Radar Rainfall Analysis

April 2019 Summary Report

Prepared for 3 Rivers Wet Weather

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301 David L. Boren Blvd., Suite 3050
Norman, Oklahoma 73072
www.vieuxinc.com

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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 ($mm^6\ m^{-3}$) 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-km^2 grid domain shapefile containing 2313 1-km^2 pixels covering the study area. CDM Smith provided two basin shapefiles consisting of 440 RFM basins and 871 RFM sheds that are located within the 1-km^2 pixel domain.

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

Figure 1. Spatial Distribution of the Rain Gauge Network, KPBZ NEXRAD, RFM Basins and 1-km^2 Pixels

Table 1. Rain Gauge ID, Name and Source

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

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

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

Methodology

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

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

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

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

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

After RG pairs have been removed on an event basis by either the MSTT, outlier check or gauge performance review, there must be at least two remaining RG pairs to proceed with gauge-adjustment of the radar. The individual biases of the remaining RG pairs are then distributed spatially over the analysis area using the LB weighted distance method. The resulting LB value over each radar bin is the multiplicative factor that adjusts the radar. For example, a bias of 1.5 can be interpreted as a 33% underestimation by the radar. The statistical measures reported are 1) average difference (AD) and 2) calibrated average difference (CAD). Both of these statistical measures are expressed as an absolute percentage about the mean of G/R accumulations for each event period. GARR is then spatially aggregated from the final adjusted radar bins to the basins and 1-km^2 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 2019-04-01 00:00 EDT to 2019-05-01 00:00 EDT. Shapefiles of the 1-km pixels, RFM basins and RFM sheds are located in the Shapefiles subfolder.

1-km^2 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 April 2019 are shown in Figure 2. The rainfall amounts for the 2313 1-km^2 pixels range from 3.3 to 6.1 inches with a mean of 4.3 inches. The rainfall amounts for the 440 RFM basins range from 3.4 to 5.2 inches with a mean of 4.2 inches. The rainfall amounts for the 871 RFM sheds range from 3.4 to 5.2 inches with a mean of 4.1 inches.

Figure 2. GARR Storm Total for April 2019

GARR was processed continuously at five-minute increments and covers the period from 2019-04-01 00:00 EDT to 2019-05-01 00:00 EDT. Ten rainfall events were identified as having met the storm definition during April 2019. The GARR statistics for each event are listed in Table 2. Nine of the events were split into multiple sub-event periods to improve gauge-adjustment of the radar, resulting in a total of forty-six 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 ten 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 forty-six event and sub-event periods, the event CAD averaged 2.7%, indicating that the mean GARR agrees with the mean gauge accumulation to within ±1.3%.

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	2019-04-12	2019-04-12 11:05	2019-04-12 14:00	13	0.047	0.906	19.4	1.8
E1b	KPBZ LII	2019-04-12	2019-04-12 14:05	2019-04-12 18:00	34	0.180	0.867	18.8	2.2
E2a	KPBZ LII	2019-04-14 AM	2019-04-14 06:05	2019-04-14 08:50	4	0.020	0.893	17.0	1.6
E2b	KPBZ LII	2019-04-14 AM	2019-04-14 08:55	2019-04-14 10:00	29	0.073	0.730	46.3	6.5
E2c	KPBZ LII	2019-04-14 AM	2019-04-14 10:05	2019-04-14 11:00	31	0.096	1.254	18.6	3.1
E2d	KPBZ LII	2019-04-14 AM	2019-04-14 11:05	2019-04-14 11:55	34	0.126	0.957	10.5	1.7
E2e	KPBZ LII	2019-04-14 AM	2019-04-14 12:00	2019-04-14 12:30	26	0.082	0.939	15.0	1.9
E2f	KPBZ LII	2019-04-14 AM	2019-04-14 12:35	2019-04-14 16:00	33	0.143	0.720	40.1	3.0
E3a	KPBZ LII	2019-04-14 PM	2019-04-14 16:05	2019-04-14 21:05	28	0.172	1.075	17.7	2.0
E3b	KPBZ LII	2019-04-14 PM	2019-04-14 21:10	2019-04-14 21:55	34	0.191	1.356	25.8	2.2
E3c	KPBZ LII	2019-04-14 PM	2019-04-14 22:00	2019-04-14 23:10	33	0.170	0.820	22.4	2.8
E3d	KPBZ LII	2019-04-14 PM	2019-04-14 23:15	2019-04-15 01:00	3	0.029	0.761	37.9	0.0
E3e	KPBZ LII	2019-04-14 PM	2019-04-15 01:05	2019-04-15 10:00	13	0.047	0.556	79.3	7.8
E4a	KPBZ LII	2019-04-19	2019-04-19 05:05	2019-04-19 13:45	18	0.039	0.707	42.4	2.2
E4b	KPBZ LII	2019-04-19	2019-04-19 13:50	2019-04-19 15:00	25	0.071	0.895	17.0	1.8
E4c	KPBZ LII	2019-04-19	2019-04-19 15:05	2019-04-19 16:20	35	0.098	1.302	22.5	2.3
E4d	KPBZ LII	2019-04-19	2019-04-19 16:25	2019-04-20 01:00	35	0.084	0.790	28.3	2.6

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E5a	KPBZ LII	2019-04-20 AM	2019-04-20 01:05	2019-04-20 03:00	3	0.008	0.703	48.4	0.0
E5b	KPBZ LII	2019-04-20 AM	2019-04-20 03:05	2019-04-20 04:30	19	0.067	0.846	20.3	1.5
E5c	KPBZ LII	2019-04-20 AM	2019-04-20 04:35	2019-04-20 06:30	24	0.087	0.526	74.7	3.1
E5d	KPBZ LII	2019-04-20 AM	2019-04-20 06:35	2019-04-20 07:25	3	0.016	0.731	44.0	3.0
E5e	KPBZ LII	2019-04-20 AM	2019-04-20 07:30	2019-04-20 11:00	9	0.022	0.725	62.6	3.5
E6a	KPBZ LII	2019-04-20 PM	2019-04-20 11:05	2019-04-20 16:55	8	0.105	0.664	65.3	3.2
E6b	KPBZ LII	2019-04-20 PM	2019-04-20 17:00	2019-04-20 17:55	15	0.121	0.716	43.2	3.6
E6c	KPBZ LII	2019-04-20 PM	2019-04-20 18:00	2019-04-20 18:15	9	0.037	0.696	45.9	0.8
E6d	KPBZ LII	2019-04-20 PM	2019-04-20 18:20	2019-04-20 19:20	29	0.155	0.823	32.5	3.9
E6e	KPBZ LII	2019-04-20 PM	2019-04-20 19:25	2019-04-20 20:10	26	0.101	0.734	41.4	5.1
E6f	KPBZ LII	2019-04-20 PM	2019-04-20 20:15	2019-04-20 21:20	30	0.133	0.541	77.1	3.6
E6g	KPBZ LII	2019-04-20 PM	2019-04-20 21:25	2019-04-21 02:00	19	0.054	0.779	34.1	4.2
E7a	KPBZ LII	2019-04-26 AM	2019-04-25 14:05	2019-04-25 20:45	18	0.056	0.678	51.2	3.4
E7b	KPBZ LII	2019-04-26 AM	2019-04-25 20:50	2019-04-25 23:20	6	0.029	1.199	30.4	2.6
E7c	KPBZ LII	2019-04-26 AM	2019-04-25 23:25	2019-04-26 00:45	4	0.014	0.843	31.3	2.8
E7d	KPBZ LII	2019-04-26 AM	2019-04-26 00:50	2019-04-26 03:40	13	0.047	0.729	37.9	2.4
E7e	KPBZ LII	2019-04-26 AM	2019-04-26 03:45	2019-04-26 04:40	9	0.056	0.571	51.8	0.2
E7f	KPBZ LII	2019-04-26 AM	2019-04-26 04:45	2019-04-26 06:15	35	0.097	1.399	26.7	1.6
E7g	KPBZ LII	2019-04-26 AM	2019-04-26 06:20	2019-04-26 10:00	34	0.100	1.194	18.5	3.2

Event #	Source	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E7h	KPBZ LII	2019-04-26 AM	2019-04-26 10:05	2019-04-26 10:30	8	0.024	1.077	29.9	2.8
E7i	KPBZ LII	2019-04-26 AM	2019-04-26 10:35	2019-04-26 10:55	12	0.033	0.803	32.9	4.1
E7j	KPBZ LII	2019-04-26 AM	2019-04-26 11:00	2019-04-26 11:45	25	0.116	0.980	17.1	3.0
E7k	KPBZ LII	2019-04-26 AM	2019-04-26 11:50	2019-04-26 12:40	33	0.217	1.129	17.0	2.0
E7l	KPBZ LII	2019-04-26 AM	2019-04-26 12:45	2019-04-26 20:00	28	0.081	0.794	27.9	2.7
E8	KPBZ LII	2019-04-26 PM	2019-04-26 20:05	2019-04-27 01:00	25	0.063	0.504	96.8	1.8
E9a	KPBZ LII	2019-04-28	2019-04-27 18:05	2019-04-28 01:50	6	0.041	0.597	69.6	0.0
E9b	KPBZ LII	2019-04-28	2019-04-28 01:55	2019-04-28 08:00	31	0.097	0.990	15.4	2.5
E10a	KPBZ LII	2019-04-30	2019-04-30 13:05	2019-04-30 15:40	32	0.102	0.895	20.8	3.0
E10b	KPBZ LII	2019-04-30	2019-04-30 15:45	2019-04-30 19:00	30	0.103	0.834	27.7	3.9

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 - L. CDPs are useful for visualizing rain gauge performance. Figure 3 shows the rainfall accumulation at the Arnold (Loc32) gauge during the 2019-04-20 PM event as measured by the gauge (green), unadjusted radar (blue), and gauge-adjusted radar (red). Rain gauges that are not performing consistently with the radar or surrounding gauges have characteristics such as clogs, synchronization or other mechanical/transmission malfunctions that can be visually identified in the CDP graph.

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

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

Table 3. Reasons for Gauge Exclusion Based on Performance

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

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

Table 4. Reasons for Gauge Exclusion Based on Statistical Criteria

Reason	Explanation
Minimum Storm Total Threshold (MSTT)	The radar or gauge cumulative sum during the event or sub-event period was less than MSTT
Outlier Based on Mean Field Bias (OMFB)	The RG pair bias (G/R) was greater than three standard deviations from the mean bias (e.g. G>>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: 2019-04-12

The analysis period was from 2019-04-12 11:00 EDT to 2019-04-12 18:00 EDT. The event was then split into two sub-event periods at 2019-04-12 14:00 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 5 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 6 - 7 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 4 - 5 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 6 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.1 - 0.5 inches with a mean of 0.2 inches. The GARR amounts for the 440 RFM basins range from 0.1 - 0.3 inches with a mean of 0.2 inches. The GARR amounts for the 871 RFM sheds range from

0.1 - 0.3 inches with a mean of 0.2 inches. Table 8 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 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	2019-04-12	2019-04-12 11:05	2019-04-12 14:00	13	0.047	0.906	19.4	1.8
E1b	KPBZ LII	2019-04-12	2019-04-12 14:05	2019-04-12 18:00	34	0.180	0.867	18.8	2.2

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	0.07	0.05	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.06	0.10	0.06	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.11	0.13	0.11	0.00	0.0	
Loc03	Shaler Munic Bldg	0.13	0.14	0.13	0.00	0.0	
Loc06	Carnegie Transit Time	0.05	0.05	0.05	0.00	0.0	
Loc22	North Fayette TWP	0.06	0.09	0.06	0.00	0.0	
Loc23	Clinton Munic Bldg	0.16	0.17	0.16	0.00	0.0	
Loc27	Marshall TWP	0.24	0.22	0.24	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.14	0.15	0.14	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.09	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
Loc33	Richland TWP	0.09	0.10	0.09	0.00	0.0	
Loc21	Moon TWP	0.12	0.12	0.11	0.01	8.3	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.05	---	---	---	---	U
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.00	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.00	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc12	Baldwin	0.00	---	---	---	---	MSTT
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	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	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
Loc32	Arnold	0.00	---	---	---	---	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
Loc21	Moon TWP	0.09	0.12	0.10	-0.01	-11.1	
Loc03	Shaler Munic Bldg	0.14	0.18	0.15	-0.01	-7.1	
Loc05	Upper St. Clair	0.14	0.16	0.15	-0.01	-7.1	
Loc08	AC Health Dept Bldg	0.14	0.18	0.15	-0.01	-7.1	
Loc19	Sandy Creek Eq Facility	0.16	0.24	0.17	-0.01	-6.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.14	0.16	0.14	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.22	0.28	0.22	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.14	0.17	0.14	0.00	0.0	
Loc04	Kennedy Twp PS	0.16	0.17	0.16	0.00	0.0	
Loc06	Carnegie Transit Time	0.17	0.18	0.17	0.00	0.0	
Loc07	Greentree Munic Bldg	0.17	0.18	0.17	0.00	0.0	
Loc09	Univ of Pittsburgh	0.16	0.19	0.16	0.00	0.0	
Loc11	M-46 Access Shaft	0.18	0.23	0.18	0.00	0.0	
Loc12	Baldwin	0.17	0.22	0.17	0.00	0.0	
Loc13	M-59 Access Shaft	0.20	0.28	0.20	0.00	0.0	
Loc14	Churchill Munic Bldg	0.21	0.27	0.21	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc15	Trafford Maint Bldg	0.23	0.28	0.23	0.00	0.0	
Loc16	Castle Shannon	0.17	0.18	0.17	0.00	0.0	
Loc20	Gascola Eq Facility	0.21	0.27	0.21	0.00	0.0	
Loc22	North Fayette TWP	0.14	0.13	0.14	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.07	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.24	0.31	0.24	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.24	0.27	0.24	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.39	0.38	0.39	0.00	0.0	
Loc27	Marshall TWP	0.09	0.10	0.09	0.00	0.0	
Loc28	Plum Municipal Bldg	0.23	0.29	0.23	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.09	0.10	0.09	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.14	0.10	0.00	0.0	
Loc32	Arnold	0.20	0.24	0.20	0.00	0.0	
Loc33	Richland TWP	0.22	0.19	0.22	0.00	0.0	
Loc10	PWSA-Highland Park	0.18	0.18	0.17	0.01	5.6	
Loc31	Hampton Municipal Bldg	0.18	0.17	0.17	0.01	5.6	
Loc17	Chartiers Pump Station	0.17	0.17	0.16	0.01	5.9	
KPIT	Greater Pittsburgh Int'l	0.13	0.11	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.10	---	---	---	---	U
Loc01	PWSA-Montana St.	0.12	---	---	---	---	U
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND

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

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

Figure 6. GARR Storm Total for Event 1

Table 8. Depth Duration Frequency Analyses for Event 1

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.222	154167	2019-04-12 15:20	<1 yr.
30 minutes	0.337	154167	2019-04-12 15:30	<1 yr.
1 hour	0.409	154167	2019-04-12 15:55	<1 yr.
2 hour	0.501	154166	2019-04-12 16:00	<1 yr.
3 hour	0.501	154166	2019-04-12 16:00	<1 yr.
6 hour	0.501	154166	2019-04-12 17:00	<1 yr.

Event 2: 2019-04-14 AM

The analysis period was from 2019-04-14 06:00 EDT to 2019-04-14 16:00 EDT. The event was then split into six sub-event periods at 2019-04-14 08:50 EDT, 2019-04-14 10:00 EDT, 2019-04-14 11:00 EDT, 2019-04-14 11:55 EDT and 2019-04-14 12:30 EDT to improve gauge adjustment of the radar.

