Analysis of the August 12, 2021, Flash Flood in and near Gibson City, IL

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Summary

Very heavy rainfall from slow-moving, training thunderstorms occurred in the vicinity of Gibson City, Illinois, the morning of August 12, 2021, causing flash flooding in portions of Ford, McLean, and Champaign counties. The thunderstorms with heaviest rainfall rates impacted the area from about 8:00 AM (1300 UTC) through about 2:00 PM (1900 UTC), with few breaks in intensity during that time (Figure 1).

Gridded rainfall estimates indicated that portions of Ford, McLean, and Champaign counties received heavy rainfall, with the heaviest rainfall occurring near and just south of the Gibson City and Elliott areas. Data from 56 rain gauges was collected and analyzed along with the gridded radar-based rainfall estimates. Additional rainfall reports were collected from private citizens during a subsequent flash flood survey and via requests made through social media. Rainfall was then compared to the NOAA Atlas 14 to provide climatological context. The highest analyzed storm total rainfall was approximately 11.5 inches which occurred over a 6-hr period ending at 2:00 PM July 12 (1900 UTC). Observed rainfall was extreme near Gibson City and Elliott with a very sharp gradient toward values that were common over a distance of just 10 miles from the maximum. Based upon a combination of all available data, it was estimated that maximum rainfall amounts had less than a 0.1% chance of occurring in a given year.

Based upon the extreme nature of rainfall in the Gibson City and Elliott areas, flood impacts were particularly severe. A post-event survey was conducted by National Weather Service personnel on August 13. Information about flooded areas was collected including what was damaged, approximate elevations of water evidenced by high water marks, and the estimated direction of flow. Residents in the impacted area were also asked about how the water behaved and if any rainfall was collected in private rain gauges. Additional information was collected using social media over a several day period following the event. In total, over 200 reports of flooding were collected across southwest Ford County, far eastern McLean County, and far northern Champaign County.

