.00	0.0	
Loc23	Clinton Munic Bldg	0.17	0.11	0.17	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	
Loc27	Marshall TWP	0.07	0.06	0.07	0.00	0.0	
Loc28	Plum Municipal Bldg	0.08	0.09	0.08	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.12	0.09	0.12	0.00	0.0	
Loc30	McCandless Twn Hall	0.06	0.05	0.06	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.09	0.10	0.09	0.00	0.0	
Loc33	Richland TWP	0.12	0.08	0.12	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.14	0.08	0.13	0.01	7.1	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.06	---	---	---	---	U
Loc32	Arnold	0.05	---	---	---	---	OAD

Table 51. Summary of Individual RG Pairs for Event 5h

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	0.16	0.10	0.17	-0.01	-6.3	
03049500	Allegheny River at Natrona	0.16	0.06	0.16	0.00	0.0	
Loc01	PWSA-Montana St.	0.19	0.10	0.19	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.21	0.10	0.21	0.00	0.0	
Loc03	Shaler Munic Bldg	0.20	0.09	0.20	0.00	0.0	
Loc04	Kennedy Twp PS	0.19	0.10	0.19	0.00	0.0	
Loc06	Carnegie Transit Time	0.24	0.09	0.24	0.00	0.0	
Loc08	AC Health Dept Bldg	0.20	0.08	0.20	0.00	0.0	
Loc09	Univ of Pittsburgh	0.20	0.09	0.20	0.00	0.0	
Loc10	PWSA-Highland Park	0.18	0.08	0.18	0.00	0.0	
Loc11	M-46 Access Shaft	0.19	0.07	0.19	0.00	0.0	
Loc12	Baldwin	0.20	0.09	0.20	0.00	0.0	
Loc14	Churchill Munic Bldg	0.16	0.07	0.16	0.00	0.0	
Loc15	Trafford Maint Bldg	0.18	0.06	0.18	0.00	0.0	
Loc16	Castle Shannon	0.24	0.10	0.24	0.00	0.0	
Loc17	Chartiers Pump Station	0.23	0.09	0.23	0.00	0.0	
Loc18	Oakdale Pump Station	0.18	0.10	0.18	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.17	0.07	0.17	0.00	0.0	
Loc20	Gascola Eq Facility	0.14	0.07	0.14	0.00	0.0	
Loc21	Moon TWP	0.16	0.11	0.16	0.00	0.0	
Loc22	North Fayette TWP	0.15	0.09	0.15	0.00	0.0	
Loc23	Clinton Munic Bldg	0.16	0.09	0.16	0.00	0.0	
Loc24	Jefferson Hills	0.18	0.08	0.18	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.18	0.06	0.18	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.22	0.08	0.22	0.00	0.0	
Loc27	Marshall TWP	0.17	0.09	0.17	0.00	0.0	
Loc28	Plum Municipal Bldg	0.18	0.06	0.18	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.20	0.10	0.20	0.00	0.0	
Loc30	McCandless Twn Hall	0.20	0.11	0.20	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.22	0.10	0.22	0.00	0.0	
Loc32	Arnold	0.18	0.06	0.18	0.00	0.0	
Loc33	Richland TWP	0.30	0.09	0.30	0.00	0.0	
Loc07	Greentree Munic Bldg	0.25	0.09	0.24	0.01	4.0	
KAGC	Pittsburgh Allegheny Cty	0.16	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.23	---	---	---	---	O

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.17	---	---	---	---	U
Loc13	M-59 Access Shaft	0.13	---	---	---	---	U

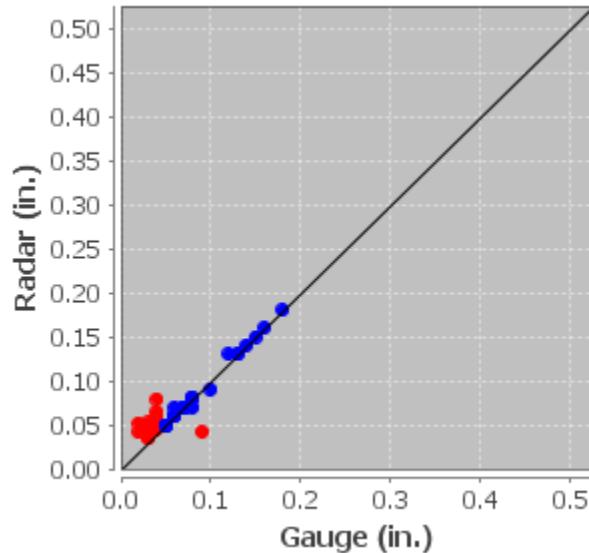


Figure 37. Scatter Plot of RG Pairs for Event 5a

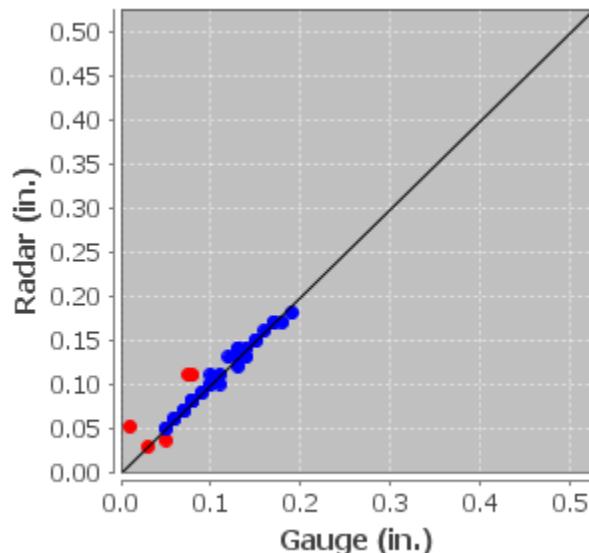


Figure 38. Scatter Plot of RG Pairs for Event 5b

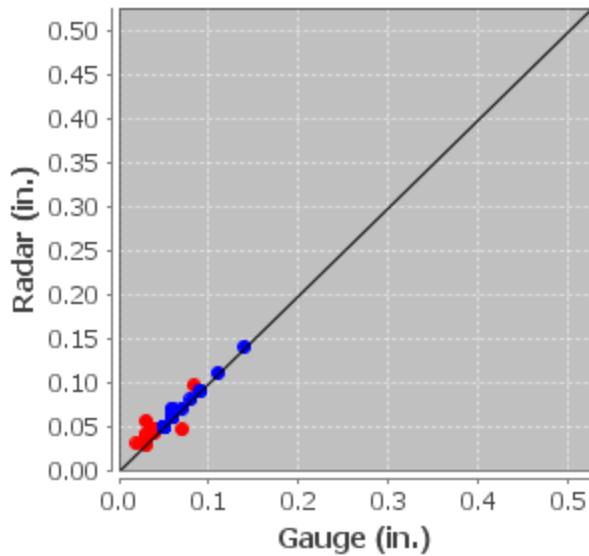


Figure 39. Scatter Plot of RG Pairs for Event 5c

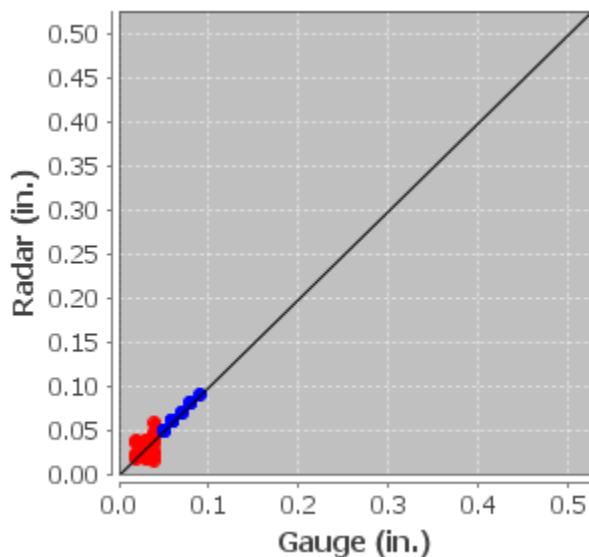


Figure 40. Scatter Plot of RG Pairs for Event 5d

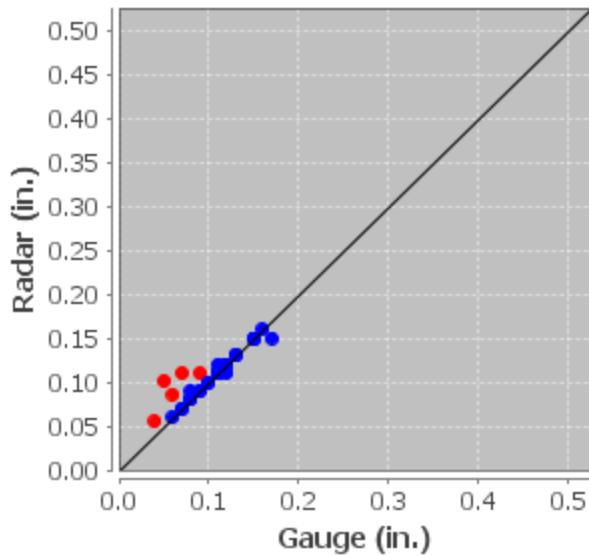


Figure 41. Scatter Plot of RG Pairs for Event 5e

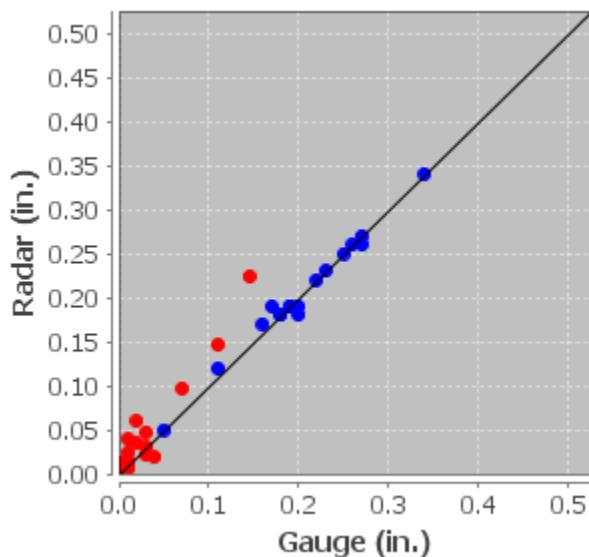


Figure 42. Scatter Plot of RG Pairs for Event 5f

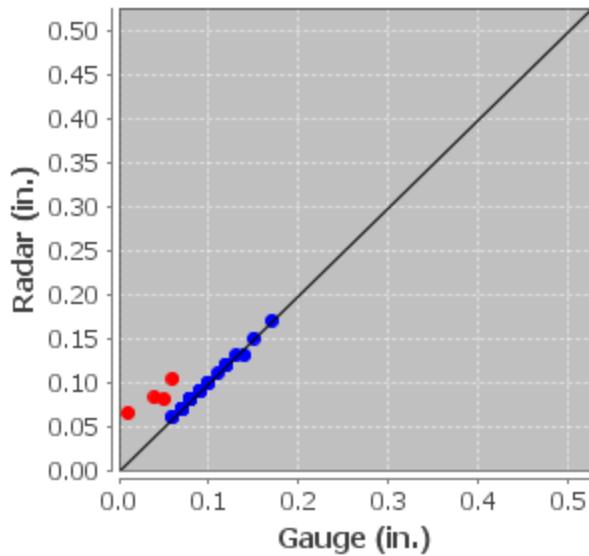


Figure 43. Scatter Plot of RG Pairs for Event 5g

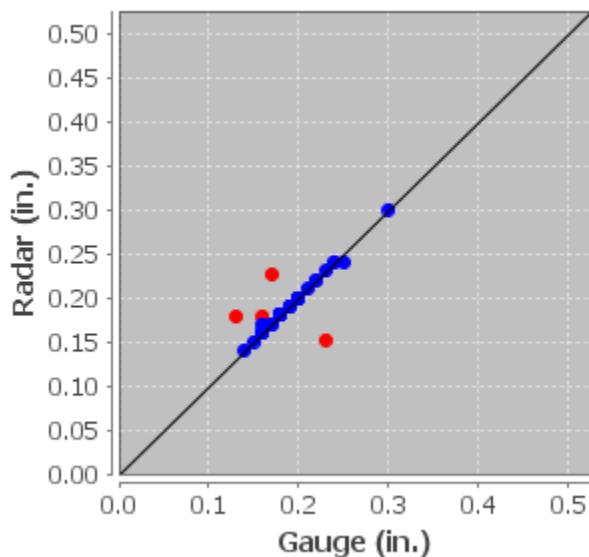


Figure 44. Scatter Plot of RG Pairs for Event 5h

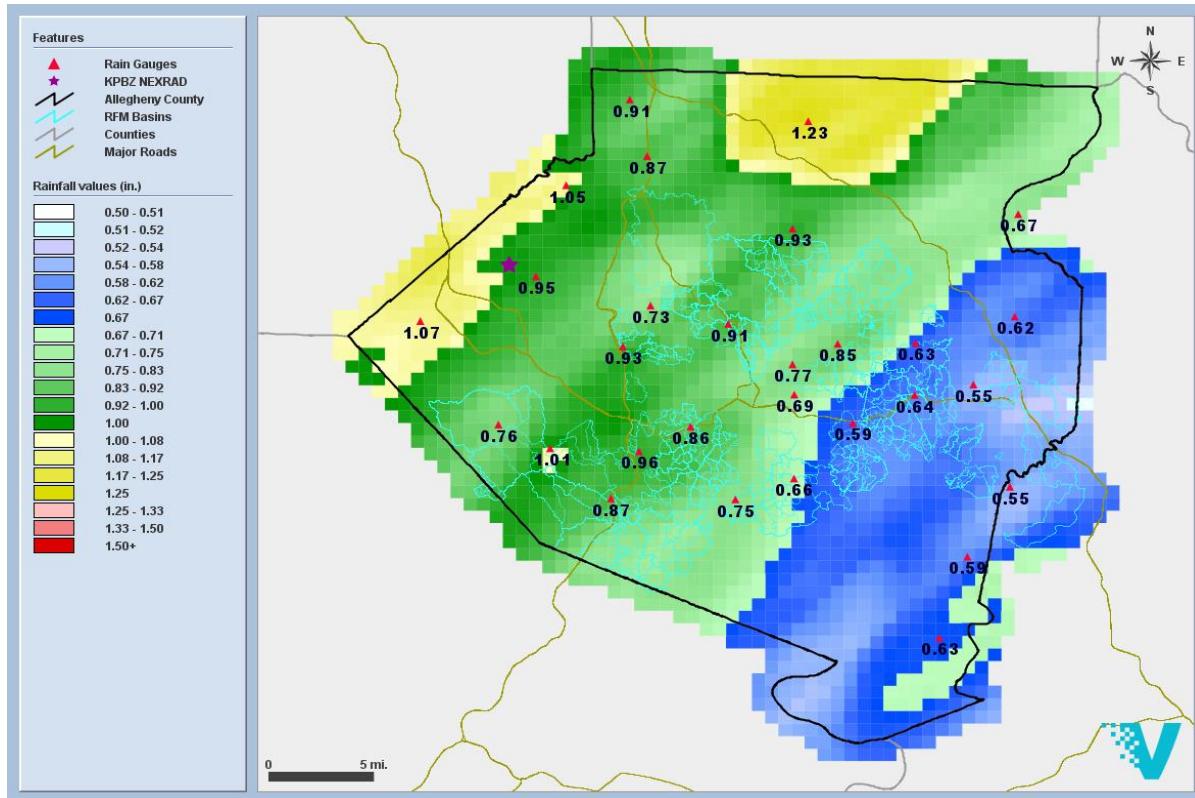


Figure 45. GARR Storm Total for Event 5

Table 52. Depth Duration Frequency Analyses for Event 5

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.169	164112	2019-10-27 04:25	<1 yr.
30 minutes	0.232	147117	2019-10-27 05:35	<1 yr.
1 hour	0.368	164112	2019-10-27 05:05	<1 yr.
2 hour	0.652	131143	2019-10-27 05:30	<1 yr.
3 hour	0.685	131143	2019-10-27 05:45	<1 yr.
6 hour	0.787	149114	2019-10-27 06:00	<1 yr.
12 hour	1.135	155118	2019-10-27 06:00	<1 yr.

Event 6: 2019-10-30

The analysis period was from 2019-10-30 14:00 EDT to 2019-10-31 07:00 EDT. The event was then split into seven sub-event periods at 2019-10-30 20:15 EDT, 2019-10-30 21:25 EDT, 2019-10-30 23:15 EDT, 2019-10-31 01:00 EDT, 2019-10-31 01:50 EDT and 2019-10-31 02:15 EDT to improve gauge adjustment of the radar. Gauge Only was used during Event 6d since all radar sources were either unavailable or provided insufficient rainfall information. Gauge Only was used during Event 6g 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 53 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 54 - 60 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 46 - 50 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 51 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.3 - 1.1 inches with a mean of 0.7 inches. The GARR amounts for the 440 RFM basins range from 0.6 - 1.1 inches with a mean of 0.9 inches. The GARR amounts for the 871 RFM sheds range from 0.6 - 1.1 inches with a mean of 0.9 inches. Table 61 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 53. 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	2019-10-30	2019-10-30 14:05	2019-10-30 20:15	33	0.074	0.906	16.0	2.1
E6b	KPBZ LII	2019-10-30	2019-10-30 20:20	2019-10-30 21:25	32	0.137	1.055	17.8	1.6
E6c	KPBZ LII	2019-10-30	2019-10-30 21:30	2019-10-30 23:15	33	0.293	2.495	59.9	2.5
E6d	Gauge Only	2019-10-30	2019-10-30 23:20	2019-10-31 01:00	33	0.050	---	---	---
E6e	KPBZ LII	2019-10-30	2019-10-31 01:05	2019-10-31 01:50	31	0.102	0.880	17.9	2.6
E6f	KPBZ LII	2019-10-30	2019-10-31 01:55	2019-10-31 02:15	11	0.042	0.912	18.0	1.8
E6g	Gauge Only	2019-10-30	2019-10-31 02:20	2019-10-31 07:00	33	0.051	---	---	---

Table 54. Summary of Individual RG Pairs for Event 6a

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.09	0.07	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.09	0.10	0.09	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.08	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.09	0.10	0.09	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.09	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.07	0.09	0.07	0.00	0.0	
Loc07	Greentree Munic Bldg	0.08	0.09	0.08	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.09	0.07	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.09	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.08	0.07	0.00	0.0	
Loc12	Baldwin	0.08	0.08	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.07	0.09	0.07	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc15	Trafford Maint Bldg	0.07	0.10	0.07	0.00	0.0	
Loc16	Castle Shannon	0.08	0.08	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.09	0.08	0.00	0.0	
Loc18	Oakdale Pump Station	0.10	0.09	0.10	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.08	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.08	0.07	0.00	0.0	
Loc21	Moon TWP	0.06	0.09	0.06	0.00	0.0	
Loc22	North Fayette TWP	0.10	0.09	0.10	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.08	0.10	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.06	0.07	0.06	0.00	0.0	
Loc27	Marshall TWP	0.07	0.06	0.07	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.08	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.08	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.06	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.09	0.08	0.09	0.00	0.0	
Loc32	Arnold	0.07	0.10	0.07	0.00	0.0	
Loc33	Richland TWP	0.08	0.06	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.10	0.09	0.01	10.0	
Loc10	PWSA-Highland Park	0.09	0.08	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	U
Loc02	ALCOSAN WWTP Lab	0.06	---	---	---	---	U

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.05	---	---	---	---	U
Loc24	Jefferson Hills	0.06	---	---	---	---	OAD

Table 55. Summary of Individual RG Pairs for Event 6b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.11	0.09	0.12	-0.01	-9.1	
Loc08	AC Health Dept Bldg	0.15	0.14	0.16	-0.01	-6.7	
Loc22	North Fayette TWP	0.19	0.27	0.20	-0.01	-5.3	
Loc01	PWSA-Montana St.	0.18	0.18	0.18	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.19	0.19	0.19	0.00	0.0	
Loc03	Shaler Munic Bldg	0.13	0.13	0.13	0.00	0.0	
Loc04	Kennedy Twp PS	0.20	0.21	0.20	0.00	0.0	
Loc06	Carnegie Transit Time	0.22	0.20	0.22	0.00	0.0	
Loc07	Greentree Munic Bldg	0.22	0.20	0.22	0.00	0.0	
Loc09	Univ of Pittsburgh	0.14	0.13	0.14	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.10	0.11	0.00	0.0	
Loc13	M-59 Access Shaft	0.09	0.08	0.09	0.00	0.0	
Loc14	Churchill Munic Bldg	0.11	0.08	0.11	0.00	0.0	
Loc15	Trafford Maint Bldg	0.09	0.06	0.09	0.00	0.0	
Loc16	Castle Shannon	0.19	0.13	0.19	0.00	0.0	
Loc17	Chartiers Pump Station	0.23	0.20	0.23	0.00	0.0	
Loc18	Oakdale Pump Station	0.22	0.25	0.22	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.10	0.08	0.10	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.07	0.08	0.00	0.0	
Loc21	Moon TWP	0.16	0.21	0.16	0.00	0.0	
Loc23	Clinton Munic Bldg	0.21	0.24	0.21	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.09	0.11	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.08	0.07	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.12	0.08	0.12	0.00	0.0	
Loc27	Marshall TWP	0.12	0.14	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.07	0.09	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.18	0.13	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.12	0.13	0.00	0.0	
Loc32	Arnold	0.09	0.06	0.09	0.00	0.0	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc33	Richland TWP	0.10	0.10	0.10	0.00	0.0	
Loc10	PWSA-Highland Park	0.16	0.11	0.15	0.01	6.3	
Loc12	Baldwin	0.16	0.11	0.15	0.01	6.3	
03049500	Allegheny River at Natrona	0.05	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.14	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.14	---	---	---	---	U
Loc05	Upper St. Clair	0.18	---	---	---	---	U
Loc30	McCandless Twn Hall	0.10	---	---	---	---	U

Table 56. Summary of Individual RG Pairs for Event 6c

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.28	0.12	0.30	-0.02	-7.1	
Loc19	Sandy Creek Eq Facility	0.29	0.09	0.31	-0.02	-6.9	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.31	0.19	0.33	-0.02	-6.5	
Loc07	Greentree Munic Bldg	0.36	0.15	0.38	-0.02	-5.6	
Loc22	North Fayette TWP	0.36	0.19	0.38	-0.02	-5.6	
Loc30	McCandless Twn Hall	0.22	0.13	0.23	-0.01	-4.5	
Loc16	Castle Shannon	0.31	0.08	0.32	-0.01	-3.2	
Loc08	AC Health Dept Bldg	0.33	0.14	0.34	-0.01	-3.0	
Loc03	Shaler Munic Bldg	0.34	0.17	0.35	-0.01	-2.9	
Loc01	PWSA-Montana St.	0.37	0.17	0.38	-0.01	-2.7	
KPIT	Greater Pittsburgh Int'l	0.33	0.19	0.33	0.00	0.0	
Loc13	M-59 Access Shaft	0.26	0.08	0.26	0.00	0.0	
Loc15	Trafford Maint Bldg	0.29	0.06	0.29	0.00	0.0	
Loc17	Chartiers Pump Station	0.39	0.13	0.39	0.00	0.0	
Loc21	Moon TWP	0.29	0.19	0.29	0.00	0.0	
Loc23	Clinton Munic Bldg	0.35	0.18	0.35	0.00	0.0	
Loc24	Jefferson Hills	0.22	0.05	0.22	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.22	0.05	0.22	0.00	0.0	
Loc27	Marshall TWP	0.17	0.08	0.17	0.00	0.0	
Loc28	Plum Municipal Bldg	0.29	0.07	0.29	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.26	0.15	0.26	0.00	0.0	

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.36	0.11	0.36	0.00	0.0	
Loc33	Richland TWP	0.28	0.14	0.28	0.00	0.0	
Loc18	Oakdale Pump Station	0.44	0.18	0.43	0.01	2.3	
Loc31	Hampton Municipal Bldg	0.38	0.17	0.37	0.01	2.6	
Loc04	Kennedy Twp PS	0.37	0.19	0.36	0.01	2.7	
Loc10	PWSA-Highland Park	0.36	0.13	0.35	0.01	2.8	
Loc12	Baldwin	0.36	0.08	0.35	0.01	2.8	
Loc20	Gascola Eq Facility	0.32	0.08	0.31	0.01	3.1	
Loc14	Churchill Munic Bldg	0.31	0.08	0.30	0.01	3.2	
Loc11	M-46 Access Shaft	0.28	0.08	0.27	0.01	3.6	
Loc06	Carnegie Transit Time	0.47	0.15	0.45	0.02	4.3	
Loc02	ALCOSAN WWTP Lab	0.40	0.17	0.38	0.02	5.0	
03049500	Allegheny River at Natrona	0.60	---	---	---	---	O
KAGC	Pittsburgh Allegheny Cty	0.21	---	---	---	---	U
Loc05	Upper St. Clair	0.26	---	---	---	---	U
Loc26	Elizabeth TWP Municipal Bldg	0.10	---	---	---	---	MSTT

Table 57. Summary of Individual RG Pairs for Event 6d

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc13	M-59 Access Shaft	0.02	---	---	---	---	
Loc05	Upper St. Clair	0.03	---	---	---	---	
Loc06	Carnegie Transit Time	0.03	---	---	---	---	
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	
Loc17	Chartiers Pump Station	0.03	---	---	---	---	
Loc21	Moon TWP	0.03	---	---	---	---	
Loc22	North Fayette TWP	0.03	---	---	---	---	
Loc01	PWSA-Montana St.	0.04	---	---	---	---	
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	
Loc11	M-46 Access Shaft	0.04	---	---	---	---	
Loc16	Castle Shannon	0.04	---	---	---	---	
Loc18	Oakdale Pump Station	0.04	---	---	---	---	
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	
Loc26	Elizabeth TWP Municipal Bldg	0.04	---	---	---	---	
Loc30	McCandless Twn Hall	0.04	---	---	---	---	
Loc03	Shaler Munic Bldg	0.05	---	---	---	---	
Loc04	Kennedy Twp PS	0.05	---	---	---	---	
Loc10	PWSA-Highland Park	0.05	---	---	---	---	
Loc12	Baldwin	0.05	---	---	---	---	
Loc14	Churchill Munic Bldg	0.05	---	---	---	---	
Loc20	Gascola Eq Facility	0.05	---	---	---	---	
Loc23	Clinton Munic Bldg	0.05	---	---	---	---	
Loc31	Hampton Municipal Bldg	0.05	---	---	---	---	
Loc33	Richland TWP	0.05	---	---	---	---	
Loc15	Trafford Maint Bldg	0.06	---	---	---	---	
Loc24	Jefferson Hills	0.06	---	---	---	---	
Loc28	Plum Municipal Bldg	0.06	---	---	---	---	
Loc29	Bell Acres Munic Bldg	0.06	---	---	---	---	
Loc27	Marshall TWP	0.07	---	---	---	---	
Loc32	Arnold	0.10	---	---	---	---	
03049500	Allegheny River at Natrona	0.14	---	---	---	---	T
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	T
KAGC	Pittsburgh Allegheny Cty	0.03	---	---	---	---	T
KPIT	Greater Pittsburgh Int'l	0.06	---	---	---	---	T

Table 58. Summary of Individual RG Pairs for Event 6e

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	0.13	0.10	-0.01	-11.1	
Loc22	North Fayette TWP	0.09	0.12	0.10	-0.01	-11.1	
Loc20	Gascola Eq Facility	0.11	0.15	0.12	-0.01	-9.1	
KAGC	Pittsburgh Allegheny Cty	0.12	0.12	0.13	-0.01	-8.3	
Loc06	Carnegie Transit Time	0.15	0.18	0.16	-0.01	-6.7	
Loc09	Univ of Pittsburgh	0.15	0.21	0.16	-0.01	-6.7	
KPIT	Greater Pittsburgh Int'l	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
Loc01	PWSA-Montana St.	0.13	0.19	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.13	0.19	0.13	0.00	0.0	
Loc03	Shaler Munic Bldg	0.14	0.17	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.12	0.15	0.12	0.00	0.0	
Loc08	AC Health Dept Bldg	0.16	0.20	0.16	0.00	0.0	
Loc11	M-46 Access Shaft	0.16	0.19	0.16	0.00	0.0	
Loc12	Baldwin	0.18	0.17	0.18	0.00	0.0	
Loc13	M-59 Access Shaft	0.13	0.13	0.13	0.00	0.0	
Loc15	Trafford Maint Bldg	0.08	0.11	0.08	0.00	0.0	
Loc16	Castle Shannon	0.19	0.17	0.19	0.00	0.0	
Loc17	Chartiers Pump Station	0.18	0.18	0.18	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.17	0.21	0.17	0.00	0.0	
Loc21	Moon TWP	0.05	0.05	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.12	0.11	0.12	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.09	0.10	0.09	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
Loc28	Plum Municipal Bldg	0.17	0.18	0.17	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.12	0.13	0.12	0.00	0.0	
Loc32	Arnold	0.13	0.15	0.13	0.00	0.0	
Loc33	Richland TWP	0.07	0.07	0.07	0.00	0.0	
Loc18	Oakdale Pump Station	0.21	0.18	0.20	0.01	4.8	
Loc10	PWSA-Highland Park	0.20	0.21	0.19	0.01	5.0	
Loc07	Greentree Munic Bldg	0.19	0.20	0.18	0.01	5.3	
Loc14	Churchill Munic Bldg	0.16	0.17	0.15	0.01	6.3	
03049500	Allegheny River at Natrona	0.11	---	---	---	---	U
Loc05	Upper St. Clair	0.13	---	---	---	---	U
Loc23	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
Loc27	Marshall TWP	0.03	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.03	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.03	---	---	---	---	MSTT

Table 59. Summary of Individual RG Pairs for Event 6f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.11	0.12	0.11	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.09	0.11	0.09	0.00	0.0	
Loc03	Shaler Munic Bldg	0.16	0.14	0.16	0.00	0.0	
Loc04	Kennedy Twp PS	0.08	0.07	0.08	0.00	0.0	
Loc11	M-46 Access Shaft	0.05	0.05	0.05	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.10	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.06	0.08	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.10	0.12	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.12	0.13	0.00	0.0	
Loc32	Arnold	0.11	0.14	0.11	0.00	0.0	
03049500	Allegheny River at Natrona	0.07	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.05	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.04	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.04	---	---	---	---	MSTT
Loc16	Castle Shannon	0.02	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.06	---	---	---	---	MSTT
Loc21	Moon TWP	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.05	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.03	---	---	---	---	MSTT

Table 60. Summary of Individual RG Pairs for Event 6g

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.02	---	---	---	---	
Loc02	ALCOSAN WWTP Lab	0.02	---	---	---	---	
Loc18	Oakdale Pump Station	0.02	---	---	---	---	
Loc22	North Fayette TWP	0.02	---	---	---	---	
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	
Loc24	Jefferson Hills	0.02	---	---	---	---	
Loc27	Marshall TWP	0.02	---	---	---	---	
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	
Loc21	Moon TWP	0.03	---	---	---	---	
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	
Loc26	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	
Loc30	McCandless Twn Hall	0.03	---	---	---	---	
Loc05	Upper St. Clair	0.04	---	---	---	---	
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	
Loc13	M-59 Access Shaft	0.04	---	---	---	---	
Loc29	Bell Acres Munic Bldg	0.04	---	---	---	---	
Loc03	Shaler Munic Bldg	0.05	---	---	---	---	
Loc10	PWSA-Highland Park	0.05	---	---	---	---	
Loc17	Chartiers Pump Station	0.05	---	---	---	---	
Loc20	Gascola Eq Facility	0.05	---	---	---	---	
Loc04	Kennedy Twp PS	0.06	---	---	---	---	
Loc06	Carnegie Transit Time	0.06	---	---	---	---	
Loc07	Greentree Munic Bldg	0.06	---	---	---	---	
Loc09	Univ of Pittsburgh	0.06	---	---	---	---	
Loc11	M-46 Access Shaft	0.06	---	---	---	---	
Loc16	Castle Shannon	0.06	---	---	---	---	
Loc19	Sandy Creek Eq Facility	0.06	---	---	---	---	
Loc12	Baldwin	0.07	---	---	---	---	
Loc14	Churchill Munic Bldg	0.07	---	---	---	---	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
<u>Loc28</u>	Plum Municipal Bldg	0.07	---	---	---	---	
<u>Loc31</u>	Hampton Municipal Bldg	0.10	---	---	---	---	
<u>Loc32</u>	Arnold	0.10	---	---	---	---	
<u>Loc33</u>	Richland TWP	0.11	---	---	---	---	
<u>03049500</u>	Allegheny River at Natrona	0.14	---	---	---	---	T
<u>03085734</u>	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	---	---	---	---	T
<u>KAGC</u>	Pittsburgh Allegheny Cty	0.04	---	---	---	---	T
<u>KPIT</u>	Greater Pittsburgh Int'l	0.06	---	---	---	---	T

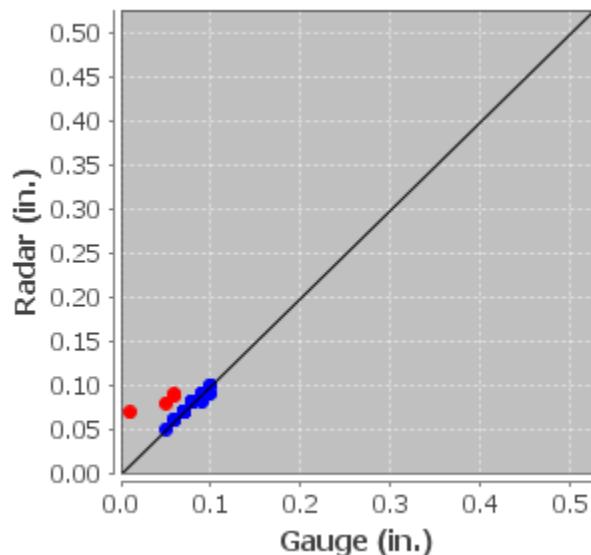


Figure 46. Scatter Plot of RG Pairs for Event 6a

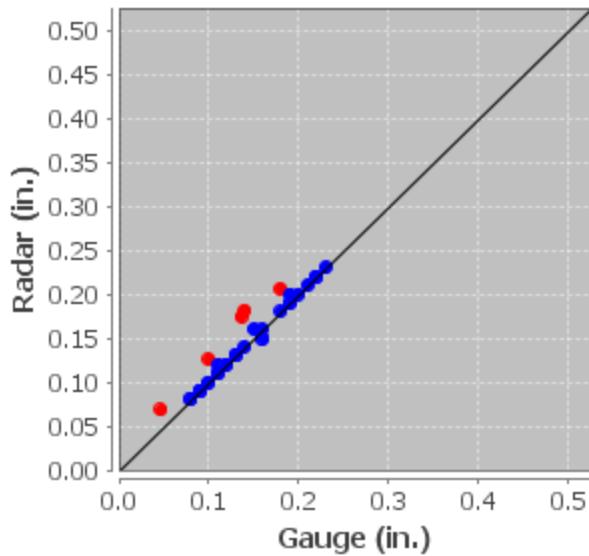


Figure 47. Scatter Plot of RG Pairs for Event 6b

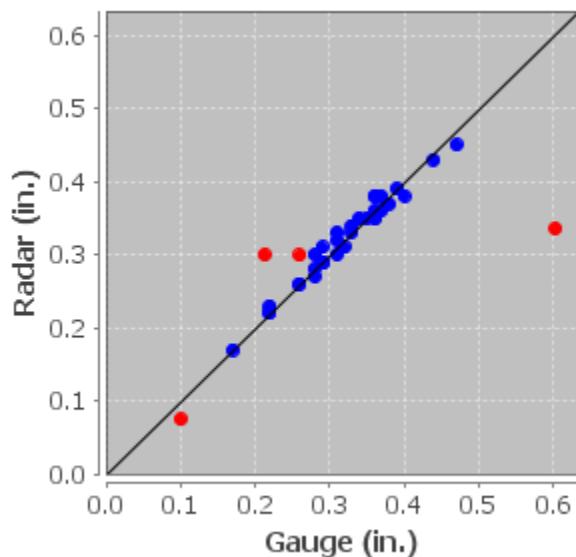


Figure 48. Scatter Plot of RG Pairs for Event 6c

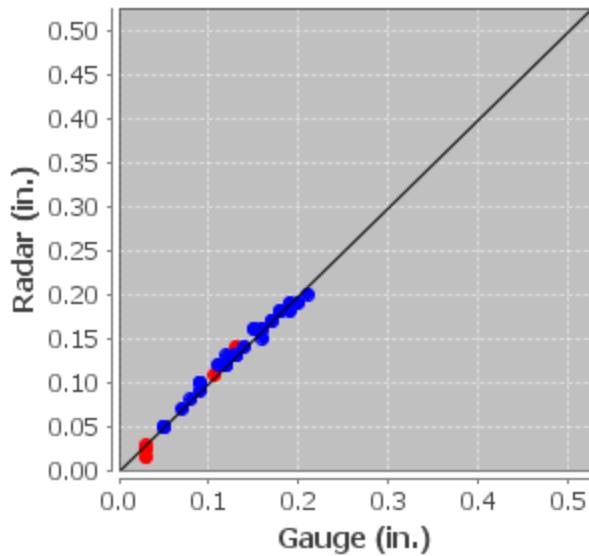


Figure 49. Scatter Plot of RG Pairs for Event 6e

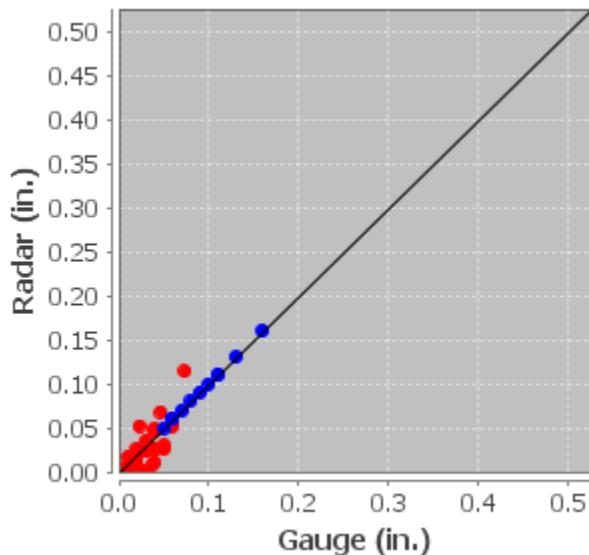


Figure 50. Scatter Plot of RG Pairs for Event 6f

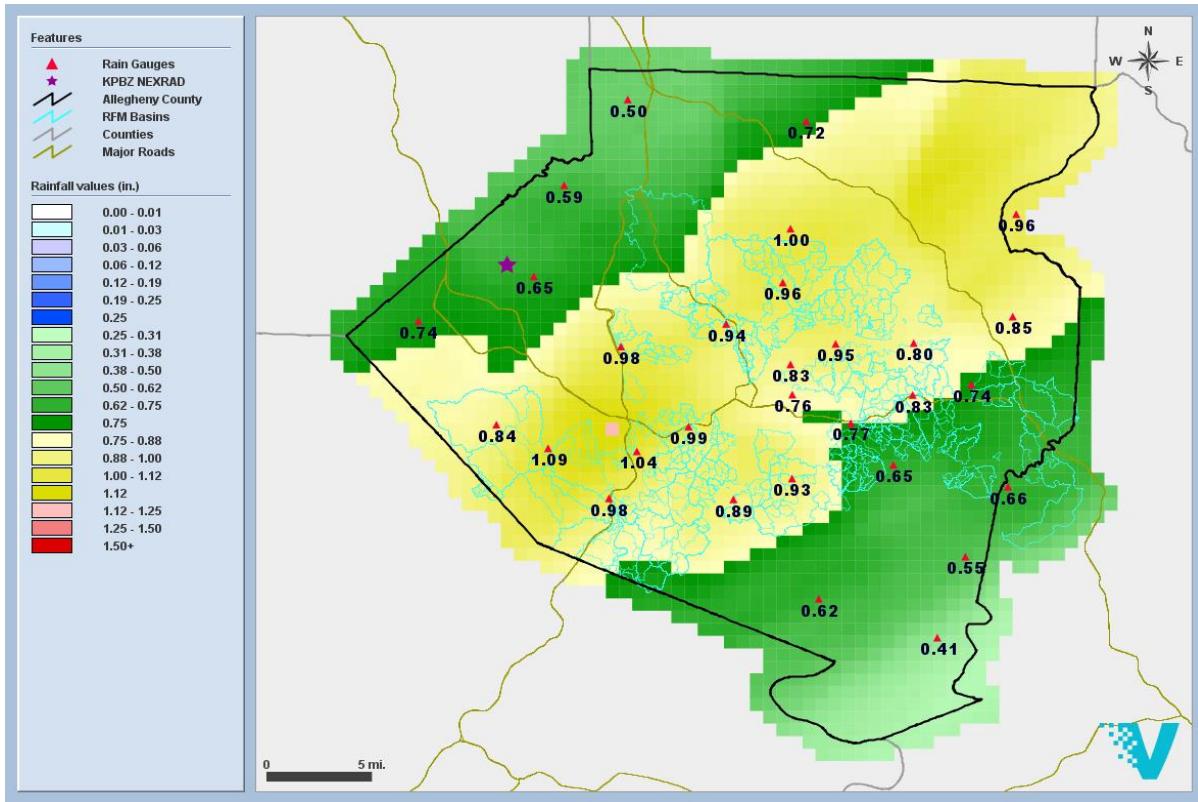


Figure 51. GARR Storm Total for Event 6

Table 61. Depth Duration Frequency Analyses for Event 6

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.132	128150	2019-10-30 21:50	<1 yr.
30 minutes	0.261	134144	2019-10-30 21:55	<1 yr.
1 hour	0.432	136141	2019-10-30 22:05	<1 yr.
2 hour	0.656	136141	2019-10-30 22:40	<1 yr.
3 hour	0.748	136141	2019-10-30 23:05	<1 yr.
6 hour	1.012	136141	2019-10-31 02:10	<1 yr.
12 hour	1.125	136141	2019-10-31 04:30	<1 yr.

Event 7: 2019-10-31

The analysis period was from 2019-10-31 07:00 EDT to 2019-11-01 01:00 EDT. The event was then split into eight sub-event periods at 2019-10-31 10:45 EDT, 2019-10-31 12:00 EDT, 2019-10-31 13:00 EDT, 2019-10-31 13:50 EDT, 2019-10-31 15:20 EDT, 2019-10-31 16:05 EDT and 2019-10-31 18:00 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 62 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 63 - 70 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i^* is the GARR estimate, and $\text{Diff}^* (\%)$ is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 52 - 59 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 60 depicts the GARR storm total over the 1-km² pixels. The GARR amounts for the 2313 1-km² pixels range from 0.6 - 2.2 inches with a mean of 1.1 inches. The GARR amounts for the 440 RFM basins range from 0.8 - 1.3 inches with a mean of 1.0 inches. The GARR amounts for the 871 RFM sheds range from 0.8 - 1.3 inches with a mean of 1.0 inches. Table 71 shows the Depth Duration Frequency (DDF) maximum values for the 1-km² pixels.

Table 62. 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	2019-10-31	2019-10-31 07:05	2019-10-31 10:45	33	0.116	0.797	31.0	2.5
E7b	KPBZ LII	2019-10-31	2019-10-31 10:50	2019-10-31 12:00	19	0.069	0.898	21.0	3.9
E7c	KPBZ LII	2019-10-31	2019-10-31 12:05	2019-10-31 13:00	6	0.035	1.473	31.4	0.3
E7d	KPBZ LII	2019-10-31	2019-10-31 13:05	2019-10-31 13:50	10	0.058	0.708	36.9	0.8
E7e	KPBZ LII	2019-10-31	2019-10-31 13:55	2019-10-31 15:20	32	0.493	1.372	24.6	1.0
E7f	KPBZ LII	2019-10-31	2019-10-31 15:25	2019-10-31 16:05	33	0.263	0.917	12.9	2.1
E7g	KPBZ LII	2019-10-31	2019-10-31 16:10	2019-10-31 18:00	9	0.049	1.255	19.4	1.3
E7h	KPBZ LII	2019-10-31	2019-10-31 18:05	2019-11-01 01:00	2	0.025	0.908	11.6	0.6

Table 63. Summary of Individual RG Pairs for Event 7a

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.05	0.08	0.06	-0.01	-20.0	
Loc02	ALCOSAN WWTP Lab	0.10	0.18	0.11	-0.01	-10.0	
Loc22	North Fayette TWP	0.12	0.17	0.13	-0.01	-8.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.16	0.19	0.16	0.00	0.0	
Loc01	PWSA-Montana St.	0.12	0.18	0.12	0.00	0.0	
Loc03	Shaler Munic Bldg	0.15	0.18	0.15	0.00	0.0	
Loc06	Carnegie Transit Time	0.11	0.14	0.11	0.00	0.0	
Loc07	Greentree Munic Bldg	0.08	0.12	0.08	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.10	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.09	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.08	0.06	0.00	0.0	
Loc12	Baldwin	0.07	0.08	0.07	0.00	0.0	
Loc13	M-59 Access Shaft	0.06	0.08	0.06	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.17	0.21	0.17	0.00	0.0	
Loc16	Castle Shannon	0.05	0.07	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.11	0.12	0.11	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.06	0.08	0.06	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.10	0.08	0.00	0.0	
Loc21	Moon TWP	0.08	0.12	0.08	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.12	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.09	0.08	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.21	0.23	0.21	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.19	0.20	0.19	0.00	0.0	
Loc27	Marshall TWP	0.07	0.11	0.07	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.10	0.09	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.12	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.13	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.18	0.22	0.18	0.00	0.0	
Loc32	Arnold	0.06	0.11	0.06	0.00	0.0	
Loc33	Richland TWP	0.26	0.28	0.26	0.00	0.0	
Loc04	Kennedy Twp PS	0.18	0.18	0.17	0.01	5.6	
Loc18	Oakdale Pump Station	0.17	0.17	0.16	0.01	5.9	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.05	---	---	---	---	MSTT

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.07	---	---	---	---	U
Loc05	Upper St. Clair	0.05	---	---	---	---	U

Table 64. Summary of Individual RG Pairs for Event 7b

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.05	0.06	0.06	-0.01	-20.0	
KPIT	Greater Pittsburgh Int'l	0.07	0.08	0.07	0.00	0.0	
Loc01	PWSA-Montana St.	0.07	0.07	0.07	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.07	0.07	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.09	0.09	0.00	0.0	
Loc05	Upper St. Clair	0.06	0.06	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.08	0.11	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.07	0.06	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.06	0.05	0.00	0.0	
Loc21	Moon TWP	0.16	0.21	0.16	0.00	0.0	
Loc23	Clinton Munic Bldg	0.21	0.22	0.21	0.00	0.0	
Loc27	Marshall TWP	0.21	0.27	0.21	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.08	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.28	0.28	0.28	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
Loc33	Richland TWP	0.05	0.08	0.05	0.00	0.0	
Loc06	Carnegie Transit Time	0.09	0.07	0.08	0.01	11.1	
Loc14	Churchill Munic Bldg	0.09	0.07	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.07	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.01	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.02	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.02	---	---	---	---	MSTT
Loc12	Baldwin	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.04	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.10	---	---	---	---	U
Loc32	Arnold	0.03	---	---	---	---	MSTT

Table 65. Summary of Individual RG Pairs for Event 7c

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.14	0.09	0.14	0.00	0.0	
Loc21	Moon TWP	0.17	0.11	0.17	0.00	0.0	
Loc23	Clinton Munic Bldg	0.10	0.08	0.10	0.00	0.0	
Loc27	Marshall TWP	0.15	0.11	0.15	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.19	0.12	0.19	0.00	0.0	
Loc30	McCandless Twn Hall	0.17	0.12	0.17	0.00	0.0	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.00	---	---	---	---	MSTT
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	0.01	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.02	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.02	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

Table 66. Summary of Individual RG Pairs for Event 7d

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	0.08	0.14	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.15	0.09	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.07	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.05	0.05	0.00	0.0	
Loc18	Oakdale Pump Station	0.15	0.22	0.15	0.00	0.0	
Loc21	Moon TWP	0.07	0.10	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.14	0.20	0.14	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.05	0.05	0.00	0.0	
Loc33	Richland TWP	0.09	0.12	0.09	0.00	0.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.02	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.04	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc16	Castle Shannon	0.03	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT

Table 67. Summary of Individual RG Pairs for Event 7e

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc20	Gascola Eq Facility	0.30	0.26	0.31	-0.01	-3.3	
Loc02	ALCOSAN WWTP Lab	0.39	0.35	0.40	-0.01	-2.6	
Loc01	PWSA-Montana St.	0.40	0.35	0.41	-0.01	-2.5	
Loc16	Castle Shannon	0.40	0.32	0.41	-0.01	-2.5	
Loc27	Marshall TWP	1.04	0.70	1.06	-0.02	-1.9	
Loc06	Carnegie Transit Time	0.57	0.46	0.58	-0.01	-1.8	
Loc04	Kennedy Twp PS	0.60	0.47	0.61	-0.01	-1.7	
Loc29	Bell Acres Munic Bldg	1.44	0.95	1.45	-0.01	-0.7	

Gauge ID	Name	Gi (in)	Ri (in)	Ri* (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.45	0.35	0.45	0.00	0.0	
Loc08	AC Health Dept Bldg	0.42	0.33	0.42	0.00	0.0	
Loc09	Univ of Pittsburgh	0.43	0.34	0.43	0.00	0.0	
Loc11	M-46 Access Shaft	0.43	0.35	0.43	0.00	0.0	
Loc14	Churchill Munic Bldg	0.35	0.28	0.35	0.00	0.0	
Loc15	Trafford Maint Bldg	0.20	0.14	0.20	0.00	0.0	
Loc18	Oakdale Pump Station	0.68	0.52	0.68	0.00	0.0	
Loc21	Moon TWP	1.32	0.84	1.32	0.00	0.0	
Loc22	North Fayette TWP	0.78	0.57	0.78	0.00	0.0	
Loc23	Clinton Munic Bldg	1.41	0.99	1.41	0.00	0.0	
Loc24	Jefferson Hills	0.26	0.17	0.26	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.20	0.14	0.20	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.14	0.12	0.14	0.00	0.0	
Loc28	Plum Municipal Bldg	0.35	0.27	0.35	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.53	0.40	0.53	0.00	0.0	
Loc32	Arnold	0.43	0.31	0.43	0.00	0.0	
Loc33	Richland TWP	0.85	0.61	0.85	0.00	0.0	
Loc17	Chartiers Pump Station	0.60	0.46	0.59	0.01	1.7	
Loc30	McCandless Twn Hall	1.15	0.66	1.13	0.02	1.7	
Loc07	Greentree Munic Bldg	0.54	0.41	0.53	0.01	1.9	
Loc12	Baldwin	0.49	0.33	0.48	0.01	2.0	
Loc10	PWSA-Highland Park	0.48	0.37	0.47	0.01	2.1	
Loc19	Sandy Creek Eq Facility	0.41	0.31	0.40	0.01	2.4	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.56	0.40	0.54	0.02	3.6	
03049500	Allegheny River at Natrona	0.34	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.38	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.73	---	---	---	---	U
Loc05	Upper St. Clair	0.42	---	---	---	---	U
Loc13	M-59 Access Shaft	0.30	---	---	---	---	U

Table 68. Summary of Individual RG Pairs for Event 7f

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.13	0.14	0.14	-0.01	-7.7	
Loc08	AC Health Dept Bldg	0.31	0.38	0.33	-0.02	-6.5	
Loc02	ALCOSAN WWTP Lab	0.29	0.33	0.30	-0.01	-3.4	
Loc06	Carnegie Transit Time	0.30	0.31	0.31	-0.01	-3.3	
Loc31	Hampton Municipal Bldg	0.42	0.55	0.43	-0.01	-2.4	
Loc11	M-46 Access Shaft	0.44	0.53	0.45	-0.01	-2.3	
Loc19	Sandy Creek Eq Facility	0.45	0.57	0.46	-0.01	-2.2	
Loc01	PWSA-Montana St.	0.43	0.47	0.43	0.00	0.0	
Loc05	Upper St. Clair	0.30	0.26	0.30	0.00	0.0	
Loc07	Greentree Munic Bldg	0.31	0.35	0.31	0.00	0.0	
Loc12	Baldwin	0.42	0.45	0.42	0.00	0.0	
Loc13	M-59 Access Shaft	0.38	0.44	0.38	0.00	0.0	
Loc14	Churchill Munic Bldg	0.38	0.45	0.38	0.00	0.0	
Loc15	Trafford Maint Bldg	0.26	0.35	0.26	0.00	0.0	
Loc16	Castle Shannon	0.42	0.46	0.42	0.00	0.0	
Loc18	Oakdale Pump Station	0.12	0.11	0.12	0.00	0.0	
Loc21	Moon TWP	0.09	0.10	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.09	0.09	0.00	0.0	
Loc23	Clinton Munic Bldg	0.06	0.05	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.25	0.25	0.25	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.17	0.20	0.17	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.13	0.13	0.13	0.00	0.0	
Loc27	Marshall TWP	0.07	0.08	0.07	0.00	0.0	
Loc28	Plum Municipal Bldg	0.53	0.53	0.53	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.08	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.14	0.12	0.14	0.00	0.0	
Loc32	Arnold	0.50	0.61	0.50	0.00	0.0	
Loc33	Richland TWP	0.53	0.46	0.53	0.00	0.0	
Loc20	Gascola Eq Facility	0.48	0.50	0.47	0.01	2.1	
Loc03	Shaler Munic Bldg	0.44	0.51	0.43	0.01	2.3	
Loc17	Chartiers Pump Station	0.25	0.22	0.24	0.01	4.0	
Loc09	Univ of Pittsburgh	0.35	0.36	0.33	0.02	5.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.20	0.14	0.18	0.02	10.0	
03049500	Allegheny River at Natrona	0.39	---	---	---	---	U
KAGC	Pittsburgh Allegheny Cty	0.34	---	---	---	---	U

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.78	---	---	---	---	O
Loc10	PWSA-Highland Park	0.25	---	---	---	---	U

Table 69. Summary of Individual RG Pairs for Event 7g

Gauge ID	Name	G _i (in)	R _i (in)	R _i * (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.08	0.07	0.08	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	0.06	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.16	0.10	0.16	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.08	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.07	0.08	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.16	0.11	0.16	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.20	0.12	0.20	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.07	0.07	0.00	0.0	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.02	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.01	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.04	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.01	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.02	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	0.01	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.02	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	MSTT
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.04	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.01	---	---	---	---	MSTT

Table 70. Summary of Individual RG Pairs for Event 7h

Gauge ID	Name	G_i (in)	R_i (in)	R_i^* (in)	Diff* (in)	Diff* (%)	Flag
Loc15	Trafford Maint Bldg	0.06	0.06	0.06	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.06	0.07	0.06	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	Z
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.00	---	---	---	---	MSTT
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	0.02	---	---	---	---	MSTT
Loc12	Baldwin	0.02	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	MSTT
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	0.00	---	---	---	---	MSTT
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.14	---	---	---	---	O
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

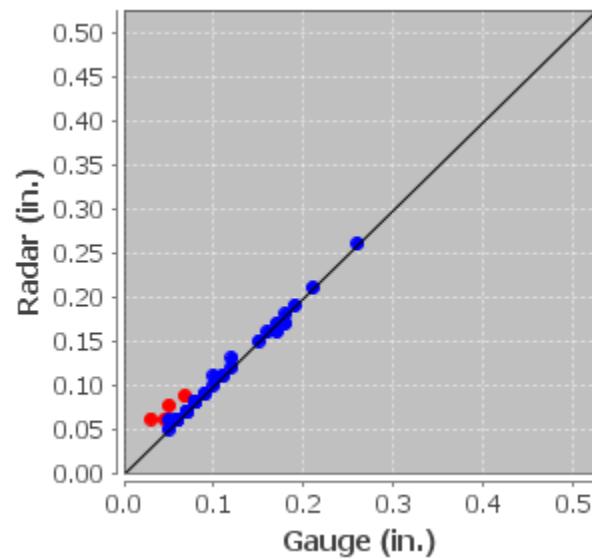


Figure 52. Scatter Plot of RG Pairs for Event 7a

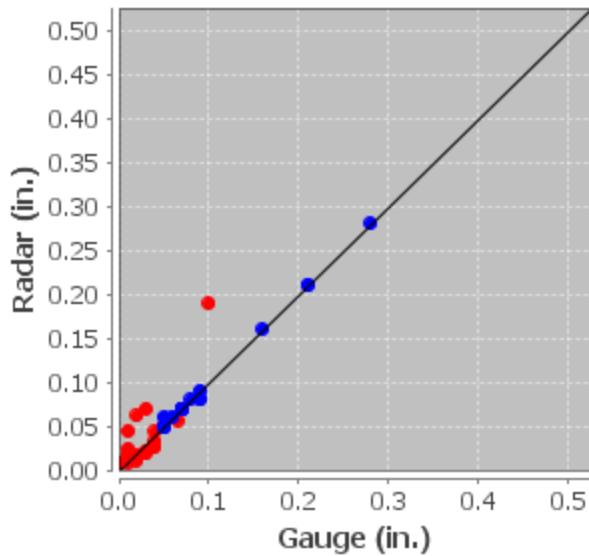


Figure 53. Scatter Plot of RG Pairs for Event 7b

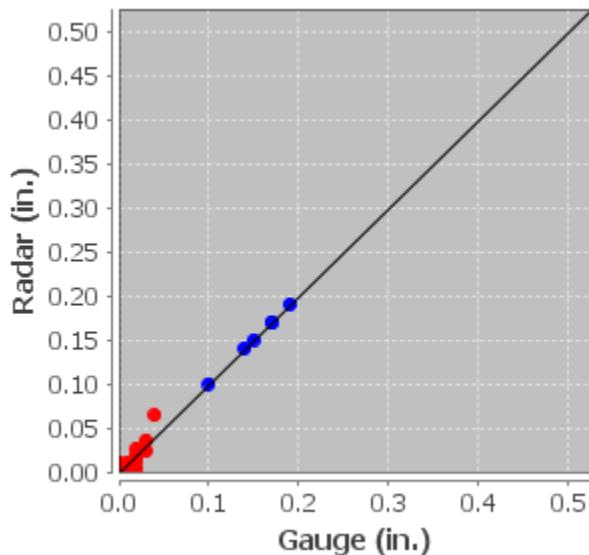


Figure 54. Scatter Plot of RG Pairs for Event 7c

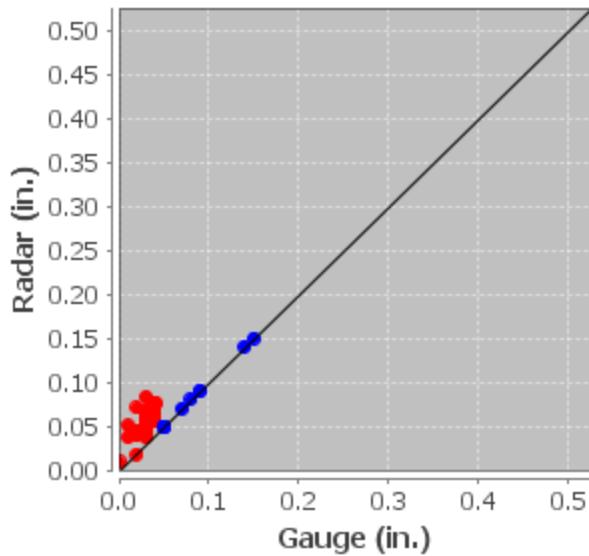


Figure 55. Scatter Plot of RG Pairs for Event 7d

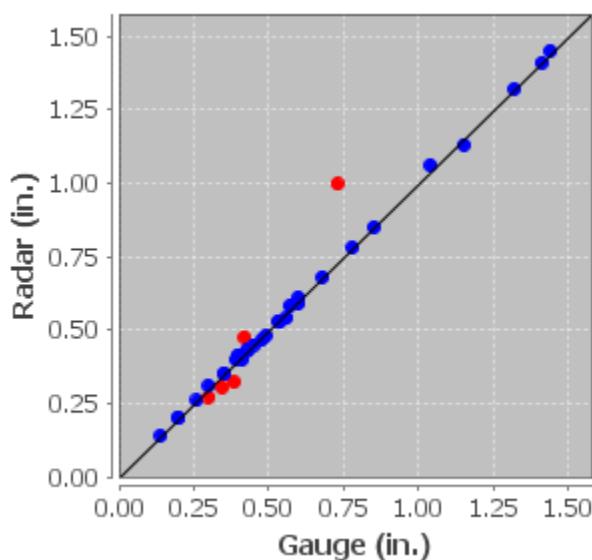


Figure 56. Scatter Plot of RG Pairs for Event 7e

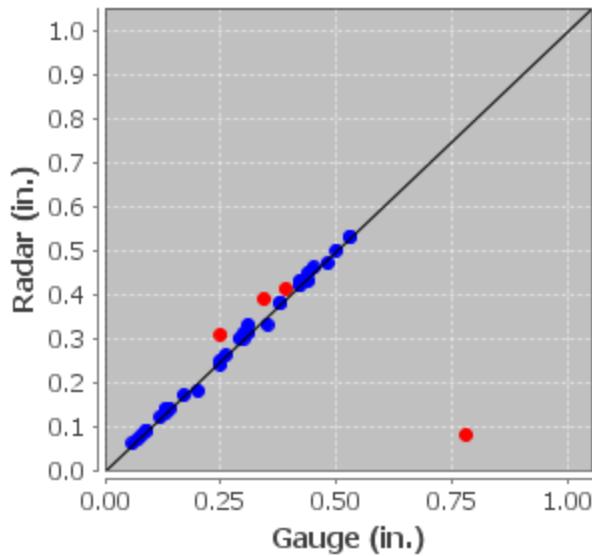


Figure 57. Scatter Plot of RG Pairs for Event 7f

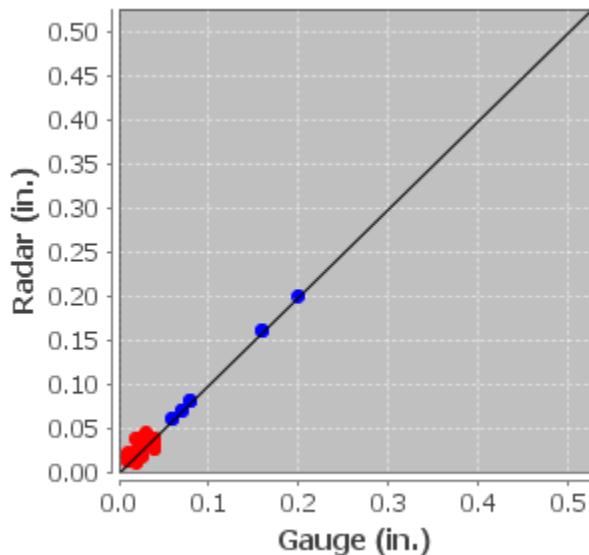


Figure 58. Scatter Plot of RG Pairs for Event 7g

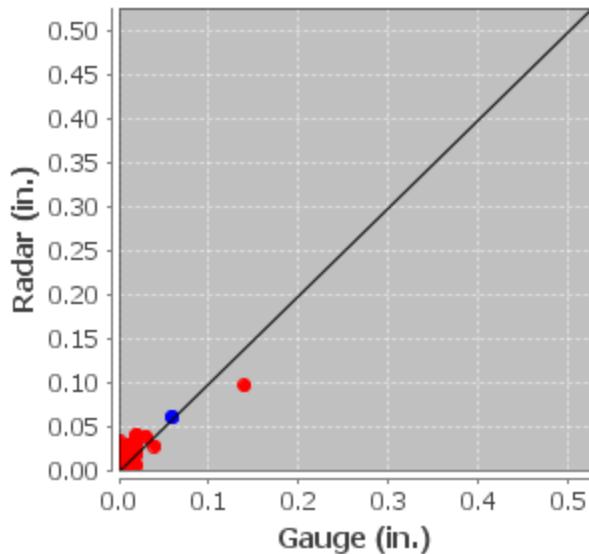


Figure 59. Scatter Plot of RG Pairs for Event 7h

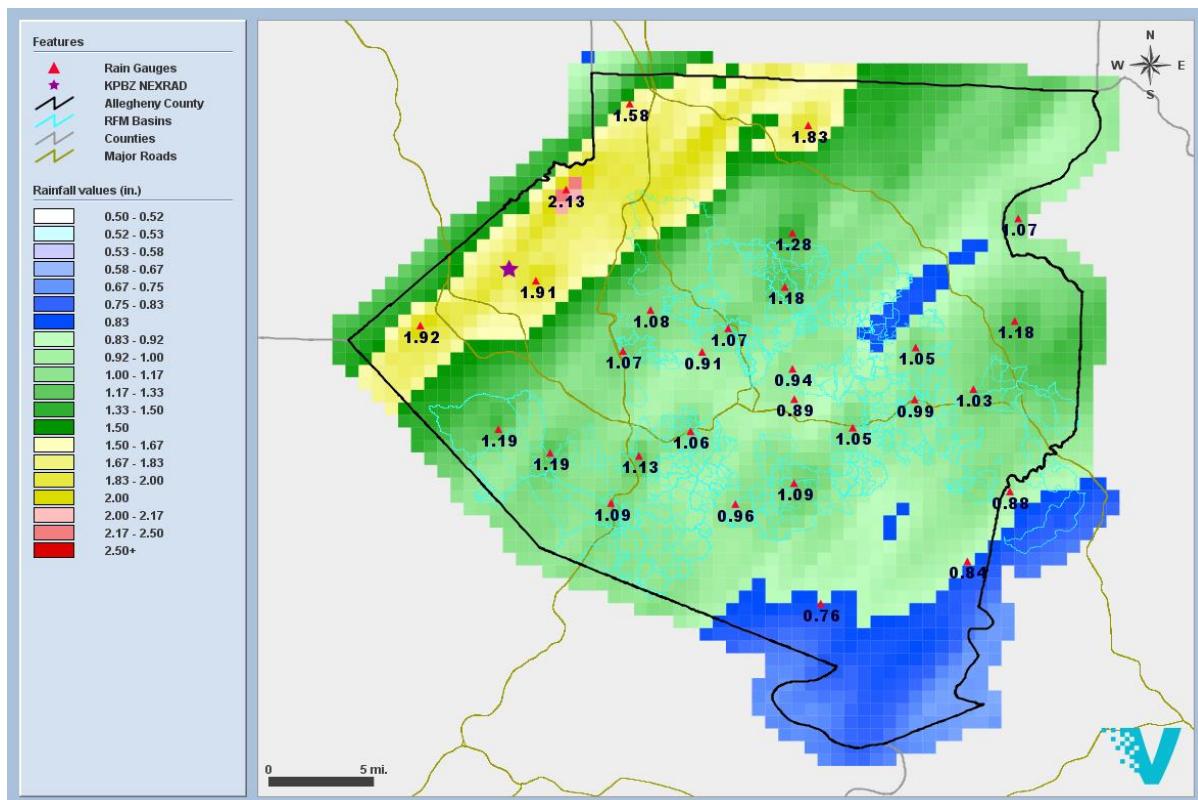


Figure 60. GARR Storm Total for Event 7

Table 71. Depth Duration Frequency Analyses for Event 7

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.543	142120	2019-10-31 15:15	<1 yr.
30 minutes	0.936	142120	2019-10-31 15:25	1 yr.
1 hour	1.333	132122	2019-10-31 15:05	2 yr.
2 hour	1.609	143117	2019-10-31 15:40	2 yr.
3 hour	1.673	143118	2019-10-31 16:00	2 yr.
6 hour	2.115	132122	2019-10-31 15:40	2 yr.
12 hour	2.190	132122	2019-10-31 19:00	2 yr.

Appendices

- [Appendix A](#) - Gauge Performance Exclusion Table
- [Appendix B](#) - Gauge Statistical Criteria Exclusion Table
- [Appendix C](#) - Event 1 (2019-10-03) CDPs
- [Appendix D](#) - Event 2 (2019-10-07) CDPs
- [Appendix E](#) - Event 3 (2019-10-16) CDPs
- [Appendix F](#) - Event 4 (2019-10-22) CDPs
- [Appendix G](#) - Event 5 (2019-10-27) CDPs
- [Appendix H](#) - Event 6 (2019-10-30) CDPs
- [Appendix I](#) - Event 7 (2019-10-31) CDPs

Appendix A - Gauge Performance Exclusion Table

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

Event #	E1a	E1b	E1c	E1d	E1e
Event Date	2019-10-03	2019-10-03	2019-10-03	2019-10-03	2019-10-03
Start Time (EDT)	2019-10-02 15:05	2019-10-03 01:05	2019-10-03 02:30	2019-10-03 04:30	2019-10-03 05:30
End Time (EDT)	2019-10-03 01:00	2019-10-03 02:25	2019-10-03 04:25	2019-10-03 05:25	2019-10-03 08:00
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10	ND	ND	ND	ND	ND
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					
Loc24					
Loc25					

Event #	<u>E1a</u>	<u>E1b</u>	<u>E1c</u>	<u>E1d</u>	<u>E1e</u>
Event Date	2019-10-03	2019-10-03	2019-10-03	2019-10-03	2019-10-03
Start Time (EDT)	2019-10-02 15:05	2019-10-03 01:05	2019-10-03 02:30	2019-10-03 04:30	2019-10-03 05:30
End Time (EDT)	2019-10-03 01:00	2019-10-03 02:25	2019-10-03 04:25	2019-10-03 05:25	2019-10-03 08:00
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT				U	
03049500	U				
03085734					

Event #	E2a	E2b	E2c	E2d	E2e
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-06 07:05	2019-10-06 22:05	2019-10-06 23:05	2019-10-07 00:05	2019-10-07 01:05
End Time (EDT)	2019-10-06 22:00	2019-10-06 23:00	2019-10-07 00:00	2019-10-07 01:00	2019-10-07 02:00
Loc01					
Loc02					
Loc03					
Loc04					
Loc05				U	U
Loc06					
Loc07					
Loc08					U
Loc09					
Loc10	ND	ND	ND	ND	ND
Loc11					
Loc12					
Loc13					U
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					U
Loc22					
Loc23					

Event #	E2a	E2b	E2c	E2d	E2e
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-06 07:05	2019-10-06 22:05	2019-10-06 23:05	2019-10-07 00:05	2019-10-07 01:05
End Time (EDT)	2019-10-06 22:00	2019-10-06 23:00	2019-10-07 00:00	2019-10-07 01:00	2019-10-07 02:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30			U		U
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500	Z	U			
03085734					

Event #	E2f	E2g	E2h	E2i	E2j
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-07 02:05	2019-10-07 03:05	2019-10-07 04:05	2019-10-07 06:20	2019-10-07 08:05
End Time (EDT)	2019-10-07 03:00	2019-10-07 04:00	2019-10-07 06:15	2019-10-07 08:00	2019-10-07 10:00
Loc01					
Loc02					
Loc03					
Loc04					
Loc05	U	U	U	U	
Loc06					
Loc07					
Loc08		U			
Loc09					
Loc10	ND	ND	ND	ND	ND
Loc11					
Loc12					
Loc13		U	U	U	U
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E2f	E2g	E2h	E2i	E2j
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-07 02:05	2019-10-07 03:05	2019-10-07 04:05	2019-10-07 06:20	2019-10-07 08:05
End Time (EDT)	2019-10-07 03:00	2019-10-07 04:00	2019-10-07 06:15	2019-10-07 08:00	2019-10-07 10:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30	U				
Loc31					
Loc32					
Loc33				O	
KAGC					
KPIT	U	O			
03049500				U	
03085734	U		U		

Event #	E2k	E2l	E2m	E3a	E3b
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-16	2019-10-16
Start Time (EDT)	2019-10-07 10:05	2019-10-07 12:40	2019-10-07 13:05	2019-10-16 05:05	2019-10-16 07:35
End Time (EDT)	2019-10-07 12:35	2019-10-07 13:00	2019-10-07 20:00	2019-10-16 07:30	2019-10-16 08:25
Loc01				U	
Loc02					
Loc03					
Loc04					
Loc05	U		U	U	U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10	ND	ND	ND		
Loc11					
Loc12					
Loc13	U		U		
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	<u>E2k</u>	<u>E2l</u>	<u>E2m</u>	<u>E3a</u>	<u>E3b</u>
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-16	2019-10-16
Start Time (EDT)	2019-10-07 10:05	2019-10-07 12:40	2019-10-07 13:05	2019-10-16 05:05	2019-10-16 07:35
End Time (EDT)	2019-10-07 12:35	2019-10-07 13:00	2019-10-07 20:00	2019-10-16 07:30	2019-10-16 08:25
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC		T			
KPIT		T		U	O
03049500	U	T	U	Z	U
03085734		T			

Event #	E3c	E3d	E3e	E4a	E4b
Event Date	2019-10-16	2019-10-16	2019-10-16	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-16 08:30	2019-10-16 09:25	2019-10-16 11:05	2019-10-22 01:05	2019-10-22 07:35
End Time (EDT)	2019-10-16 09:20	2019-10-16 11:00	2019-10-16 15:00	2019-10-22 07:30	2019-10-22 08:05
Loc01					
Loc02					
Loc03				ND	ND
Loc04					
Loc05	U	U	U		U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13		U	U		
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	<u>E3c</u>	<u>E3d</u>	<u>E3e</u>	<u>E4a</u>	<u>E4b</u>
Event Date	2019-10-16	2019-10-16	2019-10-16	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-16 08:30	2019-10-16 09:25	2019-10-16 11:05	2019-10-22 01:05	2019-10-22 07:35
End Time (EDT)	2019-10-16 09:20	2019-10-16 11:00	2019-10-16 15:00	2019-10-22 07:30	2019-10-22 08:05
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30	U				
Loc31					
Loc32					
Loc33					
KAGC					
KPIT	U				
03049500		U		U	
03085734					

Event #	<u>E4c</u>	<u>E4d</u>	<u>E4e</u>	<u>E4f</u>	<u>E4g</u>
Event Date	2019-10-22	2019-10-22	2019-10-22	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-22 08:10	2019-10-22 08:50	2019-10-22 09:25	2019-10-22 10:30	2019-10-22 11:05
End Time (EDT)	2019-10-22 08:45	2019-10-22 09:20	2019-10-22 10:25	2019-10-22 11:00	2019-10-22 15:00
Loc01					
Loc02					
Loc03	ND	ND	ND	ND	ND
Loc04					
Loc05	U	U	U		U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13			U		
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22		U			
Loc23					

Event #	E4c	E4d	E4e	E4f	E4g
Event Date	2019-10-22	2019-10-22	2019-10-22	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-22 08:10	2019-10-22 08:50	2019-10-22 09:25	2019-10-22 10:30	2019-10-22 11:05
End Time (EDT)	2019-10-22 08:45	2019-10-22 09:20	2019-10-22 10:25	2019-10-22 11:00	2019-10-22 15:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC			O		
KPIT		U	O		
03049500		U	U		U
03085734					

Event #	E5a	E5b	E5c	E5d	E5e
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-27	2019-10-27
Start Time (EDT)	2019-10-26 10:05	2019-10-26 18:35	2019-10-26 19:35	2019-10-26 20:15	2019-10-26 21:35
End Time (EDT)	2019-10-26 18:30	2019-10-26 19:30	2019-10-26 20:10	2019-10-26 21:30	2019-10-27 03:00
Loc01					
Loc02					U
Loc03					
Loc04					
Loc05	U	U			U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					U
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E5a	E5b	E5c	E5d	E5e
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-27	2019-10-27
Start Time (EDT)	2019-10-26 10:05	2019-10-26 18:35	2019-10-26 19:35	2019-10-26 20:15	2019-10-26 21:35
End Time (EDT)	2019-10-26 18:30	2019-10-26 19:30	2019-10-26 20:10	2019-10-26 21:30	2019-10-27 03:00
Loc24					U
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC	O	U			
KPIT					
03049500	U	U	U		
03085734					

Event #	E5f	E5g	E5h	E6a	E6b
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-27 03:05	2019-10-27 04:35	2019-10-27 05:05	2019-10-30 14:05	2019-10-30 20:20
End Time (EDT)	2019-10-27 04:30	2019-10-27 05:00	2019-10-27 08:00	2019-10-30 20:15	2019-10-30 21:25
Loc01					
Loc02				U	
Loc03	U				
Loc04					
Loc05	U	U	U	U	U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13			U		
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	<u>E5f</u>	<u>E5g</u>	<u>E5h</u>	<u>E6a</u>	<u>E6b</u>
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-27 03:05	2019-10-27 04:35	2019-10-27 05:05	2019-10-30 14:05	2019-10-30 20:20
End Time (EDT)	2019-10-27 04:30	2019-10-27 05:00	2019-10-27 08:00	2019-10-30 20:15	2019-10-30 21:25
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					U
Loc31					
Loc32					
Loc33					
KAGC			U		
KPIT	U		O		U
03049500		U		U	U
03085734					U

Event #	<u>E6c</u>	<u>E6d</u>	<u>E6e</u>	<u>E6f</u>	<u>E6g</u>
Event Date	2019-10-30	2019-10-30	2019-10-30	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-30 21:30	2019-10-30 23:20	2019-10-31 01:05	2019-10-31 01:55	2019-10-31 02:20
End Time (EDT)	2019-10-30 23:15	2019-10-31 01:00	2019-10-31 01:50	2019-10-31 02:15	2019-10-31 07:00
Loc01					
Loc02					
Loc03					
Loc04					
Loc05	U		U		
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E6c	E6d	E6e	E6f	E6g
Event Date	2019-10-30	2019-10-30	2019-10-30	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-30 21:30	2019-10-30 23:20	2019-10-31 01:05	2019-10-31 01:55	2019-10-31 02:20
End Time (EDT)	2019-10-30 23:15	2019-10-31 01:00	2019-10-31 01:50	2019-10-31 02:15	2019-10-31 07:00
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC	U	T			T
KPIT		T			T
03049500	O	T	U	U	T
03085734		T		U	T

Event #	E7a	E7b	E7c	E7d	E7e
Event Date	2019-10-31	2019-10-31	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 07:05	2019-10-31 10:50	2019-10-31 12:05	2019-10-31 13:05	2019-10-31 13:55
End Time (EDT)	2019-10-31 10:45	2019-10-31 12:00	2019-10-31 13:00	2019-10-31 13:50	2019-10-31 15:20
Loc01					
Loc02					
Loc03					
Loc04					
Loc05	U				U
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					U
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	<u>E7a</u>	<u>E7b</u>	<u>E7c</u>	<u>E7d</u>	<u>E7e</u>
Event Date	2019-10-31	2019-10-31	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 07:05	2019-10-31 10:50	2019-10-31 12:05	2019-10-31 13:05	2019-10-31 13:55
End Time (EDT)	2019-10-31 10:45	2019-10-31 12:00	2019-10-31 13:00	2019-10-31 13:50	2019-10-31 15:20
Loc24					
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30		U			
Loc31					
Loc32					
Loc33					
KAGC					O
KPIT	U				U
03049500	U				U
03085734					

Event #	E7f	E7g	E7h
Event Date	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 15:25	2019-10-31 16:10	2019-10-31 18:05
End Time (EDT)	2019-10-31 16:05	2019-10-31 18:00	2019-11-01 01:00
Loc01			
Loc02			
Loc03			
Loc04			
Loc05			
Loc06			
Loc07			
Loc08			
Loc09			
Loc10	U		
Loc11			
Loc12			
Loc13			
Loc14			
Loc15			
Loc16			
Loc17			
Loc18			
Loc19			
Loc20			
Loc21			
Loc22			
Loc23			
Loc24			
Loc25			

Event #	<u>E7f</u>	<u>E7g</u>	<u>E7h</u>
Event Date	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 15:25	2019-10-31 16:10	2019-10-31 18:05
End Time (EDT)	2019-10-31 16:05	2019-10-31 18:00	2019-11-01 01:00
Loc26			O
Loc27			
Loc28			
Loc29			
Loc30			
Loc31			
Loc32			
Loc33			
KAGC	U		
KPIT	O		
03049500	U		Z
03085734			

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	E1c	E1d	E1e
Event Date	2019-10-03	2019-10-03	2019-10-03	2019-10-03	2019-10-03
Start Time (EDT)	2019-10-02 15:05	2019-10-03 01:05	2019-10-03 02:30	2019-10-03 04:30	2019-10-03 05:30
End Time (EDT)	2019-10-03 01:00	2019-10-03 02:25	2019-10-03 04:25	2019-10-03 05:25	2019-10-03 08:00
Source	KPBZ LII				
Loc01	MSTT			MSTT	MSTT
Loc02	MSTT				
Loc03			MSTT	MSTT	MSTT
Loc04	MSTT				
Loc05	MSTT	MSTT	MSTT	MSTT	MSTT
Loc06	MSTT				
Loc07	MSTT				
Loc08	MSTT				
Loc09	MSTT				
Loc10					
Loc11	MSTT	MSTT			
Loc12	MSTT	MSTT			
Loc13	MSTT	MSTT			
Loc14	MSTT				
Loc15	MSTT	MSTT			
Loc16	MSTT		MSTT		MSTT
Loc17	MSTT	MSTT	MSTT	MSTT	MSTT
Loc18	MSTT		MSTT		
Loc19	MSTT	MSTT		MSTT	MSTT
Loc20	MSTT	MSTT		MSTT	
Loc21	MSTT	MSTT	MSTT		MSTT
Loc22	MSTT				
Loc23	MSTT				
Loc24	MSTT	MSTT	MSTT	MSTT	MSTT

Event #	E1a	E1b	E1c	E1d	E1e
Event Date	2019-10-03	2019-10-03	2019-10-03	2019-10-03	2019-10-03
Start Time (EDT)	2019-10-02 15:05	2019-10-03 01:05	2019-10-03 02:30	2019-10-03 04:30	2019-10-03 05:30
End Time (EDT)	2019-10-03 01:00	2019-10-03 02:25	2019-10-03 04:25	2019-10-03 05:25	2019-10-03 08:00
Source	KPBZ LII				
Loc25	MSTT	MSTT	MSTT	MSTT	
Loc26	MSTT	MSTT	MSTT	MSTT	MSTT
Loc27		MSTT	MSTT	MSTT	MSTT
Loc28	MSTT	MSTT	MSTT	MSTT	MSTT
Loc29			MSTT	MSTT	MSTT
Loc30			MSTT	MSTT	MSTT
Loc31			MSTT	MSTT	MSTT
Loc32		MSTT	MSTT	MSTT	MSTT
Loc33			MSTT	MSTT	MSTT
KAGC	MSTT	MSTT	MSTT		
KPIT	MSTT				
03049500		MSTT	MSTT	MSTT	MSTT
03085734	MSTT	MSTT			MSTT

Event #	E2a	E2b	E2c	E2d	E2e
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-06 07:05	2019-10-06 22:05	2019-10-06 23:05	2019-10-07 00:05	2019-10-07 01:05
End Time (EDT)	2019-10-06 22:00	2019-10-06 23:00	2019-10-07 00:00	2019-10-07 01:00	2019-10-07 02:00
Source	KPBZ LII				
Loc01	MSTT	MSTT			
Loc02	MSTT	MSTT			
Loc03		MSTT			
Loc04		MSTT			
Loc05	MSTT		MSTT		
Loc06	MSTT	MSTT	MSTT		
Loc07	MSTT	MSTT	MSTT		
Loc08	MSTT		MSTT		
Loc09			MSTT		
Loc10					
Loc11	MSTT		MSTT		
Loc12	MSTT		MSTT		
Loc13	MSTT		MSTT		
Loc14	MSTT		MSTT		
Loc15	MSTT	MSTT	MSTT		
Loc16	MSTT		MSTT		
Loc17	MSTT	MSTT	MSTT		
Loc18	MSTT	MSTT			
Loc19			MSTT		
Loc20	MSTT		MSTT		
Loc21	MSTT	MSTT			
Loc22	MSTT	MSTT			

Event #	E2a	E2b	E2c	E2d	E2e
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-06 07:05	2019-10-06 22:05	2019-10-06 23:05	2019-10-07 00:05	2019-10-07 01:05
End Time (EDT)	2019-10-06 22:00	2019-10-06 23:00	2019-10-07 00:00	2019-10-07 01:00	2019-10-07 02:00
Source	KPBZ LII				
Loc23	MSTT				
Loc24	MSTT	MSTT	MSTT		
Loc25	MSTT	MSTT	MSTT		
Loc26	MSTT	MSTT	MSTT		
Loc27		MSTT			
Loc28	MSTT		MSTT	MSTT	
Loc29	MSTT	MSTT			
Loc30		MSTT			
Loc31		MSTT			
Loc32					
Loc33		MSTT			
KAGC	MSTT	MSTT	MSTT		
KPIT	MSTT	MSTT			
03049500				MSTT	OMFB
03085734	MSTT	MSTT			

Event #	E2f	E2g	E2h	E2i	E2j
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-07 02:05	2019-10-07 03:05	2019-10-07 04:05	2019-10-07 06:20	2019-10-07 08:05
End Time (EDT)	2019-10-07 03:00	2019-10-07 04:00	2019-10-07 06:15	2019-10-07 08:00	2019-10-07 10:00
Source	KPBZ LII				
Loc01					MSTT
Loc02					MSTT
Loc03					MSTT
Loc04					MSTT
Loc05					MSTT
Loc06					MSTT
Loc07					
Loc08					MSTT
Loc09					MSTT
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					MSTT
Loc18					MSTT
Loc19					MSTT
Loc20					
Loc21					MSTT
Loc22					MSTT

Event #	E2f	E2g	E2h	E2i	E2j
Event Date	2019-10-07	2019-10-07	2019-10-07	2019-10-07	2019-10-07
Start Time (EDT)	2019-10-07 02:05	2019-10-07 03:05	2019-10-07 04:05	2019-10-07 06:20	2019-10-07 08:05
End Time (EDT)	2019-10-07 03:00	2019-10-07 04:00	2019-10-07 06:15	2019-10-07 08:00	2019-10-07 10:00
Source	KPBZ LII				
Loc23					MSTT
Loc24					
Loc25					
Loc26					
Loc27					MSTT
Loc28					
Loc29					MSTT
Loc30					MSTT
Loc31					MSTT
Loc32					MSTT
Loc33					MSTT
KAGC					
KPIT					MSTT
03049500					MSTT
03085734					MSTT

Event #	E2k	E2m	E3a	E3b	E3c
Event Date	2019-10-07	2019-10-07	2019-10-16	2019-10-16	2019-10-16
Start Time (EDT)	2019-10-07 10:05	2019-10-07 13:05	2019-10-16 05:05	2019-10-16 07:35	2019-10-16 08:30
End Time (EDT)	2019-10-07 12:35	2019-10-07 20:00	2019-10-16 07:30	2019-10-16 08:25	2019-10-16 09:20
Source	KPBZ LII				
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11			MSTT		
Loc12			MSTT		
Loc13			MSTT		
Loc14			MSTT		
Loc15			MSTT		
Loc16					
Loc17					
Loc18					
Loc19			MSTT		
Loc20			MSTT		
Loc21					
Loc22					

Event #	E2k	E2m	E3a	E3b	E3c
Event Date	2019-10-07	2019-10-07	2019-10-16	2019-10-16	2019-10-16
Start Time (EDT)	2019-10-07 10:05	2019-10-07 13:05	2019-10-16 05:05	2019-10-16 07:35	2019-10-16 08:30
End Time (EDT)	2019-10-07 12:35	2019-10-07 20:00	2019-10-16 07:30	2019-10-16 08:25	2019-10-16 09:20
Source	KPBZ LII				
Loc23				OMFB	
Loc24			MSTT		
Loc25			MSTT		
Loc26					
Loc27					
Loc28			MSTT		
Loc29					
Loc30					
Loc31					
Loc32			MSTT		
Loc33					
KAGC			MSTT		
KPIT					
03049500					
03085734					

Event #	E3d	E3e	E4a	E4b	E4c
Event Date	2019-10-16	2019-10-16	2019-10-22	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-16 09:25	2019-10-16 11:05	2019-10-22 01:05	2019-10-22 07:35	2019-10-22 08:10
End Time (EDT)	2019-10-16 11:00	2019-10-16 15:00	2019-10-22 07:30	2019-10-22 08:05	2019-10-22 08:45
Source	KPBZ LII				
Loc01				MSTT	
Loc02			MSTT	MSTT	
Loc03					
Loc04				MSTT	
Loc05			MSTT		
Loc06			MSTT	MSTT	
Loc07				MSTT	
Loc08			MSTT	MSTT	
Loc09			MSTT	MSTT	
Loc10				MSTT	
Loc11			MSTT	MSTT	
Loc12				MSTT	
Loc13			MSTT	MSTT	MSTT
Loc14			MSTT	MSTT	MSTT
Loc15				MSTT	MSTT
Loc16			MSTT	MSTT	
Loc17					
Loc18					
Loc19			MSTT	MSTT	MSTT
Loc20				MSTT	MSTT
Loc21					
Loc22					

Event #	E3d	E3e	E4a	E4b	E4c
Event Date	2019-10-16	2019-10-16	2019-10-22	2019-10-22	2019-10-22
Start Time (EDT)	2019-10-16 09:25	2019-10-16 11:05	2019-10-22 01:05	2019-10-22 07:35	2019-10-22 08:10
End Time (EDT)	2019-10-16 11:00	2019-10-16 15:00	2019-10-22 07:30	2019-10-22 08:05	2019-10-22 08:45
Source	KPBZ LII				
Loc23					
Loc24			MSTT	MSTT	MSTT
Loc25				MSTT	MSTT
Loc26				MSTT	MSTT
Loc27					
Loc28				MSTT	MSTT
Loc29					
Loc30				MSTT	
Loc31				MSTT	
Loc32			MSTT	MSTT	MSTT
Loc33				MSTT	
KAGC				MSTT	MSTT
KPIT					
03049500				MSTT	MSTT
03085734			MSTT	MSTT	