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

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 9 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 10 - 15 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 7 - 12 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 13 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.3 - 0.9 inches with a mean of 0.5 inches. The GARR amounts for the 440 RFM basins range from 0.3 - 0.7 inches with a mean of 0.6 inches. The GARR amounts for the 871 RFM sheds range from 0.3 - 0.7 inches with a mean of 0.6 inches. Table 16 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 9. GARR Statistics for Event 2

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E2a	KPBZ LII	2019-04-14 AM	2019-04-14 06:05	2019-04-14 08:50	4	0.020	0.893	17.0	1.6
E2b	KPBZ LII	2019-04-14 AM	2019-04-14 08:55	2019-04-14 10:00	29	0.073	0.730	46.3	6.5

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E2c	KPBZ LII	2019-04-14 AM	2019-04-14 10:05	2019-04-14 11:00	31	0.096	1.254	18.6	3.1
E2d	KPBZ LII	2019-04-14 AM	2019-04-14 11:05	2019-04-14 11:55	34	0.126	0.957	10.5	1.7
E2e	KPBZ LII	2019-04-14 AM	2019-04-14 12:00	2019-04-14 12:30	26	0.082	0.939	15.0	1.9
E2f	KPBZ LII	2019-04-14 AM	2019-04-14 12:35	2019-04-14 16:00	33	0.143	0.720	40.1	3.0

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.05	0.05	0.05	0.00	0.0	
Loc27	Marshall TWP	0.07	0.07	0.07	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	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.03	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	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
Loc31	Hampton Municipal Bldg	0.01	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.01	---	---	---	---	MSTT

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.06	0.13	0.08	-0.02	-33.3	
Loc19	Sandy Creek Eq Facility	0.05	0.11	0.06	-0.01	-20.0	
Loc30	McCandless Twn Hall	0.05	0.08	0.06	-0.01	-20.0	
Loc08	AC Health Dept Bldg	0.08	0.15	0.09	-0.01	-12.5	
Loc05	Upper St. Clair	0.12	0.18	0.13	-0.01	-8.3	
03049500	Allegheny River at Natrona	0.05	0.11	0.05	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.10	0.15	0.10	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.15	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.06	0.09	0.06	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.07	0.09	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.10	0.14	0.10	0.00	0.0	
Loc12	Baldwin	0.07	0.09	0.07	0.00	0.0	
Loc13	M-59 Access Shaft	0.09	0.12	0.09	0.00	0.0	
Loc16	Castle Shannon	0.05	0.10	0.05	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.08	0.05	0.00	0.0	
Loc22	North Fayette TWP	0.15	0.19	0.15	0.00	0.0	
Loc23	Clinton Munic Bldg	0.11	0.11	0.11	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.10	0.13	0.10	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.07	0.08	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
Loc32	Arnold	0.08	0.11	0.08	0.00	0.0	
Loc33	Richland TWP	0.06	0.08	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.15	0.13	0.01	7.1	
Loc17	Chartiers Pump Station	0.14	0.16	0.13	0.01	7.1	
Loc03	Shaler Munic Bldg	0.11	0.11	0.10	0.01	9.1	
Loc09	Univ of Pittsburgh	0.11	0.15	0.10	0.01	9.1	
Loc21	Moon TWP	0.10	0.11	0.09	0.01	10.0	
Loc27	Marshall TWP	0.10	0.08	0.09	0.01	10.0	
Loc14	Churchill Munic Bldg	0.07	0.10	0.06	0.01	14.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	MSTT

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.08	0.08	-0.01	-14.3	
Loc06	Carnegie Transit Time	0.07	0.07	0.08	-0.01	-14.3	
Loc13	M-59 Access Shaft	0.08	0.07	0.09	-0.01	-12.5	
Loc08	AC Health Dept Bldg	0.09	0.08	0.10	-0.01	-11.1	
Loc19	Sandy Creek Eq Facility	0.14	0.10	0.15	-0.01	-7.1	
03049500	Allegheny River at Natrona	0.13	0.10	0.13	0.00	0.0	
Loc01	PWSA-Montana St.	0.10	0.09	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.09	0.08	0.09	0.00	0.0	
Loc03	Shaler Munic Bldg	0.11	0.09	0.11	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.08	0.07	0.08	0.00	0.0	
Loc12	Baldwin	0.08	0.08	0.08	0.00	0.0	
Loc15	Trafford Maint Bldg	0.06	0.05	0.06	0.00	0.0	
Loc16	Castle Shannon	0.08	0.08	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.08	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.14	0.10	0.14	0.00	0.0	
Loc21	Moon TWP	0.09	0.08	0.09	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.07	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.06	0.07	0.00	0.0	
Loc27	Marshall TWP	0.10	0.07	0.10	0.00	0.0	
Loc28	Plum Municipal Bldg	0.23	0.15	0.23	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.07	0.10	0.00	0.0	
Loc30	McCandless Twn Hall	0.12	0.10	0.12	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.11	0.10	0.11	0.00	0.0	
Loc32	Arnold	0.17	0.11	0.17	0.00	0.0	
Loc33	Richland TWP	0.10	0.09	0.10	0.00	0.0	
Loc14	Churchill Munic Bldg	0.18	0.11	0.17	0.01	5.6	
Loc11	M-46 Access Shaft	0.13	0.09	0.12	0.01	7.7	
Loc10	PWSA-Highland Park	0.12	0.08	0.11	0.01	8.3	
Loc05	Upper St. Clair	0.11	0.08	0.10	0.01	9.1	
Loc07	Greentree Munic Bldg	0.10	0.07	0.09	0.01	10.0	
Loc04	Kennedy Twp PS	0.09	0.07	0.08	0.01	11.1	
KAGC	Pittsburgh Allegheny Cty	0.13	---	---	---	---	O
KPIT	Greater Pittsburgh Int'l	0.14	---	---	---	---	O
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.12	0.15	0.13	-0.01	-8.3	
Loc04	Kennedy Twp PS	0.23	0.28	0.24	-0.01	-4.3	
03049500	Allegheny River at Natrona	0.12	0.12	0.12	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.11	0.10	0.11	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.14	0.16	0.14	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.16	0.18	0.16	0.00	0.0	
Loc03	Shaler Munic Bldg	0.16	0.19	0.16	0.00	0.0	
Loc05	Upper St. Clair	0.10	0.11	0.10	0.00	0.0	
Loc06	Carnegie Transit Time	0.18	0.16	0.18	0.00	0.0	
Loc07	Greentree Munic Bldg	0.15	0.15	0.15	0.00	0.0	
Loc09	Univ of Pittsburgh	0.10	0.11	0.10	0.00	0.0	
Loc10	PWSA-Highland Park	0.12	0.13	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.11	0.11	0.00	0.0	
Loc12	Baldwin	0.10	0.10	0.10	0.00	0.0	
Loc13	M-59 Access Shaft	0.12	0.10	0.12	0.00	0.0	
Loc14	Churchill Munic Bldg	0.11	0.11	0.11	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.07	0.05	0.00	0.0	
Loc16	Castle Shannon	0.09	0.09	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.15	0.14	0.15	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.11	0.12	0.11	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.09	0.07	0.00	0.0	
Loc21	Moon TWP	0.12	0.11	0.12	0.00	0.0	
Loc22	North Fayette TWP	0.17	0.18	0.17	0.00	0.0	
Loc23	Clinton Munic Bldg	0.15	0.13	0.15	0.00	0.0	
Loc24	Jefferson Hills	0.09	0.11	0.09	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.05	0.05	0.05	0.00	0.0	
Loc27	Marshall TWP	0.12	0.12	0.12	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.09	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.13	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.11	0.12	0.11	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.18	0.19	0.18	0.00	0.0	
Loc32	Arnold	0.13	0.15	0.13	0.00	0.0	
Loc33	Richland TWP	0.20	0.19	0.20	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.22	0.23	0.21	0.01	4.5	
Loc01	PWSA-Montana St.	0.12	---	---	---	---	U
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc26	Elizabeth TWP Municipal Bldg	0.04	---	---	---	---	MSTT

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.14	0.18	0.15	-0.01	-7.1	
KPIT	Greater Pittsburgh Int'l	0.06	0.06	0.06	0.00	0.0	
Loc01	PWSA-Montana St.	0.05	0.07	0.05	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.06	0.07	0.06	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.05	0.06	0.05	0.00	0.0	
Loc05	Upper St. Clair	0.11	0.11	0.11	0.00	0.0	
Loc06	Carnegie Transit Time	0.09	0.10	0.09	0.00	0.0	
Loc07	Greentree Munic Bldg	0.09	0.10	0.09	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.08	0.07	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.08	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.07	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.09	0.11	0.00	0.0	
Loc13	M-59 Access Shaft	0.21	0.19	0.21	0.00	0.0	
Loc14	Churchill Munic Bldg	0.14	0.12	0.14	0.00	0.0	
Loc15	Trafford Maint Bldg	0.10	0.14	0.10	0.00	0.0	
Loc16	Castle Shannon	0.09	0.10	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.09	0.10	0.09	0.00	0.0	
Loc20	Gascola Eq Facility	0.20	0.20	0.20	0.00	0.0	
Loc22	North Fayette TWP	0.06	0.07	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.14	0.14	0.14	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.09	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.10	0.11	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.05	0.07	0.05	0.00	0.0	
Loc33	Richland TWP	0.07	0.06	0.07	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.06	0.05	0.01	16.7	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	Z
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc21	Moon TWP	0.04	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.05	---	---	---	---	S
Loc27	Marshall TWP	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.04	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.05	---	---	---	---	MSTT

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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.09	0.17	0.10	-0.01	-11.1	
Loc09	Univ of Pittsburgh	0.11	0.20	0.12	-0.01	-9.1	
Loc06	Carnegie Transit Time	0.13	0.21	0.14	-0.01	-7.7	
Loc20	Gascola Eq Facility	0.13	0.22	0.14	-0.01	-7.7	
Loc08	AC Health Dept Bldg	0.14	0.25	0.15	-0.01	-7.1	
Loc02	ALCOSAN WWTP Lab	0.16	0.24	0.17	-0.01	-6.3	
Loc03	Shaler Munic Bldg	0.17	0.28	0.18	-0.01	-5.9	
03049500	Allegheny River at Natrona	0.24	0.33	0.24	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	0.13	0.09	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.06	0.08	0.06	0.00	0.0	
Loc13	M-59 Access Shaft	0.12	0.15	0.12	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.27	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.13	0.20	0.13	0.00	0.0	
Loc16	Castle Shannon	0.11	0.15	0.11	0.00	0.0	
Loc21	Moon TWP	0.06	0.08	0.06	0.00	0.0	
Loc22	North Fayette TWP	0.06	0.07	0.06	0.00	0.0	
Loc23	Clinton Munic Bldg	0.06	0.06	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.13	0.11	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.21	0.22	0.21	0.00	0.0	
Loc27	Marshall TWP	0.09	0.10	0.09	0.00	0.0	
Loc28	Plum Municipal Bldg	0.27	0.34	0.27	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.09	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.19	0.27	0.19	0.00	0.0	
Loc32	Arnold	0.23	0.31	0.23	0.00	0.0	
Loc33	Richland TWP	0.16	0.21	0.16	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.21	0.27	0.20	0.01	4.8	
Loc01	PWSA-Montana St.	0.18	0.24	0.17	0.01	5.6	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc07	Greentree Munic Bldg	0.18	0.23	0.17	0.01	5.6	
Loc10	PWSA-Highland Park	0.16	0.24	0.15	0.01	6.3	
Loc11	M-46 Access Shaft	0.16	0.20	0.15	0.01	6.3	
Loc17	Chartiers Pump Station	0.15	0.19	0.14	0.01	6.7	
Loc04	Kennedy Twp PS	0.11	0.13	0.10	0.01	9.1	
KAGC	Pittsburgh Allegheny Cty	0.17	---	---	---	---	O
Loc12	Baldwin	0.02	---	---	---	---	S
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.18	---	---	---	---	O

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

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

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

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

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

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

Figure 13. GARR Storm Total for Event 2

Table 16. Depth Duration Frequency Analyses for Event 2

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.416	163164	2019-04-14 13:05	<1 yr.
30 minutes	0.588	162165	2019-04-14 13:15	<1 yr.
1 hour	0.756	163164	2019-04-14 13:15	<1 yr.
2 hour	0.819	165162	2019-04-14 13:20	<1 yr.
3 hour	0.874	165162	2019-04-14 13:25	<1 yr.
6 hour	0.899	165162	2019-04-14 13:55	<1 yr.

Event 3: 2019-04-14 PM

The analysis period was from 2019-04-14 16:00 EDT to 2019-04-15 10:00 EDT. The event was then split into five sub-event periods at 2019-04-14 21:05 EDT, 2019-04-14 21:55 EDT, 2019-04-14 23:10 EDT and 2019-04-15 01:00 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 17 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 18 - 22 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 14 - 18 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 19 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.3 - 1.1 inches with a mean of 0.6 inches. The GARR amounts for the 440 RFM basins range from 0.3 - 1.0 inches with a mean of 0.5 inches. The GARR amounts for the 871 RFM sheds range from 0.3 - 1.0 inches with a mean of 0.5 inches. Table 23 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 17. 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	2019-04-14 PM	2019-04-14 16:05	2019-04-14 21:05	28	0.172	1.075	17.7	2.0
E3b	KPBZ LII	2019-04-14 PM	2019-04-14 21:10	2019-04-14 21:55	34	0.191	1.356	25.8	2.2

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E3c	KPBZ LII	2019-04-14 PM	2019-04-14 22:00	2019-04-14 23:10	33	0.170	0.820	22.4	2.8
E3d	KPBZ LII	2019-04-14 PM	2019-04-14 23:15	2019-04-15 01:00	3	0.029	0.761	37.9	0.0
E3e	KPBZ LII	2019-04-14 PM	2019-04-15 01:05	2019-04-15 10:00	13	0.047	0.556	79.3	7.8

Table 18. Summary of Individual RG Pairs for Event 3a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc13	M-59 Access Shaft	0.07	0.11	0.08	-0.01	-14.3	
Loc12	Baldwin	0.12	0.15	0.13	-0.01	-8.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.14	0.17	0.14	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.16	0.14	0.16	0.00	0.0	
Loc03	Shaler Munic Bldg	0.12	0.12	0.12	0.00	0.0	
Loc04	Kennedy Twp PS	0.12	0.14	0.12	0.00	0.0	
Loc06	Carnegie Transit Time	0.17	0.14	0.17	0.00	0.0	
Loc07	Greentree Munic Bldg	0.14	0.12	0.14	0.00	0.0	
Loc08	AC Health Dept Bldg	0.19	0.17	0.19	0.00	0.0	
Loc10	PWSA-Highland Park	0.11	0.11	0.11	0.00	0.0	
Loc11	M-46 Access Shaft	0.15	0.16	0.15	0.00	0.0	
Loc14	Churchill Munic Bldg	0.13	0.16	0.13	0.00	0.0	
Loc16	Castle Shannon	0.13	0.13	0.13	0.00	0.0	
Loc17	Chartiers Pump Station	0.17	0.14	0.17	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.09	0.07	0.00	0.0	
Loc21	Moon TWP	0.28	0.21	0.28	0.00	0.0	
Loc22	North Fayette TWP	0.13	0.11	0.13	0.00	0.0	
Loc23	Clinton Munic Bldg	0.34	0.27	0.34	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.15	0.15	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.13	0.18	0.13	0.00	0.0	
Loc27	Marshall TWP	0.51	0.47	0.51	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.33	0.27	0.33	0.00	0.0	
Loc30	McCandless Twn Hall	0.33	0.28	0.33	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.14	0.12	0.14	0.00	0.0	
Loc33	Richland TWP	0.24	0.20	0.24	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.18	0.13	0.17	0.01	5.6	
Loc02	ALCOSAN WWTP Lab	0.13	0.11	0.12	0.01	7.7	
Loc09	Univ of Pittsburgh	0.11	0.09	0.10	0.01	9.1	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.05	---	---	---	---	U
Loc01	PWSA-Montana St.	0.07	---	---	---	---	U
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc20	Gascola Eq Facility	0.07	---	---	---	---	OAD
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	U
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.02	---	---	---	---	MSTT

Table 19. Summary of Individual RG Pairs for Event 3b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc12	Baldwin	0.16	0.14	0.18	-0.02	-12.5	
Loc17	Chartiers Pump Station	0.11	0.11	0.12	-0.01	-9.1	
Loc08	AC Health Dept Bldg	0.17	0.13	0.18	-0.01	-5.9	
03049500	Allegheny River at Natrona	0.25	0.19	0.25	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	0.10	0.11	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.15	0.14	0.15	0.00	0.0	
Loc03	Shaler Munic Bldg	0.21	0.14	0.21	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.09	0.10	0.00	0.0	
Loc06	Carnegie Transit Time	0.13	0.12	0.13	0.00	0.0	
Loc07	Greentree Munic Bldg	0.19	0.16	0.19	0.00	0.0	
Loc09	Univ of Pittsburgh	0.17	0.12	0.17	0.00	0.0	
Loc11	M-46 Access Shaft	0.21	0.15	0.21	0.00	0.0	
Loc13	M-59 Access Shaft	0.18	0.14	0.18	0.00	0.0	
Loc14	Churchill Munic Bldg	0.24	0.18	0.24	0.00	0.0	
Loc15	Trafford Maint Bldg	0.32	0.23	0.32	0.00	0.0	
Loc16	Castle Shannon	0.17	0.12	0.17	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.26	0.17	0.26	0.00	0.0	
Loc20	Gascola Eq Facility	0.28	0.20	0.28	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.12	0.09	0.12	0.00	0.0	
Loc22	North Fayette TWP	0.12	0.07	0.12	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.06	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.16	0.09	0.16	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.26	0.20	0.26	0.00	0.0	
Loc27	Marshall TWP	0.17	0.13	0.17	0.00	0.0	
Loc28	Plum Municipal Bldg	0.36	0.29	0.36	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.15	0.10	0.15	0.00	0.0	
Loc30	McCandless Twn Hall	0.15	0.13	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.25	0.18	0.25	0.00	0.0	
Loc32	Arnold	0.34	0.27	0.34	0.00	0.0	
Loc33	Richland TWP	0.19	0.11	0.19	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.24	0.13	0.23	0.01	4.2	
Loc10	PWSA-Highland Park	0.22	0.13	0.21	0.01	4.5	
Loc05	Upper St. Clair	0.15	0.11	0.14	0.01	6.7	
KPIT	Greater Pittsburgh Int'l	0.12	0.07	0.11	0.01	8.3	
Loc01	PWSA-Montana St.	0.11	---	---	---	---	U
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.11	---	---	---	---	S

Table 20. Summary of Individual RG Pairs for Event 3c

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.06	0.09	0.07	-0.01	-16.7	
Loc01	PWSA-Montana St.	0.08	0.11	0.09	-0.01	-12.5	
Loc08	AC Health Dept Bldg	0.12	0.14	0.13	-0.01	-8.3	
Loc11	M-46 Access Shaft	0.16	0.22	0.17	-0.01	-6.3	
Loc14	Churchill Munic Bldg	0.20	0.30	0.21	-0.01	-5.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.09	0.10	0.09	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.16	0.19	0.16	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.09	0.08	0.00	0.0	
Loc03	Shaler Munic Bldg	0.13	0.12	0.13	0.00	0.0	
Loc05	Upper St. Clair	0.06	0.08	0.06	0.00	0.0	
Loc06	Carnegie Transit Time	0.07	0.08	0.07	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc07	Greentree Munic Bldg	0.09	0.09	0.09	0.00	0.0	
Loc13	M-59 Access Shaft	0.19	0.26	0.19	0.00	0.0	
Loc15	Trafford Maint Bldg	0.38	0.50	0.38	0.00	0.0	
Loc16	Castle Shannon	0.09	0.14	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.06	0.08	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.18	0.22	0.18	0.00	0.0	
Loc20	Gascola Eq Facility	0.34	0.48	0.34	0.00	0.0	
Loc21	Moon TWP	0.07	0.09	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.08	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.16	0.22	0.16	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.38	0.54	0.38	0.00	0.0	
Loc27	Marshall TWP	0.13	0.10	0.13	0.00	0.0	
Loc28	Plum Municipal Bldg	0.36	0.43	0.36	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.07	0.07	0.07	0.00	0.0	
Loc30	McCandless Twn Hall	0.12	0.12	0.12	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.14	0.11	0.14	0.00	0.0	
Loc32	Arnold	0.24	0.30	0.24	0.00	0.0	
Loc33	Richland TWP	0.15	0.15	0.15	0.00	0.0	
Loc10	PWSA-Highland Park	0.18	0.16	0.17	0.01	5.6	
Loc09	Univ of Pittsburgh	0.14	0.14	0.13	0.01	7.1	
Loc02	ALCOSAN WWTP Lab	0.10	0.11	0.09	0.01	10.0	
03049500	Allegheny River at Natrona	0.20	---	---	---	---	U
Loc12	Baldwin	0.01	---	---	---	---	S
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.04	---	---	---	---	S