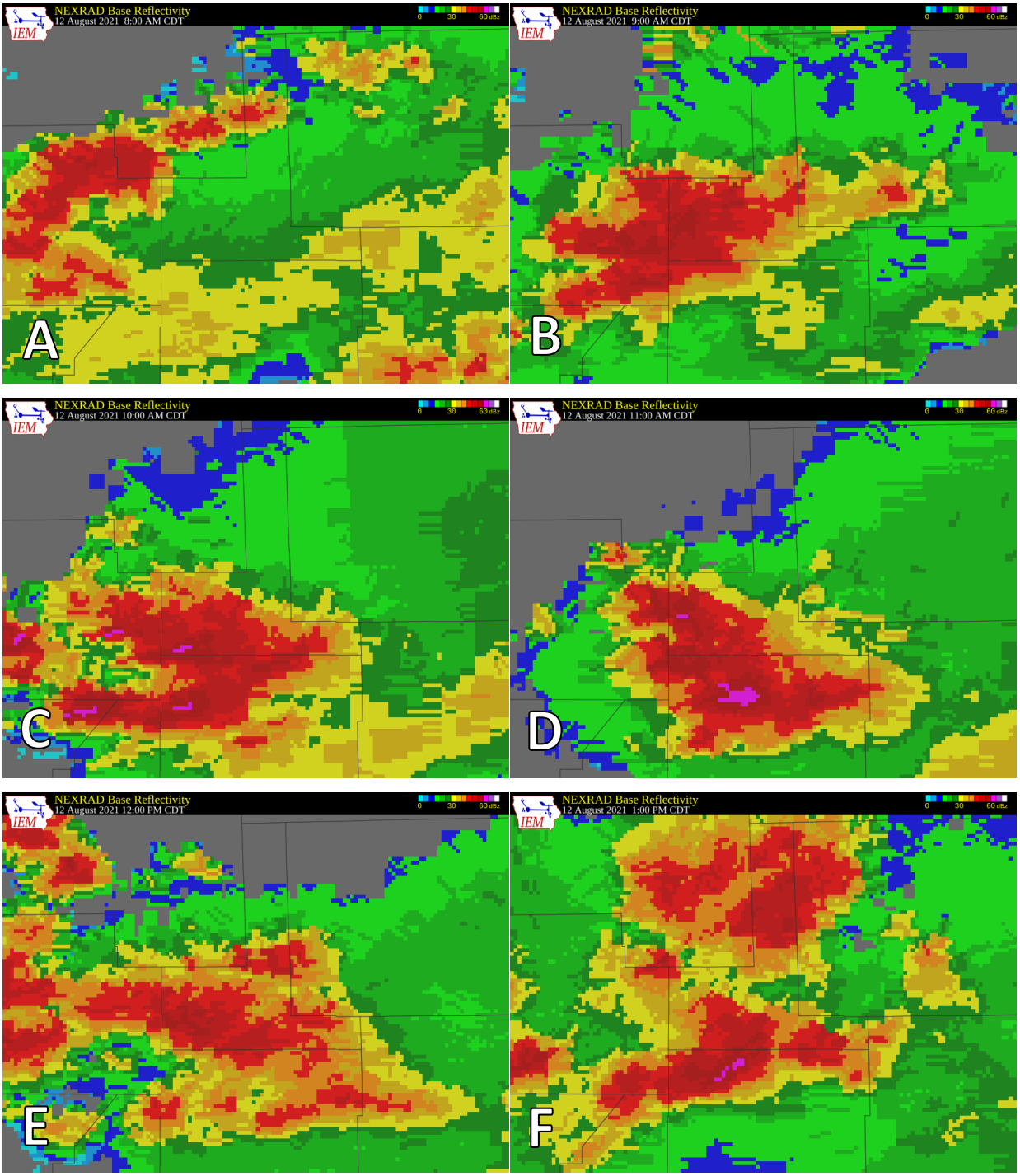


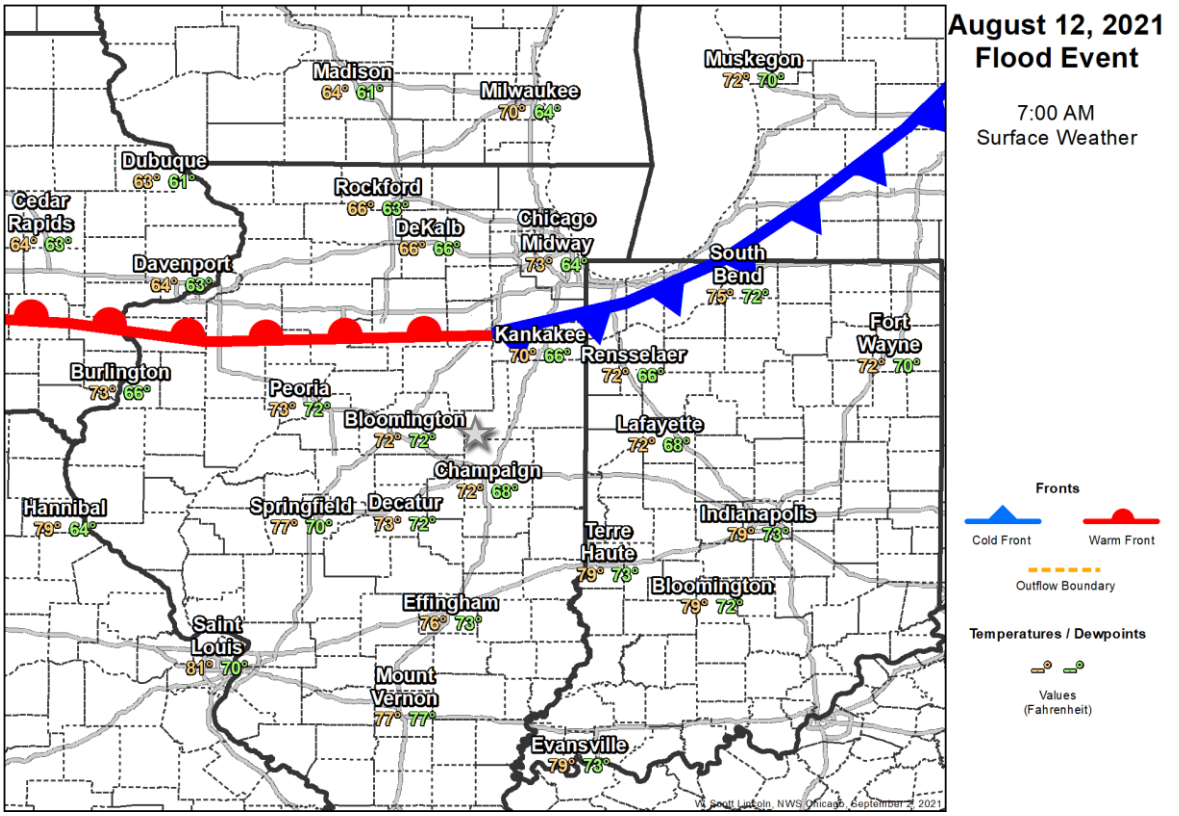
Figure 1. Radar imagery of the thunderstorms which caused flash flooding on August 12, 2021, near Gibson City, Illinois. Images are one hour apart, showing 8:00 AM (1300 UTC; A), 9:00 AM (1400 UTC; B), 10:00 AM (1500 UTC; C), 11:00 AM (1600 UTC; D), 12:00 PM (1700 UTC; E), and 1:00 PM (1800 UTC; F). The areas with heaviest rainfall in southwest Ford County were in near continuous thunderstorm activity over this period. Radar imagery from Iowa State University's Iowa Environmental Mesonet.