Event #	E4d	E4e	E4f	E4g	E5a
Event Date	2019-10-22	2019-10-22	2019-10-22	2019-10-22	2019-10-27
Start Time (EDT)	2019-10-22 08:50	2019-10-22 09:25	2019-10-22 10:30	2019-10-22 11:05	2019-10-26 10:05
End Time (EDT)	2019-10-22 09:20	2019-10-22 10:25	2019-10-22 11:00	2019-10-22 15:00	2019-10-26 18:30
Source	KPBZ LII				
Loc01			MSTT		
Loc02			MSTT		MSTT
Loc03					
Loc04			MSTT		
Loc05					
Loc06					
Loc07					
Loc08			MSTT		
Loc09			MSTT		MSTT
Loc10			MSTT		
Loc11			MSTT		MSTT
Loc12			MSTT		MSTT
Loc13			MSTT		
Loc14			MSTT		
Loc15			MSTT		MSTT
Loc16			MSTT		MSTT
Loc17					
Loc18			MSTT		
Loc19			MSTT		
Loc20			MSTT		
Loc21			MSTT		
Loc22			MSTT		

Event #	E4d	E4e	E4f	E4g	E5a
Event Date	2019-10-22	2019-10-22	2019-10-22	2019-10-22	2019-10-27
Start Time (EDT)	2019-10-22 08:50	2019-10-22 09:25	2019-10-22 10:30	2019-10-22 11:05	2019-10-26 10:05
End Time (EDT)	2019-10-22 09:20	2019-10-22 10:25	2019-10-22 11:00	2019-10-22 15:00	2019-10-26 18:30
Source	KPBZ LII				
Loc23			MSTT	MSTT	
Loc24					MSTT
Loc25					MSTT
Loc26			MSTT		MSTT
Loc27			MSTT		
Loc28			MSTT		
Loc29			MSTT		
Loc30			MSTT		
Loc31			MSTT		
Loc32			MSTT		
Loc33			MSTT		
KAGC			MSTT		
KPIT			MSTT		
03049500			MSTT		
03085734			MSTT		

Event #	E5b	E5c	E5d	E5e	E5f
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-27	2019-10-27
Start Time (EDT)	2019-10-26 18:35	2019-10-26 19:35	2019-10-26 20:15	2019-10-26 21:35	2019-10-27 03:05
End Time (EDT)	2019-10-26 19:30	2019-10-26 20:10	2019-10-26 21:30	2019-10-27 03:00	2019-10-27 04:30
Source	KPBZ LII				
Loc01			MSTT		
Loc02			MSTT		
Loc03					
Loc04			MSTT		
Loc05		MSTT	MSTT		
Loc06			MSTT		
Loc07		MSTT	MSTT		
Loc08					
Loc09		MSTT			MSTT
Loc10					MSTT
Loc11		MSTT	MSTT		MSTT
Loc12			MSTT		MSTT
Loc13			MSTT		MSTT
Loc14		MSTT	MSTT		MSTT
Loc15		MSTT	MSTT		MSTT
Loc16		MSTT	MSTT		MSTT
Loc17		MSTT	MSTT		
Loc18		MSTT	MSTT		
Loc19			MSTT		MSTT
Loc20			MSTT		MSTT
Loc21					
Loc22		MSTT	MSTT	MSTT	

Event #	E5b	E5c	E5d	E5e	E5f
Event Date	2019-10-27	2019-10-27	2019-10-27	2019-10-27	2019-10-27
Start Time (EDT)	2019-10-26 18:35	2019-10-26 19:35	2019-10-26 20:15	2019-10-26 21:35	2019-10-27 03:05
End Time (EDT)	2019-10-26 19:30	2019-10-26 20:10	2019-10-26 21:30	2019-10-27 03:00	2019-10-27 04:30
Source	KPBZ LII				
Loc23					
Loc24		MSTT	MSTT		MSTT
Loc25		MSTT	MSTT		MSTT
Loc26		MSTT	MSTT		MSTT
Loc27	MSTT	OMFB			
Loc28			MSTT		MSTT
Loc29					
Loc30					
Loc31					
Loc32			MSTT		MSTT
Loc33	MSTT				
KAGC			MSTT		MSTT
KPIT					
03049500					MSTT
03085734			MSTT		

Event #	E5g	E5h	E6a	E6b	E6c
Event Date	2019-10-27	2019-10-27	2019-10-30	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-27 04:35	2019-10-27 05:05	2019-10-30 14:05	2019-10-30 20:20	2019-10-30 21:30
End Time (EDT)	2019-10-27 05:00	2019-10-27 08:00	2019-10-30 20:15	2019-10-30 21:25	2019-10-30 23:15
Source	KPBZ LII				
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18					
Loc19					
Loc20					
Loc21					
Loc22					

Event #	E5g	E5h	E6a	E6b	E6c
Event Date	2019-10-27	2019-10-27	2019-10-30	2019-10-30	2019-10-30
Start Time (EDT)	2019-10-27 04:35	2019-10-27 05:05	2019-10-30 14:05	2019-10-30 20:20	2019-10-30 21:30
End Time (EDT)	2019-10-27 05:00	2019-10-27 08:00	2019-10-30 20:15	2019-10-30 21:25	2019-10-30 23:15
Source	KPBZ LII				
Loc23					
Loc24			OAD		
Loc25					
Loc26					MSTT
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32	OAD				
Loc33					
KAGC	MSTT				
KPIT					
03049500					
03085734					

Event #	E6e	E6f	E7a	E7b	E7c
Event Date	2019-10-30	2019-10-30	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 01:05	2019-10-31 01:55	2019-10-31 07:05	2019-10-31 10:50	2019-10-31 12:05
End Time (EDT)	2019-10-31 01:50	2019-10-31 02:15	2019-10-31 10:45	2019-10-31 12:00	2019-10-31 13:00
Source	KPBZ LII				
Loc01					MSTT
Loc02					MSTT
Loc03					MSTT
Loc04				MSTT	MSTT
Loc05		MSTT			MSTT
Loc06		MSTT			MSTT
Loc07		MSTT			MSTT
Loc08		MSTT			MSTT
Loc09		MSTT		MSTT	MSTT
Loc10		MSTT		MSTT	MSTT
Loc11				MSTT	MSTT
Loc12		MSTT		MSTT	MSTT
Loc13		MSTT			MSTT
Loc14					MSTT
Loc15		MSTT		MSTT	MSTT
Loc16		MSTT		MSTT	MSTT
Loc17		MSTT			MSTT
Loc18		MSTT		MSTT	MSTT
Loc19				MSTT	MSTT
Loc20					MSTT
Loc21		MSTT			
Loc22		MSTT		MSTT	MSTT

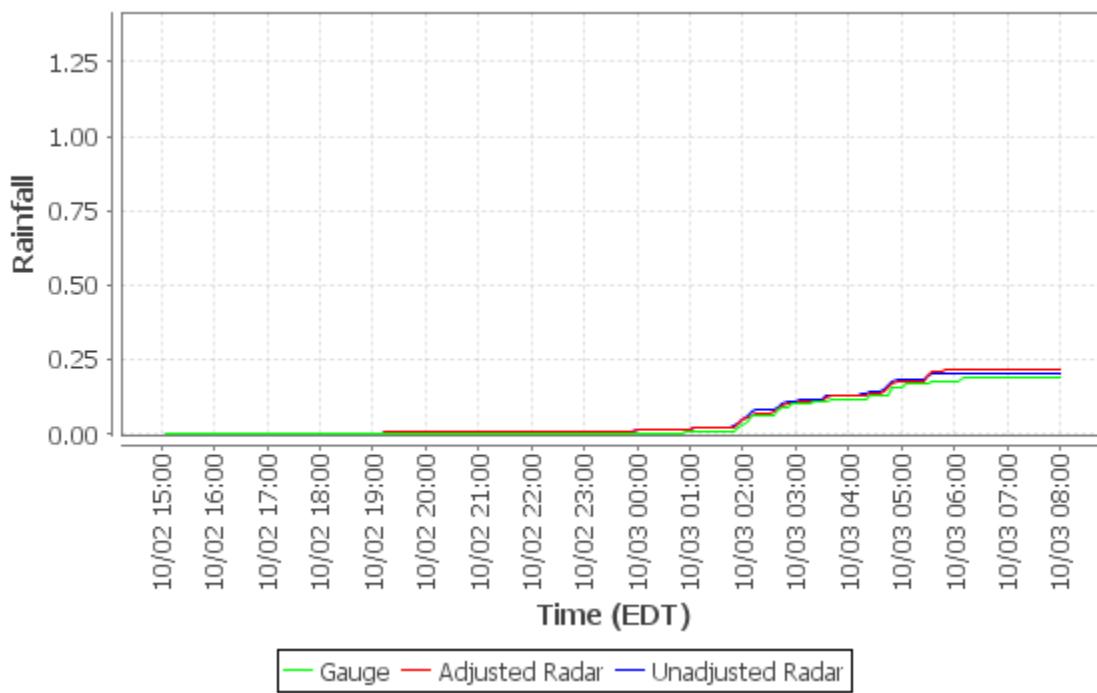
Event #	E6e	E6f	E7a	E7b	E7c
Event Date	2019-10-30	2019-10-30	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 01:05	2019-10-31 01:55	2019-10-31 07:05	2019-10-31 10:50	2019-10-31 12:05
End Time (EDT)	2019-10-31 01:50	2019-10-31 02:15	2019-10-31 10:45	2019-10-31 12:00	2019-10-31 13:00
Source	KPBZ LII				
Loc23	MSTT	MSTT			
Loc24		MSTT		MSTT	MSTT
Loc25		MSTT		MSTT	MSTT
Loc26		MSTT		MSTT	MSTT
Loc27	MSTT	MSTT			
Loc28					MSTT
Loc29	MSTT	MSTT			
Loc30	MSTT	MSTT			
Loc31					MSTT
Loc32				MSTT	MSTT
Loc33		MSTT			MSTT
KAGC		MSTT	MSTT	MSTT	MSTT
KPIT		MSTT			
03049500				MSTT	MSTT
03085734				MSTT	MSTT

Event #	E7d	E7e	E7f	E7g	E7h
Event Date	2019-10-31	2019-10-31	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 13:05	2019-10-31 13:55	2019-10-31 15:25	2019-10-31 16:10	2019-10-31 18:05
End Time (EDT)	2019-10-31 13:50	2019-10-31 15:20	2019-10-31 16:05	2019-10-31 18:00	2019-11-01 01:00
Source	KPBZ LII				
Loc01	MSTT			MSTT	MSTT
Loc02	MSTT			MSTT	MSTT
Loc03	MSTT			MSTT	MSTT
Loc04				MSTT	MSTT
Loc05	MSTT			MSTT	MSTT
Loc06	MSTT			MSTT	MSTT
Loc07				MSTT	MSTT
Loc08				MSTT	MSTT
Loc09	MSTT			MSTT	MSTT
Loc10	MSTT			MSTT	MSTT
Loc11	MSTT			MSTT	MSTT
Loc12	MSTT			MSTT	MSTT
Loc13	MSTT				MSTT
Loc14	MSTT				MSTT
Loc15	MSTT				
Loc16	MSTT			MSTT	MSTT
Loc17				MSTT	MSTT
Loc18				MSTT	MSTT
Loc19	MSTT			MSTT	MSTT
Loc20	MSTT				MSTT
Loc21				MSTT	MSTT
Loc22				MSTT	MSTT

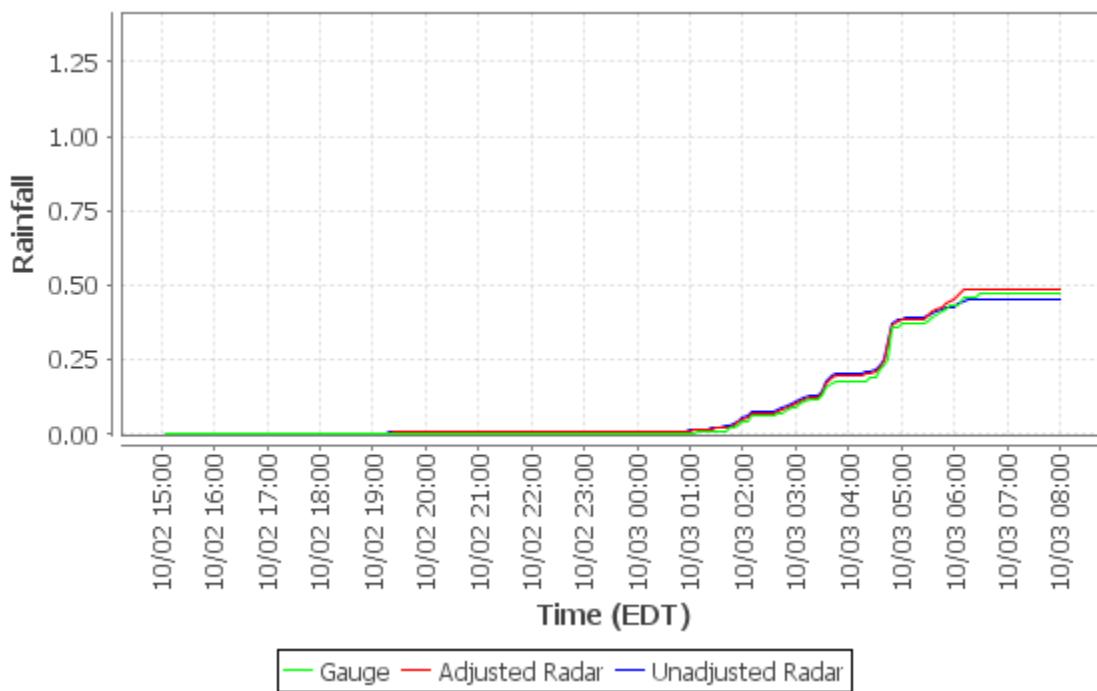
Event #	E7d	E7e	E7f	E7g	E7h
Event Date	2019-10-31	2019-10-31	2019-10-31	2019-10-31	2019-10-31
Start Time (EDT)	2019-10-31 13:05	2019-10-31 13:55	2019-10-31 15:25	2019-10-31 16:10	2019-10-31 18:05
End Time (EDT)	2019-10-31 13:50	2019-10-31 15:20	2019-10-31 16:05	2019-10-31 18:00	2019-11-01 01:00
Source	KPBZ LII				
Loc23	MSTT			MSTT	MSTT
Loc24	MSTT				MSTT
Loc25	MSTT				
Loc26	MSTT				
Loc27	MSTT			MSTT	MSTT
Loc28	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

Appendix C - Event 1 (2019-10-03) CDPs

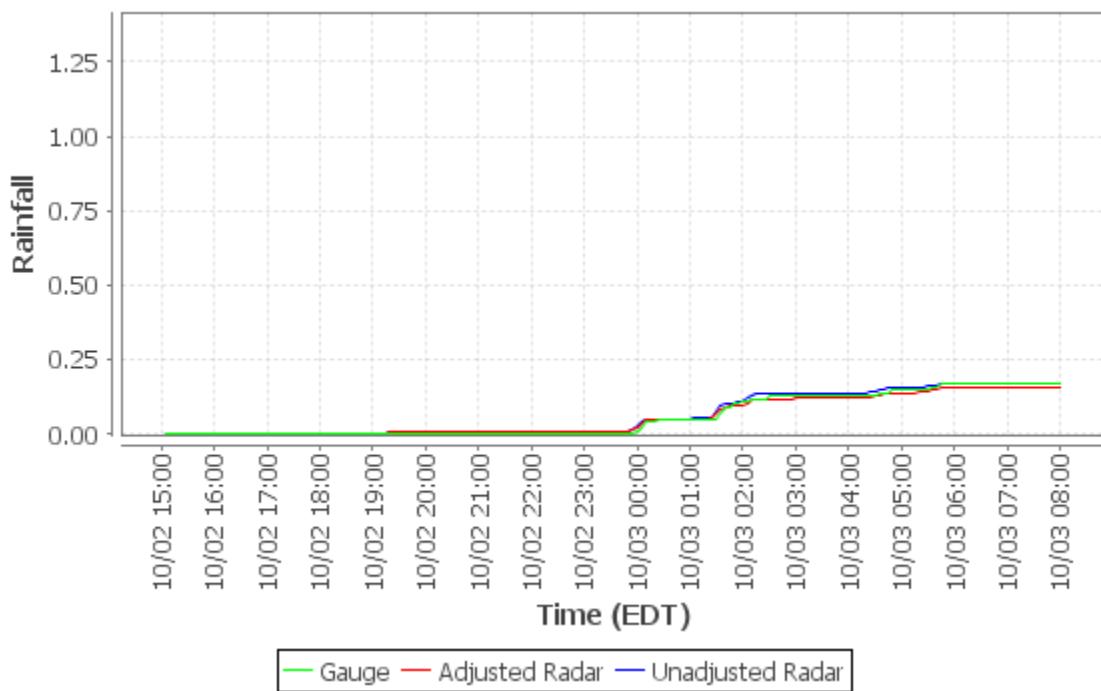
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



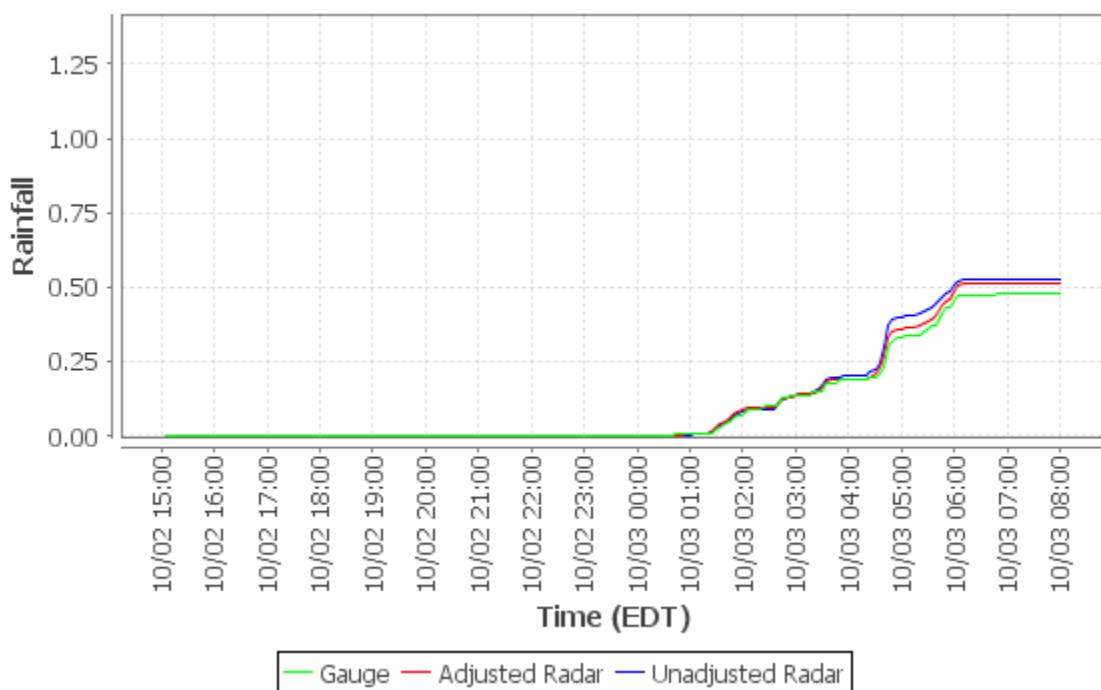
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



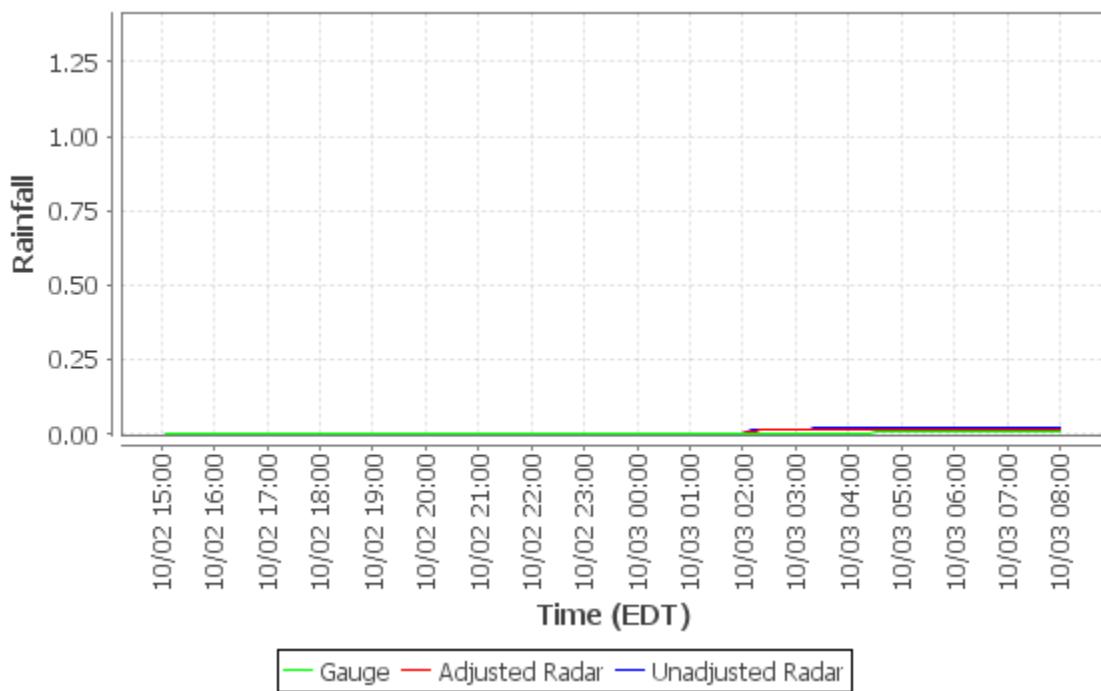
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



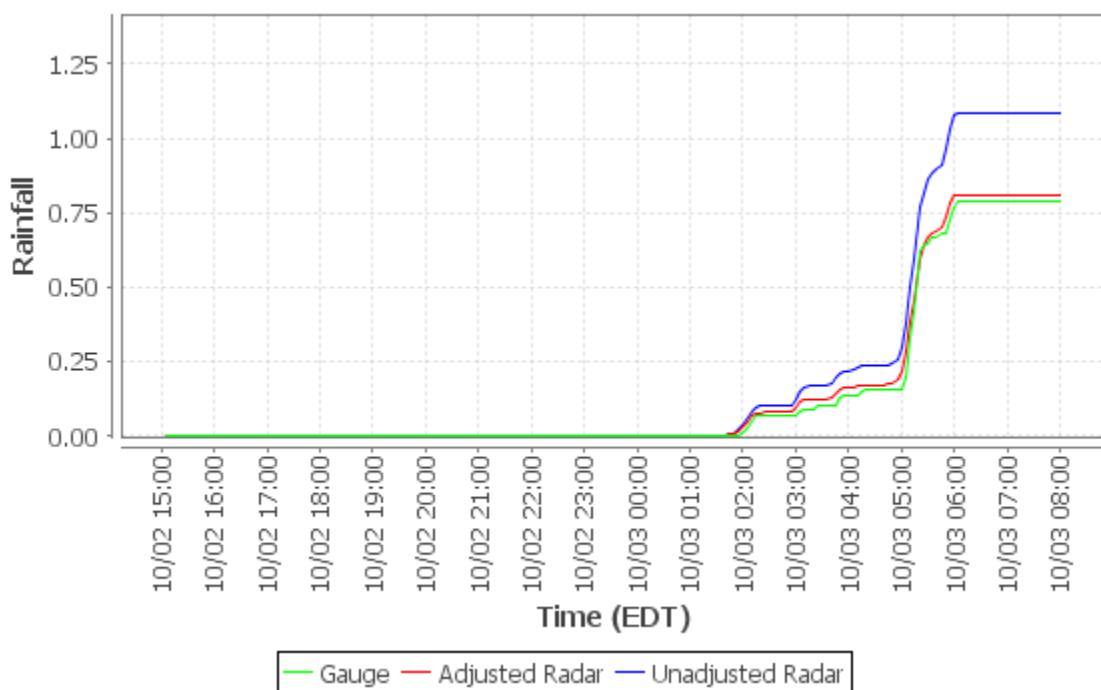
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



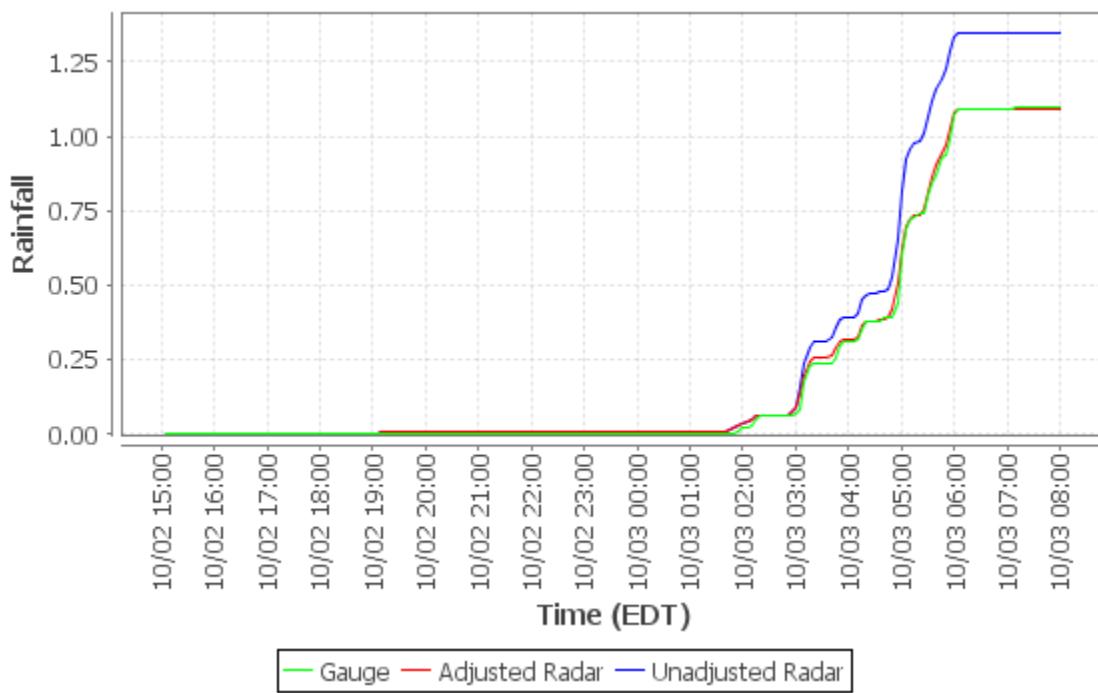
Cumulative Distribution Plot - Upper St. Clair (Loc05)



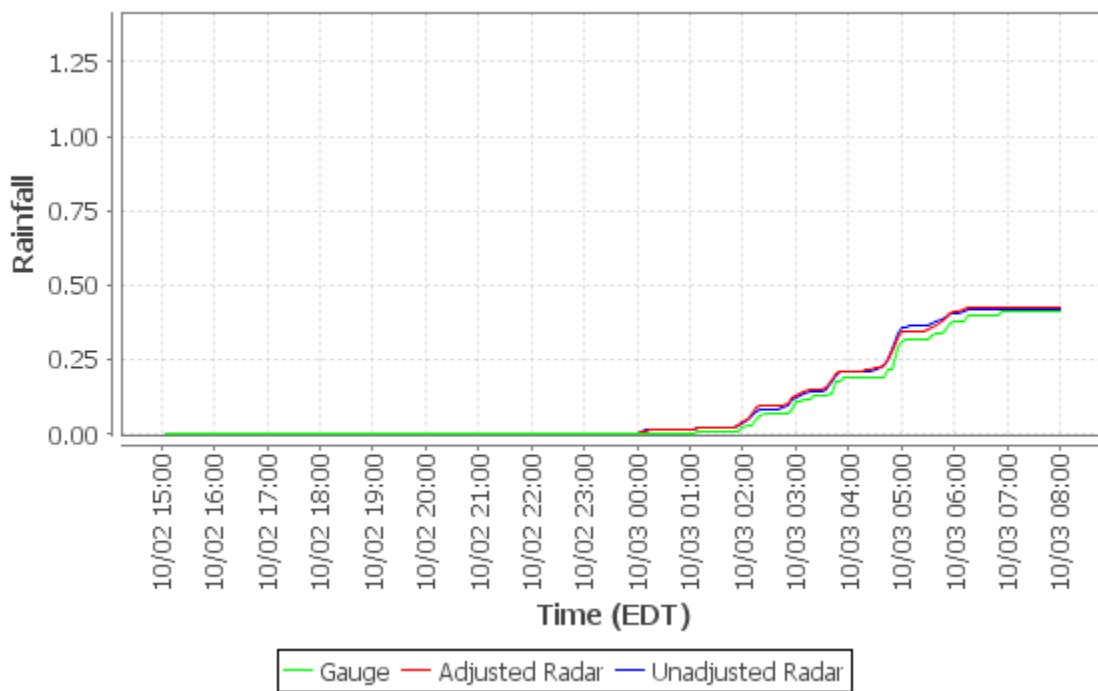
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



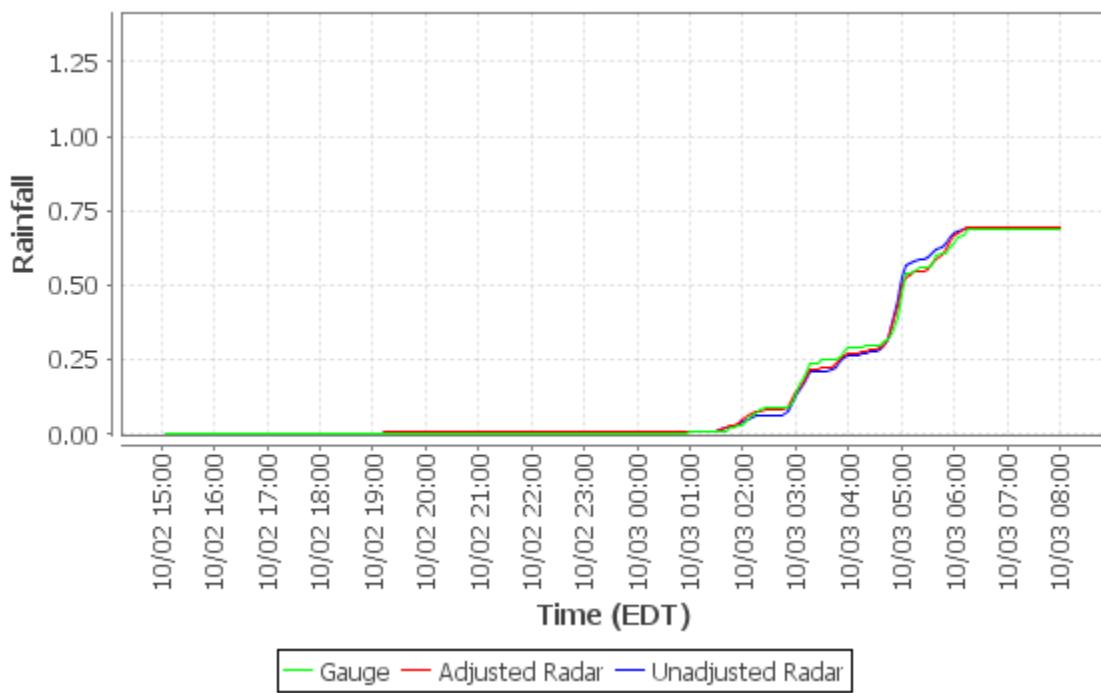
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



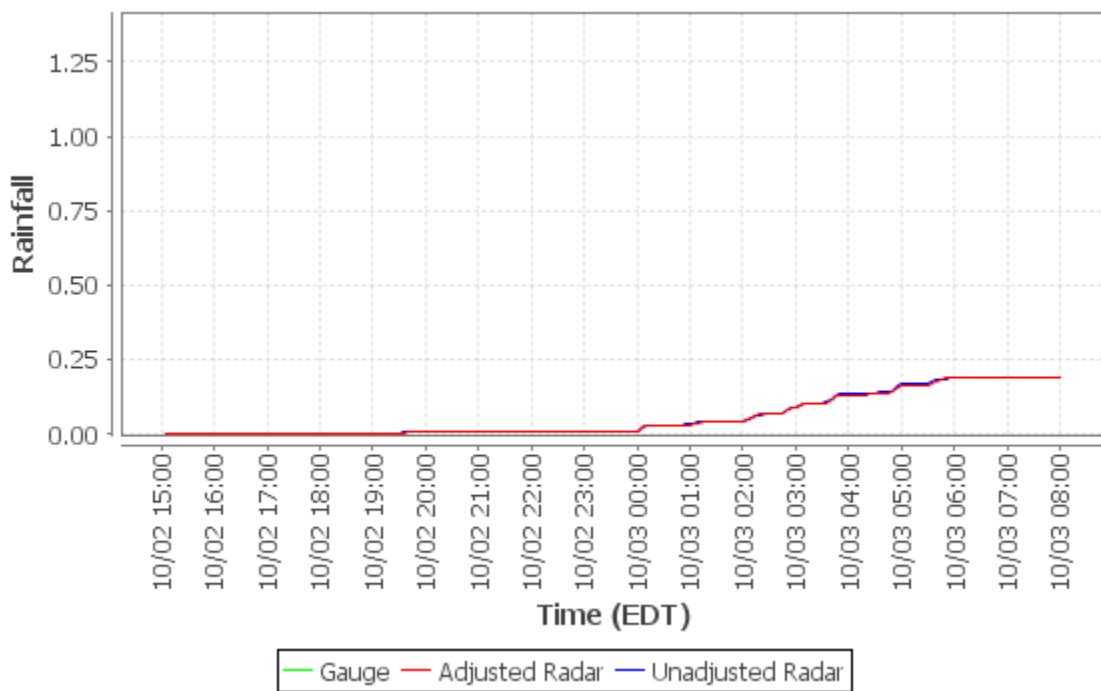
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



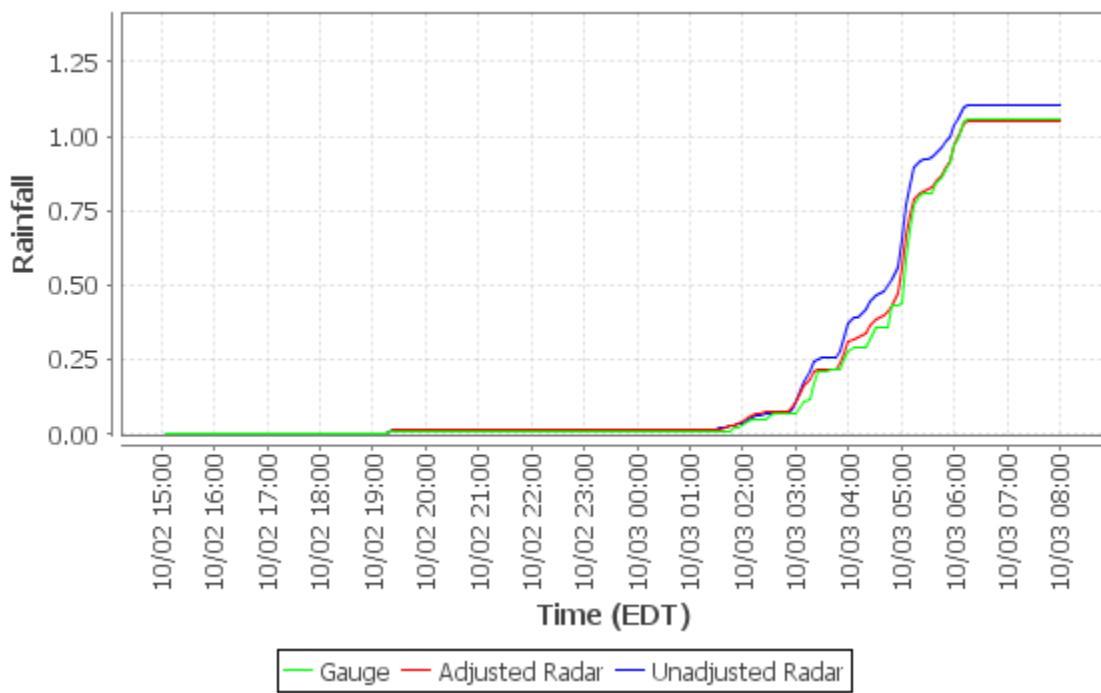
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



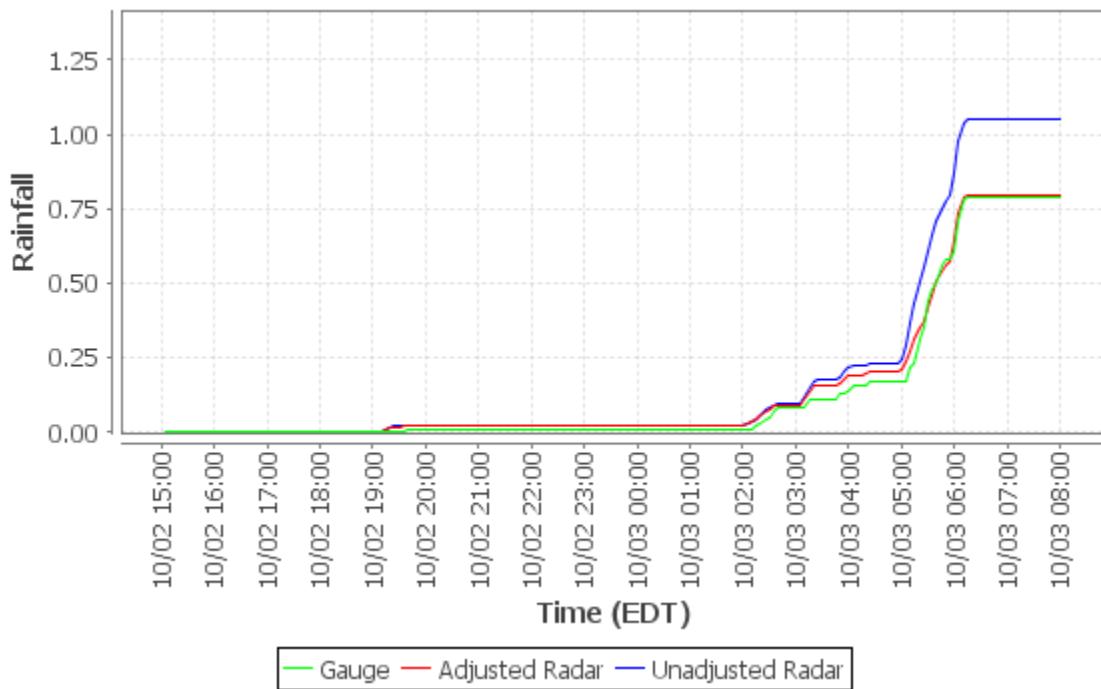
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



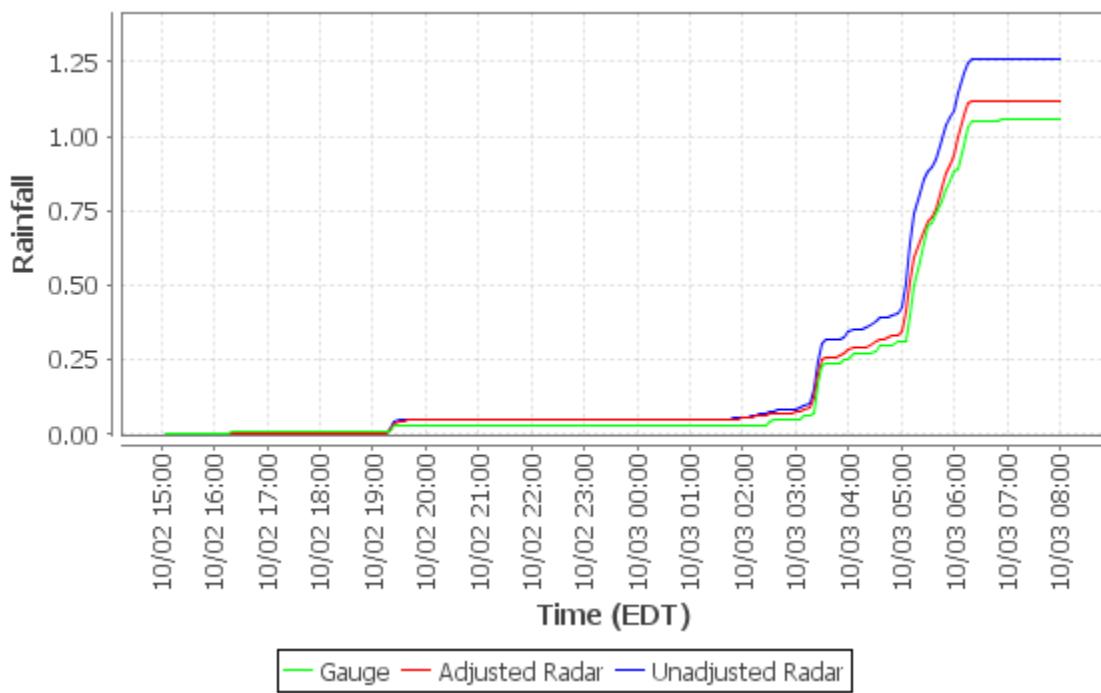
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



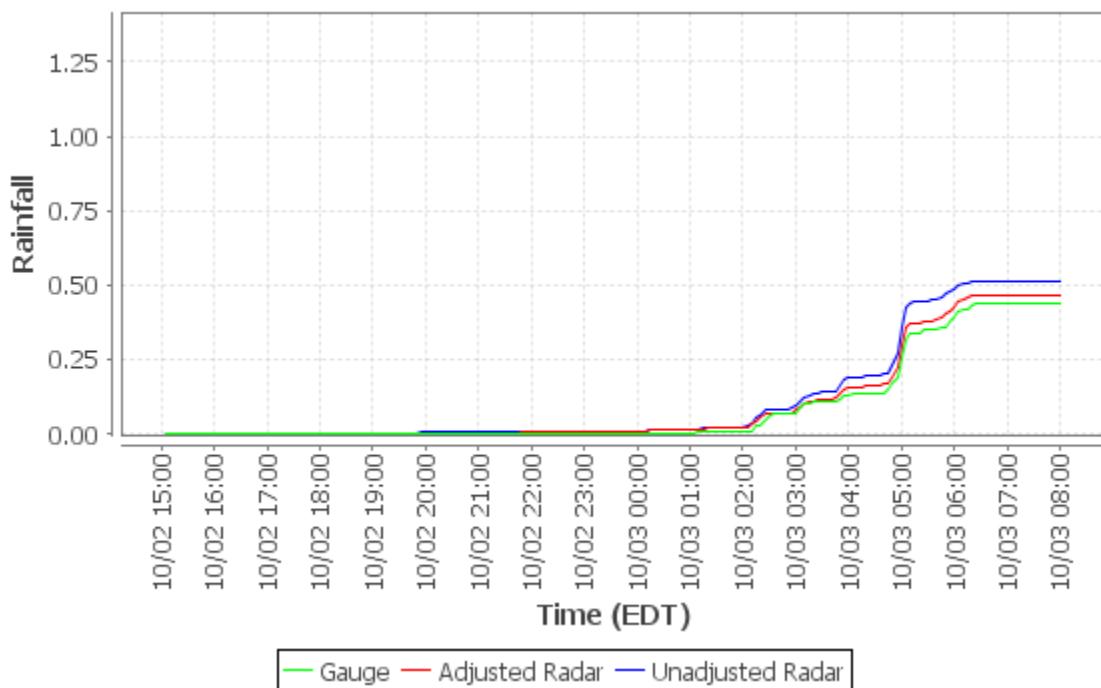
Cumulative Distribution Plot - Baldwin (Loc12)



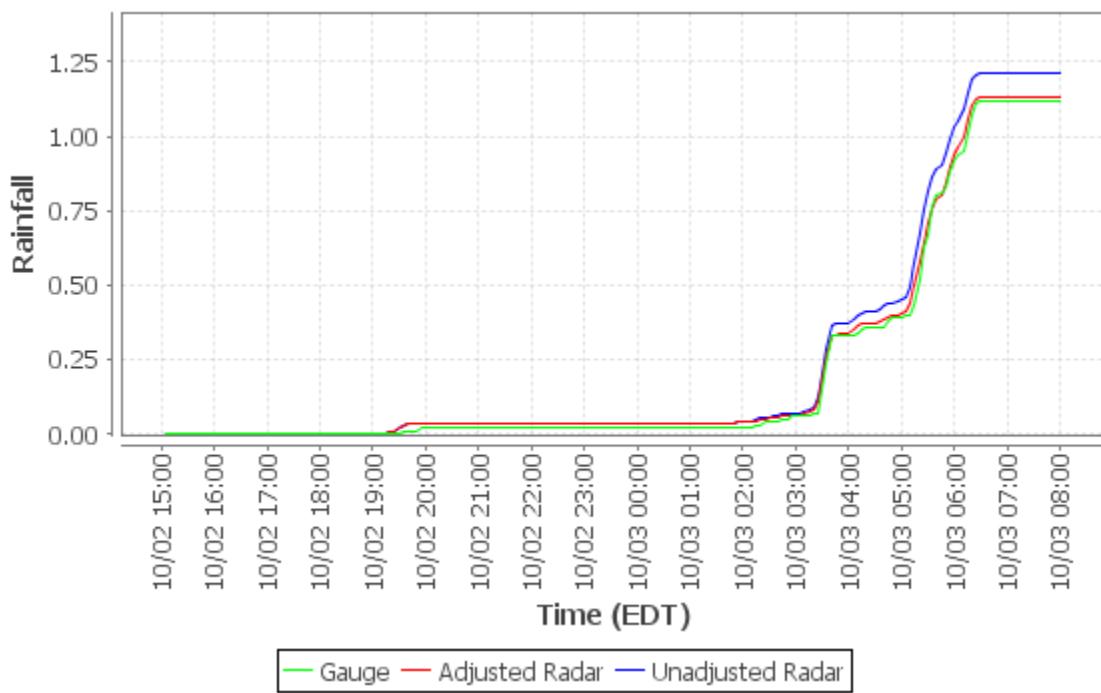
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



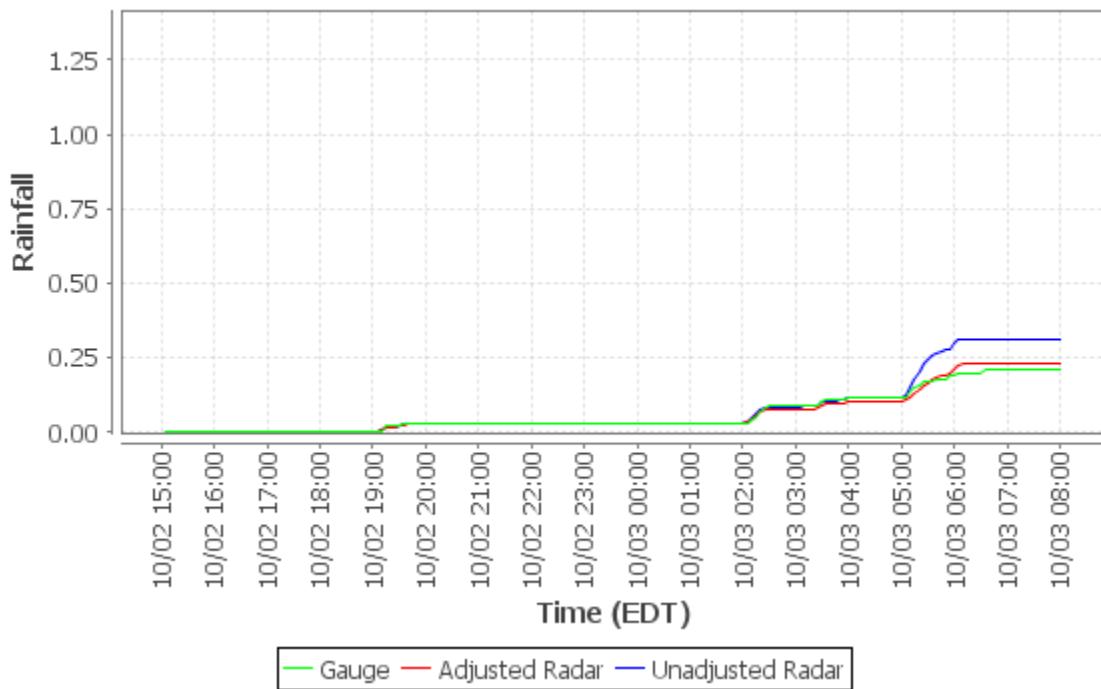
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



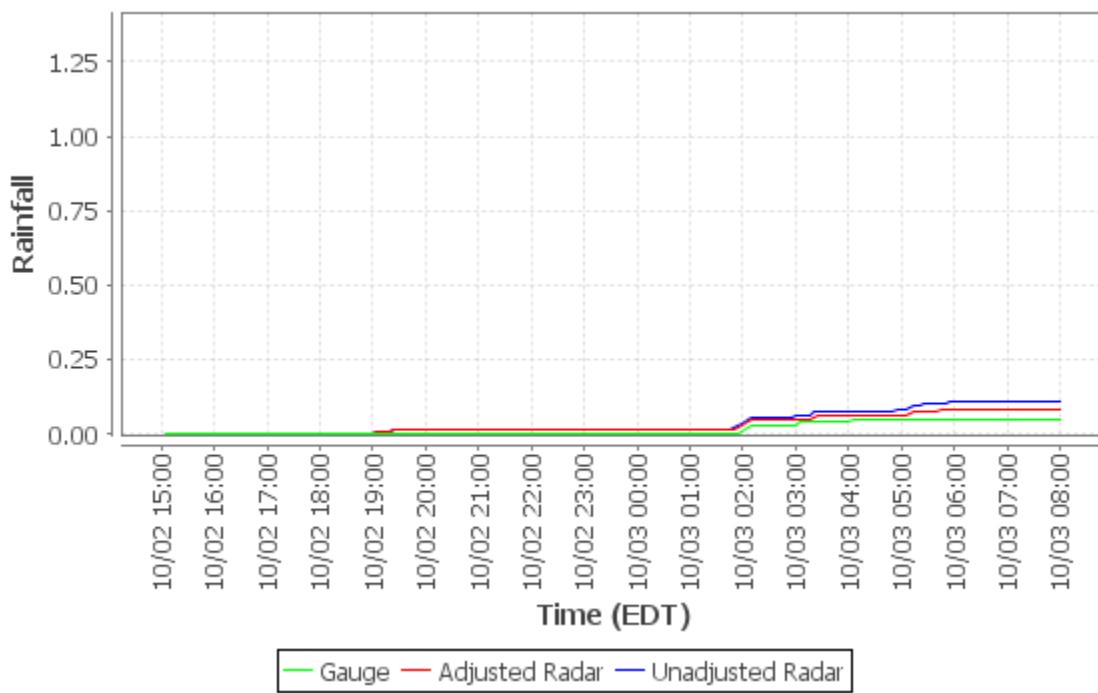
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



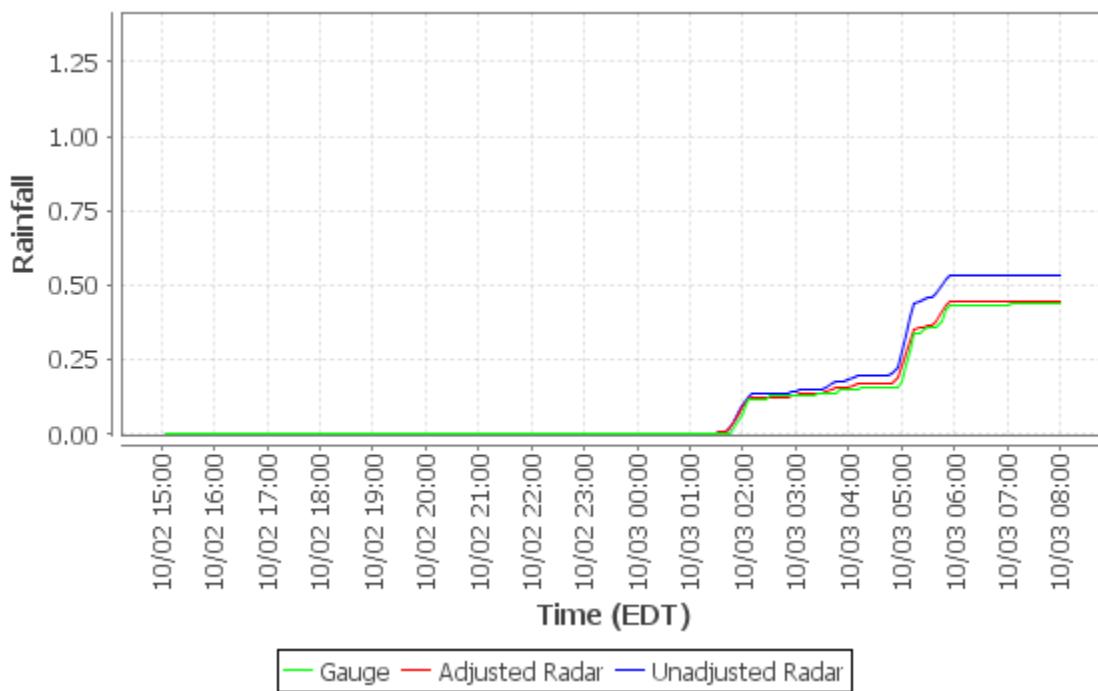
Cumulative Distribution Plot - Castle Shannon (Loc16)



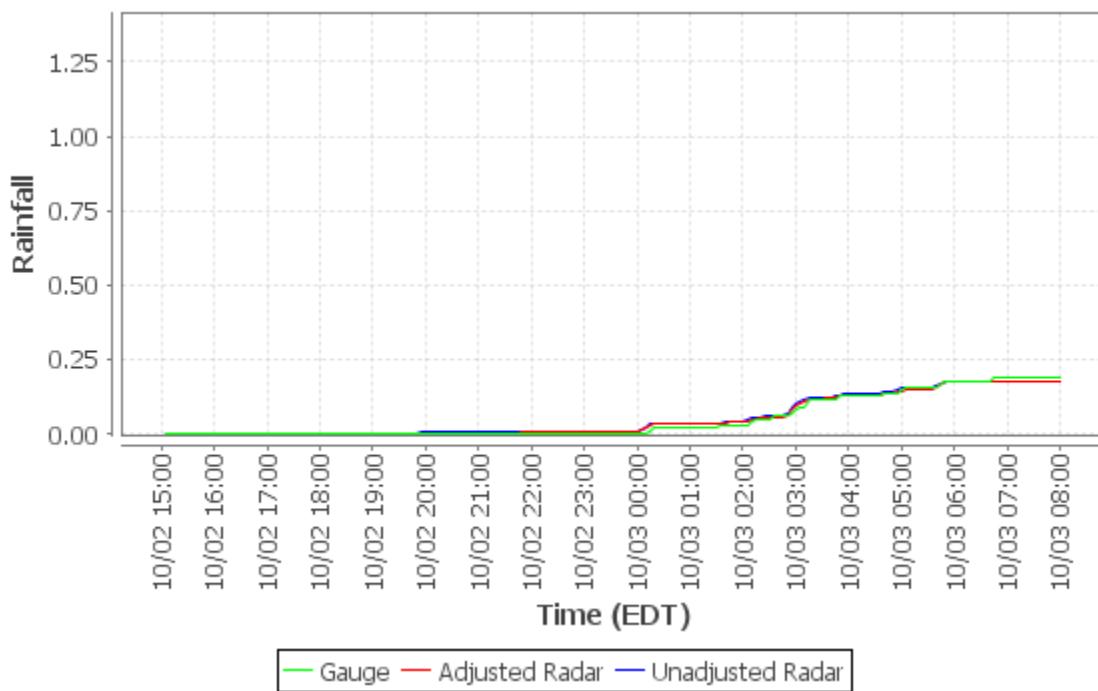
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



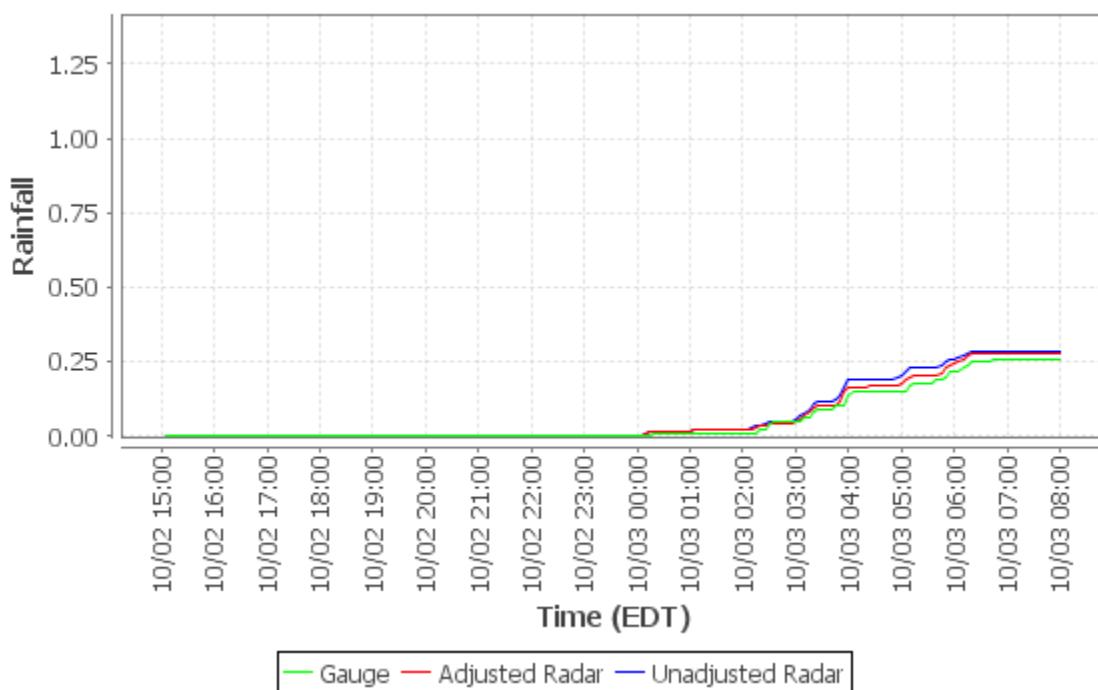
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



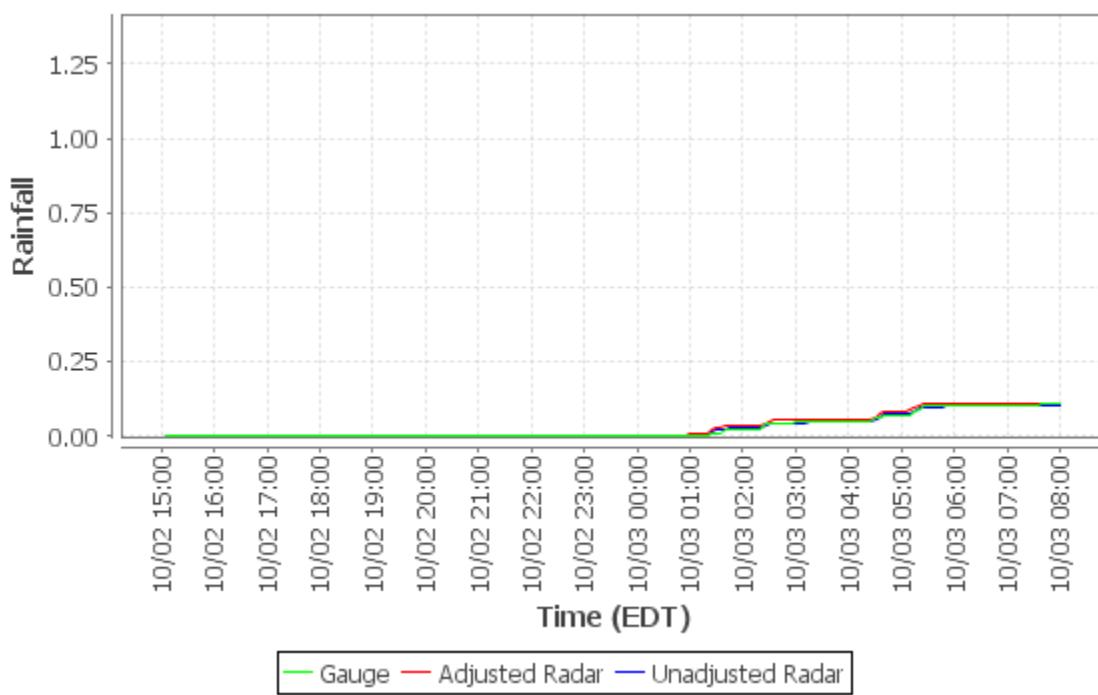
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



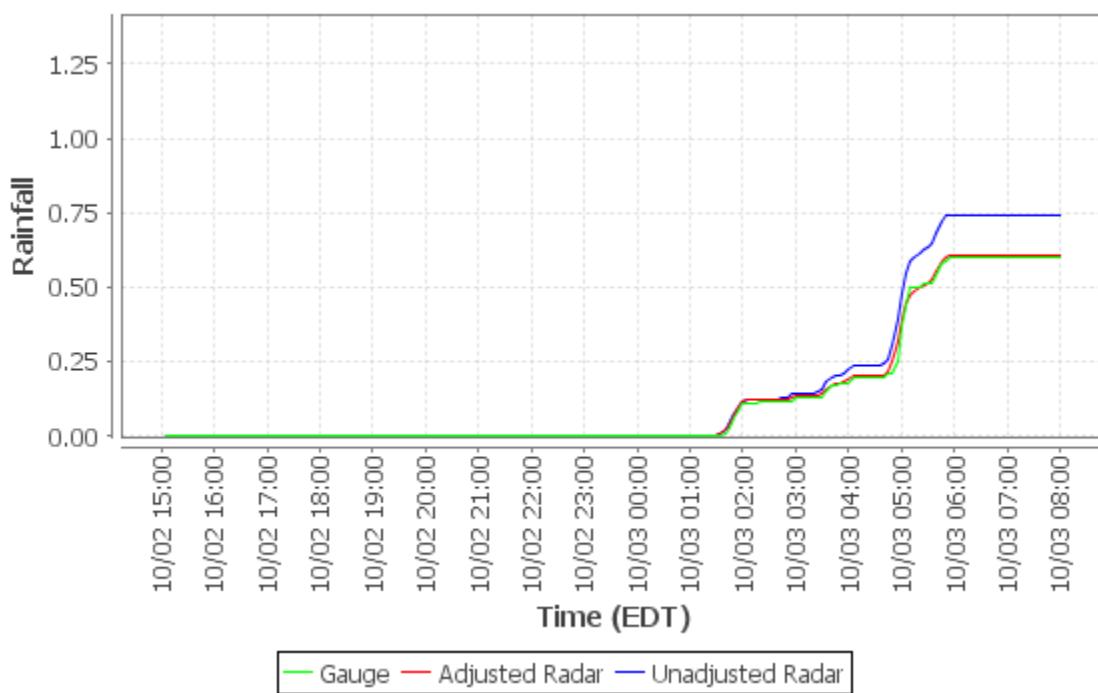
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



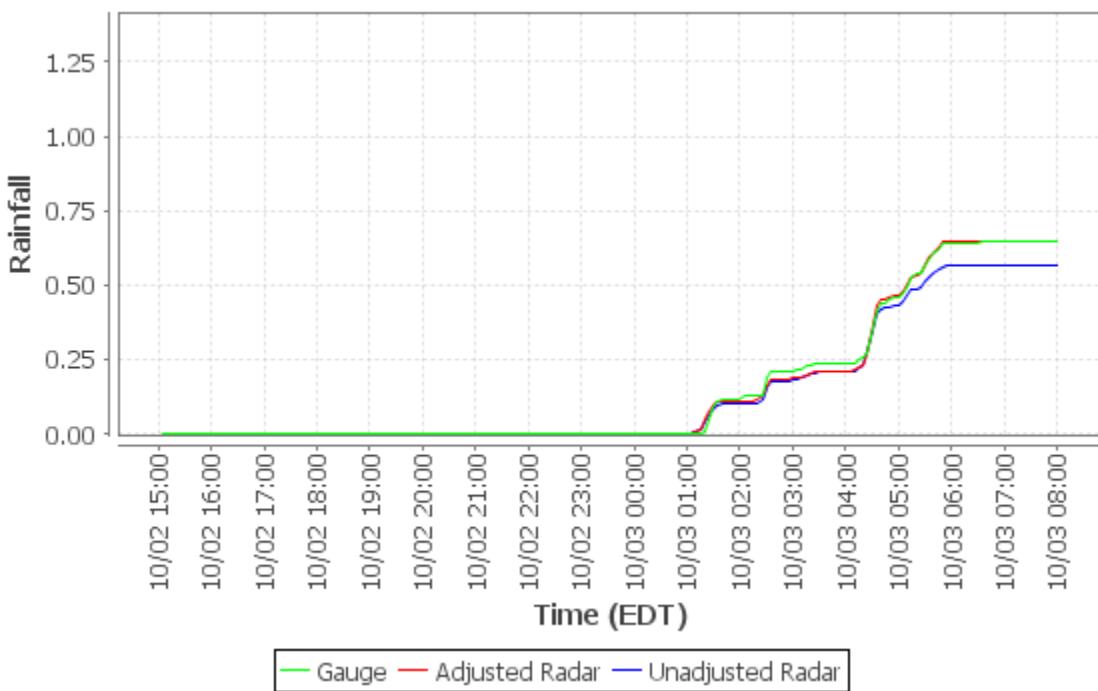
Cumulative Distribution Plot - Moon TWP (Loc21)



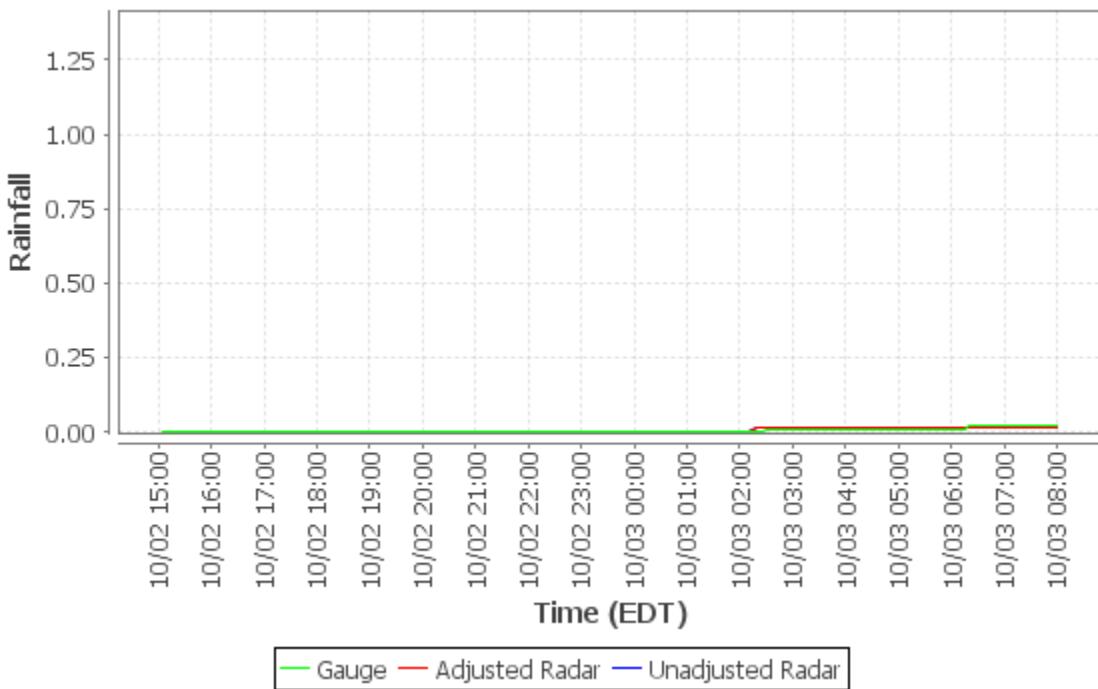
Cumulative Distribution Plot - North Fayette TWP (Loc22)



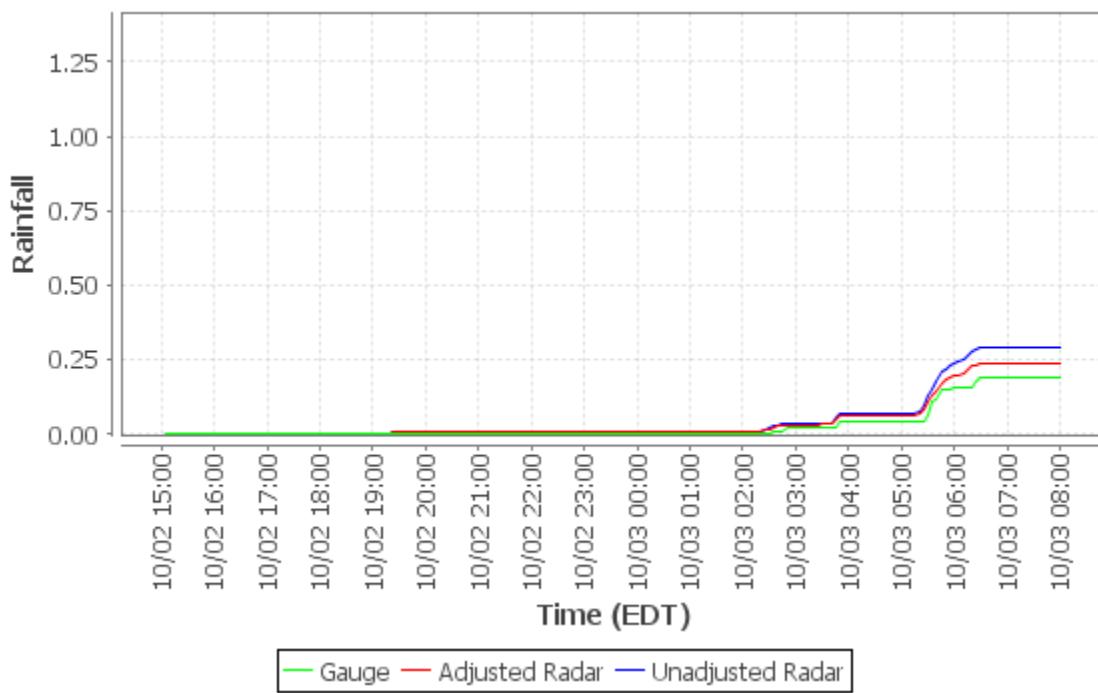
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



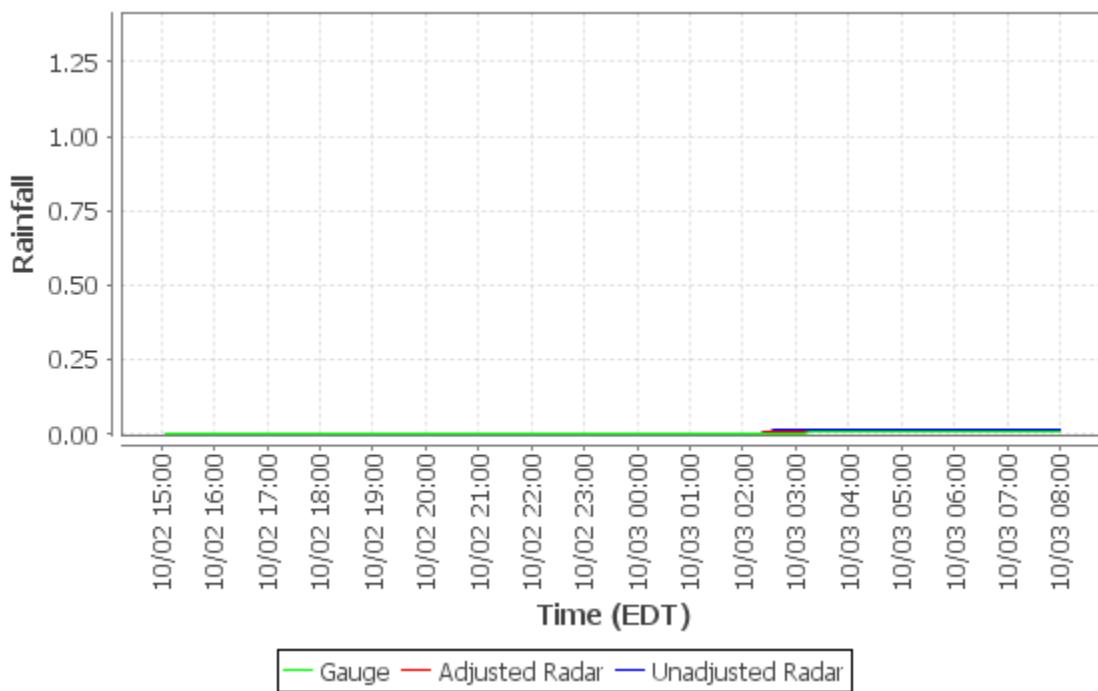
Cumulative Distribution Plot - Jefferson Hills (Loc24)



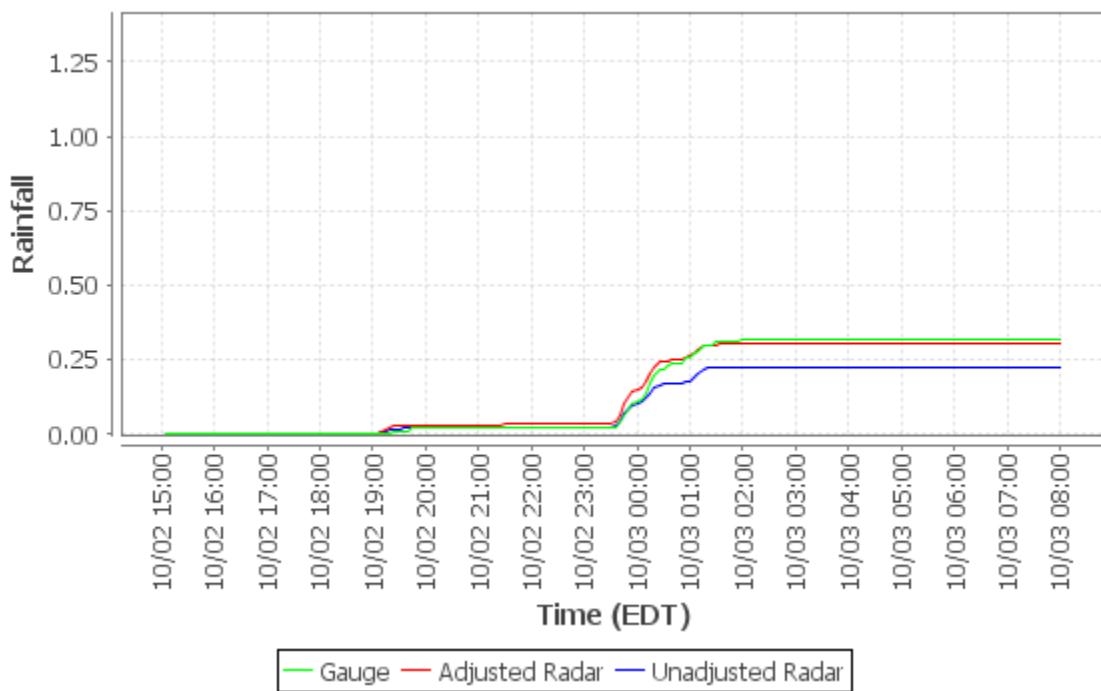
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



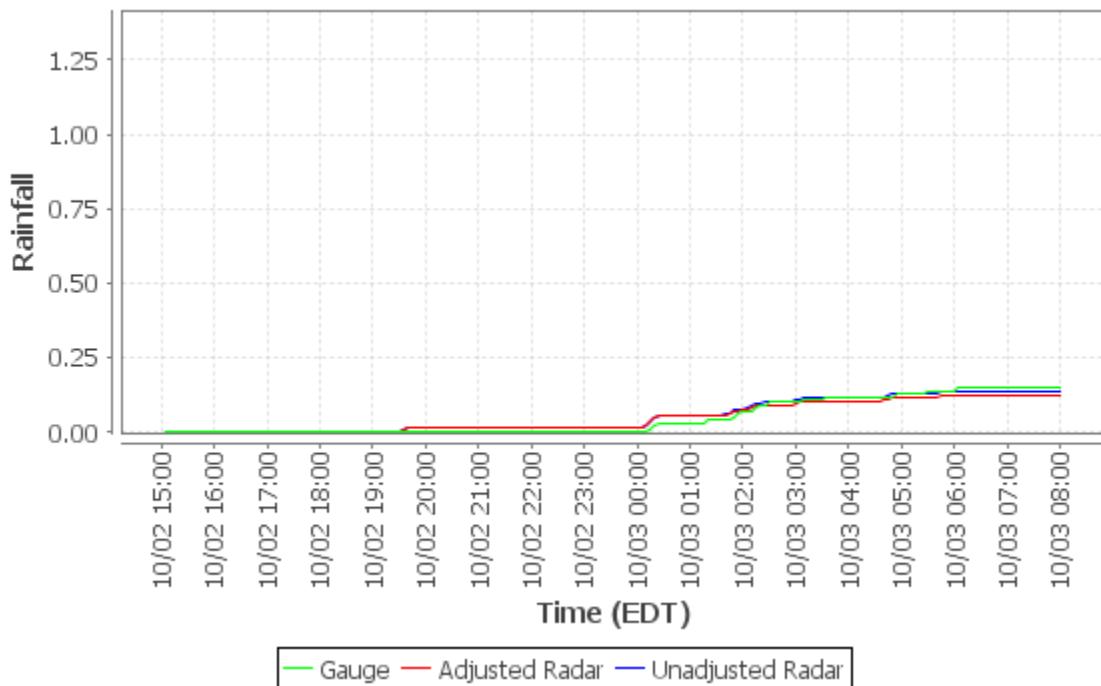
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



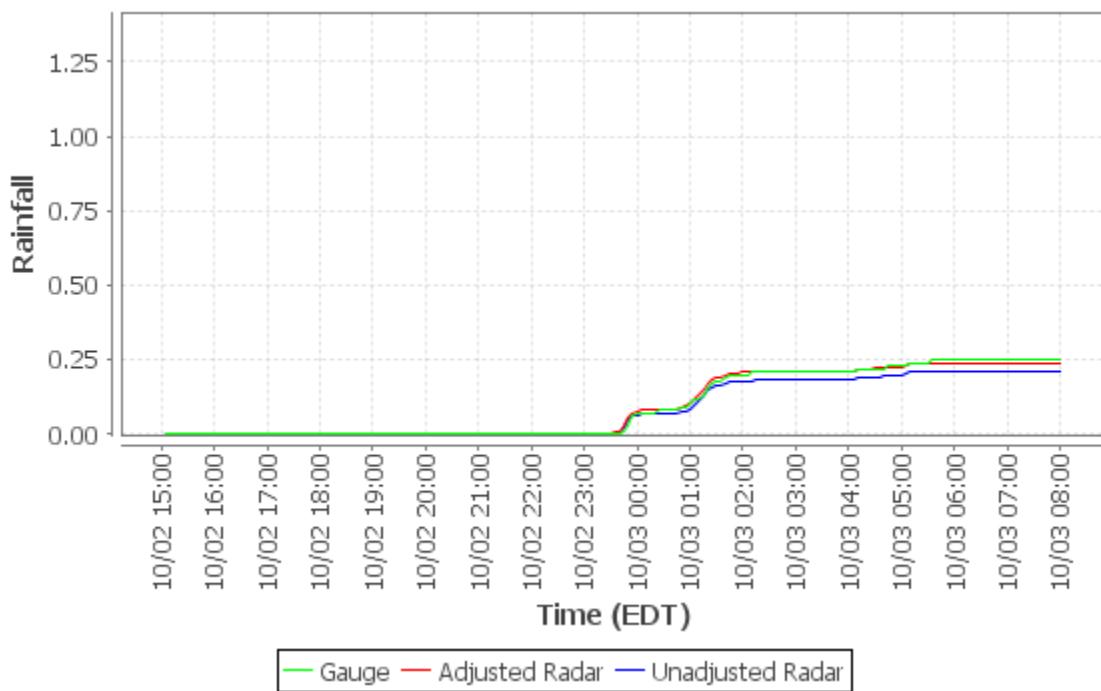
Cumulative Distribution Plot - Marshall TWP (Loc27)



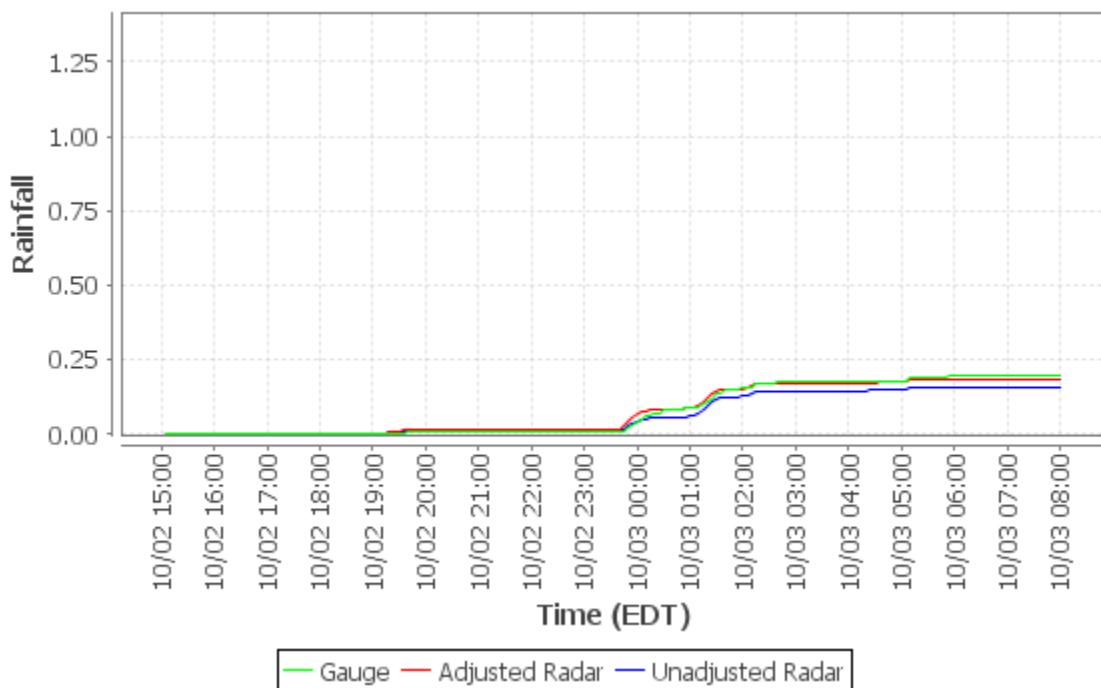
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



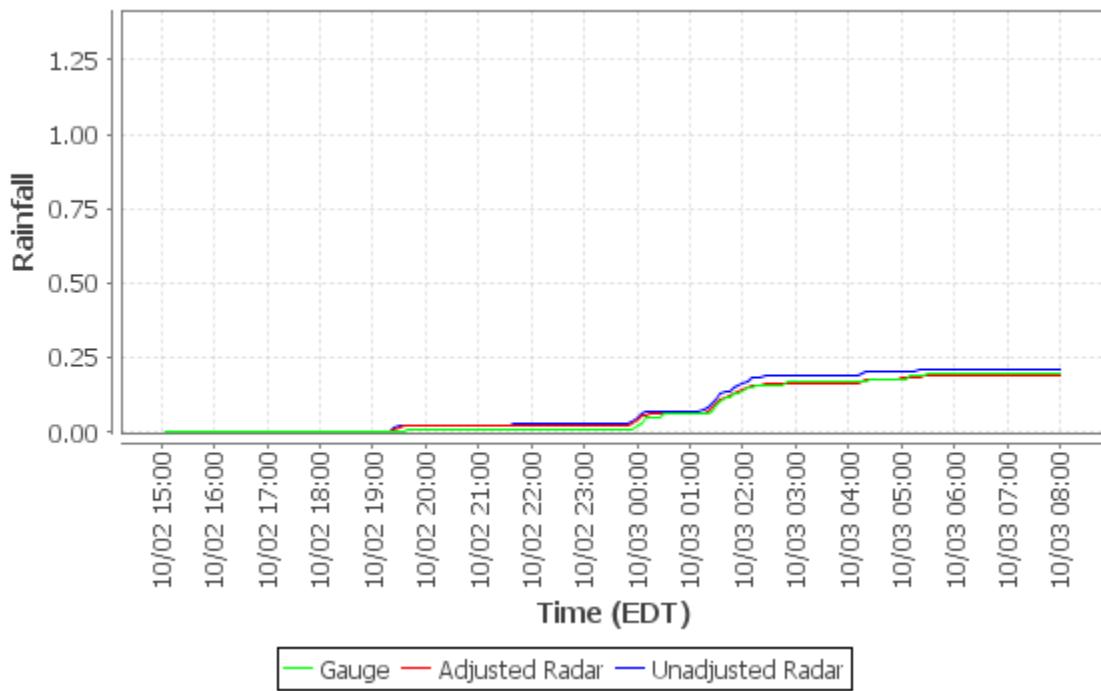
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



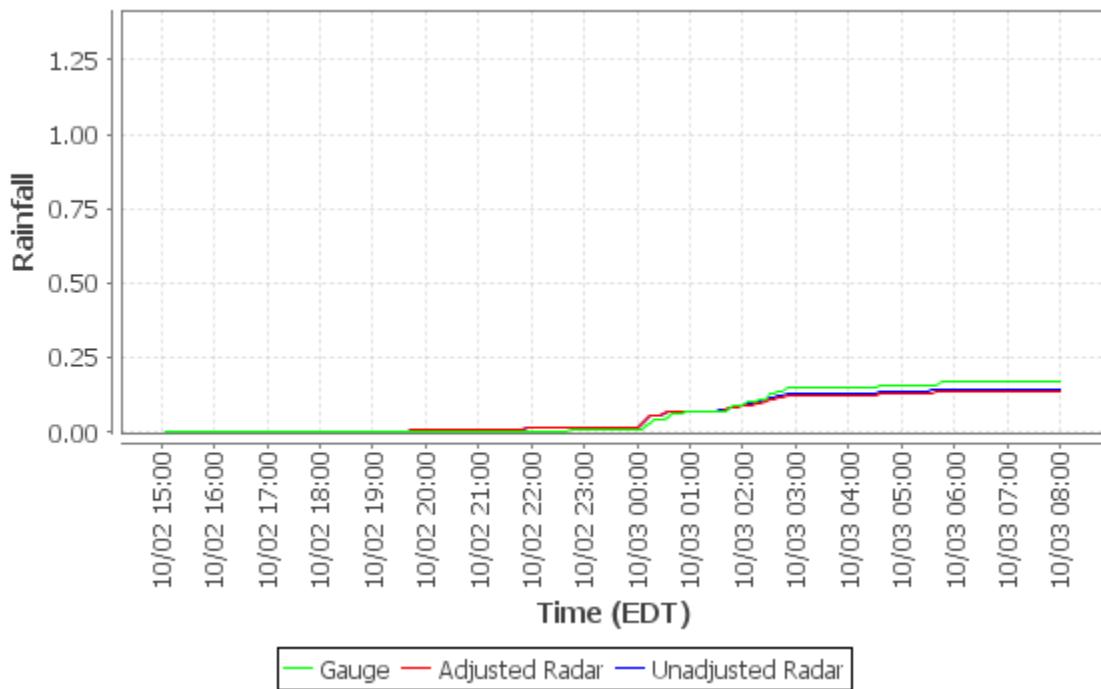
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



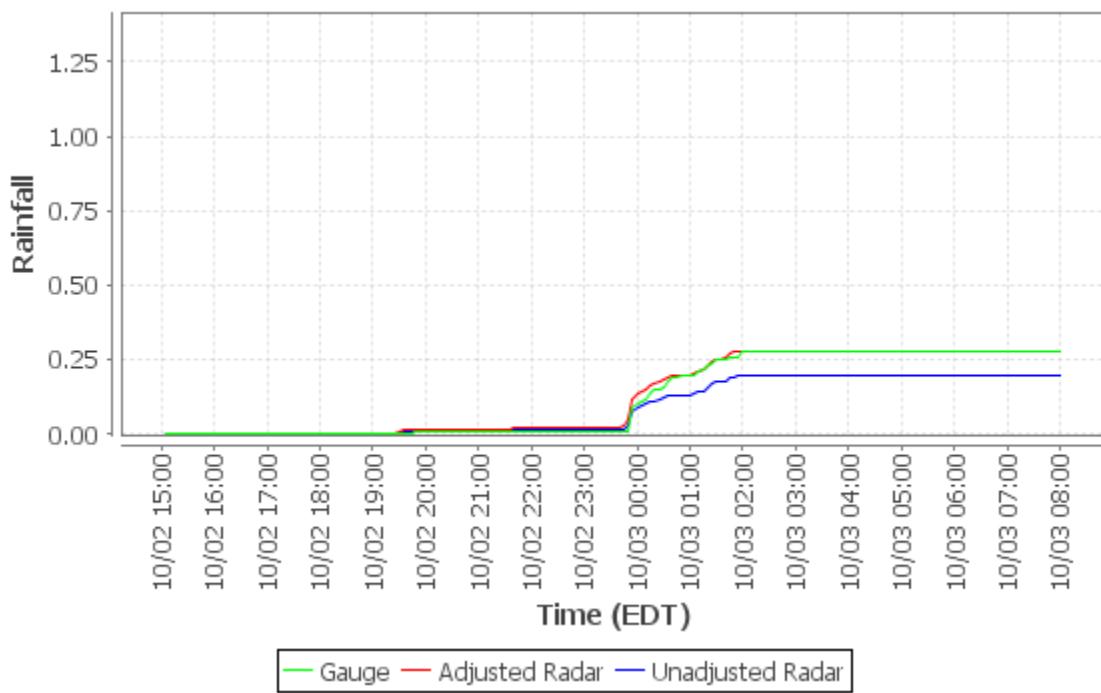
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