Table 21. Summary of Individual RG Pairs for Event 3d

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.09	0.05	0.00	0.0	
Loc32	Arnold	0.05	0.06	0.05	0.00	0.0	
Loc33	Richland TWP	0.06	0.06	0.06	0.00	0.0	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT

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

Table 22. Summary of Individual RG Pairs for Event 3e

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc31	Hampton Municipal Bldg	0.11	0.55	0.15	-0.04	-36.4	
Loc19	Sandy Creek Eq Facility	0.07	0.21	0.09	-0.02	-28.6	
Loc09	Univ of Pittsburgh	0.07	0.13	0.08	-0.01	-14.3	
KAGC	Pittsburgh Allegheny Cty	0.06	0.05	0.06	0.00	0.0	
Loc05	Upper St. Clair	0.10	0.12	0.10	0.00	0.0	
Loc14	Churchill Munic Bldg	0.07	0.12	0.07	0.00	0.0	
Loc16	Castle Shannon	0.09	0.08	0.09	0.00	0.0	
Loc27	Marshall TWP	0.05	0.05	0.05	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.10	0.09	0.00	0.0	
Loc32	Arnold	0.07	0.16	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.13	0.13	0.12	0.01	7.7	
Loc20	Gascola Eq Facility	0.11	0.13	0.10	0.01	9.1	
Loc03	Shaler Munic Bldg	0.05	0.08	0.04	0.01	20.0	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.01	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.03	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.18	---	---	---	---	O
Loc13	M-59 Access Shaft	0.11	---	---	---	---	O
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.12	---	---	---	---	O
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	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	0.03	---	---	---	---	MSTT
Loc33	Richland TWP	0.03	---	---	---	---	MSTT

Figure 14. Scatter Plot of RG Pairs for Event 3a

Figure 15. Scatter Plot of RG Pairs for Event 3b

Figure 16. Scatter Plot of RG Pairs for Event 3c

Figure 17. Scatter Plot of RG Pairs for Event 3d

Figure 18. Scatter Plot of RG Pairs for Event 3e

Figure 19. GARR Storm Total for Event 3

Table 23. Depth Duration Frequency Analyses for Event 3

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.397	165162	2019-04-14 21:15	<1 yr.
30 minutes	0.509	174146	2019-04-14 21:30	<1 yr.
1 hour	0.611	174146	2019-04-14 22:05	<1 yr.
2 hour	0.999	174146	2019-04-14 23:05	<1 yr.
3 hour	1.051	174146	2019-04-14 23:55	<1 yr.
6 hour	1.087	172113	2019-04-15 02:05	<1 yr.
12 hour	1.091	174146	2019-04-15 04:05	<1 yr.

Event 4: 2019-04-19

The analysis period was from 2019-04-19 05:00 EDT to 2019-04-20 01:00 EDT. The event was then split into four sub-event periods at 2019-04-19 13:45 EDT, 2019-04-19 15:00 EDT and 2019-04-19 16:20 EDT to improve gauge adjustment of the radar.

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

A convective Z-R relationship was used to convert radar reflectivity to rainfall rates. Table 24 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 25 - 28 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and 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 20 - 23 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 24 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.2 - 0.7 inches with a mean of 0.3 inches. The GARR amounts for the 440 RFM basins range from 0.2 - 0.5 inches with a mean of 0.3 inches. The GARR amounts for the 871 RFM sheds range from 0.2 - 0.5 inches with a mean of 0.3 inches. Table 29 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 24. 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	2019-04-19	2019-04-19 05:05	2019-04-19 13:45	18	0.039	0.707	42.4	2.2
E4b	KPBZ LII	2019-04-19	2019-04-19 13:50	2019-04-19 15:00	25	0.071	0.895	17.0	1.8

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E4c	KPBZ LII	2019-04-19	2019-04-19 15:05	2019-04-19 16:20	35	0.098	1.302	22.5	2.3
E4d	KPBZ LII	2019-04-19	2019-04-19 16:25	2019-04-20 01:00	35	0.084	0.790	28.3	2.6

Table 25. Summary of Individual RG Pairs for Event 4a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.05	0.08	0.06	-0.01	-20.0	
KAGC	Pittsburgh Allegheny Cty	0.06	0.09	0.06	0.00	0.0	
Loc05	Upper St. Clair	0.05	0.08	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.08	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.09	0.06	0.00	0.0	
Loc12	Baldwin	0.06	0.09	0.06	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	0.09	0.07	0.00	0.0	
Loc15	Trafford Maint Bldg	0.08	0.11	0.08	0.00	0.0	
Loc16	Castle Shannon	0.06	0.10	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.09	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.10	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.07	0.10	0.07	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.07	0.11	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.09	0.07	0.00	0.0	
Loc32	Arnold	0.06	0.09	0.06	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.09	0.06	0.01	14.3	
03049500	Allegheny River at Natrona	0.04	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.02	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.02	---	---	---	---	MSTT
Loc33	Richland TWP	0.01	---	---	---	---	MSTT

Table 26. Summary of Individual RG Pairs for Event 4b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03049500	Allegheny River at Natrona	0.08	0.09	0.08	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.09	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.05	0.07	0.05	0.00	0.0	
Loc03	Shaler Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc05	Upper St. Clair	0.05	0.06	0.05	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.06	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.08	0.07	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.08	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.08	0.09	0.08	0.00	0.0	
Loc12	Baldwin	0.08	0.09	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.08	0.09	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.08	0.09	0.08	0.00	0.0	
Loc15	Trafford Maint Bldg	0.13	0.13	0.13	0.00	0.0	
Loc16	Castle Shannon	0.06	0.07	0.06	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.06	0.05	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.09	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.08	0.11	0.08	0.00	0.0	
Loc24	Jefferson Hills	0.07	0.09	0.07	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.25	0.22	0.25	0.00	0.0	
Loc28	Plum Municipal Bldg	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
Loc31	Hampton Municipal Bldg	0.05	0.07	0.05	0.00	0.0	
Loc32	Arnold	0.08	0.08	0.08	0.00	0.0	
Loc33	Richland TWP	0.05	0.06	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.09	0.08	0.08	0.01	11.1	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.02	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.07	---	---	---	---	S
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT

Table 27. Summary of Individual RG Pairs for Event 4c

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.07	0.07	0.08	-0.01	-14.3	
Loc20	Gascola Eq Facility	0.08	0.08	0.09	-0.01	-12.5	
03049500	Allegheny River at Natrona	0.11	0.09	0.11	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.08	0.07	0.08	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.09	0.06	0.09	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.10	0.09	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.08	0.07	0.08	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.07	0.09	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.07	0.09	0.00	0.0	
Loc05	Upper St. Clair	0.08	0.06	0.08	0.00	0.0	
Loc06	Carnegie Transit Time	0.10	0.06	0.10	0.00	0.0	
Loc07	Greentree Munic Bldg	0.09	0.07	0.09	0.00	0.0	
Loc08	AC Health Dept Bldg	0.10	0.07	0.10	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.10	0.07	0.10	0.00	0.0	
Loc10	PWSA-Highland Park	0.11	0.07	0.11	0.00	0.0	
Loc11	M-46 Access Shaft	0.10	0.07	0.10	0.00	0.0	
Loc12	Baldwin	0.08	0.06	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.08	0.08	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.10	0.08	0.10	0.00	0.0	
Loc15	Trafford Maint Bldg	0.10	0.07	0.10	0.00	0.0	
Loc16	Castle Shannon	0.09	0.06	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.09	0.06	0.09	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.09	0.08	0.09	0.00	0.0	
Loc21	Moon TWP	0.13	0.09	0.13	0.00	0.0	
Loc22	North Fayette TWP	0.11	0.09	0.11	0.00	0.0	
Loc23	Clinton Munic Bldg	0.14	0.09	0.14	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.06	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.09	0.06	0.09	0.00	0.0	
Loc27	Marshall TWP	0.14	0.09	0.14	0.00	0.0	
Loc28	Plum Municipal Bldg	0.11	0.09	0.11	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.10	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.09	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.07	0.07	0.00	0.0	
Loc32	Arnold	0.13	0.09	0.13	0.00	0.0	
Loc33	Richland TWP	0.10	0.07	0.10	0.00	0.0	
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Table 28. Summary of Individual RG Pairs for Event 4d

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.06	0.07	0.07	-0.01	-16.7	
03049500	Allegheny River at Natrona	0.10	0.13	0.10	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.08	0.06	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.11	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.11	0.13	0.11	0.00	0.0	
Loc03	Shaler Munic Bldg	0.06	0.07	0.06	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.06	0.09	0.06	0.00	0.0	
Loc05	Upper St. Clair	0.07	0.11	0.07	0.00	0.0	
Loc07	Greentree Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc08	AC Health Dept Bldg	0.06	0.08	0.06	0.00	0.0	
Loc09	Univ of Pittsburgh	0.06	0.08	0.06	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.10	0.07	0.00	0.0	
Loc12	Baldwin	0.07	0.09	0.07	0.00	0.0	
Loc13	M-59 Access Shaft	0.07	0.11	0.07	0.00	0.0	
Loc14	Churchill Munic Bldg	0.08	0.10	0.08	0.00	0.0	
Loc15	Trafford Maint Bldg	0.11	0.15	0.11	0.00	0.0	
Loc16	Castle Shannon	0.07	0.08	0.07	0.00	0.0	
Loc17	Chartiers Pump Station	0.07	0.10	0.07	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.09	0.10	0.09	0.00	0.0	
Loc20	Gascola Eq Facility	0.09	0.12	0.09	0.00	0.0	
Loc21	Moon TWP	0.11	0.12	0.11	0.00	0.0	
Loc22	North Fayette TWP	0.09	0.14	0.09	0.00	0.0	
Loc23	Clinton Munic Bldg	0.12	0.15	0.12	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.12	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.10	0.15	0.10	0.00	0.0	
Loc27	Marshall TWP	0.10	0.10	0.10	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.13	0.09	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.13	0.10	0.00	0.0	
Loc30	McCandless Twn Hall	0.06	0.08	0.06	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.06	0.06	0.06	0.00	0.0	
Loc32	Arnold	0.08	0.12	0.08	0.00	0.0	
Loc33	Richland TWP	0.06	0.06	0.06	0.00	0.0	
Loc06	Carnegie Transit Time	0.09	0.09	0.08	0.01	11.1	
Loc10	PWSA-Highland Park	0.09	0.08	0.08	0.01	11.1	
Loc01	PWSA-Montana St.	0.08	0.07	0.07	0.01	12.5	
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Figure 20. Scatter Plot of RG Pairs for Event 4a

Figure 21. Scatter Plot of RG Pairs for Event 4b

Figure 22. Scatter Plot of RG Pairs for Event 4c

Figure 23. Scatter Plot of RG Pairs for Event 4d

Figure 24. GARR Storm Total for Event 4

Table 29. Depth Duration Frequency Analyses for Event 4

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.122	162165	2019-04-19 14:50	<1 yr.
30 minutes	0.217	165164	2019-04-19 15:05	<1 yr.
1 hour	0.347	162165	2019-04-19 15:10	<1 yr.
2 hour	0.483	164163	2019-04-19 15:30	<1 yr.
3 hour	0.536	164163	2019-04-19 15:40	<1 yr.
6 hour	0.605	165162	2019-04-19 18:35	<1 yr.
12 hour	0.681	164164	2019-04-19 21:30	<1 yr.

Event 5: 2019-04-20 AM

The analysis period was from 2019-04-20 01:00 EDT to 2019-04-20 11:00 EDT. The event was then split into five sub-event periods at 2019-04-20 03:00 EDT, 2019-04-20 04:30 EDT, 2019-04-20 06:30 EDT and 2019-04-20 07:25 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 30 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 31 - 35 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 25 - 29 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 30 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.0 - 0.7 inches with a mean of 0.2 inches. The GARR amounts for the 440 RFM basins range from 0.0 - 0.5 inches with a mean of 0.2 inches. The GARR amounts for the 871 RFM sheds range from 0.0 - 0.6 inches with a mean of 0.2 inches. Table 36 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 30. 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	2019-04-20 AM	2019-04-20 01:05	2019-04-20 03:00	3	0.008	0.703	48.4	0.0
E5b	KPBZ LII	2019-04-20 AM	2019-04-20 03:05	2019-04-20 04:30	19	0.067	0.846	20.3	1.5
E5c	KPBZ LII	2019-04-20 AM	2019-04-20 04:35	2019-04-20 06:30	24	0.087	0.526	74.7	3.1
E5d	KPBZ LII	2019-04-20 AM	2019-04-20 06:35	2019-04-20 07:25	3	0.016	0.731	44.0	3.0
E5e	KPBZ LII	2019-04-20 AM	2019-04-20 07:30	2019-04-20 11:00	9	0.022	0.725	62.6	3.5

Table 31. Summary of Individual RG Pairs for Event 5a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.05	0.06	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.11	0.05	0.00	0.0	
Loc27	Marshall TWP	0.08	0.09	0.08	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.04	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.01	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.00	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.00	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
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
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	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
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 32. Summary of Individual RG Pairs for Event 5b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.05	0.07	0.06	-0.01	-20.0	
Loc07	Greentree Munic Bldg	0.20	0.27	0.21	-0.01	-5.0	
Loc01	PWSA-Montana St.	0.13	0.18	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.18	0.24	0.18	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.08	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.19	0.23	0.19	0.00	0.0	
Loc05	Upper St. Clair	0.18	0.19	0.18	0.00	0.0	
Loc16	Castle Shannon	0.10	0.11	0.10	0.00	0.0	
Loc17	Chartiers Pump Station	0.19	0.19	0.19	0.00	0.0	
Loc21	Moon TWP	0.06	0.07	0.06	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.07	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.05	0.06	0.05	0.00	0.0	
Loc27	Marshall TWP	0.18	0.19	0.18	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.12	0.10	0.00	0.0	
Loc30	McCandless Twn Hall	0.15	0.19	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.09	0.07	0.00	0.0	
Loc33	Richland TWP	0.09	0.11	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.24	0.25	0.23	0.01	4.2	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.21	0.24	0.20	0.01	4.8	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.14	---	---	---	---	O
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT

Table 33. Summary of Individual RG Pairs for Event 5c

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.17	0.47	0.19	-0.02	-11.8	
Loc10	PWSA-Highland Park	0.15	0.22	0.16	-0.01	-6.7	
Loc13	M-59 Access Shaft	0.20	0.62	0.21	-0.01	-5.0	
03049500	Allegheny River at Natrona	0.07	0.16	0.07	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.05	0.09	0.05	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.06	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.06	0.12	0.06	0.00	0.0	
Loc05	Upper St. Clair	0.06	0.07	0.06	0.00	0.0	
Loc06	Carnegie Transit Time	0.06	0.11	0.06	0.00	0.0	
Loc09	Univ of Pittsburgh	0.06	0.09	0.06	0.00	0.0	
Loc12	Baldwin	0.09	0.11	0.09	0.00	0.0	
Loc14	Churchill Munic Bldg	0.19	0.46	0.19	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.07	0.05	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.22	0.50	0.22	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.10	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.06	0.12	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.31	0.43	0.31	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.05	0.06	0.05	0.00	0.0	
Loc27	Marshall TWP	0.08	0.11	0.08	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.12	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.10	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.05	0.05	0.05	0.00	0.0	
Loc33	Richland TWP	0.05	0.07	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.07	0.08	0.06	0.01	14.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.14	---	---	---	---	U
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.04	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT
Loc32	Arnold	0.02	---	---	---	---	MSTT

Table 34. Summary of Individual RG Pairs for Event 5d

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.16	0.27	0.17	-0.01	-6.3	
Loc22	North Fayette TWP	0.08	0.06	0.08	0.00	0.0	
Loc05	Upper St. Clair	0.13	0.18	0.12	0.01	7.7	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.03	---	---	---	---	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
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	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	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	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 35. Summary of Individual RG Pairs for Event 5e

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.05	0.18	0.06	-0.01	-20.0	
Loc04	Kennedy Twp PS	0.12	0.15	0.12	0.00	0.0	
Loc21	Moon TWP	0.07	0.06	0.07	0.00	0.0	
Loc22	North Fayette TWP	0.05	0.07	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.09	0.06	0.09	0.00	0.0	
Loc27	Marshall TWP	0.11	0.12	0.11	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.09	0.06	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.07	0.05	0.06	0.01	14.3	
Loc17	Chartiers Pump Station	0.07	0.15	0.06	0.01	14.3	
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	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	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	0.00	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	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
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.01	---	---	---	---	MSTT

Figure 25. Scatter Plot of RG Pairs for Event 5a

Figure 26. Scatter Plot of RG Pairs for Event 5b

Figure 27. Scatter Plot of RG Pairs for Event 5c

Figure 28. Scatter Plot of RG Pairs for Event 5d

Figure 29. Scatter Plot of RG Pairs for Event 5e

Figure 30. GARR Storm Total for Event 5

Table 36. Depth Duration Frequency Analyses for Event 5

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.403	157153	2019-04-20 04:55	<1 yr.
30 minutes	0.431	157153	2019-04-20 05:10	<1 yr.
1 hour	0.442	157153	2019-04-20 05:15	<1 yr.
2 hour	0.447	157153	2019-04-20 05:30	<1 yr.
3 hour	0.447	134136	2019-04-20 08:00	<1 yr.
6 hour	0.690	135136	2019-04-20 08:05	<1 yr.

Event 6: 2019-04-20 PM

The analysis period was from 2019-04-20 11:00 EDT to 2019-04-21 02:00 EDT. The event was then split into seven sub-event periods at 2019-04-20 16:55 EDT, 2019-04-20 17:55 EDT, 2019-04-20 18:15 EDT, 2019-04-20 19:20 EDT, 2019-04-20 20:10 EDT and 2019-04-20 21:20 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 37 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 38 - 44 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 31 - 37 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 38 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.0 - 2.2 inches with a mean of 0.7 inches. The GARR amounts for the 440 RFM basins range from 0.1 - 1.3 inches with a mean of 0.6 inches. The GARR amounts for the 871 RFM sheds range from 0.1 - 1.5 inches with a mean of 0.6 inches. Table 45 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 37. 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	2019-04-20 PM	2019-04-20 11:05	2019-04-20 16:55	8	0.105	0.664	65.3	3.2
E6b	KPBZ LII	2019-04-20 PM	2019-04-20 17:00	2019-04-20 17:55	15	0.121	0.716	43.2	3.6

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E6c	KPBZ LII	2019-04-20 PM	2019-04-20 18:00	2019-04-20 18:15	9	0.037	0.696	45.9	0.8
E6d	KPBZ LII	2019-04-20 PM	2019-04-20 18:20	2019-04-20 19:20	29	0.155	0.823	32.5	3.9
E6e	KPBZ LII	2019-04-20 PM	2019-04-20 19:25	2019-04-20 20:10	26	0.101	0.734	41.4	5.1
E6f	KPBZ LII	2019-04-20 PM	2019-04-20 20:15	2019-04-20 21:20	30	0.133	0.541	77.1	3.6
E6g	KPBZ LII	2019-04-20 PM	2019-04-20 21:25	2019-04-21 02:00	19	0.054	0.779	34.1	4.2

Table 38. Summary of Individual RG Pairs for Event 6a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.23	0.59	0.25	-0.02	-8.7	
Loc20	Gascola Eq Facility	0.28	0.72	0.30	-0.02	-7.1	
03049500	Allegheny River at Natrona	0.27	0.37	0.27	0.00	0.0	
Loc15	Trafford Maint Bldg	0.78	1.01	0.78	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.36	0.37	0.36	0.00	0.0	
Loc32	Arnold	0.50	0.60	0.50	0.00	0.0	
Loc28	Plum Municipal Bldg	0.71	0.96	0.70	0.01	1.4	
Loc14	Churchill Munic Bldg	0.27	0.50	0.25	0.02	7.4	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.00	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc11	M-46 Access Shaft	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	ND
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 39. Summary of Individual RG Pairs for Event 6b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.10	0.17	0.13	-0.03	-30.0	
Loc28	Plum Municipal Bldg	0.18	0.29	0.19	-0.01	-5.6	
KAGC	Pittsburgh Allegheny Cty	0.48	0.88	0.48	0.00	0.0	
Loc10	PWSA-Highland Park	0.12	0.16	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.29	0.31	0.29	0.00	0.0	
Loc12	Baldwin	0.10	0.20	0.10	0.00	0.0	
Loc13	M-59 Access Shaft	0.23	0.24	0.23	0.00	0.0	
Loc15	Trafford Maint Bldg	0.06	0.06	0.06	0.00	0.0	
Loc25	White Oak Public Works Bldg	0.14	0.15	0.14	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.15	0.12	0.15	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
Loc32	Arnold	0.19	0.33	0.19	0.00	0.0	
Loc33	Richland TWP	0.16	0.32	0.16	0.00	0.0	
Loc20	Gascola Eq Facility	0.13	0.09	0.12	0.01	7.7	
Loc14	Churchill Munic Bldg	0.11	0.09	0.10	0.01	9.1	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03049500	Allegheny River at Natrona	0.07	---	---	---	---	U
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.04	---	---	---	---	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	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.09	---	---	---	---	OAD
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT

Table 40. Summary of Individual RG Pairs for Event 6c

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc05	Upper St. Clair	0.09	0.21	0.09	0.00	0.0	
Loc10	PWSA-Highland Park	0.05	0.05	0.05	0.00	0.0	
Loc13	M-59 Access Shaft	0.06	0.10	0.06	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.10	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.05	0.08	0.05	0.00	0.0	
Loc24	Jefferson Hills	0.16	0.18	0.16	0.00	0.0	
Loc32	Arnold	0.08	0.12	0.08	0.00	0.0	
Loc33	Richland TWP	0.09	0.13	0.09	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.09	0.09	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.02	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.00	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.02	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.03	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc21	Moon TWP	0.00	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.06	---	---	---	---	T
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	0.00	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT

Table 41. Summary of Individual RG Pairs for Event 6d

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.08	0.17	0.10	-0.02	-25.0	
Loc01	PWSA-Montana St.	0.13	0.17	0.15	-0.02	-15.4	
Loc31	Hampton Municipal Bldg	0.16	0.18	0.17	-0.01	-6.3	
Loc04	Kennedy Twp PS	0.41	0.38	0.43	-0.02	-4.9	
KAGC	Pittsburgh Allegheny Cty	0.16	0.17	0.16	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.13	0.08	0.00	0.0	
Loc06	Carnegie Transit Time	0.16	0.22	0.16	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.07	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.10	0.11	0.10	0.00	0.0	
Loc11	M-46 Access Shaft	0.10	0.14	0.10	0.00	0.0	
Loc13	M-59 Access Shaft	0.10	0.14	0.10	0.00	0.0	
Loc14	Churchill Munic Bldg	0.14	0.19	0.14	0.00	0.0	
Loc16	Castle Shannon	0.10	0.10	0.10	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.16	0.22	0.16	0.00	0.0	
Loc20	Gascola Eq Facility	0.15	0.23	0.15	0.00	0.0	
Loc21	Moon TWP	0.31	0.49	0.31	0.00	0.0	
Loc22	North Fayette TWP	0.16	0.19	0.16	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.09	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.19	0.27	0.19	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.06	0.10	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.15	0.20	0.15	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.34	0.41	0.34	0.00	0.0	
Loc32	Arnold	0.07	0.09	0.07	0.00	0.0	
Loc33	Richland TWP	0.13	0.08	0.13	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.19	0.14	0.18	0.01	5.3	
Loc03	Shaler Munic Bldg	0.15	0.12	0.14	0.01	6.7	
Loc02	ALCOSAN WWTP Lab	0.13	0.13	0.12	0.01	7.7	
Loc07	Greentree Munic Bldg	0.12	0.11	0.11	0.01	8.3	
Loc05	Upper St. Clair	0.20	0.24	0.18	0.02	10.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.05	---	---	---	---	OAD
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.03	---	---	---	---	S

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.02	---	---	---	---	MSTT

Table 42. Summary of Individual RG Pairs for Event 6e

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.06	0.11	0.07	-0.01	-16.7	
Loc04	Kennedy Twp PS	0.13	0.25	0.15	-0.02	-15.4	
Loc13	M-59 Access Shaft	0.13	0.30	0.15	-0.02	-15.4	
Loc14	Churchill Munic Bldg	0.07	0.11	0.08	-0.01	-14.3	
Loc01	PWSA-Montana St.	0.17	0.29	0.19	-0.02	-11.8	
Loc08	AC Health Dept Bldg	0.10	0.13	0.11	-0.01	-10.0	
Loc21	Moon TWP	0.16	0.28	0.17	-0.01	-6.3	
Loc29	Bell Acres Munic Bldg	0.45	0.62	0.46	-0.01	-2.2	
KAGC	Pittsburgh Allegheny Cty	0.09	0.14	0.09	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.17	0.23	0.17	0.00	0.0	
Loc09	Univ of Pittsburgh	0.12	0.16	0.12	0.00	0.0	
Loc11	M-46 Access Shaft	0.14	0.20	0.14	0.00	0.0	
Loc12	Baldwin	0.15	0.24	0.15	0.00	0.0	
Loc15	Trafford Maint Bldg	0.15	0.15	0.15	0.00	0.0	
Loc16	Castle Shannon	0.14	0.24	0.14	0.00	0.0	
Loc20	Gascola Eq Facility	0.06	0.06	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.18	0.16	0.18	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.13	0.09	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.14	0.13	0.14	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.12	0.17	0.12	0.00	0.0	
Loc07	Greentree Munic Bldg	0.16	0.17	0.15	0.01	6.3	
Loc03	Shaler Munic Bldg	0.15	0.18	0.14	0.01	6.7	
Loc02	ALCOSAN WWTP Lab	0.14	0.20	0.13	0.01	7.1	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.20	0.25	0.18	0.02	10.0	
Loc10	PWSA-Highland Park	0.08	0.08	0.07	0.01	12.5	
Loc19	Sandy Creek Eq Facility	0.07	0.06	0.06	0.01	14.3	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.06	---	---	---	---	S
Loc27	Marshall TWP	0.19	---	---	---	---	OMFB
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.03	---	---	---	---	MSTT

Table 43. Summary of Individual RG Pairs for Event 6f

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	0.16	0.08	-0.02	-33.3	
Loc21	Moon TWP	0.11	0.19	0.12	-0.01	-9.1	
Loc13	M-59 Access Shaft	0.19	0.50	0.20	-0.01	-5.3	
Loc30	McCandless Twn Hall	0.20	0.54	0.21	-0.01	-5.0	
Loc11	M-46 Access Shaft	0.23	0.52	0.24	-0.01	-4.3	
Loc19	Sandy Creek Eq Facility	0.23	0.49	0.24	-0.01	-4.3	
Loc10	PWSA-Highland Park	0.25	0.46	0.26	-0.01	-4.0	
03049500	Allegheny River at Natrona	0.05	0.05	0.05	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.13	0.34	0.13	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.07	0.09	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.18	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.08	0.09	0.08	0.00	0.0	
Loc07	Greentree Munic Bldg	0.17	0.23	0.17	0.00	0.0	
Loc12	Baldwin	0.09	0.25	0.09	0.00	0.0	
Loc15	Trafford Maint Bldg	0.15	0.22	0.15	0.00	0.0	
Loc16	Castle Shannon	0.08	0.20	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.16	0.28	0.16	0.00	0.0	
Loc22	North Fayette TWP	0.05	0.05	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.05	0.05	0.05	0.00	0.0	
Loc28	Plum Municipal Bldg	0.08	0.06	0.08	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.25	0.55	0.25	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc31	Hampton Municipal Bldg	0.23	0.39	0.23	0.00	0.0	
Loc32	Arnold	0.10	0.09	0.10	0.00	0.0	
Loc33	Richland TWP	0.31	0.50	0.31	0.00	0.0	
Loc14	Churchill Munic Bldg	0.36	0.69	0.35	0.01	2.8	
Loc27	Marshall TWP	0.29	0.58	0.28	0.01	3.4	
Loc09	Univ of Pittsburgh	0.22	0.35	0.21	0.01	4.5	
Loc08	AC Health Dept Bldg	0.21	0.33	0.20	0.01	4.8	
KPIT	Greater Pittsburgh Int'l	0.09	0.08	0.08	0.01	11.1	
Loc04	Kennedy Twp PS	0.06	0.08	0.05	0.01	16.7	
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc24	Jefferson Hills	0.02	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT

Table 44. Summary of Individual RG Pairs for Event 6g

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc20	Gascola Eq Facility	0.09	0.17	0.11	-0.02	-22.2	
KAGC	Pittsburgh Allegheny Cty	0.05	0.08	0.06	-0.01	-20.0	
Loc08	AC Health Dept Bldg	0.06	0.07	0.07	-0.01	-16.7	
Loc01	PWSA-Montana St.	0.05	0.06	0.05	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.11	0.10	0.00	0.0	
Loc07	Greentree Munic Bldg	0.07	0.05	0.07	0.00	0.0	
Loc09	Univ of Pittsburgh	0.07	0.07	0.07	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.07	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.06	0.07	0.06	0.00	0.0	
Loc12	Baldwin	0.07	0.07	0.07	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	0.08	0.17	0.08	0.00	0.0	
Loc27	Marshall TWP	0.11	0.14	0.11	0.00	0.0	
Loc28	Plum Municipal Bldg	0.09	0.15	0.09	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.07	0.09	0.07	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
Loc33	Richland TWP	0.06	0.11	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.10	0.07	0.09	0.01	10.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.05	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.00	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.04	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z
Loc26	Elizabeth TWP Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.05	---	---	---	---	MSTT
Loc32	Arnold	0.04	---	---	---	---	MSTT

Figure 31. Scatter Plot of RG Pairs for Event 6a

Figure 32. Scatter Plot of RG Pairs for Event 6b

Figure 33. Scatter Plot of RG Pairs for Event 6c

Figure 34. Scatter Plot of RG Pairs for Event 6d

Figure 35. Scatter Plot of RG Pairs for Event 6e

Figure 36. Scatter Plot of RG Pairs for Event 6f

Figure 37. Scatter Plot of RG Pairs for Event 6g

Figure 38. GARR Storm Total for Event 6

Table 45. Depth Duration Frequency Analyses for Event 6

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.940	128121	2019-04-20 19:15	5 yr.
30 minutes	1.341	129120	2019-04-20 19:25	5 yr.
1 hour	1.936	157167	2019-04-20 17:40	10 yr.
2 hour	2.020	157167	2019-04-20 18:10	10 yr.
3 hour	2.160	157167	2019-04-20 19:25	10 yr.
6 hour	2.249	157167	2019-04-20 21:55	5 yr.
12 hour	2.249	157167	2019-04-20 23:00	2 yr.

Event 7: 2019-04-26 AM

The analysis period was from 2019-04-25 14:00 EDT to 2019-04-26 20:00 EDT. The event was then split into twelve sub-event periods at 2019-04-25 20:45 EDT, 2019-04-25 23:20 EDT, 2019-04-26 00:45 EDT, 2019-04-26 03:40 EDT, 2019-04-26 04:40 EDT, 2019-04-26 06:15 EDT, 2019-04-26 10:00 EDT, 2019-04-26 10:30 EDT, 2019-04-26 10:55 EDT, 2019-04-26 11:45 EDT and 2019-04-26 12:40 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 46 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 47 - 58 summarize the results for each RG pair used for final radar adjustment, where G_i is the gauge estimate, R_i is the non-adjusted radar estimate, R_i* is the GARR estimate, and Diff* (%) is the percent difference between the gauge and GARR estimate. Those gauges not used to adjust the radar are shown at the bottom of the table and are highlighted in red. The specific reason for gauge exclusion is displayed in the Flag column. Figures 39 - 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-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.5 - 1.3 inches with a mean of 0.9 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 59 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 46. 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	2019-04-26 AM	2019-04-25 14:05	2019-04-25 20:45	18	0.056	0.678	51.2	3.4
E7b	KPBZ LII	2019-04-26 AM	2019-04-25 20:50	2019-04-25 23:20	6	0.029	1.199	30.4	2.6
E7c	KPBZ LII	2019-04-26 AM	2019-04-25 23:25	2019-04-26 00:45	4	0.014	0.843	31.3	2.8
E7d	KPBZ LII	2019-04-26 AM	2019-04-26 00:50	2019-04-26 03:40	13	0.047	0.729	37.9	2.4
E7e	KPBZ LII	2019-04-26 AM	2019-04-26 03:45	2019-04-26 04:40	9	0.056	0.571	51.8	0.2
E7f	KPBZ LII	2019-04-26 AM	2019-04-26 04:45	2019-04-26 06:15	35	0.097	1.399	26.7	1.6
E7g	KPBZ LII	2019-04-26 AM	2019-04-26 06:20	2019-04-26 10:00	34	0.100	1.194	18.5	3.2
E7h	KPBZ LII	2019-04-26 AM	2019-04-26 10:05	2019-04-26 10:30	8	0.024	1.077	29.9	2.8
E7i	KPBZ LII	2019-04-26 AM	2019-04-26 10:35	2019-04-26 10:55	12	0.033	0.803	32.9	4.1
E7j	KPBZ LII	2019-04-26 AM	2019-04-26 11:00	2019-04-26 11:45	25	0.116	0.980	17.1	3.0
E7k	KPBZ LII	2019-04-26 AM	2019-04-26 11:50	2019-04-26 12:40	33	0.217	1.129	17.0	2.0
E7l	KPBZ LII	2019-04-26 AM	2019-04-26 12:45	2019-04-26 20:00	28	0.081	0.794	27.9	2.7

Table 47. Summary of Individual RG Pairs for Event 7a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.07	0.10	0.08	-0.01	-14.3	
03049500	Allegheny River at Natrona	0.07	0.15	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.05	0.10	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.08	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.06	0.07	0.06	0.00	0.0	
Loc11	M-46 Access Shaft	0.05	0.07	0.05	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.08	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.08	0.05	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc19	Sandy Creek Eq Facility	0.07	0.09	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.05	0.10	0.05	0.00	0.0	
Loc21	Moon TWP	0.07	0.08	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.06	0.08	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	0.11	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.07	0.10	0.07	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.10	0.07	0.00	0.0	
Loc32	Arnold	0.08	0.13	0.08	0.00	0.0	
Loc33	Richland TWP	0.10	0.12	0.10	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.04	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.04	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.02	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.03	---	---	---	---	MSTT
Loc16	Castle Shannon	0.02	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc22	North Fayette TWP	0.03	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.05	---	---	---	---	S
Loc26	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT

Table 48. Summary of Individual RG Pairs for Event 7b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.07	0.07	0.08	-0.01	-14.3	
Loc21	Moon TWP	0.06	0.10	0.06	0.00	0.0	
Loc23	Clinton Munic Bldg	0.14	0.10	0.14	0.00	0.0	
Loc27	Marshall TWP	0.11	0.07	0.11	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.10	0.07	0.10	0.00	0.0	
Loc33	Richland TWP	0.12	0.10	0.12	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.01	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.00	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	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	0.01	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.02	---	---	---	---	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	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT
Loc16	Castle Shannon	0.00	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	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
Loc28	Plum Municipal Bldg	0.02	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT