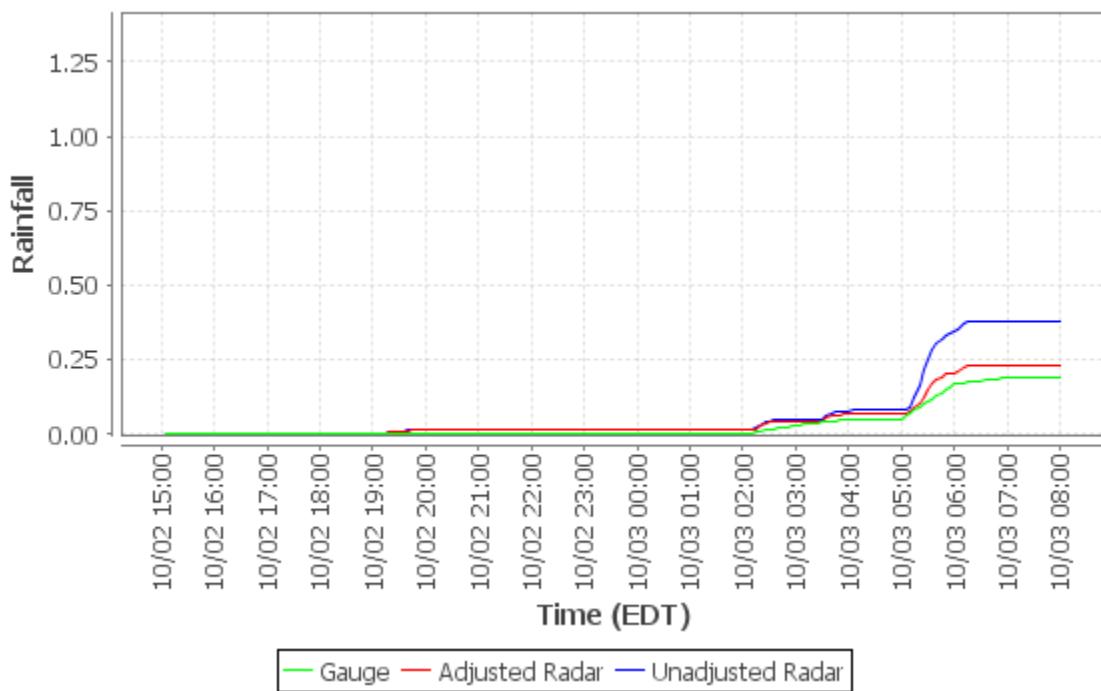
Cumulative Distribution Plot - Arnold (Loc32)



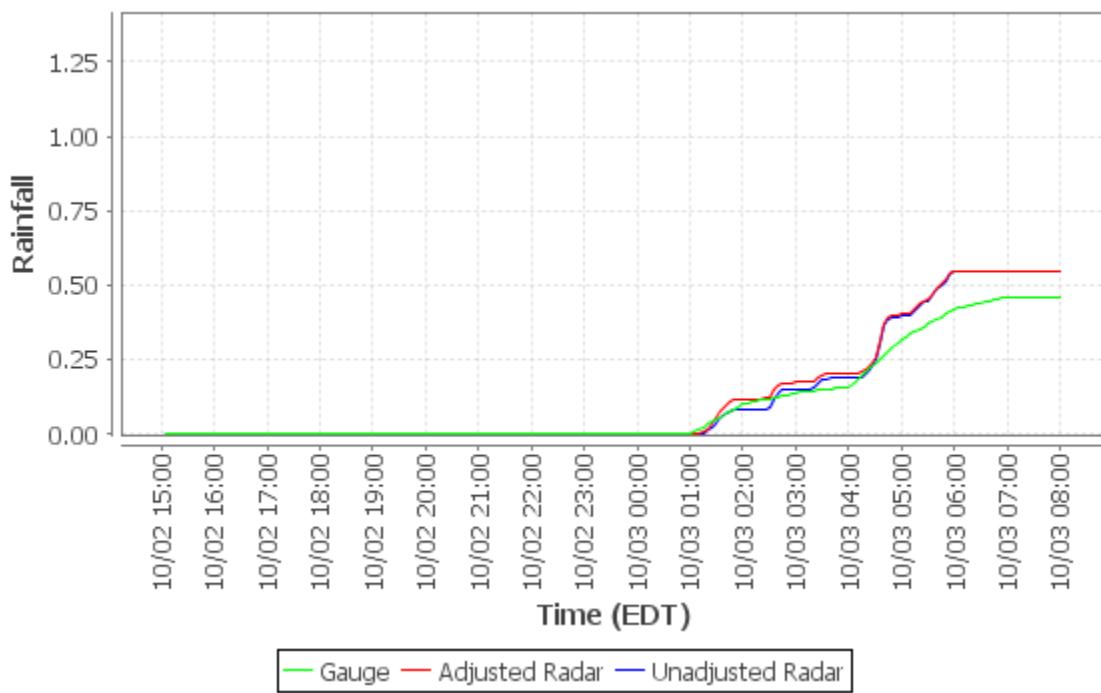
Cumulative Distribution Plot - Richland TWP (Loc33)



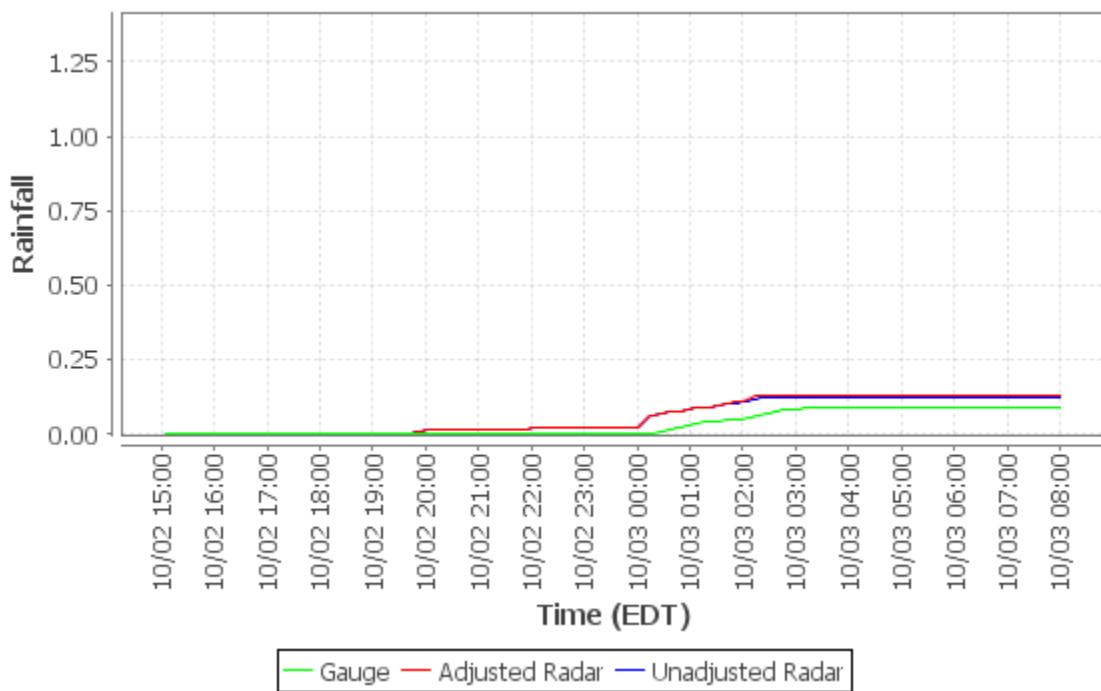
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



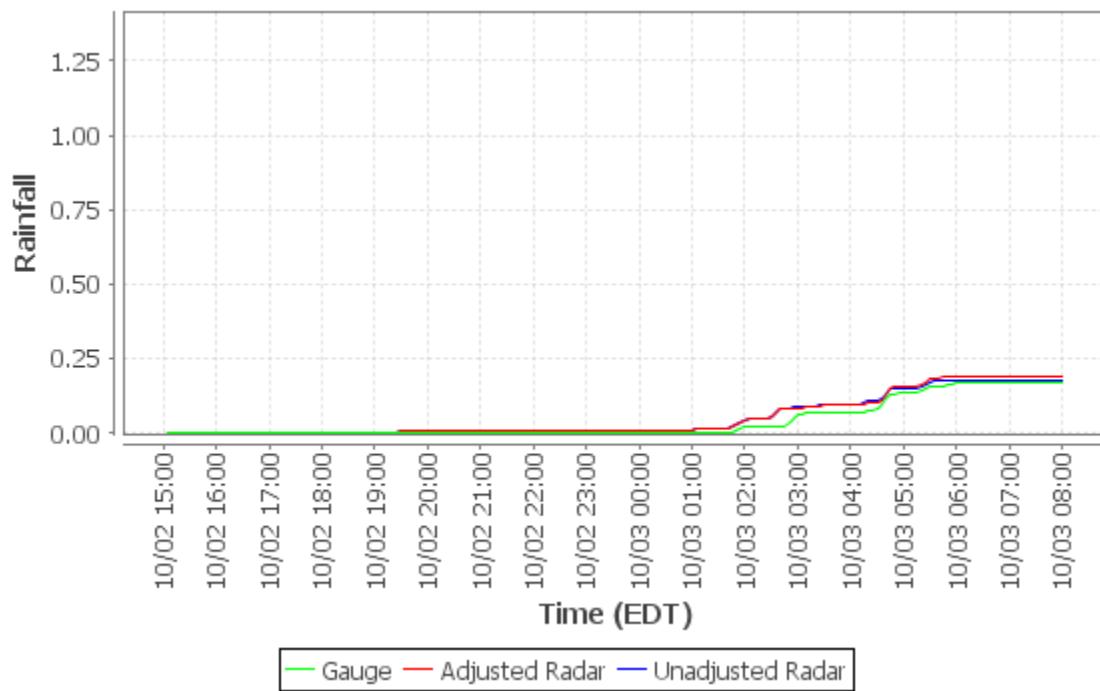
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

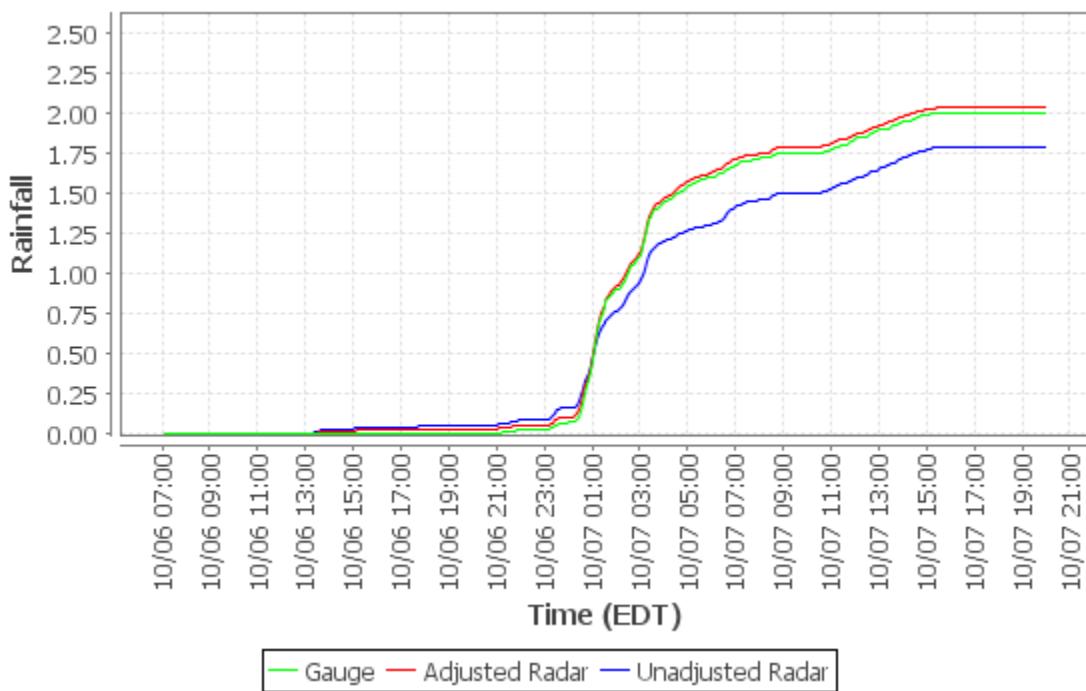


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

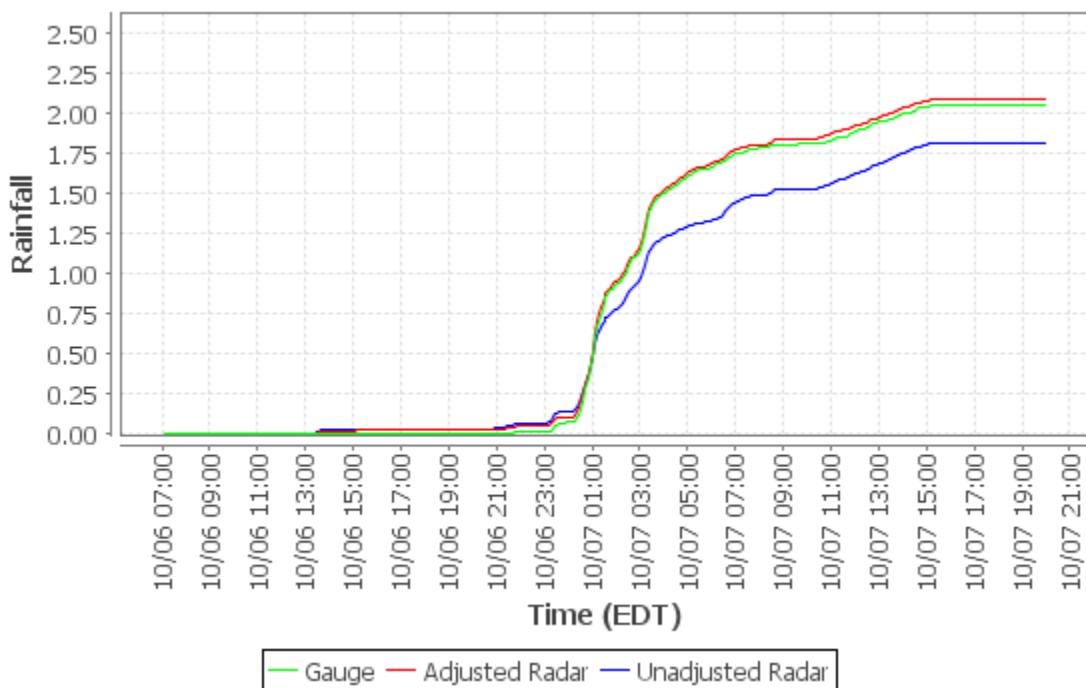


Appendix D - Event 2 (2019-10-07) CDPs

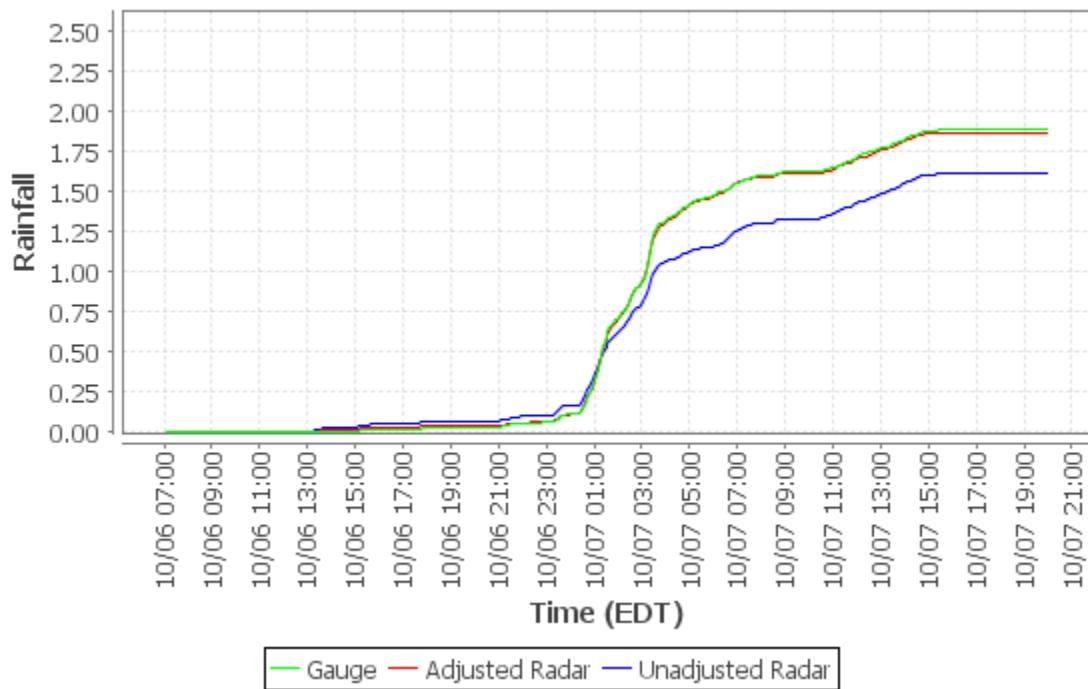
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



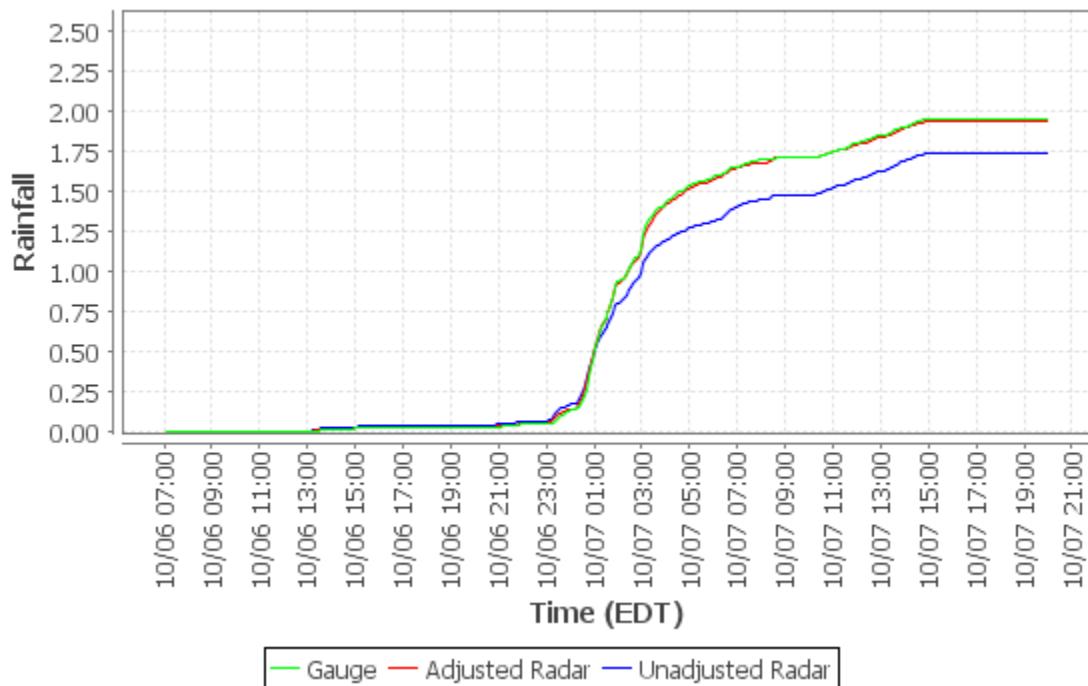
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



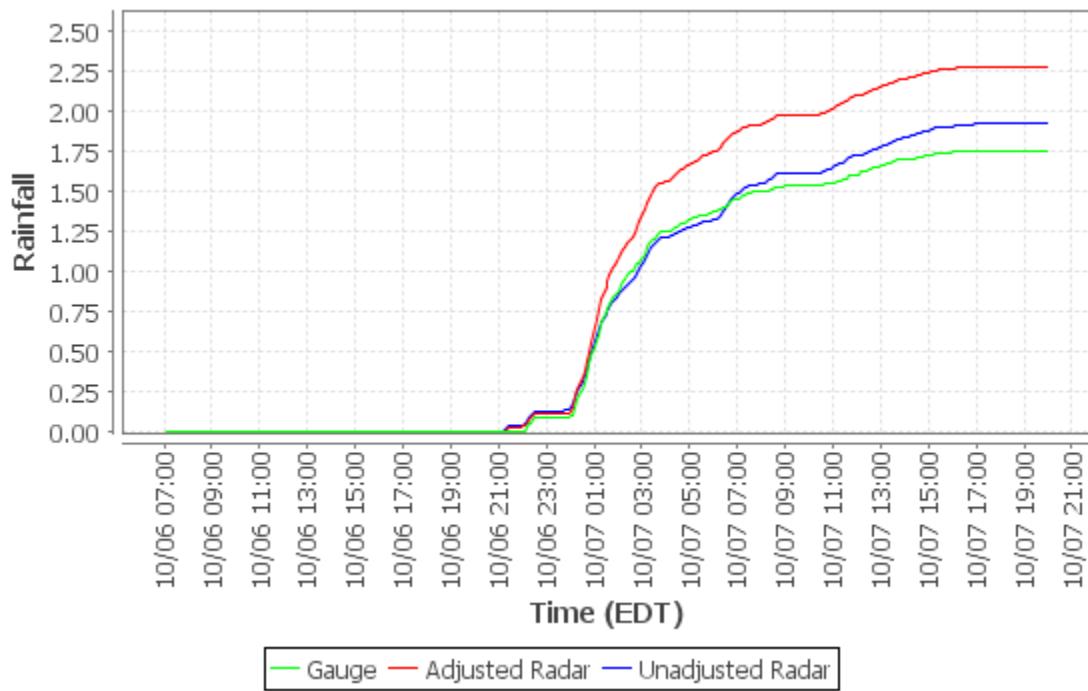
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



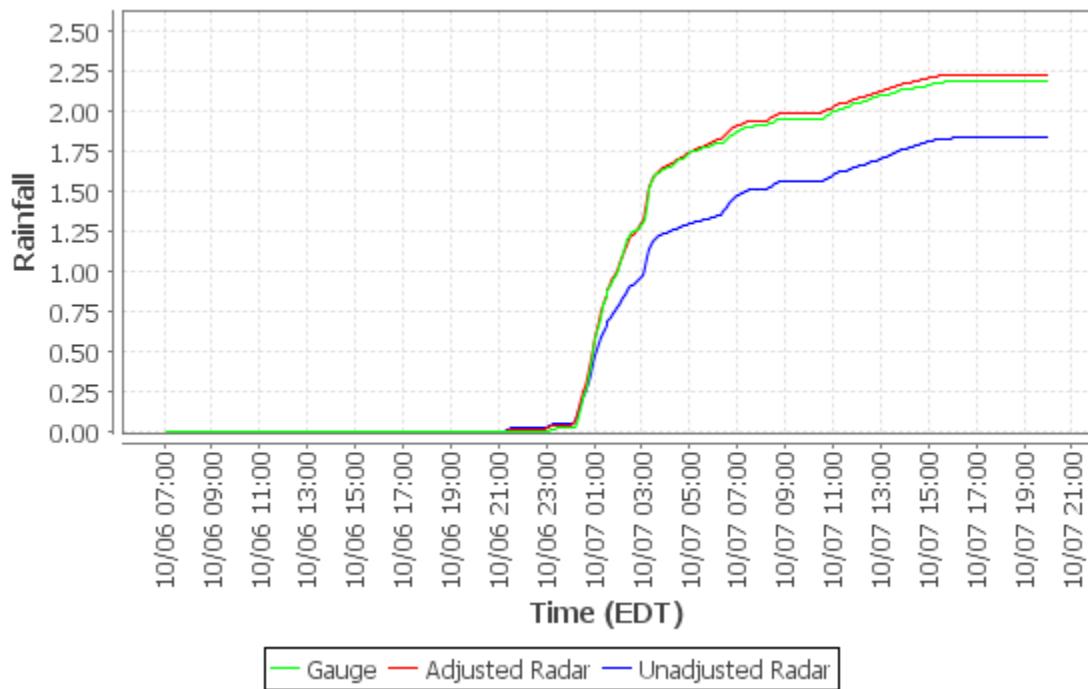
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



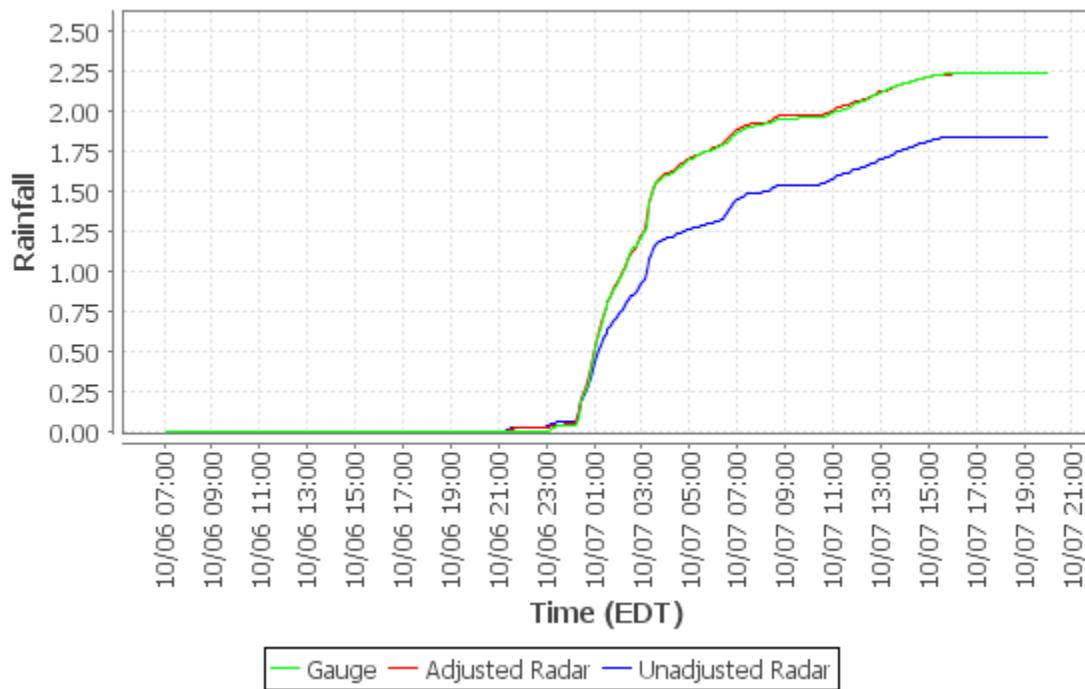
Cumulative Distribution Plot - Upper St. Clair (Loc05)



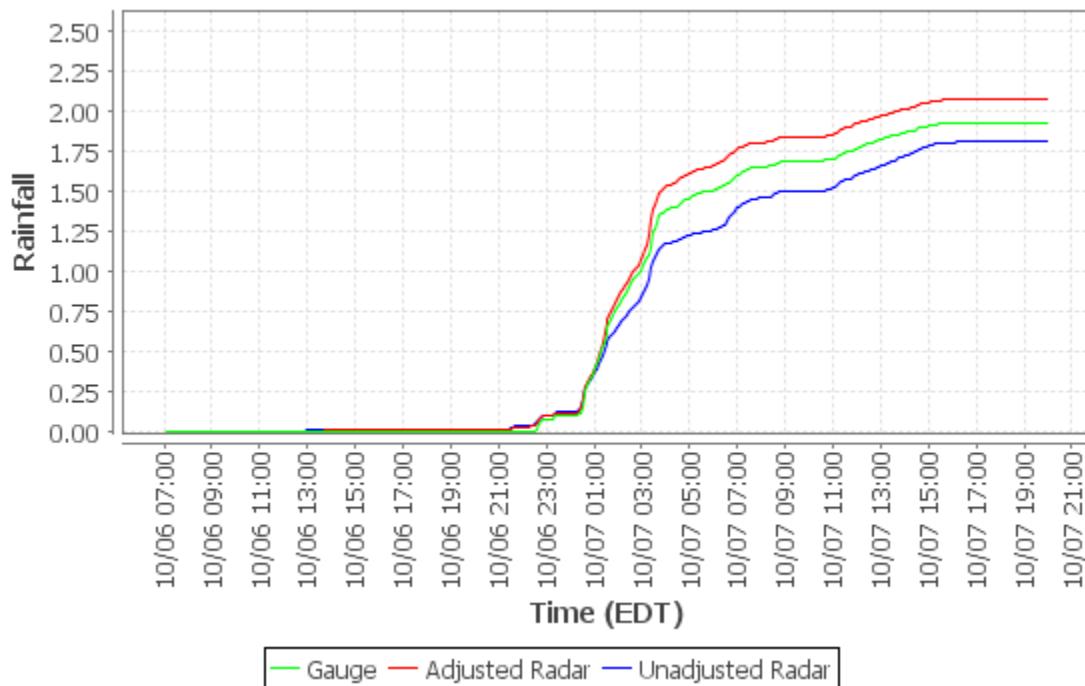
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



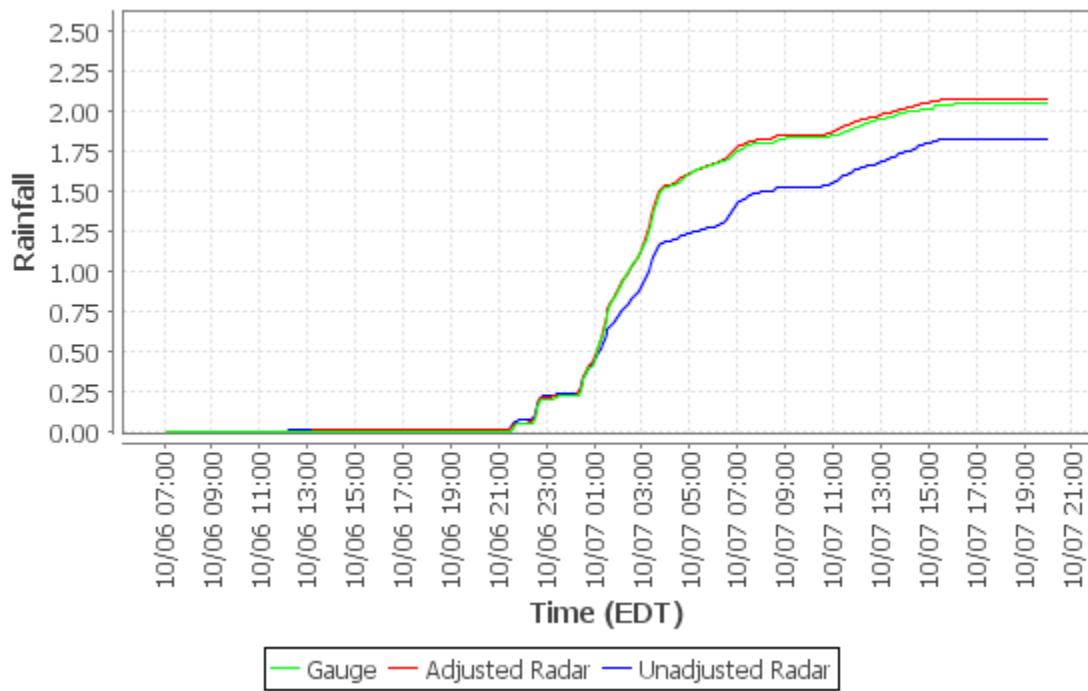
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



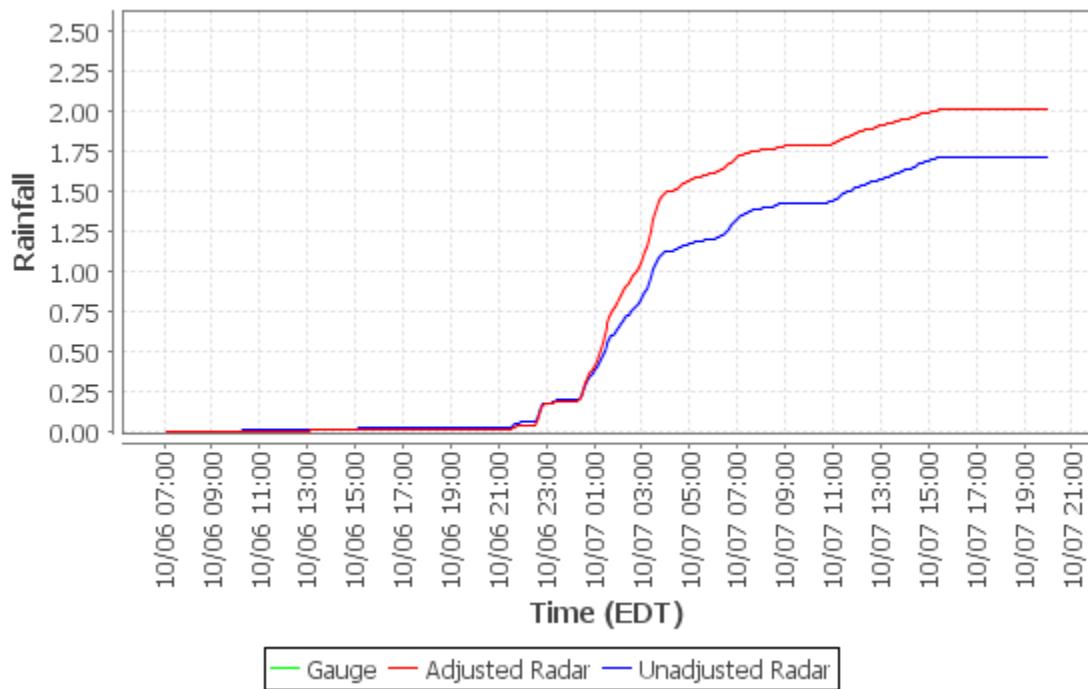
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



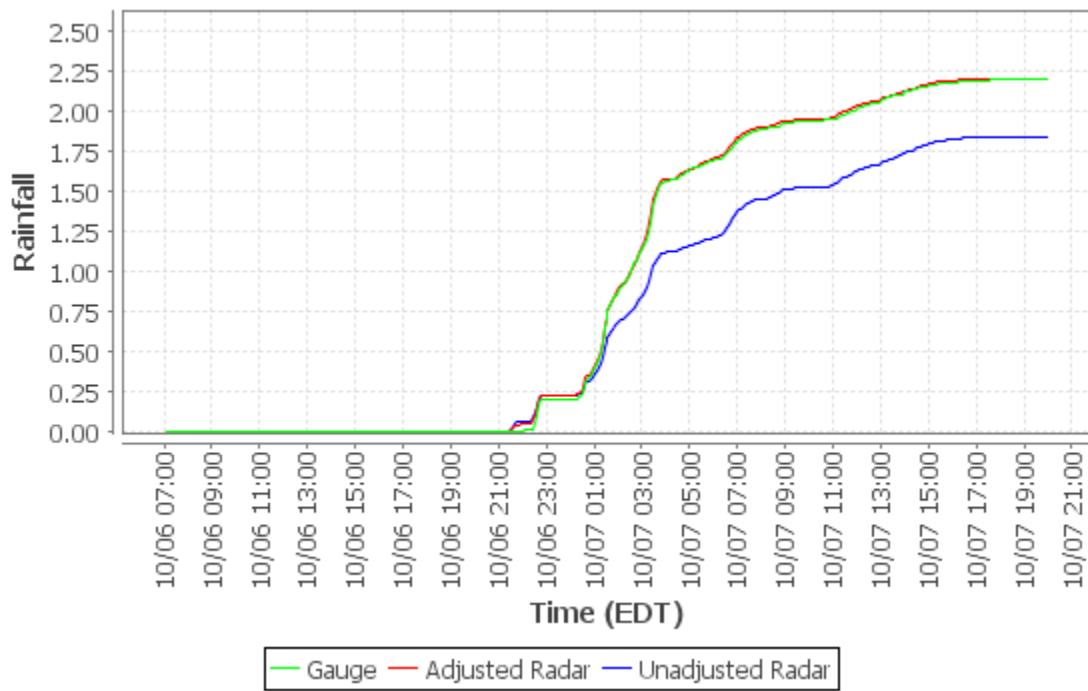
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



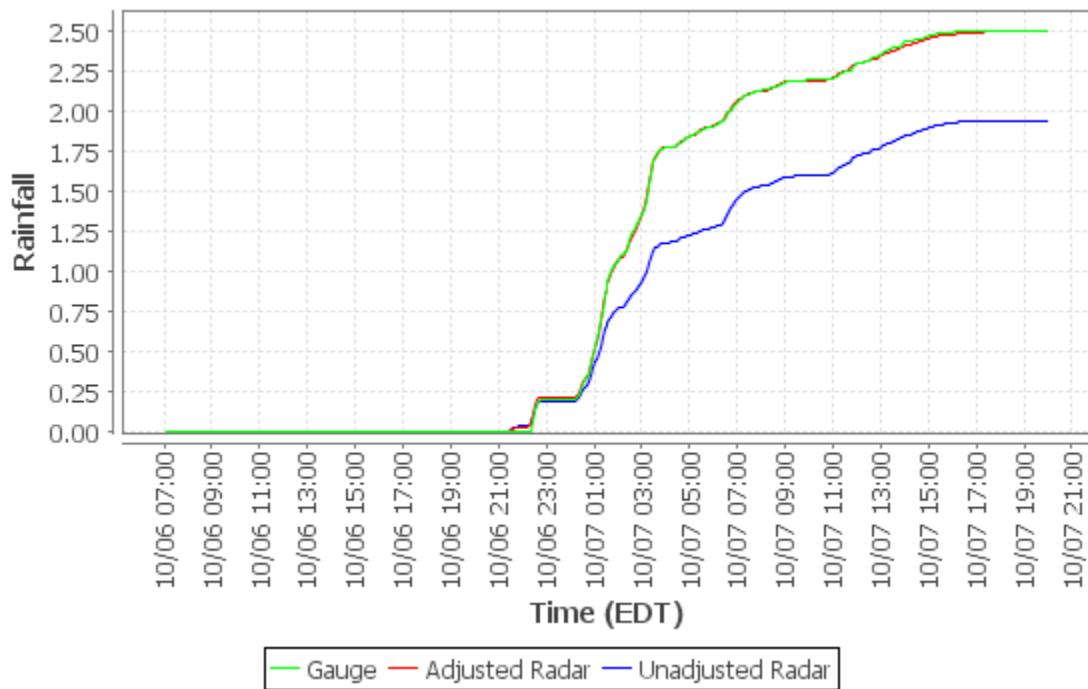
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



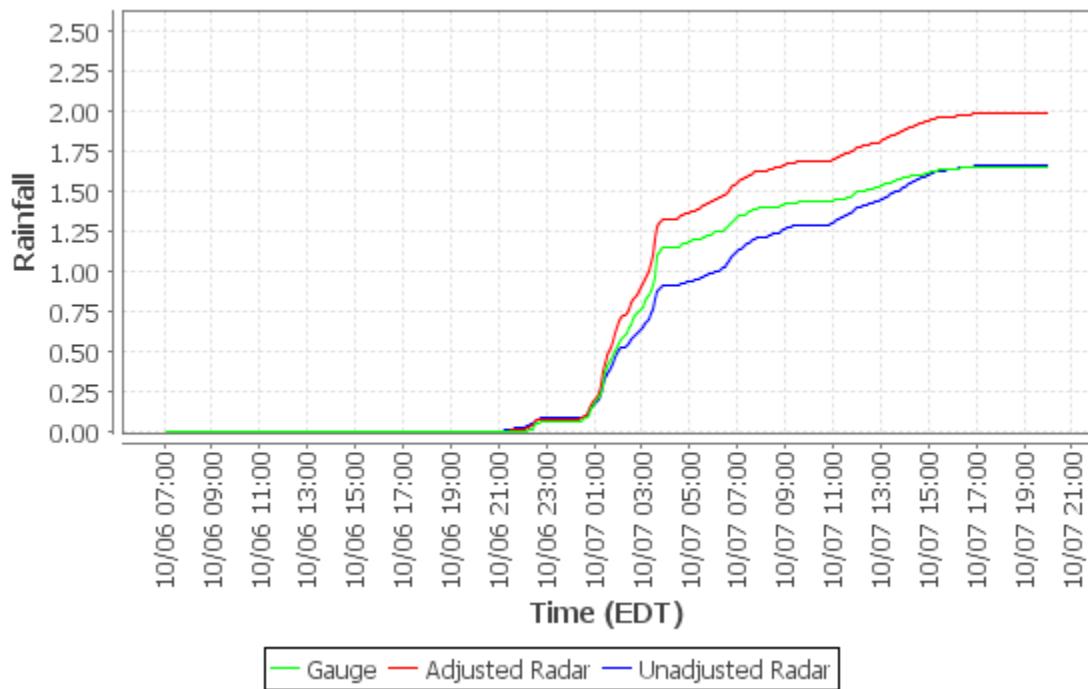
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



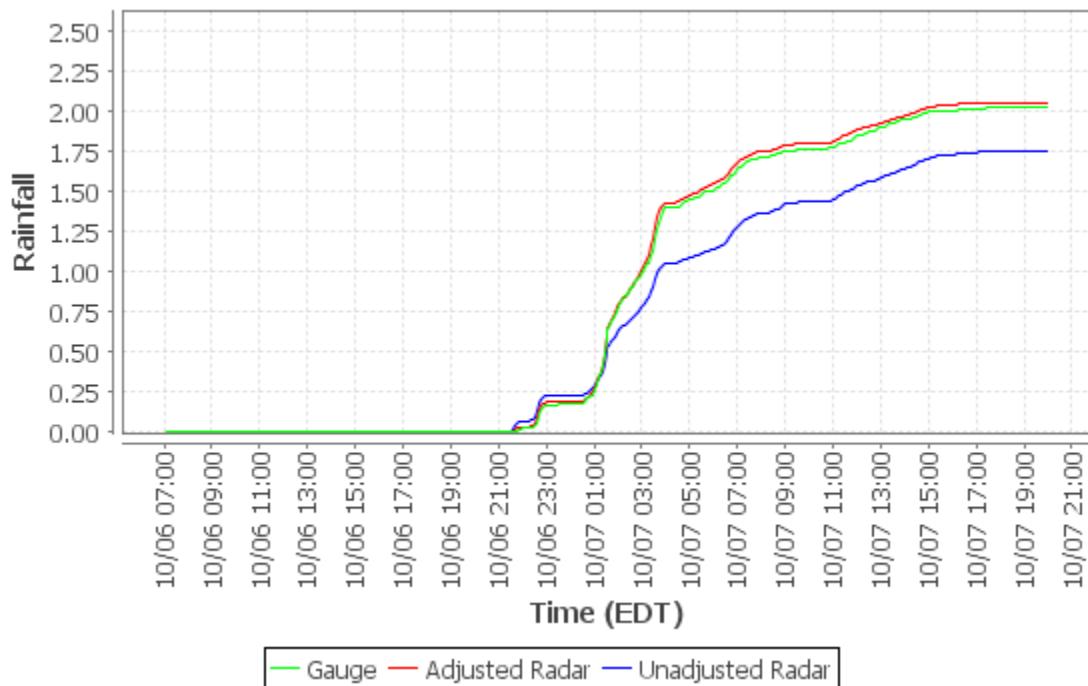
Cumulative Distribution Plot - Baldwin (Loc12)



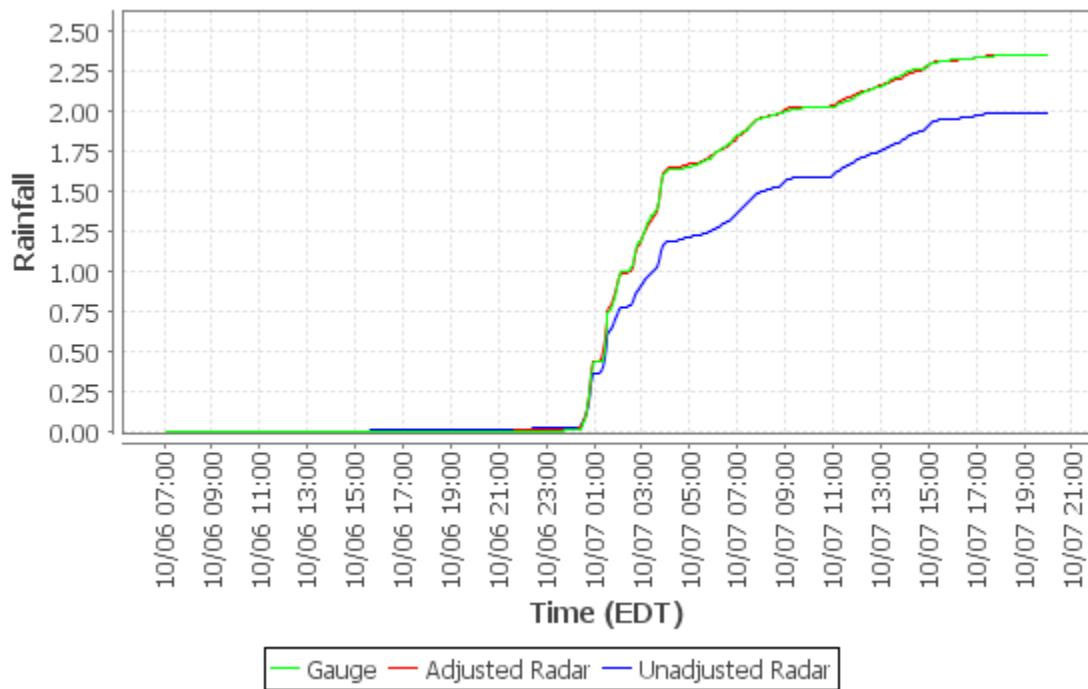
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



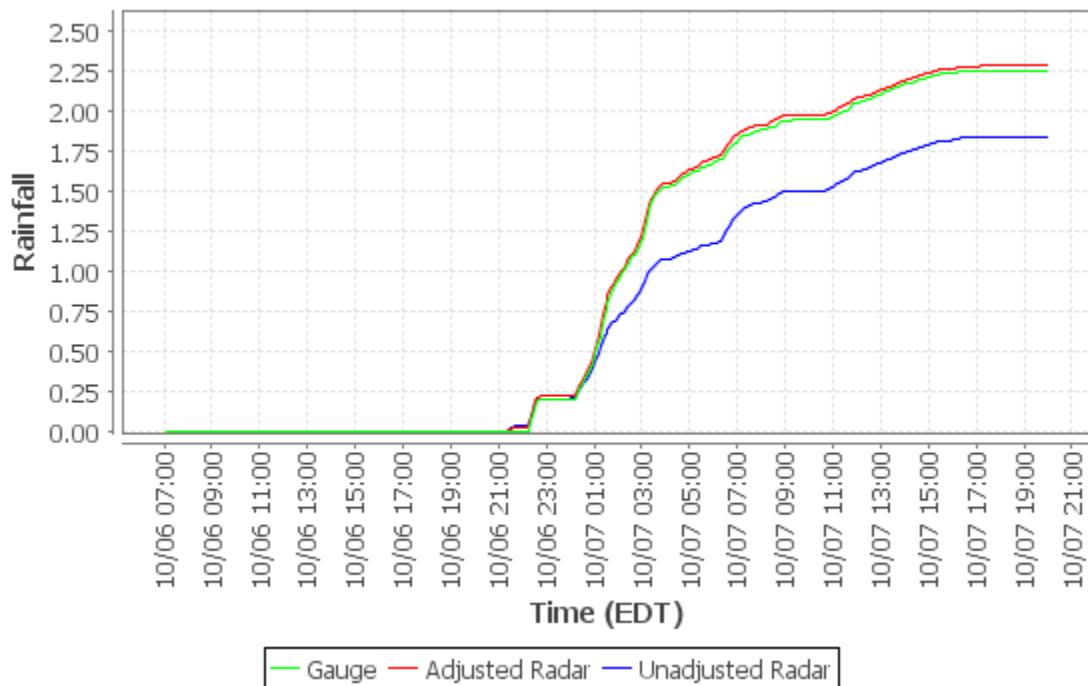
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



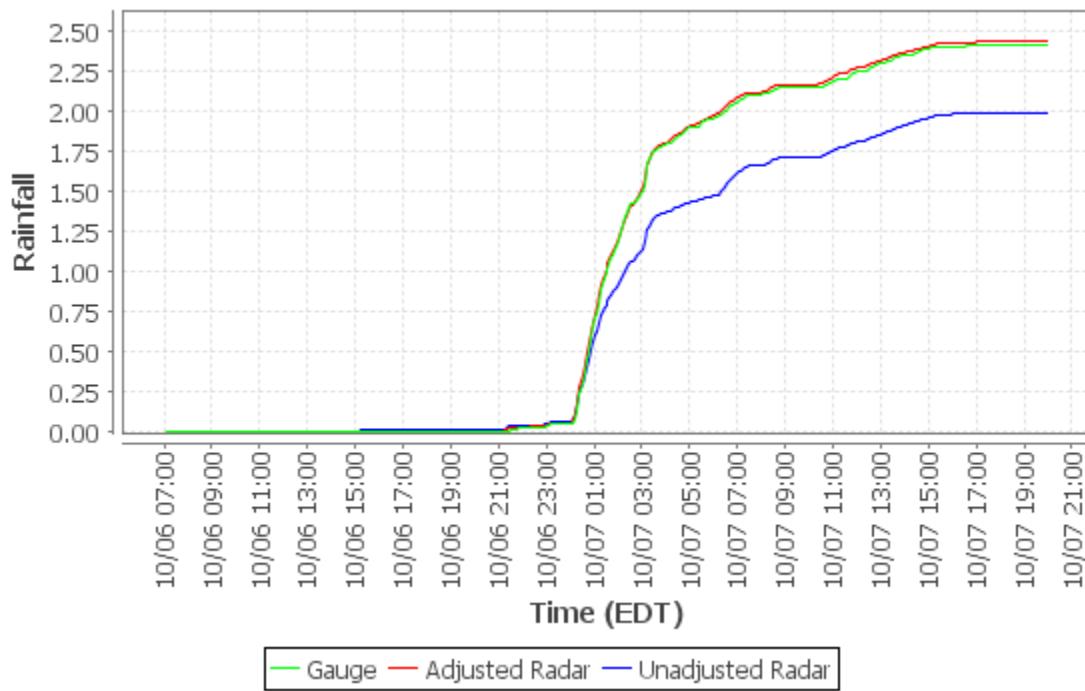
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



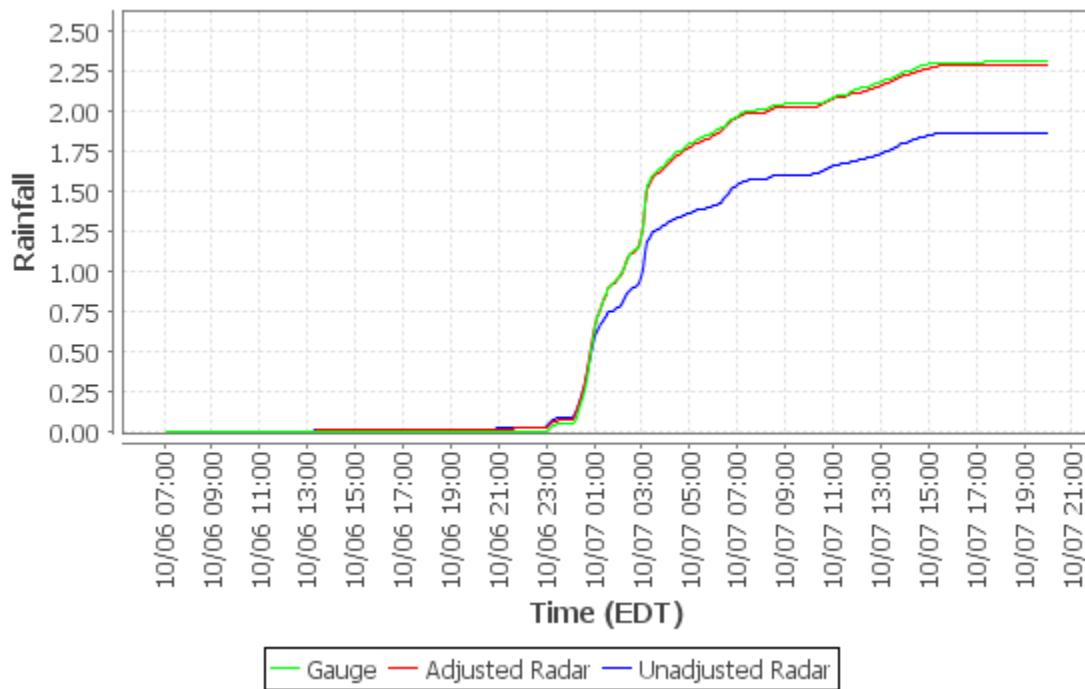
Cumulative Distribution Plot - Castle Shannon (Loc16)



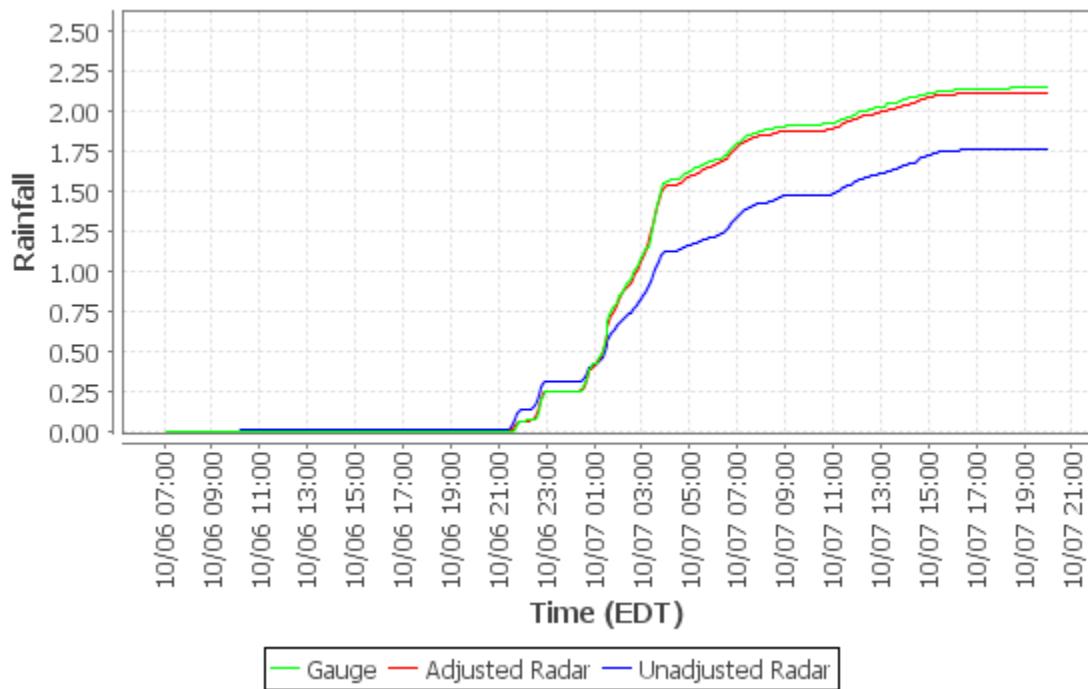
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



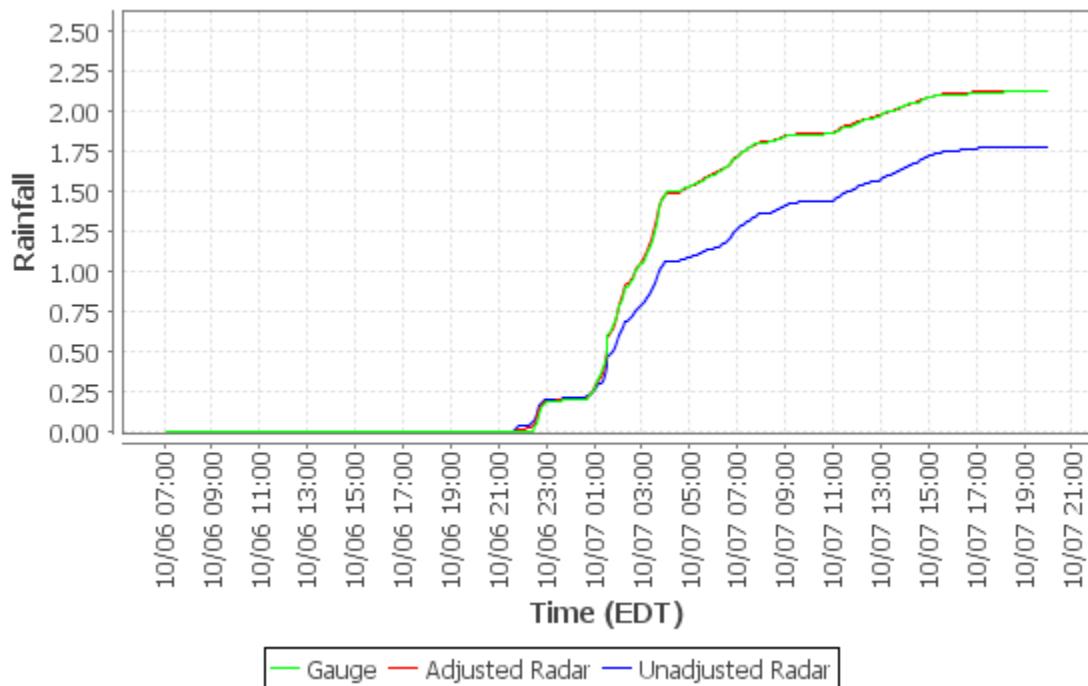
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



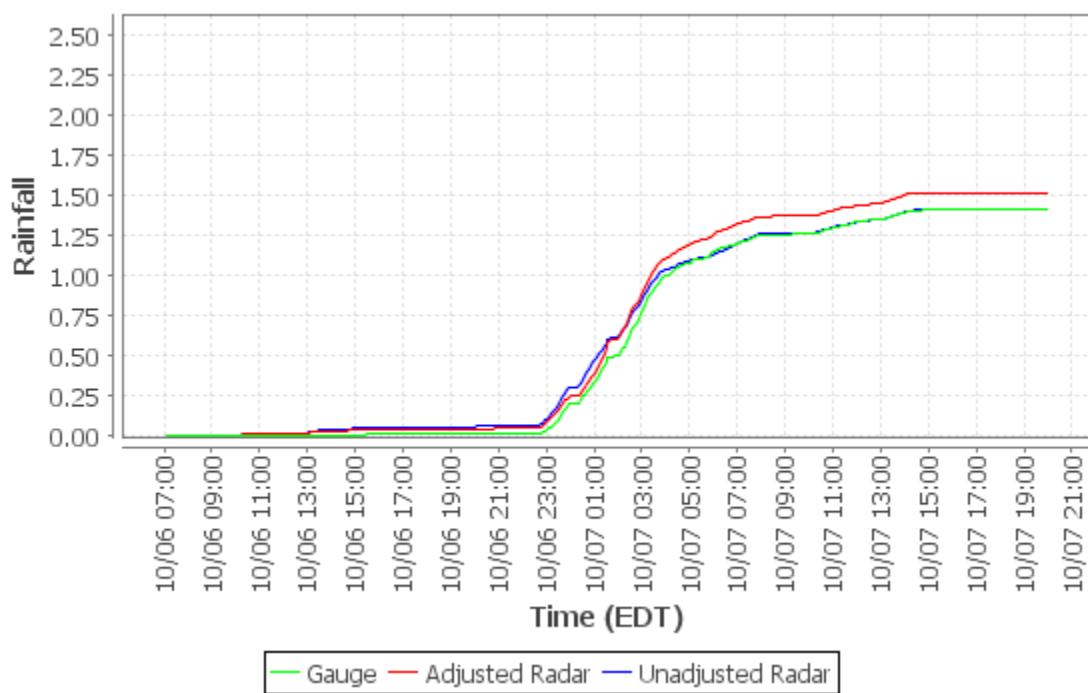
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



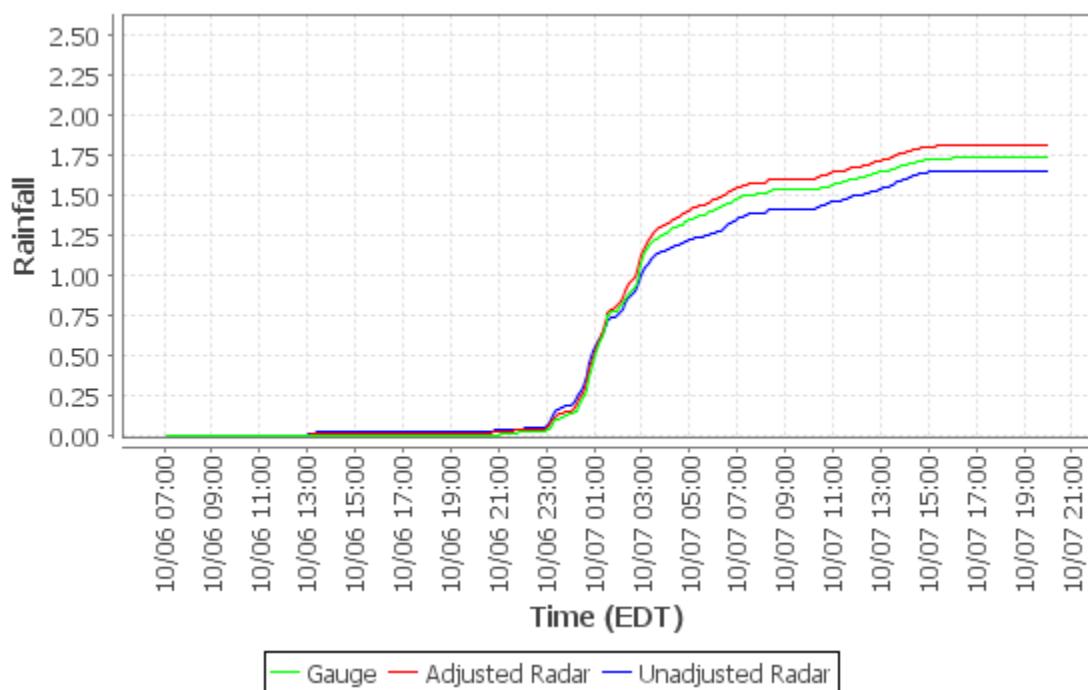
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



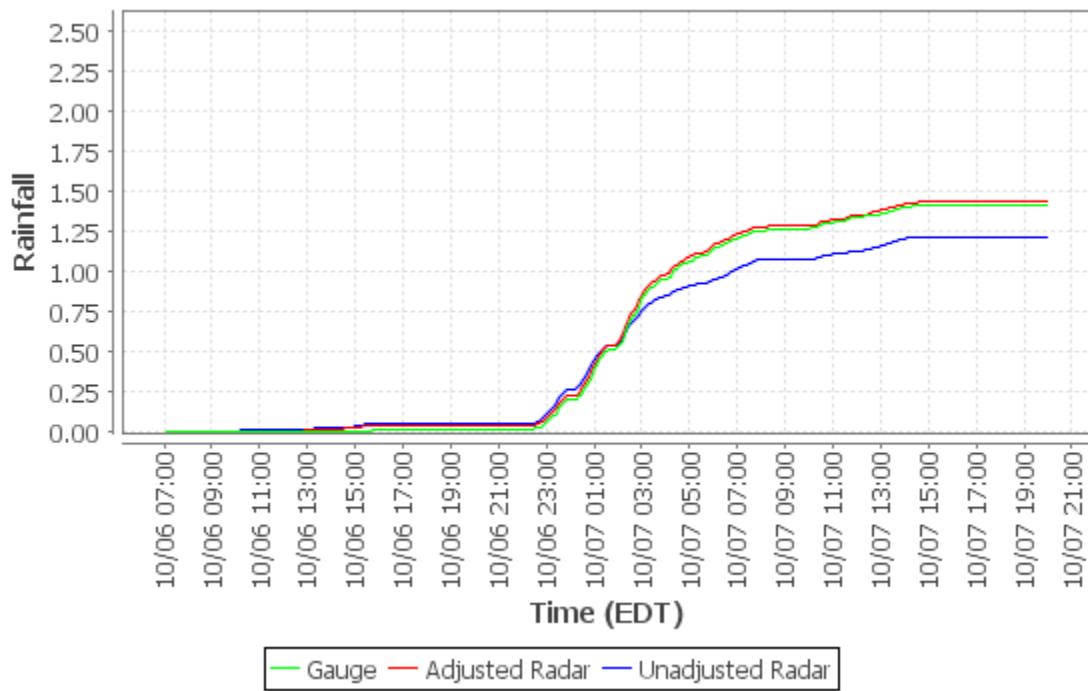
Cumulative Distribution Plot - Moon TWP (Loc21)



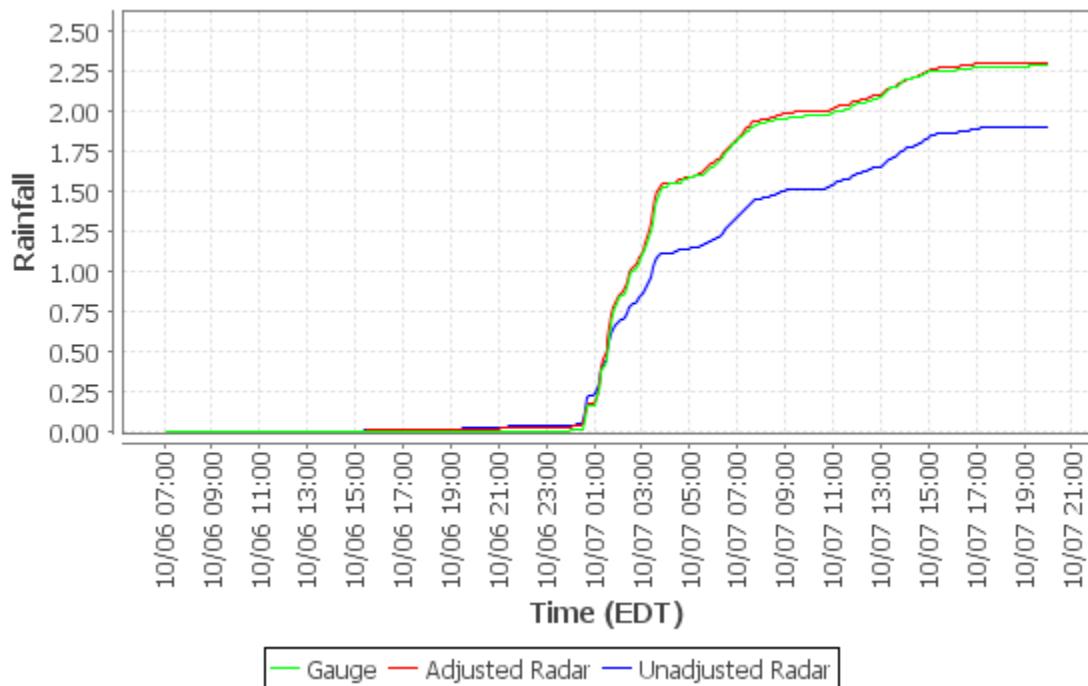
Cumulative Distribution Plot - North Fayette TWP (Loc22)



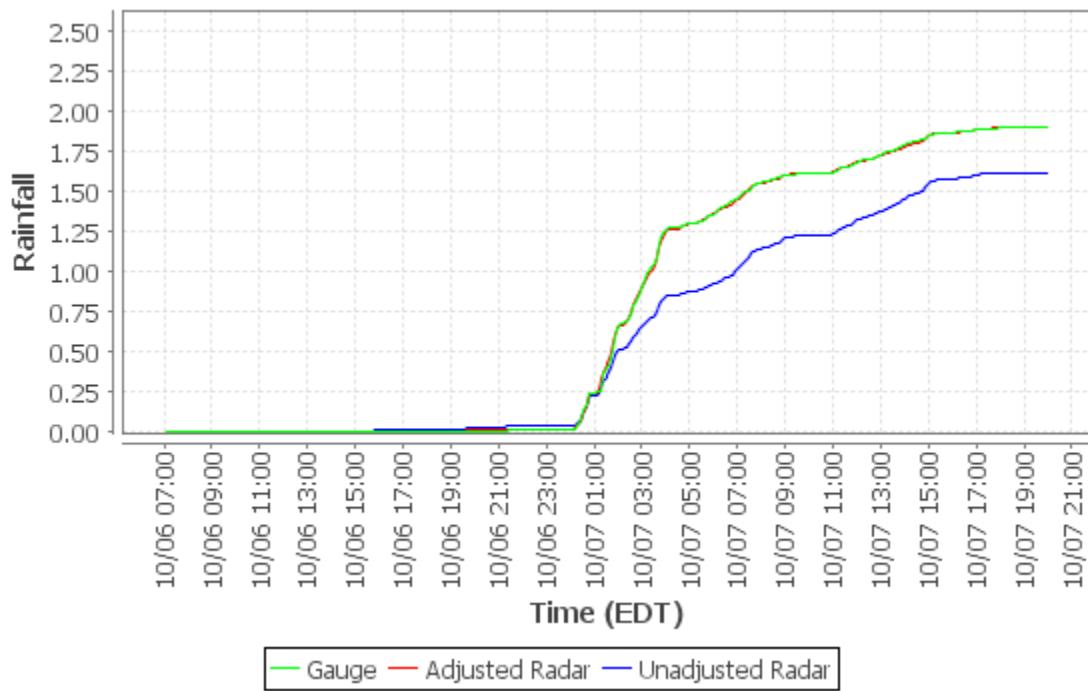
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



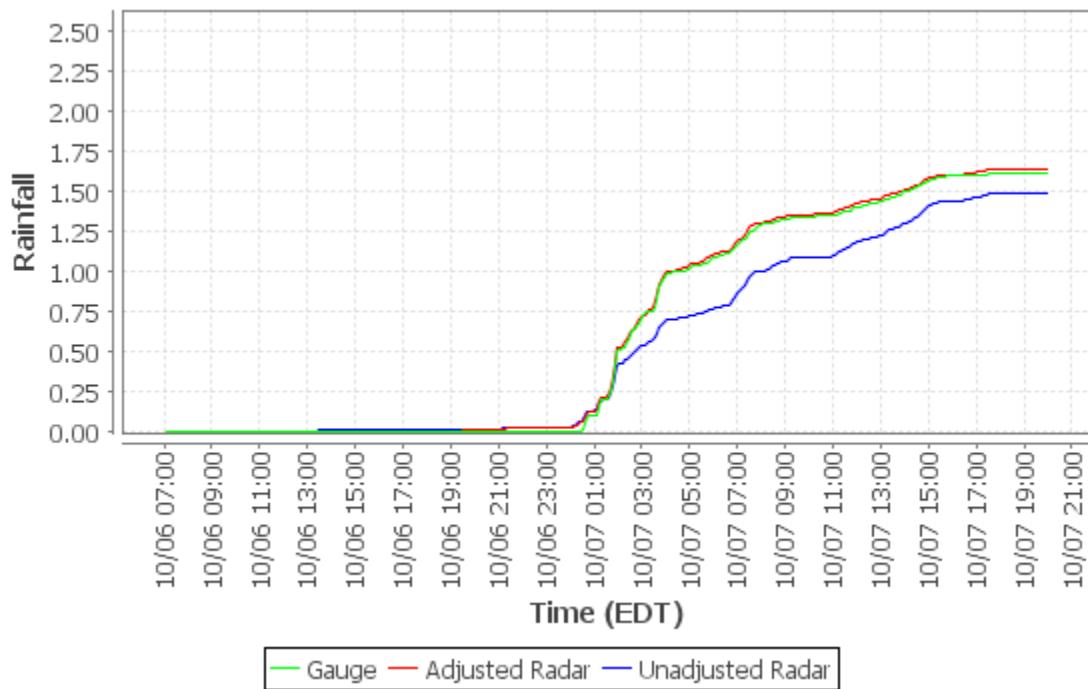
Cumulative Distribution Plot - Jefferson Hills (Loc24)



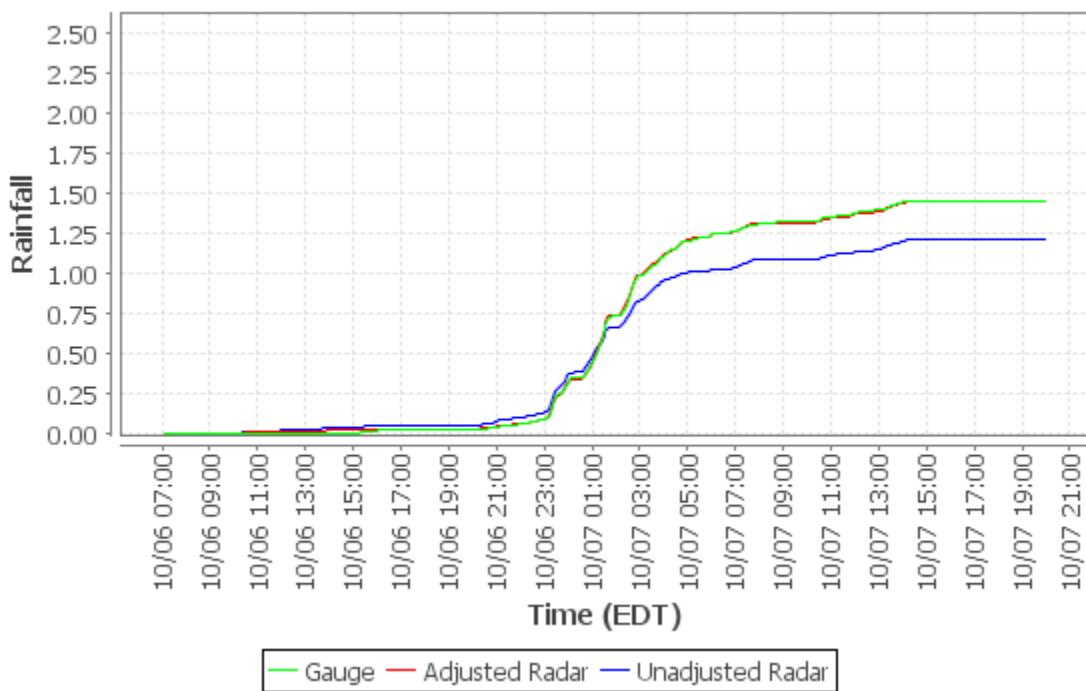
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



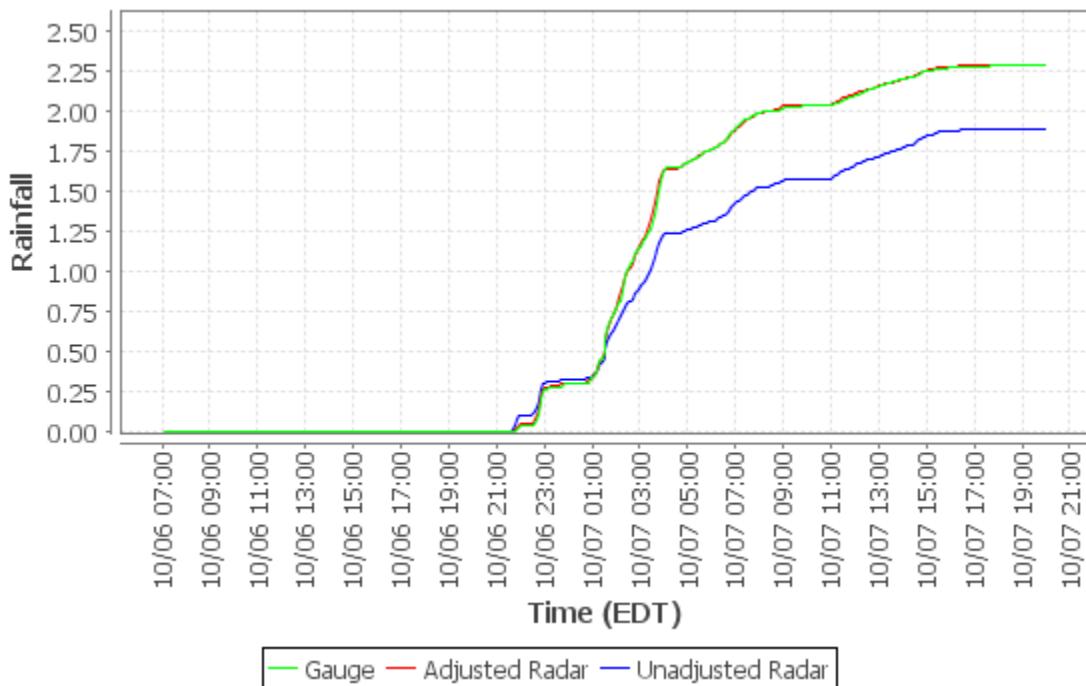
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



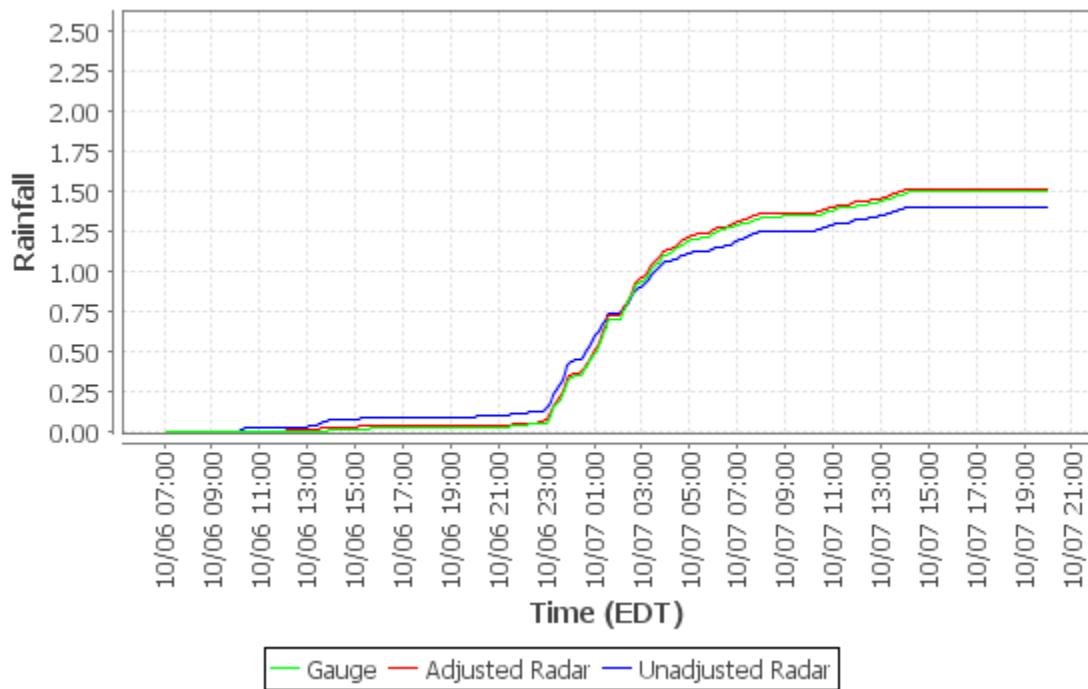
Cumulative Distribution Plot - Marshall TWP (Loc27)



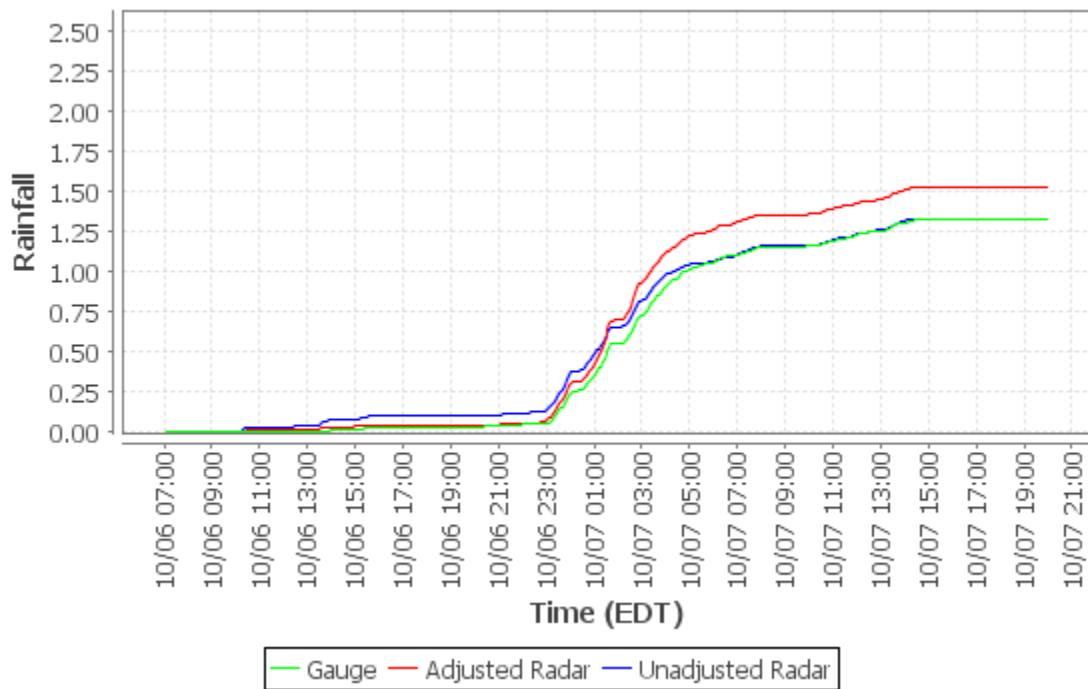
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



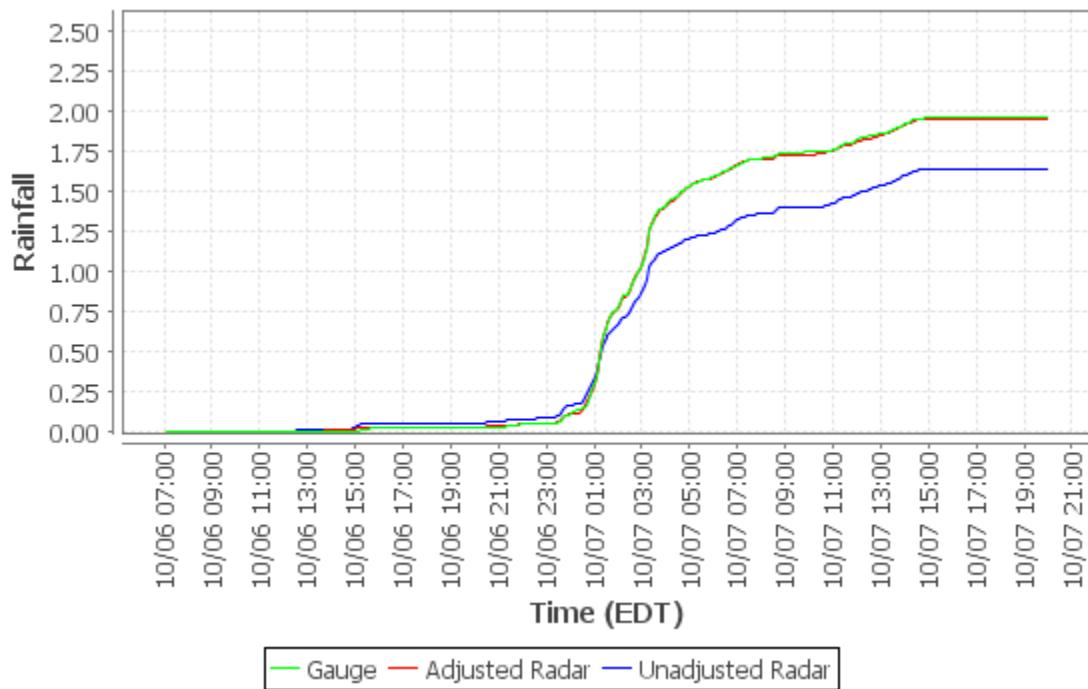
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



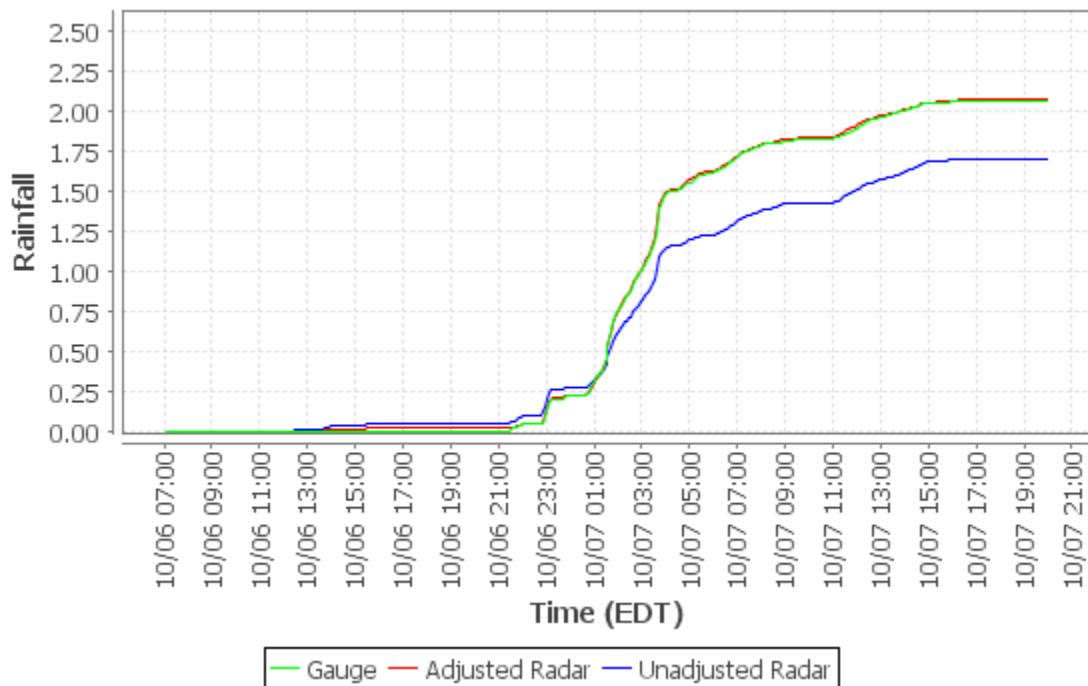
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



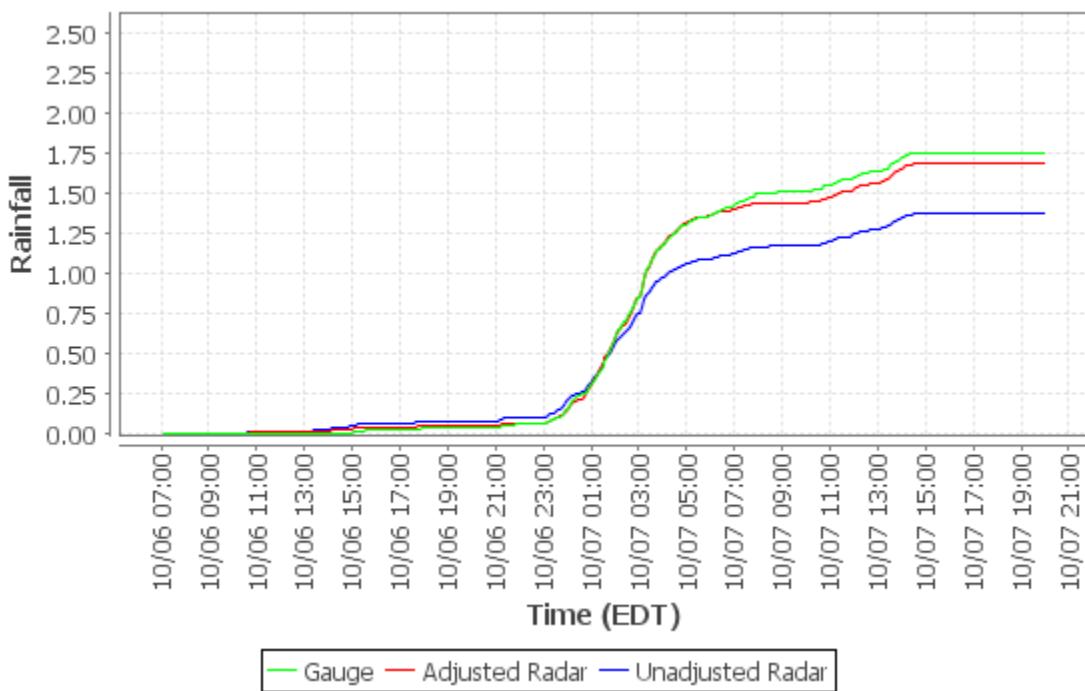
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



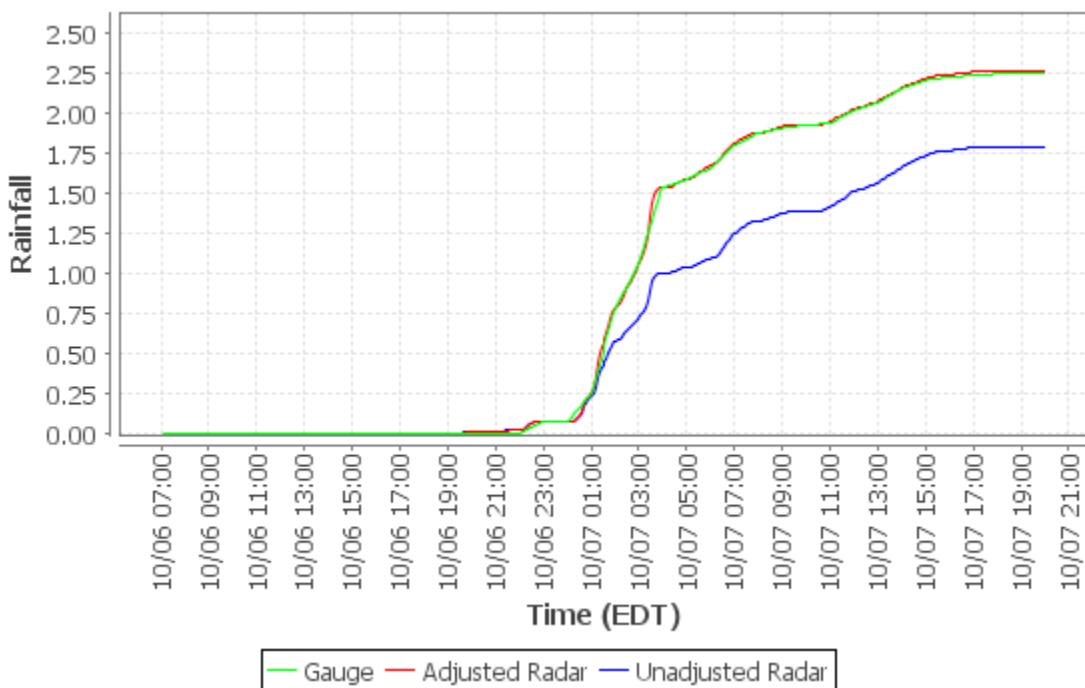
Cumulative Distribution Plot - Arnold (Loc32)



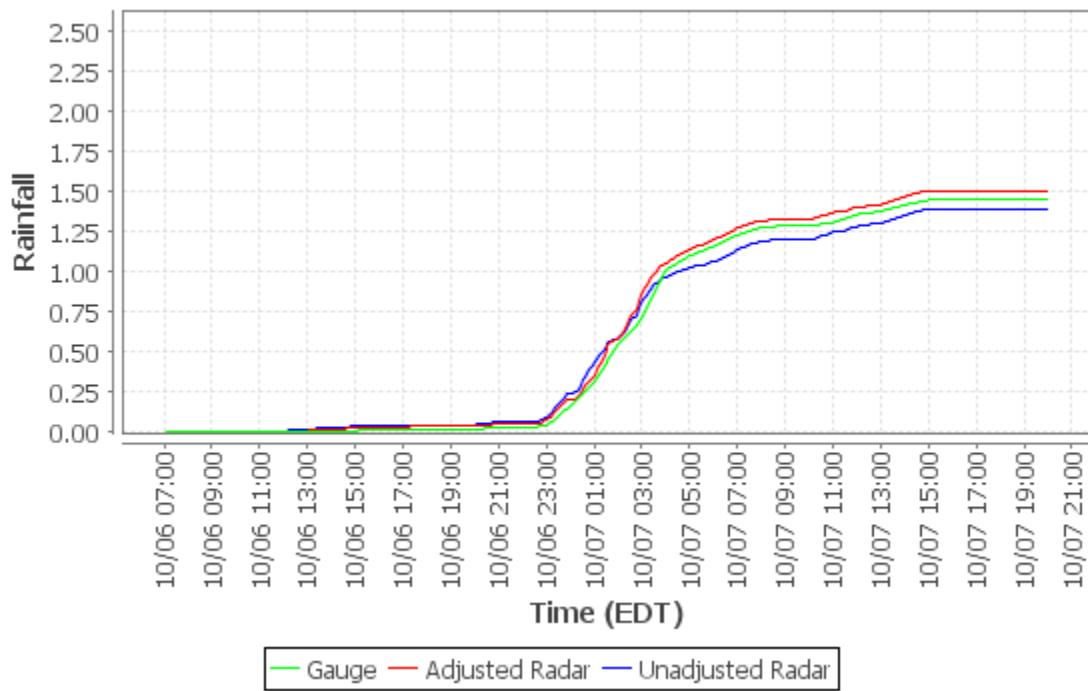
Cumulative Distribution Plot - Richland TWP (Loc33)



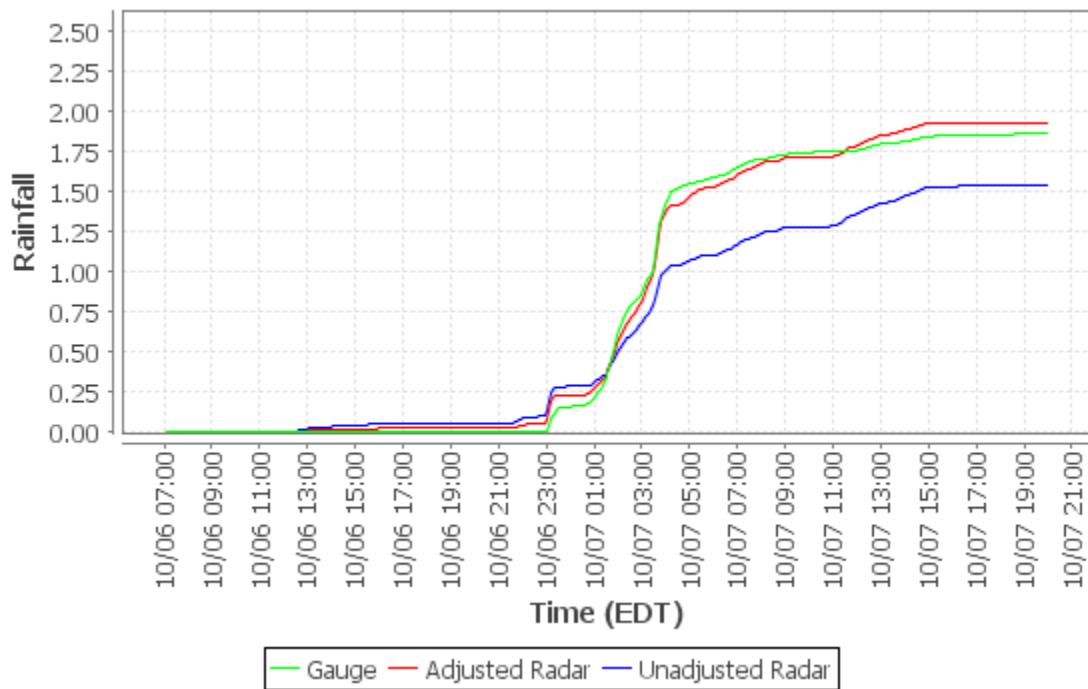
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



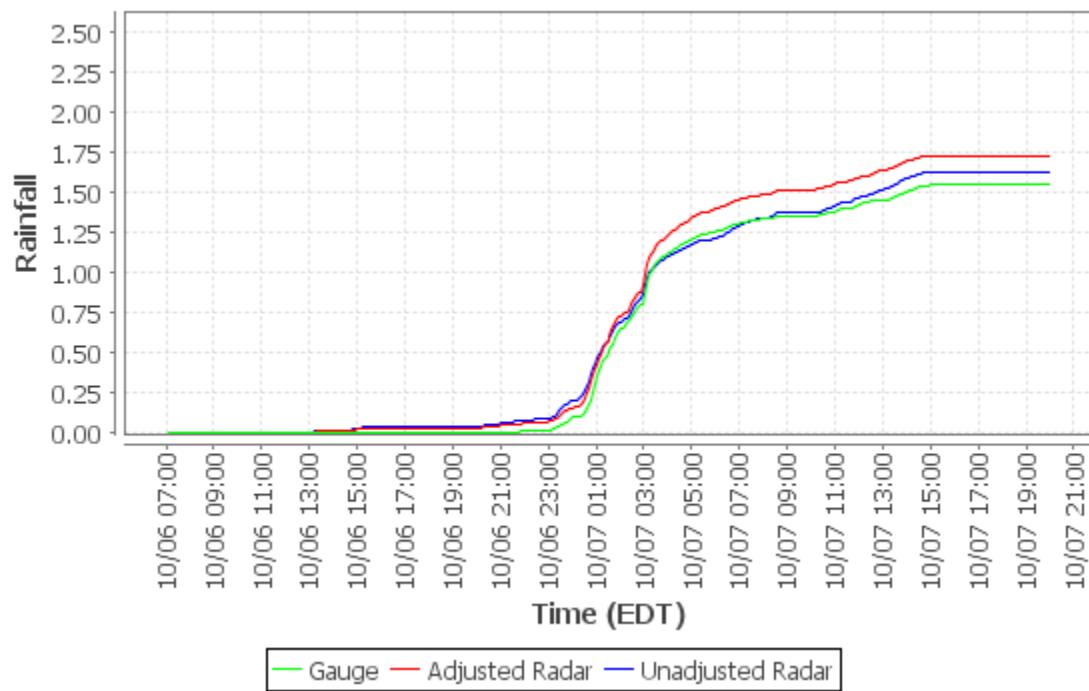
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

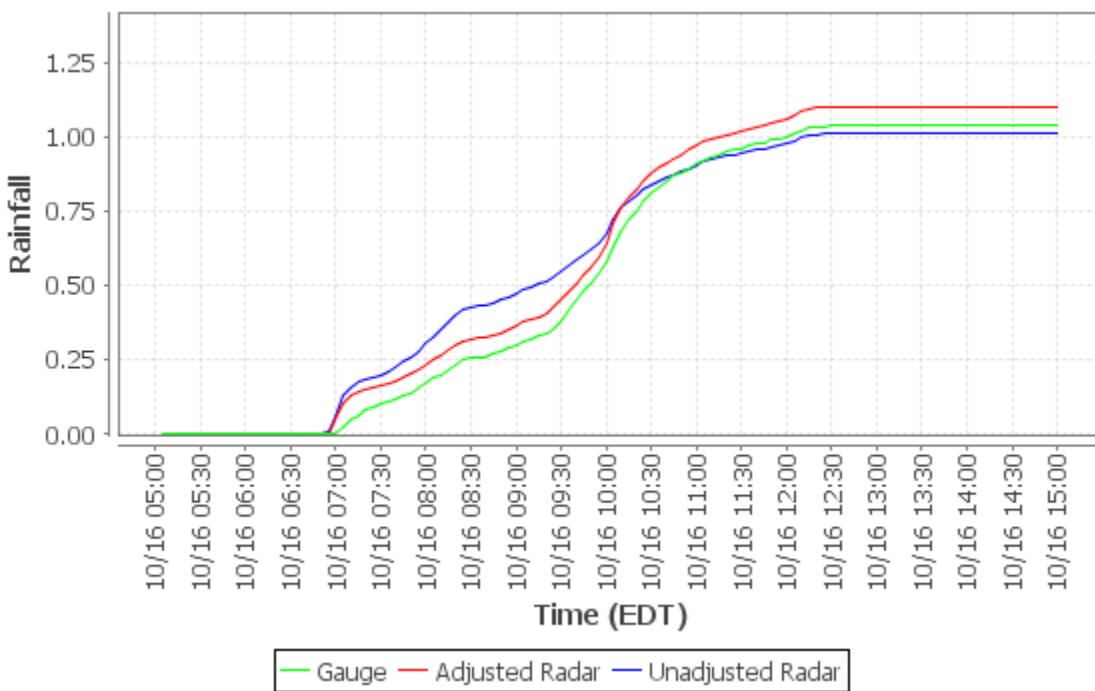


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

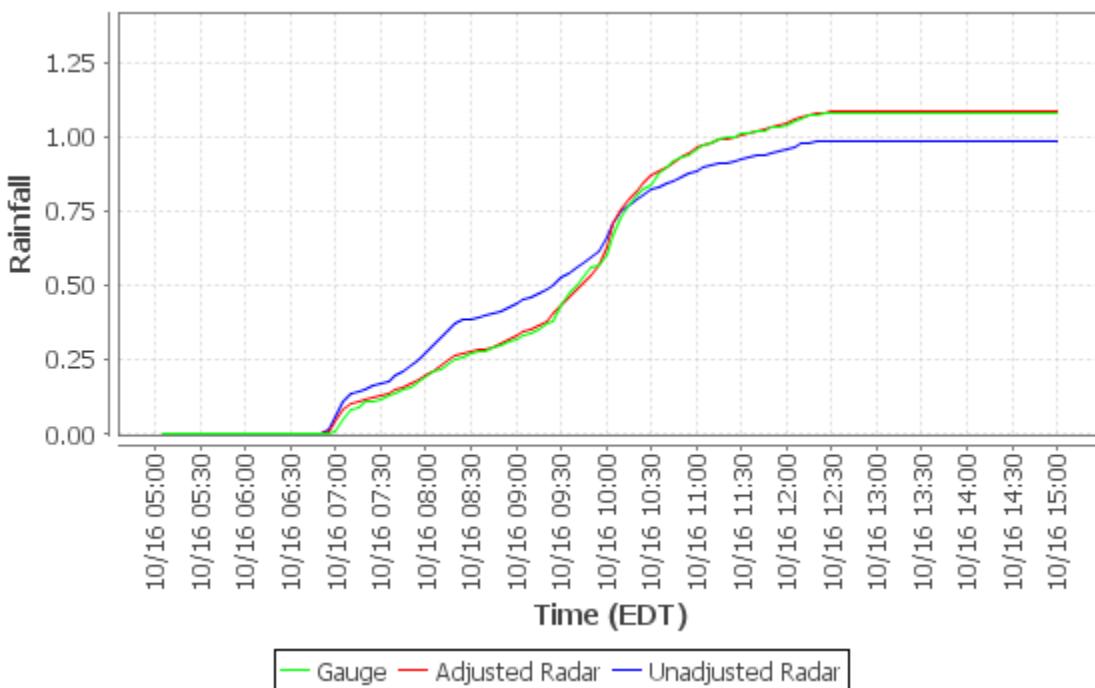


Appendix E - Event 3 (2019-10-16) CDPs

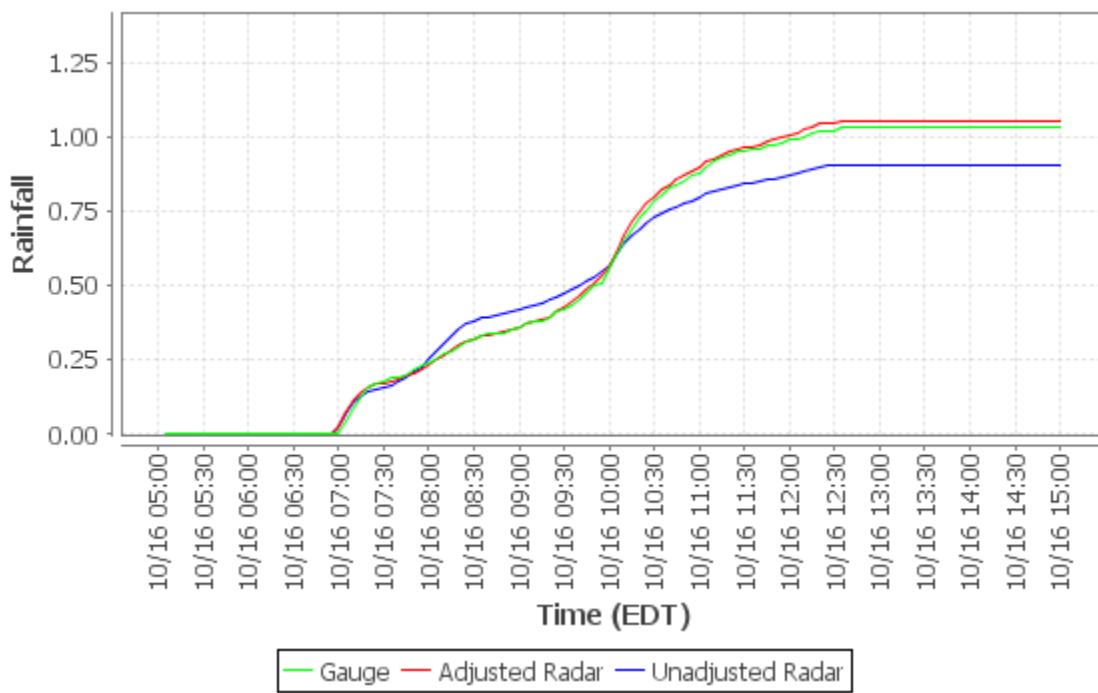
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



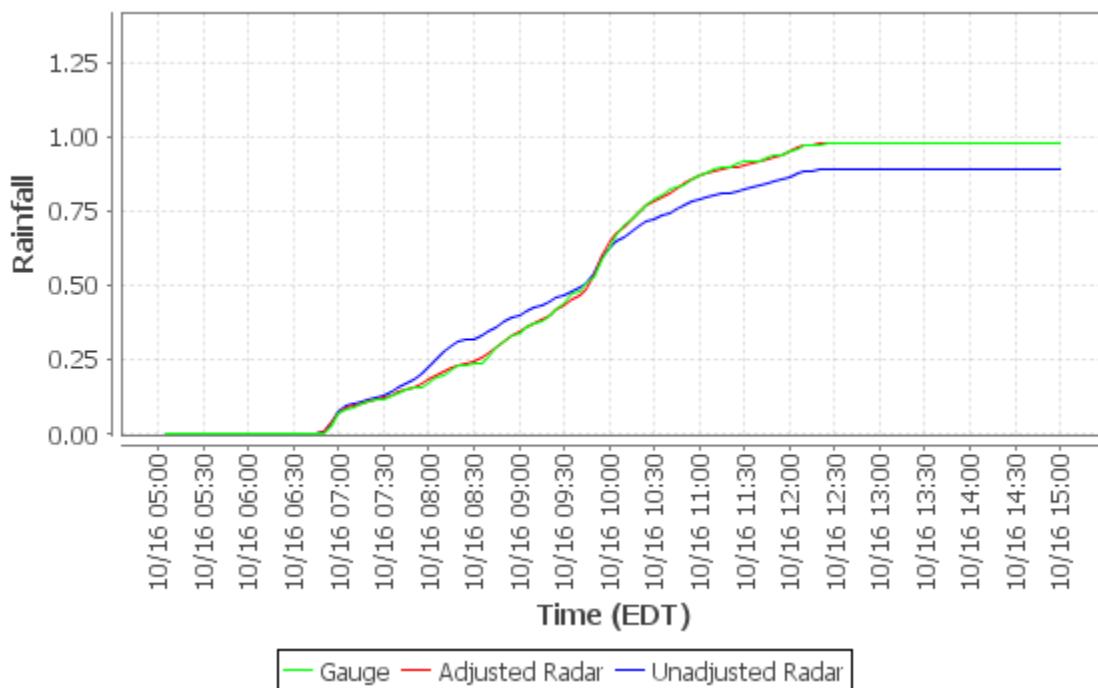
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



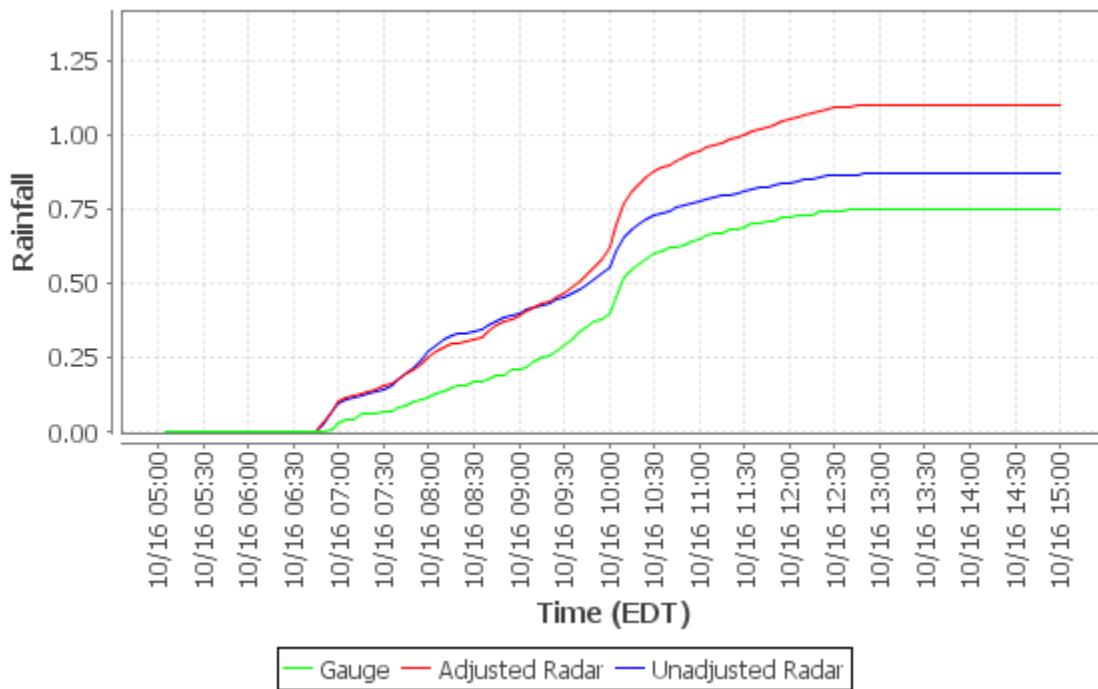
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



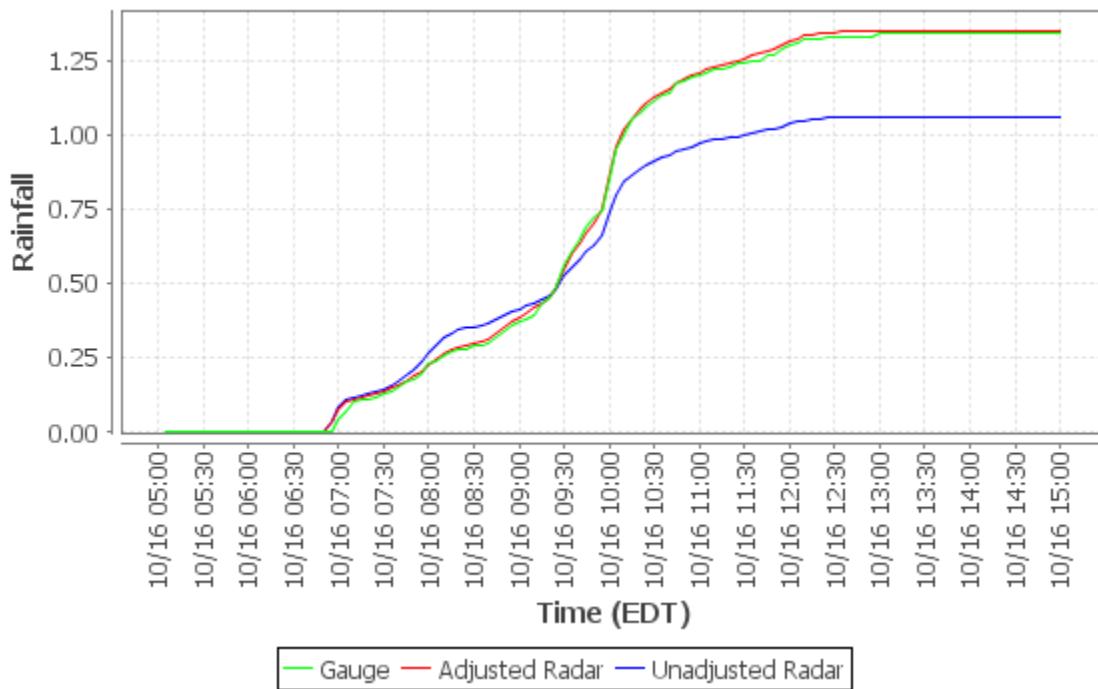
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



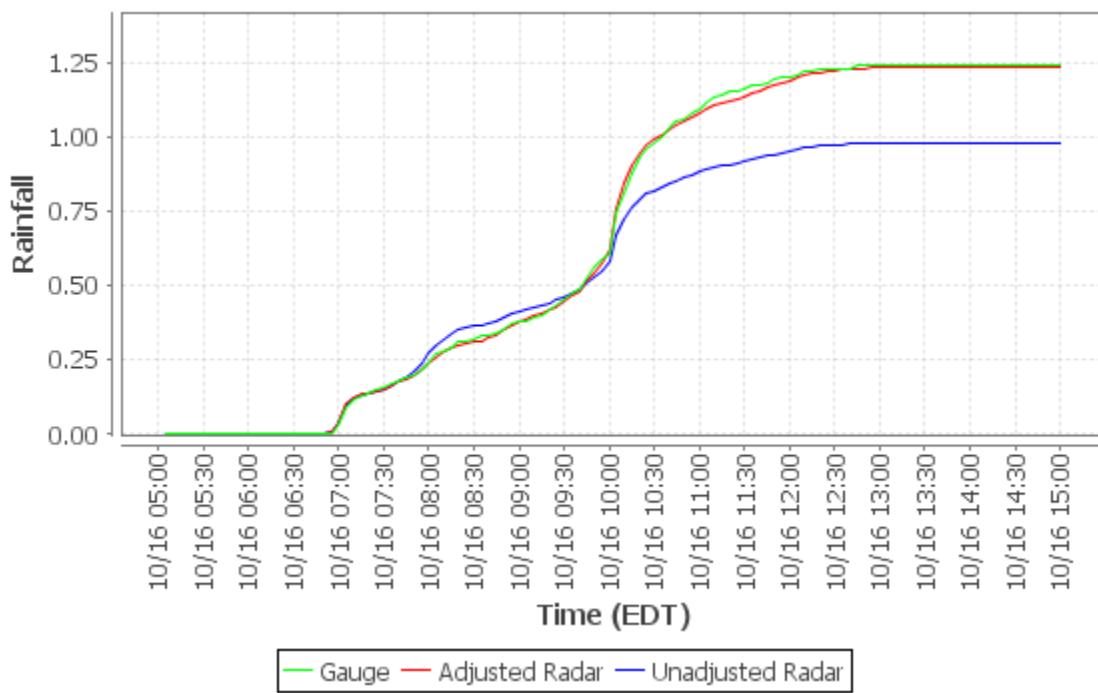
Cumulative Distribution Plot - Upper St. Clair (Loc05)



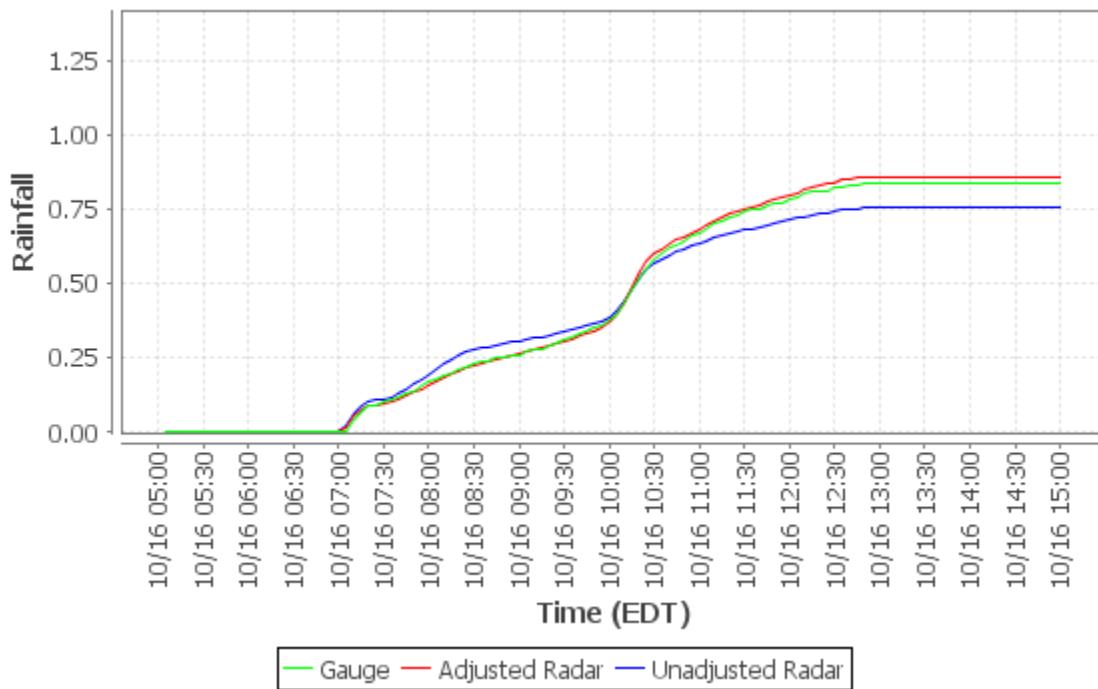
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



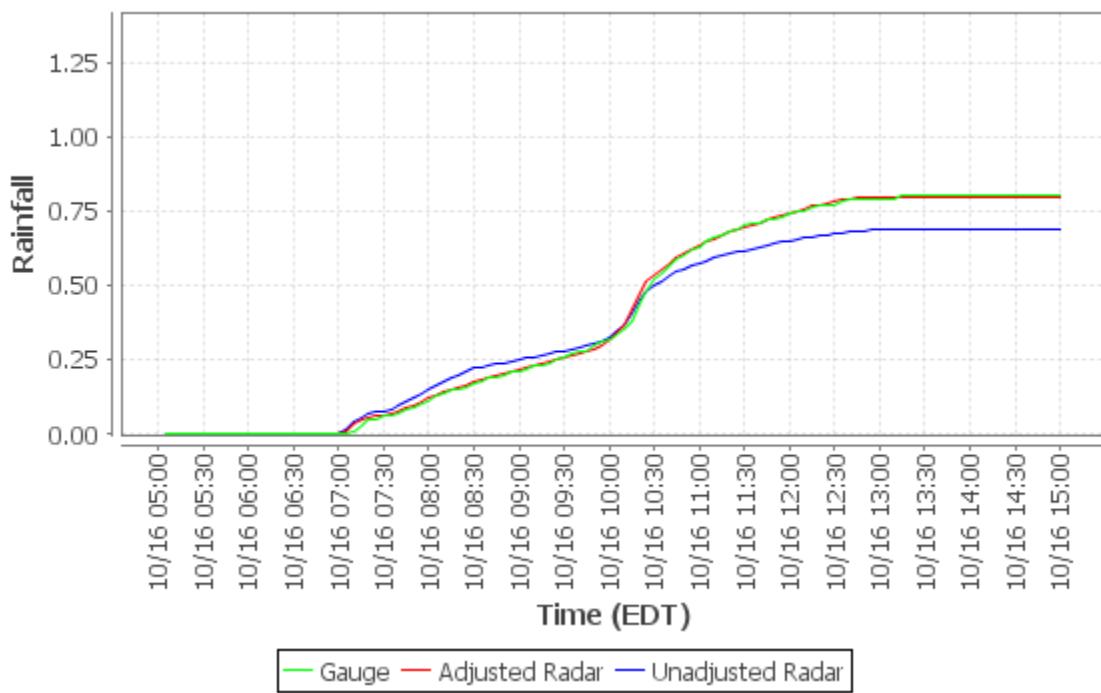
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



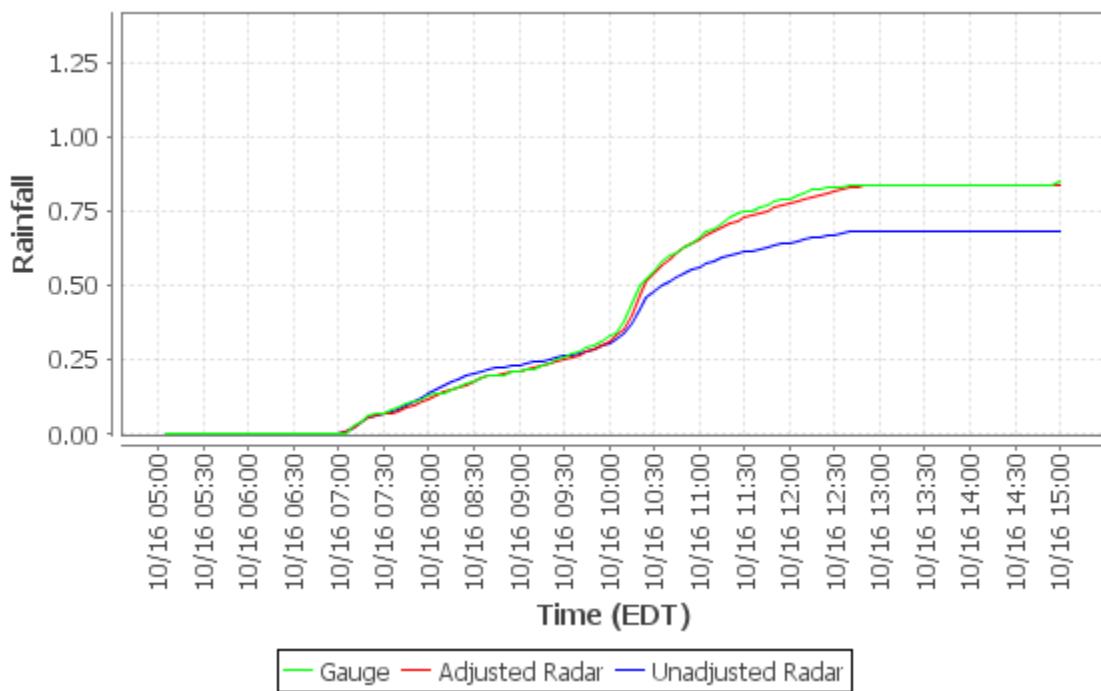
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



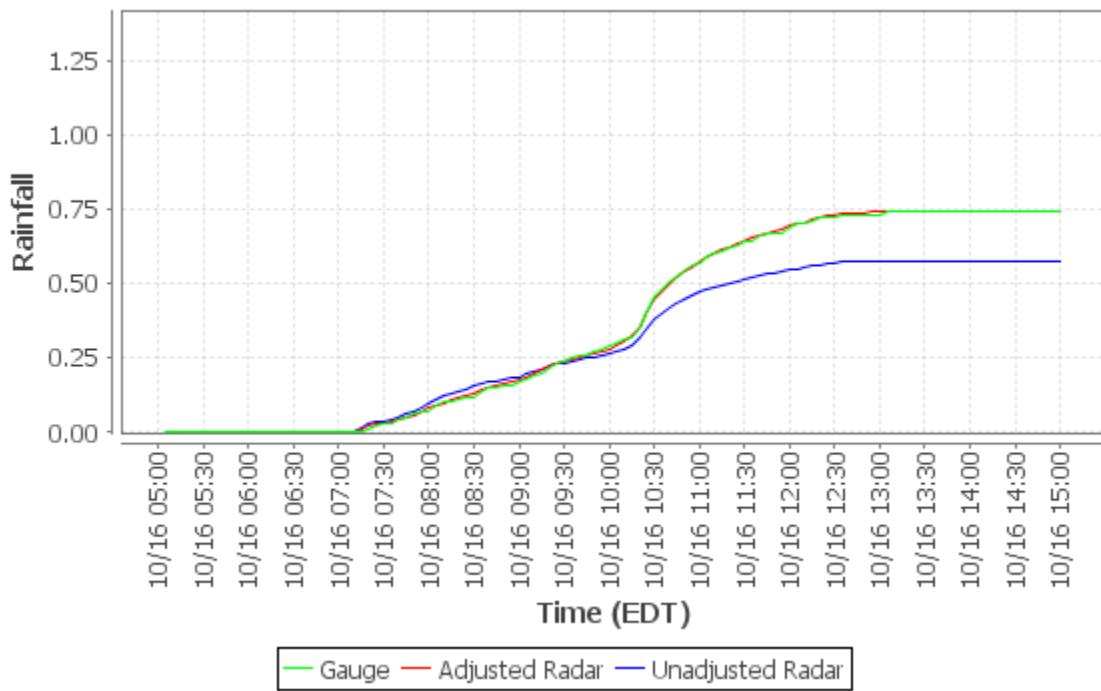
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



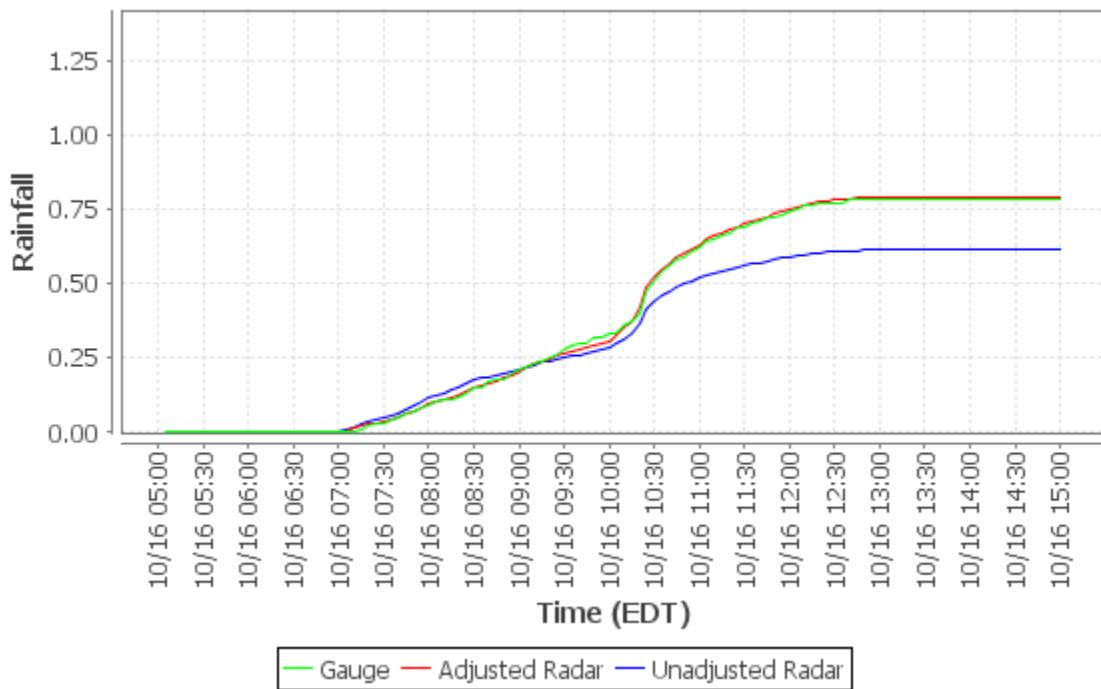
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



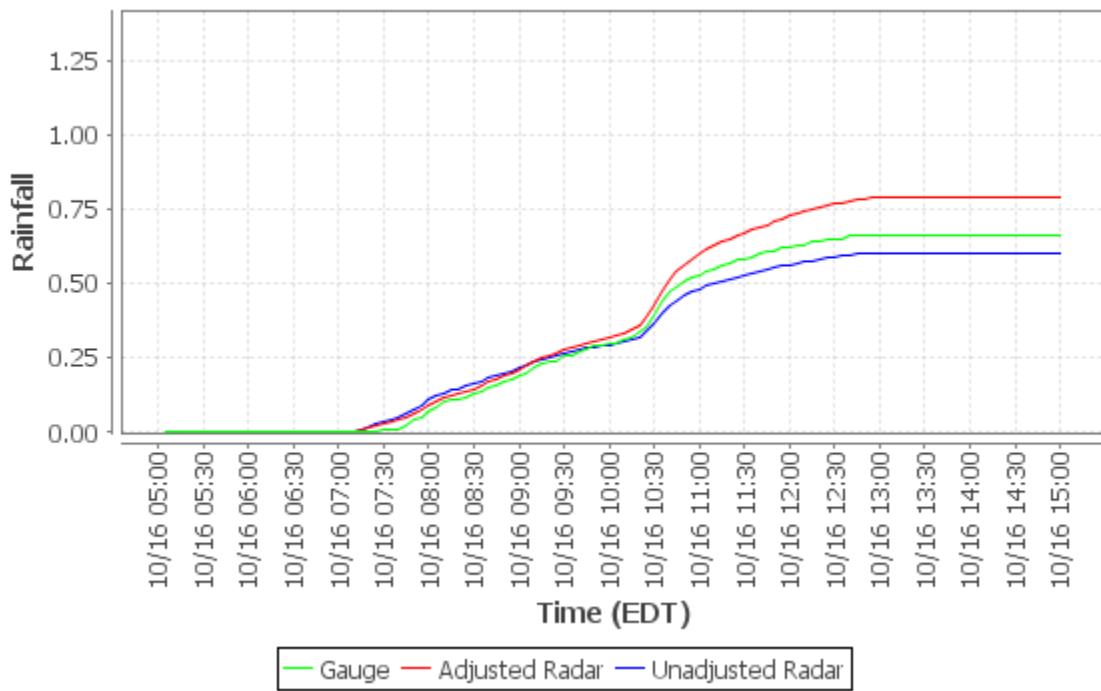
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



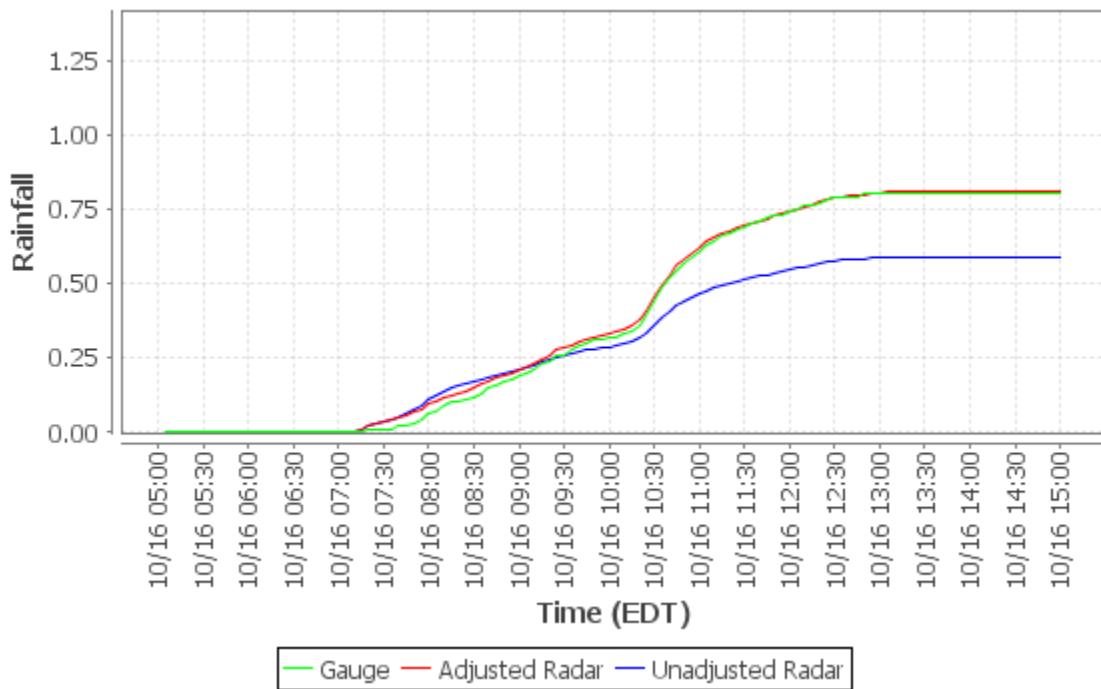
Cumulative Distribution Plot - Baldwin (Loc12)



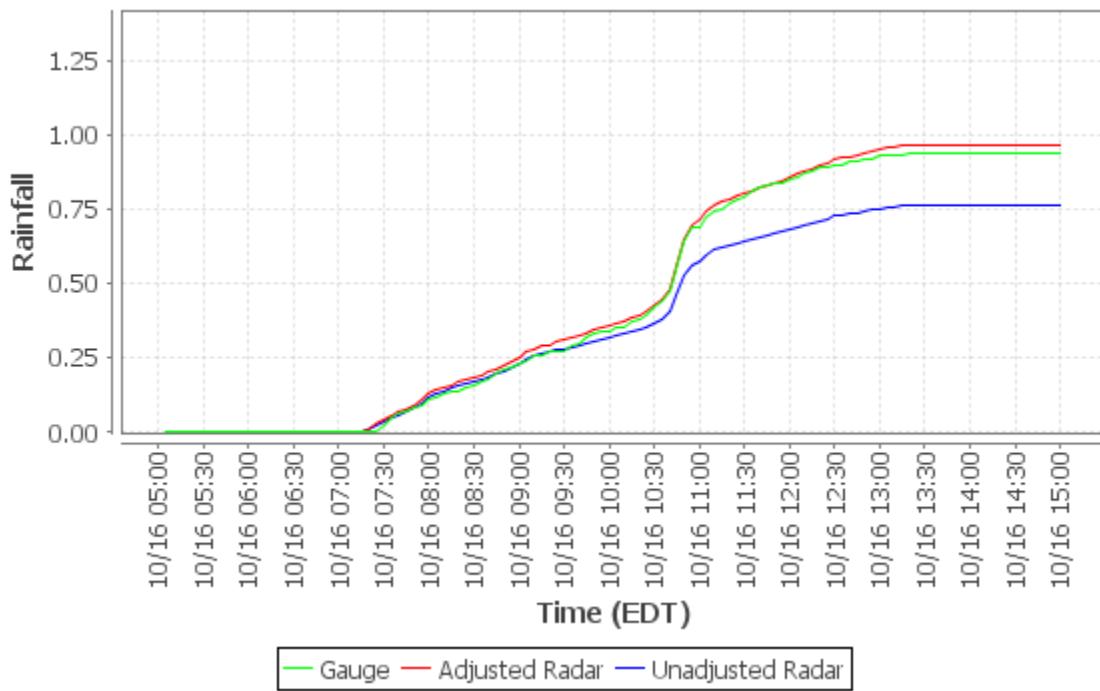
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



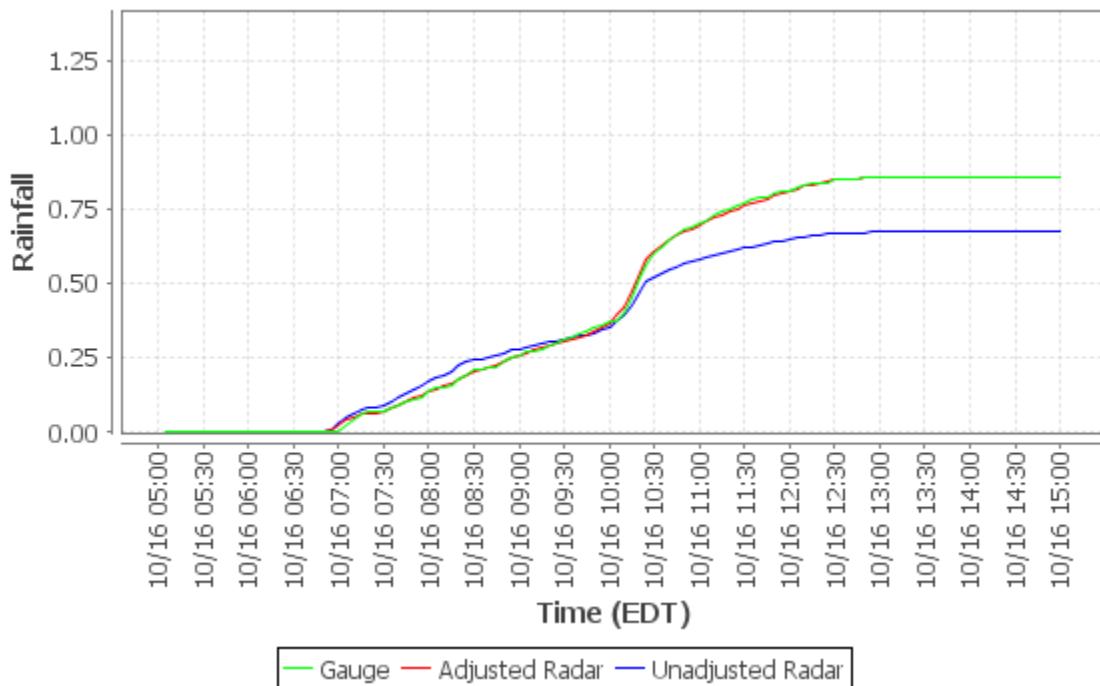
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



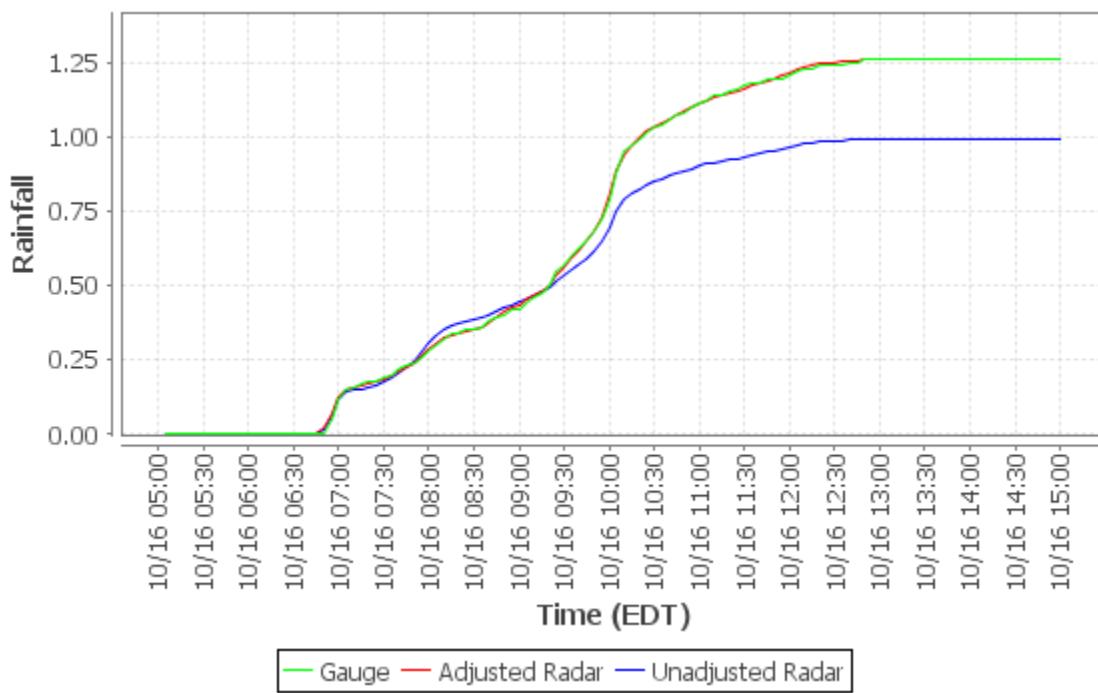
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



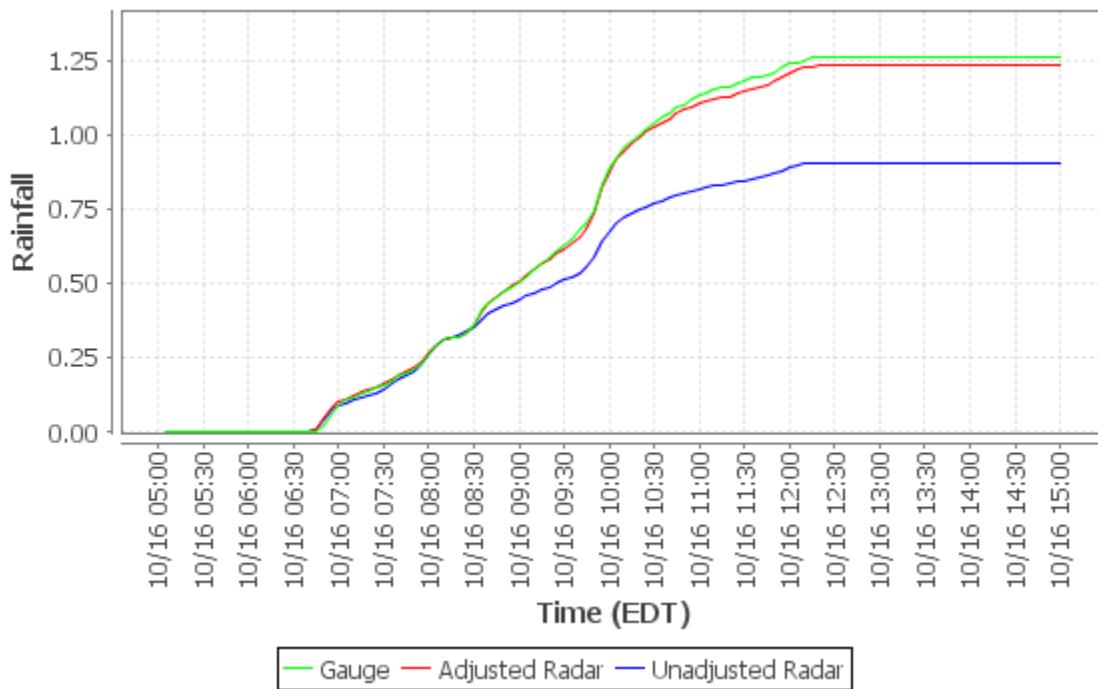
Cumulative Distribution Plot - Castle Shannon (Loc16)



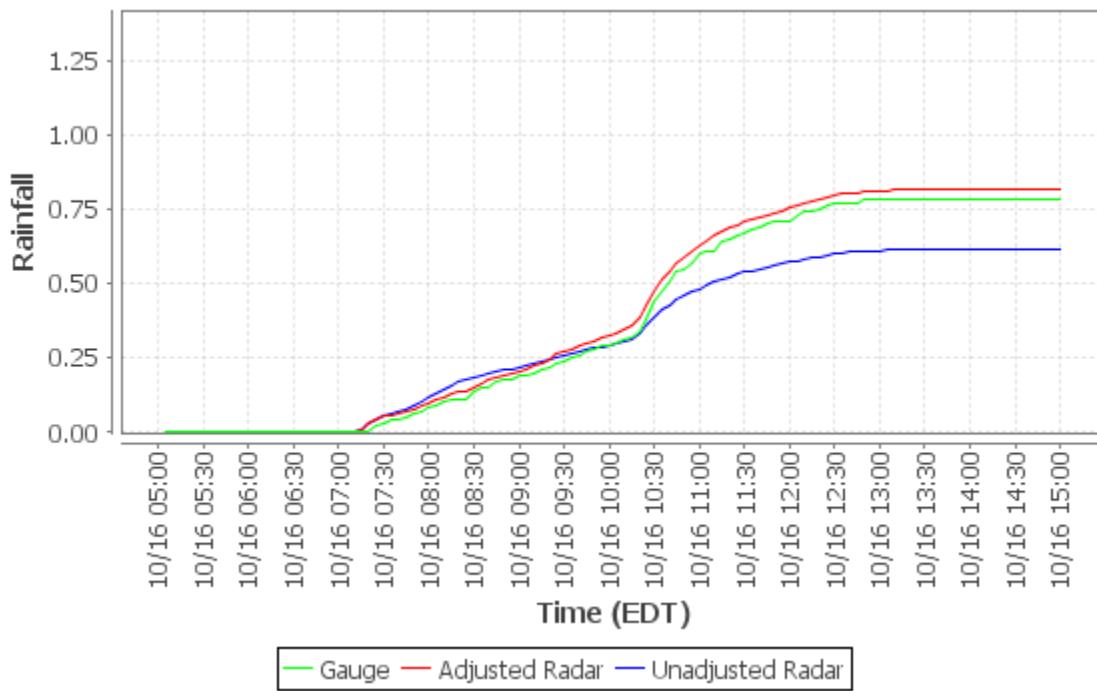
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



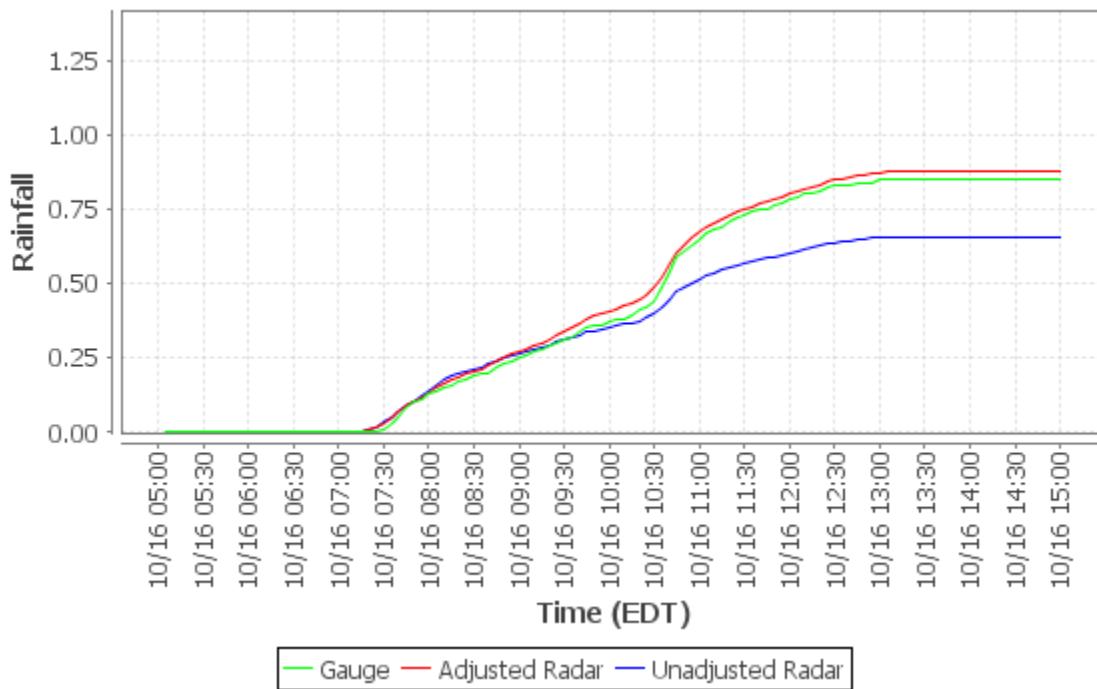
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



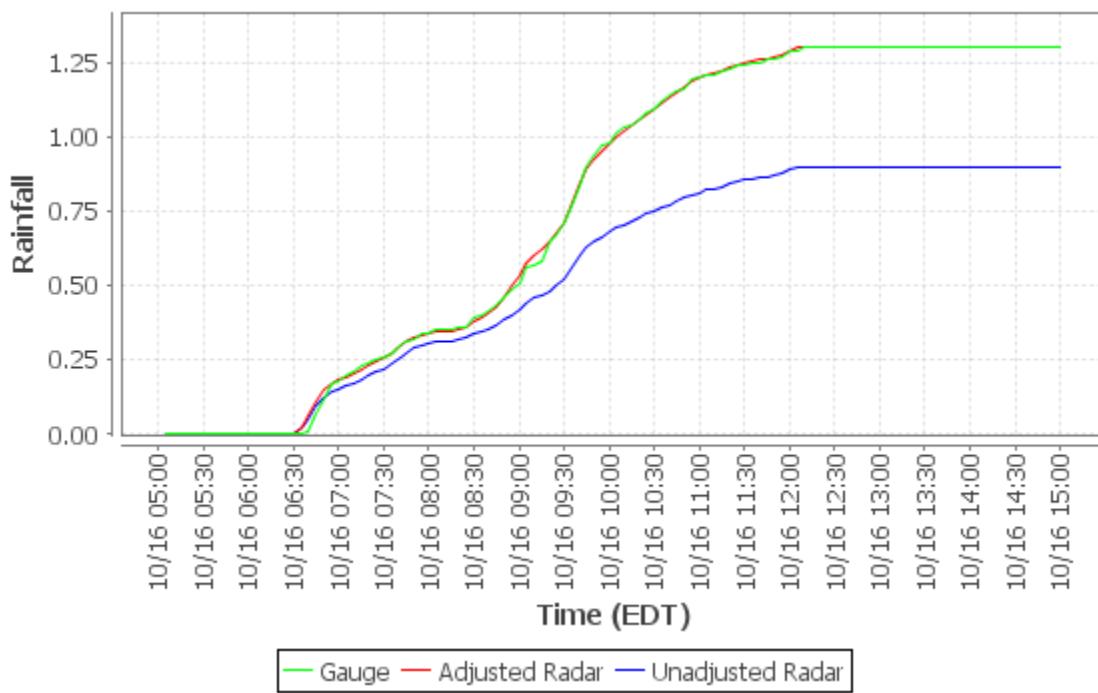
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



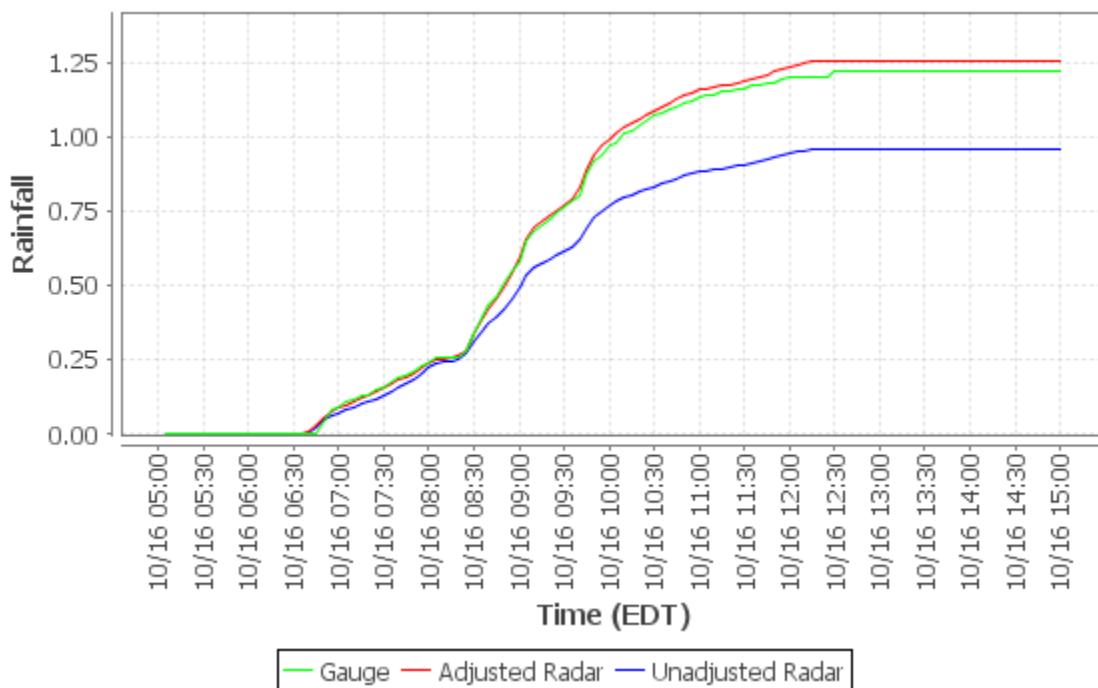
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



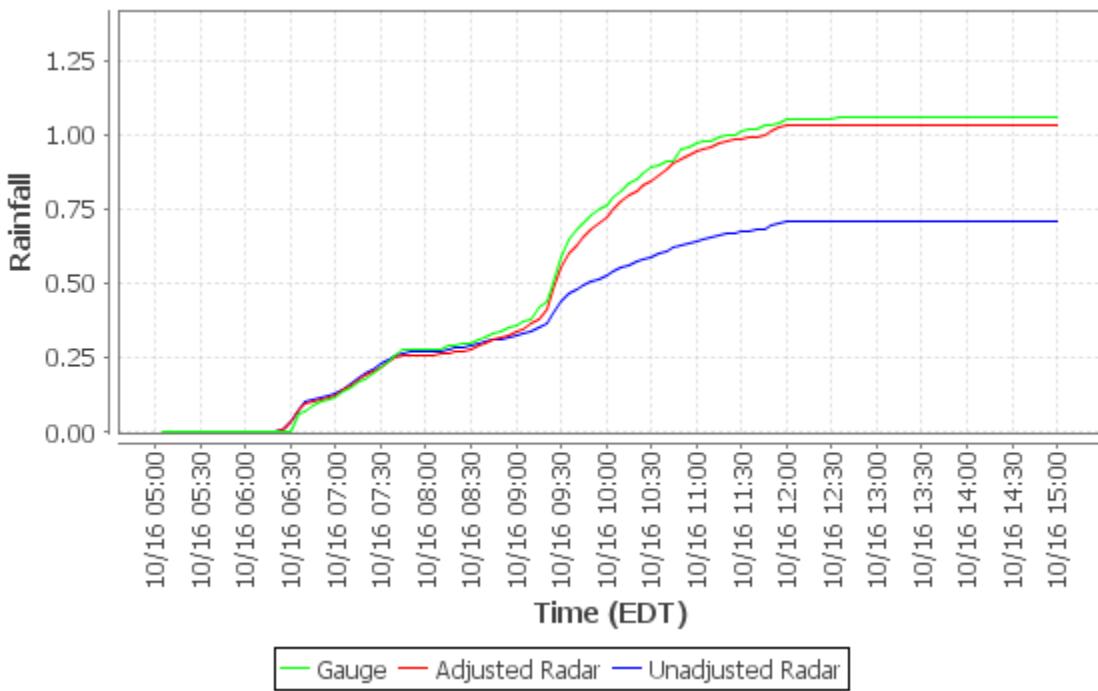
Cumulative Distribution Plot - Moon TWP (Loc21)



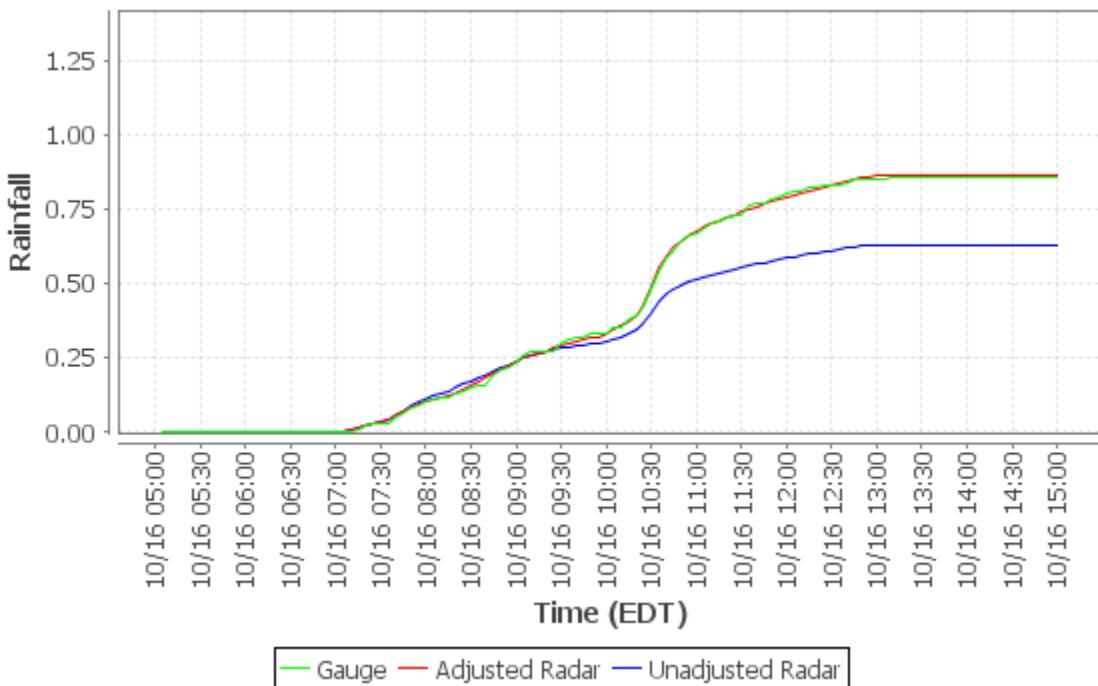
Cumulative Distribution Plot - North Fayette TWP (Loc22)



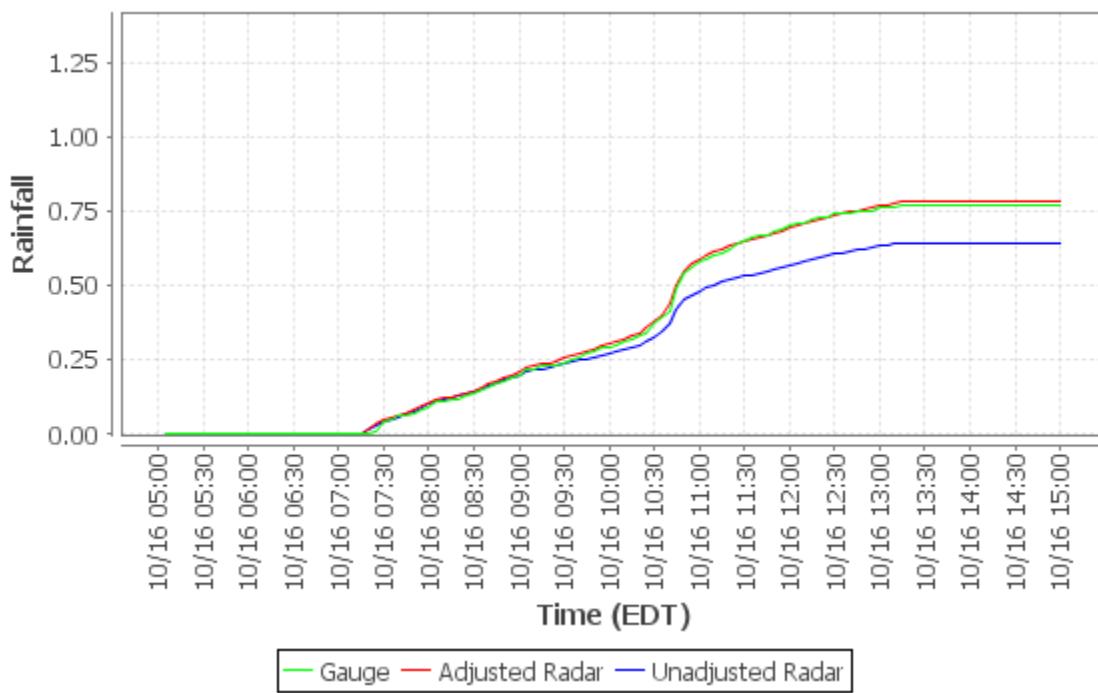
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



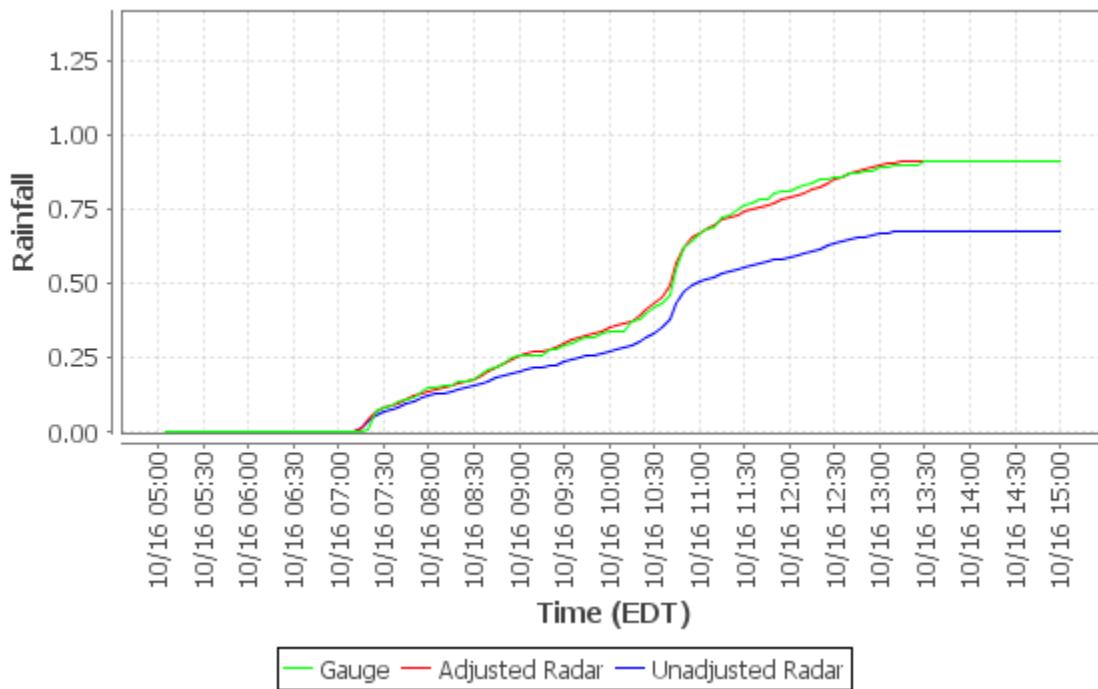
Cumulative Distribution Plot - Jefferson Hills (Loc24)



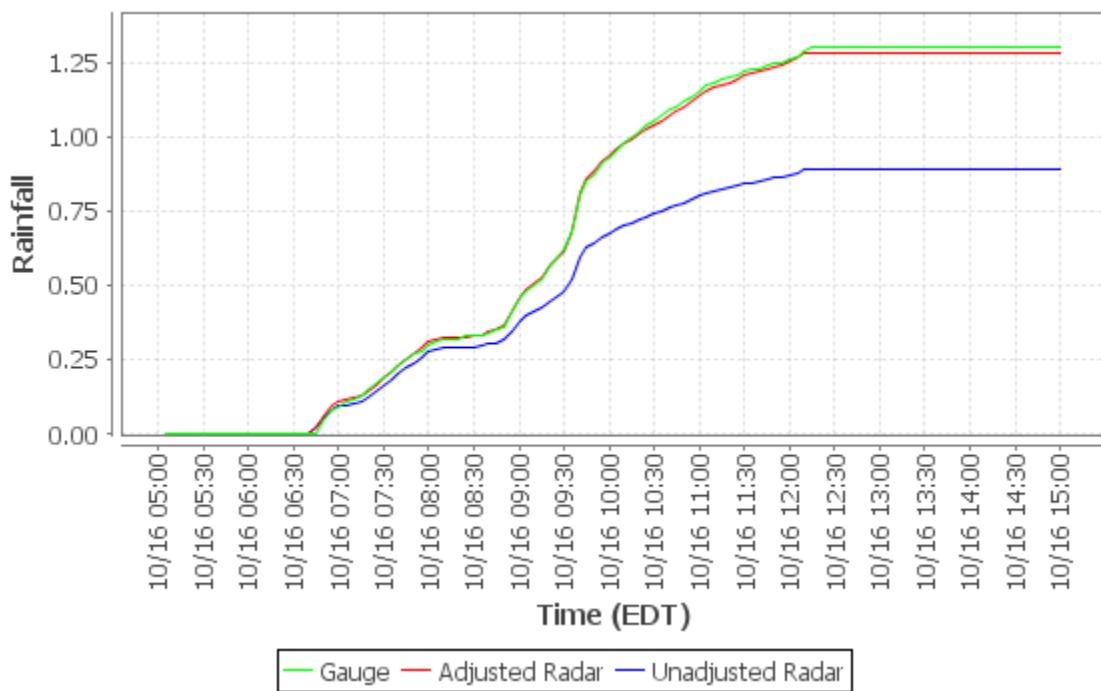
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



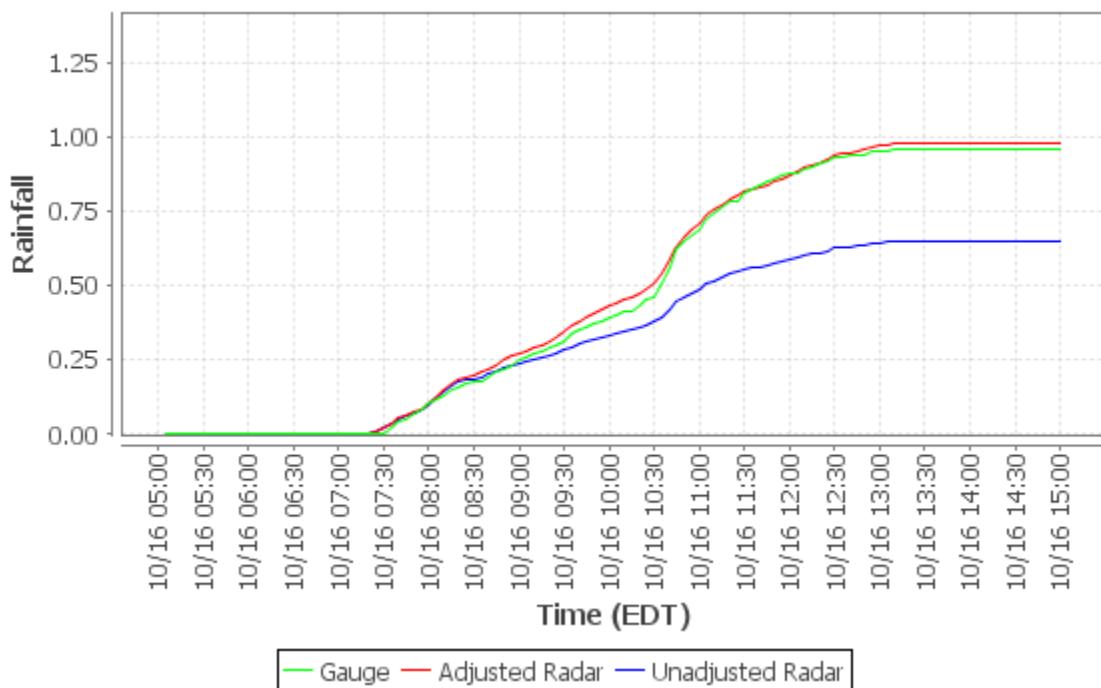
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



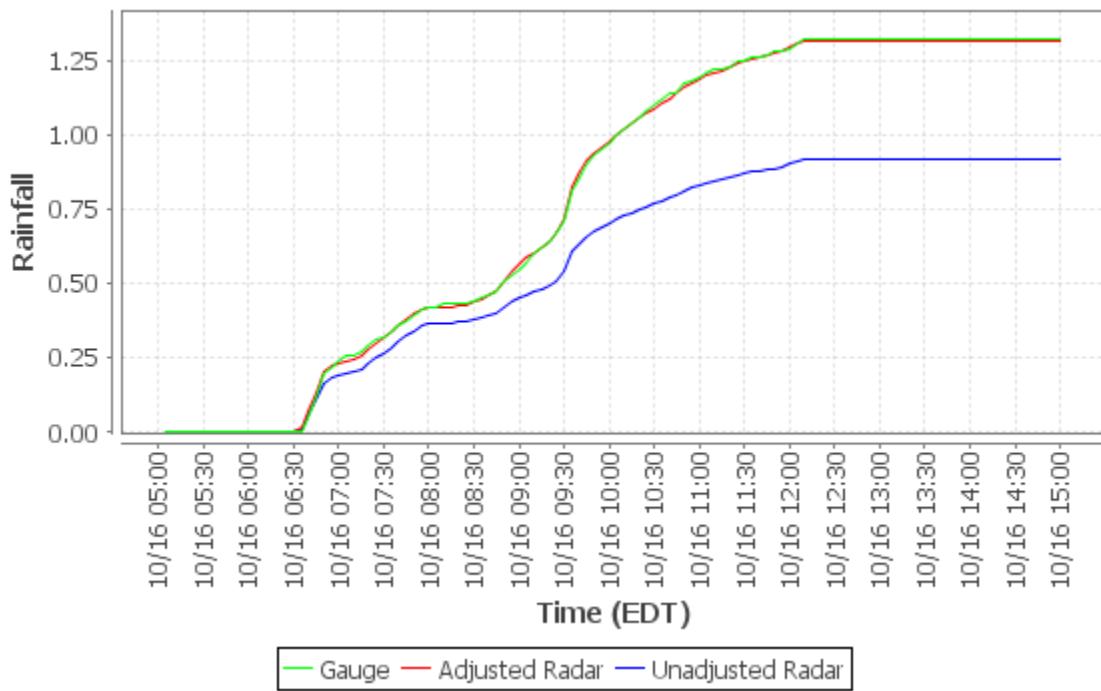
Cumulative Distribution Plot - Marshall TWP (Loc27)



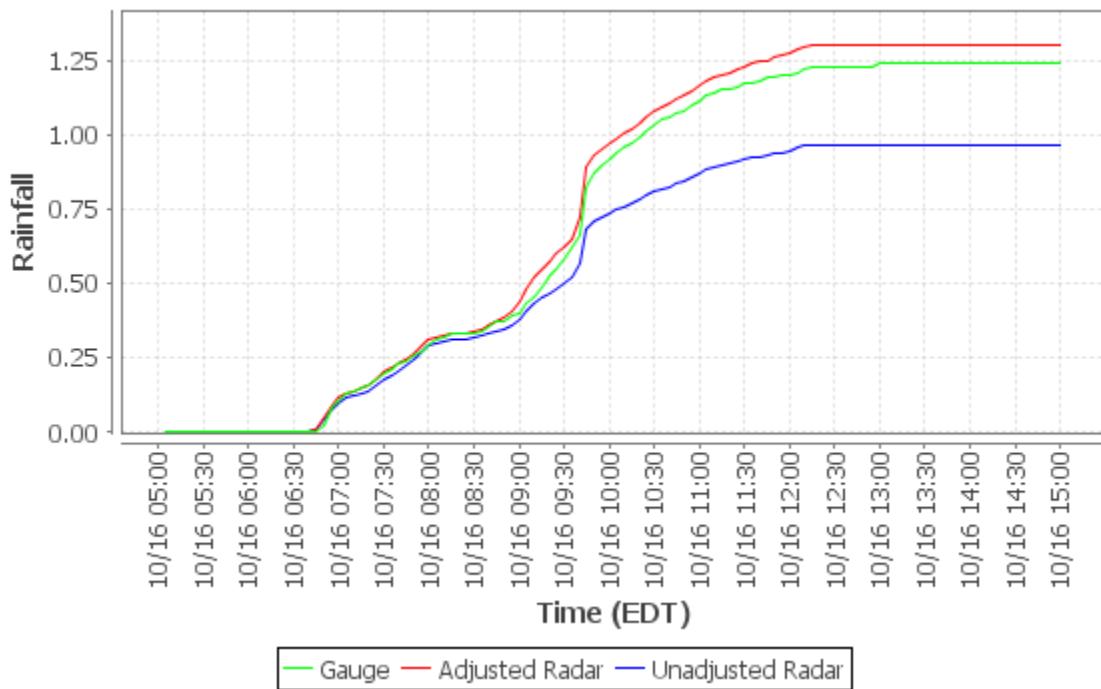
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



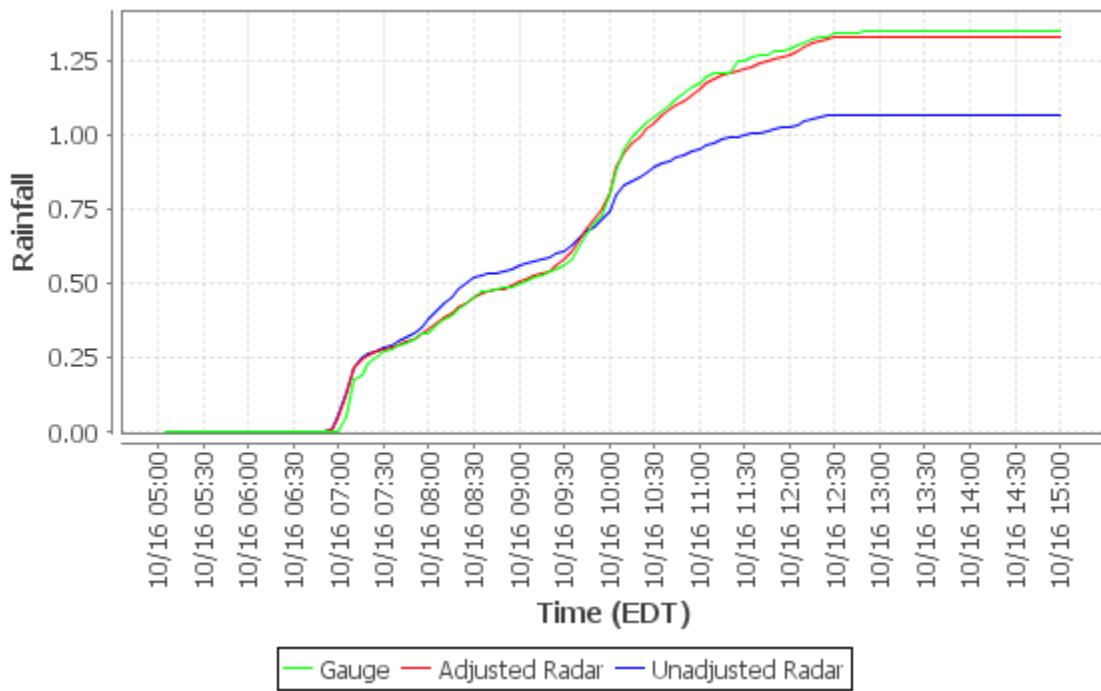
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



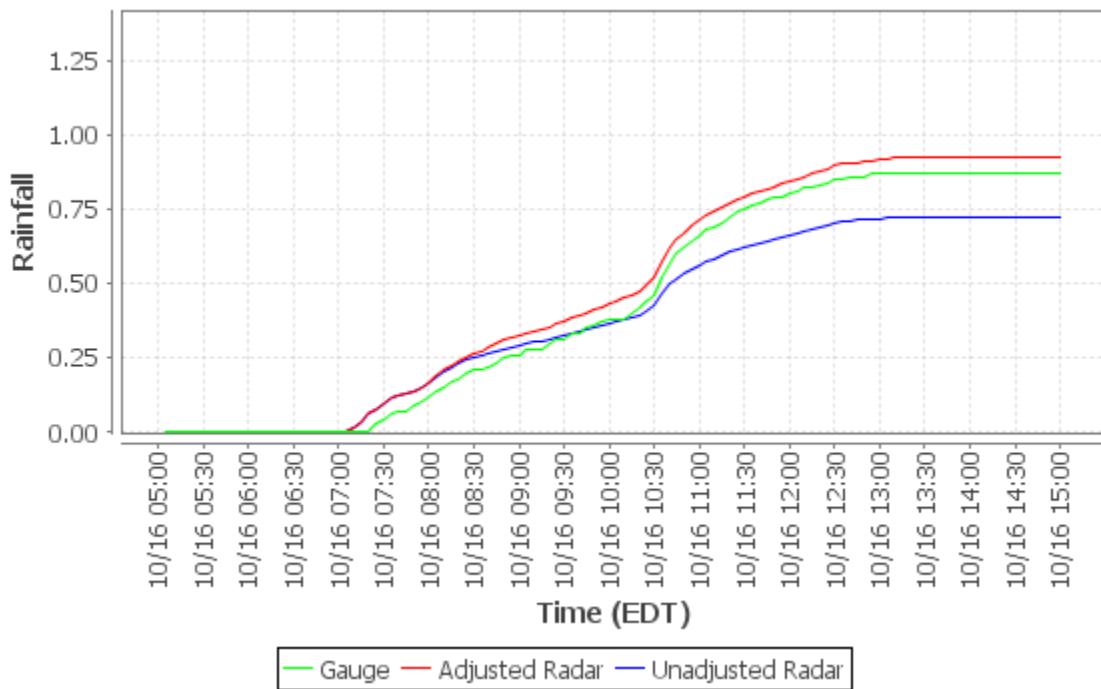
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



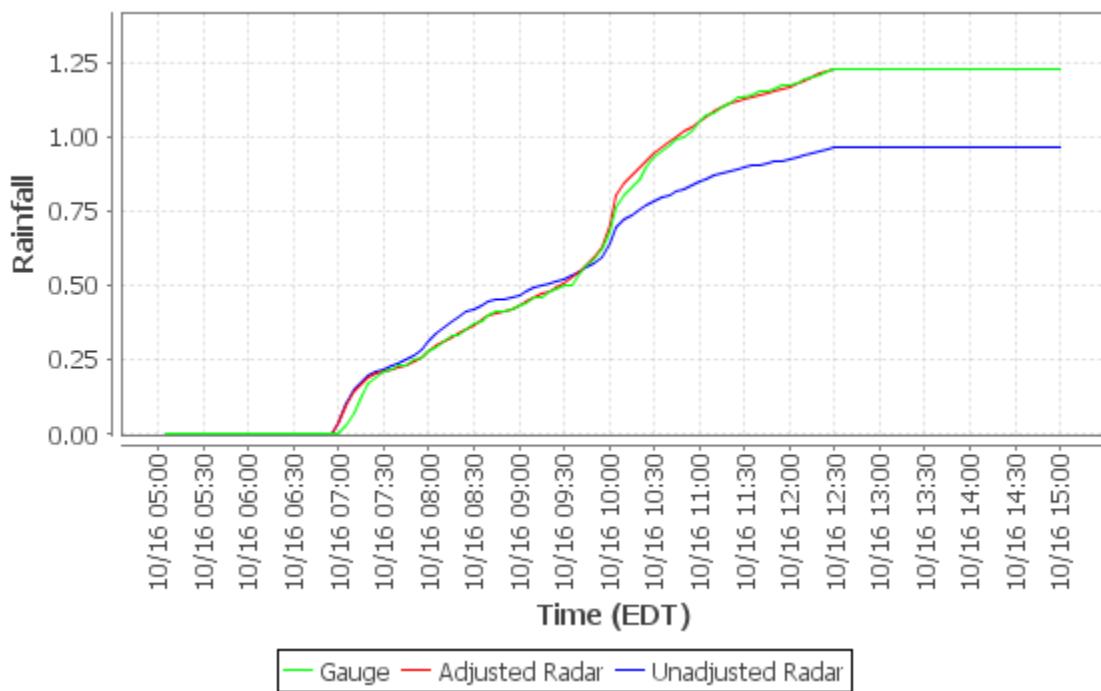
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



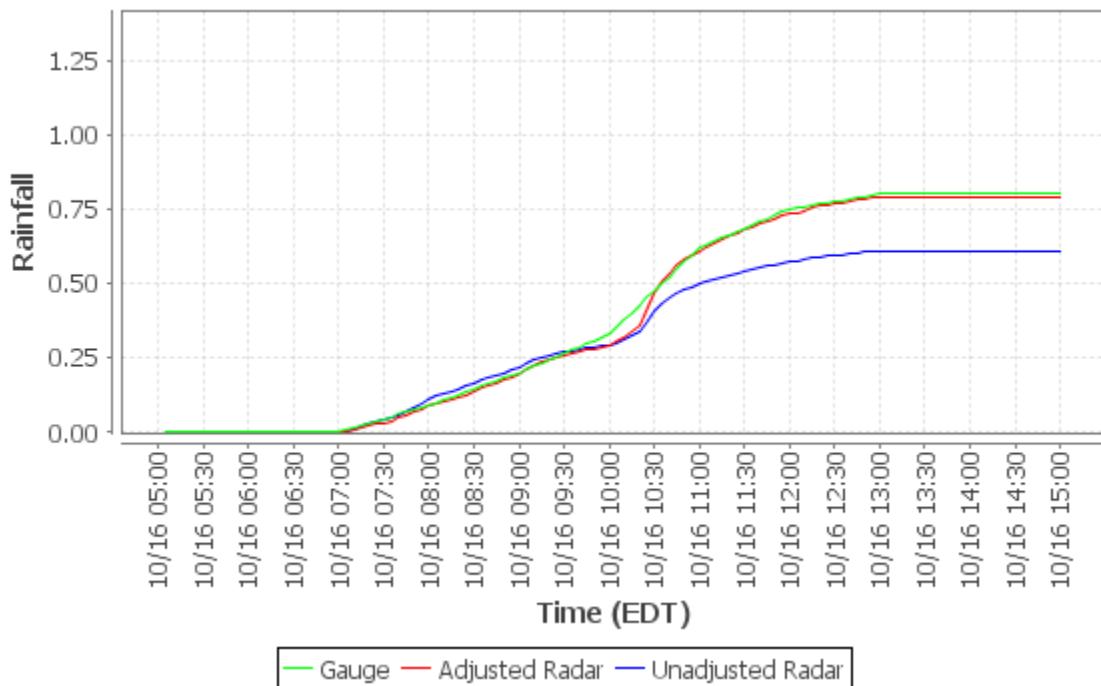
Cumulative Distribution Plot - Arnold (Loc32)