Table 49. Summary of Individual RG Pairs for Event 7c

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.10	0.14	0.11	-0.01	-10.0	
Loc21	Moon TWP	0.17	0.15	0.17	0.00	0.0	
Loc27	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.06	0.10	0.06	0.00	0.0	
03049500	Allegheny River at Natrona	0.00	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.00	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.00	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.04	---	---	---	---	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	0.02	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.01	---	---	---	---	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	0.00	---	---	---	---	MSTT
Loc12	Baldwin	0.00	---	---	---	---	MSTT
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	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.00	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.00	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc22	North Fayette TWP	0.01	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	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
Loc28	Plum Municipal Bldg	0.00	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc32	Arnold	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 50. Summary of Individual RG Pairs for Event 7d

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.05	0.08	0.06	-0.01	-20.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.12	0.16	0.12	0.00	0.0	
Loc01	PWSA-Montana St.	0.07	0.09	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.13	0.10	0.00	0.0	
Loc04	Kennedy Twp PS	0.10	0.16	0.10	0.00	0.0	
Loc07	Greentree Munic Bldg	0.07	0.07	0.07	0.00	0.0	
Loc08	AC Health Dept Bldg	0.09	0.15	0.09	0.00	0.0	
Loc10	PWSA-Highland Park	0.05	0.09	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.08	0.09	0.08	0.00	0.0	
Loc27	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.10	0.08	0.00	0.0	
Loc33	Richland TWP	0.10	0.16	0.10	0.00	0.0	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.02	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.05	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.04	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.02	---	---	---	---	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	0.01	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.01	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.01	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.04	---	---	---	---	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
Loc30	McCandless Twn Hall	0.04	---	---	---	---	MSTT
Loc32	Arnold	0.02	---	---	---	---	MSTT

Table 51. Summary of Individual RG Pairs for Event 7e

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.09	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc04	Kennedy Twp PS	0.07	0.09	0.07	0.00	0.0	
Loc14	Churchill Munic Bldg	0.11	0.24	0.11	0.00	0.0	
Loc17	Chartiers Pump Station	0.06	0.06	0.06	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.08	0.10	0.08	0.00	0.0	
Loc32	Arnold	0.21	0.47	0.21	0.00	0.0	
Loc33	Richland TWP	0.06	0.08	0.06	0.00	0.0	
03049500	Allegheny River at Natrona	0.26	0.52	0.25	0.01	3.8	
KAGC	Pittsburgh Allegheny Cty	0.03	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.03	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.03	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.02	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.00	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.02	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.01	---	---	---	---	MSTT
Loc12	Baldwin	0.01	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.03	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.02	---	---	---	---	MSTT
Loc16	Castle Shannon	0.02	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.03	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.03	---	---	---	---	MSTT
Loc21	Moon TWP	0.03	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.04	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.05	---	---	---	---	O
Loc26	Elizabeth TWP Municipal Bldg	0.03	---	---	---	---	MSTT
Loc27	Marshall TWP	0.03	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.04	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.03	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.03	---	---	---	---	MSTT

Table 52. Summary of Individual RG Pairs for Event 7f

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03049500	Allegheny River at Natrona	0.08	0.08	0.08	0.00	0.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.07	0.06	0.07	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.08	0.07	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.08	0.06	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.07	0.06	0.07	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.07	0.06	0.07	0.00	0.0	
Loc03	Shaler Munic Bldg	0.07	0.06	0.07	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc04	Kennedy Twp PS	0.07	0.06	0.07	0.00	0.0	
Loc05	Upper St. Clair	0.08	0.06	0.08	0.00	0.0	
Loc07	Greentree Munic Bldg	0.10	0.06	0.10	0.00	0.0	
Loc08	AC Health Dept Bldg	0.08	0.06	0.08	0.00	0.0	
Loc09	Univ of Pittsburgh	0.08	0.05	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	0.08	0.06	0.08	0.00	0.0	
Loc12	Baldwin	0.08	0.06	0.08	0.00	0.0	
Loc13	M-59 Access Shaft	0.11	0.08	0.11	0.00	0.0	
Loc14	Churchill Munic Bldg	0.09	0.07	0.09	0.00	0.0	
Loc15	Trafford Maint Bldg	0.10	0.05	0.10	0.00	0.0	
Loc16	Castle Shannon	0.08	0.06	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.08	0.06	0.08	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.06	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.13	0.08	0.13	0.00	0.0	
Loc21	Moon TWP	0.08	0.06	0.08	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.06	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.07	0.06	0.07	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.10	0.15	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.16	0.08	0.16	0.00	0.0	
Loc27	Marshall TWP	0.11	0.07	0.11	0.00	0.0	
Loc28	Plum Municipal Bldg	0.16	0.11	0.16	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.08	0.07	0.08	0.00	0.0	
Loc30	McCandless Twn Hall	0.08	0.06	0.08	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.09	0.06	0.09	0.00	0.0	
Loc32	Arnold	0.09	0.07	0.09	0.00	0.0	
Loc33	Richland TWP	0.10	0.07	0.10	0.00	0.0	
Loc06	Carnegie Transit Time	0.11	0.06	0.10	0.01	9.1	
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Table 53. Summary of Individual RG Pairs for Event 7g

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc07	Greentree Munic Bldg	0.08	0.07	0.09	-0.01	-12.5	
Loc11	M-46 Access Shaft	0.08	0.08	0.09	-0.01	-12.5	
Loc08	AC Health Dept Bldg	0.09	0.10	0.10	-0.01	-11.1	
03049500	Allegheny River at Natrona	0.08	0.10	0.08	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.09	0.07	0.09	0.00	0.0	
Loc01	PWSA-Montana St.	0.06	0.06	0.06	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.05	0.06	0.05	0.00	0.0	
Loc03	Shaler Munic Bldg	0.08	0.08	0.08	0.00	0.0	
Loc04	Kennedy Twp PS	0.09	0.05	0.09	0.00	0.0	
Loc05	Upper St. Clair	0.07	0.07	0.07	0.00	0.0	
Loc12	Baldwin	0.11	0.10	0.11	0.00	0.0	
Loc14	Churchill Munic Bldg	0.10	0.09	0.10	0.00	0.0	
Loc15	Trafford Maint Bldg	0.11	0.11	0.11	0.00	0.0	
Loc16	Castle Shannon	0.08	0.08	0.08	0.00	0.0	
Loc17	Chartiers Pump Station	0.06	0.05	0.06	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.08	0.07	0.00	0.0	
Loc20	Gascola Eq Facility	0.11	0.10	0.11	0.00	0.0	
Loc21	Moon TWP	0.11	0.08	0.11	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.06	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.12	0.09	0.12	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.08	0.11	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.11	0.08	0.11	0.00	0.0	
Loc27	Marshall TWP	0.15	0.10	0.15	0.00	0.0	
Loc28	Plum Municipal Bldg	0.11	0.10	0.11	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.09	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.10	0.07	0.10	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.09	0.07	0.09	0.00	0.0	
Loc32	Arnold	0.08	0.09	0.08	0.00	0.0	
Loc33	Richland TWP	0.11	0.07	0.11	0.00	0.0	
Loc13	M-59 Access Shaft	0.15	0.11	0.14	0.01	6.7	
KAGC	Pittsburgh Allegheny Cty	0.14	0.10	0.13	0.01	7.1	
Loc10	PWSA-Highland Park	0.11	0.09	0.10	0.01	9.1	
Loc06	Carnegie Transit Time	0.10	0.05	0.09	0.01	10.0	
Loc09	Univ of Pittsburgh	0.10	0.09	0.09	0.01	10.0	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.05	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Table 54. Summary of Individual RG Pairs for Event 7h

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc09	Univ of Pittsburgh	0.05	0.07	0.06	-0.01	-20.0	
Loc05	Upper St. Clair	0.06	0.07	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc08	AC Health Dept Bldg	0.06	0.07	0.06	0.00	0.0	
Loc12	Baldwin	0.08	0.05	0.08	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.07	0.07	0.07	0.00	0.0	
Loc32	Arnold	0.09	0.06	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.06	0.10	0.01	9.1	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.01	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.01	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.02	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.00	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.05	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc16	Castle Shannon	0.04	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc20	Gascola 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

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc24	Jefferson Hills	0.00	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc27	Marshall TWP	0.00	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.00	---	---	---	---	MSTT
Loc33	Richland TWP	0.00	---	---	---	---	MSTT

Table 55. Summary of Individual RG Pairs for Event 7i

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc08	AC Health Dept Bldg	0.05	0.06	0.06	-0.01	-20.0	
Loc11	M-46 Access Shaft	0.05	0.09	0.06	-0.01	-20.0	
03049500	Allegheny River at Natrona	0.08	0.10	0.08	0.00	0.0	
Loc01	PWSA-Montana St.	0.05	0.05	0.05	0.00	0.0	
Loc05	Upper St. Clair	0.12	0.17	0.12	0.00	0.0	
Loc10	PWSA-Highland Park	0.12	0.12	0.12	0.00	0.0	
Loc12	Baldwin	0.05	0.07	0.05	0.00	0.0	
Loc16	Castle Shannon	0.05	0.07	0.05	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.06	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.06	0.09	0.06	0.00	0.0	
Loc32	Arnold	0.05	0.08	0.05	0.00	0.0	
Loc09	Univ of Pittsburgh	0.14	0.12	0.12	0.02	14.3	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.01	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.01	---	---	---	---	MSTT
KPIT	Greater Pittsburgh Int'l	0.00	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.04	---	---	---	---	MSTT
Loc04	Kennedy Twp PS	0.00	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.02	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.01	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc14	Churchill Munic Bldg	0.02	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.00	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.01	---	---	---	---	MSTT
Loc21	Moon TWP	0.01	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.00	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.01	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.02	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.00	---	---	---	---	MSTT
Loc27	Marshall TWP	0.02	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.01	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 56. Summary of Individual RG Pairs for Event 7j

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.15	0.11	-0.01	-10.0	
Loc30	McCandless Twn Hall	0.15	0.17	0.16	-0.01	-6.7	
Loc03	Shaler Munic Bldg	0.16	0.20	0.17	-0.01	-6.3	
Loc12	Baldwin	0.18	0.21	0.19	-0.01	-5.6	
KAGC	Pittsburgh Allegheny Cty	0.05	0.05	0.05	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.14	0.21	0.14	0.00	0.0	
Loc01	PWSA-Montana St.	0.14	0.18	0.14	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.14	0.18	0.14	0.00	0.0	
Loc05	Upper St. Clair	0.21	0.21	0.21	0.00	0.0	
Loc06	Carnegie Transit Time	0.17	0.19	0.17	0.00	0.0	
Loc07	Greentree Munic Bldg	0.18	0.18	0.18	0.00	0.0	
Loc10	PWSA-Highland Park	0.22	0.16	0.22	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.09	0.07	0.00	0.0	
Loc17	Chartiers Pump Station	0.17	0.17	0.17	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.10	0.12	0.10	0.00	0.0	
Loc22	North Fayette TWP	0.17	0.14	0.17	0.00	0.0	
Loc23	Clinton Munic Bldg	0.11	0.10	0.11	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.10	0.11	0.00	0.0	
Loc27	Marshall TWP	0.13	0.11	0.13	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.19	0.16	0.19	0.00	0.0	
Loc32	Arnold	0.05	0.06	0.05	0.00	0.0	
Loc16	Castle Shannon	0.33	0.29	0.32	0.01	3.0	
Loc08	AC Health Dept Bldg	0.24	0.16	0.23	0.01	4.2	
Loc04	Kennedy Twp PS	0.21	0.21	0.20	0.01	4.8	
Loc31	Hampton Municipal Bldg	0.19	0.19	0.18	0.01	5.3	
03049500	Allegheny River at Natrona	0.03	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.48	---	---	---	---	O
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.04	---	---	---	---	MSTT
Loc15	Trafford Maint Bldg	0.01	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.02	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.01	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.05	---	---	---	---	OAD

Table 57. Summary of Individual RG Pairs for Event 7k

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.13	0.14	0.14	-0.01	-7.7	
KAGC	Pittsburgh Allegheny Cty	0.14	0.17	0.15	-0.01	-7.1	
Loc04	Kennedy Twp PS	0.14	0.17	0.15	-0.01	-7.1	
Loc19	Sandy Creek Eq Facility	0.20	0.24	0.21	-0.01	-5.0	
Loc17	Chartiers Pump Station	0.25	0.23	0.26	-0.01	-4.0	
Loc01	PWSA-Montana St.	0.29	0.22	0.30	-0.01	-3.4	
Loc31	Hampton Municipal Bldg	0.31	0.28	0.32	-0.01	-3.2	
03049500	Allegheny River at Natrona	0.24	0.20	0.24	0.00	0.0	

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	0.17	0.18	0.17	0.00	0.0	
Loc06	Carnegie Transit Time	0.27	0.23	0.27	0.00	0.0	
Loc07	Greentree Munic Bldg	0.23	0.19	0.23	0.00	0.0	
Loc09	Univ of Pittsburgh	0.24	0.18	0.24	0.00	0.0	
Loc10	PWSA-Highland Park	0.20	0.16	0.20	0.00	0.0	
Loc11	M-46 Access Shaft	0.33	0.26	0.33	0.00	0.0	
Loc13	M-59 Access Shaft	0.23	0.18	0.23	0.00	0.0	
Loc14	Churchill Munic Bldg	0.24	0.24	0.24	0.00	0.0	
Loc15	Trafford Maint Bldg	0.39	0.45	0.39	0.00	0.0	
Loc16	Castle Shannon	0.23	0.18	0.23	0.00	0.0	
Loc20	Gascola Eq Facility	0.16	0.17	0.16	0.00	0.0	
Loc22	North Fayette TWP	0.17	0.15	0.17	0.00	0.0	
Loc23	Clinton Munic Bldg	0.17	0.15	0.17	0.00	0.0	
Loc24	Jefferson Hills	0.31	0.26	0.31	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.37	0.38	0.37	0.00	0.0	
Loc27	Marshall TWP	0.14	0.09	0.14	0.00	0.0	
Loc28	Plum Municipal Bldg	0.23	0.24	0.23	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.13	0.11	0.13	0.00	0.0	
Loc30	McCandless Twn Hall	0.14	0.11	0.14	0.00	0.0	
Loc32	Arnold	0.37	0.30	0.37	0.00	0.0	
Loc33	Richland TWP	0.23	0.20	0.23	0.00	0.0	
Loc03	Shaler Munic Bldg	0.27	0.20	0.26	0.01	3.7	
Loc05	Upper St. Clair	0.21	0.16	0.20	0.01	4.8	
Loc21	Moon TWP	0.20	0.16	0.19	0.01	5.0	
Loc02	ALCOSAN WWTP Lab	0.35	0.24	0.32	0.03	8.6	
Loc08	AC Health Dept Bldg	0.15	---	---	---	---	U
Loc12	Baldwin	0.11	---	---	---	---	U
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Table 58. Summary of Individual RG Pairs for Event 7l

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

Figure 39. Scatter Plot of RG Pairs for Event 7a

Figure 40. Scatter Plot of RG Pairs for Event 7b

Figure 41. Scatter Plot of RG Pairs for Event 7c

Figure 42. Scatter Plot of RG Pairs for Event 7d

Figure 43. Scatter Plot of RG Pairs for Event 7e

Figure 44. Scatter Plot of RG Pairs for Event 7f

Figure 45. Scatter Plot of RG Pairs for Event 7g

Figure 46. Scatter Plot of RG Pairs for Event 7h

Figure 47. Scatter Plot of RG Pairs for Event 7i

Figure 48. Scatter Plot of RG Pairs for Event 7j

Figure 49. Scatter Plot of RG Pairs for Event 7k

Figure 50. Scatter Plot of RG Pairs for Event 7l

Figure 51. GARR Storm Total for Event 7

Table 59. Depth Duration Frequency Analyses for Event 7

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.374	160157	2019-04-26 12:25	<1 yr.
30 minutes	0.478	160149	2019-04-26 12:25	<1 yr.
1 hour	0.584	160148	2019-04-26 12:40	<1 yr.
2 hour	0.635	150139	2019-04-26 12:25	<1 yr.
3 hour	0.759	150139	2019-04-26 13:10	<1 yr.
6 hour	0.781	150139	2019-04-26 12:55	<1 yr.
12 hour	1.056	167124	2019-04-26 13:25	<1 yr.
24 hour	1.273	158117	2019-04-26 14:00	<1 yr.

Event 8: 2019-04-26 PM

The analysis period was from 2019-04-26 20:00 EDT to 2019-04-27 01:00 EDT.