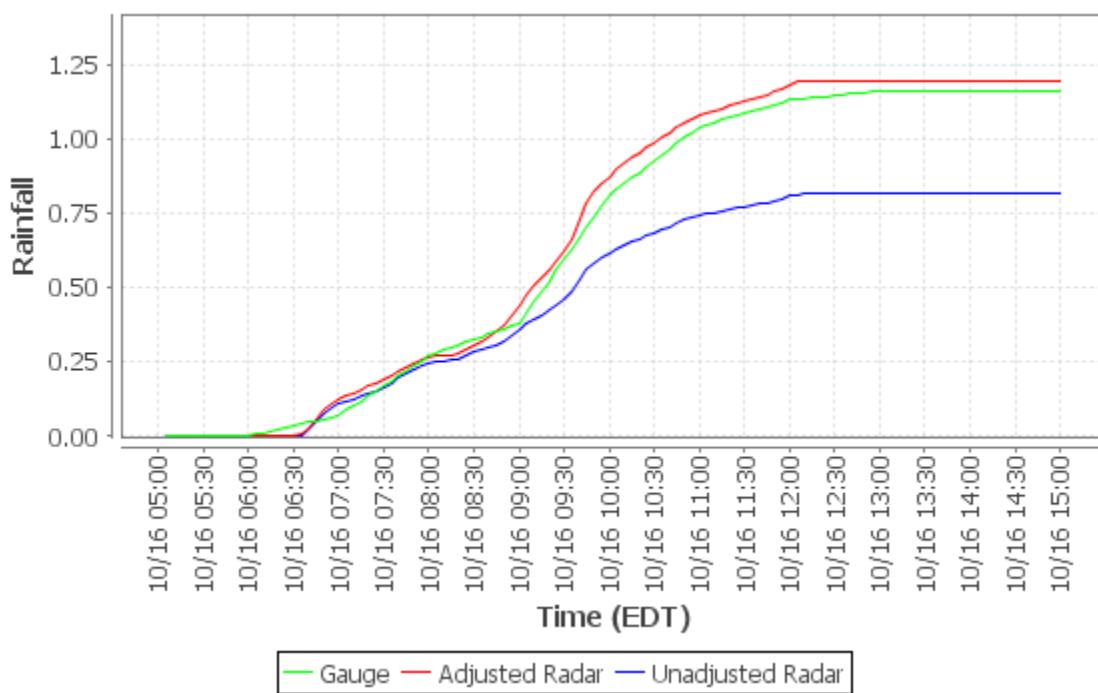
Cumulative Distribution Plot - Richland TWP (Loc33)



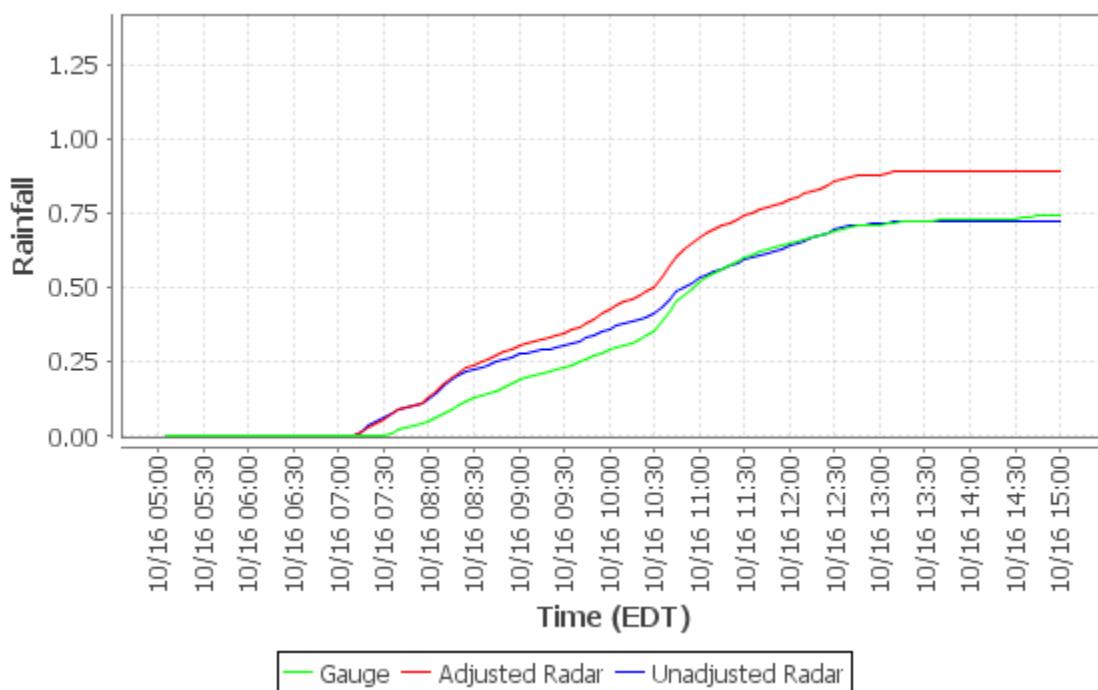
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



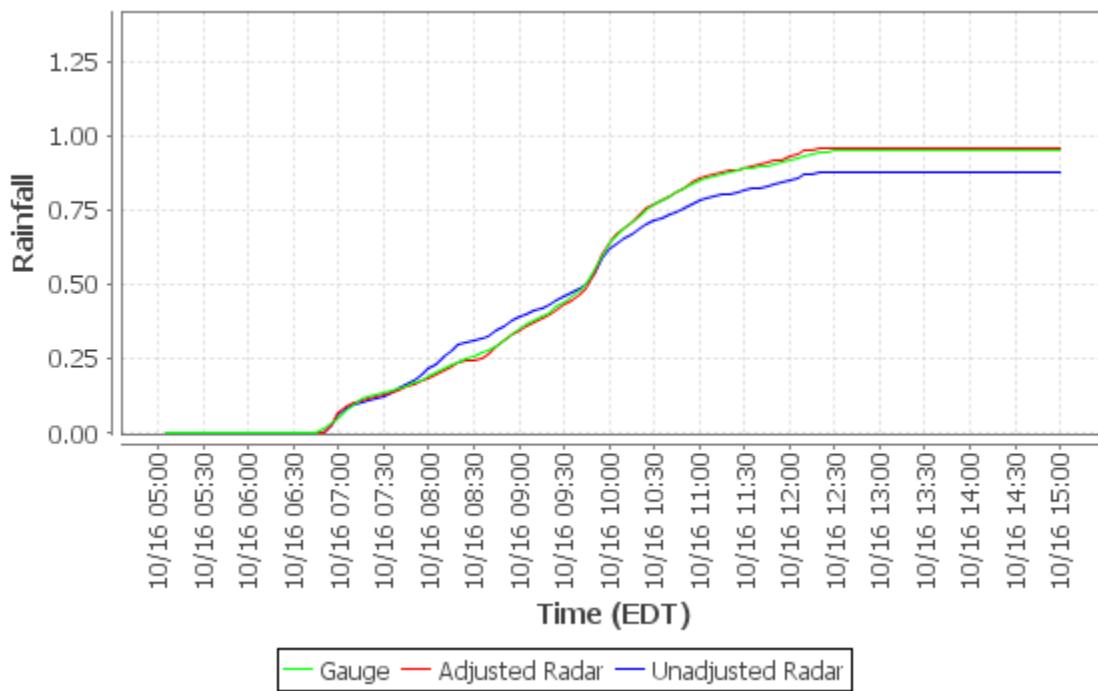
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

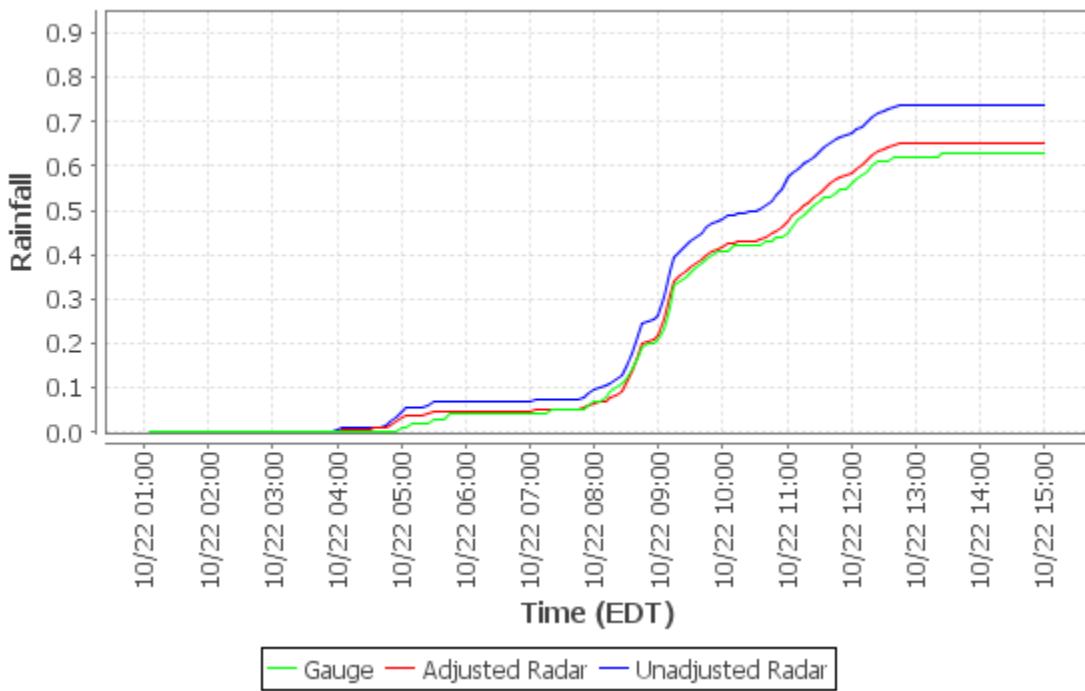


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

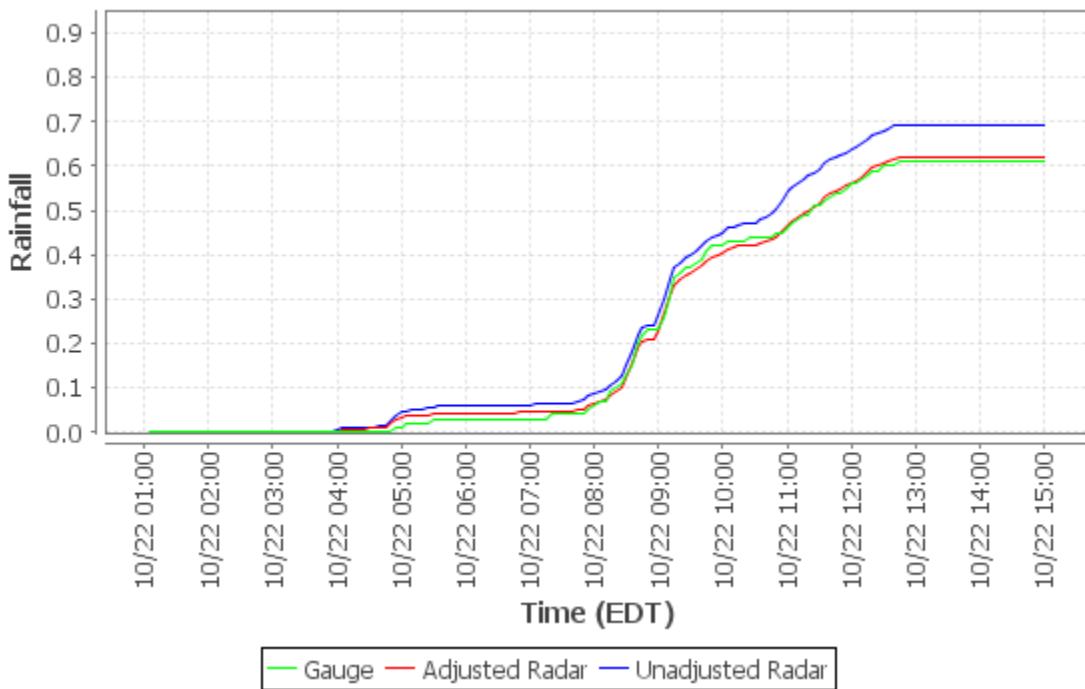


Appendix F - Event 4 (2019-10-22) CDPs

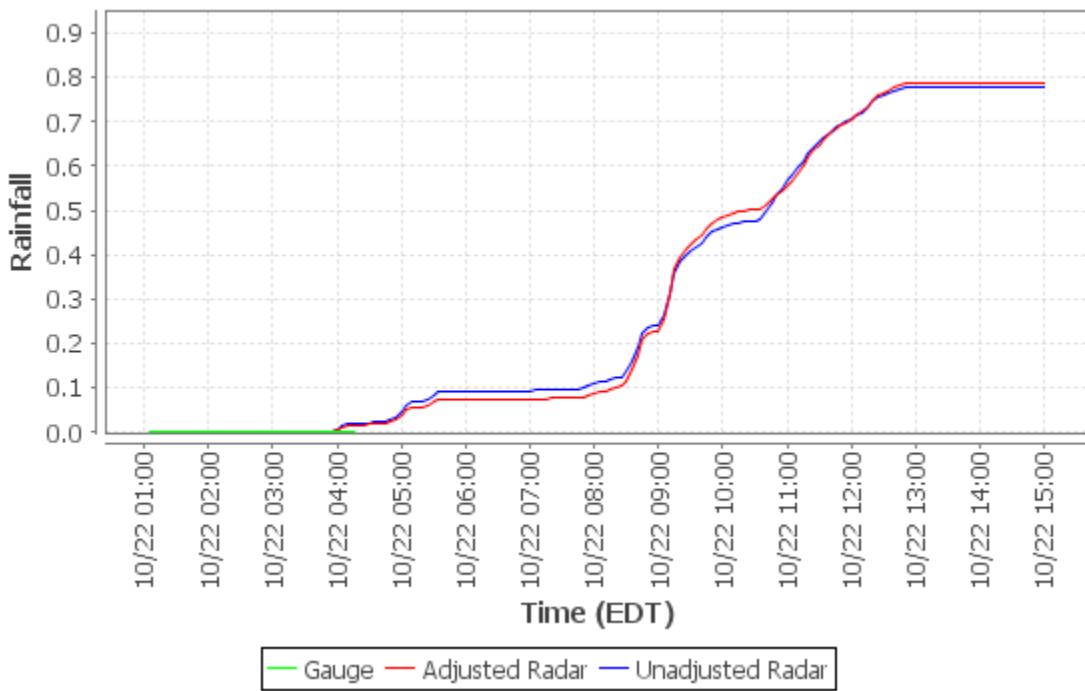
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



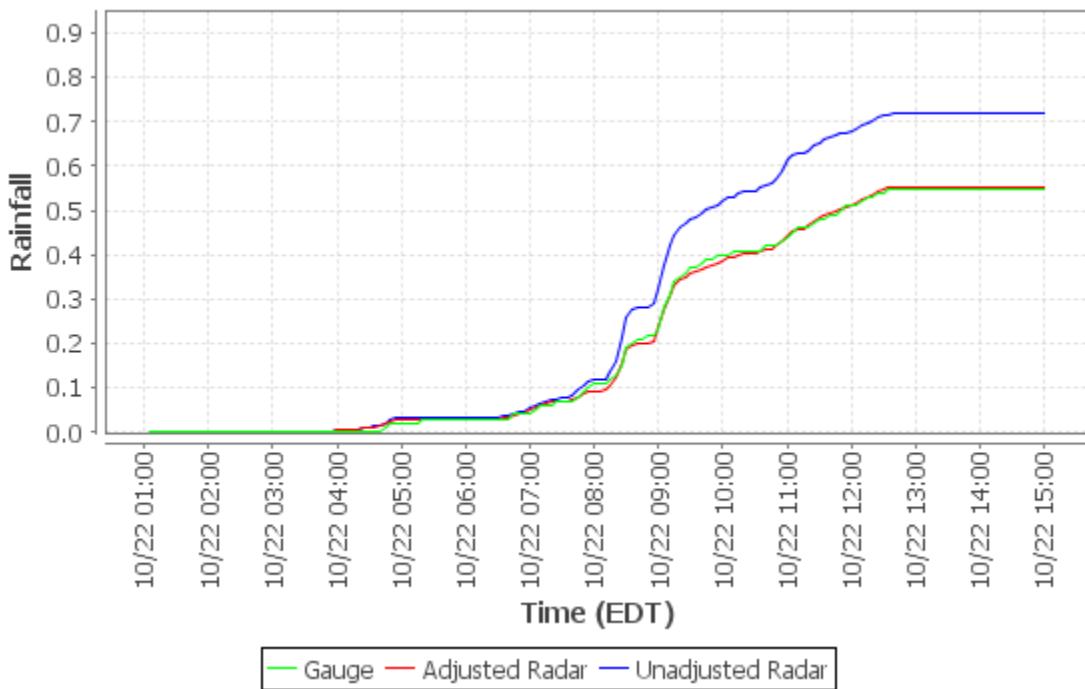
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



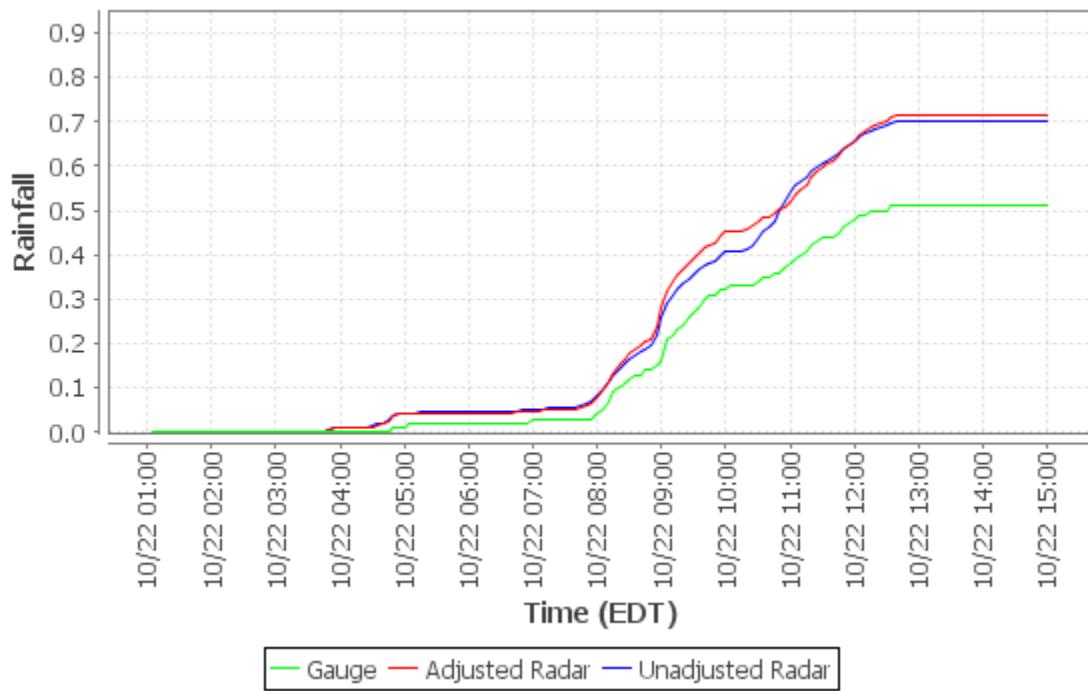
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



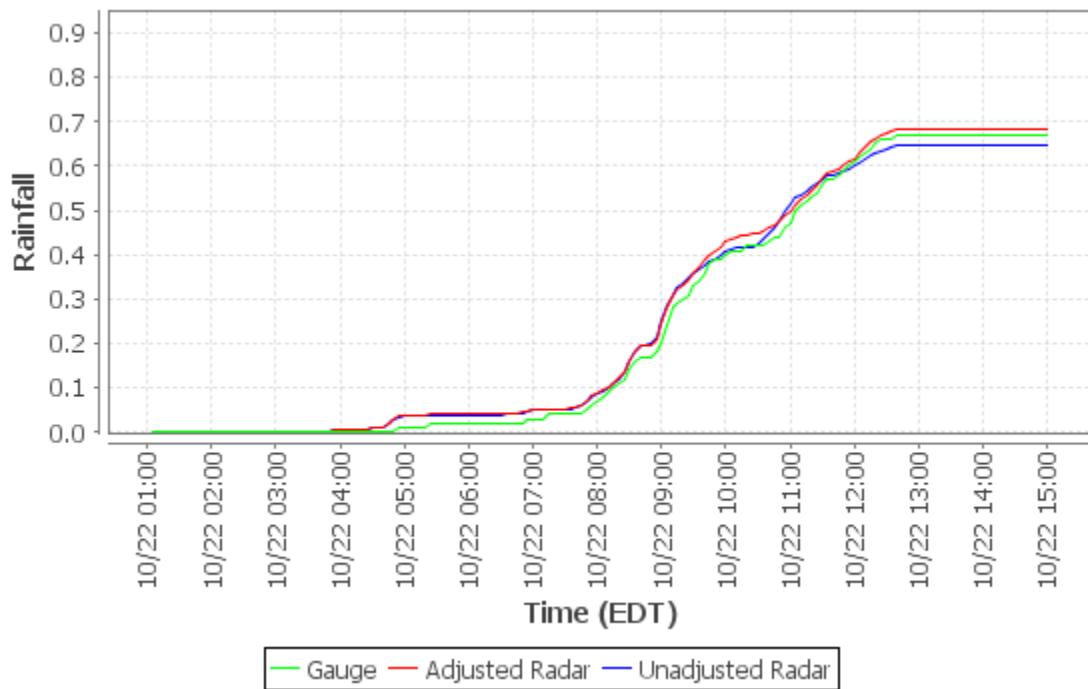
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



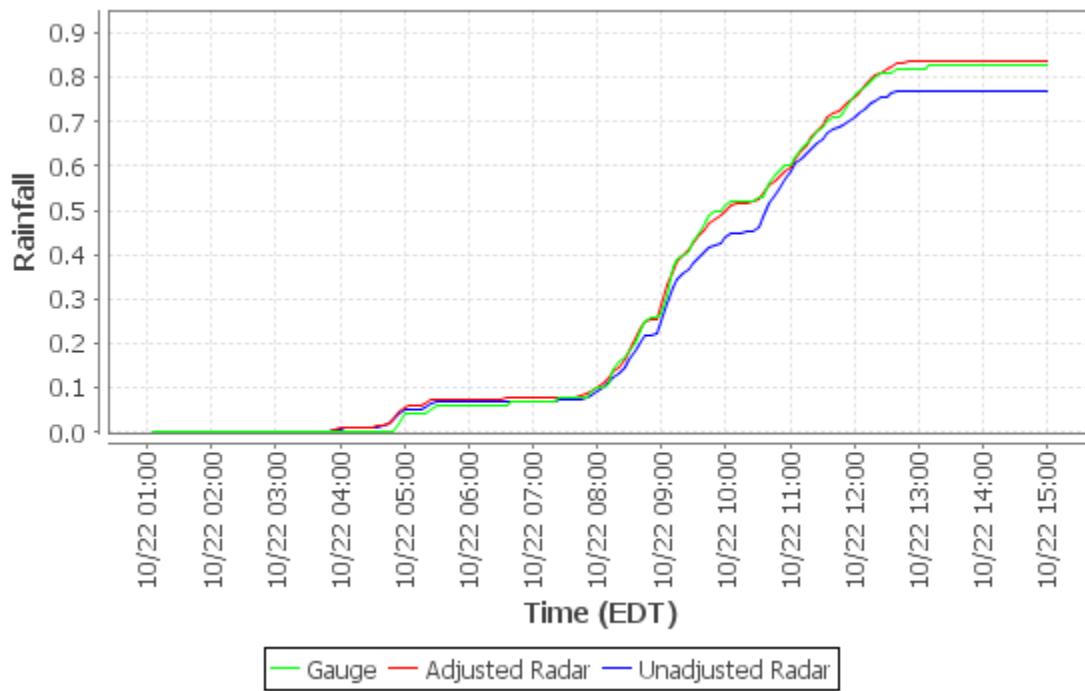
Cumulative Distribution Plot - Upper St. Clair (Loc05)



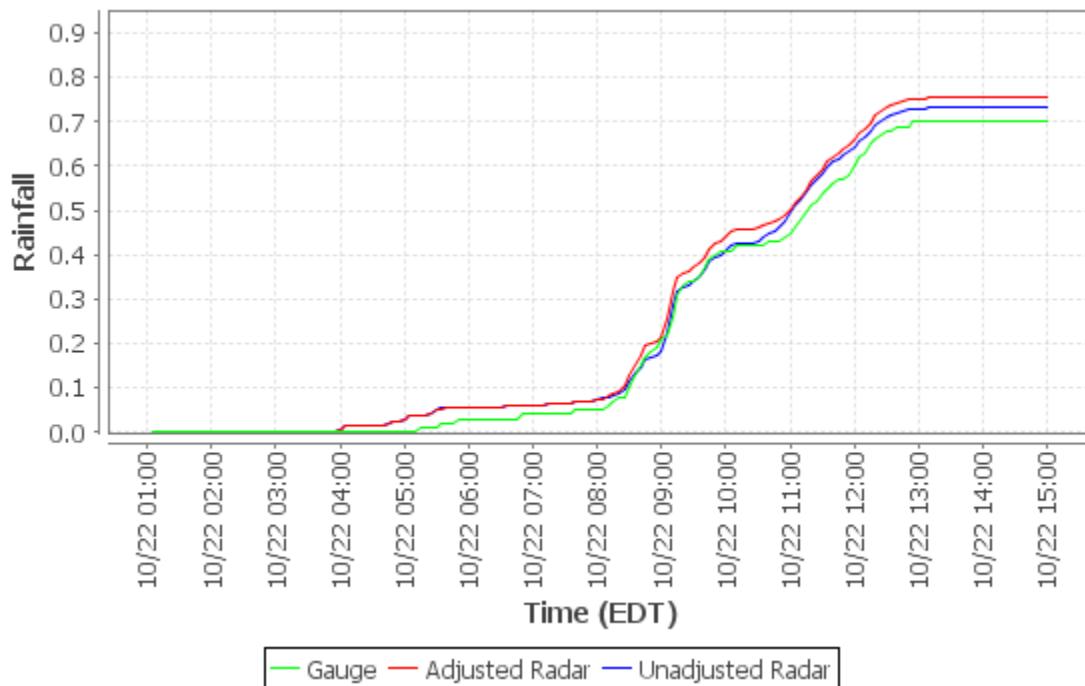
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



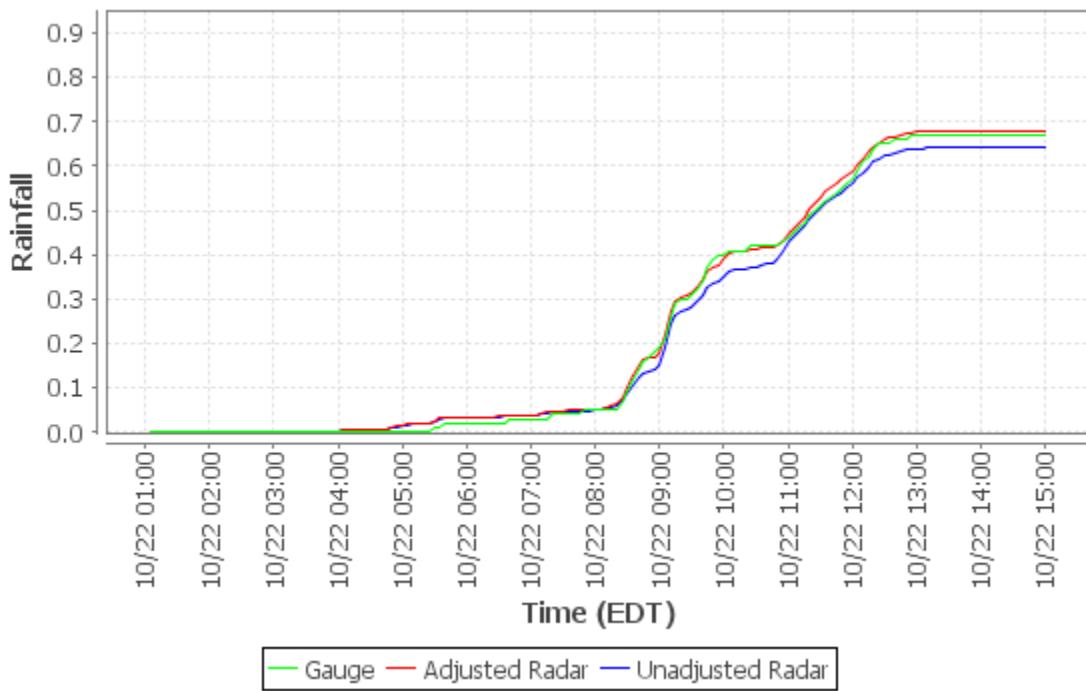
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



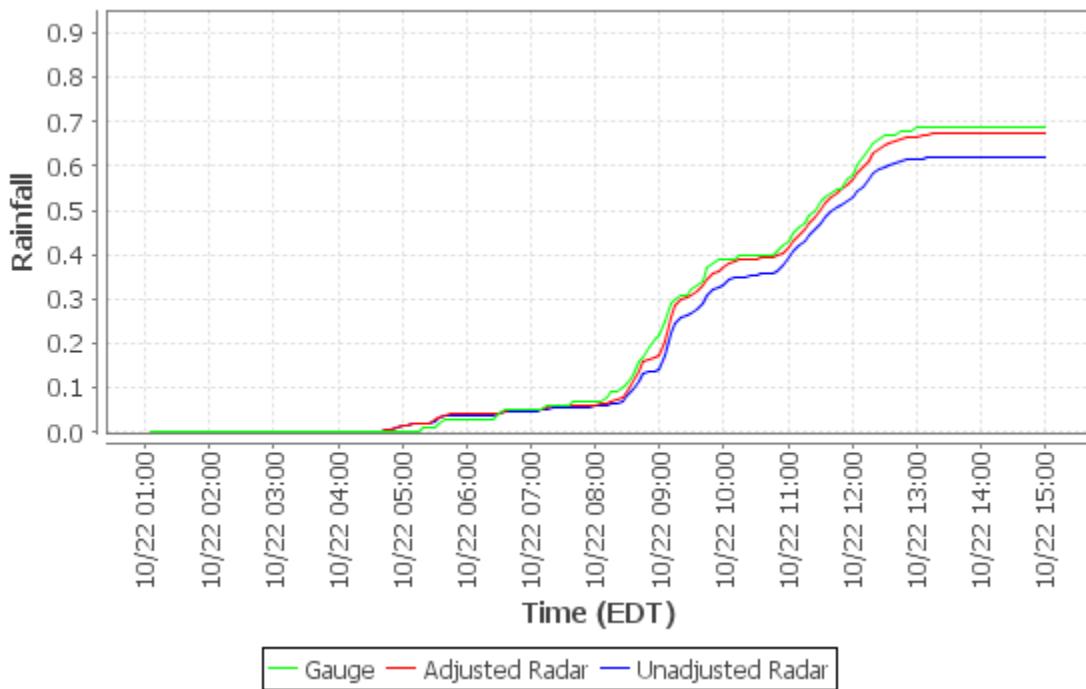
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



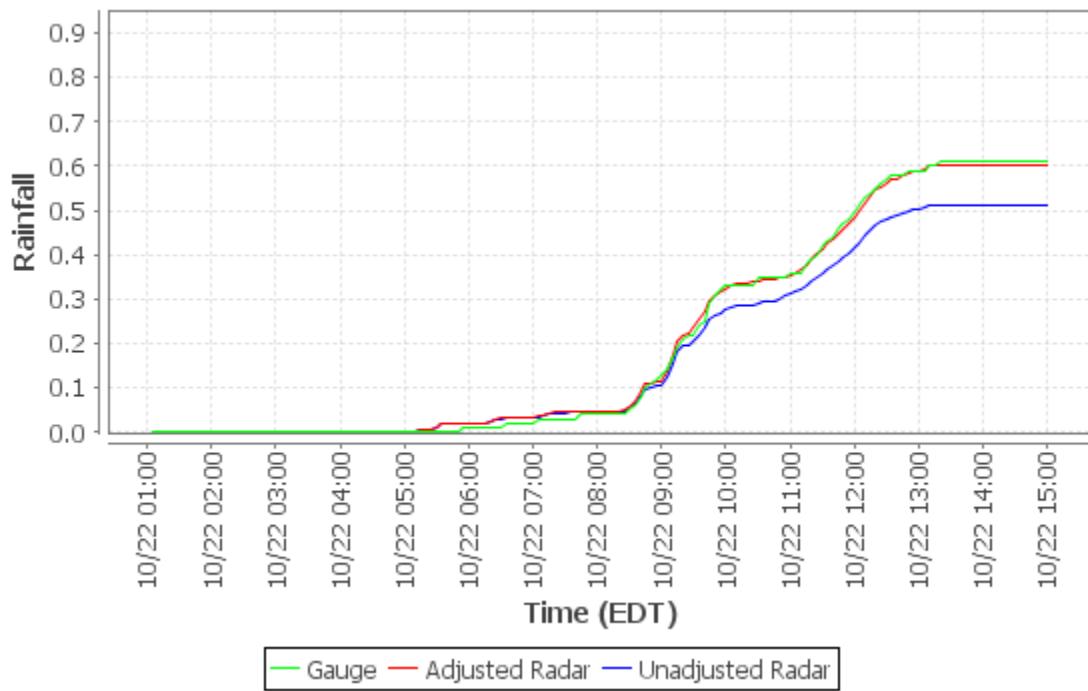
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



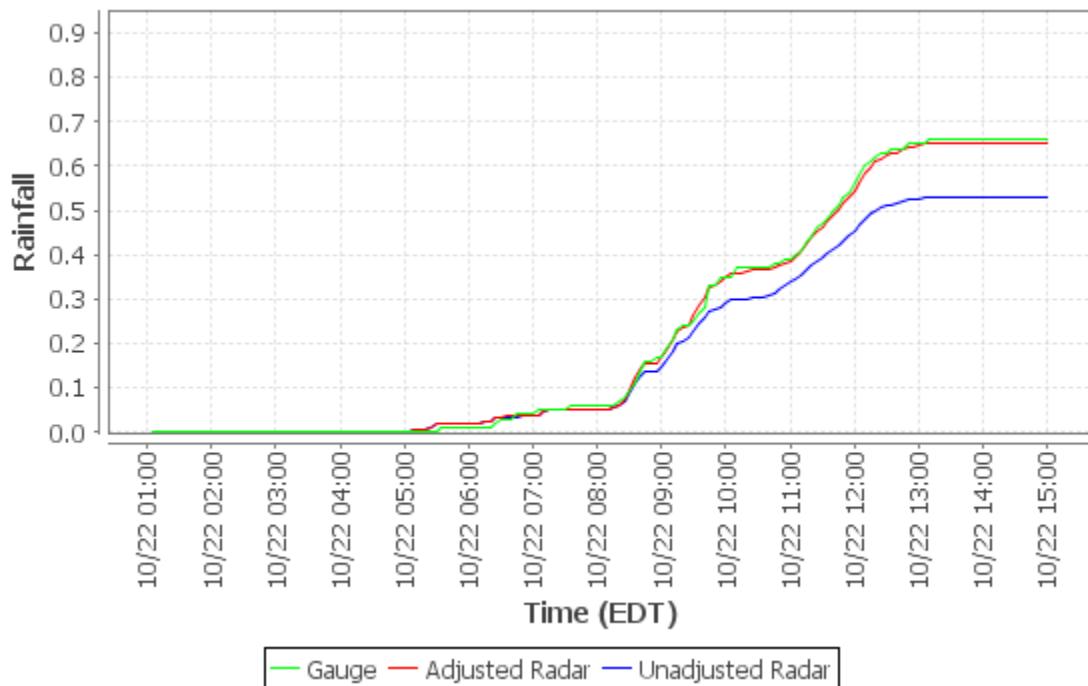
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



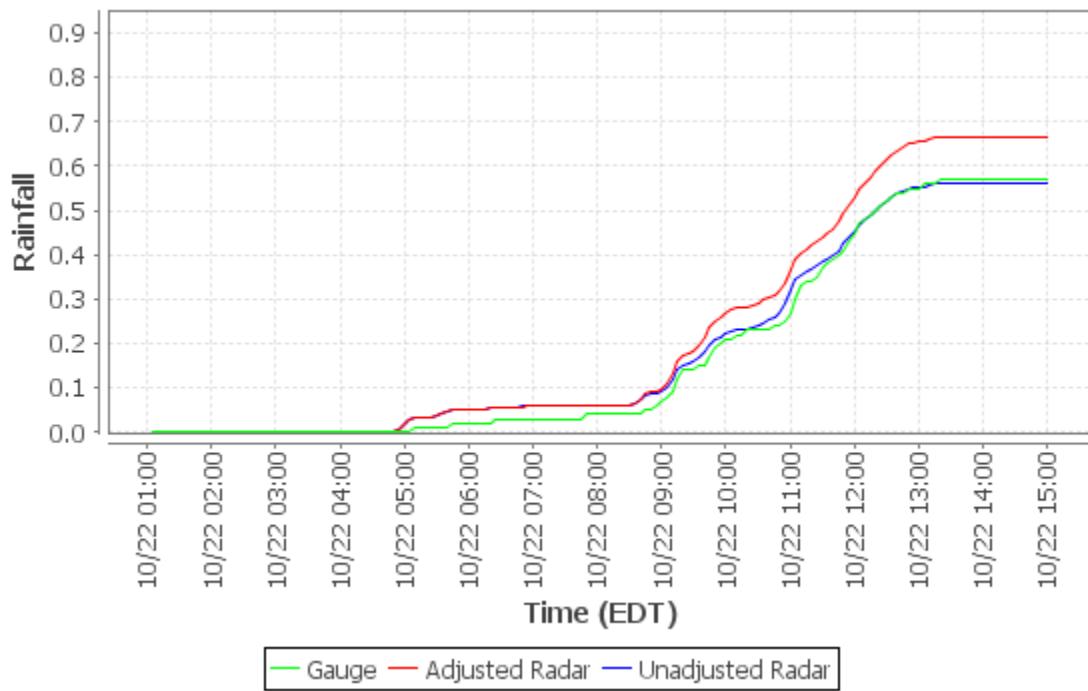
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



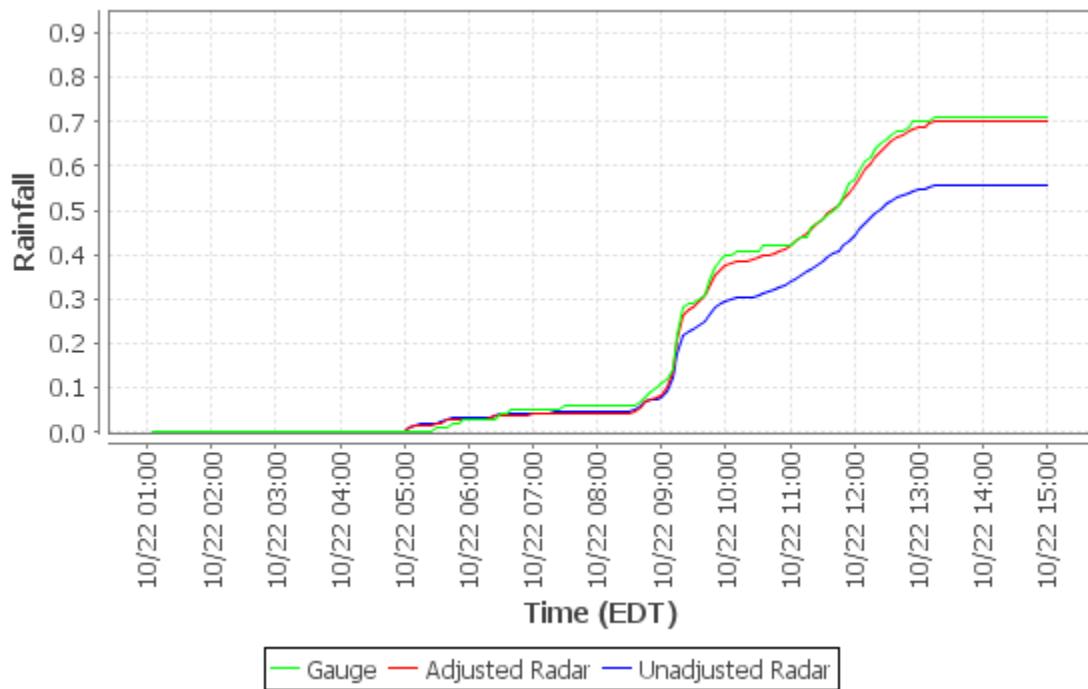
Cumulative Distribution Plot - Baldwin (Loc12)



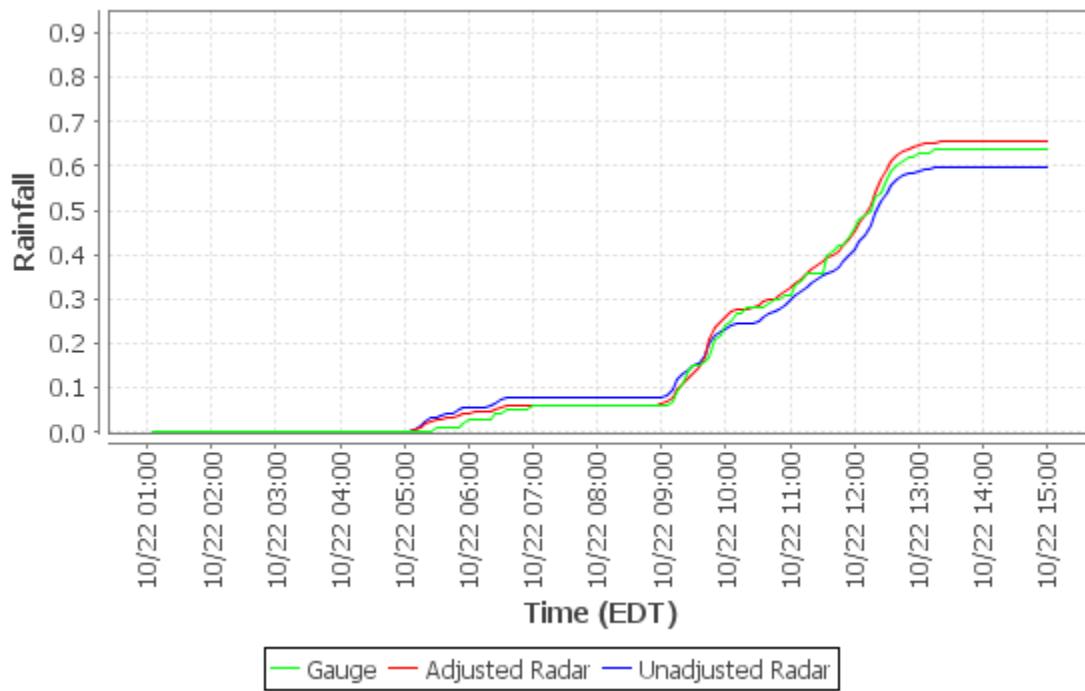
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



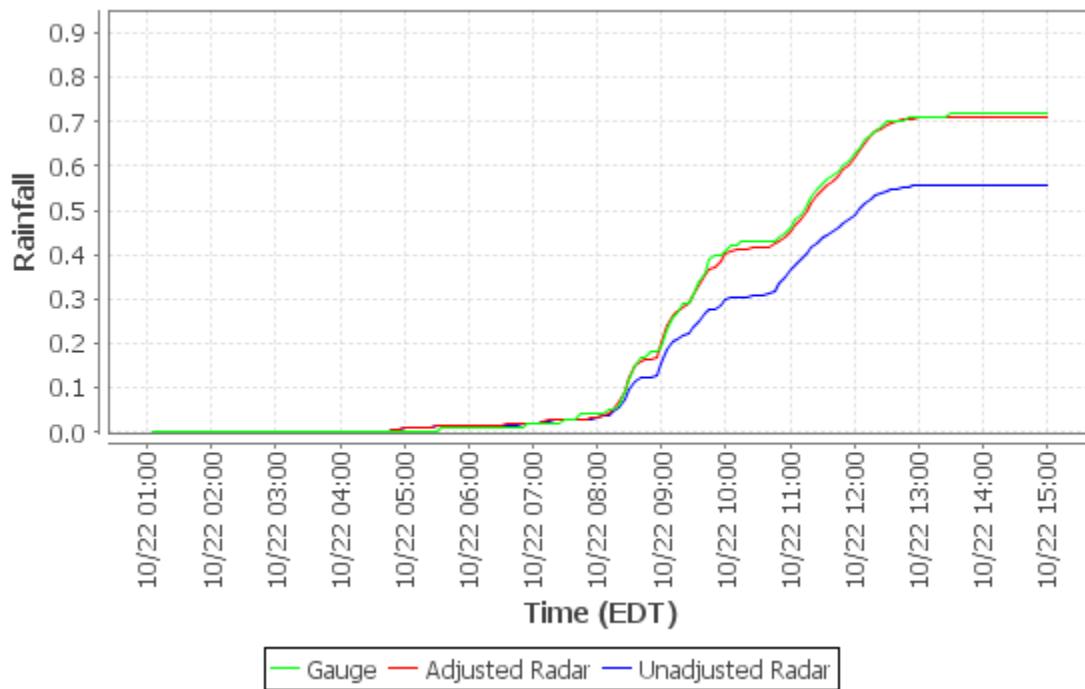
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



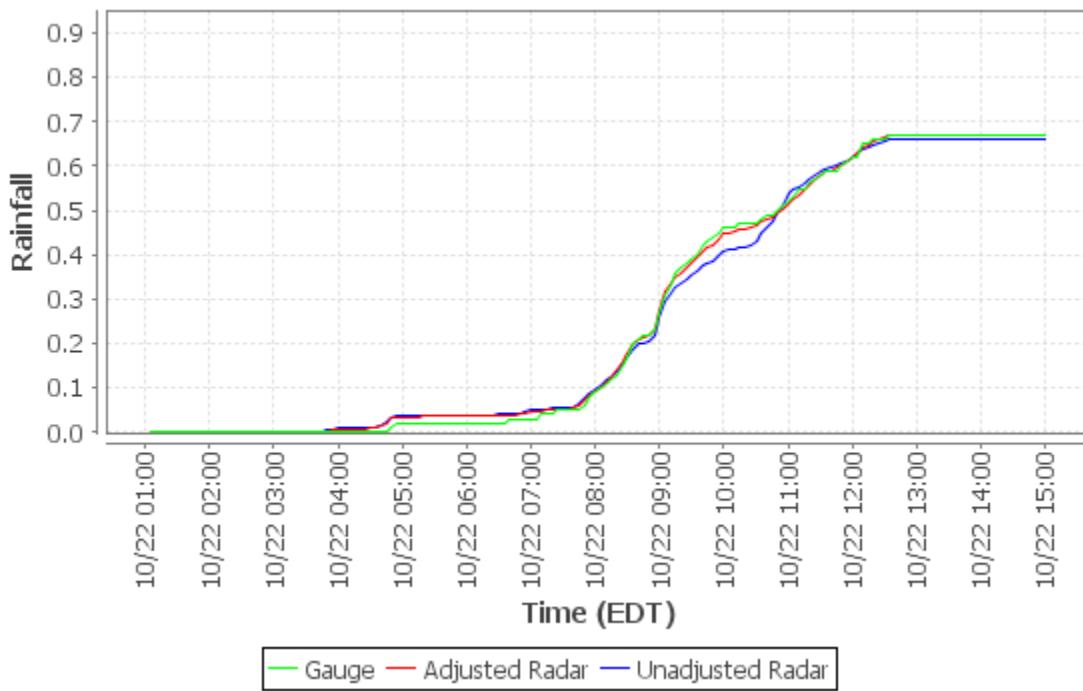
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



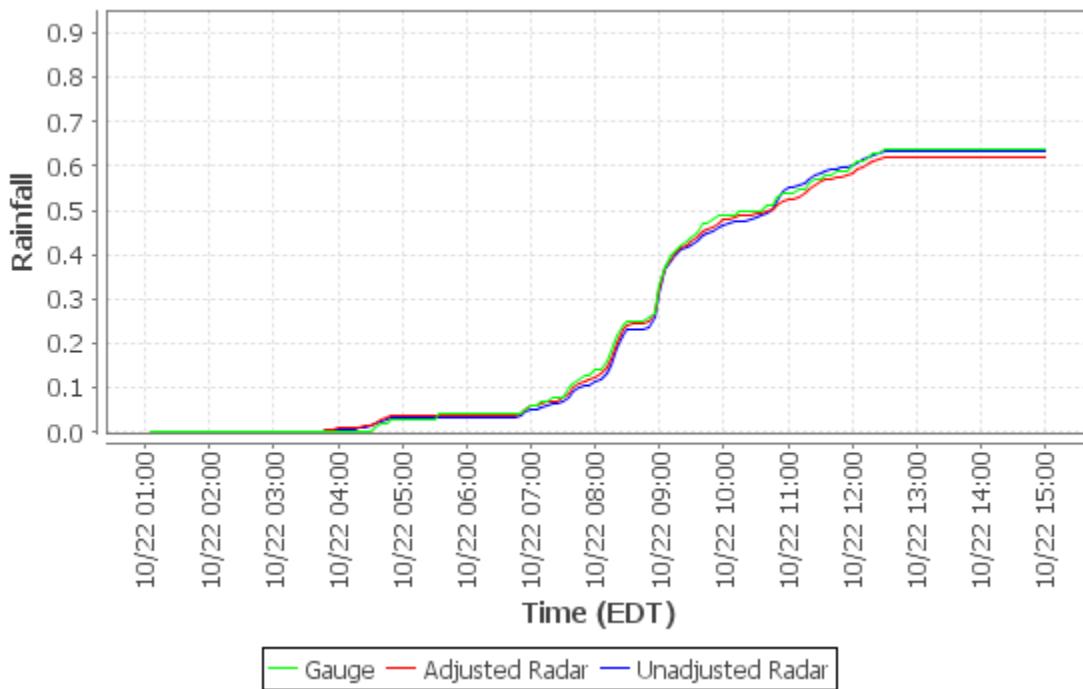
Cumulative Distribution Plot - Castle Shannon (Loc16)



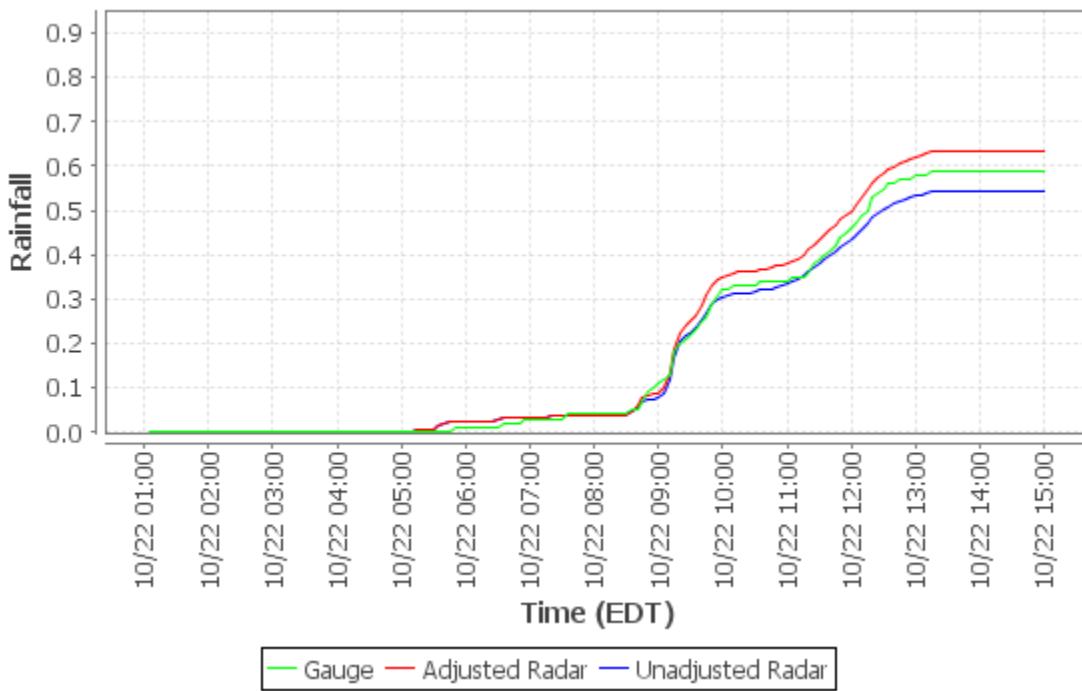
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



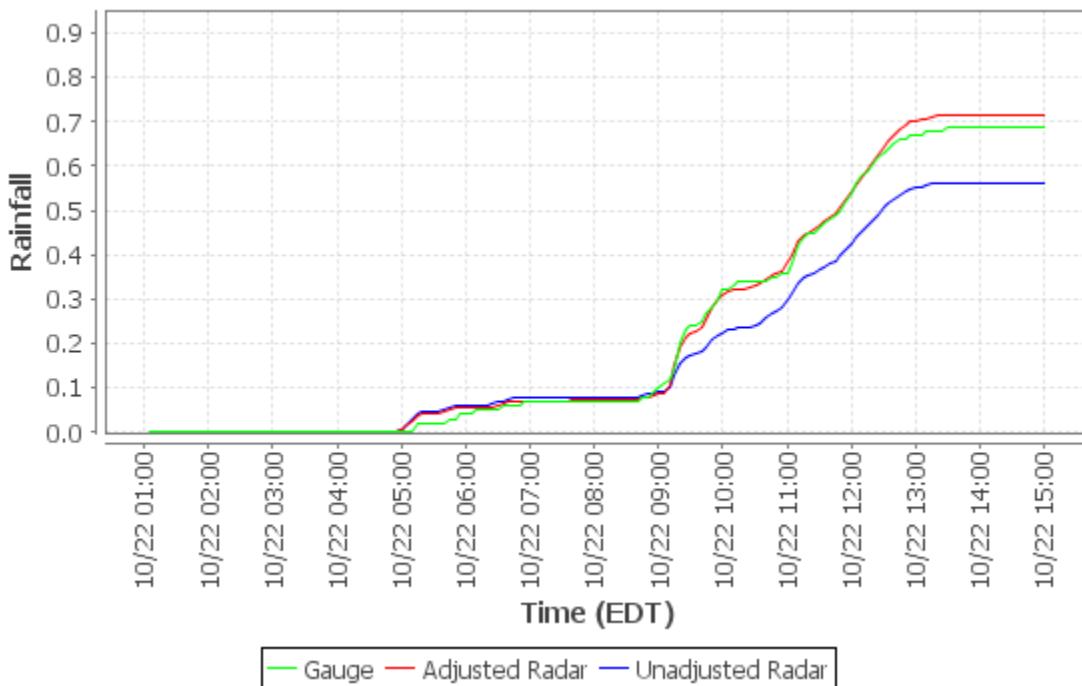
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



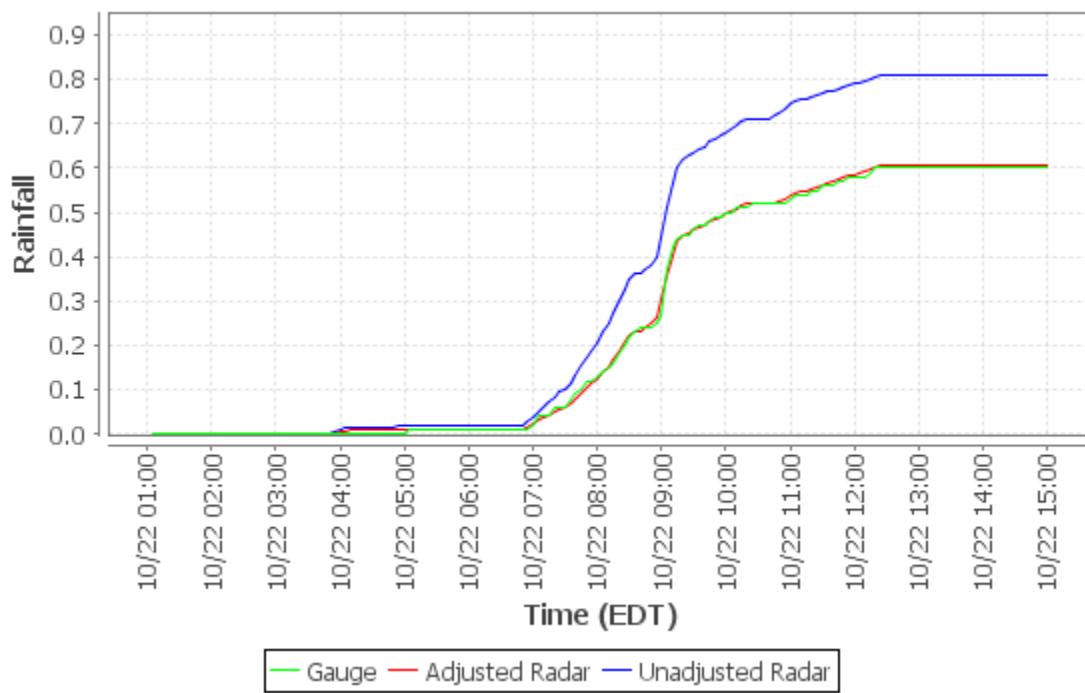
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



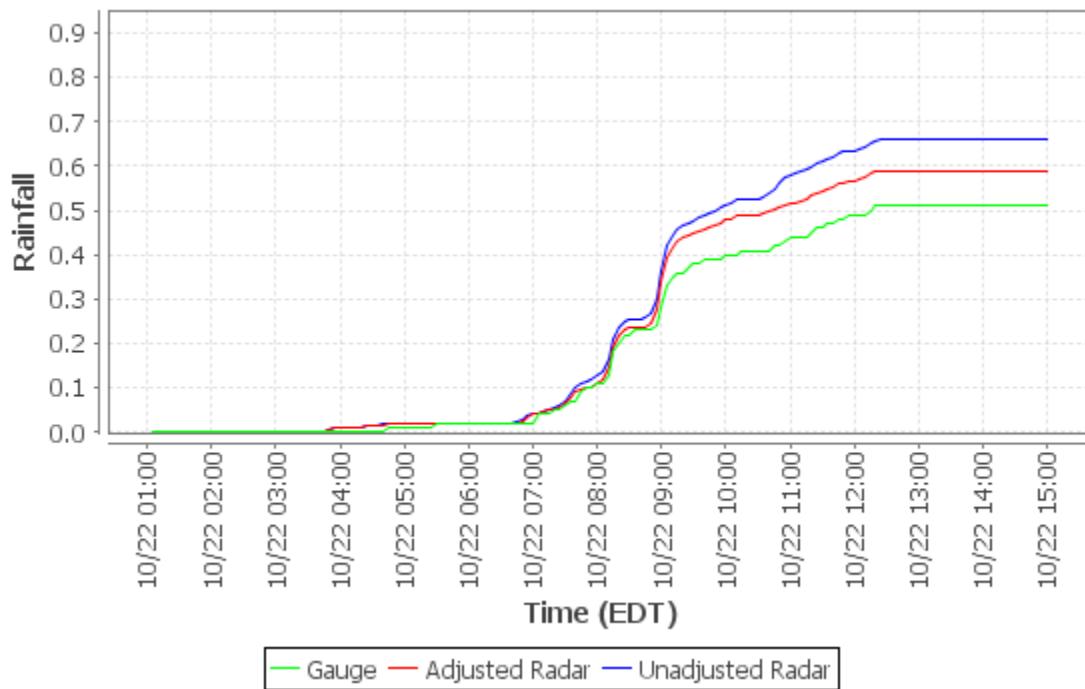
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



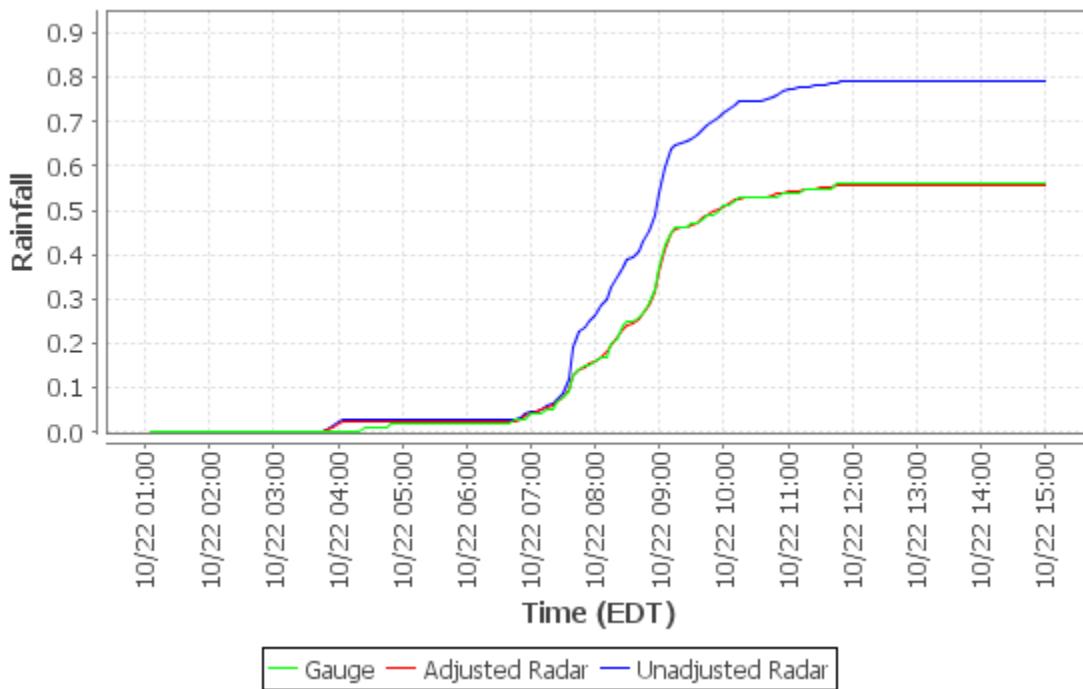
Cumulative Distribution Plot - Moon TWP (Loc21)



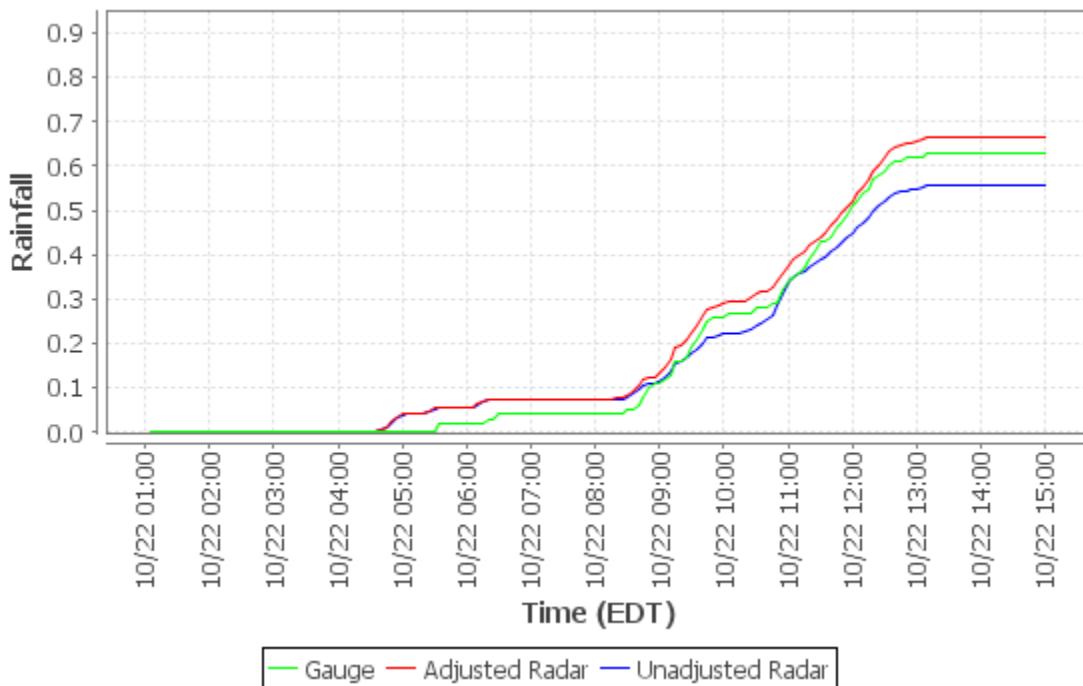
Cumulative Distribution Plot - North Fayette TWP (Loc22)



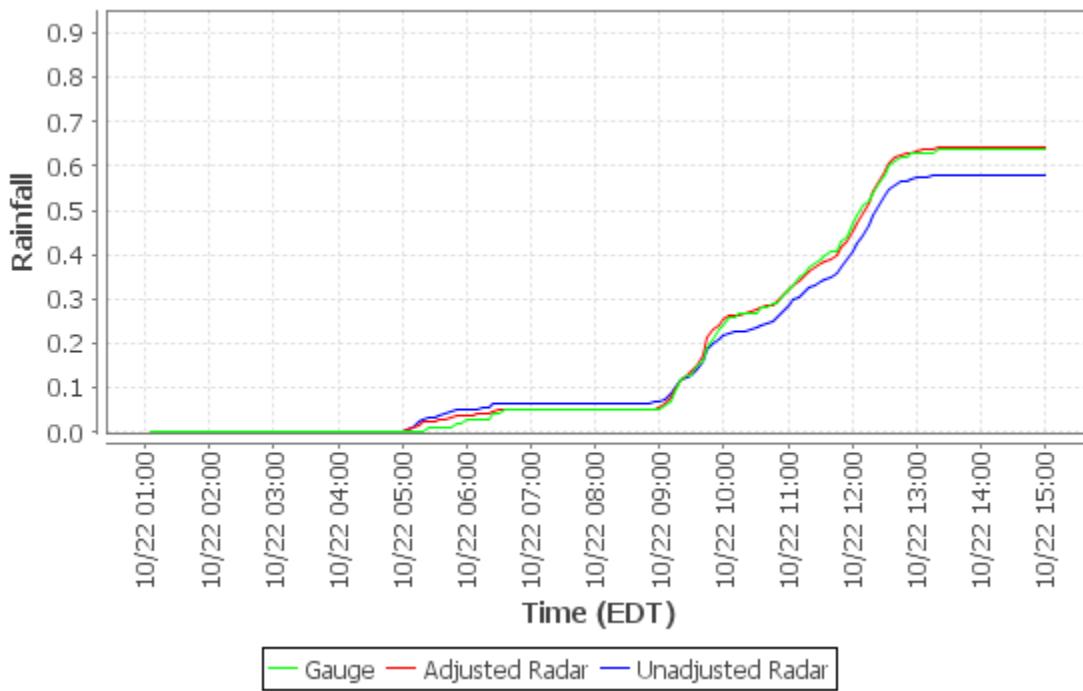
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



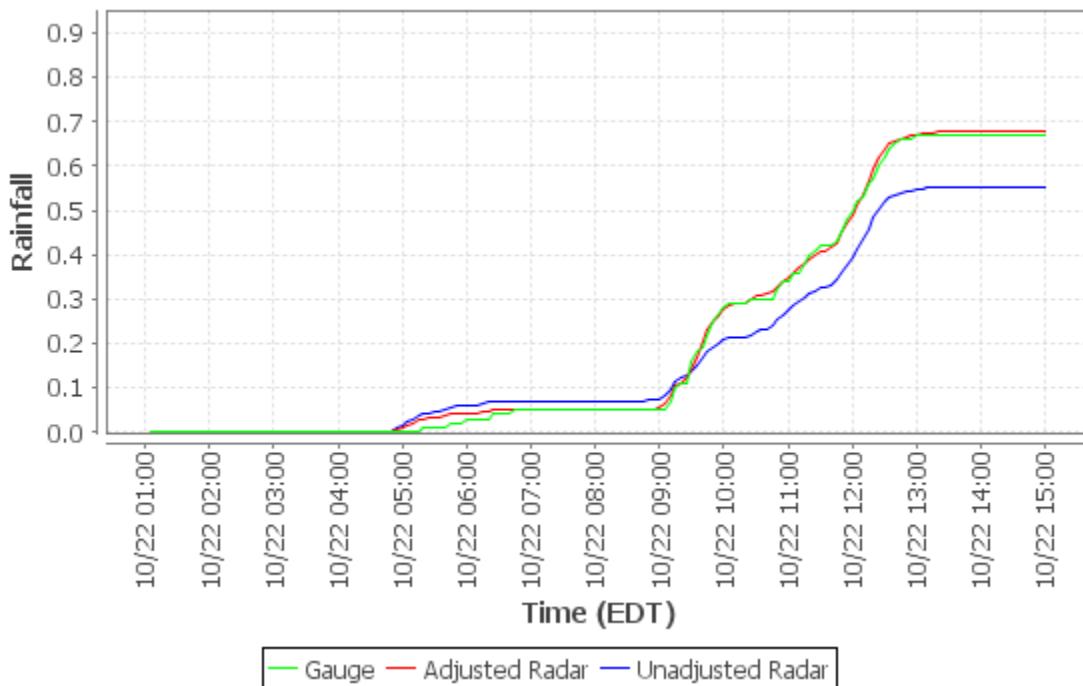
Cumulative Distribution Plot - Jefferson Hills (Loc24)



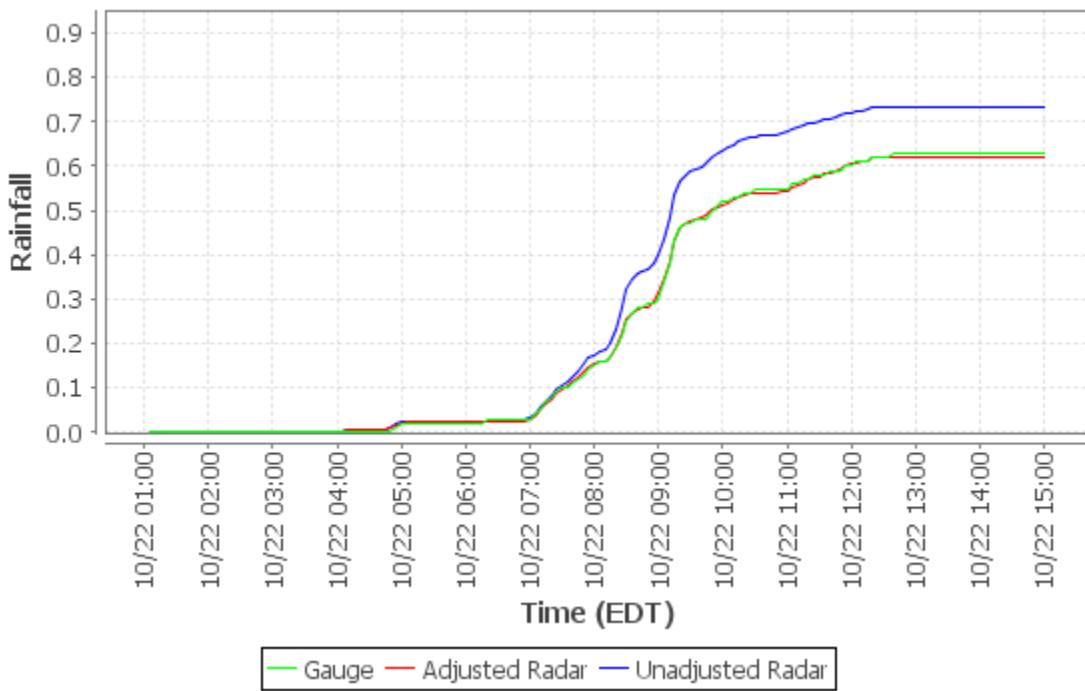
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



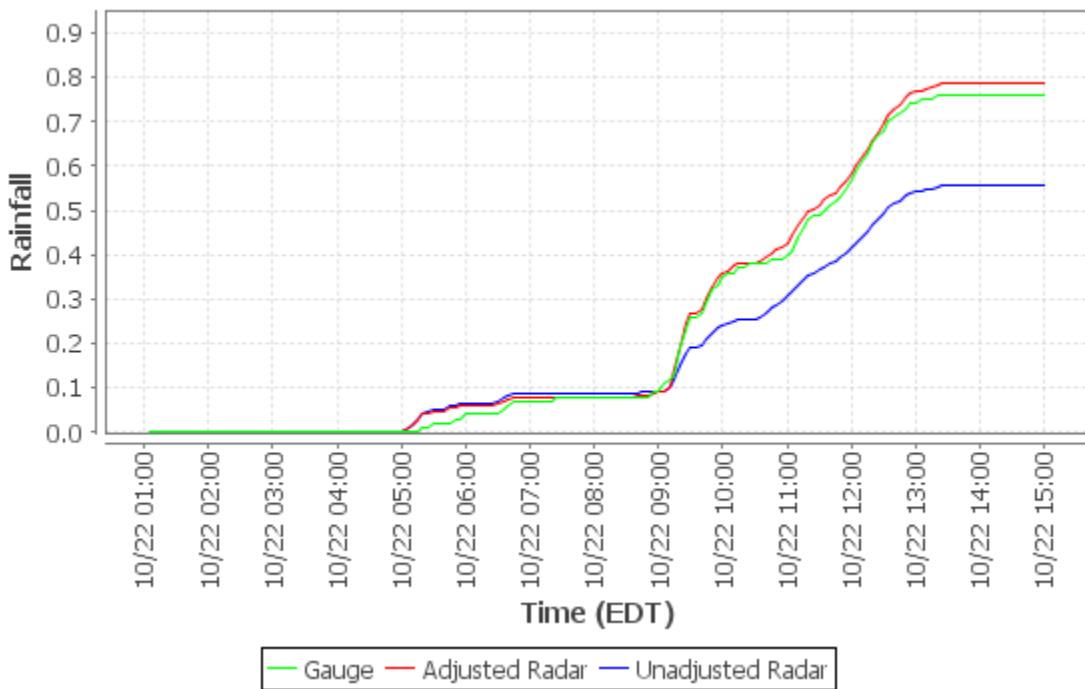
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



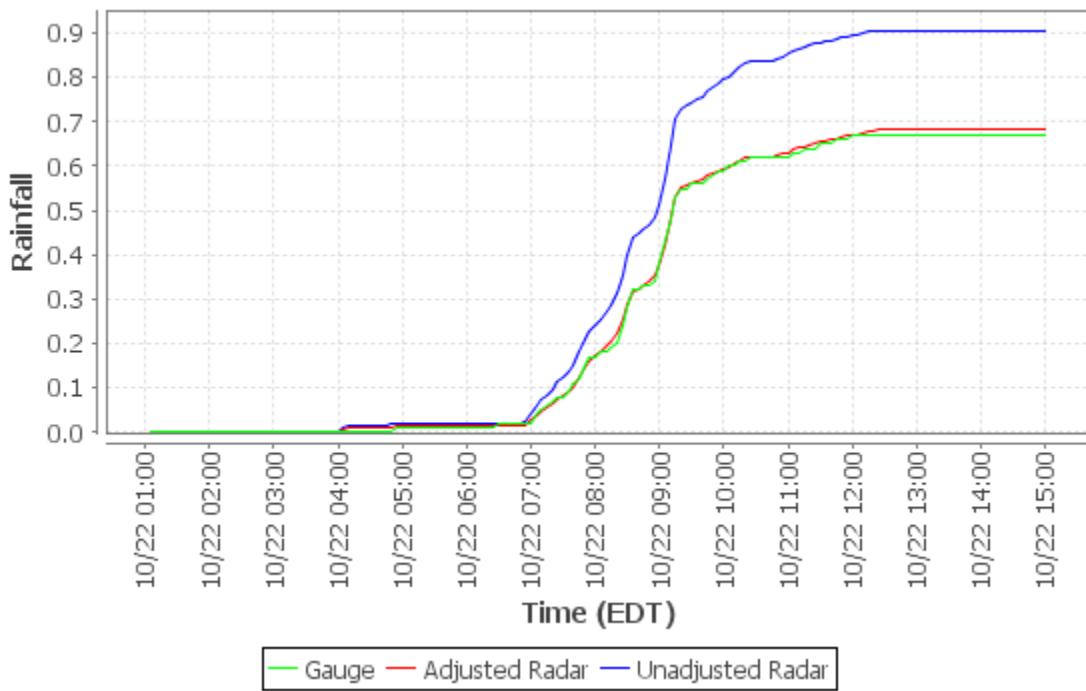
Cumulative Distribution Plot - Marshall TWP (Loc27)



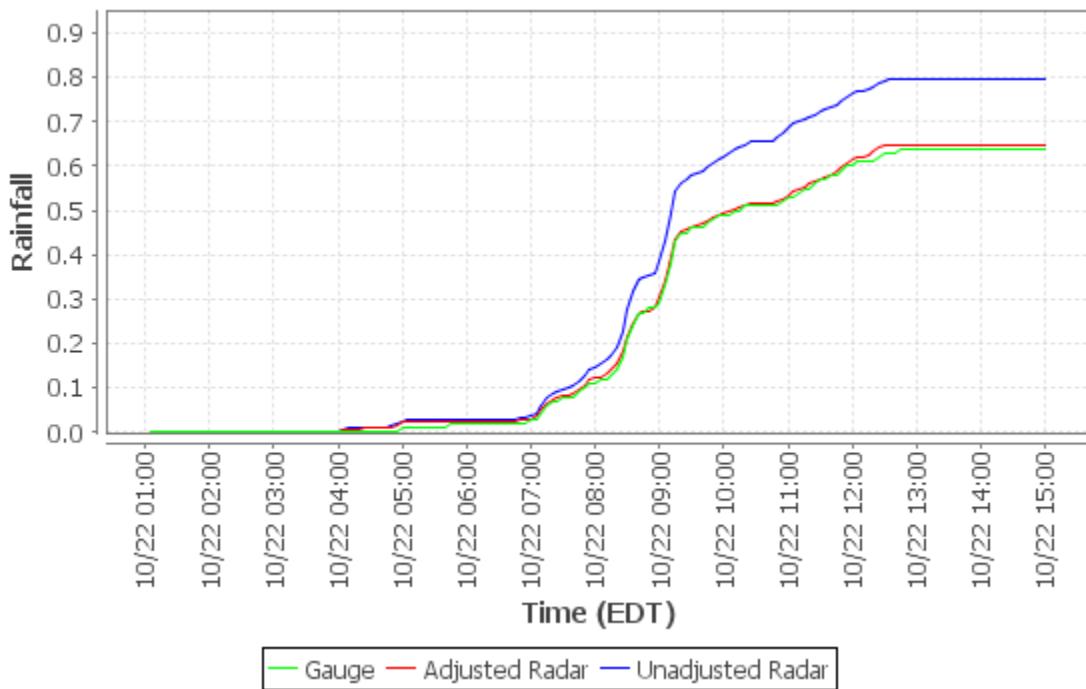
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



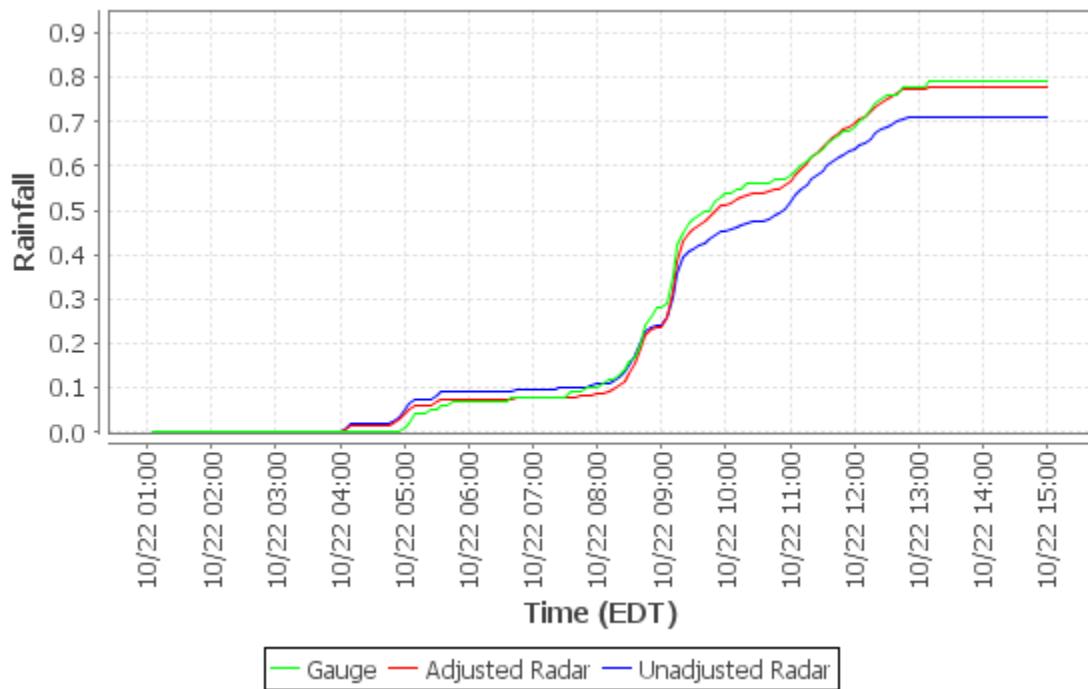
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



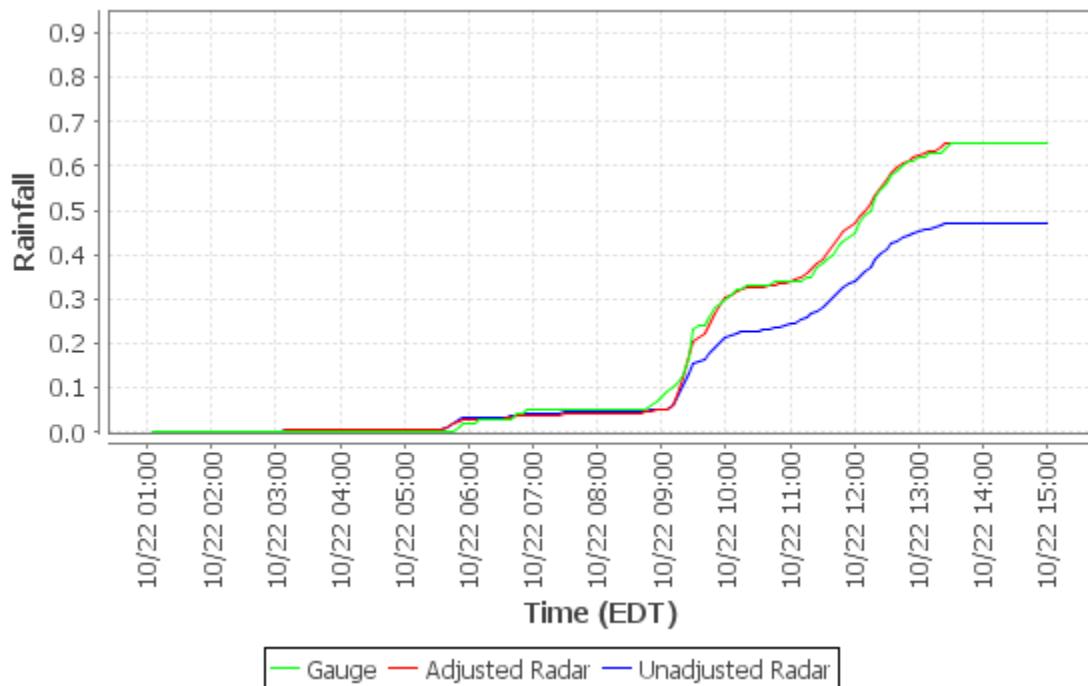
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



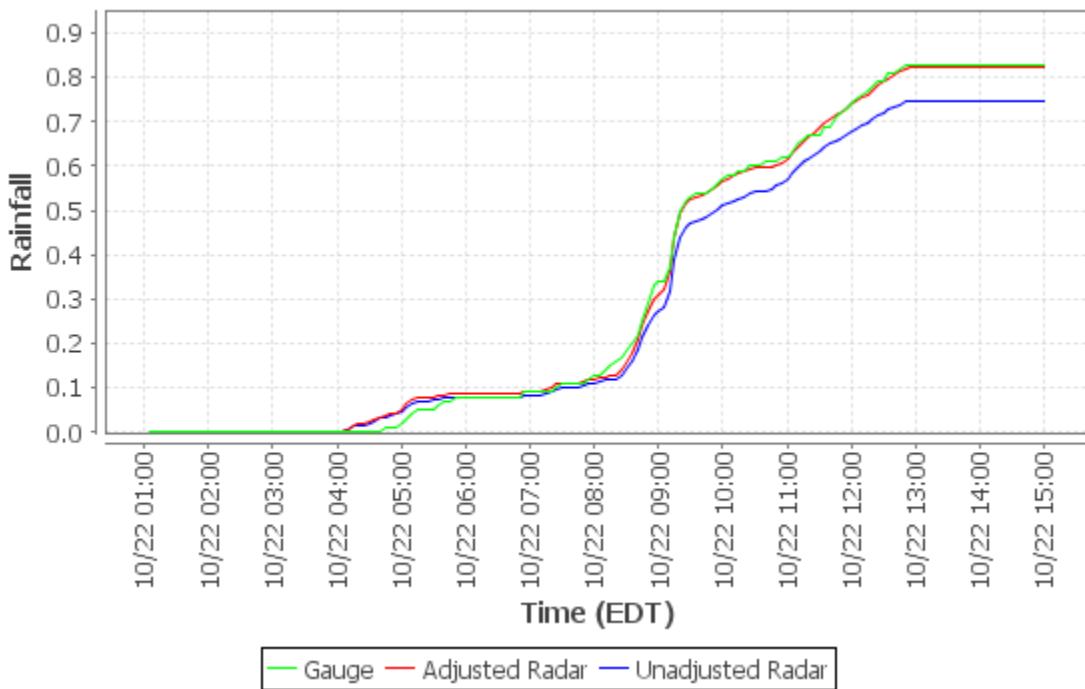
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



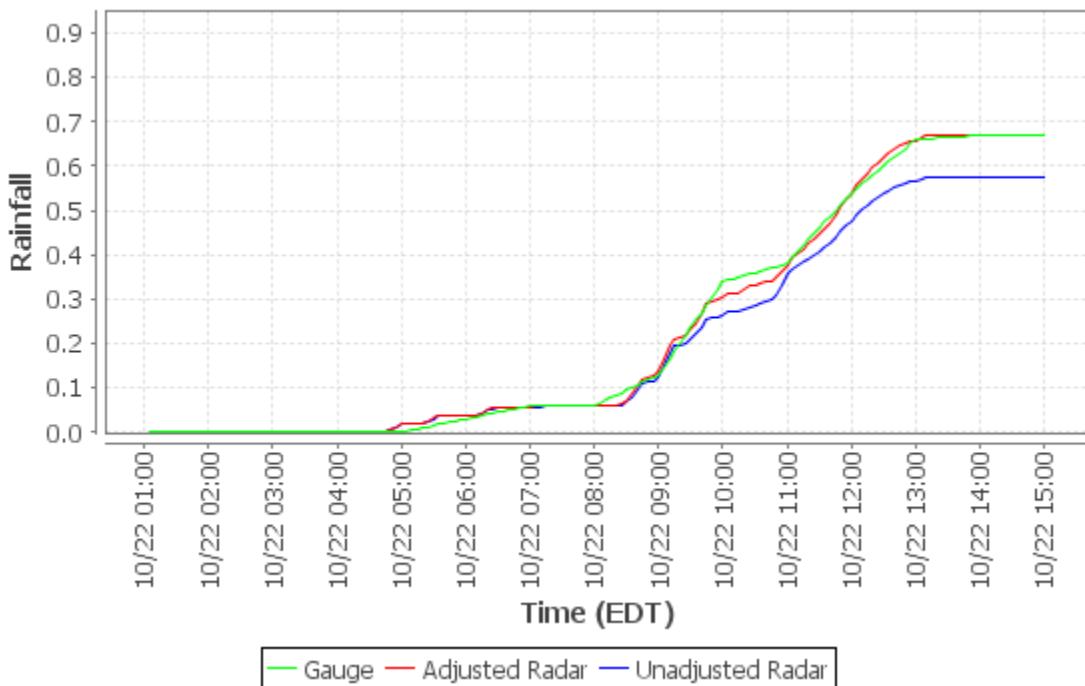
Cumulative Distribution Plot - Arnold (Loc32)



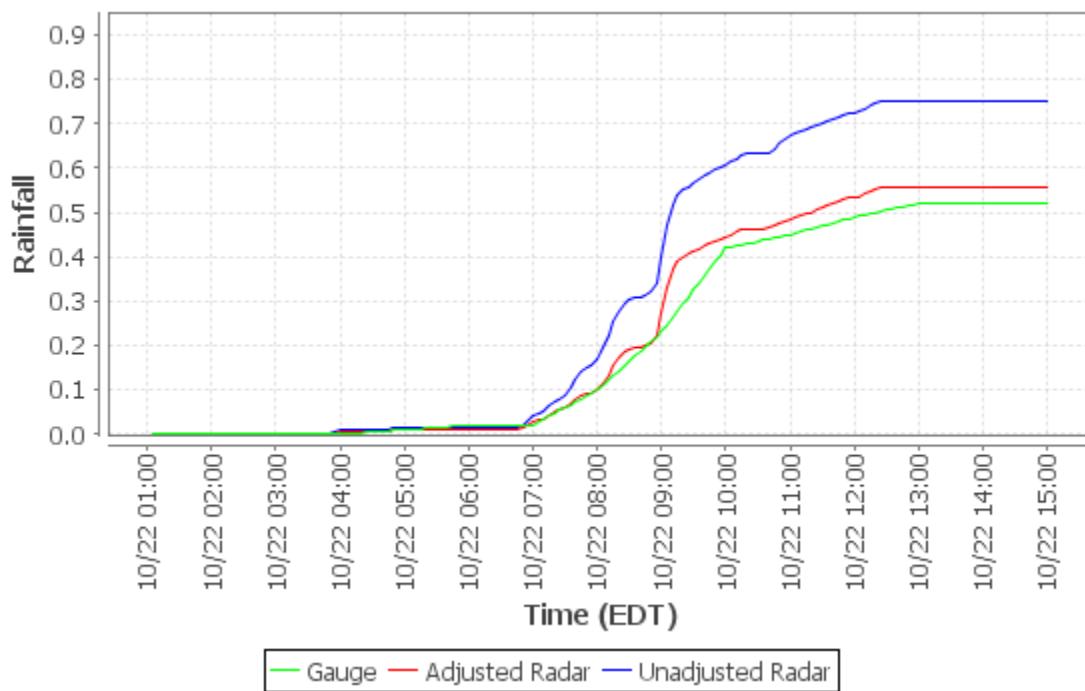
Cumulative Distribution Plot - Richland TWP (Loc33)



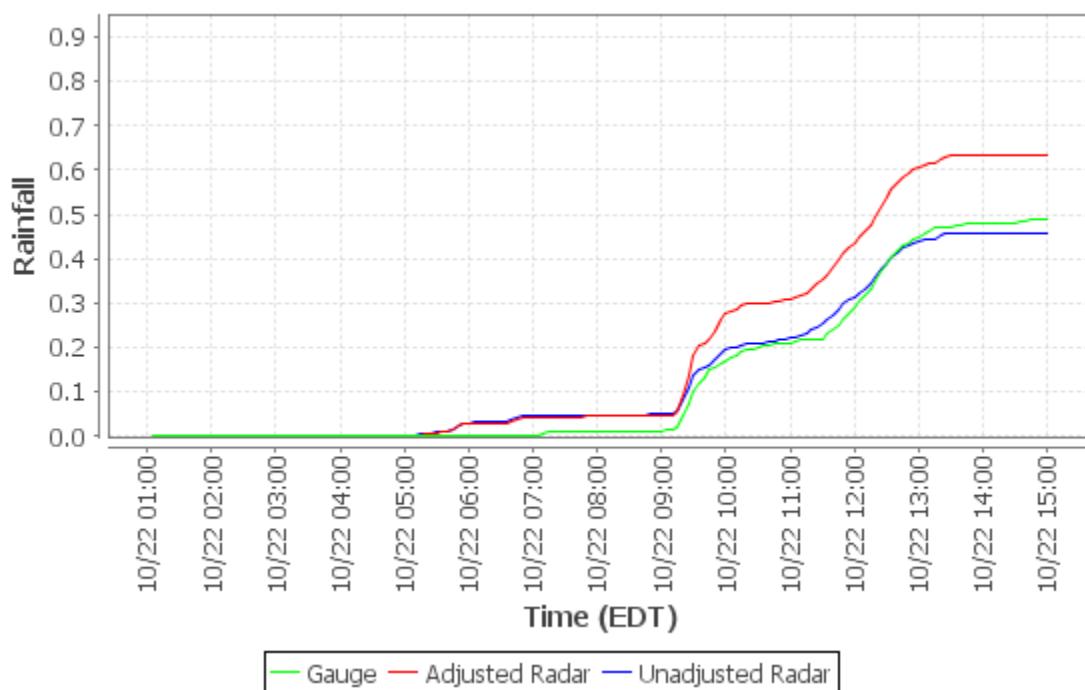
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



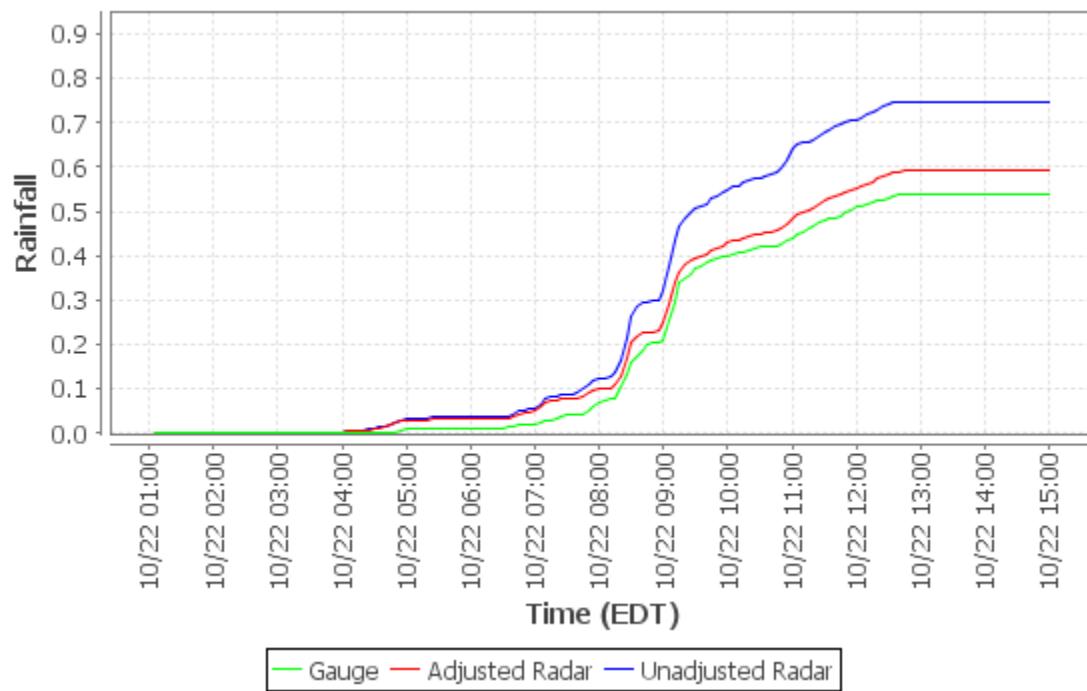
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

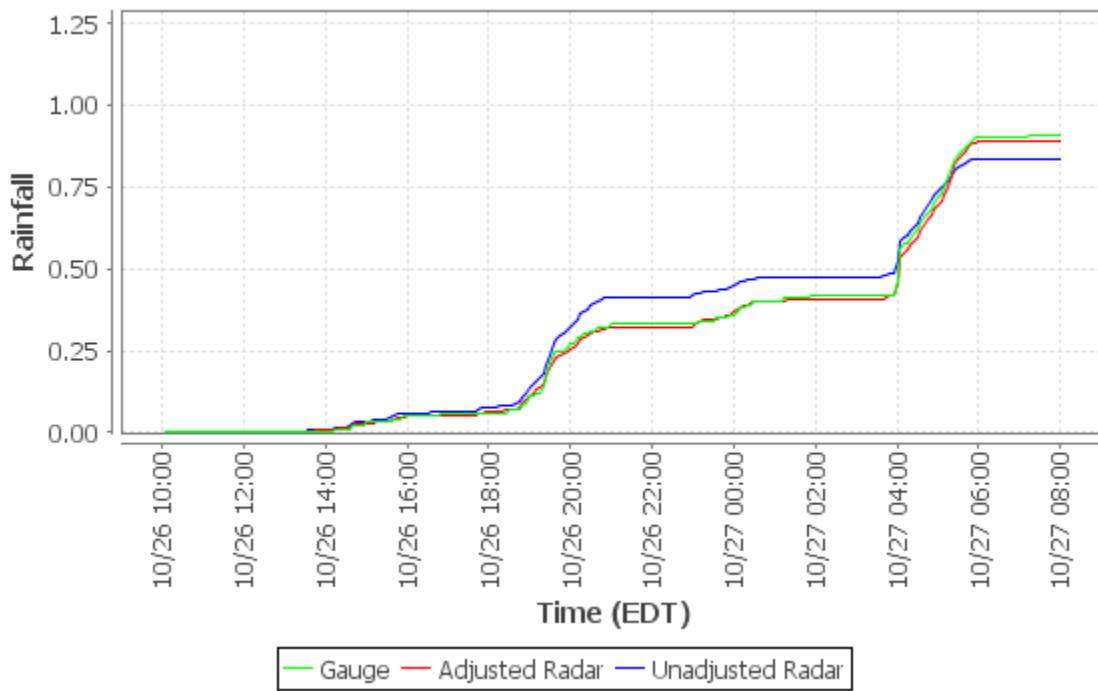


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

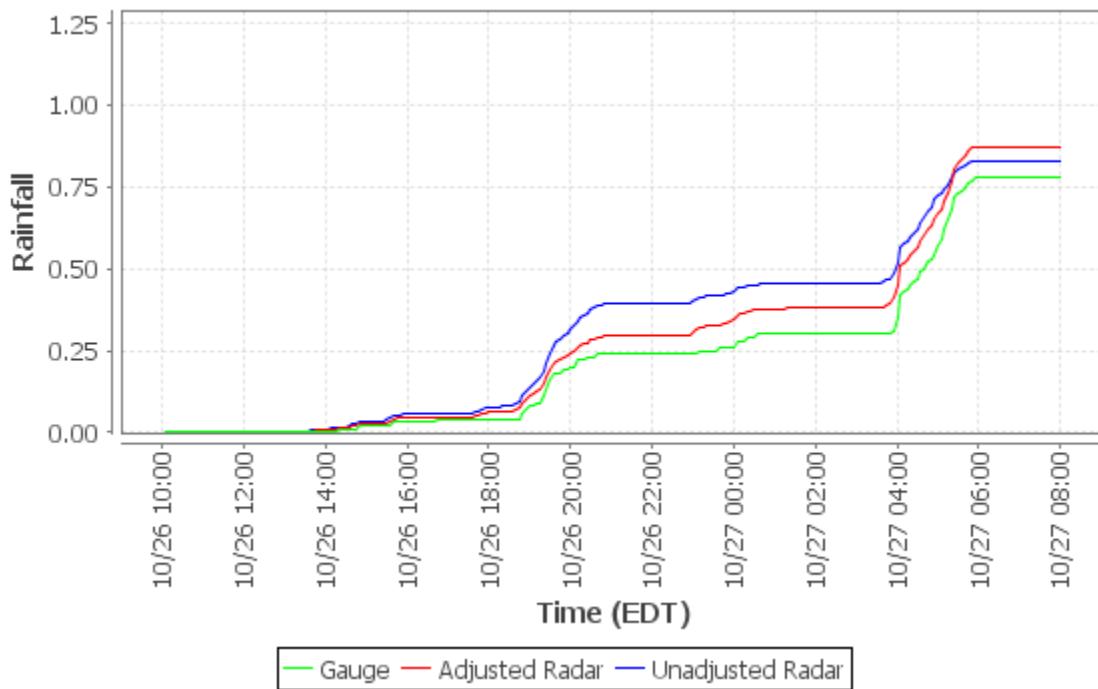


Appendix G - Event 5 (2019-10-27) CDPs

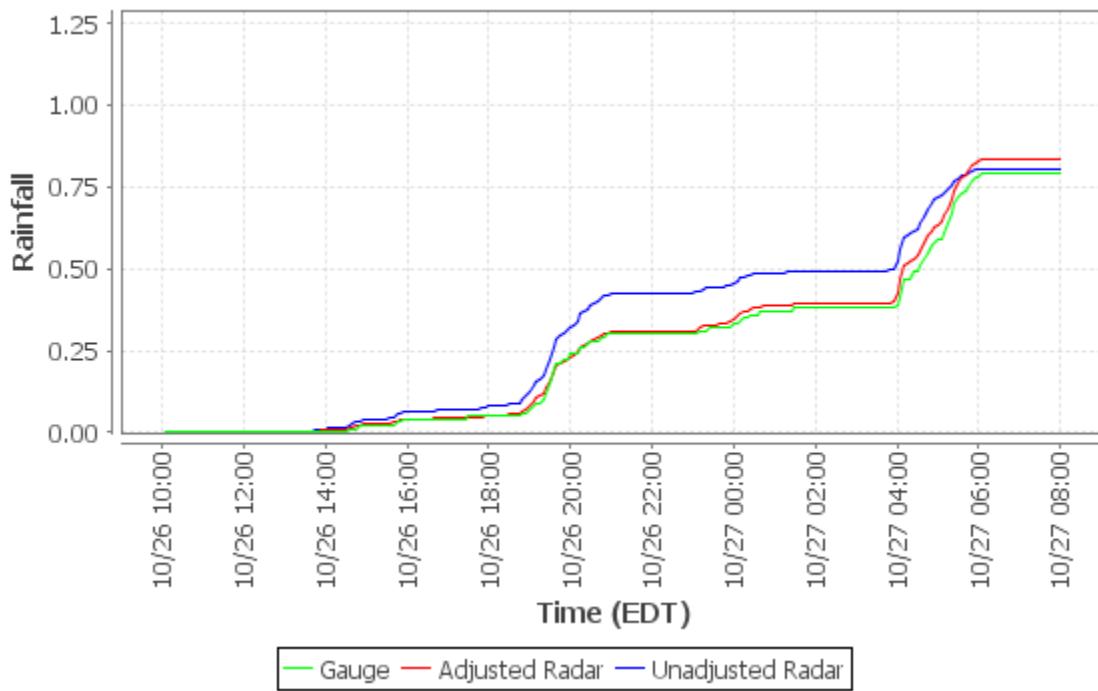
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



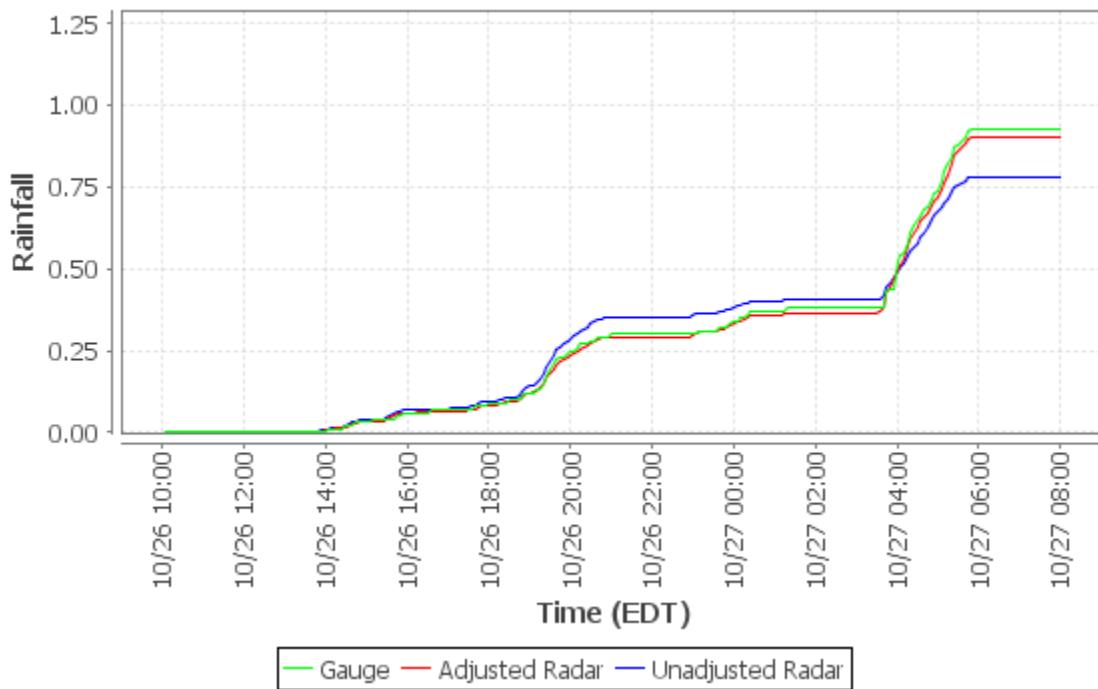
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



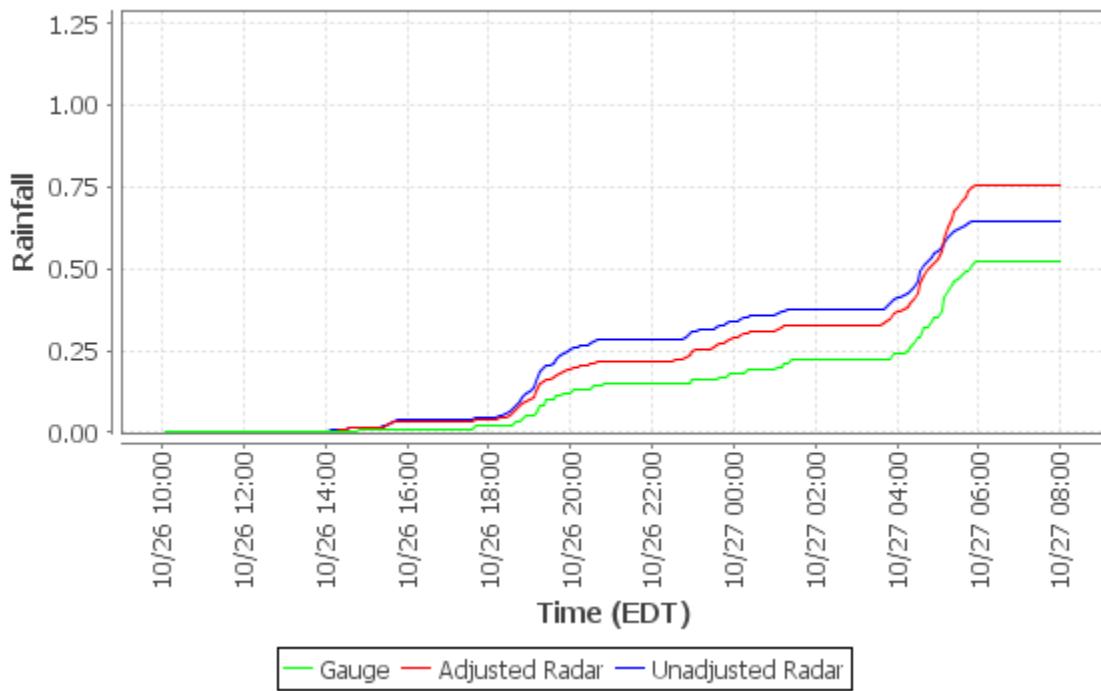
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



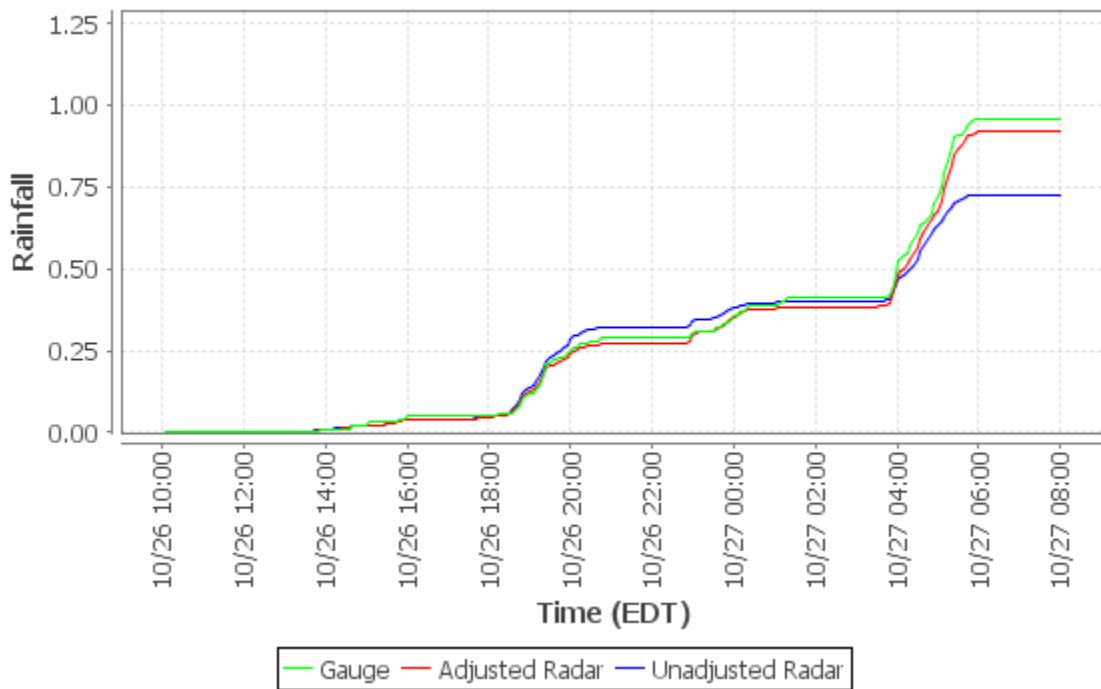
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



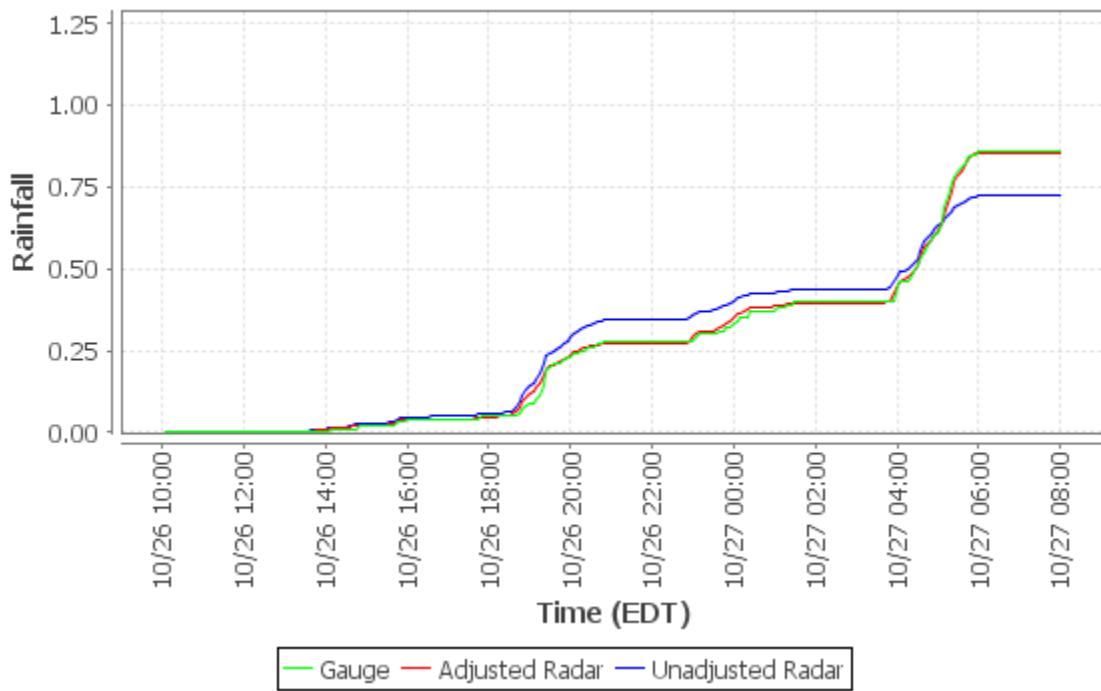
Cumulative Distribution Plot - Upper St. Clair (Loc05)



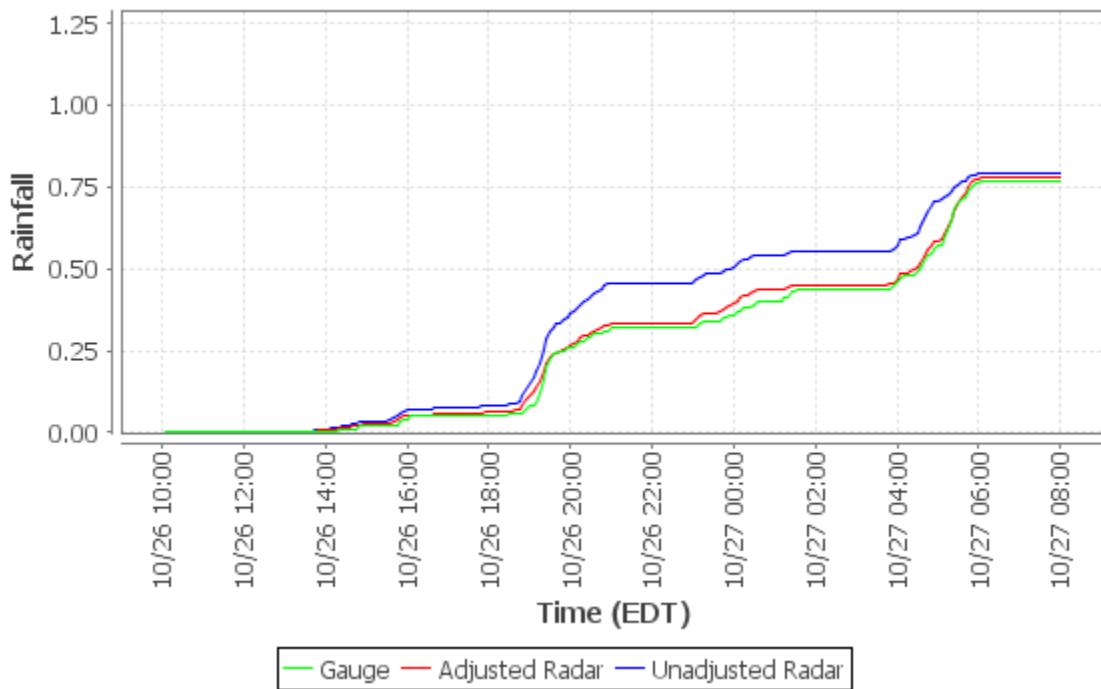
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



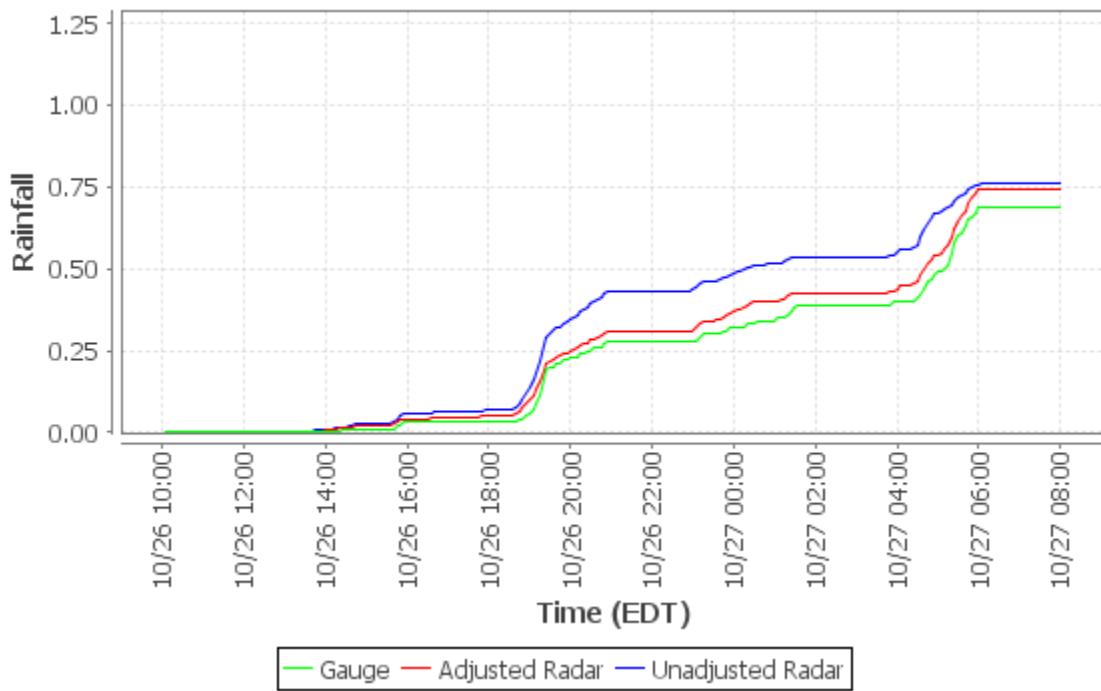
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



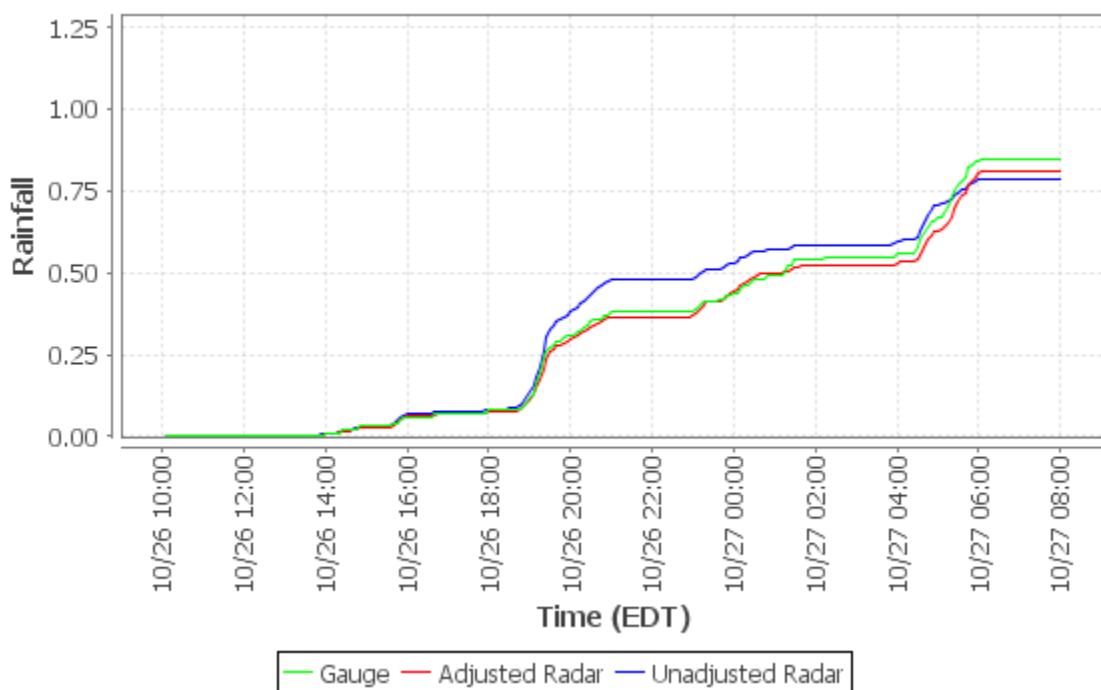
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



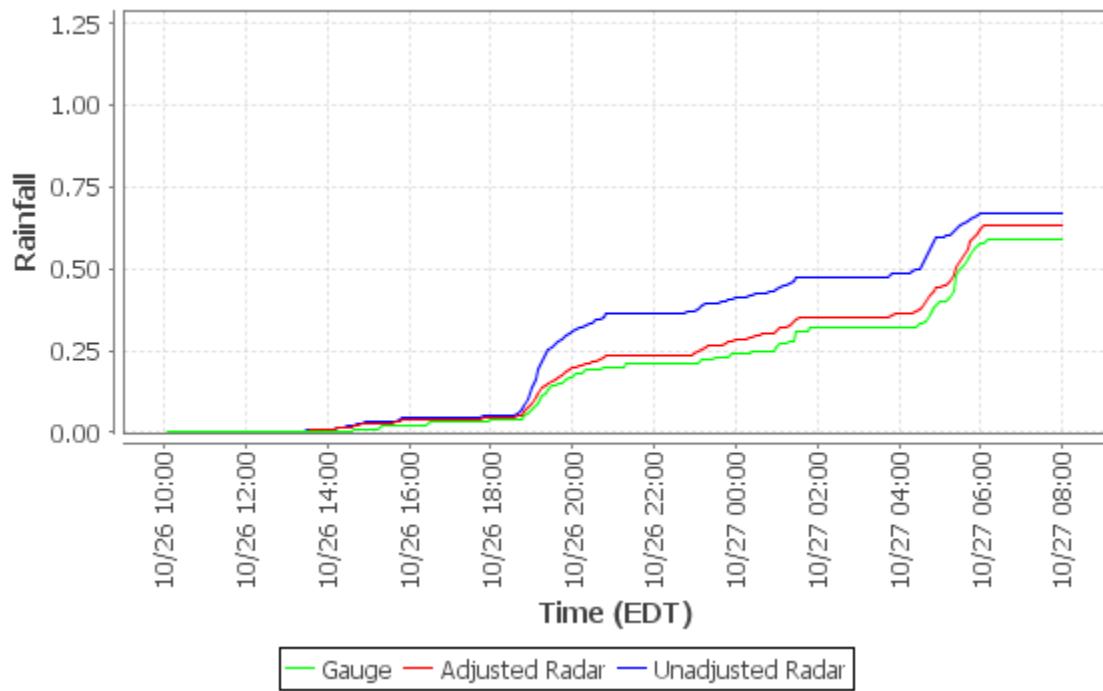
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



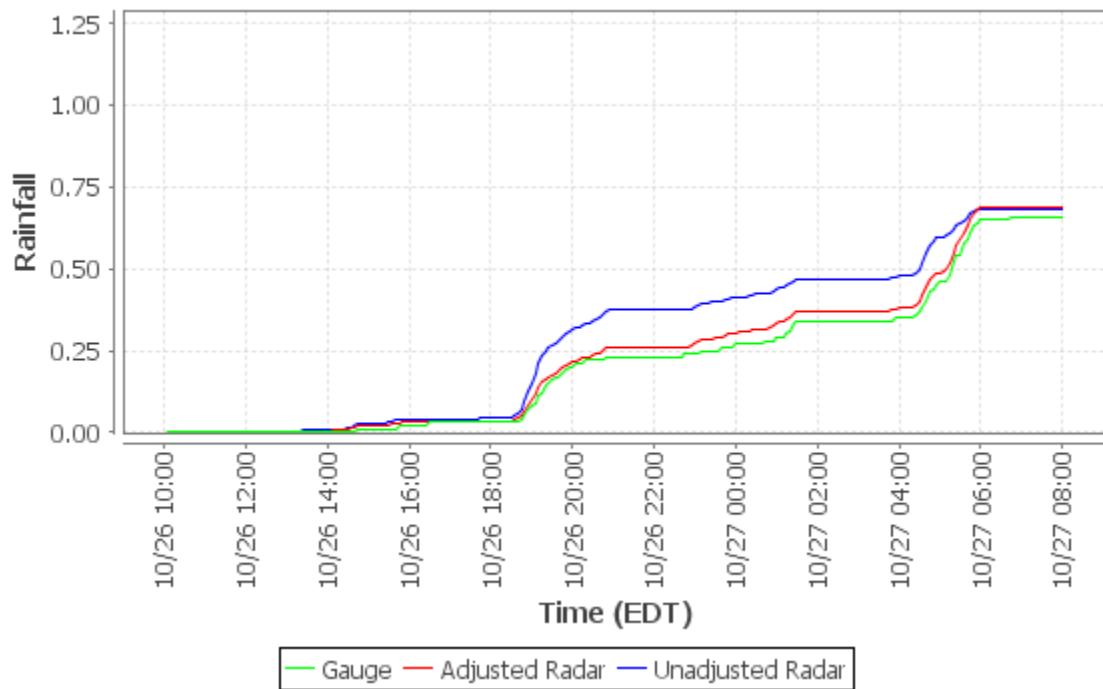
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



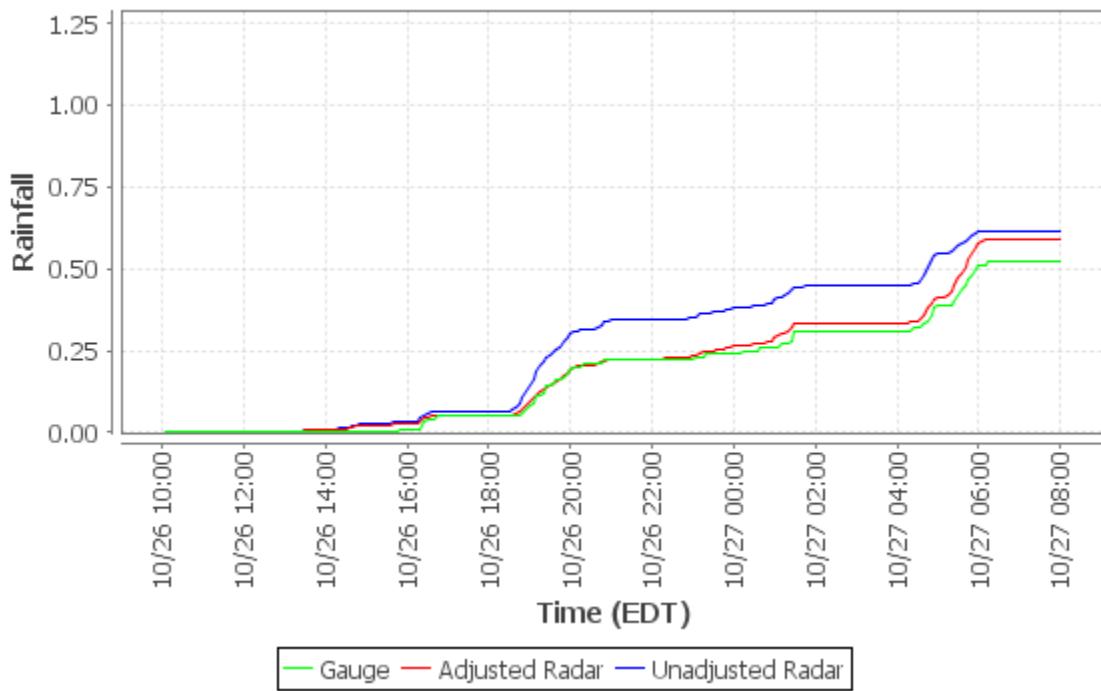
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



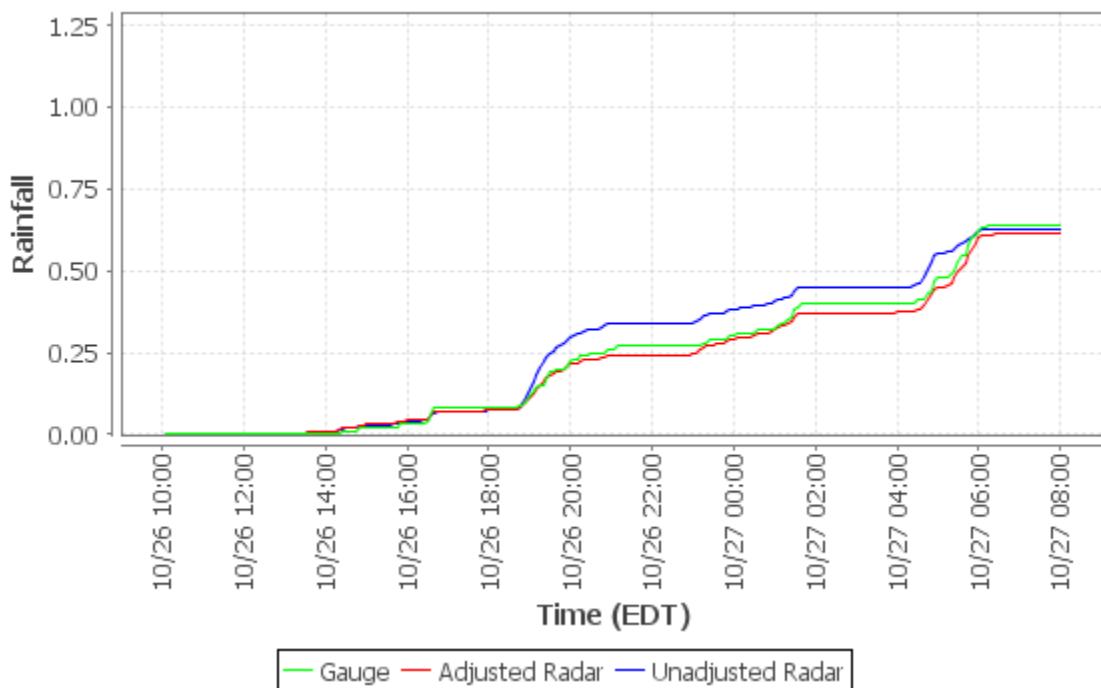
Cumulative Distribution Plot - Baldwin (Loc12)



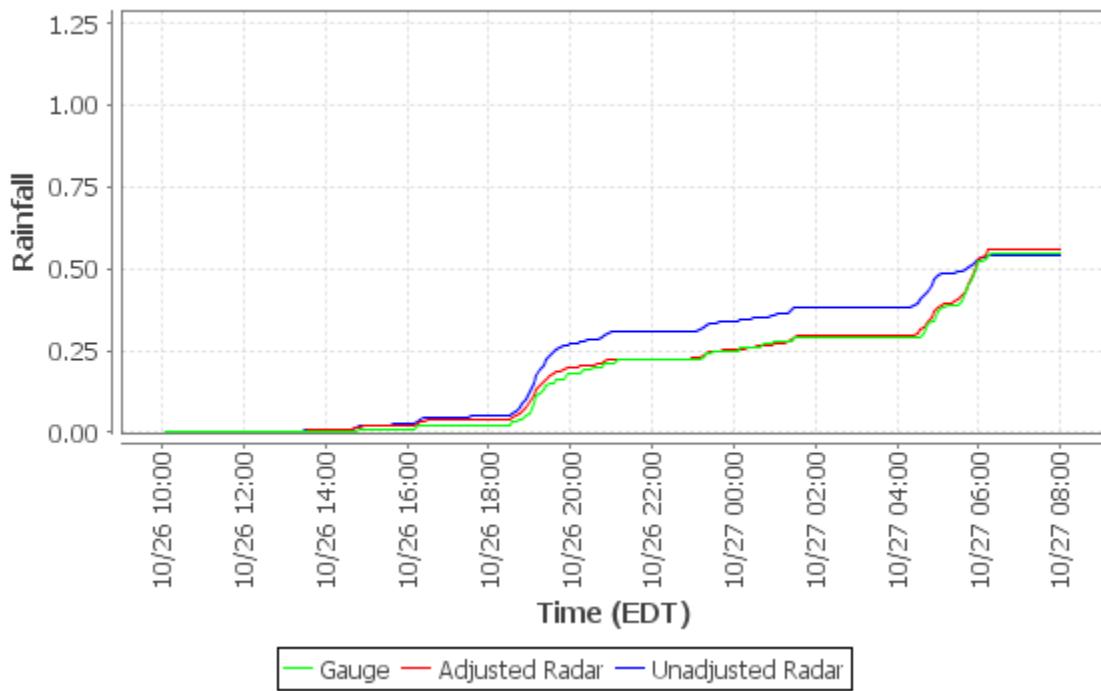
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



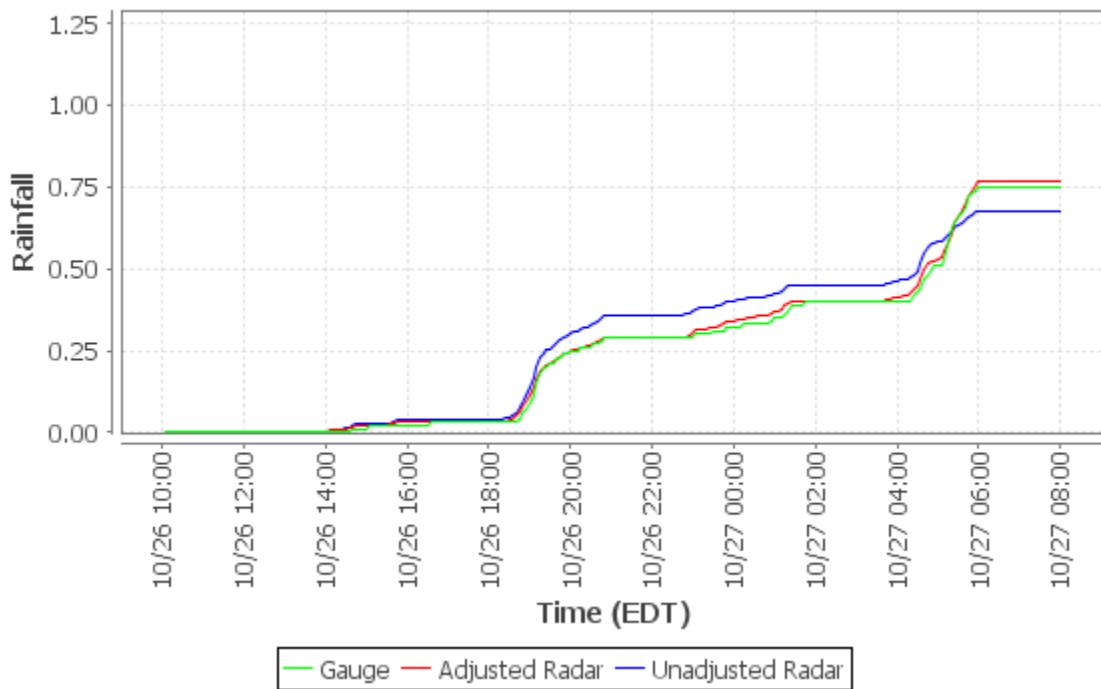
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



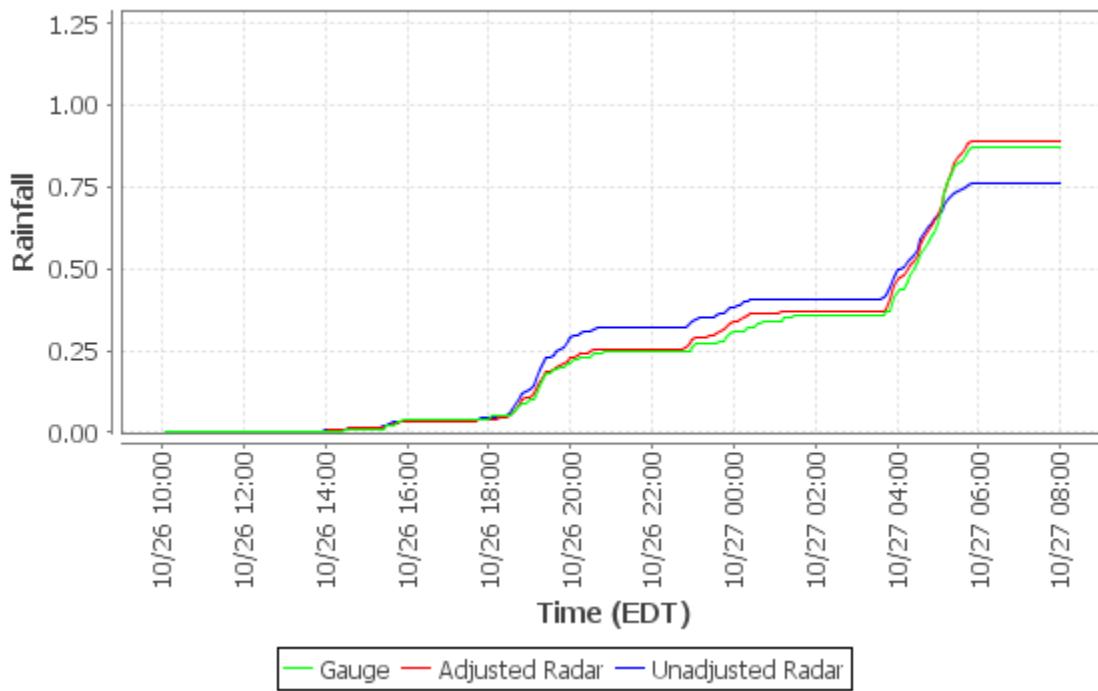
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



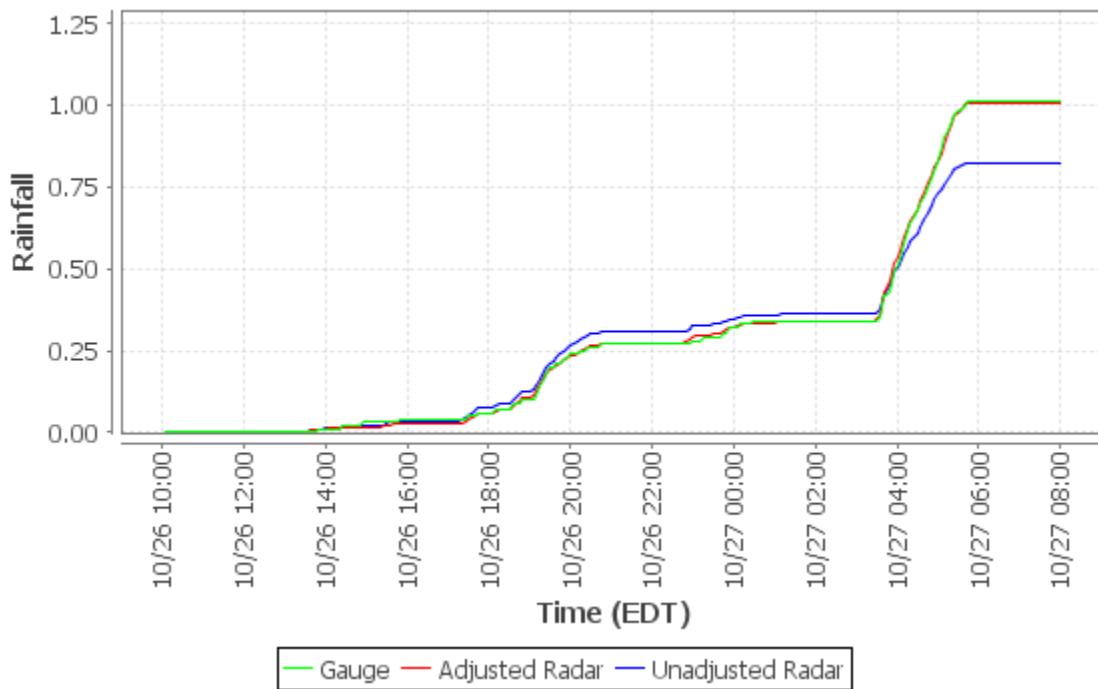
Cumulative Distribution Plot - Castle Shannon (Loc16)



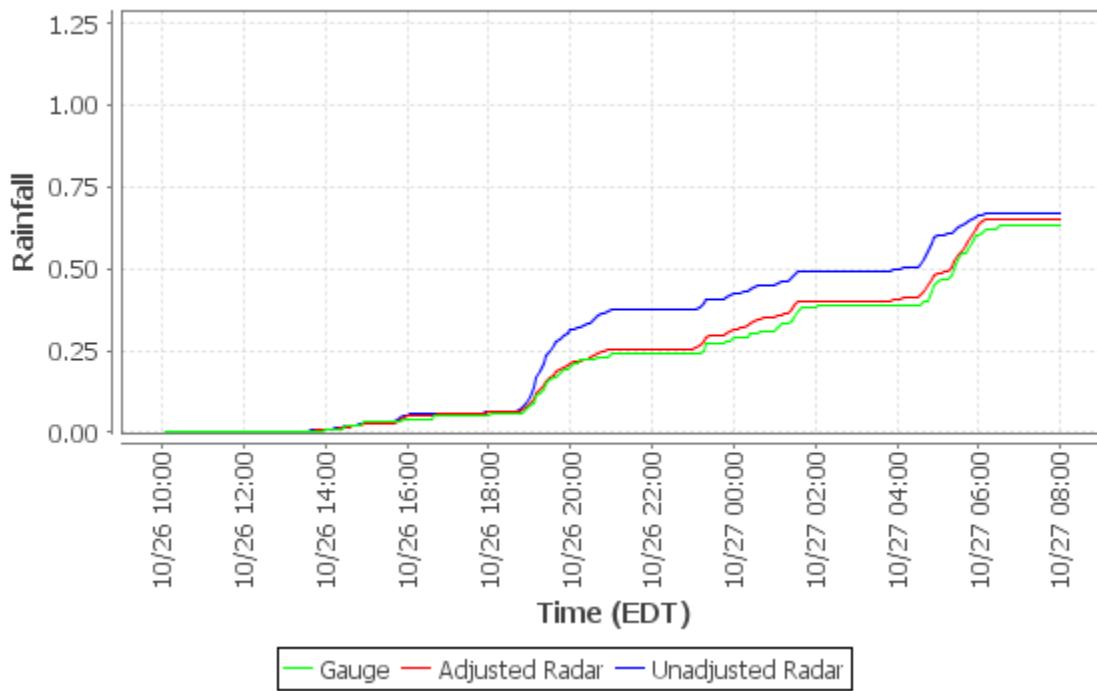
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



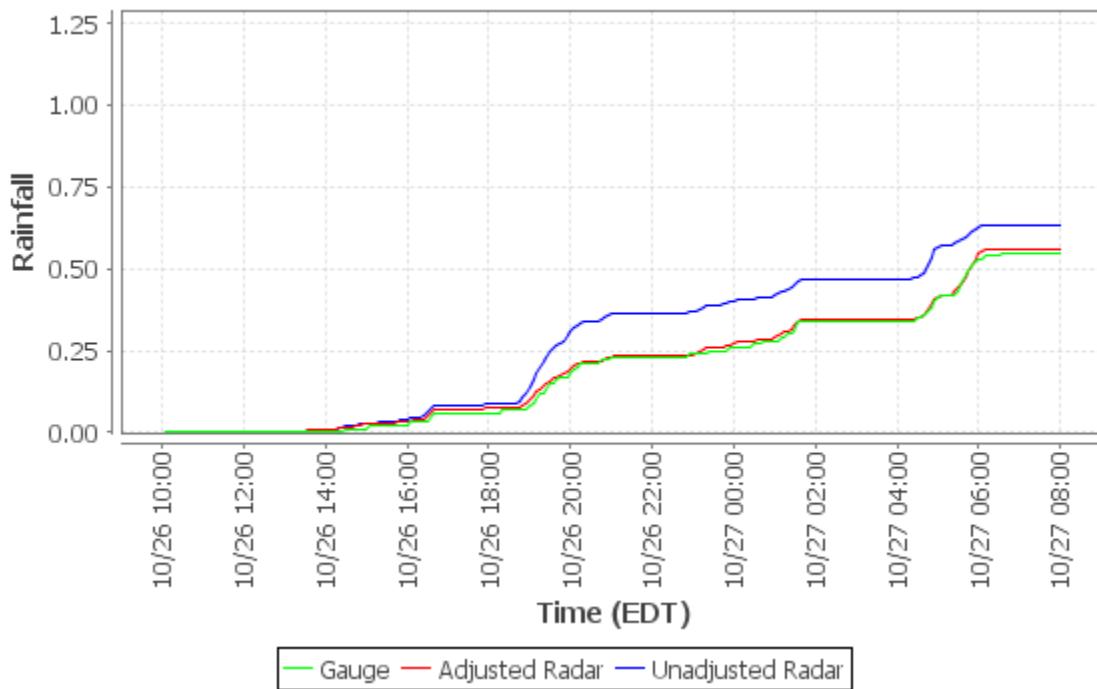
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



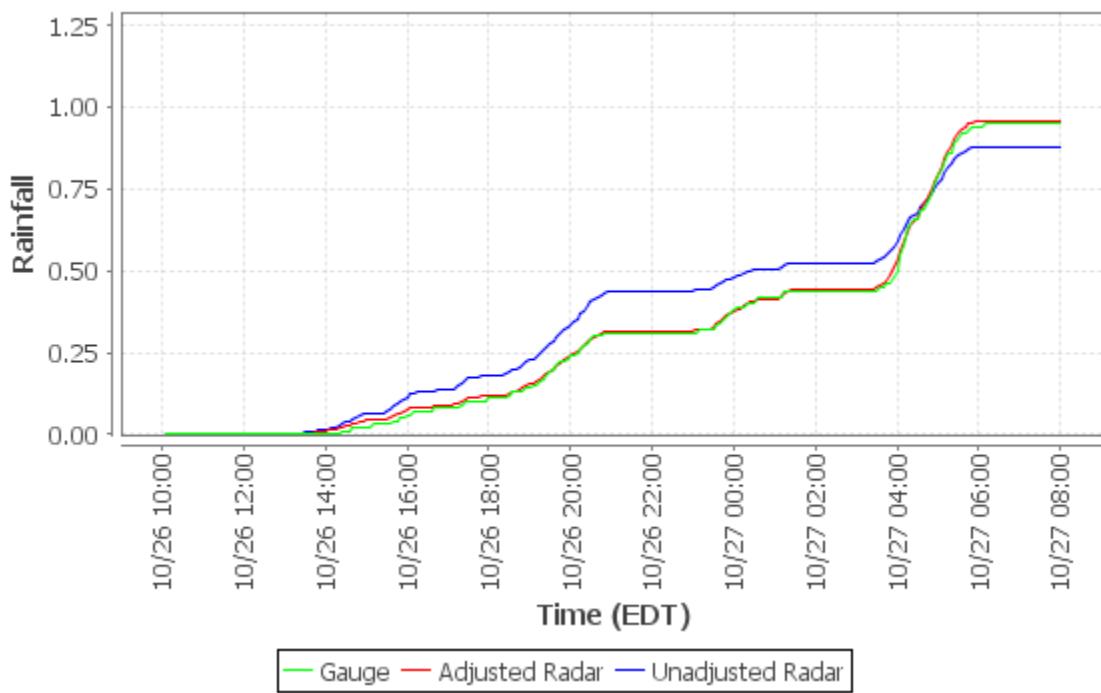
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



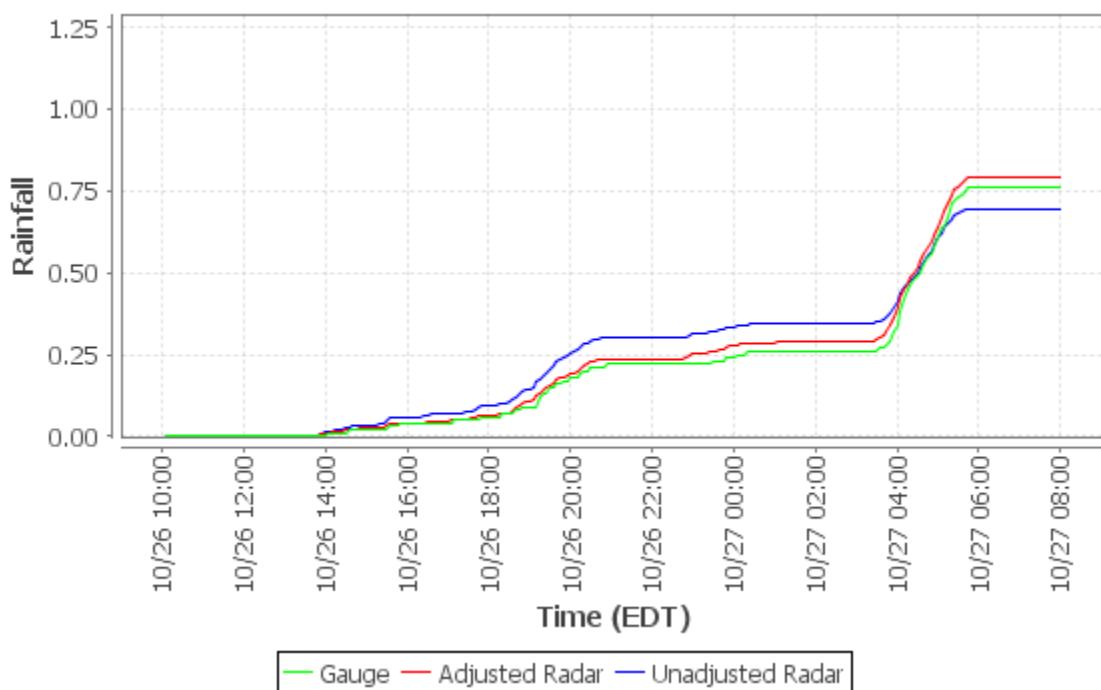
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



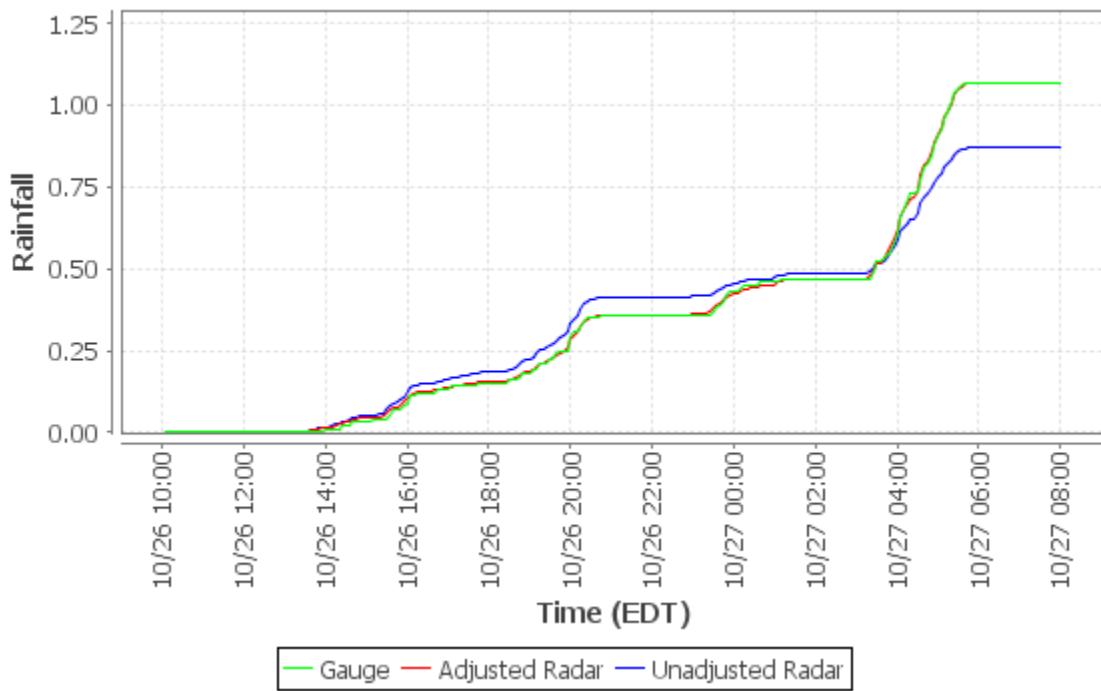
Cumulative Distribution Plot - Moon TWP (Loc21)



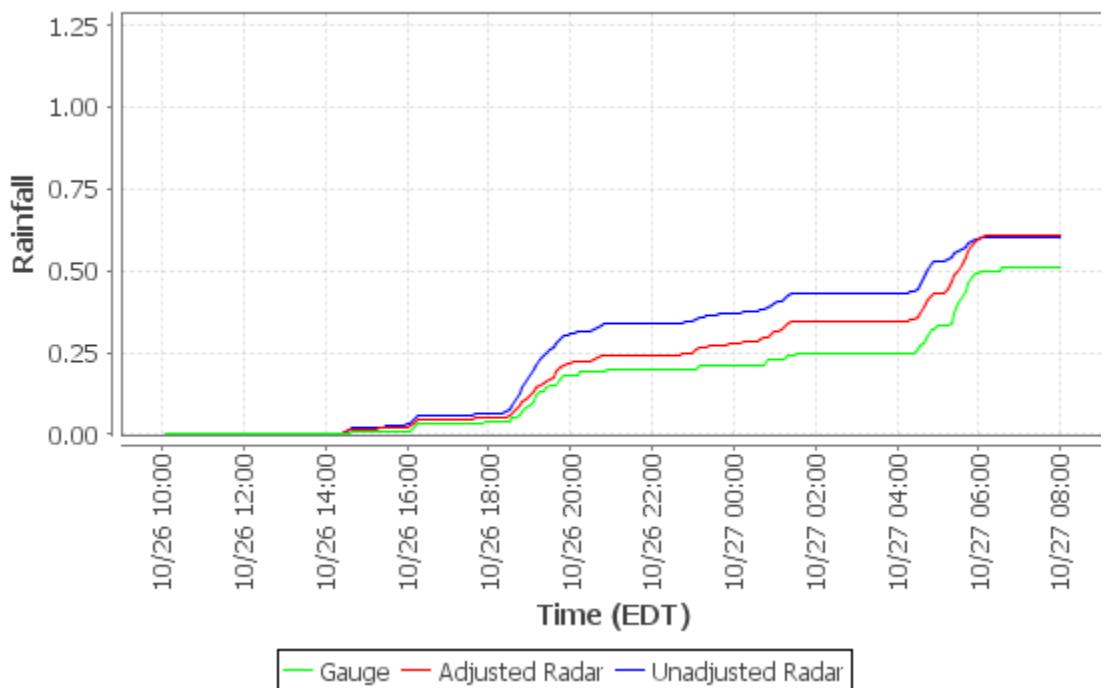
Cumulative Distribution Plot - North Fayette TWP (Loc22)



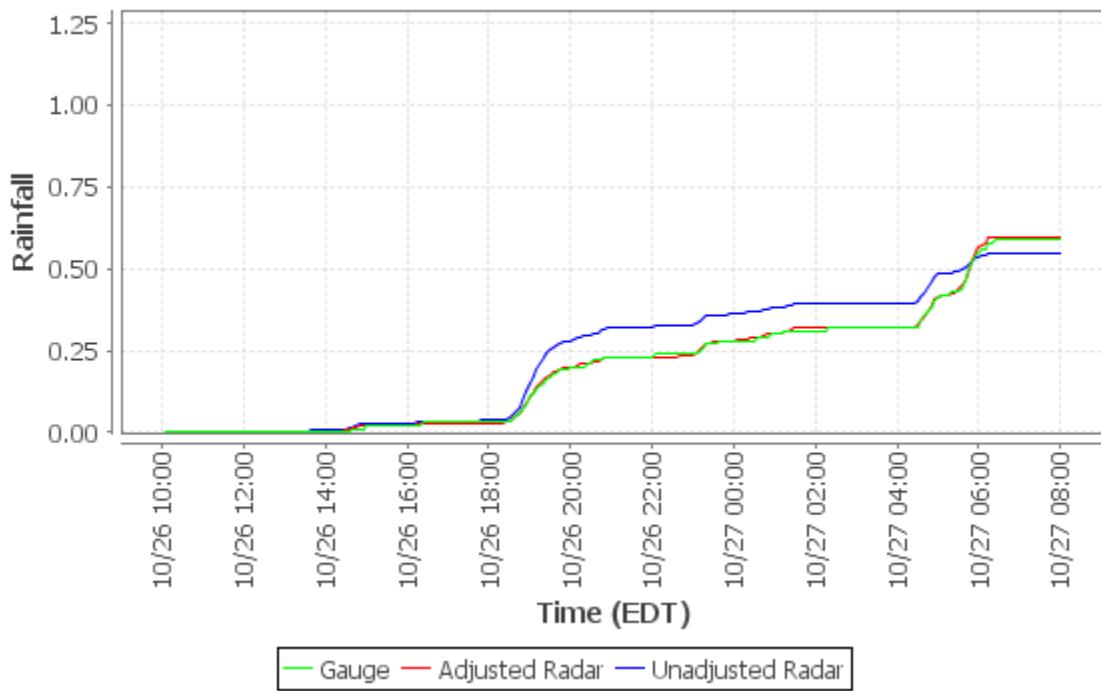
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



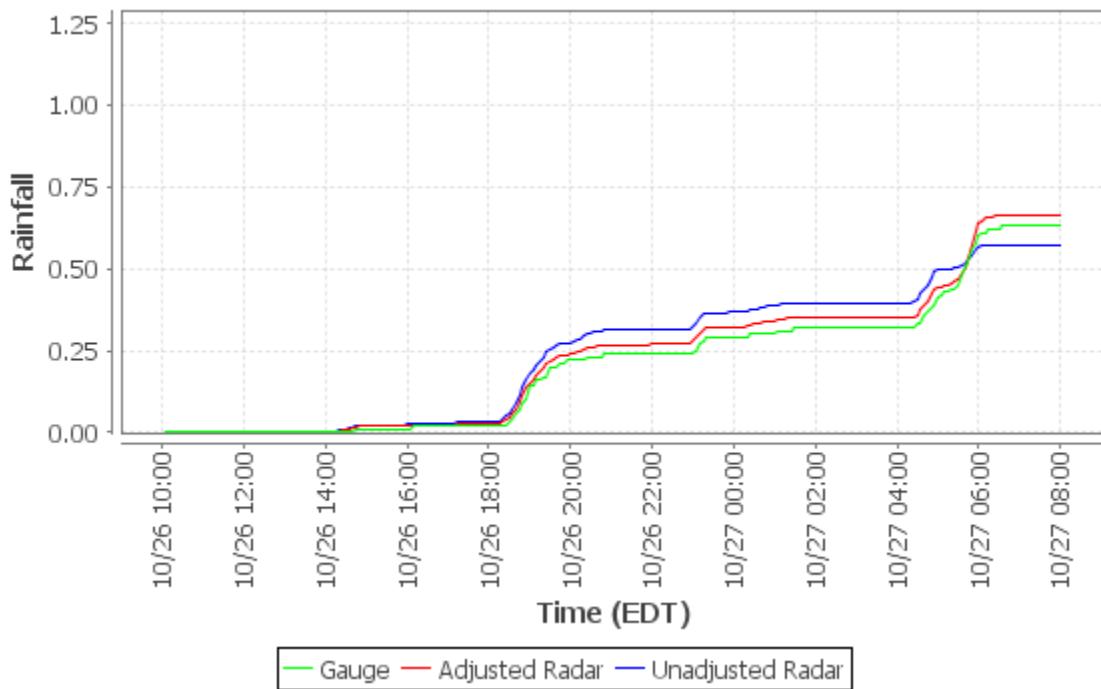
Cumulative Distribution Plot - Jefferson Hills (Loc24)



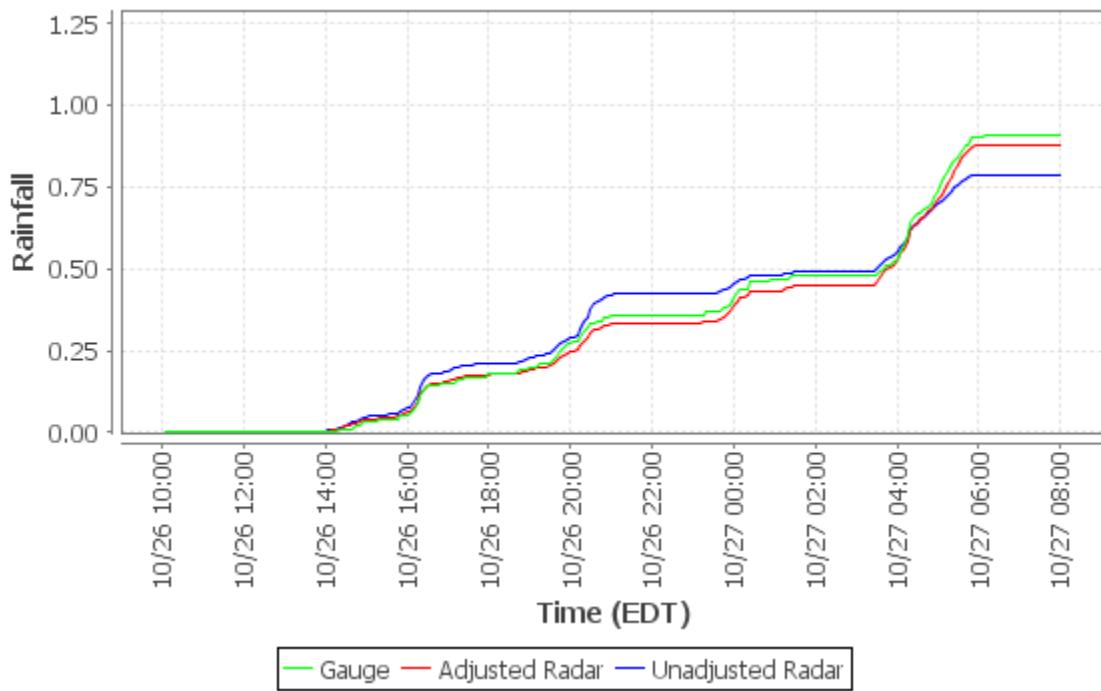
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



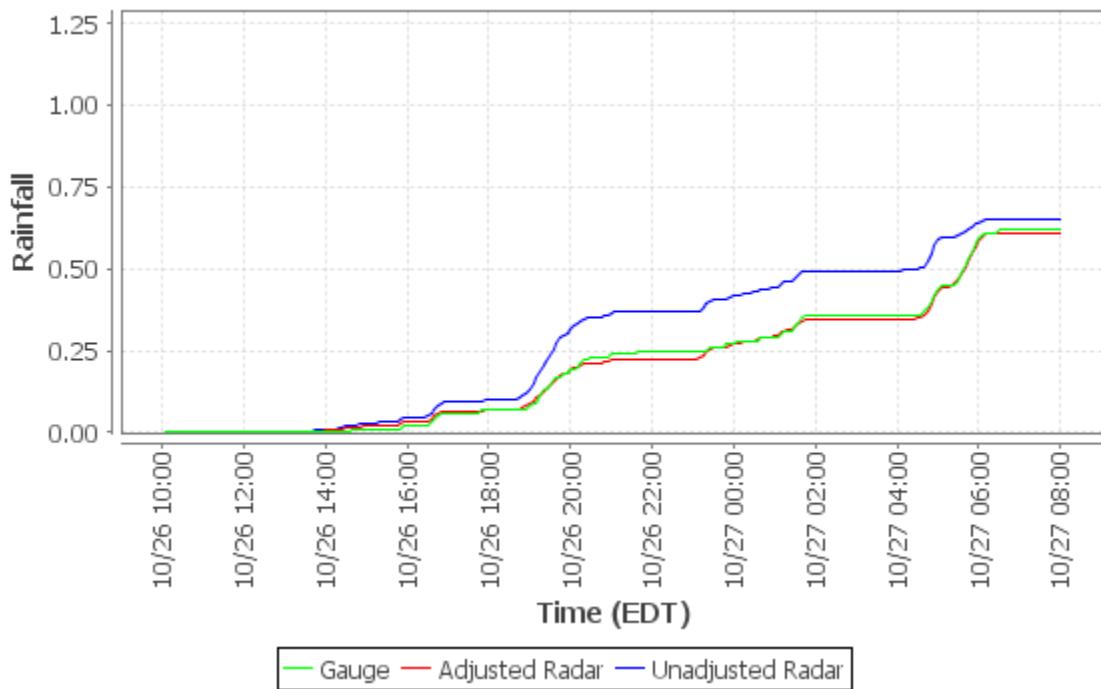
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



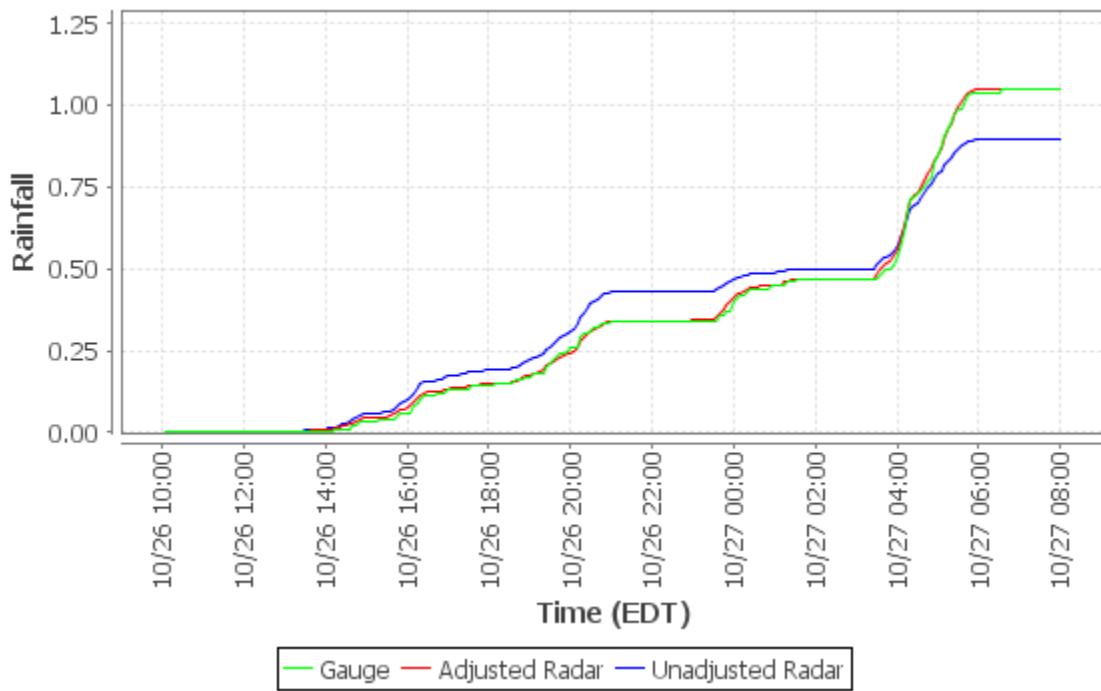
Cumulative Distribution Plot - Marshall TWP (Loc27)



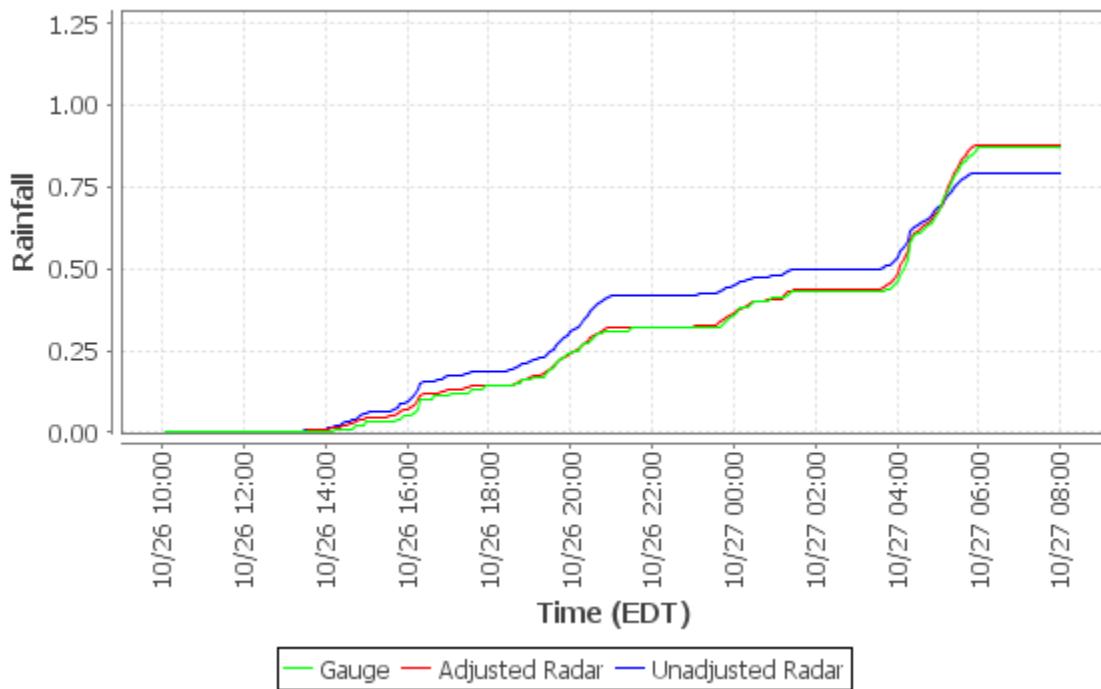
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



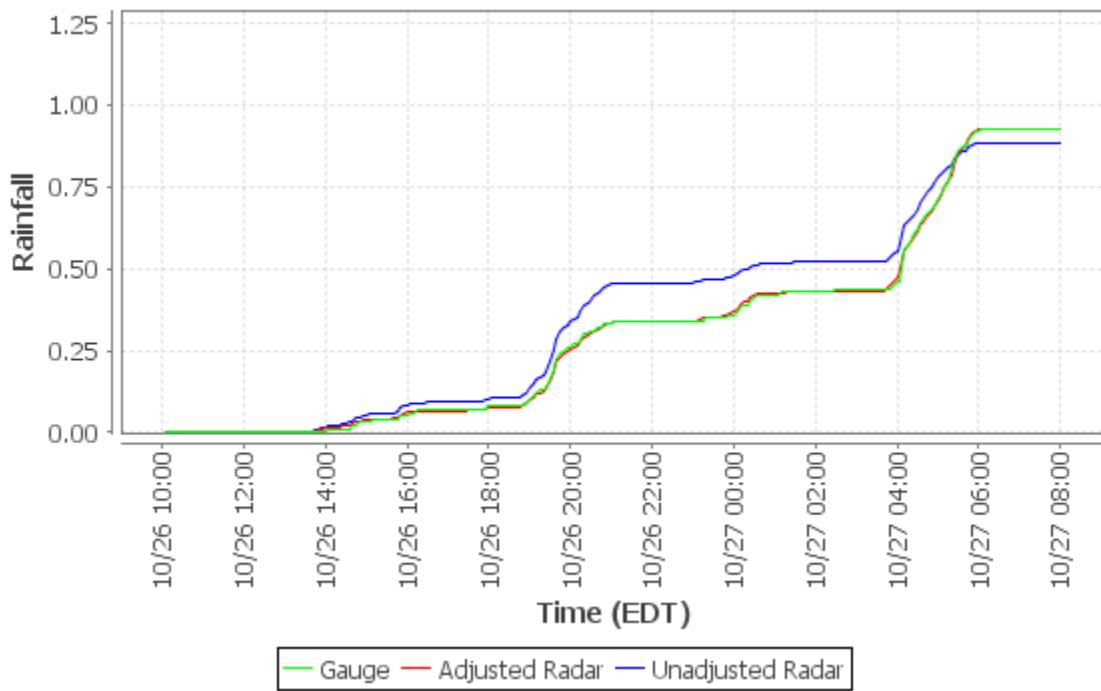
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



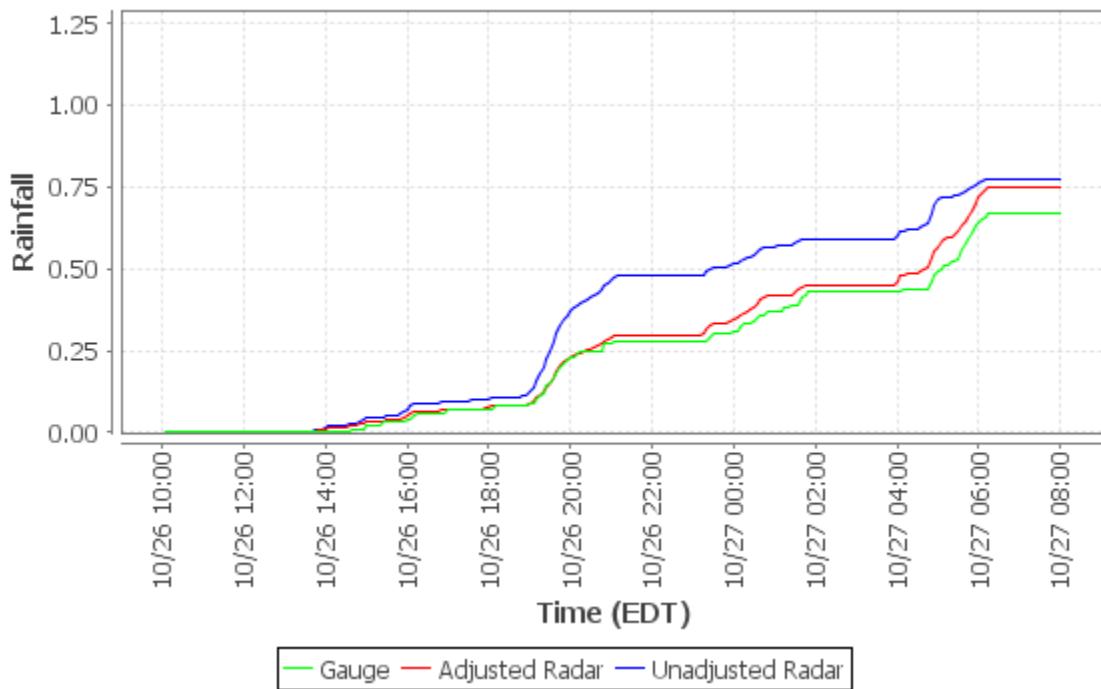
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



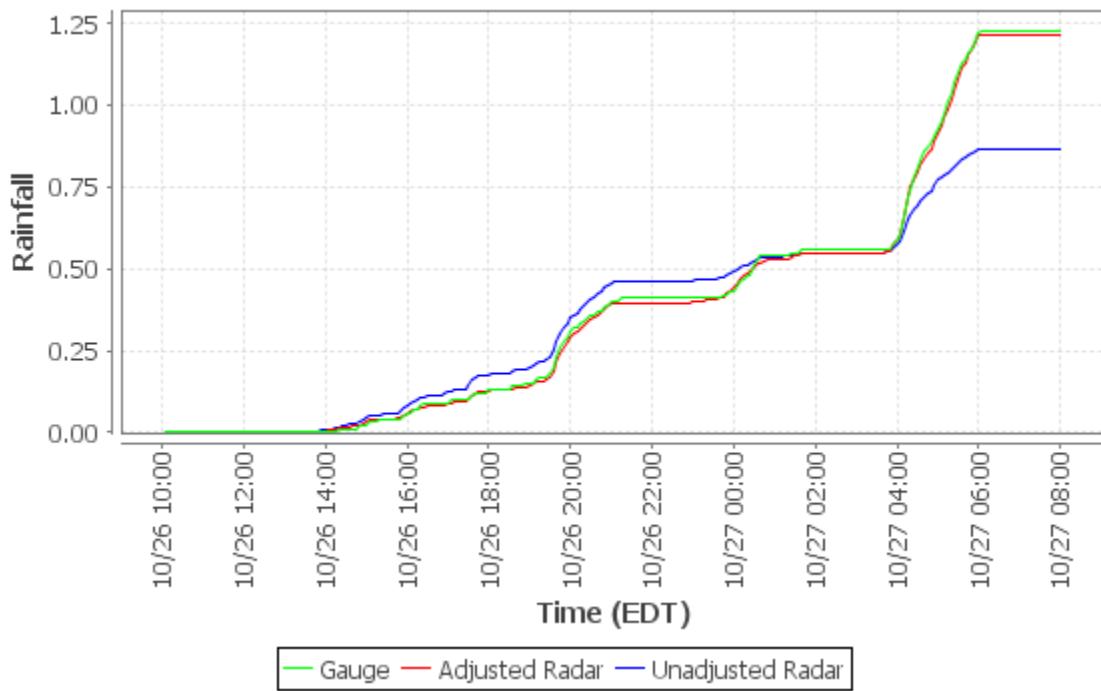
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



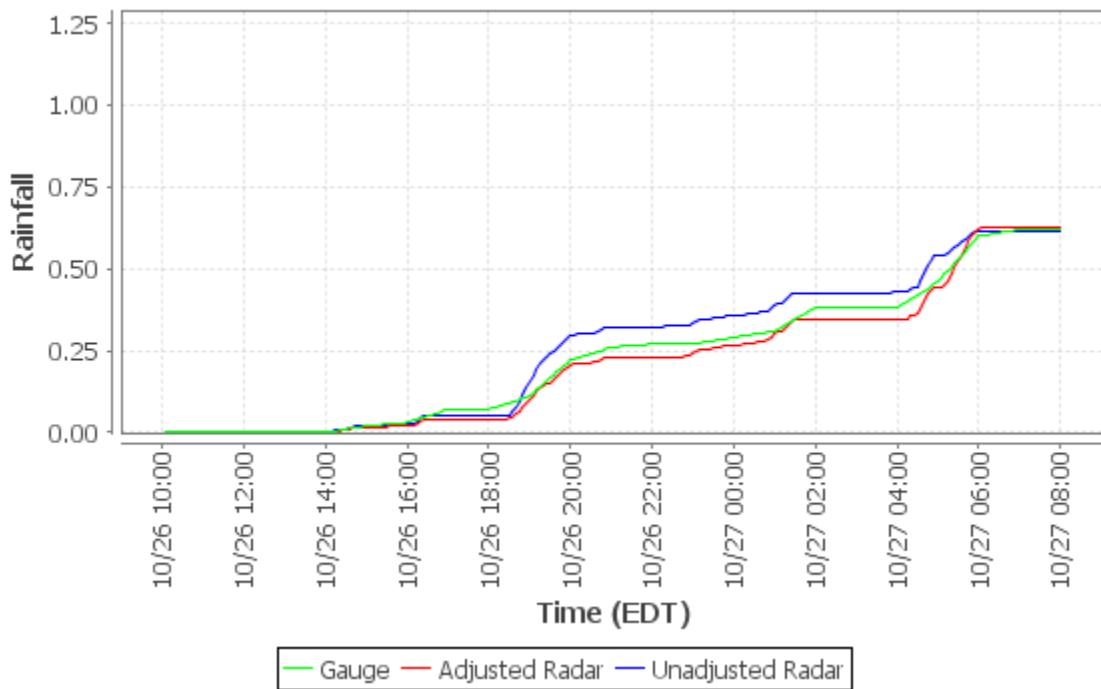
Cumulative Distribution Plot - Arnold (Loc32)



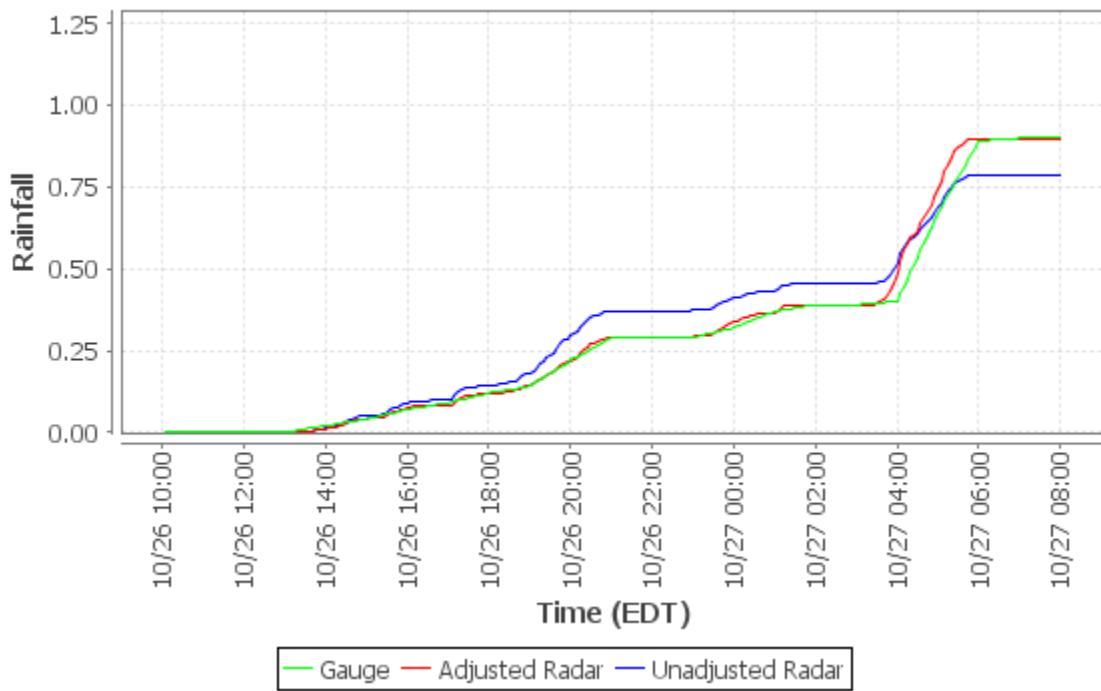
Cumulative Distribution Plot - Richland TWP (Loc33)