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 60 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Table 61 summarizes 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, Diff* (in) is the difference in inches between the gauge and 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. Figure 52 shows the scatter plot of the RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 53 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.0 - 0.2 inches with a mean of 0.1 inches. The GARR amounts for the 440 RFM basins range from 0.0 - 0.1 inches with a mean of 0.1 inches. The GARR amounts for the 871 RFM sheds range from 0.0 - 0.1 inches with a mean of 0.1 inches. Table 62 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 60. GARR Statistics for Event 8

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E8	KPBZ LII	2019-04-26 PM	2019-04-26 20:05	2019-04-27 01:00	25	0.063	0.504	96.8	1.8

Table 61. Summary of Individual RG Pairs for Event 8

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.10	0.21	0.10	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.05	0.08	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.05	0.09	0.05	0.00	0.0	
Loc05	Upper St. Clair	0.09	0.16	0.09	0.00	0.0	
Loc06	Carnegie Transit Time	0.07	0.13	0.07	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.11	0.06	0.00	0.0	
Loc08	AC Health Dept Bldg	0.05	0.09	0.05	0.00	0.0	
Loc09	Univ of Pittsburgh	0.05	0.08	0.05	0.00	0.0	
Loc10	PWSA-Highland Park	0.06	0.10	0.06	0.00	0.0	
Loc12	Baldwin	0.08	0.16	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.15	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.16	0.05	0.00	0.0	
Loc16	Castle Shannon	0.09	0.16	0.09	0.00	0.0	
Loc17	Chartiers Pump Station	0.09	0.15	0.09	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.08	0.22	0.08	0.00	0.0	
Loc20	Gascola Eq Facility	0.10	0.28	0.10	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc21	Moon TWP	0.06	0.08	0.06	0.00	0.0	
Loc22	North Fayette TWP	0.14	0.14	0.14	0.00	0.0	
Loc23	Clinton Munic Bldg	0.06	0.11	0.06	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.30	0.11	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.29	0.08	0.00	0.0	
Loc27	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.06	0.11	0.06	0.00	0.0	
Loc30	McCandless Twn Hall	0.05	0.07	0.05	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.06	0.09	0.06	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
Loc01	PWSA-Montana St.	0.03	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.04	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.01	---	---	---	---	U
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.03	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z
Loc29	Bell Acres Munic Bldg	0.03	---	---	---	---	MSTT
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.04	---	---	---	---	MSTT

Figure 52. Scatter Plot of RG Pairs for Event 8

Figure 53. GARR Storm Total for Event 8

Table 62. Depth Duration Frequency Analyses for Event 8

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.115	151121	2019-04-26 21:25	<1 yr.
30 minutes	0.147	129142	2019-04-26 21:15	<1 yr.
1 hour	0.158	129142	2019-04-26 21:20	<1 yr.
2 hour	0.158	129142	2019-04-26 22:00	<1 yr.
3 hour	0.158	129142	2019-04-26 23:00	<1 yr.

Event 9: 2019-04-28

The analysis period was from 2019-04-27 18:00 EDT to 2019-04-28 08:00 EDT. The event was then split into two sub-event periods at 2019-04-28 01:50 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 63 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 64 - 65 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 54 - 55 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 56 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.1 - 0.3 inches with a mean of 0.1 inches. The GARR amounts for the 440 RFM basins range from 0.1 - 0.2 inches with a mean of 0.1 inches. The GARR amounts for the 871 RFM sheds range from 0.1 - 0.2 inches with a mean of 0.1 inches. Table 66 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 63. GARR Statistics for Event 9

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E9a	KPBZ LII	2019-04-28	2019-04-27 18:05	2019-04-28 01:50	6	0.041	0.597	69.6	0.0
E9b	KPBZ LII	2019-04-28	2019-04-28 01:55	2019-04-28 08:00	31	0.097	0.990	15.4	2.5

Table 64. Summary of Individual RG Pairs for Event 9a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.05	0.07	0.05	0.00	0.0	
Loc04	Kennedy Twp PS	0.05	0.06	0.05	0.00	0.0	
Loc15	Trafford Maint Bldg	0.05	0.17	0.05	0.00	0.0	
Loc16	Castle Shannon	0.05	0.09	0.05	0.00	0.0	
Loc23	Clinton Munic Bldg	0.05	0.07	0.05	0.00	0.0	
Loc27	Marshall TWP	0.06	0.06	0.06	0.00	0.0	
03049500	Allegheny River at Natrona	0.01	---	---	---	---	MSTT
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.03	---	---	---	---	MSTT
KAGC	Pittsburgh Allegheny Cty	0.04	---	---	---	---	MSTT
Loc01	PWSA-Montana St.	0.02	---	---	---	---	MSTT
Loc02	ALCOSAN WWTP Lab	0.03	---	---	---	---	MSTT
Loc03	Shaler Munic Bldg	0.03	---	---	---	---	MSTT
Loc05	Upper St. Clair	0.04	---	---	---	---	MSTT
Loc06	Carnegie Transit Time	0.03	---	---	---	---	MSTT
Loc07	Greentree Munic Bldg	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.02	---	---	---	---	MSTT
Loc09	Univ of Pittsburgh	0.03	---	---	---	---	MSTT
Loc10	PWSA-Highland Park	0.04	---	---	---	---	MSTT
Loc11	M-46 Access Shaft	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.03	---	---	---	---	MSTT
Loc13	M-59 Access Shaft	0.02	---	---	---	---	MSTT
Loc14	Churchill Munic Bldg	0.03	---	---	---	---	MSTT
Loc17	Chartiers Pump Station	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc19	Sandy Creek Eq Facility	0.04	---	---	---	---	MSTT
Loc20	Gascola Eq Facility	0.04	---	---	---	---	MSTT
Loc21	Moon TWP	0.04	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc24	Jefferson Hills	0.01	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.01	---	---	---	---	MSTT
Loc26	Elizabeth TWP Municipal Bldg	0.02	---	---	---	---	MSTT
Loc28	Plum Municipal Bldg	0.03	---	---	---	---	MSTT
Loc29	Bell Acres Munic Bldg	0.02	---	---	---	---	MSTT
Loc30	McCandless Twn Hall	0.02	---	---	---	---	MSTT
Loc31	Hampton Municipal Bldg	0.03	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc32	Arnold	0.01	---	---	---	---	MSTT
Loc33	Richland TWP	0.02	---	---	---	---	MSTT

Table 65. Summary of Individual RG Pairs for Event 9b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc30	McCandless Twn Hall	0.13	0.13	0.14	-0.01	-7.7	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.10	0.11	0.10	0.00	0.0	
KAGC	Pittsburgh Allegheny Cty	0.09	0.08	0.09	0.00	0.0	
KPIT	Greater Pittsburgh Int'l	0.13	0.12	0.13	0.00	0.0	
Loc01	PWSA-Montana St.	0.10	0.10	0.10	0.00	0.0	
Loc02	ALCOSAN WWTP Lab	0.09	0.10	0.09	0.00	0.0	
Loc03	Shaler Munic Bldg	0.10	0.09	0.10	0.00	0.0	
Loc05	Upper St. Clair	0.07	0.07	0.07	0.00	0.0	
Loc07	Greentree Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc09	Univ of Pittsburgh	0.06	0.06	0.06	0.00	0.0	
Loc10	PWSA-Highland Park	0.07	0.07	0.07	0.00	0.0	
Loc11	M-46 Access Shaft	0.07	0.06	0.07	0.00	0.0	
Loc13	M-59 Access Shaft	0.08	0.09	0.08	0.00	0.0	
Loc14	Churchill Munic Bldg	0.06	0.07	0.06	0.00	0.0	
Loc15	Trafford Maint Bldg	0.09	0.13	0.09	0.00	0.0	
Loc16	Castle Shannon	0.06	0.08	0.06	0.00	0.0	
Loc17	Chartiers Pump Station	0.05	0.07	0.05	0.00	0.0	
Loc20	Gascola Eq Facility	0.07	0.08	0.07	0.00	0.0	
Loc21	Moon TWP	0.13	0.12	0.13	0.00	0.0	
Loc22	North Fayette TWP	0.07	0.08	0.07	0.00	0.0	
Loc23	Clinton Munic Bldg	0.15	0.13	0.15	0.00	0.0	
Loc24	Jefferson Hills	0.08	0.09	0.08	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.11	0.08	0.00	0.0	
Loc28	Plum Municipal Bldg	0.08	0.10	0.08	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.16	0.13	0.16	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.12	0.10	0.12	0.00	0.0	
Loc32	Arnold	0.11	0.16	0.11	0.00	0.0	
Loc33	Richland TWP	0.12	0.11	0.12	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc27	Marshall TWP	0.16	0.10	0.15	0.01	6.3	
Loc04	Kennedy Twp PS	0.12	0.10	0.11	0.01	8.3	
Loc19	Sandy Creek Eq Facility	0.08	0.06	0.07	0.01	12.5	
03049500	Allegheny River at Natrona	0.09	---	---	---	---	U
Loc06	Carnegie Transit Time	0.04	---	---	---	---	MSTT
Loc08	AC Health Dept Bldg	0.04	---	---	---	---	MSTT
Loc12	Baldwin	0.04	---	---	---	---	MSTT
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Figure 54. Scatter Plot of RG Pairs for Event 9a

Figure 55. Scatter Plot of RG Pairs for Event 9b

Figure 56. GARR Storm Total for Event 9

Table 66. Depth Duration Frequency Analyses for Event 9

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.076	123126	2019-04-28 04:15	<1 yr.
30 minutes	0.116	123126	2019-04-28 04:20	<1 yr.
1 hour	0.170	134111	2019-04-28 04:15	<1 yr.
2 hour	0.196	134111	2019-04-28 04:25	<1 yr.
3 hour	0.207	134111	2019-04-28 05:00	<1 yr.
6 hour	0.260	133112	2019-04-28 05:00	<1 yr.
12 hour	0.285	133112	2019-04-28 06:00	<1 yr.

Event 10: 2019-04-30

The analysis period was from 2019-04-30 13:00 EDT to 2019-04-30 19:00 EDT. The event was then split into two sub-event periods at 2019-04-30 15:40 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 67 shows the mean bias and average depth of the event along with the AD and CAD, respectively. Tables 68 - 69 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 57 - 58 show the scatter plots of the gauge-adjusted RG pairs. Those gauges not used to adjust the radar are shown in red. Figure 59 depicts the GARR storm total over the 1-km^2 pixels. The GARR amounts for the 2313 1-km^2 pixels range from 0.1 - 0.4 inches with a mean of 0.2 inches. The GARR amounts for the 440 RFM basins range from 0.2 - 0.3 inches with a mean of 0.2 inches. The GARR amounts for the 871 RFM sheds range from 0.2 - 0.3 inches with a mean of 0.2 inches. Table 70 shows the Depth Duration Frequency (DDF) maximum values for the 1-km^2 pixels.

Table 67. GARR Statistics for Event 10

Event #	Radar	Event Date	Start Time (EDT)	End Time (EDT)	Gauges Used (37)	Avg. Depth (in)	Bias	AD (%)	CAD (%)
E10a	KPBZ LII	2019-04-30	2019-04-30 13:05	2019-04-30 15:40	32	0.102	0.895	20.8	3.0
E10b	KPBZ LII	2019-04-30	2019-04-30 15:45	2019-04-30 19:00	30	0.103	0.834	27.7	3.9

Table 68. Summary of Individual RG Pairs for Event 10a

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc02	ALCOSAN WWTP Lab	0.07	0.10	0.08	-0.01	-14.3	
Loc09	Univ of Pittsburgh	0.10	0.13	0.11	-0.01	-10.0	
KAGC	Pittsburgh Allegheny Cty	0.11	0.18	0.12	-0.01	-9.1	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.11	0.12	0.11	0.00	0.0	
Loc04	Kennedy Twp PS	0.13	0.14	0.13	0.00	0.0	
Loc06	Carnegie Transit Time	0.12	0.19	0.12	0.00	0.0	
Loc07	Greentree Munic Bldg	0.16	0.22	0.16	0.00	0.0	
Loc10	PWSA-Highland Park	0.12	0.14	0.12	0.00	0.0	
Loc12	Baldwin	0.17	0.22	0.17	0.00	0.0	
Loc13	M-59 Access Shaft	0.12	0.17	0.12	0.00	0.0	
Loc14	Churchill Munic Bldg	0.14	0.16	0.14	0.00	0.0	
Loc15	Trafford Maint Bldg	0.17	0.24	0.17	0.00	0.0	
Loc17	Chartiers Pump Station	0.10	0.15	0.10	0.00	0.0	
Loc19	Sandy Creek Eq Facility	0.10	0.10	0.10	0.00	0.0	
Loc20	Gascola Eq Facility	0.12	0.15	0.12	0.00	0.0	
Loc21	Moon TWP	0.22	0.22	0.22	0.00	0.0	
Loc22	North Fayette TWP	0.21	0.19	0.21	0.00	0.0	
Loc23	Clinton Munic Bldg	0.21	0.18	0.21	0.00	0.0	
Loc24	Jefferson Hills	0.15	0.15	0.15	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.08	0.07	0.08	0.00	0.0	
Loc27	Marshall TWP	0.13	0.11	0.13	0.00	0.0	
Loc28	Plum Municipal Bldg	0.07	0.09	0.07	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.19	0.16	0.19	0.00	0.0	
Loc30	McCandless Twn Hall	0.11	0.10	0.11	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.07	0.08	0.07	0.00	0.0	
Loc33	Richland TWP	0.09	0.07	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.17	0.19	0.16	0.01	5.9	
Loc16	Castle Shannon	0.16	0.16	0.15	0.01	6.3	
Loc05	Upper St. Clair	0.13	0.16	0.12	0.01	7.7	
Loc08	AC Health Dept Bldg	0.13	0.14	0.12	0.01	7.7	
Loc03	Shaler Munic Bldg	0.10	0.08	0.09	0.01	10.0	
Loc01	PWSA-Montana St.	0.09	0.09	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.02	---	---	---	---	MSTT

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KPIT	Greater Pittsburgh Int'l	0.13	---	---	---	---	U
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z
Loc32	Arnold	0.04	---	---	---	---	MSTT

Table 69. Summary of Individual RG Pairs for Event 10b

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
Loc01	PWSA-Montana St.	0.08	0.10	0.09	-0.01	-12.5	
Loc09	Univ of Pittsburgh	0.08	0.14	0.09	-0.01	-12.5	
Loc12	Baldwin	0.08	0.13	0.09	-0.01	-12.5	
Loc14	Churchill Munic Bldg	0.09	0.14	0.10	-0.01	-11.1	
Loc05	Upper St. Clair	0.11	0.13	0.12	-0.01	-9.1	
03085734	Ohio River at Emsworth Dam Lower Pool at Emsworth	0.06	0.07	0.06	0.00	0.0	
Loc03	Shaler Munic Bldg	0.09	0.10	0.09	0.00	0.0	
Loc04	Kennedy Twp PS	0.06	0.06	0.06	0.00	0.0	
Loc07	Greentree Munic Bldg	0.13	0.11	0.13	0.00	0.0	
Loc08	AC Health Dept Bldg	0.09	0.12	0.09	0.00	0.0	
Loc11	M-46 Access Shaft	0.11	0.17	0.11	0.00	0.0	
Loc13	M-59 Access Shaft	0.13	0.17	0.13	0.00	0.0	
Loc15	Trafford Maint Bldg	0.14	0.18	0.14	0.00	0.0	
Loc16	Castle Shannon	0.13	0.14	0.13	0.00	0.0	
Loc17	Chartiers 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	0.09	0.13	0.09	0.00	0.0	
Loc24	Jefferson Hills	0.11	0.10	0.11	0.00	0.0	
Loc26	Elizabeth TWP Municipal Bldg	0.16	0.14	0.16	0.00	0.0	
Loc27	Marshall TWP	0.06	0.09	0.06	0.00	0.0	
Loc28	Plum Municipal Bldg	0.13	0.14	0.13	0.00	0.0	
Loc29	Bell Acres Munic Bldg	0.07	0.08	0.07	0.00	0.0	
Loc30	McCandless Twn Hall	0.08	0.12	0.08	0.00	0.0	
Loc31	Hampton Municipal Bldg	0.13	0.16	0.13	0.00	0.0	
Loc32	Arnold	0.12	0.20	0.12	0.00	0.0	
Loc33	Richland TWP	0.12	0.17	0.12	0.00	0.0	

Gauge ID	Name	G_i (in)	R_i (in)	R_i* (in)	Diff* (in)	Diff* (%)	Flag
KAGC	Pittsburgh Allegheny Cty	0.13	0.13	0.12	0.01	7.7	
Loc06	Carnegie Transit Time	0.13	0.10	0.12	0.01	7.7	
Loc10	PWSA-Highland Park	0.12	0.12	0.11	0.01	8.3	
Loc02	ALCOSAN WWTP Lab	0.09	0.09	0.08	0.01	11.1	
03049500	Allegheny River at Natrona	0.09	---	---	---	---	U
KPIT	Greater Pittsburgh Int'l	0.08	---	---	---	---	O
Loc18	Oakdale Pump Station	ND	---	---	---	---	ND
Loc21	Moon TWP	0.02	---	---	---	---	MSTT
Loc22	North Fayette TWP	0.04	---	---	---	---	MSTT
Loc23	Clinton Munic Bldg	0.03	---	---	---	---	MSTT
Loc25	White Oak Public Works Bldg	0.00	---	---	---	---	Z

Figure 57. Scatter Plot of RG Pairs for Event 10a

Figure 58. Scatter Plot of RG Pairs for Event 10b

Figure 59. GARR Storm Total for Event 10

Table 70. Depth Duration Frequency Analyses for Event 10

Duration	Depth (in)	Pixel	Time (EDT)	Frequency
15 minutes	0.206	166155	2019-04-30 15:45	<1 yr.
30 minutes	0.257	166155	2019-04-30 15:55	<1 yr.
1 hour	0.372	166155	2019-04-30 16:25	<1 yr.
2 hour	0.399	166155	2019-04-30 17:15	<1 yr.
3 hour	0.399	166155	2019-04-30 17:15	<1 yr.
6 hour	0.399	166155	2019-04-30 19:00	<1 yr.