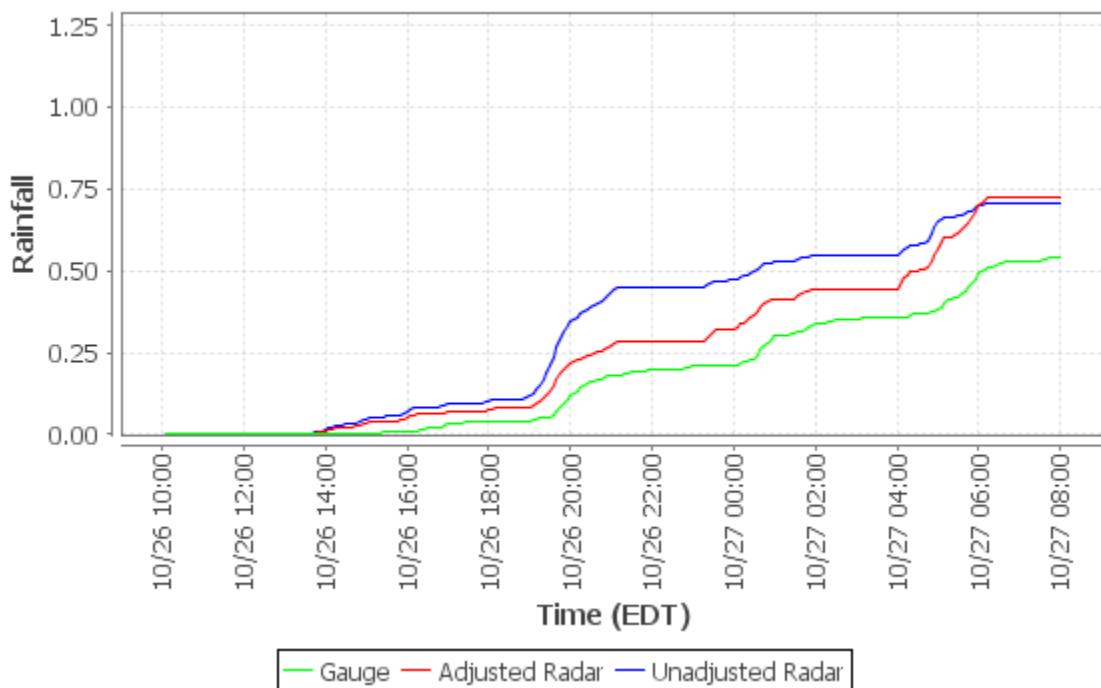
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



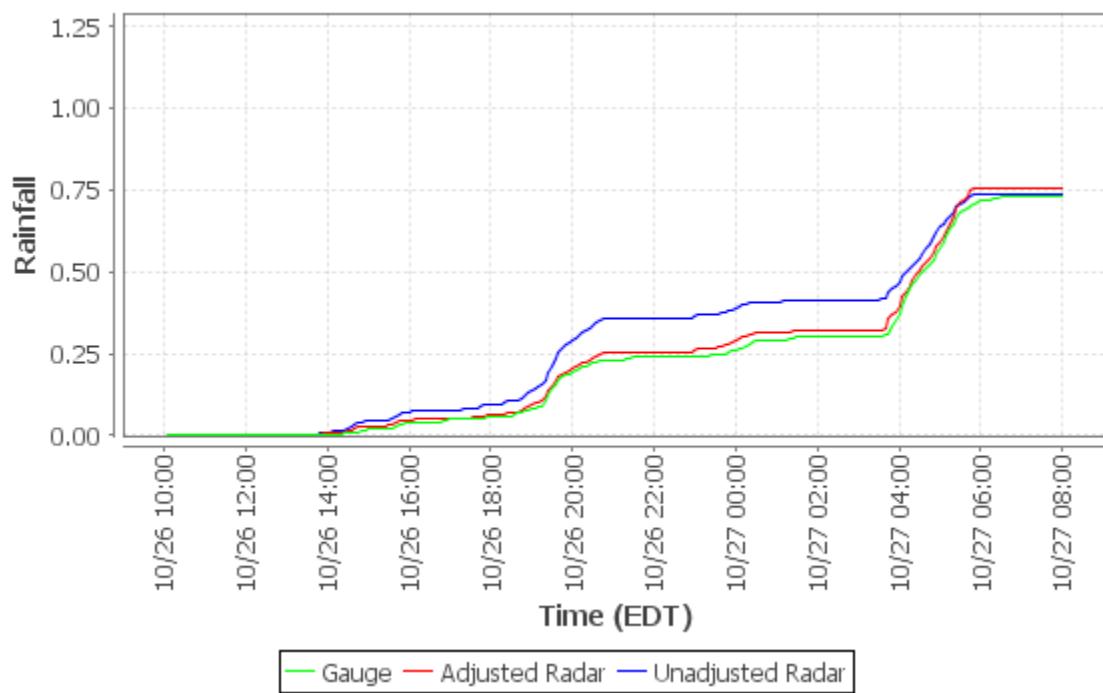
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

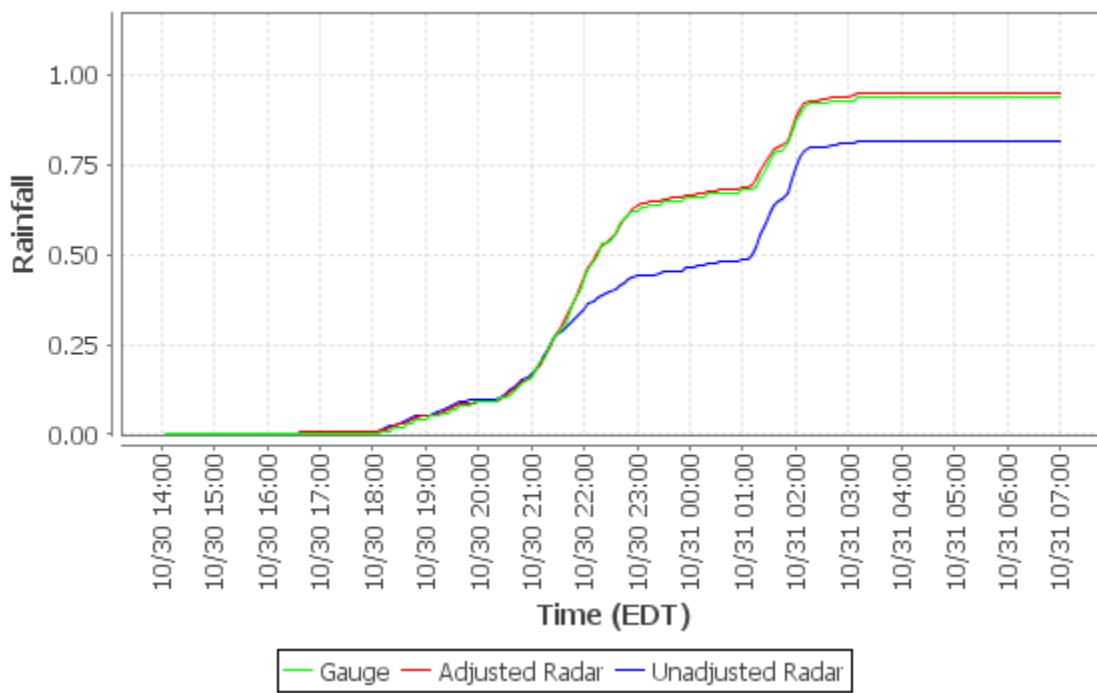


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

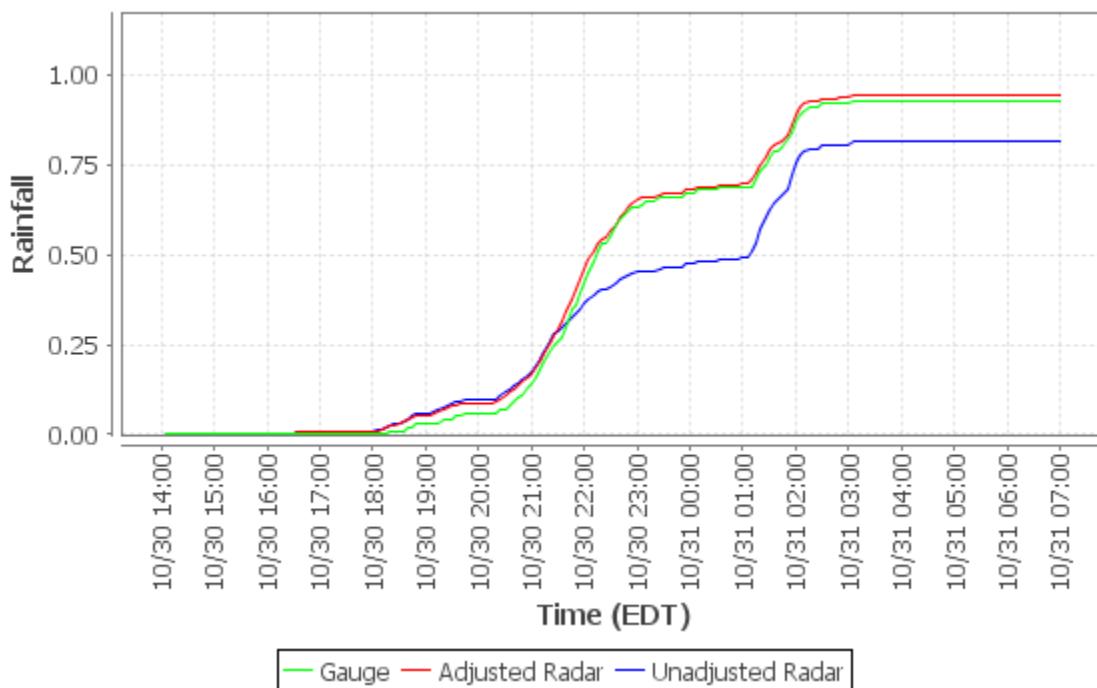


Appendix H - Event 6 (2019-10-30) CDPs

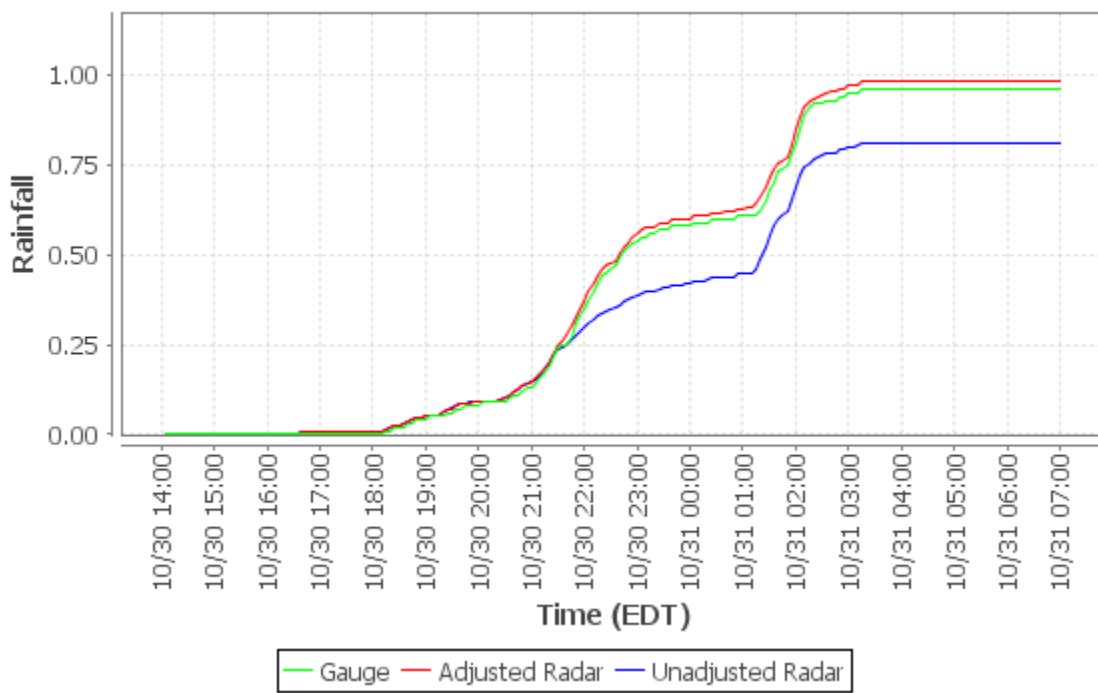
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



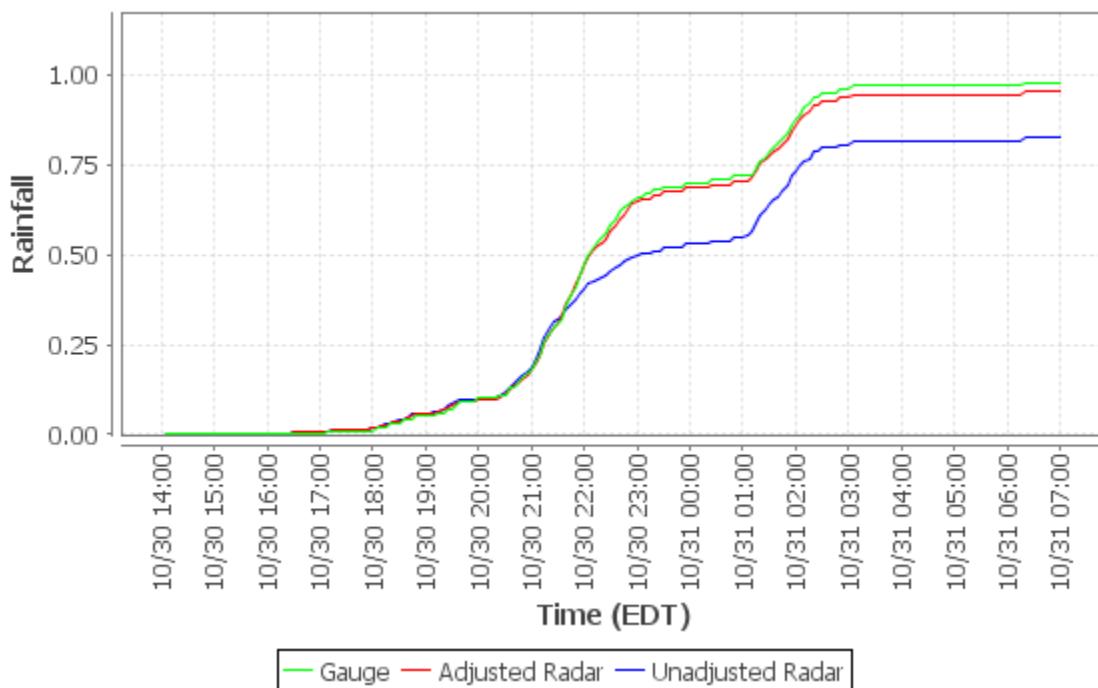
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



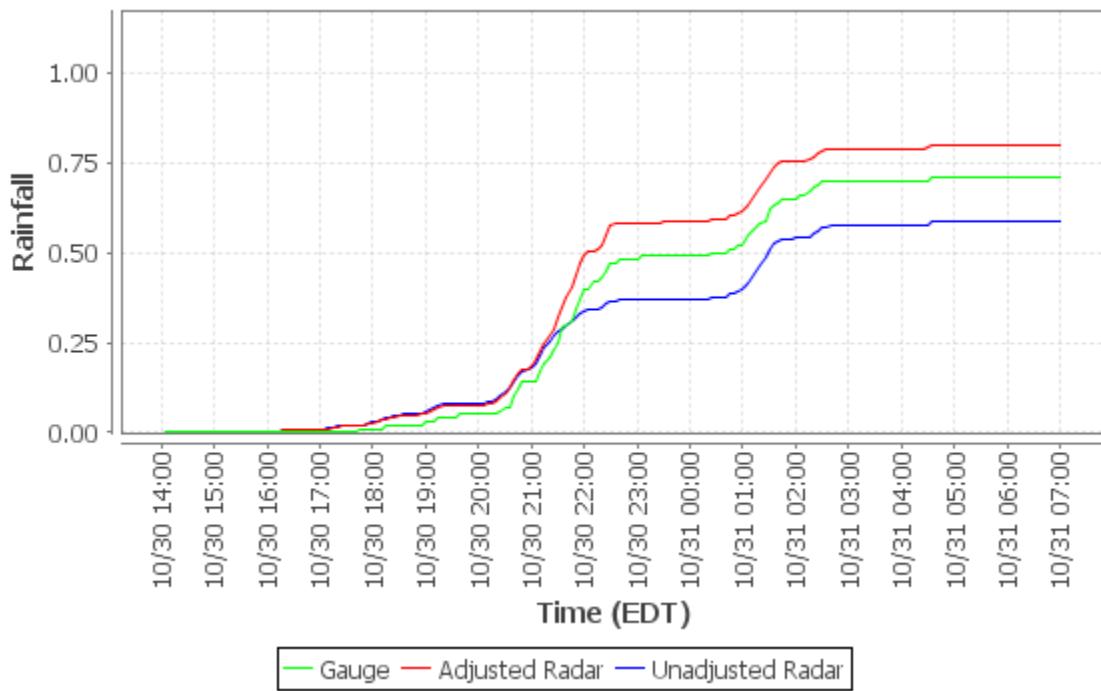
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



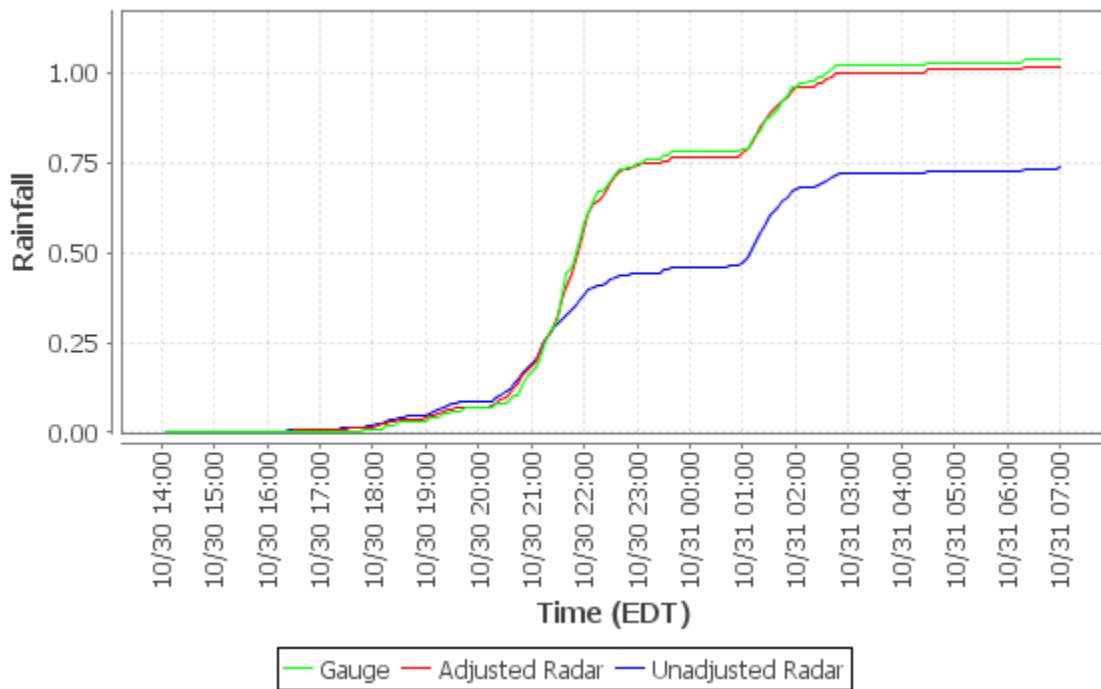
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



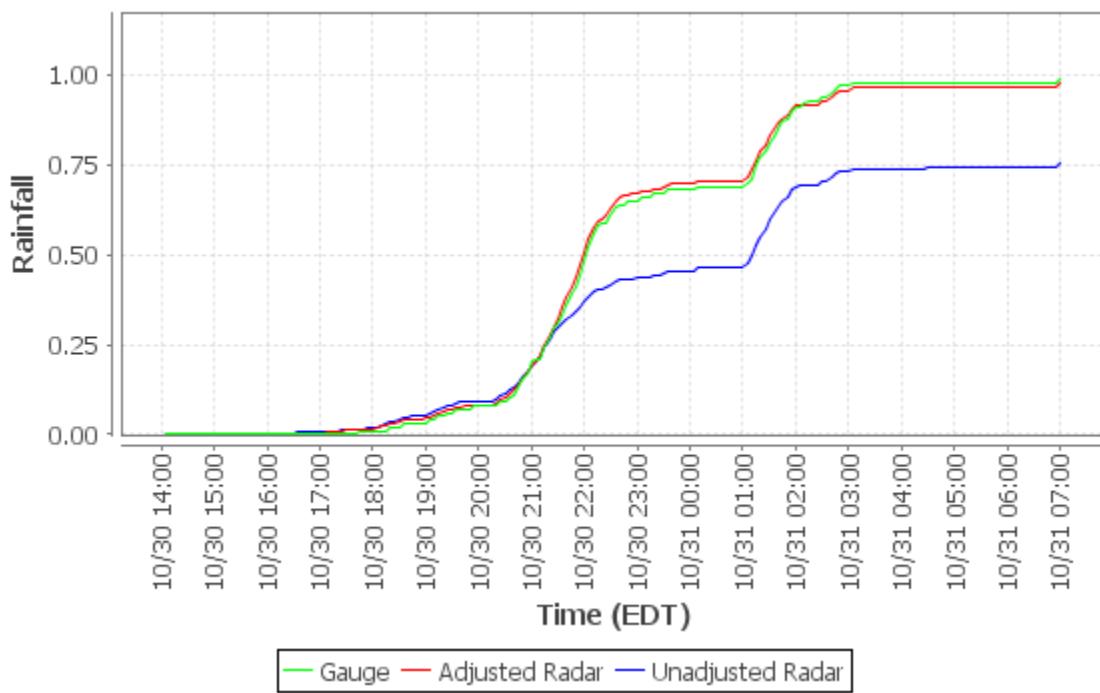
Cumulative Distribution Plot - Upper St. Clair (Loc05)



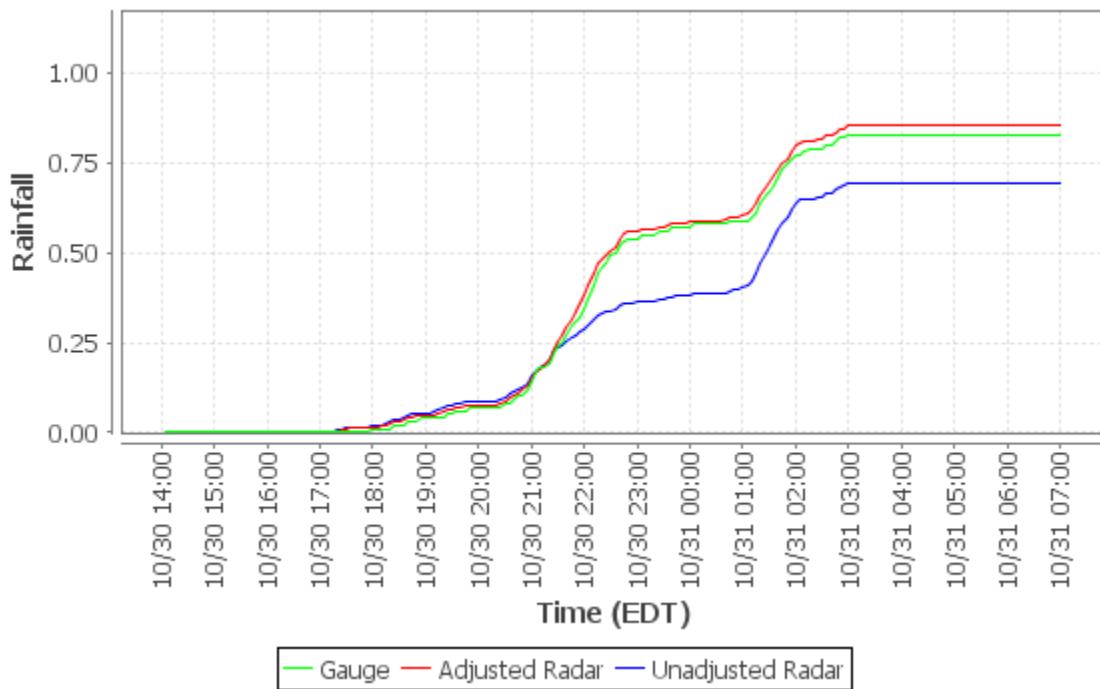
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



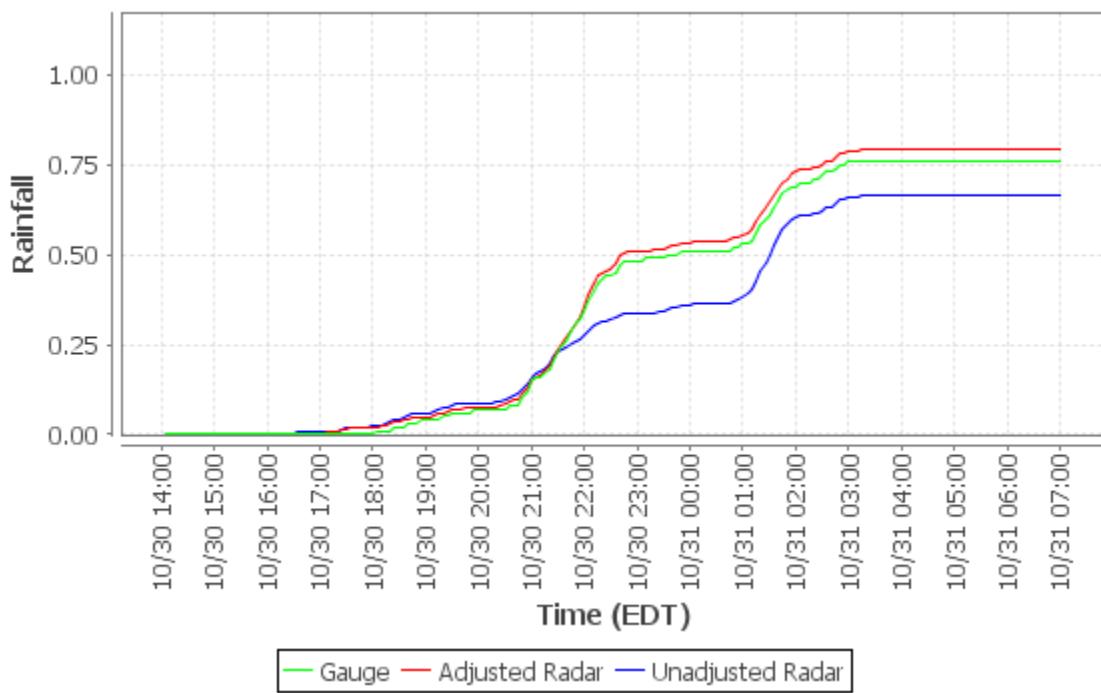
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



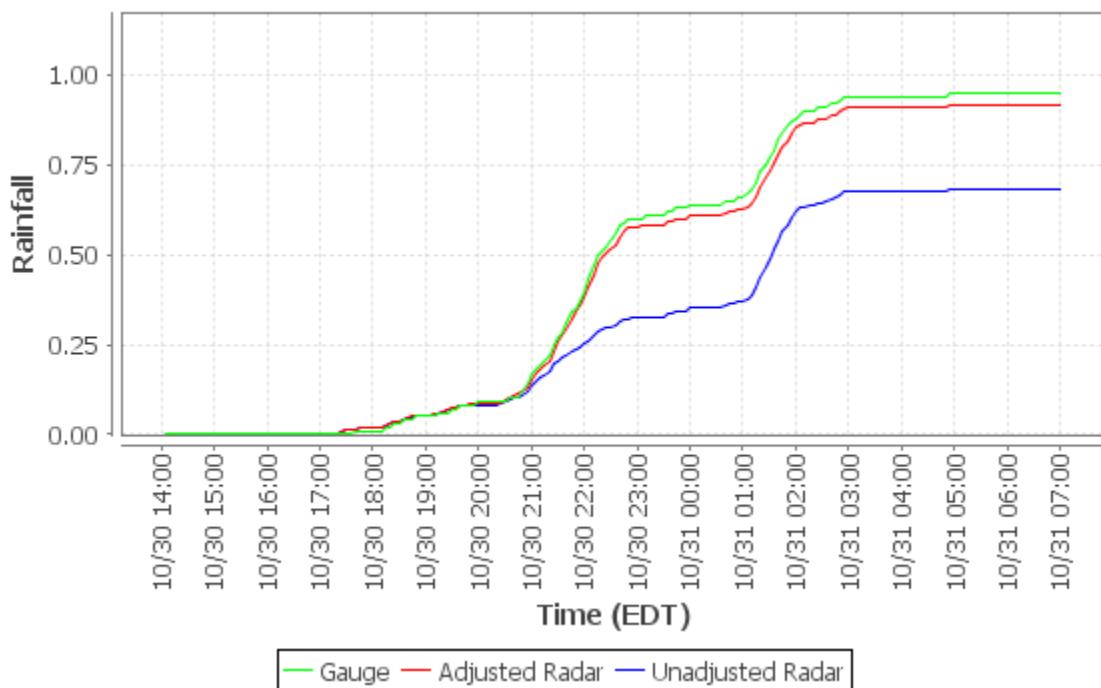
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



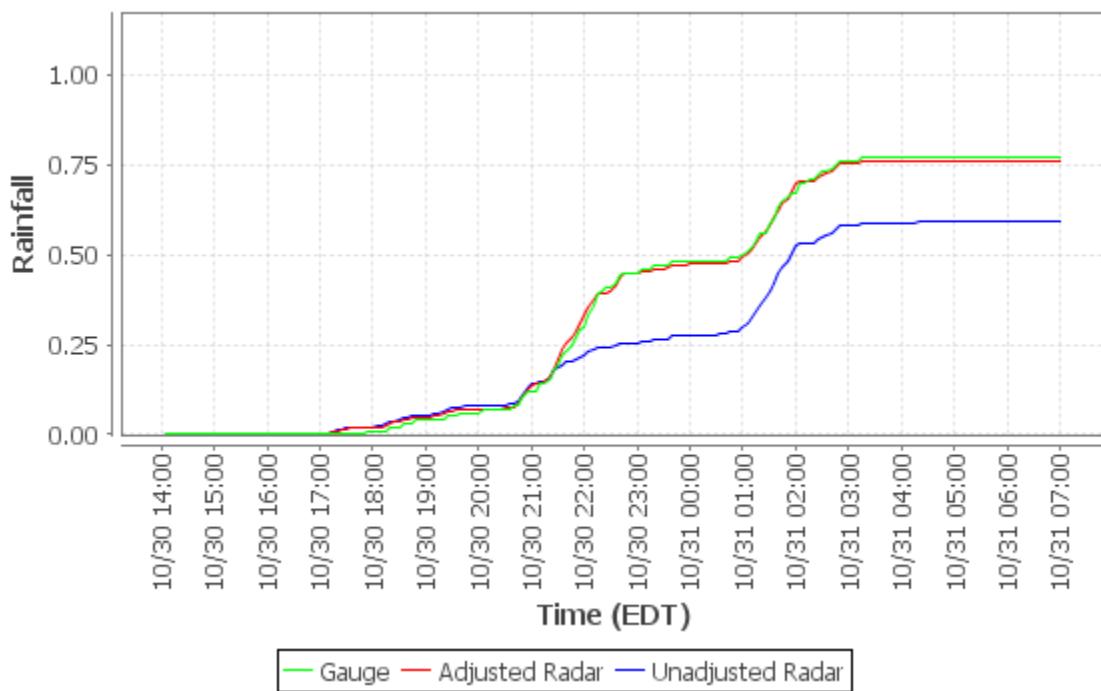
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



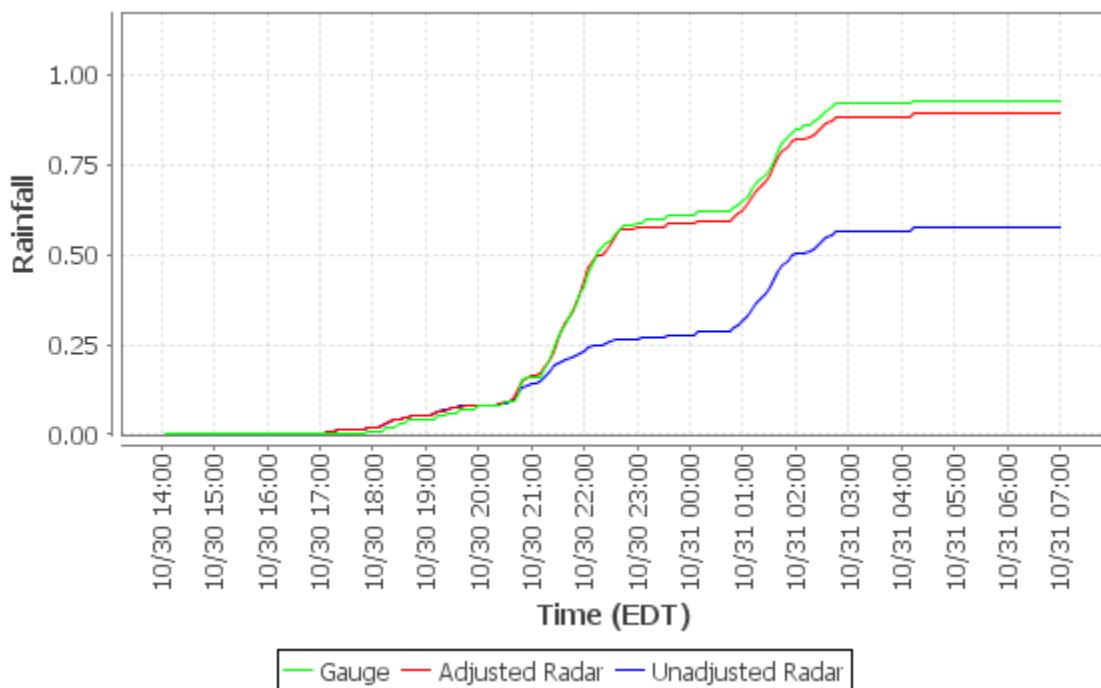
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



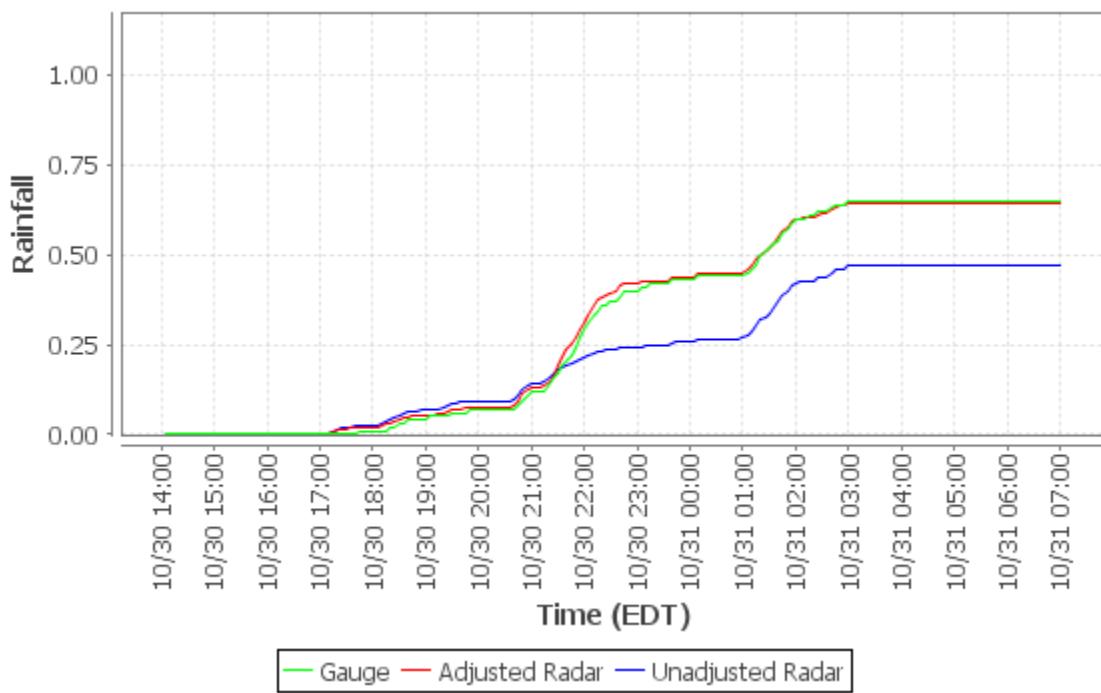
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



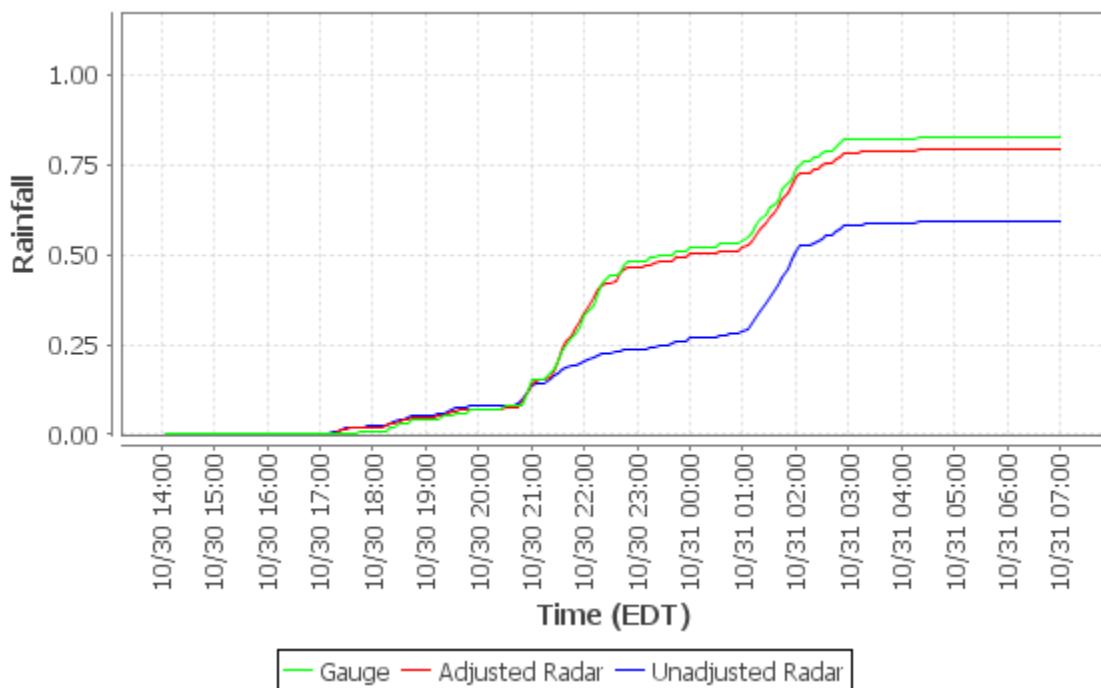
Cumulative Distribution Plot - Baldwin (Loc12)



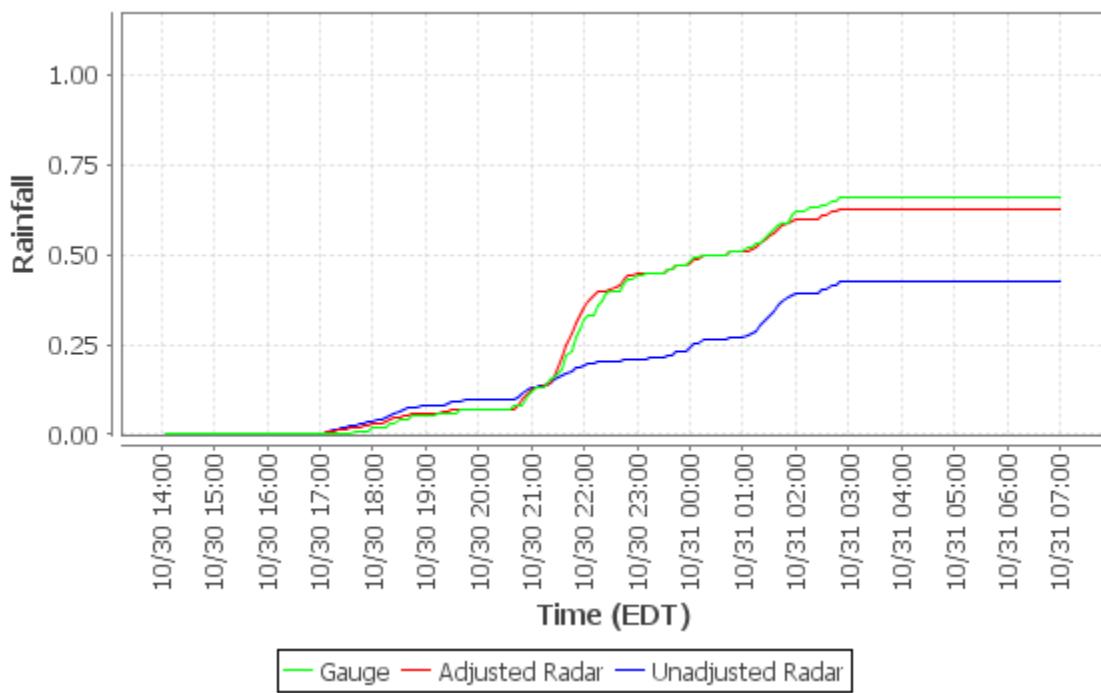
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



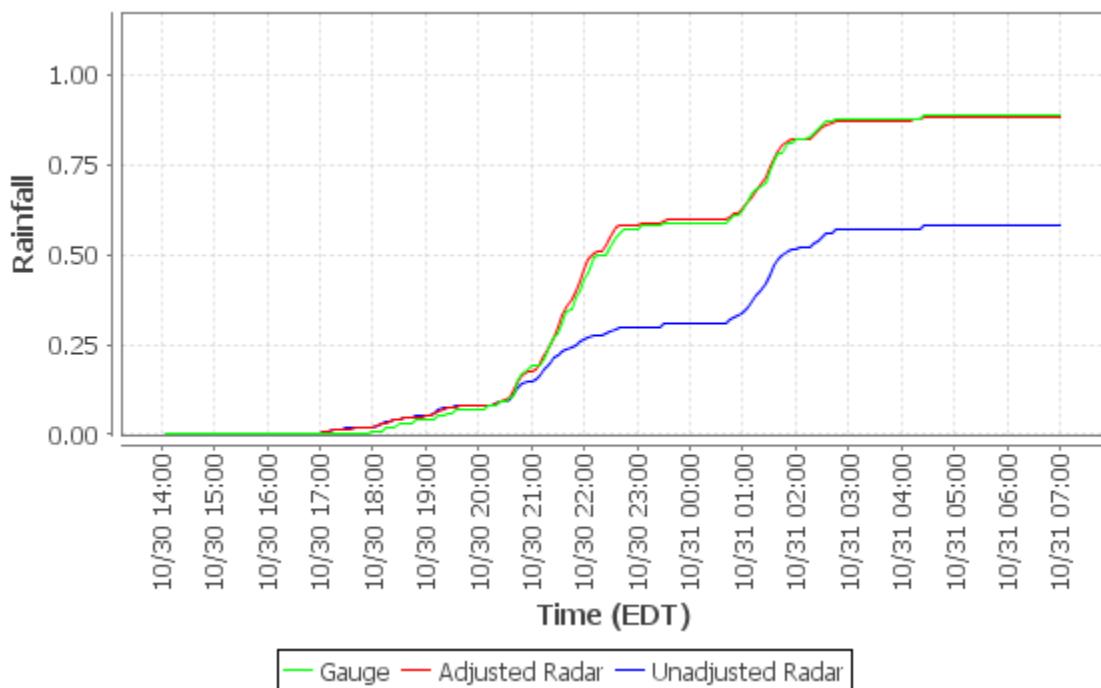
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



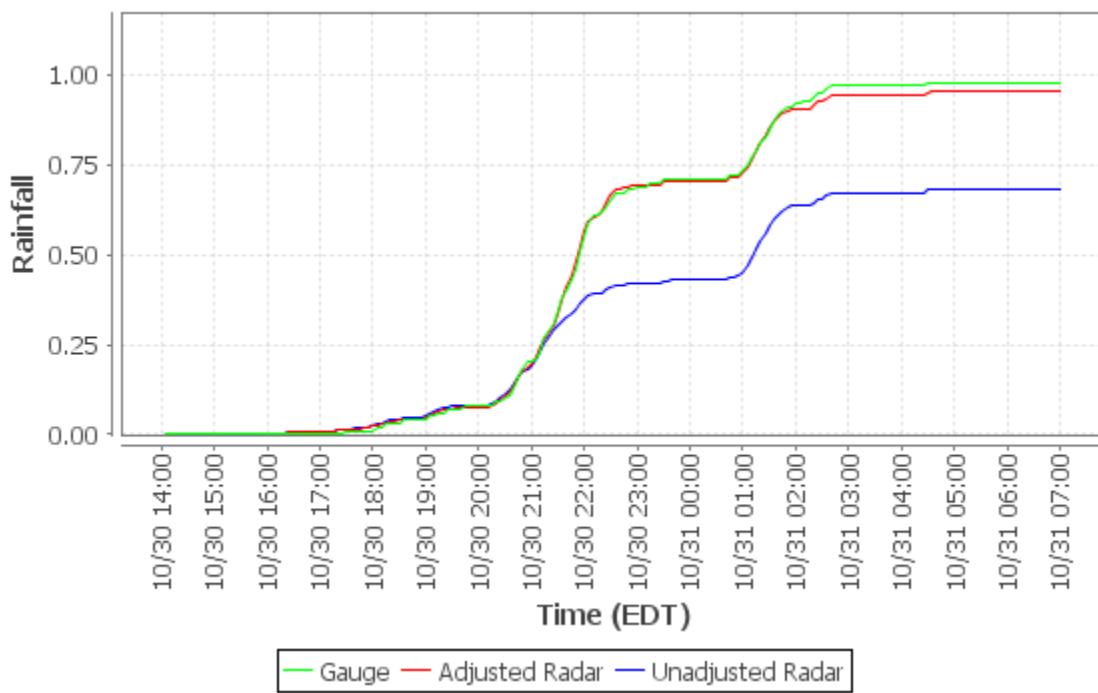
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



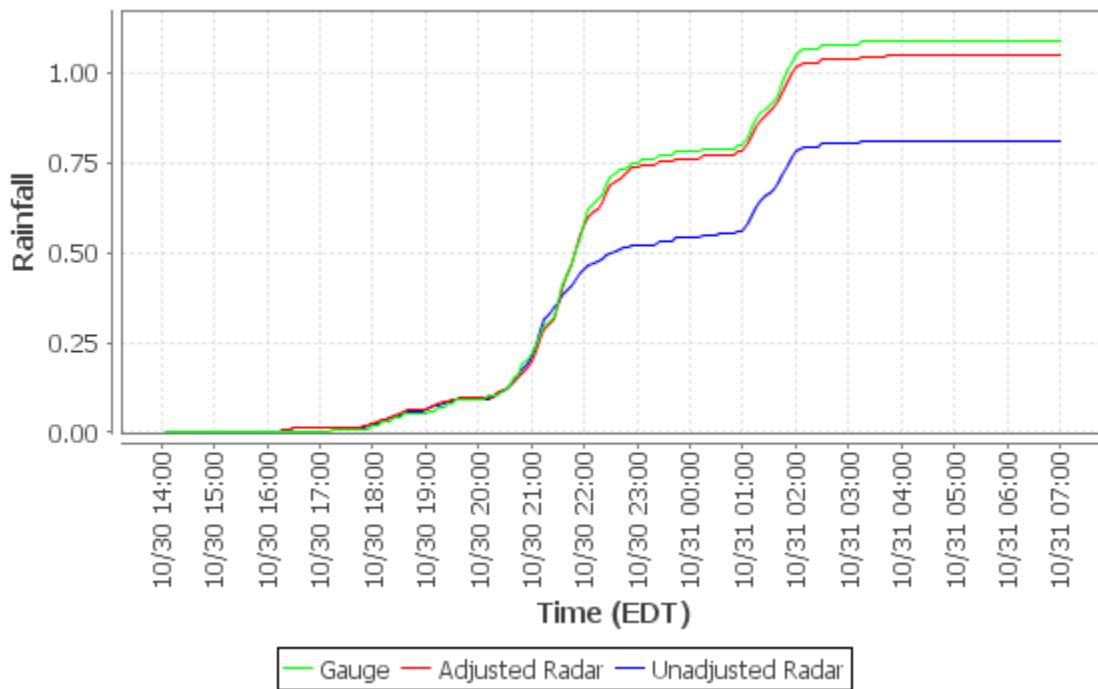
Cumulative Distribution Plot - Castle Shannon (Loc16)



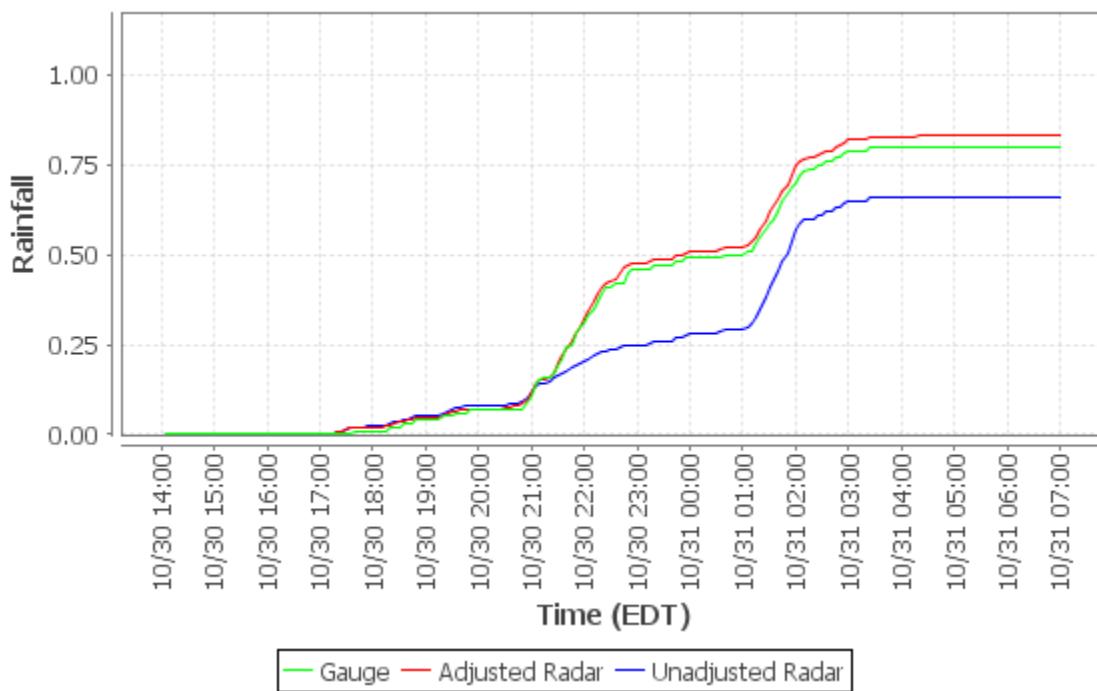
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



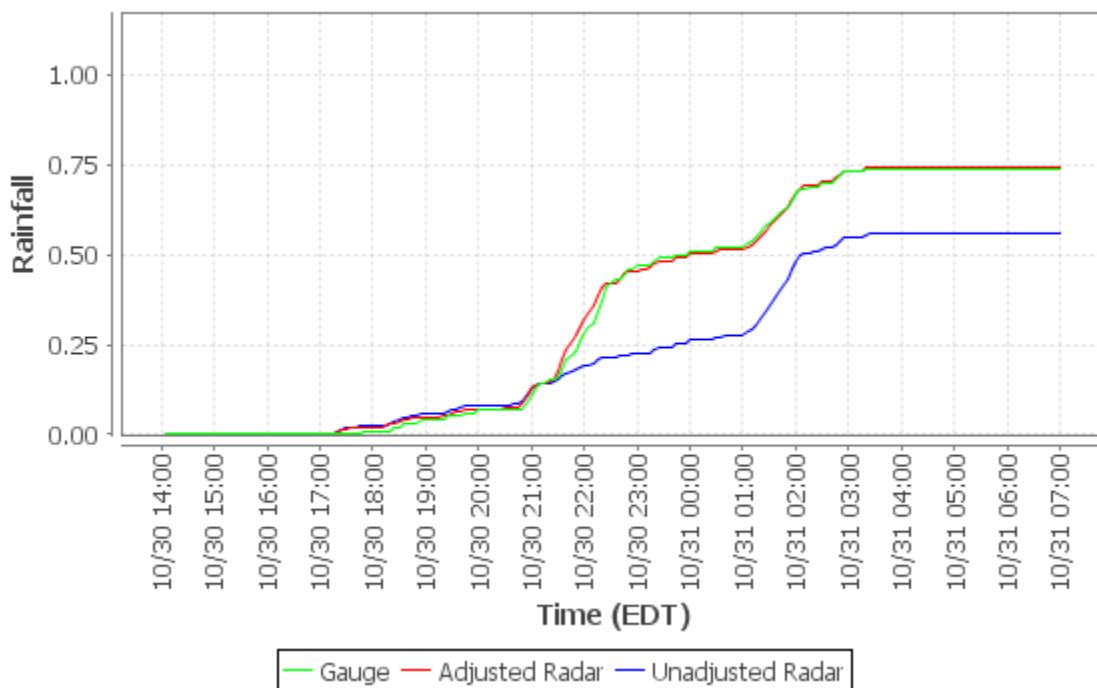
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



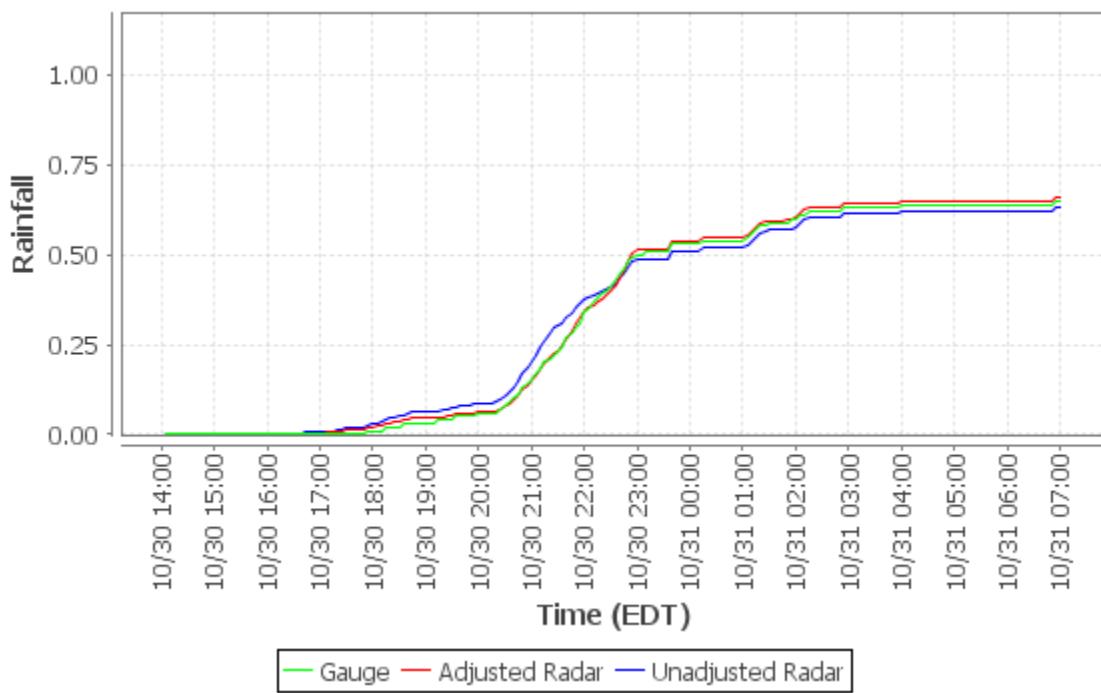
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



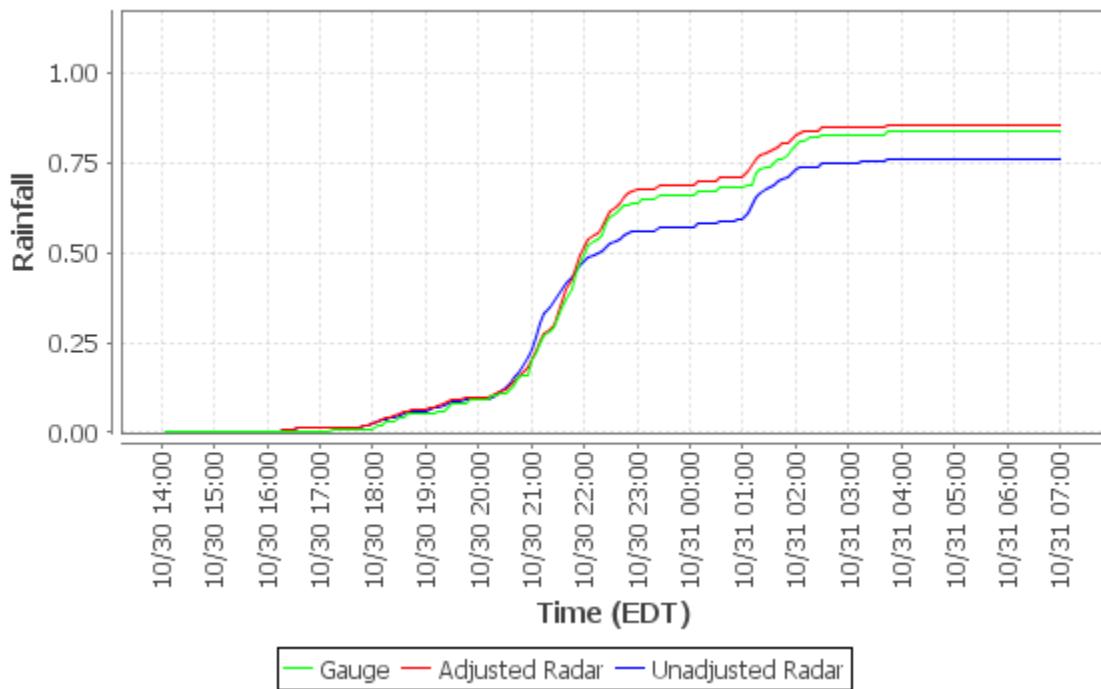
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



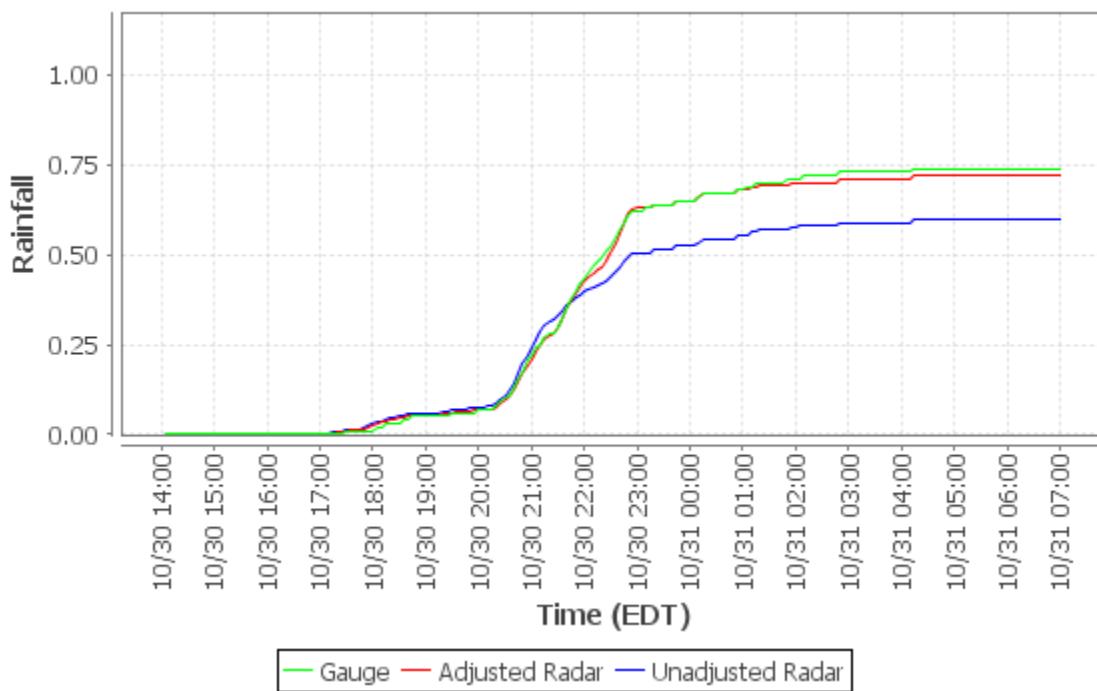
Cumulative Distribution Plot - Moon TWP (Loc21)



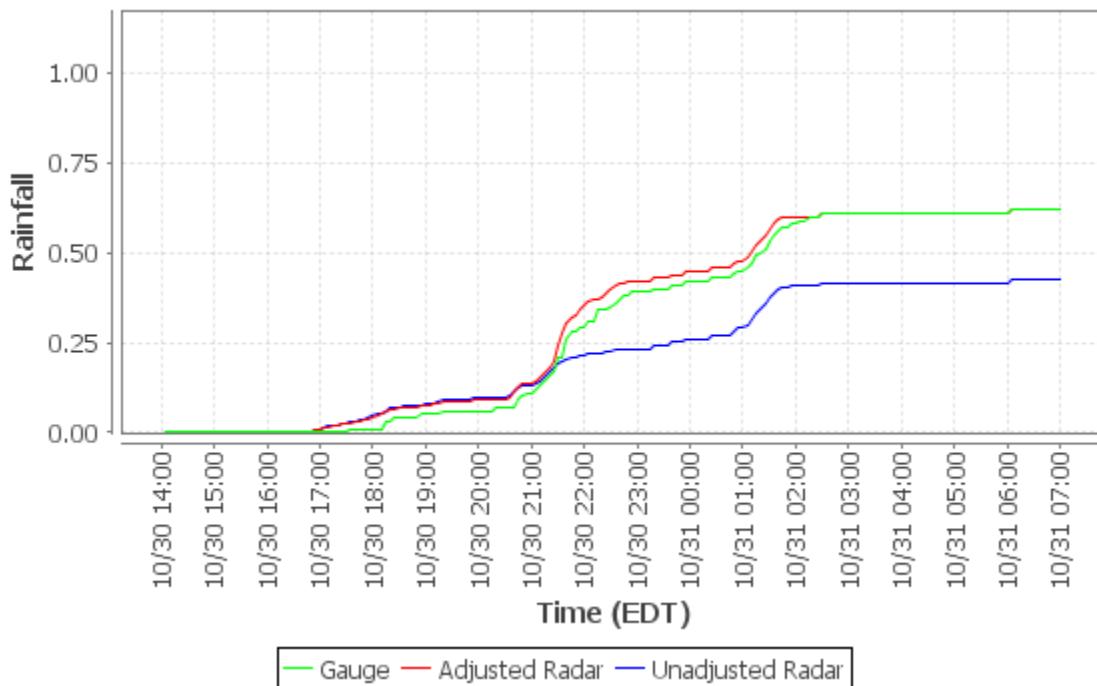
Cumulative Distribution Plot - North Fayette TWP (Loc22)



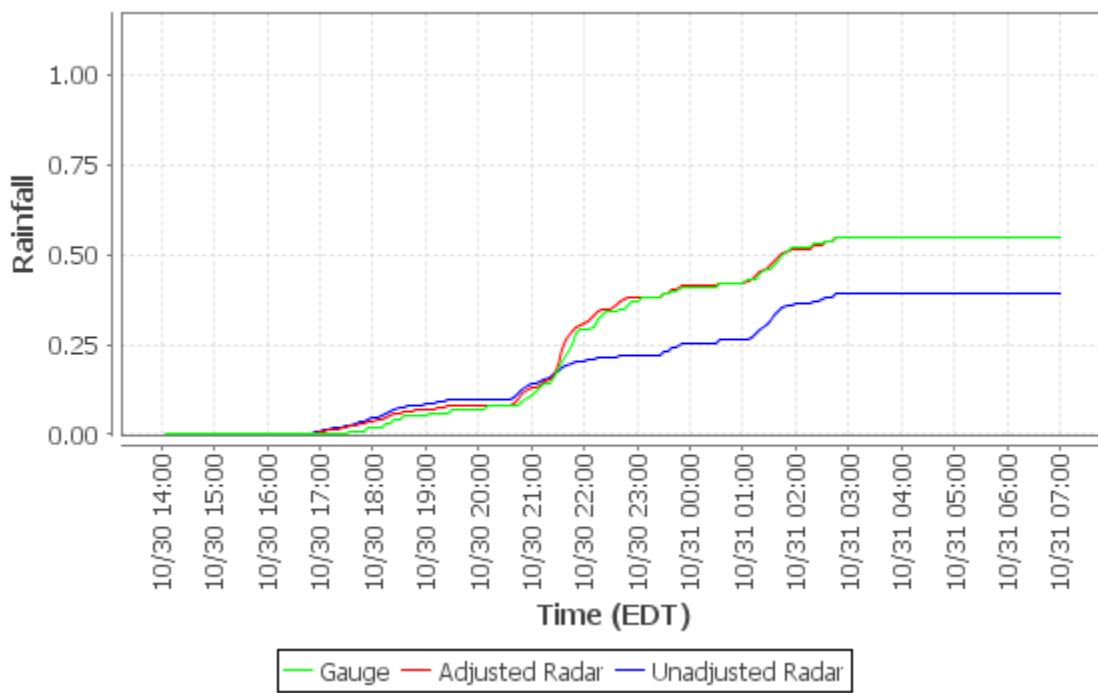
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



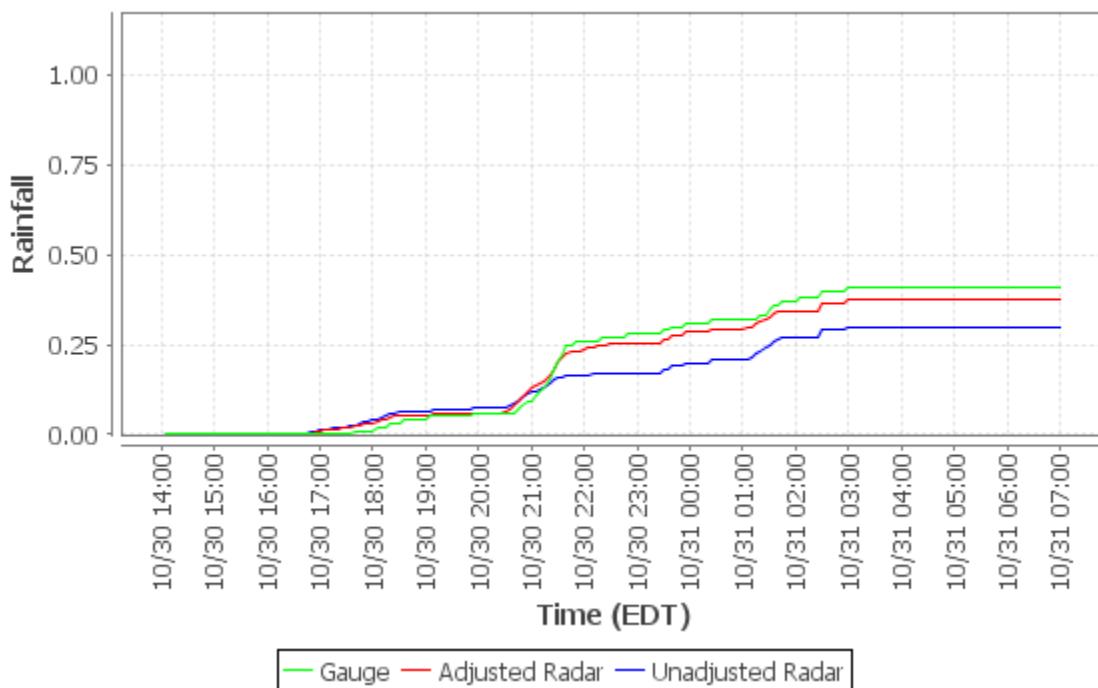
Cumulative Distribution Plot - Jefferson Hills (Loc24)



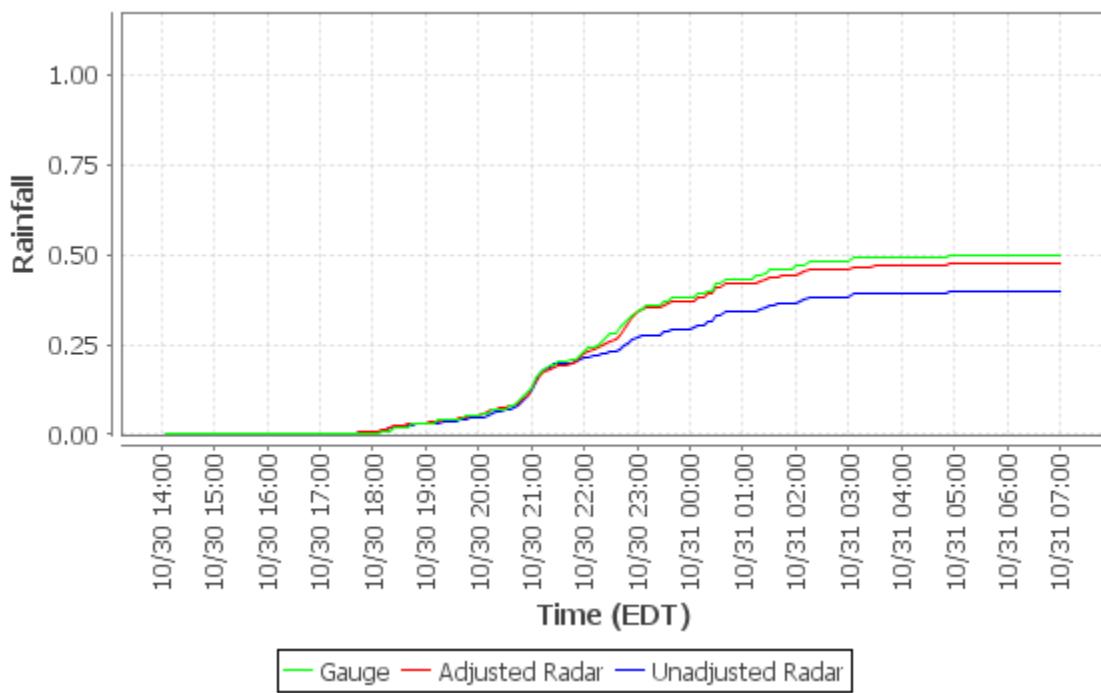
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



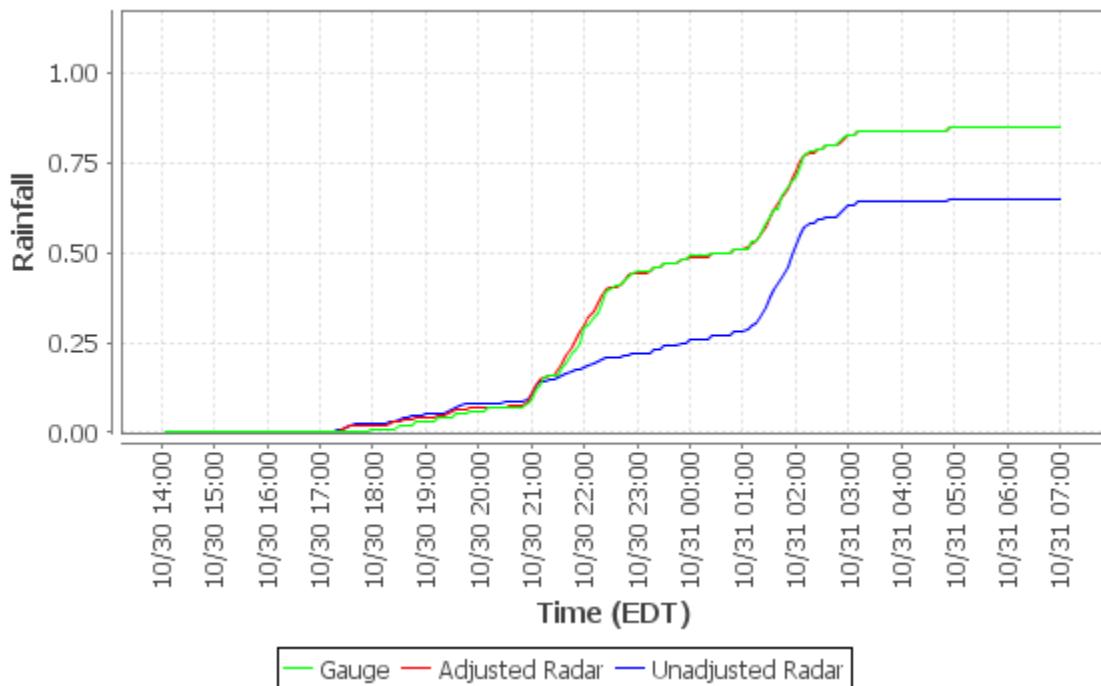
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



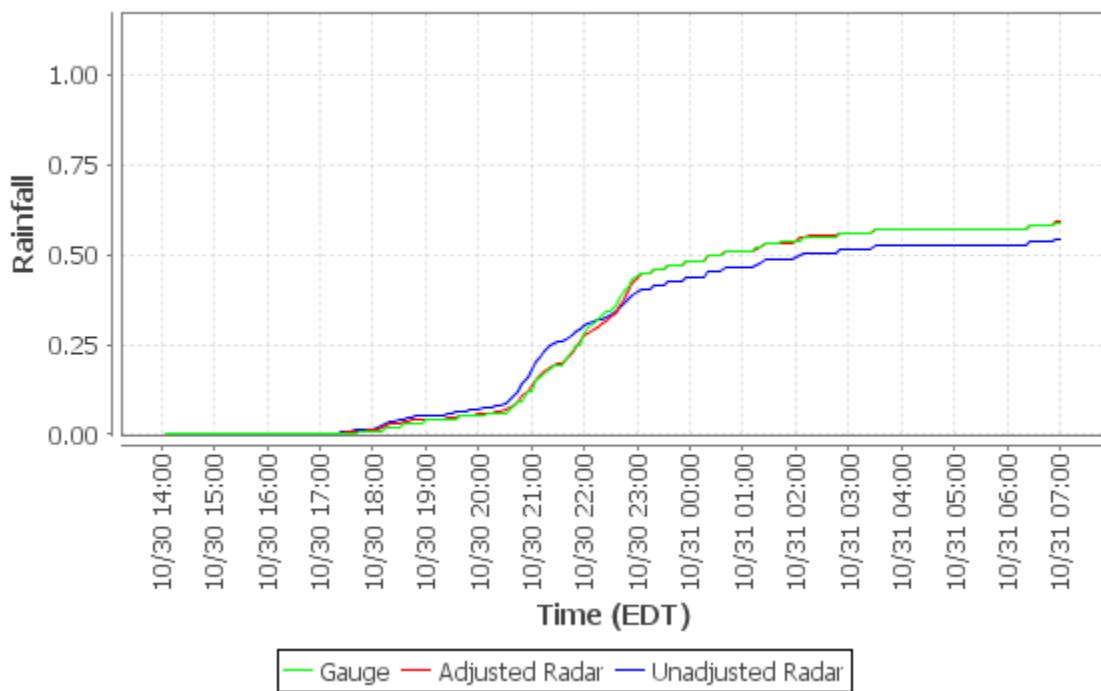
Cumulative Distribution Plot - Marshall TWP (Loc27)



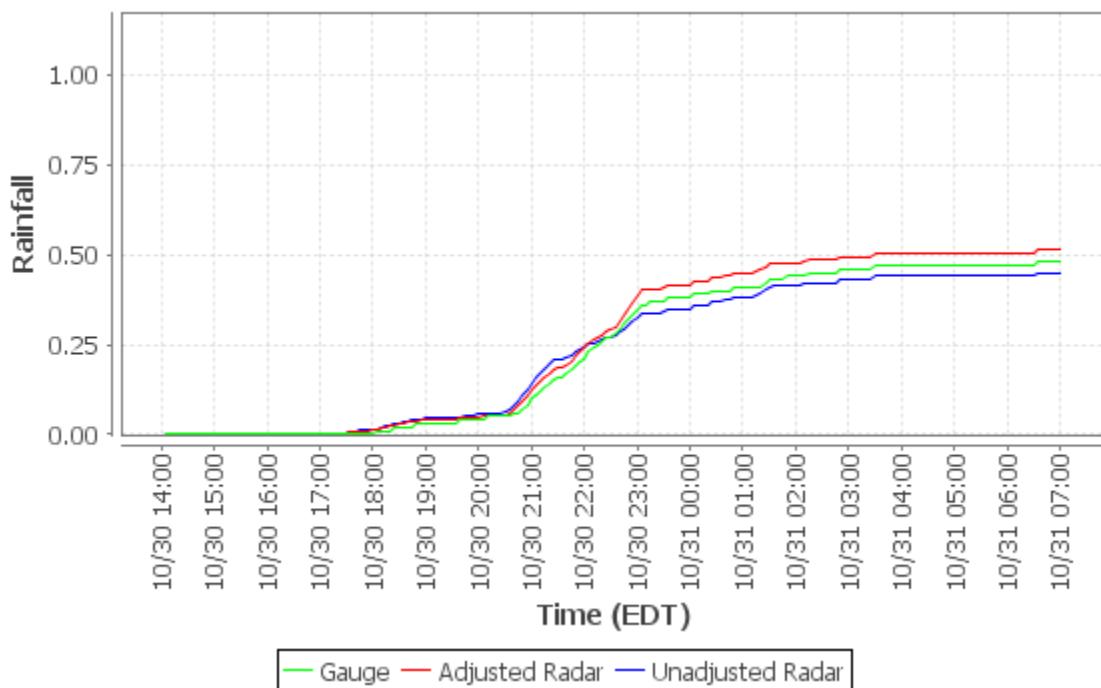
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



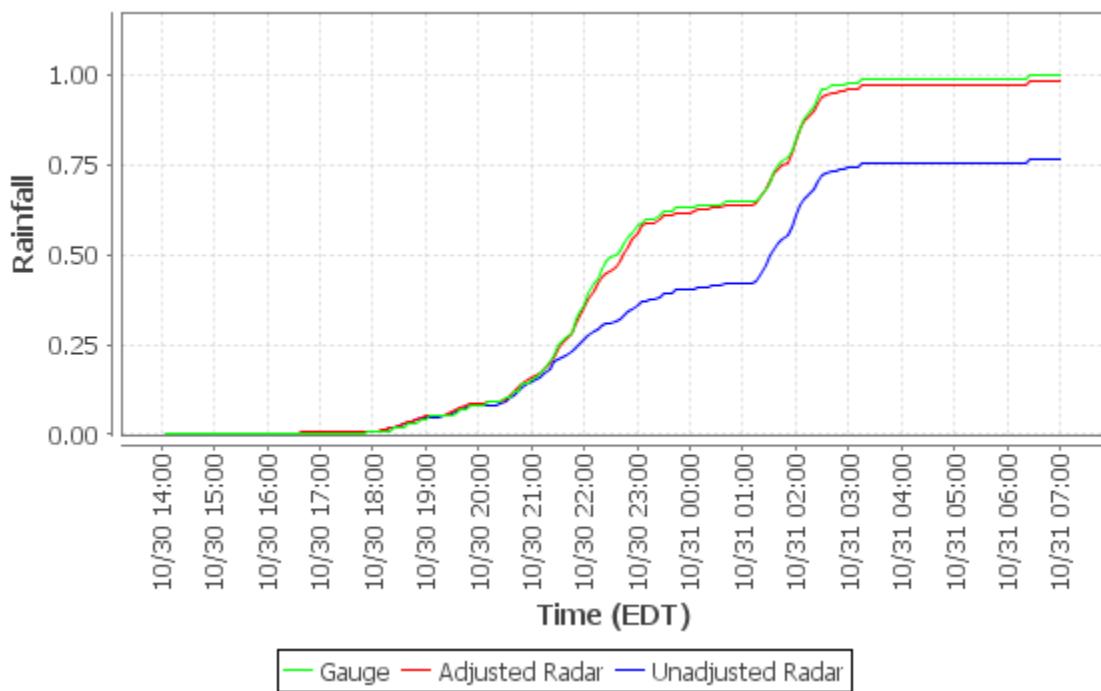
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



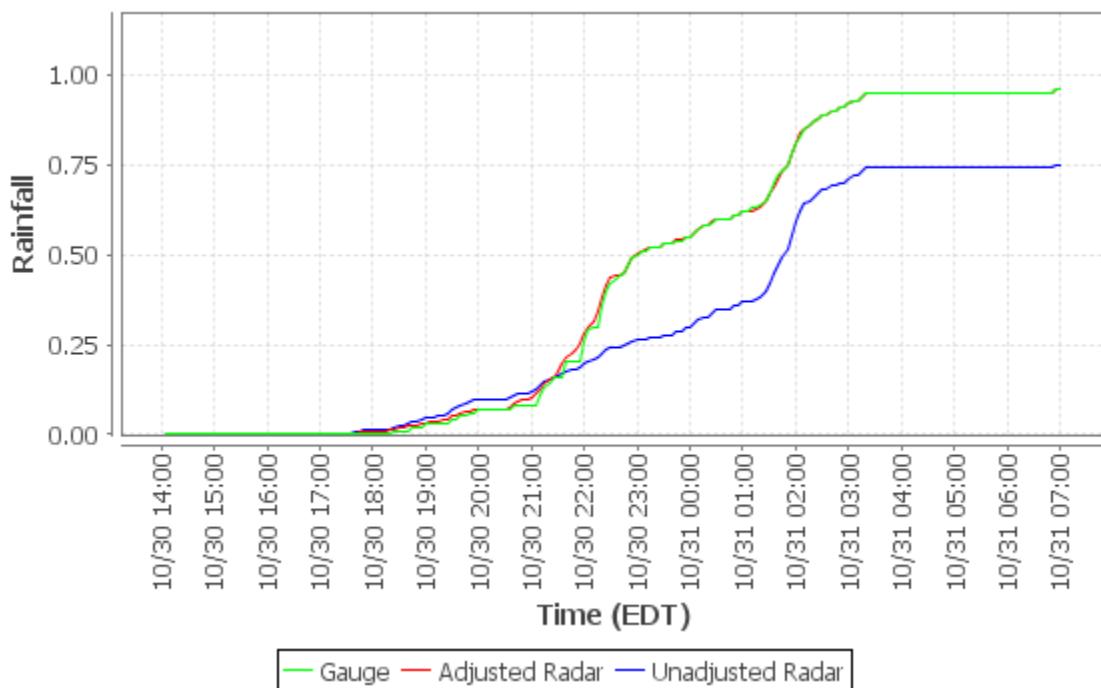
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



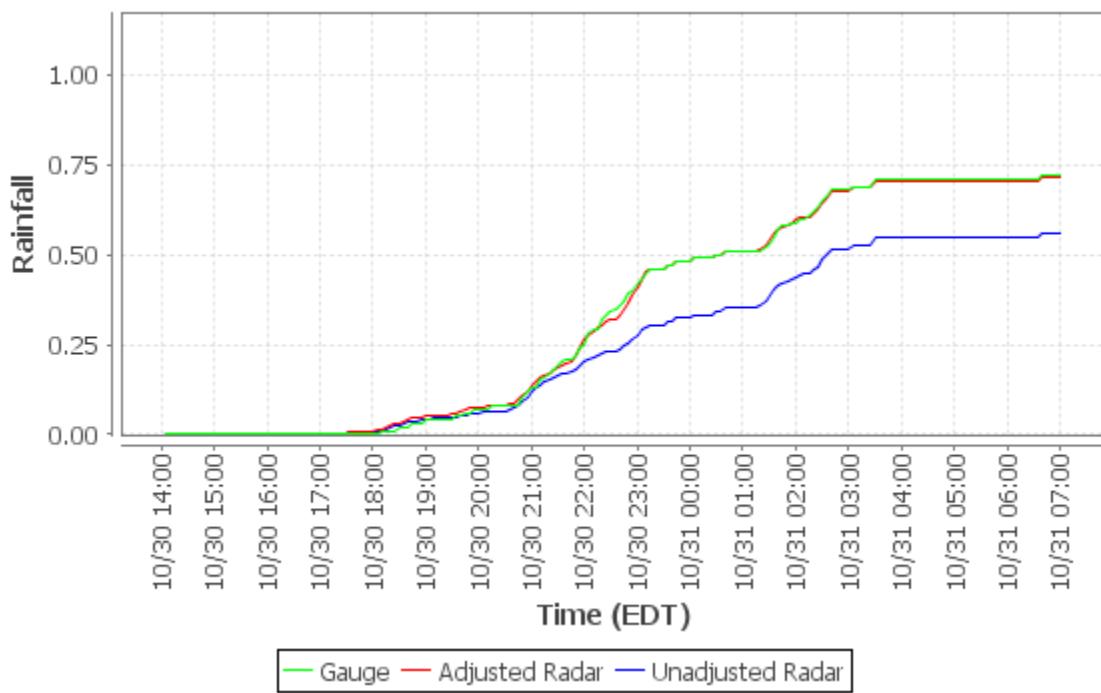
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



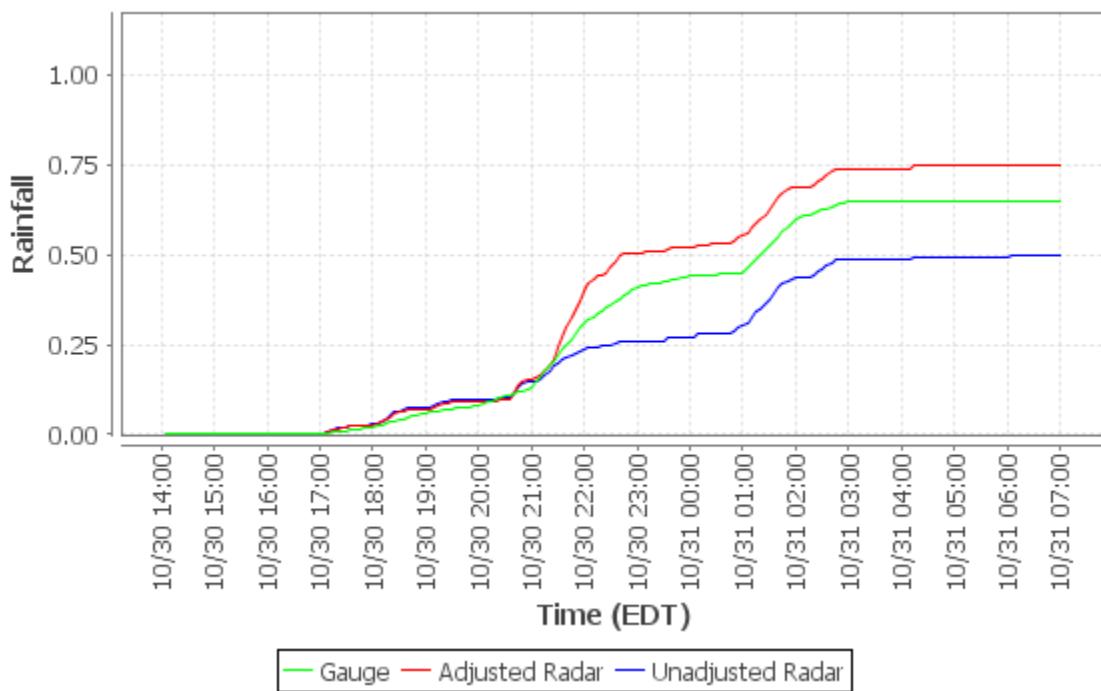
Cumulative Distribution Plot - Arnold (Loc32)



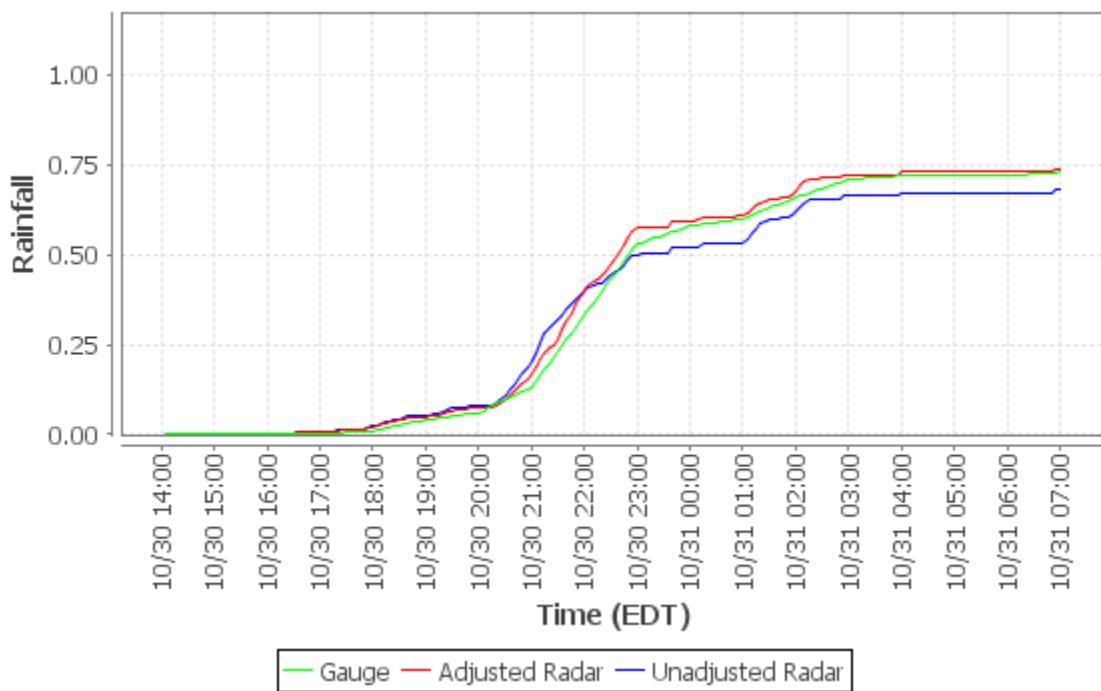
Cumulative Distribution Plot - Richland TWP (Loc33)