Appendices

Appendix A - Gauge Performance Exclusion Table
Appendix B - Gauge Statistical Criteria Exclusion Table
Appendix C - Event 1 (2019-04-12) CDPs
Appendix D - Event 2 (2019-04-14 AM) CDPs
Appendix E - Event 3 (2019-04-14 PM) CDPs
Appendix F - Event 4 (2019-04-19) CDPs
Appendix G - Event 5 (2019-04-20 AM) CDPs
Appendix H - Event 6 (2019-04-20 PM) CDPs
Appendix I - Event 7 (2019-04-26 AM) CDPs
Appendix J - Event 8 (2019-04-26 PM) CDPs
Appendix K - Event 9 (2019-04-28) CDPs
Appendix L - Event 10 (2019-04-30) CDPs

Appendix A - Gauge Performance Exclusion Table

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

Event #	E1a	E1b	E2a	E2b	E2c
Event Date	**2019-04-12**	**2019-04-12**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**
Start Time (EDT)	2019-04-12 11:05	2019-04-12 14:05	2019-04-14 06:05	2019-04-14 08:55	2019-04-14 10:05
End Time (EDT)	2019-04-12 14:00	2019-04-12 18:00	2019-04-14 08:50	2019-04-14 10:00	2019-04-14 11:00
Loc01	U	U			
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					
Loc24					

Event #	E1a	E1b	E2a	E2b	E2c
Event Date	**2019-04-12**	**2019-04-12**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**
Start Time (EDT)	2019-04-12 11:05	2019-04-12 14:05	2019-04-14 06:05	2019-04-14 08:55	2019-04-14 10:05
End Time (EDT)	2019-04-12 14:00	2019-04-12 18:00	2019-04-14 08:50	2019-04-14 10:00	2019-04-14 11:00
Loc25					
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					O
KPIT					O
03049500		U			
03085734					

Event #	E2d	E2e	E2f	E3a	E3b
Event Date	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 PM**	**2019-04-14 PM**
Start Time (EDT)	2019-04-14 11:05	2019-04-14 12:00	2019-04-14 12:35	2019-04-14 16:05	2019-04-14 21:10
End Time (EDT)	2019-04-14 11:55	2019-04-14 12:30	2019-04-14 16:00	2019-04-14 21:05	2019-04-14 21:55
Loc01	U			U	U
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12		Z	S		
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E2d	E2e	E2f	E3a	E3b
Event Date	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 PM**	**2019-04-14 PM**
Start Time (EDT)	2019-04-14 11:05	2019-04-14 12:00	2019-04-14 12:35	2019-04-14 16:05	2019-04-14 21:10
End Time (EDT)	2019-04-14 11:55	2019-04-14 12:30	2019-04-14 16:00	2019-04-14 21:05	2019-04-14 21:55
Loc24					
Loc25		S	O	U	S
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC			O	U	
KPIT					
03049500					
03085734					

Event #	E3c	E3d	E3e	E4a	E4b
Event Date	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-19**	**2019-04-19**
Start Time (EDT)	2019-04-14 22:00	2019-04-14 23:15	2019-04-15 01:05	2019-04-19 05:05	2019-04-19 13:50
End Time (EDT)	2019-04-14 23:10	2019-04-15 01:00	2019-04-15 10:00	2019-04-19 13:45	2019-04-19 15:00
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12	S	Z	O		
Loc13			O		
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E3c	E3d	E3e	E4a	E4b
Event Date	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-19**	**2019-04-19**
Start Time (EDT)	2019-04-14 22:00	2019-04-14 23:15	2019-04-15 01:05	2019-04-19 05:05	2019-04-19 13:50
End Time (EDT)	2019-04-14 23:10	2019-04-15 01:00	2019-04-15 10:00	2019-04-19 13:45	2019-04-19 15:00
Loc24					
Loc25	S	Z	O		S
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500	U			U	
03085734					

Event #	E4c	E4d	E5a	E5b	E5c
Event Date	**2019-04-19**	**2019-04-19**	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 AM**
Start Time (EDT)	2019-04-19 15:05	2019-04-19 16:25	2019-04-20 01:05	2019-04-20 03:05	2019-04-20 04:35
End Time (EDT)	2019-04-19 16:20	2019-04-20 01:00	2019-04-20 03:00	2019-04-20 04:30	2019-04-20 06:30
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E4c	E4d	E5a	E5b	E5c
Event Date	**2019-04-19**	**2019-04-19**	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 AM**
Start Time (EDT)	2019-04-19 15:05	2019-04-19 16:25	2019-04-20 01:05	2019-04-20 03:05	2019-04-20 04:35
End Time (EDT)	2019-04-19 16:20	2019-04-20 01:00	2019-04-20 03:00	2019-04-20 04:30	2019-04-20 06:30
Loc24					
Loc25	Z	Z			Z
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC				O	U
KPIT					
03049500					
03085734					

Event #	E5d	E5e	E6a	E6b	E6c
Event Date	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**
Start Time (EDT)	2019-04-20 06:35	2019-04-20 07:30	2019-04-20 11:05	2019-04-20 17:00	2019-04-20 18:00
End Time (EDT)	2019-04-20 07:25	2019-04-20 11:00	2019-04-20 16:55	2019-04-20 17:55	2019-04-20 18:15
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E5d	E5e	E6a	E6b	E6c
Event Date	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**
Start Time (EDT)	2019-04-20 06:35	2019-04-20 07:30	2019-04-20 11:05	2019-04-20 17:00	2019-04-20 18:00
End Time (EDT)	2019-04-20 07:25	2019-04-20 11:00	2019-04-20 16:55	2019-04-20 17:55	2019-04-20 18:15
Loc24					
Loc25			ND		T
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500				U	
03085734					

Event #	E6d	E6e	E6f	E6g	E7a
Event Date	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-20 18:20	2019-04-20 19:25	2019-04-20 20:15	2019-04-20 21:25	2019-04-25 14:05
End Time (EDT)	2019-04-20 19:20	2019-04-20 20:10	2019-04-20 21:20	2019-04-21 02:00	2019-04-25 20:45
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E6d	E6e	E6f	E6g	E7a
Event Date	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-20 18:20	2019-04-20 19:25	2019-04-20 20:15	2019-04-20 21:25	2019-04-25 14:05
End Time (EDT)	2019-04-20 19:20	2019-04-20 20:10	2019-04-20 21:20	2019-04-21 02:00	2019-04-25 20:45
Loc24					
Loc25	S	S	Z	Z	S
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500					
03085734					

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-25 20:50	2019-04-25 23:25	2019-04-26 00:50	2019-04-26 03:45	2019-04-26 04:45
End Time (EDT)	2019-04-25 23:20	2019-04-26 00:45	2019-04-26 03:40	2019-04-26 04:40	2019-04-26 06:15
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-25 20:50	2019-04-25 23:25	2019-04-26 00:50	2019-04-26 03:45	2019-04-26 04:45
End Time (EDT)	2019-04-25 23:20	2019-04-26 00:45	2019-04-26 03:40	2019-04-26 04:40	2019-04-26 06:15
Loc24					
Loc25				O	Z
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500					
03085734					

Event #	E7g	E7h	E7i	E7j	E7k
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-26 06:20	2019-04-26 10:05	2019-04-26 10:35	2019-04-26 11:00	2019-04-26 11:50
End Time (EDT)	2019-04-26 10:00	2019-04-26 10:30	2019-04-26 10:55	2019-04-26 11:45	2019-04-26 12:40
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					U
Loc09				O	
Loc10					
Loc11					
Loc12					U
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E7g	E7h	E7i	E7j	E7k
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-26 06:20	2019-04-26 10:05	2019-04-26 10:35	2019-04-26 11:00	2019-04-26 11:50
End Time (EDT)	2019-04-26 10:00	2019-04-26 10:30	2019-04-26 10:55	2019-04-26 11:45	2019-04-26 12:40
Loc24					
Loc25	Z				Z
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC					
KPIT					
03049500					
03085734					

Event #	E7l	E8	E9a	E9b	E10a
Event Date	**2019-04-26 AM**	**2019-04-26 PM**	**2019-04-28**	**2019-04-28**	**2019-04-30**
Start Time (EDT)	2019-04-26 12:45	2019-04-26 20:05	2019-04-27 18:05	2019-04-28 01:55	2019-04-30 13:05
End Time (EDT)	2019-04-26 20:00	2019-04-27 01:00	2019-04-28 01:50	2019-04-28 08:00	2019-04-30 15:40
Loc01					
Loc02					
Loc03		U			
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15					
Loc16					
Loc17					
Loc18	ND	ND	ND	ND	ND
Loc19					
Loc20					
Loc21					
Loc22					
Loc23					

Event #	E7l	E8	E9a	E9b	E10a
Event Date	**2019-04-26 AM**	**2019-04-26 PM**	**2019-04-28**	**2019-04-28**	**2019-04-30**
Start Time (EDT)	2019-04-26 12:45	2019-04-26 20:05	2019-04-27 18:05	2019-04-28 01:55	2019-04-30 13:05
End Time (EDT)	2019-04-26 20:00	2019-04-27 01:00	2019-04-28 01:50	2019-04-28 08:00	2019-04-30 15:40
Loc24					
Loc25	Z	Z		Z	Z
Loc26					
Loc27					
Loc28					
Loc29					
Loc30					
Loc31					
Loc32					
Loc33					
KAGC	O				
KPIT					U
03049500				U	
03085734					

Event #	E10b
Event Date	**2019-04-30**
Start Time (EDT)	2019-04-30 15:45
End Time (EDT)	2019-04-30 19:00
Loc01	
Loc02	
Loc03	
Loc04	
Loc05	
Loc06	
Loc07	
Loc08	
Loc09	
Loc10	
Loc11	
Loc12	
Loc13	
Loc14	
Loc15	
Loc16	
Loc17	
Loc18	ND
Loc19	
Loc20	
Loc21	
Loc22	
Loc23	
Loc24	
Loc25	Z

Event #	E10b
Event Date	**2019-04-30**
Start Time (EDT)	2019-04-30 15:45
End Time (EDT)	2019-04-30 19:00
Loc26	
Loc27	
Loc28	
Loc29	
Loc30	
Loc31	
Loc32	
Loc33	
KAGC	
KPIT	O
03049500	U
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	E2a	E2b	E2c
Event Date	**2019-04-12**	**2019-04-12**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**
Start Time (EDT)	2019-04-12 11:05	2019-04-12 14:05	2019-04-14 06:05	2019-04-14 08:55	2019-04-14 10:05
End Time (EDT)	2019-04-12 14:00	2019-04-12 18:00	2019-04-14 08:50	2019-04-14 10:00	2019-04-14 11:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01			MSTT		
Loc02			MSTT		
Loc03			MSTT		
Loc04	MSTT		MSTT	MSTT	
Loc05	MSTT		MSTT		
Loc06			MSTT		
Loc07	MSTT		MSTT		
Loc08	MSTT		MSTT		
Loc09	MSTT		MSTT		
Loc10	MSTT		MSTT		
Loc11	MSTT		MSTT	MSTT	
Loc12	MSTT		MSTT		
Loc13	MSTT		MSTT		
Loc14	MSTT		MSTT		
Loc15	MSTT		MSTT	MSTT	
Loc16	MSTT		MSTT		
Loc17	MSTT		MSTT		
Loc18					
Loc19	MSTT		MSTT		
Loc20	MSTT		MSTT		
Loc21					
Loc22			MSTT		
Loc23			MSTT		

Event #	E1a	E1b	E2a	E2b	E2c
Event Date	**2019-04-12**	**2019-04-12**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**
Start Time (EDT)	2019-04-12 11:05	2019-04-12 14:05	2019-04-14 06:05	2019-04-14 08:55	2019-04-14 10:05
End Time (EDT)	2019-04-12 14:00	2019-04-12 18:00	2019-04-14 08:50	2019-04-14 10:00	2019-04-14 11:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc24	MSTT		MSTT		MSTT
Loc25	MSTT		MSTT	MSTT	MSTT
Loc26	MSTT		MSTT	MSTT	MSTT
Loc27					
Loc28	MSTT		MSTT	MSTT	
Loc29					
Loc30					
Loc31			MSTT		
Loc32	MSTT		MSTT		
Loc33			MSTT		
KAGC	MSTT		MSTT		
KPIT			MSTT		
03049500	MSTT		MSTT		
03085734			MSTT	MSTT	

Event #	E2d	E2e	E2f	E3a	E3b
Event Date	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 PM**	**2019-04-14 PM**
Start Time (EDT)	2019-04-14 11:05	2019-04-14 12:00	2019-04-14 12:35	2019-04-14 16:05	2019-04-14 21:10
End Time (EDT)	2019-04-14 11:55	2019-04-14 12:30	2019-04-14 16:00	2019-04-14 21:05	2019-04-14 21:55
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01					
Loc02					
Loc03					
Loc04					
Loc05					
Loc06					
Loc07					
Loc08					
Loc09					
Loc10					
Loc11					
Loc12					
Loc13					
Loc14					
Loc15				MSTT	
Loc16					
Loc17					
Loc18					
Loc19		MSTT			
Loc20				OAD	
Loc21		MSTT			
Loc22					

Event #	E2d	E2e	E2f	E3a	E3b
Event Date	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 AM**	**2019-04-14 PM**	**2019-04-14 PM**
Start Time (EDT)	2019-04-14 11:05	2019-04-14 12:00	2019-04-14 12:35	2019-04-14 16:05	2019-04-14 21:10
End Time (EDT)	2019-04-14 11:55	2019-04-14 12:30	2019-04-14 16:00	2019-04-14 21:05	2019-04-14 21:55
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23		MSTT			
Loc24					
Loc25					
Loc26	MSTT				
Loc27		MSTT			
Loc28				MSTT	
Loc29		MSTT			
Loc30		MSTT			
Loc31					
Loc32		MSTT		MSTT	
Loc33					
KAGC					
KPIT					
03049500		MSTT		MSTT	
03085734					

Event #	E3c	E3d	E3e	E4a	E4b
Event Date	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-19**	**2019-04-19**
Start Time (EDT)	2019-04-14 22:00	2019-04-14 23:15	2019-04-15 01:05	2019-04-19 05:05	2019-04-19 13:50
End Time (EDT)	2019-04-14 23:10	2019-04-15 01:00	2019-04-15 10:00	2019-04-19 13:45	2019-04-19 15:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01		MSTT	MSTT	MSTT	
Loc02		MSTT	MSTT	MSTT	MSTT
Loc03		MSTT		MSTT	
Loc04		MSTT	MSTT	MSTT	MSTT
Loc05		MSTT			
Loc06		MSTT	MSTT	MSTT	
Loc07		MSTT	MSTT	MSTT	
Loc08		MSTT	MSTT		
Loc09		MSTT			
Loc10		MSTT	MSTT		
Loc11		MSTT			
Loc12					
Loc13		MSTT			
Loc14		MSTT			
Loc15		MSTT	MSTT		
Loc16		MSTT			
Loc17		MSTT	MSTT	MSTT	
Loc18					
Loc19		MSTT			
Loc20		MSTT			
Loc21		MSTT	MSTT	MSTT	MSTT
Loc22		MSTT	MSTT	MSTT	MSTT

Event #	E3c	E3d	E3e	E4a	E4b
Event Date	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-14 PM**	**2019-04-19**	**2019-04-19**
Start Time (EDT)	2019-04-14 22:00	2019-04-14 23:15	2019-04-15 01:05	2019-04-19 05:05	2019-04-19 13:50
End Time (EDT)	2019-04-14 23:10	2019-04-15 01:00	2019-04-15 10:00	2019-04-19 13:45	2019-04-19 15:00
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23		MSTT	MSTT	MSTT	MSTT
Loc24		MSTT	MSTT		
Loc25					
Loc26			MSTT		
Loc27		MSTT		MSTT	MSTT
Loc28		MSTT			
Loc29		MSTT	MSTT	MSTT	MSTT
Loc30		MSTT	MSTT	MSTT	MSTT
Loc31		MSTT		MSTT	
Loc32					
Loc33			MSTT	MSTT	
KAGC		MSTT			
KPIT		MSTT	MSTT	MSTT	MSTT
03049500		MSTT	MSTT		
03085734		MSTT	MSTT	MSTT	MSTT

Event #	E4c	E4d	E5a	E5b	E5c
Event Date	**2019-04-19**	**2019-04-19**	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 AM**
Start Time (EDT)	2019-04-19 15:05	2019-04-19 16:25	2019-04-20 01:05	2019-04-20 03:05	2019-04-20 04:35
End Time (EDT)	2019-04-19 16:20	2019-04-20 01:00	2019-04-20 03:00	2019-04-20 04:30	2019-04-20 06:30
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01			MSTT		MSTT
Loc02			MSTT		MSTT
Loc03			MSTT		
Loc04					
Loc05			MSTT		
Loc06			MSTT		
Loc07			MSTT		MSTT
Loc08			MSTT	MSTT	
Loc09			MSTT	MSTT	
Loc10			MSTT	MSTT	
Loc11			MSTT	MSTT	
Loc12			MSTT	MSTT	
Loc13			MSTT	MSTT	
Loc14			MSTT	MSTT	
Loc15			MSTT	MSTT	MSTT
Loc16			MSTT		MSTT
Loc17					
Loc18					
Loc19			MSTT	MSTT	
Loc20			MSTT	MSTT	
Loc21			MSTT		MSTT
Loc22			MSTT		MSTT

Event #	E4c	E4d	E5a	E5b	E5c
Event Date	**2019-04-19**	**2019-04-19**	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 AM**
Start Time (EDT)	2019-04-19 15:05	2019-04-19 16:25	2019-04-20 01:05	2019-04-20 03:05	2019-04-20 04:35
End Time (EDT)	2019-04-19 16:20	2019-04-20 01:00	2019-04-20 03:00	2019-04-20 04:30	2019-04-20 06:30
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23			MSTT	MSTT	
Loc24			MSTT		
Loc25			MSTT	MSTT	
Loc26			MSTT	MSTT	
Loc27					
Loc28			MSTT	MSTT	MSTT
Loc29			MSTT		
Loc30			MSTT		
Loc31			MSTT		
Loc32			MSTT	MSTT	MSTT
Loc33			MSTT		
KAGC			MSTT		
KPIT			MSTT		
03049500			MSTT	MSTT	
03085734			MSTT		MSTT

Event #	E5d	E5e	E6a	E6b	E6c
Event Date	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**
Start Time (EDT)	2019-04-20 06:35	2019-04-20 07:30	2019-04-20 11:05	2019-04-20 17:00	2019-04-20 18:00
End Time (EDT)	2019-04-20 07:25	2019-04-20 11:00	2019-04-20 16:55	2019-04-20 17:55	2019-04-20 18:15
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01	MSTT	MSTT	MSTT	MSTT	MSTT
Loc02	MSTT	MSTT	MSTT	MSTT	MSTT
Loc03	MSTT	MSTT	MSTT	MSTT	MSTT
Loc04	MSTT		MSTT	MSTT	MSTT
Loc05			MSTT	MSTT	
Loc06	MSTT	MSTT	MSTT	MSTT	MSTT
Loc07	MSTT	MSTT	MSTT	MSTT	MSTT
Loc08	MSTT	MSTT	MSTT	MSTT	MSTT
Loc09	MSTT	MSTT	MSTT	MSTT	MSTT
Loc10	MSTT	MSTT	MSTT		
Loc11	MSTT	MSTT	MSTT		MSTT
Loc12	MSTT	MSTT	MSTT		MSTT
Loc13	MSTT	MSTT	MSTT		
Loc14	MSTT	MSTT			
Loc15	MSTT	MSTT			MSTT
Loc16	MSTT	MSTT	MSTT	MSTT	MSTT
Loc17			MSTT	MSTT	MSTT
Loc18					
Loc19	MSTT	MSTT			
Loc20	MSTT	MSTT			MSTT
Loc21	MSTT		MSTT	MSTT	MSTT
Loc22			MSTT	MSTT	MSTT

Event #	E5d	E5e	E6a	E6b	E6c
Event Date	**2019-04-20 AM**	**2019-04-20 AM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**
Start Time (EDT)	2019-04-20 06:35	2019-04-20 07:30	2019-04-20 11:05	2019-04-20 17:00	2019-04-20 18:00
End Time (EDT)	2019-04-20 07:25	2019-04-20 11:00	2019-04-20 16:55	2019-04-20 17:55	2019-04-20 18:15
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23	MSTT		MSTT	MSTT	MSTT
Loc24	MSTT	MSTT	MSTT	OAD	
Loc25	MSTT	MSTT			
Loc26	MSTT	MSTT			MSTT
Loc27	MSTT		MSTT	MSTT	MSTT
Loc28	MSTT	MSTT			MSTT
Loc29	MSTT		MSTT	MSTT	MSTT
Loc30	MSTT	MSTT	MSTT	MSTT	MSTT
Loc31	MSTT	MSTT	MSTT		MSTT
Loc32	MSTT	MSTT			
Loc33	MSTT	MSTT	MSTT		
KAGC	MSTT	MSTT	MSTT		
KPIT	MSTT		MSTT	MSTT	MSTT
03049500	MSTT	MSTT			MSTT
03085734	MSTT	MSTT	MSTT	MSTT	MSTT

Event #	E6d	E6e	E6f	E6g	E7a
Event Date	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-20 18:20	2019-04-20 19:25	2019-04-20 20:15	2019-04-20 21:25	2019-04-25 14:05
End Time (EDT)	2019-04-20 19:20	2019-04-20 20:10	2019-04-20 21:20	2019-04-21 02:00	2019-04-25 20:45
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01			MSTT		MSTT
Loc02				MSTT	MSTT
Loc03					
Loc04				MSTT	MSTT
Loc05		MSTT	MSTT	MSTT	MSTT
Loc06				MSTT	MSTT
Loc07					MSTT
Loc08					
Loc09	MSTT				MSTT
Loc10					
Loc11					
Loc12	MSTT				MSTT
Loc13					MSTT
Loc14					
Loc15	OAD				
Loc16				MSTT	MSTT
Loc17		MSTT	MSTT	MSTT	MSTT
Loc18					
Loc19					
Loc20					
Loc21				MSTT	
Loc22		MSTT		MSTT	MSTT

Event #	E6d	E6e	E6f	E6g	E7a
Event Date	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-20 PM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-20 18:20	2019-04-20 19:25	2019-04-20 20:15	2019-04-20 21:25	2019-04-25 14:05
End Time (EDT)	2019-04-20 19:20	2019-04-20 20:10	2019-04-20 21:20	2019-04-21 02:00	2019-04-25 20:45
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23		MSTT		MSTT	
Loc24			MSTT	MSTT	MSTT
Loc25					
Loc26			MSTT	MSTT	MSTT
Loc27	MSTT	OMFB			
Loc28		MSTT			
Loc29				MSTT	
Loc30	MSTT				
Loc31					
Loc32		MSTT		MSTT	
Loc33		MSTT			
KAGC					MSTT
KPIT				MSTT	MSTT
03049500	MSTT	MSTT		MSTT	
03085734				MSTT	MSTT

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-25 20:50	2019-04-25 23:25	2019-04-26 00:50	2019-04-26 03:45	2019-04-26 04:45
End Time (EDT)	2019-04-25 23:20	2019-04-26 00:45	2019-04-26 03:40	2019-04-26 04:40	2019-04-26 06:15
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01	MSTT	MSTT		MSTT	
Loc02	MSTT	MSTT		MSTT	
Loc03	MSTT	MSTT			
Loc04	MSTT	MSTT			
Loc05	MSTT	MSTT	MSTT	MSTT	
Loc06	MSTT	MSTT	MSTT	MSTT	
Loc07	MSTT	MSTT		MSTT	
Loc08	MSTT	MSTT		MSTT	
Loc09	MSTT	MSTT	MSTT	MSTT	
Loc10	MSTT	MSTT		MSTT	
Loc11	MSTT	MSTT	MSTT	MSTT	
Loc12	MSTT	MSTT	MSTT	MSTT	
Loc13	MSTT	MSTT	MSTT	MSTT	
Loc14	MSTT	MSTT	MSTT		
Loc15	MSTT	MSTT	MSTT	MSTT	
Loc16	MSTT	MSTT	MSTT	MSTT	
Loc17	MSTT	MSTT	MSTT		
Loc18					
Loc19	MSTT	MSTT	MSTT	MSTT	
Loc20	MSTT	MSTT	MSTT	MSTT	
Loc21			MSTT	MSTT	
Loc22	MSTT	MSTT	MSTT	MSTT	

Event #	E7b	E7c	E7d	E7e	E7f
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-25 20:50	2019-04-25 23:25	2019-04-26 00:50	2019-04-26 03:45	2019-04-26 04:45
End Time (EDT)	2019-04-25 23:20	2019-04-26 00:45	2019-04-26 03:40	2019-04-26 04:40	2019-04-26 06:15
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23		MSTT		MSTT	
Loc24	MSTT	MSTT	MSTT	MSTT	
Loc25	MSTT	MSTT	MSTT		
Loc26	MSTT	MSTT	MSTT	MSTT	
Loc27				MSTT	
Loc28	MSTT	MSTT	MSTT	MSTT	
Loc29				MSTT	
Loc30			MSTT	MSTT	
Loc31	MSTT	MSTT			
Loc32	MSTT	MSTT	MSTT		
Loc33		MSTT			
KAGC	MSTT	MSTT	MSTT	MSTT	
KPIT	MSTT	MSTT	MSTT	MSTT	
03049500	MSTT	MSTT	MSTT		
03085734	MSTT	MSTT			

Event #	E7g	E7h	E7i	E7j	E7k
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-26 06:20	2019-04-26 10:05	2019-04-26 10:35	2019-04-26 11:00	2019-04-26 11:50
End Time (EDT)	2019-04-26 10:00	2019-04-26 10:30	2019-04-26 10:55	2019-04-26 11:45	2019-04-26 12:40
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01		MSTT			
Loc02		MSTT	MSTT		
Loc03		MSTT	MSTT		
Loc04		MSTT	MSTT		
Loc05					
Loc06		MSTT	MSTT		
Loc07			MSTT		
Loc08					
Loc09					
Loc10		MSTT			
Loc11					
Loc12					
Loc13		MSTT	MSTT	MSTT	
Loc14		MSTT	MSTT	MSTT	
Loc15		MSTT	MSTT	MSTT	
Loc16		MSTT			
Loc17		MSTT			
Loc18					
Loc19			MSTT	MSTT	
Loc20		MSTT	MSTT	MSTT	
Loc21		MSTT	MSTT		
Loc22		MSTT	MSTT		

Event #	E7g	E7h	E7i	E7j	E7k
Event Date	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**	**2019-04-26 AM**
Start Time (EDT)	2019-04-26 06:20	2019-04-26 10:05	2019-04-26 10:35	2019-04-26 11:00	2019-04-26 11:50
End Time (EDT)	2019-04-26 10:00	2019-04-26 10:30	2019-04-26 10:55	2019-04-26 11:45	2019-04-26 12:40
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23		MSTT	MSTT		
Loc24		MSTT	MSTT		
Loc25		MSTT	MSTT	MSTT	
Loc26		MSTT	MSTT	MSTT	
Loc27		MSTT	MSTT		
Loc28		MSTT	MSTT	MSTT	
Loc29		MSTT	MSTT		
Loc30		MSTT	MSTT		
Loc31		MSTT			
Loc32					
Loc33		MSTT	MSTT	OAD	
KAGC		MSTT	MSTT		
KPIT		MSTT	MSTT		
03049500		MSTT		MSTT	
03085734	MSTT	MSTT	MSTT		

Event #	E7l	E8	E9a	E9b	E10a
Event Date	**2019-04-26 AM**	**2019-04-26 PM**	**2019-04-28**	**2019-04-28**	**2019-04-30**
Start Time (EDT)	2019-04-26 12:45	2019-04-26 20:05	2019-04-27 18:05	2019-04-28 01:55	2019-04-30 13:05
End Time (EDT)	2019-04-26 20:00	2019-04-27 01:00	2019-04-28 01:50	2019-04-28 08:00	2019-04-30 15:40
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc01		MSTT	MSTT		
Loc02		MSTT	MSTT		
Loc03			MSTT		
Loc04					
Loc05			MSTT		
Loc06			MSTT	MSTT	
Loc07			MSTT		
Loc08	MSTT		MSTT	MSTT	
Loc09			MSTT		
Loc10			MSTT		
Loc11		MSTT	MSTT		
Loc12			MSTT	MSTT	
Loc13	MSTT	MSTT	MSTT		
Loc14	OAD		MSTT		
Loc15					
Loc16					
Loc17			MSTT		
Loc18					
Loc19			MSTT		
Loc20			MSTT		
Loc21			MSTT		
Loc22	OMFB		MSTT		

Event #	E7l	E8	E9a	E9b	E10a
Event Date	**2019-04-26 AM**	**2019-04-26 PM**	**2019-04-28**	**2019-04-28**	**2019-04-30**
Start Time (EDT)	2019-04-26 12:45	2019-04-26 20:05	2019-04-27 18:05	2019-04-28 01:55	2019-04-30 13:05
End Time (EDT)	2019-04-26 20:00	2019-04-27 01:00	2019-04-28 01:50	2019-04-28 08:00	2019-04-30 15:40
Source	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII	KPBZ LII
Loc23					
Loc24	MSTT		MSTT		
Loc25			MSTT		
Loc26	MSTT		MSTT		
Loc27					
Loc28			MSTT		
Loc29		MSTT	MSTT		
Loc30			MSTT		
Loc31			MSTT		
Loc32		MSTT	MSTT		MSTT
Loc33		MSTT	MSTT		
KAGC			MSTT		
KPIT					
03049500		MSTT	MSTT		MSTT
03085734		MSTT	MSTT		

Event #	E10b
Event Date	**2019-04-30**
Start Time (EDT)	2019-04-30 15:45
End Time (EDT)	2019-04-30 19:00
Source	KPBZ LII
Loc01	
Loc02	
Loc03	
Loc04	
Loc05	
Loc06	
Loc07	
Loc08	
Loc09	
Loc10	
Loc11	
Loc12	
Loc13	
Loc14	
Loc15	
Loc16	
Loc17	
Loc18	
Loc19	
Loc20	
Loc21	MSTT
Loc22	MSTT
Loc23	MSTT
Loc24	

Event #	E10b
Event Date	**2019-04-30**
Start Time (EDT)	2019-04-30 15:45
End Time (EDT)	2019-04-30 19:00
Source	KPBZ LII
Loc25	
Loc26	
Loc27	
Loc28	
Loc29	
Loc30	
Loc31	
Loc32	
Loc33	
KAGC	
KPIT	
03049500	
03085734	

Appendix C - Event 1 (2019-04-12) CDPs

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

Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)

Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)

Cumulative Distribution Plot - Kennedy Twp PS (Loc04)

Cumulative Distribution Plot - Upper St. Clair (Loc05)

Cumulative Distribution Plot - Carnegie Transit Time (Loc06)

Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)

Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)

Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)

Cumulative Distribution Plot - PWSA-Highland Park (Loc10)

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

Cumulative Distribution Plot - Baldwin (Loc12)

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

Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)

Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)

Cumulative Distribution Plot - Castle Shannon (Loc16)

Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)

Cumulative Distribution Plot - Gascola Eq Facility (Loc20)

Cumulative Distribution Plot - Moon TWP (Loc21)

Cumulative Distribution Plot - North Fayette TWP (Loc22)

Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)

Cumulative Distribution Plot - Jefferson Hills (Loc24)

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

Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)

Cumulative Distribution Plot - Marshall TWP (Loc27)

Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)

Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)

Cumulative Distribution Plot - McCandless Twn Hall (Loc30)

Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)

Cumulative Distribution Plot - Arnold (Loc32)

Cumulative Distribution Plot - Richland TWP (Loc33)

Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)

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

Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

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

Appendix D - Event 2 (2019-04-14 AM) 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 (2019-04-14 PM) 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 (2019-04-19) 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 (2019-04-20 AM) 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 (2019-04-20 PM) 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 (2019-04-26 AM) CDPs

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

Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)

Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)

Cumulative Distribution Plot - Kennedy Twp PS (Loc04)

Cumulative Distribution Plot - Upper St. Clair (Loc05)

Cumulative Distribution Plot - Carnegie Transit Time (Loc06)

Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)

Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)

Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)

Cumulative Distribution Plot - PWSA-Highland Park (Loc10)

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

Cumulative Distribution Plot - Baldwin (Loc12)

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

Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)

Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)

Cumulative Distribution Plot - Castle Shannon (Loc16)

Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)

Cumulative Distribution Plot - Gascola Eq Facility (Loc20)

Cumulative Distribution Plot - Moon TWP (Loc21)

Cumulative Distribution Plot - North Fayette TWP (Loc22)

Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)

Cumulative Distribution Plot - Jefferson Hills (Loc24)

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

Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)

Cumulative Distribution Plot - Marshall TWP (Loc27)

Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)

Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)

Cumulative Distribution Plot - McCandless Twn Hall (Loc30)

Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)

Cumulative Distribution Plot - Arnold (Loc32)

Cumulative Distribution Plot - Richland TWP (Loc33)

Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)

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

Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

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

Appendix J - Event 8 (2019-04-26 PM) 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 K - Event 9 (2019-04-28) CDPs

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

Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)

Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)

Cumulative Distribution Plot - Kennedy Twp PS (Loc04)

Cumulative Distribution Plot - Upper St. Clair (Loc05)

Cumulative Distribution Plot - Carnegie Transit Time (Loc06)

Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)

Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)

Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)

Cumulative Distribution Plot - PWSA-Highland Park (Loc10)

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

Cumulative Distribution Plot - Baldwin (Loc12)

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

Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)

Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)

Cumulative Distribution Plot - Castle Shannon (Loc16)

Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)

Cumulative Distribution Plot - Gascola Eq Facility (Loc20)

Cumulative Distribution Plot - Moon TWP (Loc21)

Cumulative Distribution Plot - North Fayette TWP (Loc22)

Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)

Cumulative Distribution Plot - Jefferson Hills (Loc24)

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

Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)

Cumulative Distribution Plot - Marshall TWP (Loc27)

Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)

Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)

Cumulative Distribution Plot - McCandless Twn Hall (Loc30)

Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)

Cumulative Distribution Plot - Arnold (Loc32)

Cumulative Distribution Plot - Richland TWP (Loc33)

Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)

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

Cumulative Distribution Plot - Allegheny River at Natrona (03049500)

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

Appendix L - Event 10 (2019-04-30) CDPs

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

Cumulative Distribution Plot - ALCOSAN WWTP Lab (Loc02)

Cumulative Distribution Plot - Shaler Munic Bldg (Loc03)

Cumulative Distribution Plot - Kennedy Twp PS (Loc04)

Cumulative Distribution Plot - Upper St. Clair (Loc05)

Cumulative Distribution Plot - Carnegie Transit Time (Loc06)

Cumulative Distribution Plot - Greentree Munic Bldg (Loc07)

Cumulative Distribution Plot - AC Health Dept Bldg (Loc08)

Cumulative Distribution Plot - Univ of Pittsburgh (Loc09)

Cumulative Distribution Plot - PWSA-Highland Park (Loc10)

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

Cumulative Distribution Plot - Baldwin (Loc12)

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

Cumulative Distribution Plot - Churchill Munic Bldg (Loc14)

Cumulative Distribution Plot - Trafford Maint Bldg (Loc15)

Cumulative Distribution Plot - Castle Shannon (Loc16)

Cumulative Distribution Plot - Chartiers Pump Station (Loc17)

Cumulative Distribution Plot - Oakdale Pump Station (Loc18)

Cumulative Distribution Plot - Sandy Creek Eq Facility (Loc19)

Cumulative Distribution Plot - Gascola Eq Facility (Loc20)

Cumulative Distribution Plot - Moon TWP (Loc21)

Cumulative Distribution Plot - North Fayette TWP (Loc22)

Cumulative Distribution Plot - Clinton Munic Bldg (Loc23)

Cumulative Distribution Plot - Jefferson Hills (Loc24)

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

Cumulative Distribution Plot - Elizabeth TWP Municipal Bldg (Loc26)

Cumulative Distribution Plot - Marshall TWP (Loc27)

Cumulative Distribution Plot - Plum Municipal Bldg (Loc28)

Cumulative Distribution Plot - Bell Acres Munic Bldg (Loc29)

Cumulative Distribution Plot - McCandless Twn Hall (Loc30)

Cumulative Distribution Plot - Hampton Municipal Bldg (Loc31)

Cumulative Distribution Plot - Arnold (Loc32)

Cumulative Distribution Plot - Richland TWP (Loc33)

Cumulative Distribution Plot - Pittsburgh Allegheny Cty (KAGC)

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)