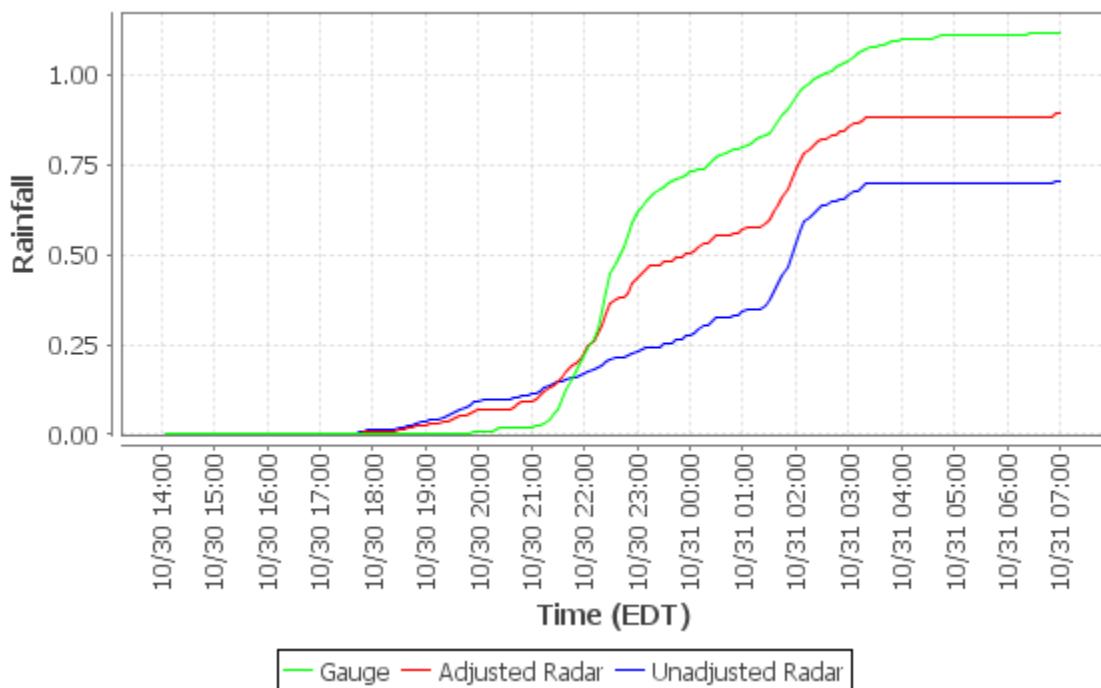
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



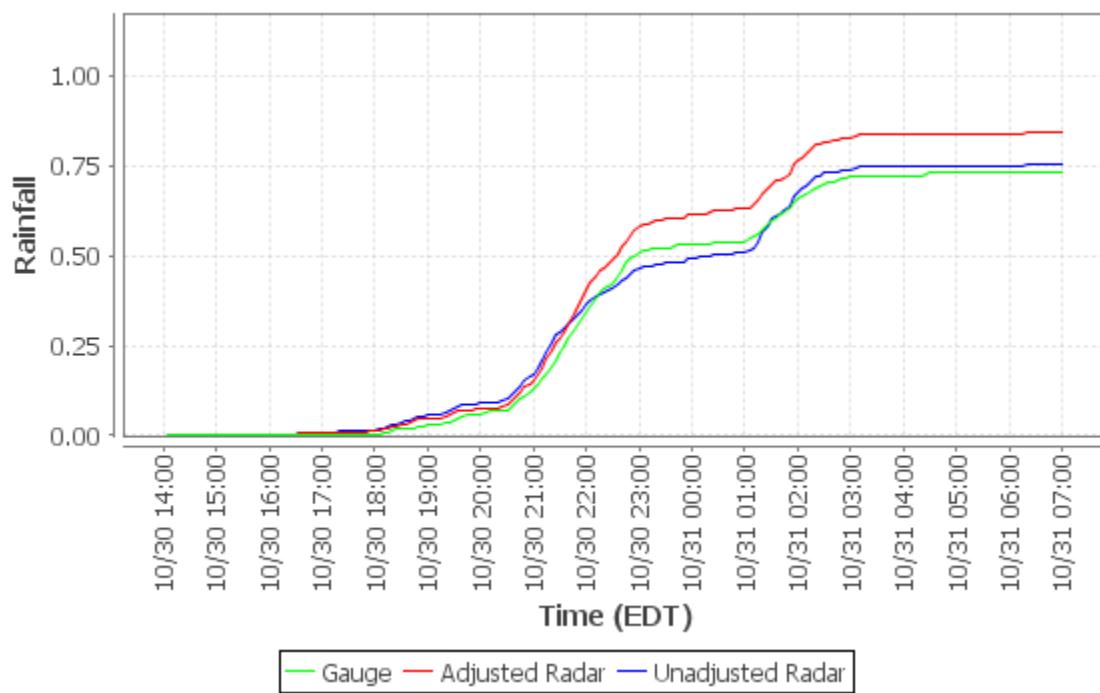
Cumulative Distribution Plot - Greater Pittsburgh Int'l (KPIT)



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

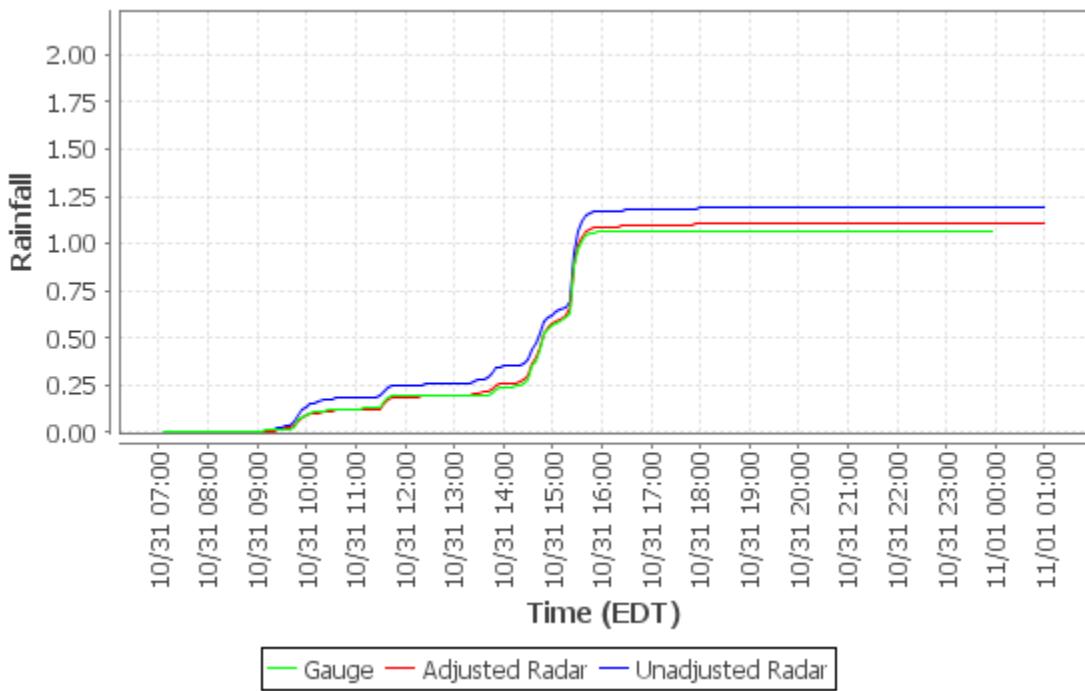


**Cumulative Distribution Plot - Ohio River at Emsworth Dam Lower Pool at Emsworth
(03085734)**

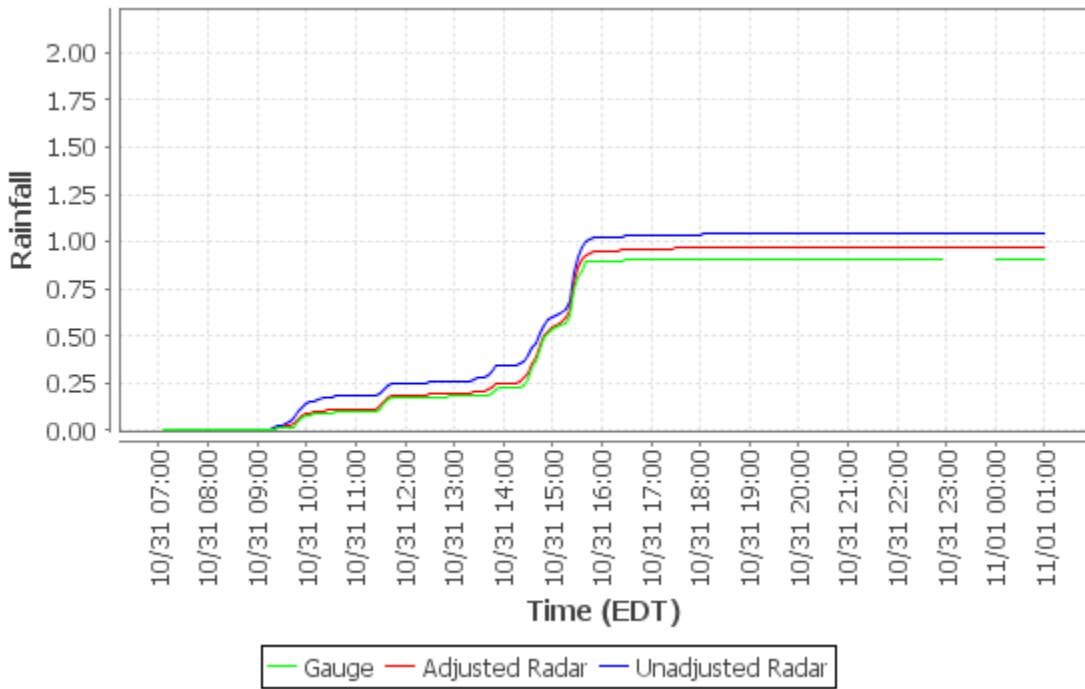


Appendix I - Event 7 (2019-10-31) CDPs

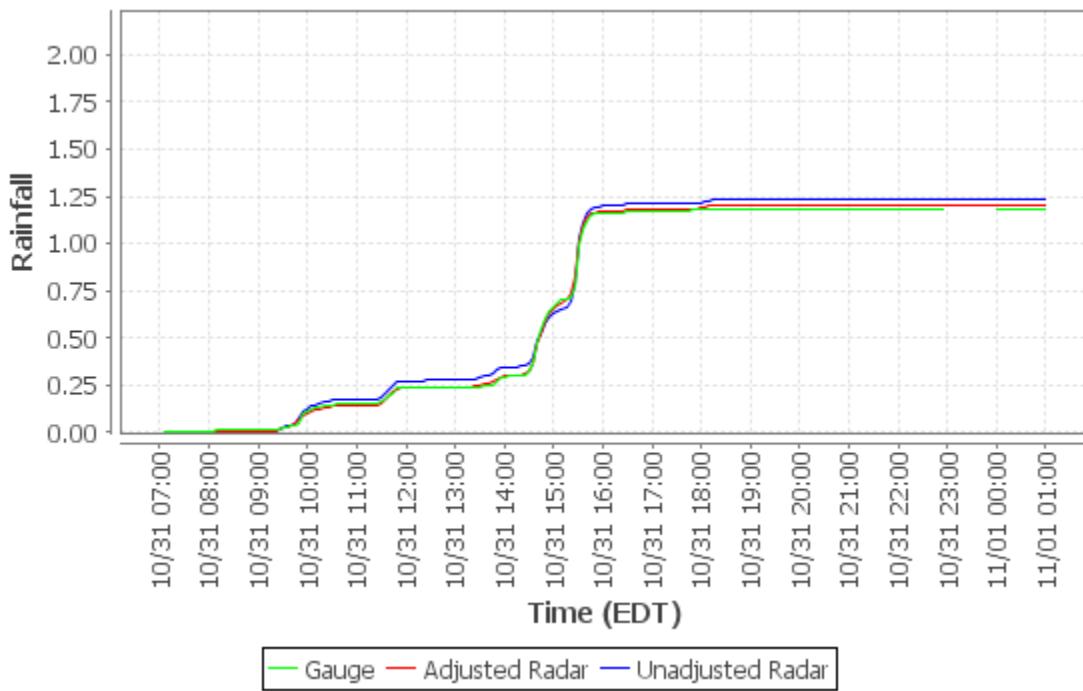
Cumulative Distribution Plot - PWSA-Montana St. (Loc01)



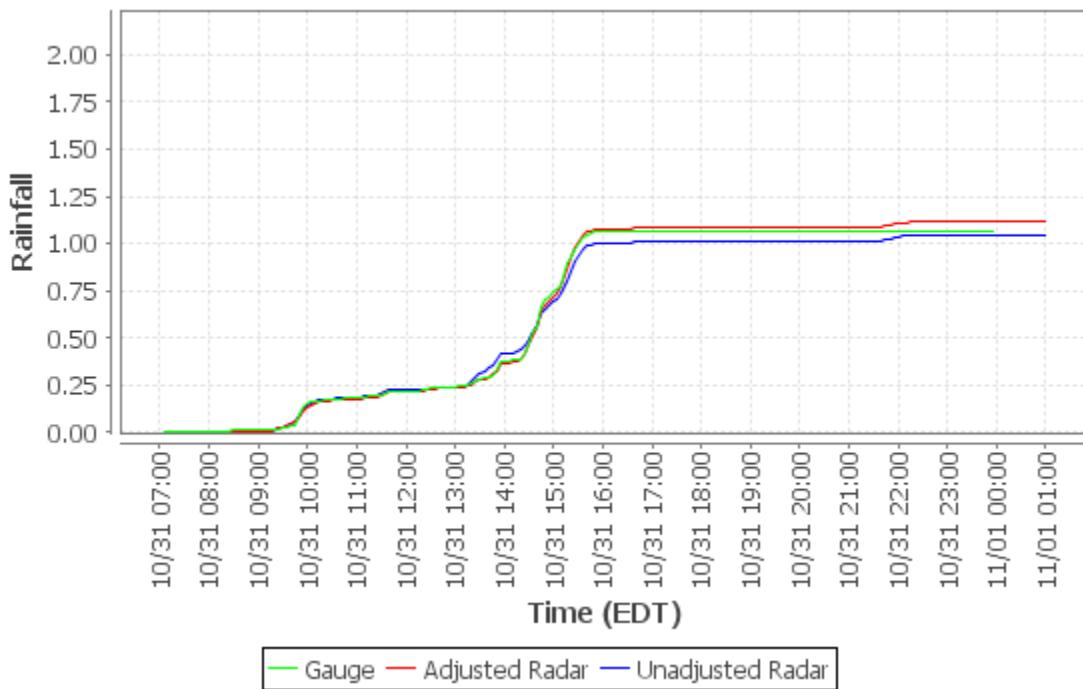
Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)



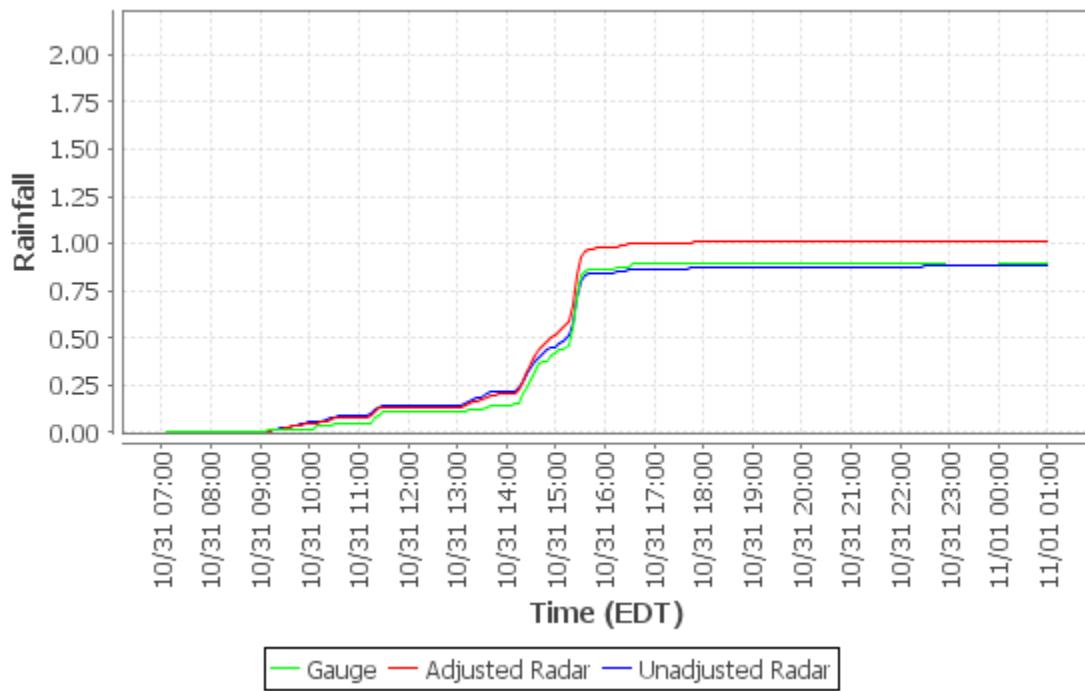
Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)



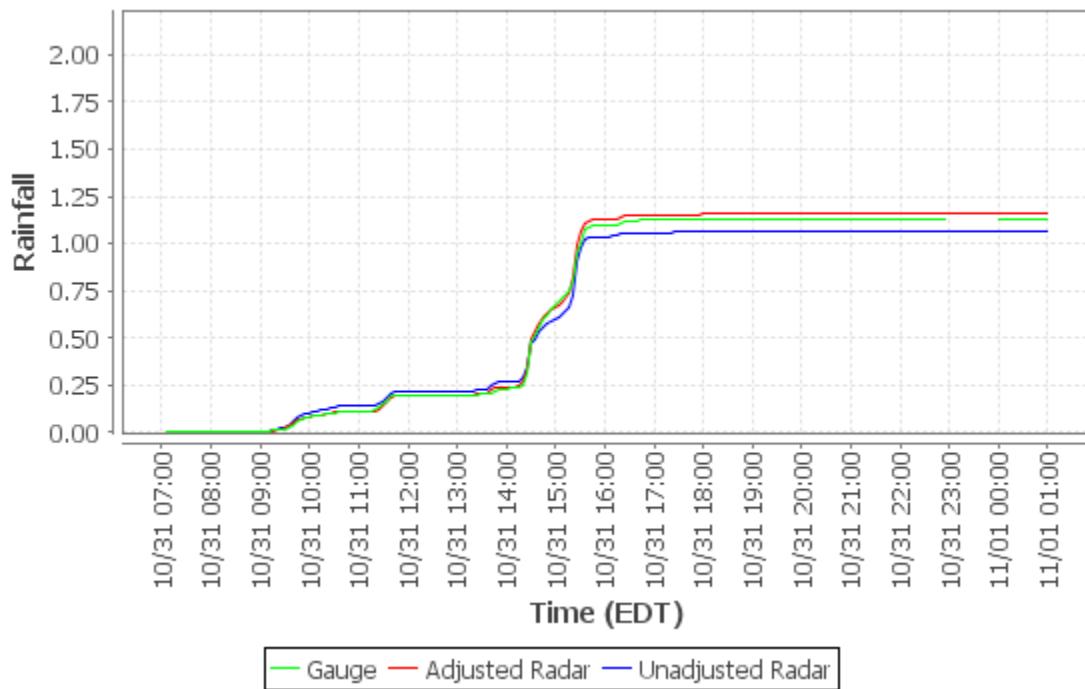
Cumulative Distribution Plot - Kennedy Twp PS (Loc04)



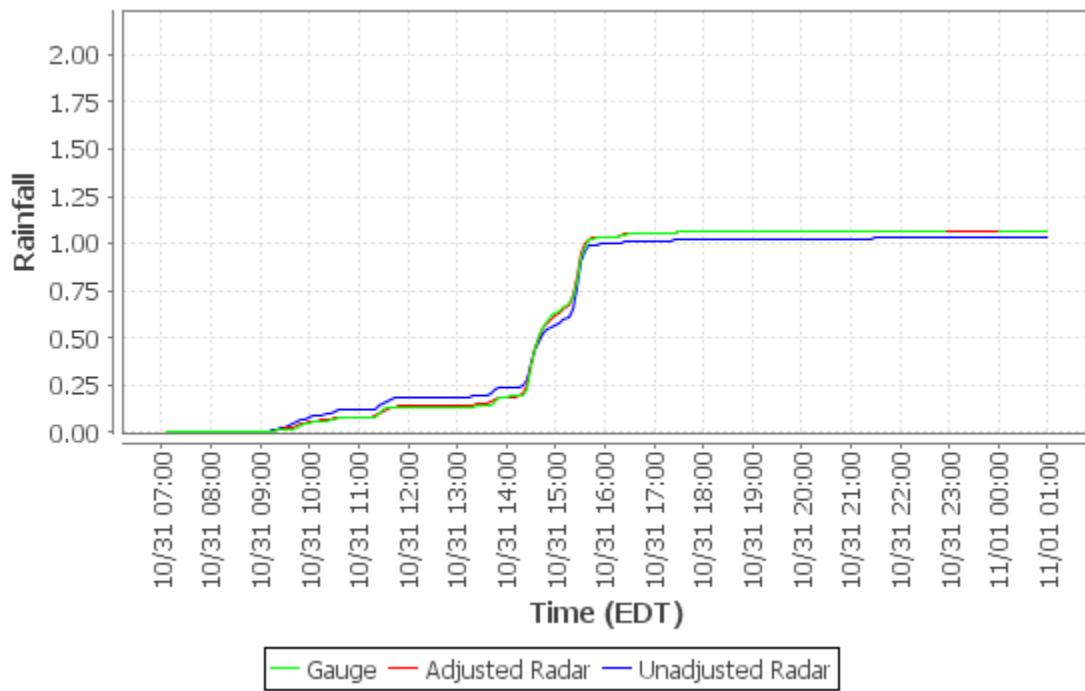
Cumulative Distribution Plot - Upper St. Clair (Loc05)



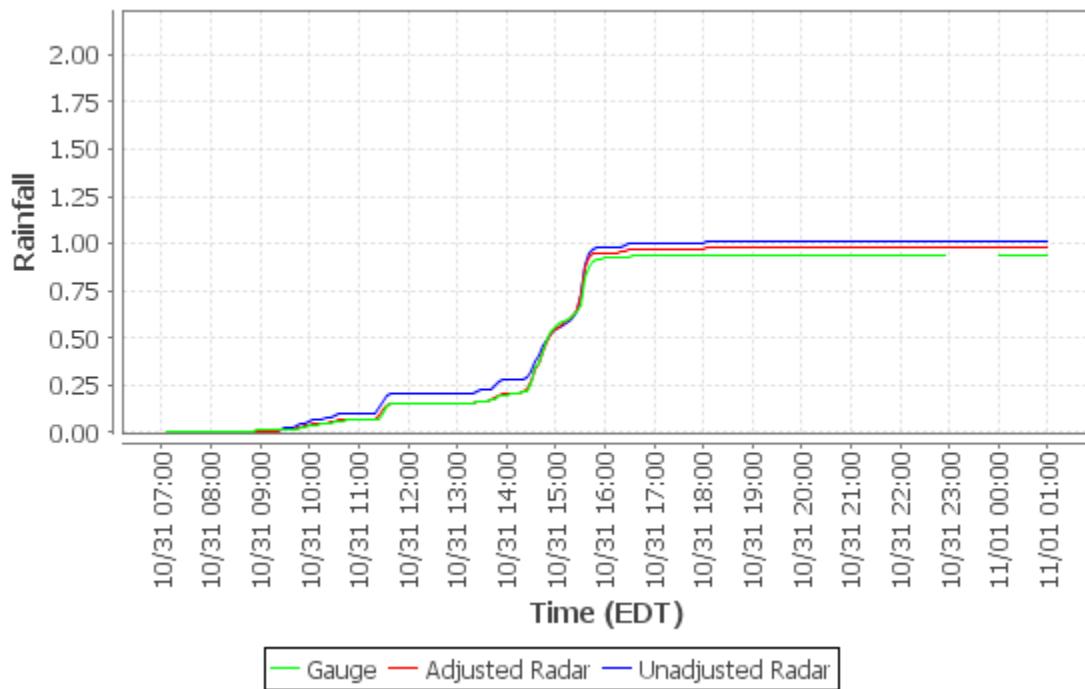
Cumulative Distribution Plot - Carnegie Transit Time (Loc06)



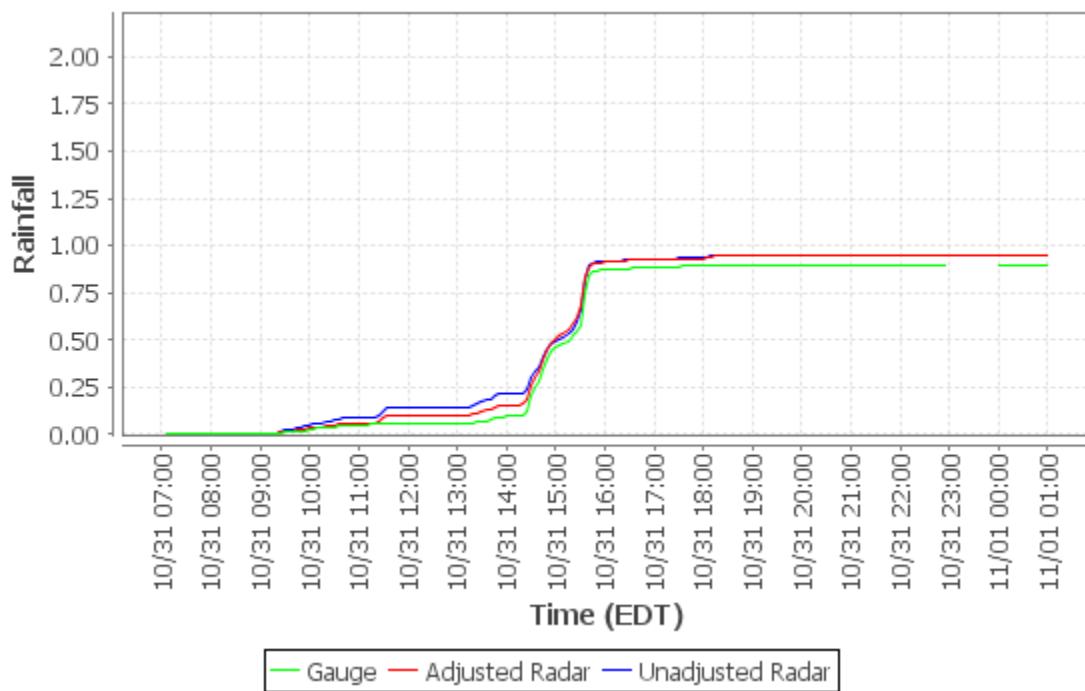
Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)



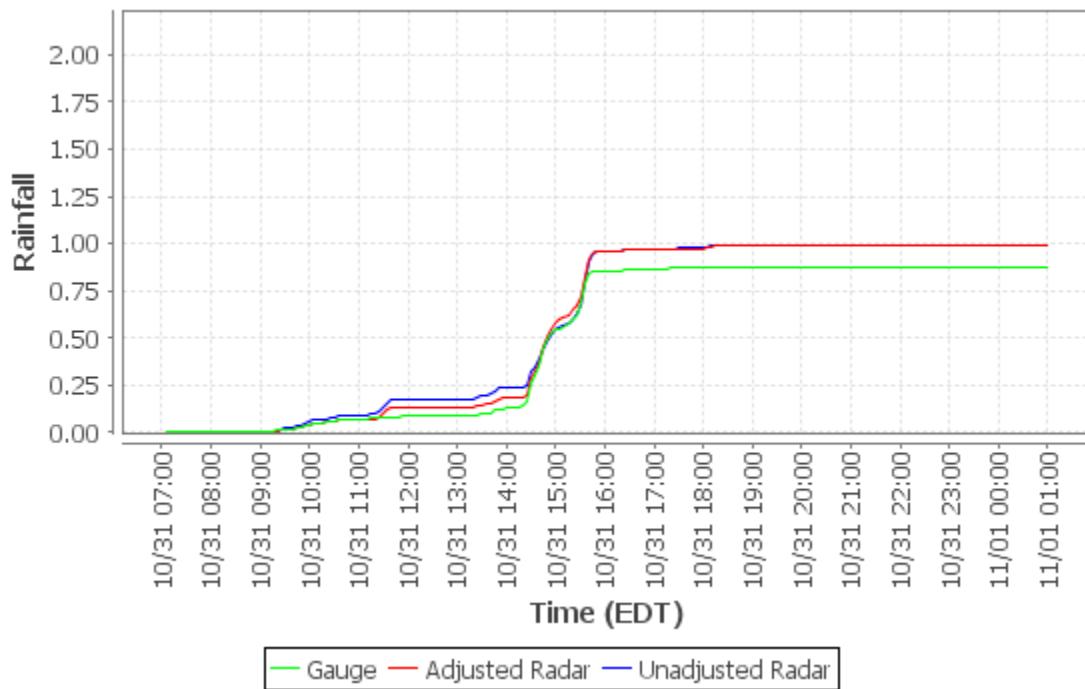
Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)



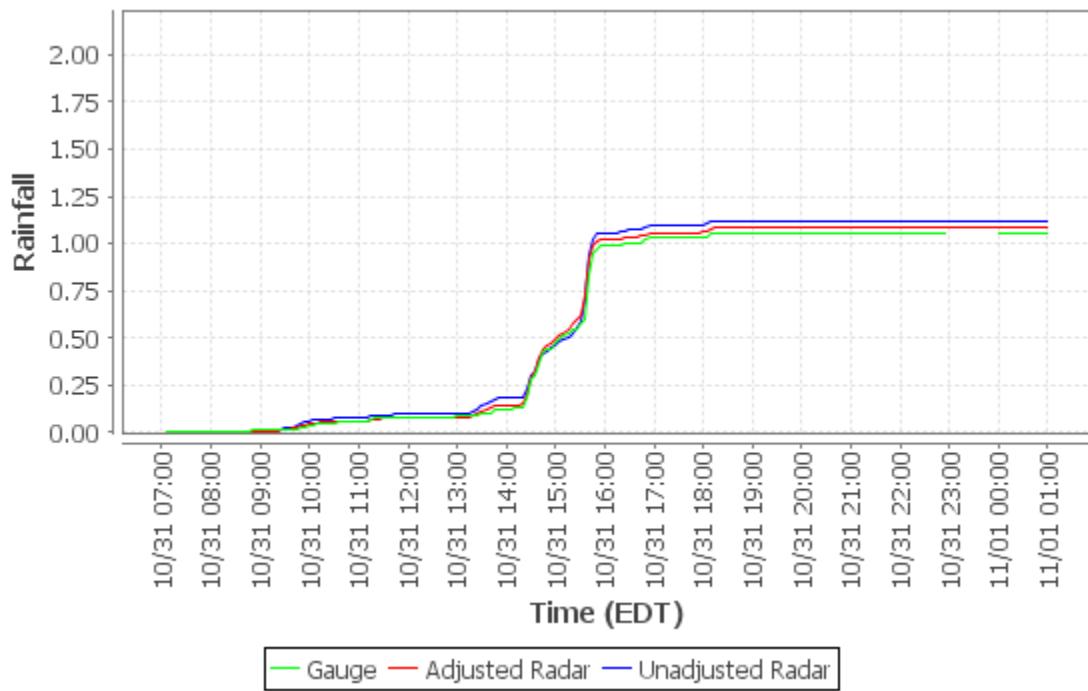
Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)



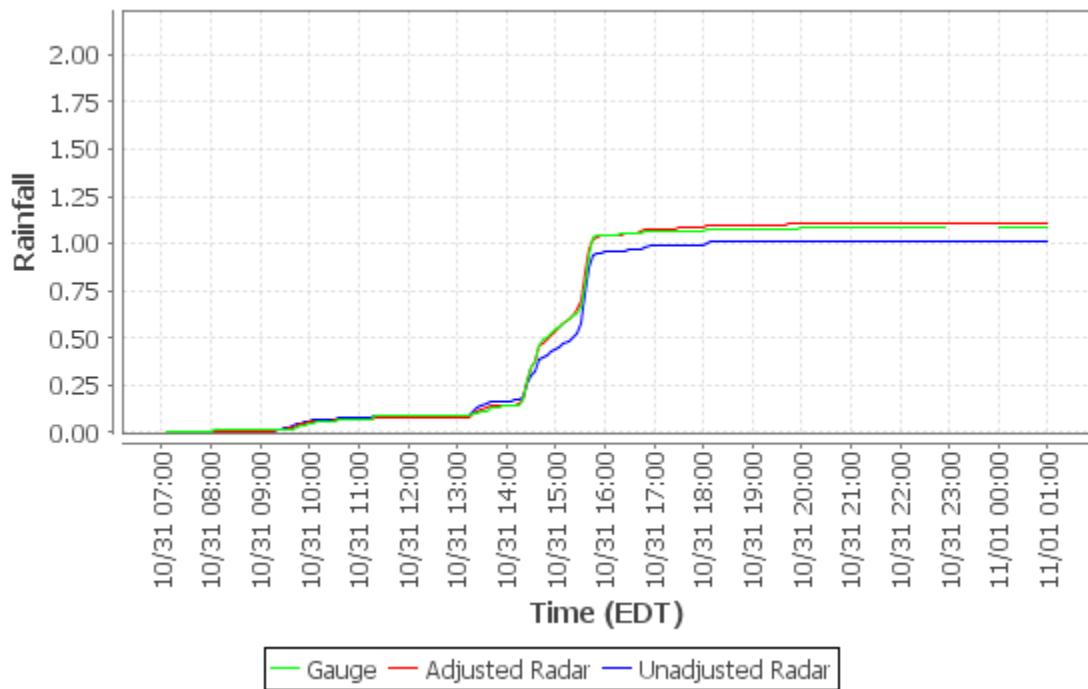
Cumulative Distribution Plot - PWSA-Highland Park (Loc10)



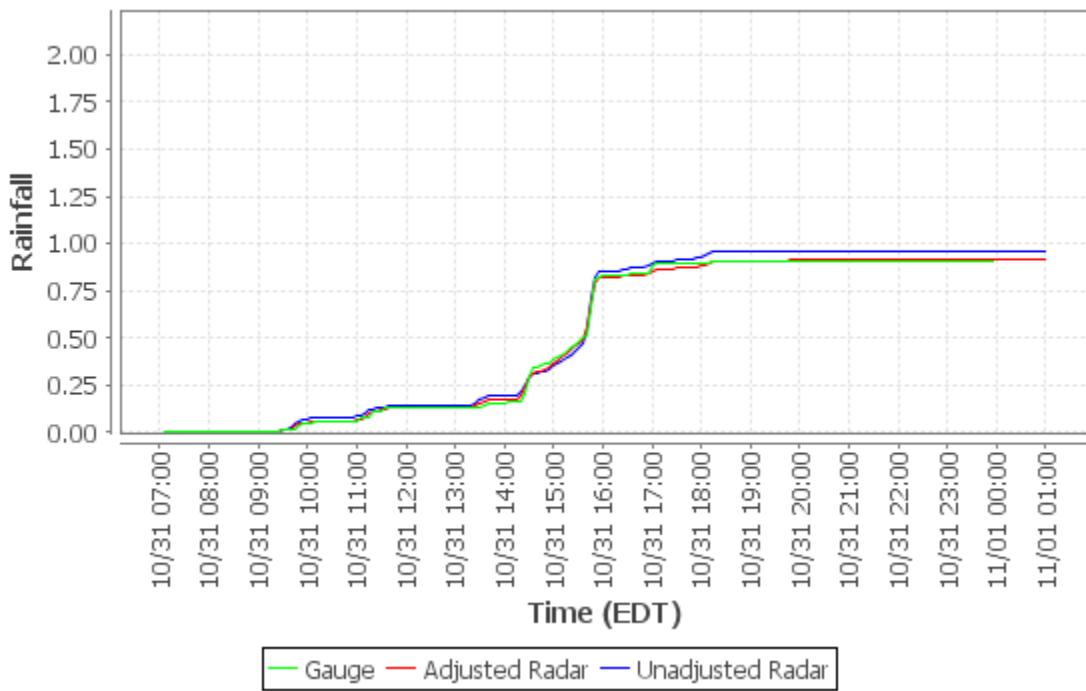
Cumulative Distribution Plot - M-46 Access Shaft (Loc11)



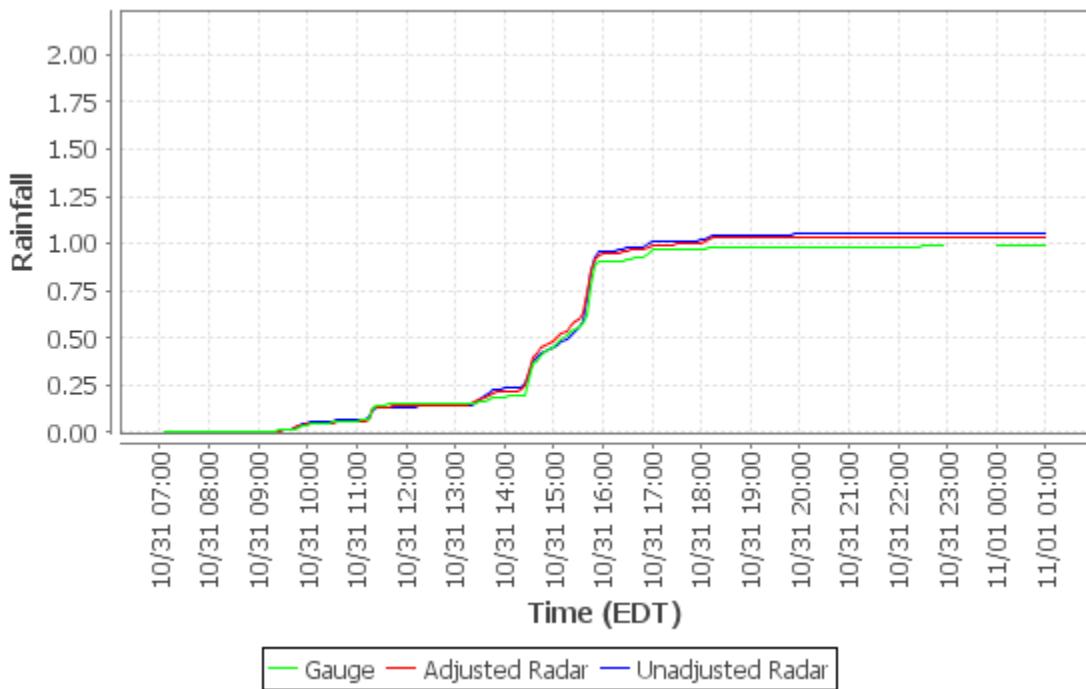
Cumulative Distribution Plot - Baldwin (Loc12)



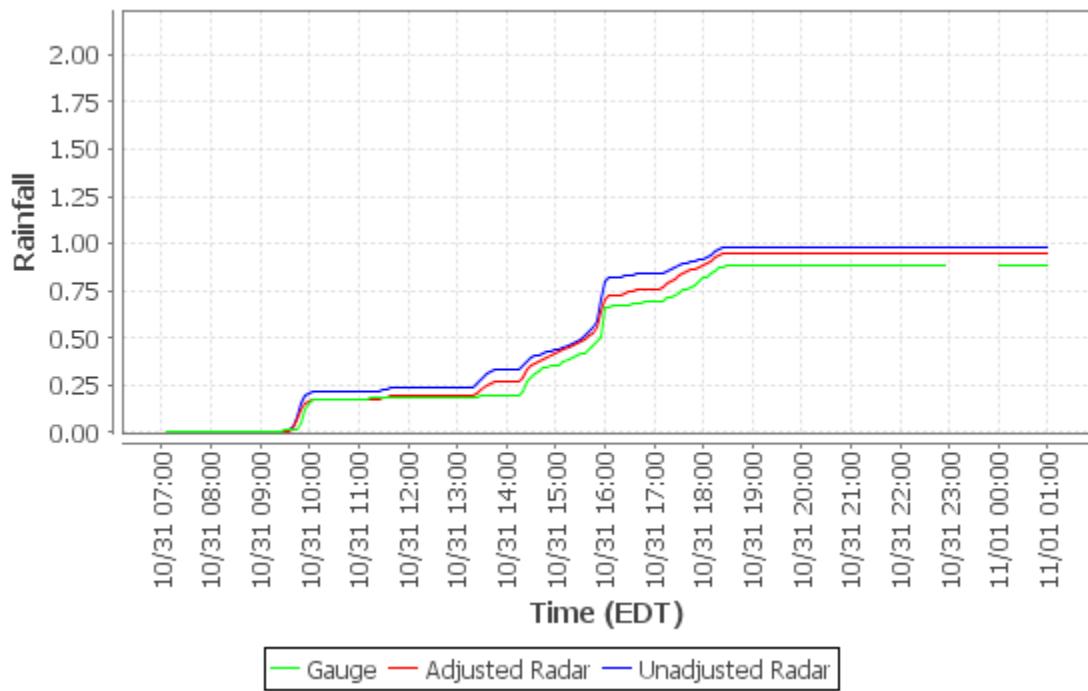
Cumulative Distribution Plot - M-59 Access Shaft (Loc13)



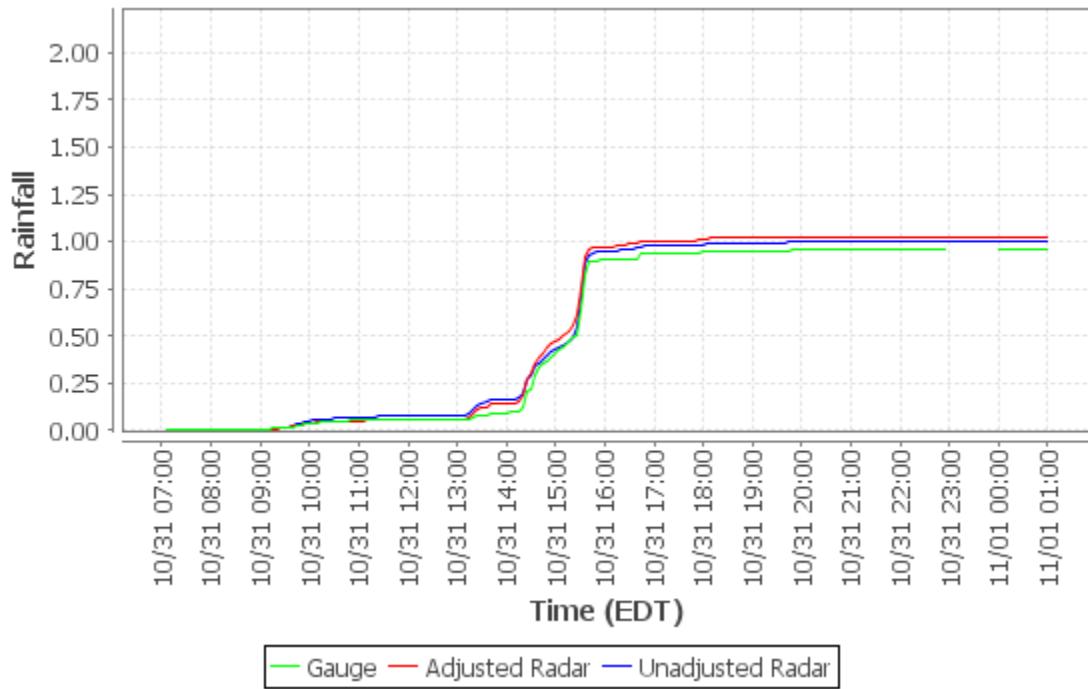
Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)



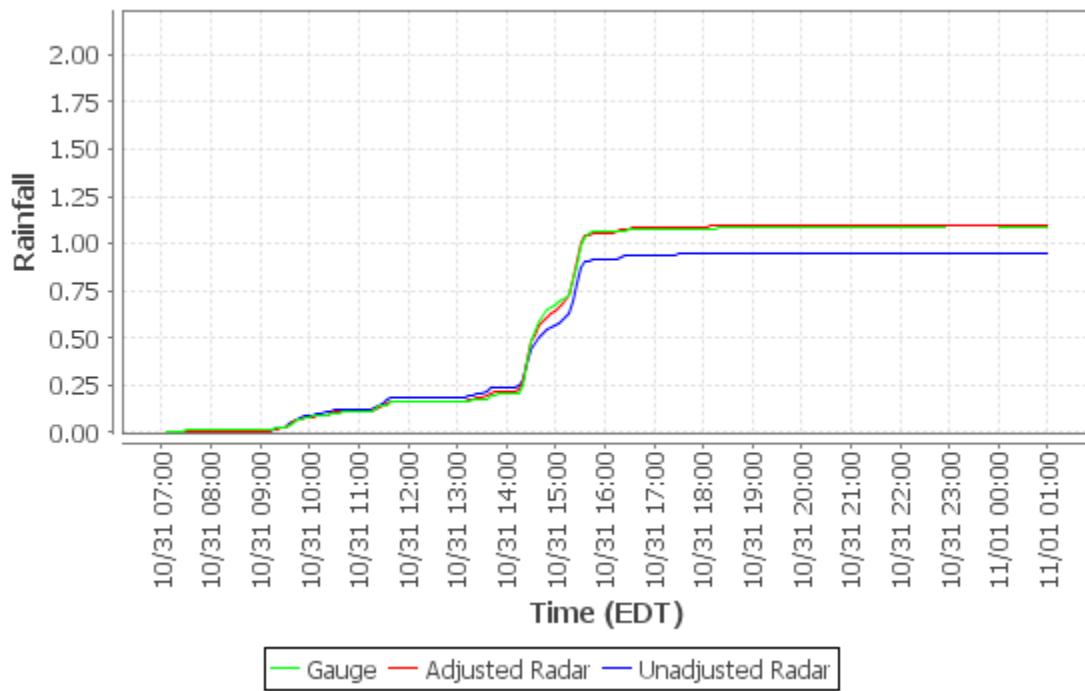
Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)



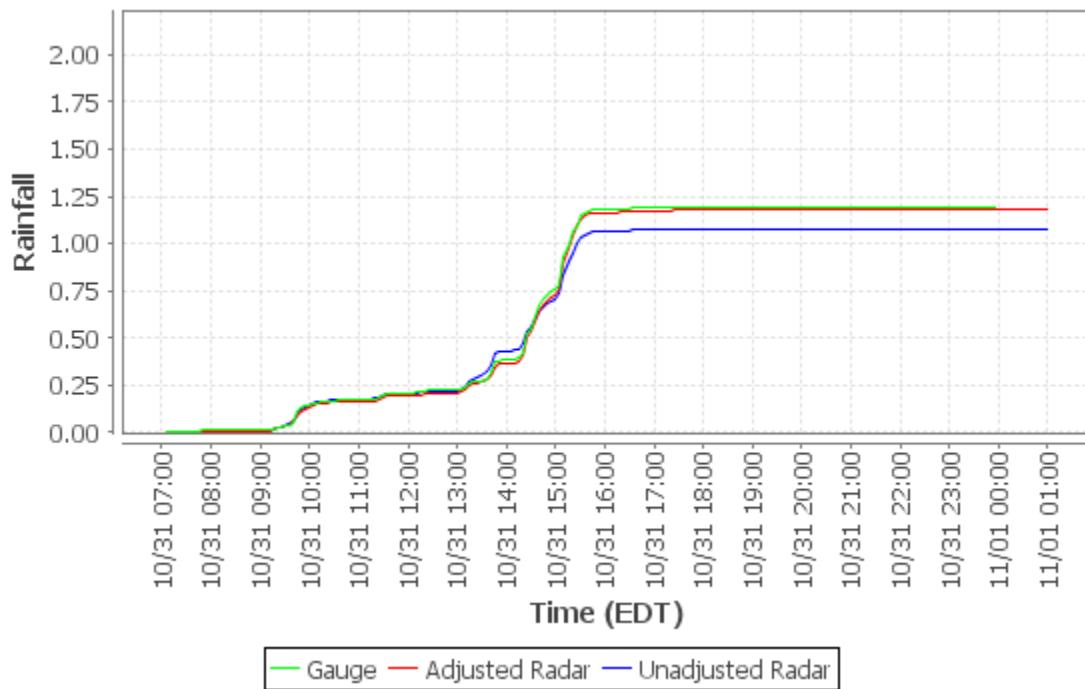
Cumulative Distribution Plot - Castle Shannon (Loc16)



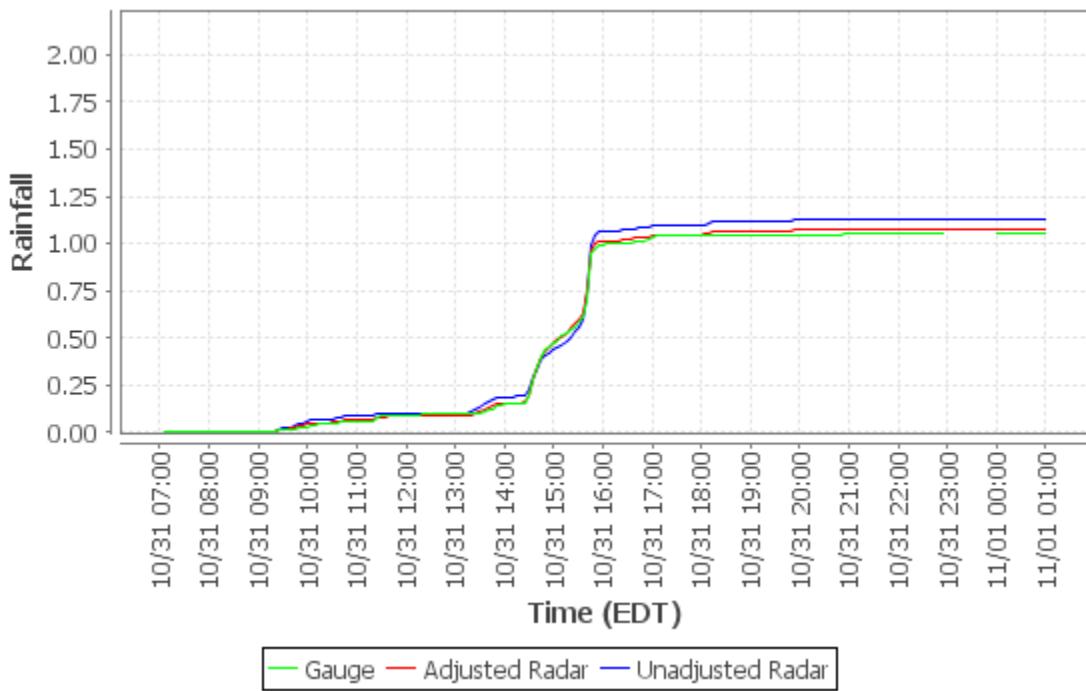
Cumulative Distribution Plot - Chartiers Pump Station (Loc17)



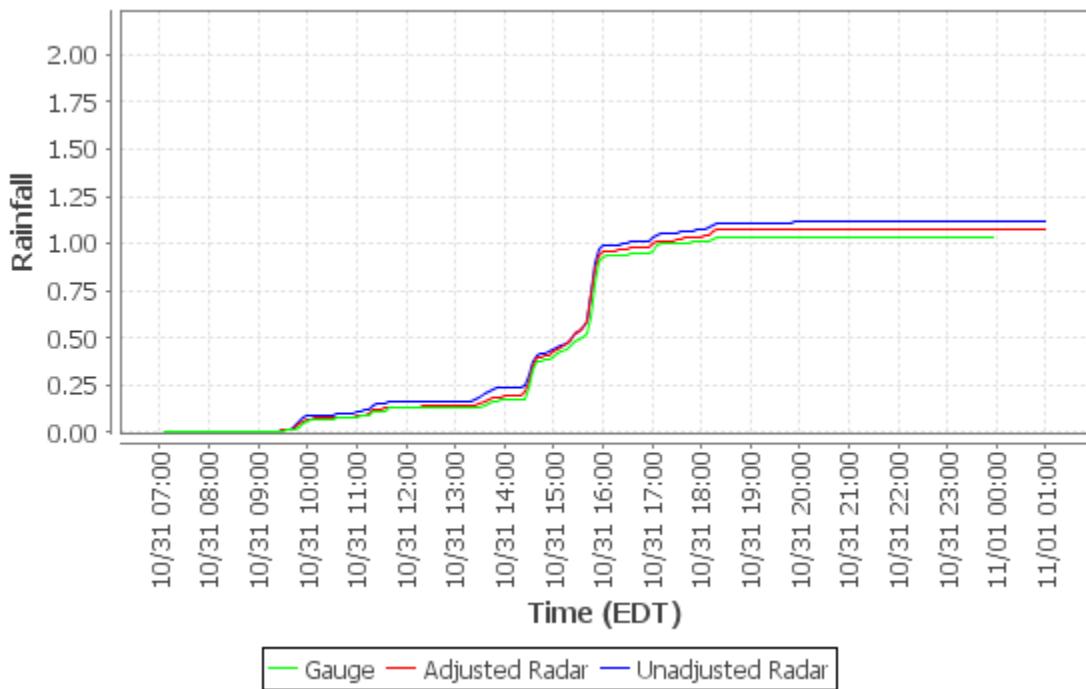
Cumulative Distribution Plot - Oakdale Pump Station (Loc18)



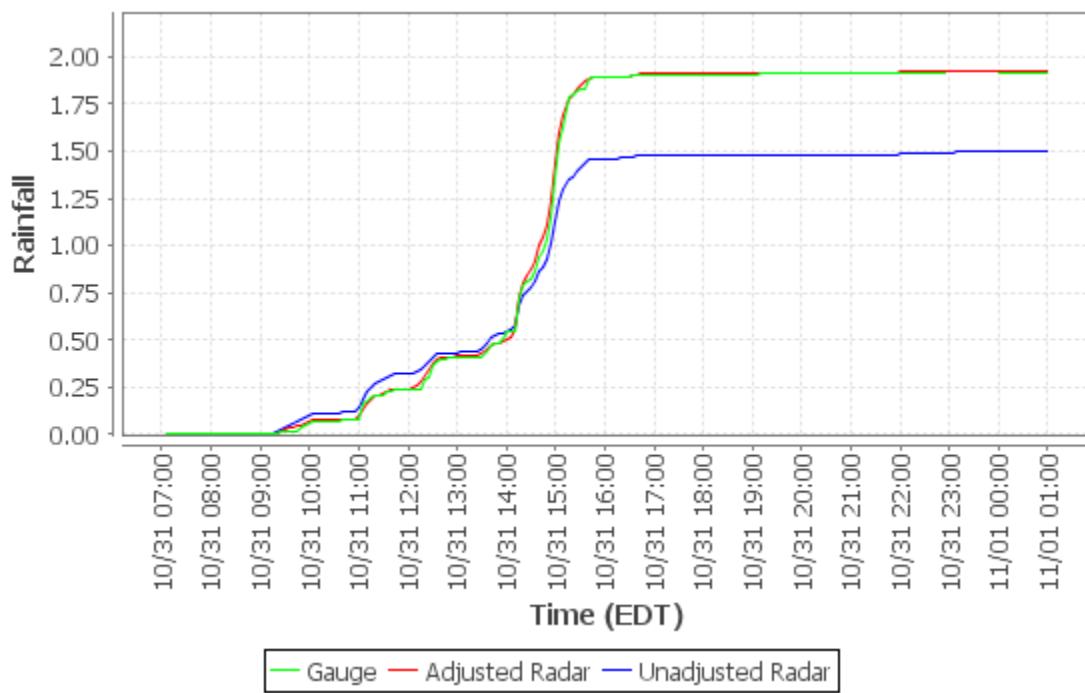
Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)



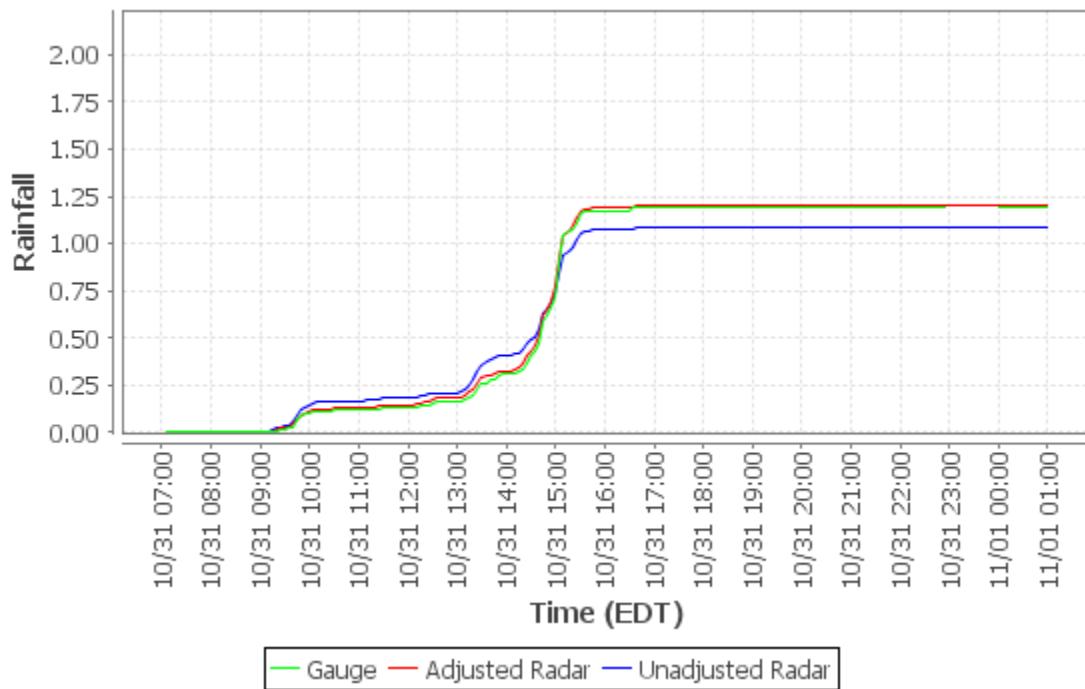
Cumulative Distribution Plot - Gascola Eq Facility (Loc20)



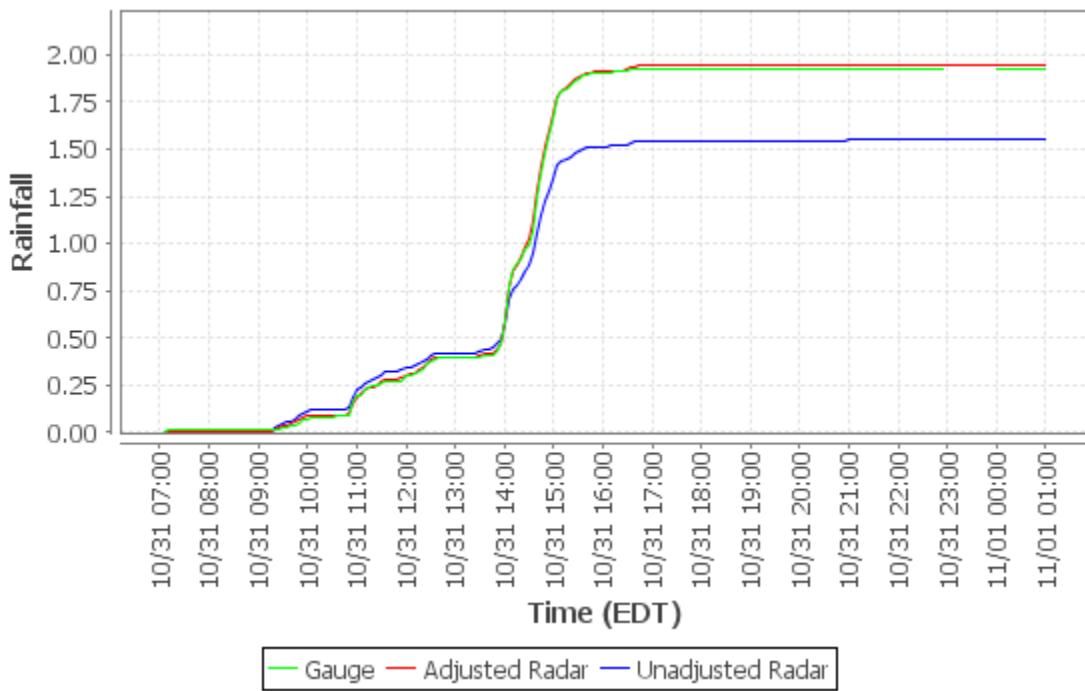
Cumulative Distribution Plot - Moon TWP (Loc21)



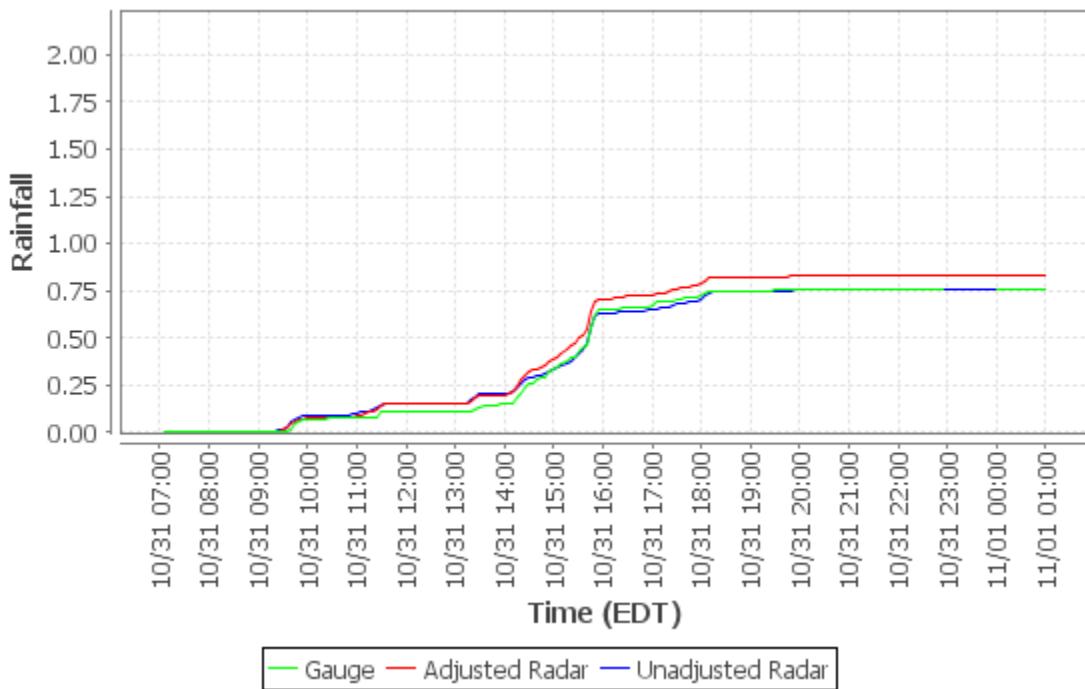
Cumulative Distribution Plot - North Fayette TWP (Loc22)



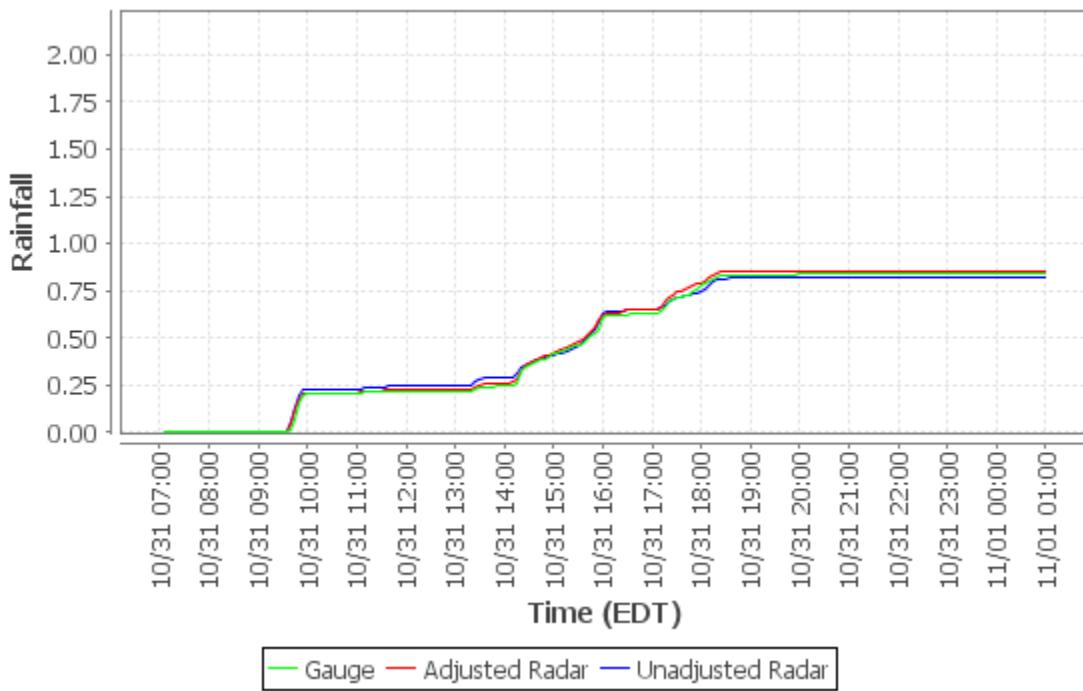
Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)



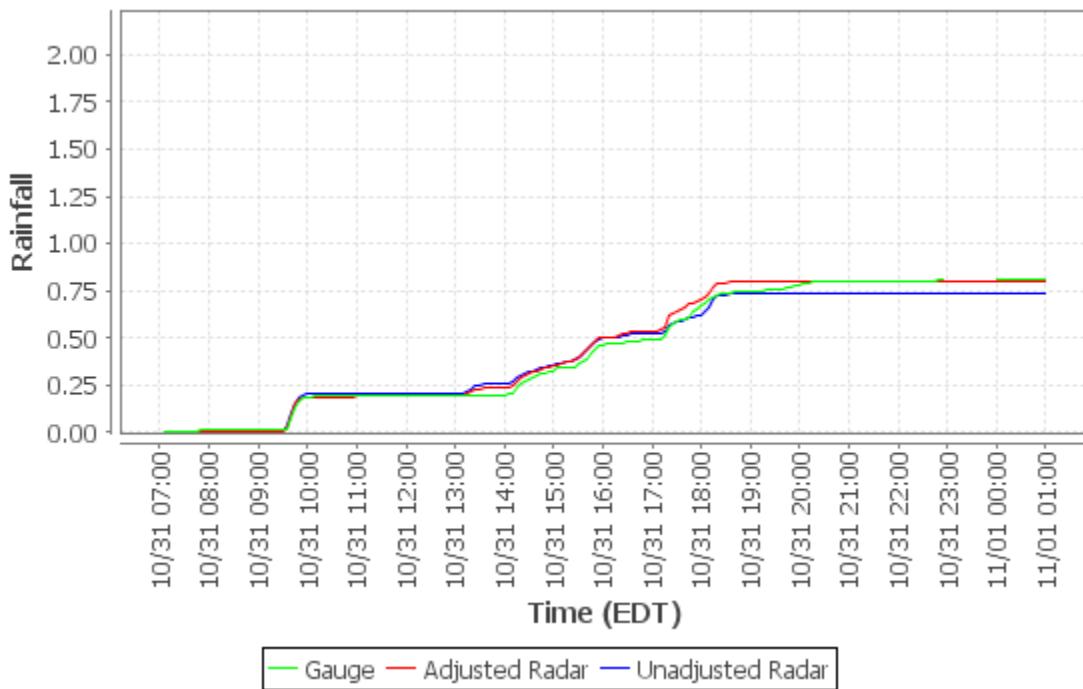
Cumulative Distribution Plot - Jefferson Hills (Loc24)



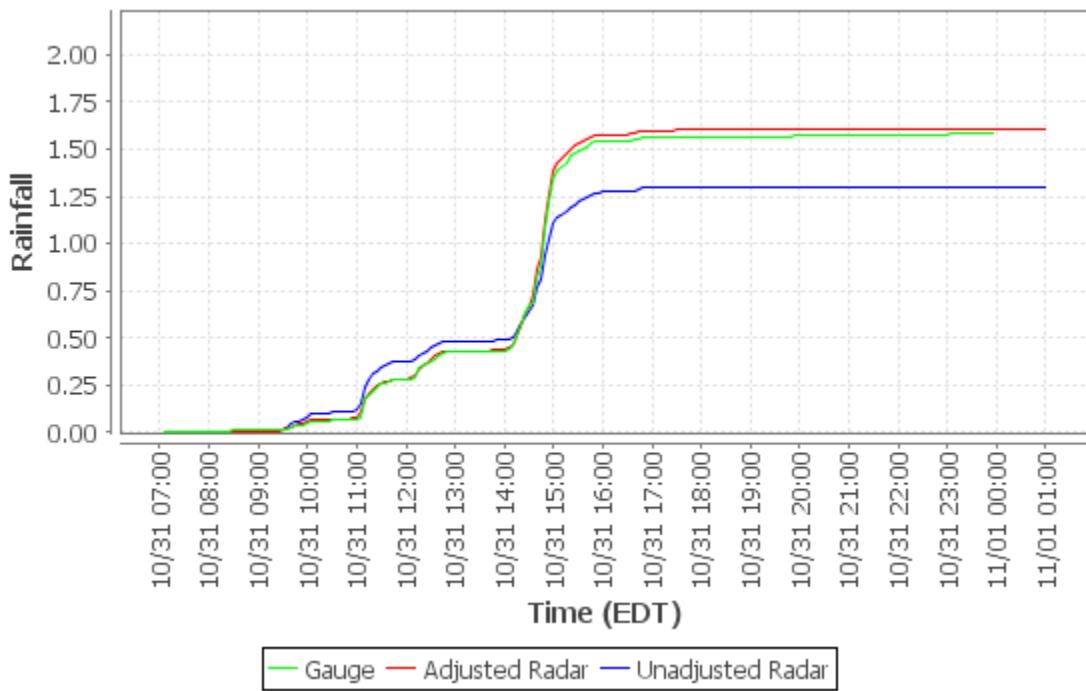
Cumulative Distribution Plot - White Oak Public Works Bldg (Loc25)



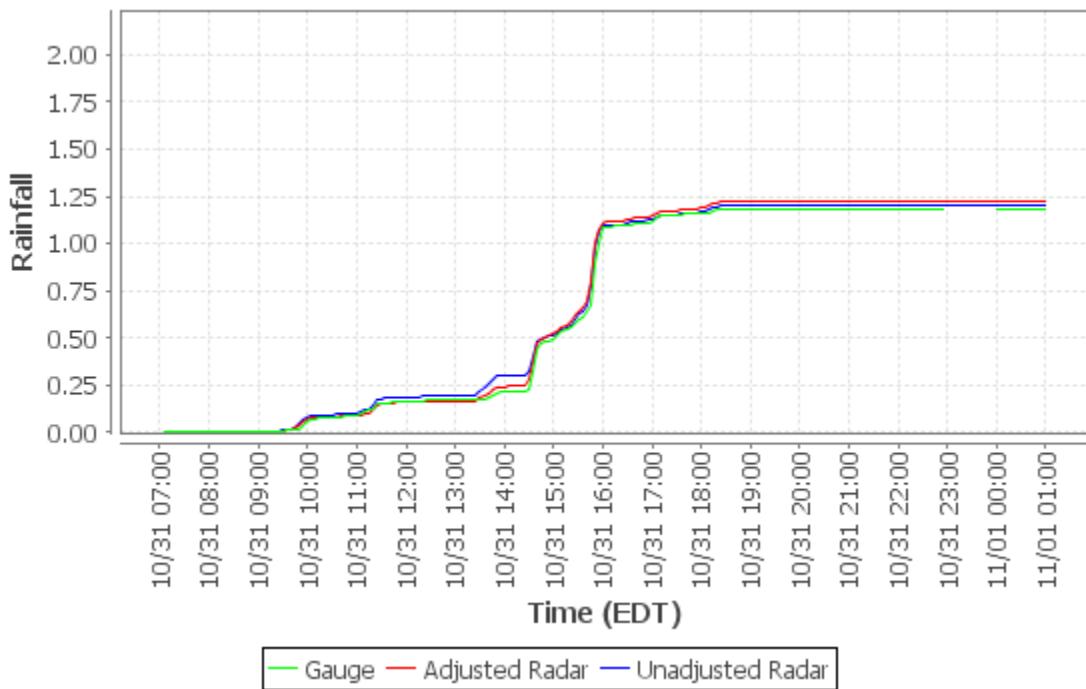
Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)



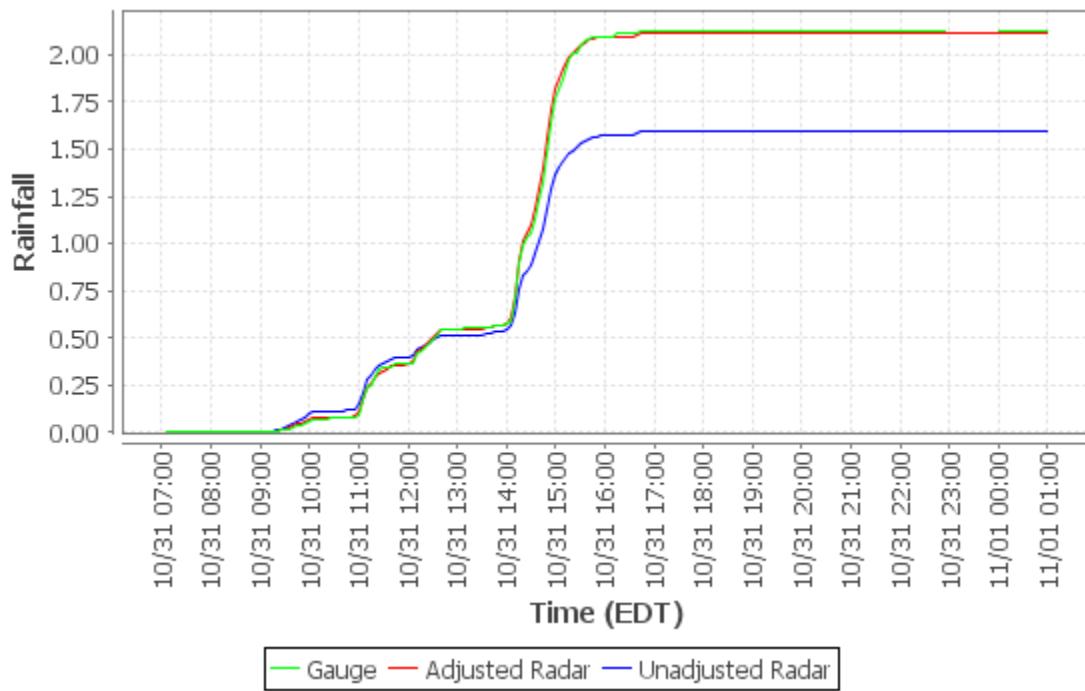
Cumulative Distribution Plot - Marshall TWP (Loc27)



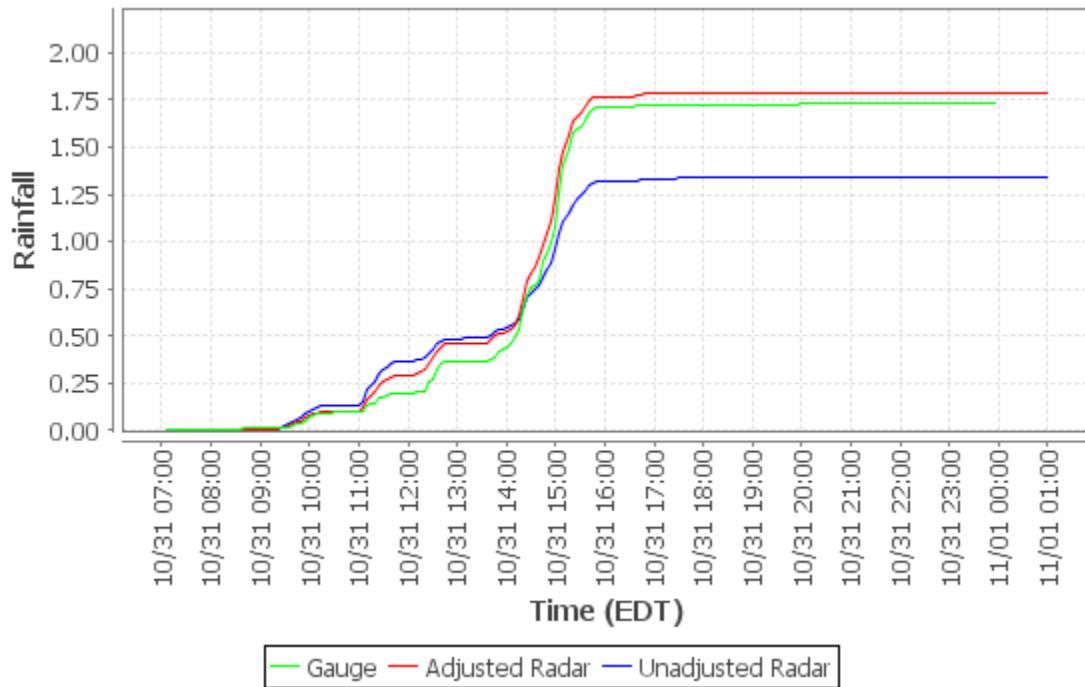
Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)



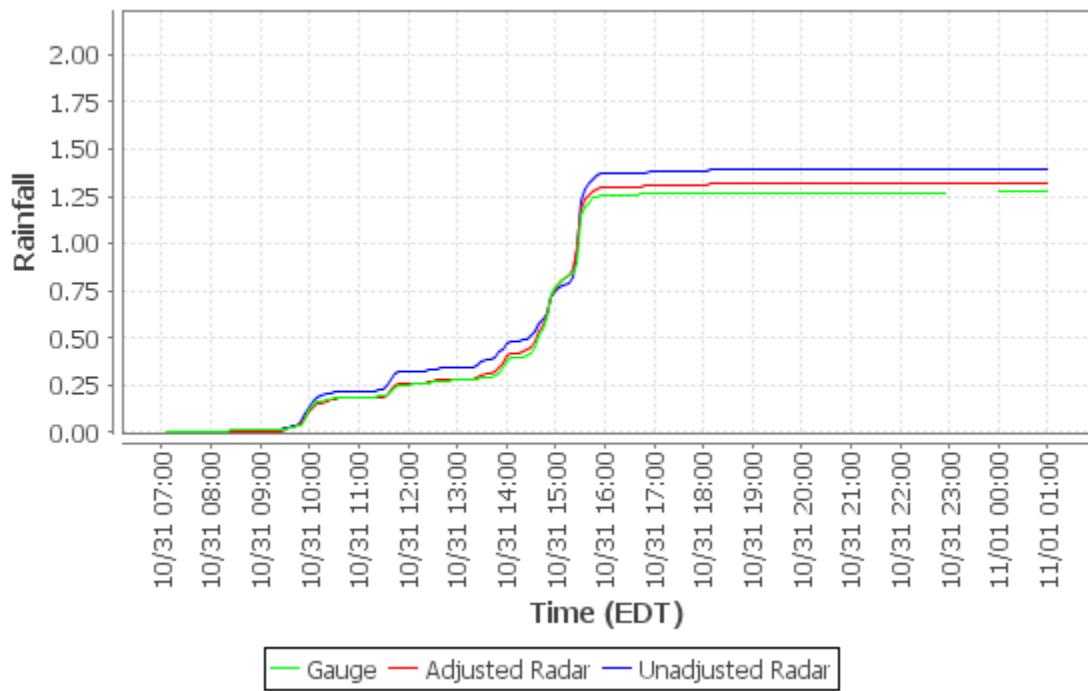
Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)



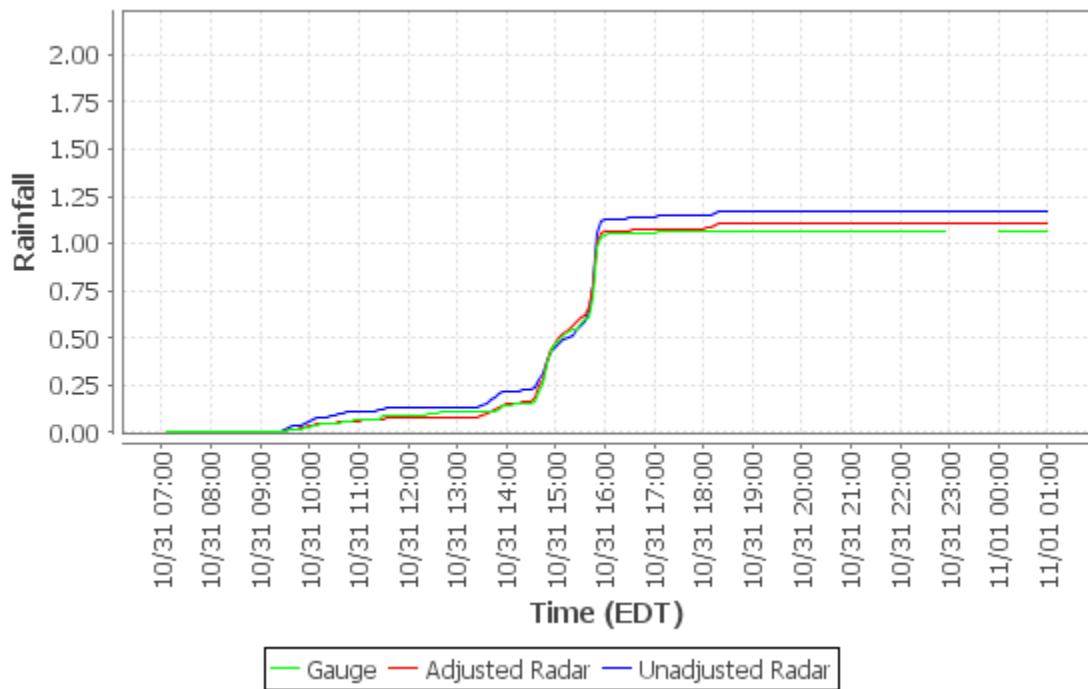
Cumulative Distribution Plot - McCandless Twn Hall (Loc30)



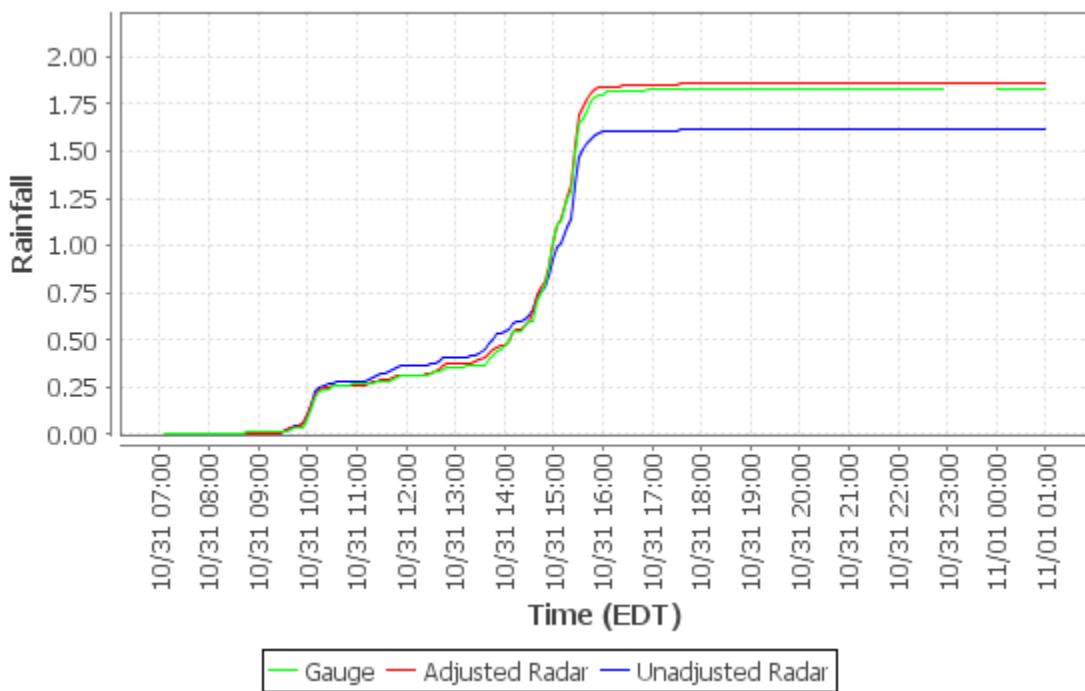
Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)



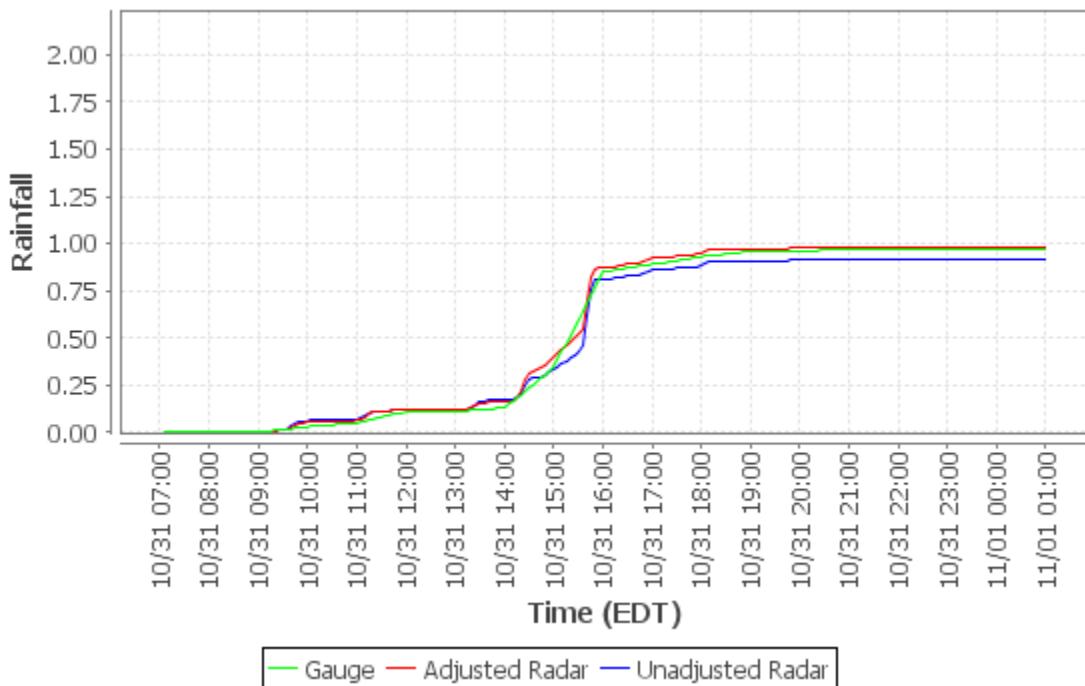
Cumulative Distribution Plot - Arnold (Loc32)



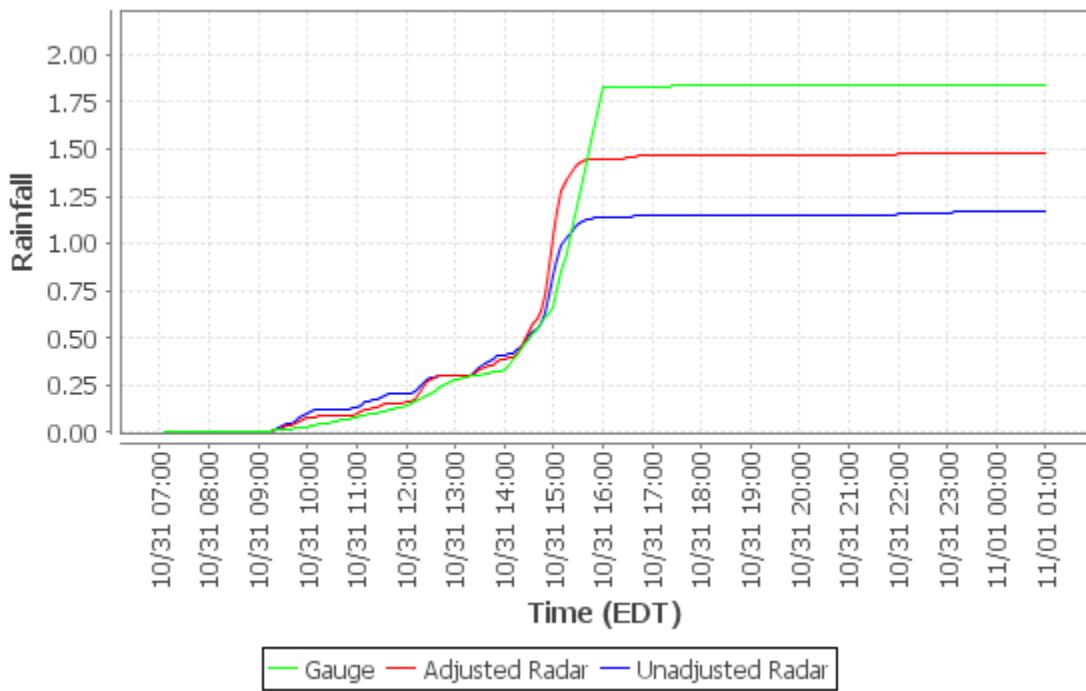
Cumulative Distribution Plot - Richland TWP (Loc33)



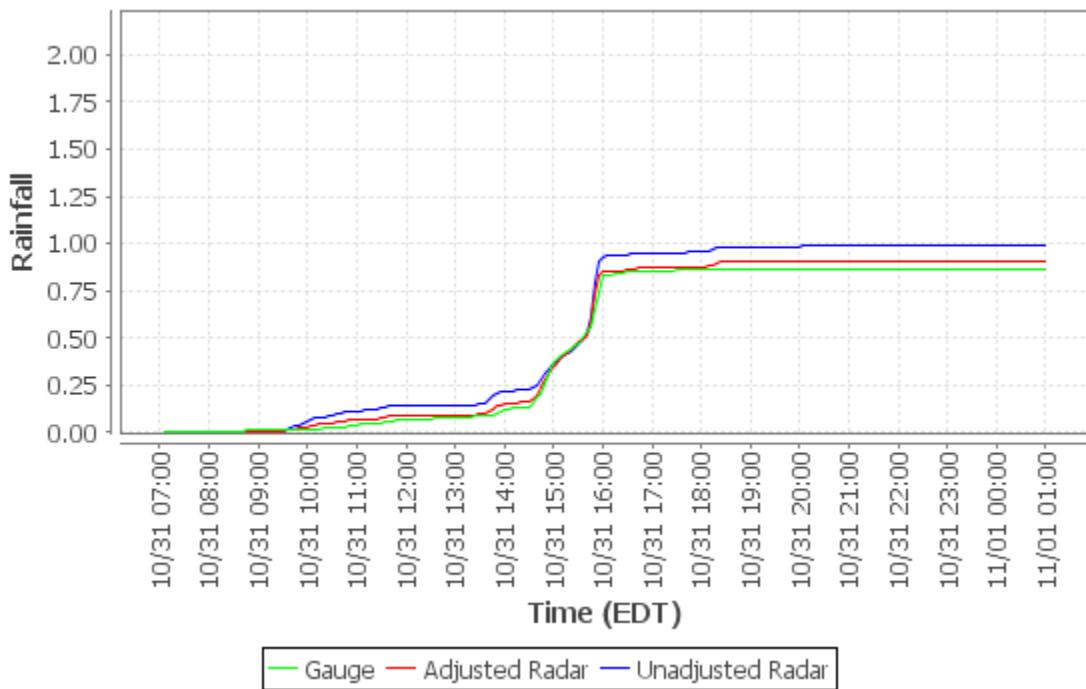
Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)



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



Cumulative Distribution Plot - Allegheny River at Natrona (03049500)



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