Meteorology and Forecastability

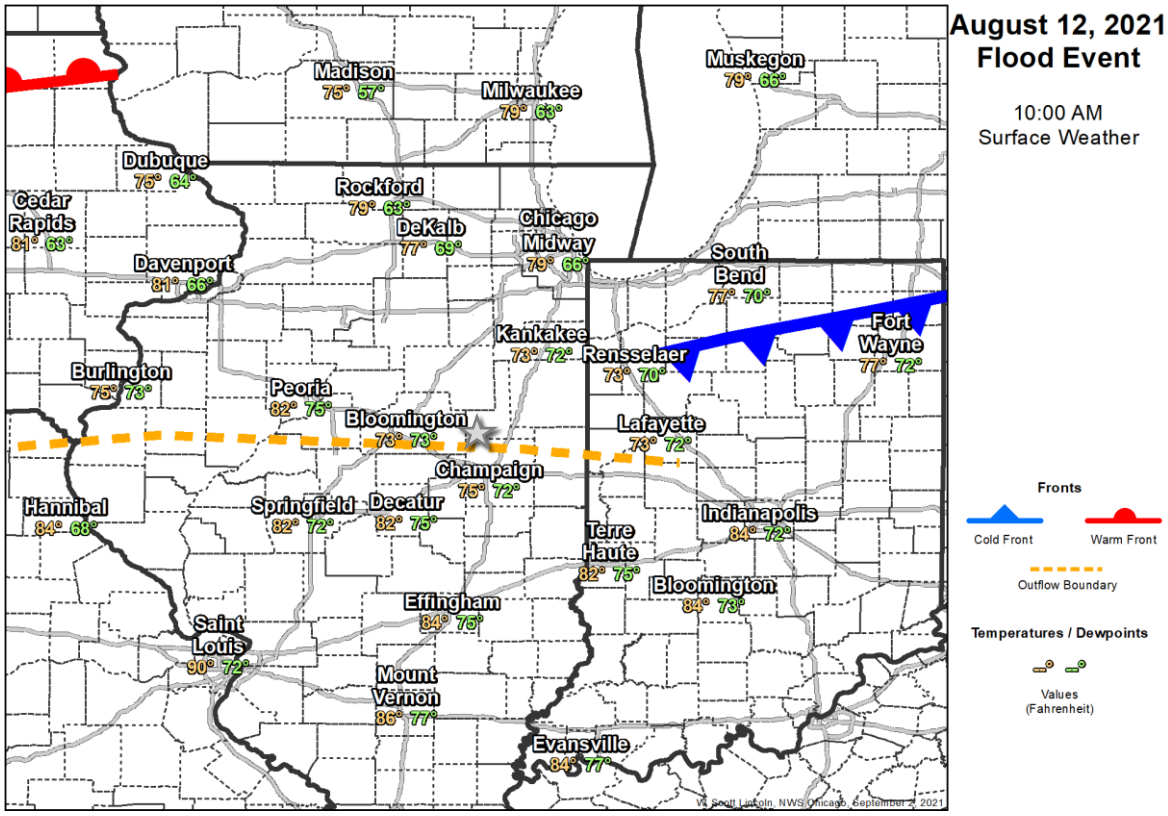
A weak stationary frontal boundary crossed central Illinois at 7:00 AM (1200 UTC) August 12 (Figure 2 a). Temperatures north of the front were generally in the mid-to-upper 60s while temperatures south of the front were generally in the low 70s. Dewpoints north of the front were generally in the low-to-mid 60s while dewpoints were generally near 70 F. This front was more evident above the surface at the 850 mb level where dewpoints were analyzed at 16-17 C; these values are in the top 5th percentile based upon climatology for sounding location KILX. Precipitable water values along and south of the front ranged from 1.5-1.7 inches. A low-level jet was present in the region, with the nose of the jet oriented along the front where there was deep, moist confluent flow all the way up to at least the 700 mb level. The general weather pattern was consistent with the conceptual model for a Maddox frontal flash flood event (Maddox, Chappell, & Hoxit, 1979). These factors helped support training and even back-building storms.

By 10:00 AM (1500 UTC), the weak front had drifted southward and diminished enough that it was analyzed as an outflow boundary (Figure 2 b). Small differences between temperatures and dewpoints remained evident between the north and south sides of the boundary. By this time, thunderstorms had already begun and were continuing to develop over the same areas. Deep moist convection for the heaviest rates also fed on modest instability along the length of the boundary. Outflow from the ongoing thunderstorms likely contributed to the slight southward movement of the front between 7:00 AM (1200 UTC) and 10:00 AM (1500 UTC), and the eventual transition into an outflow boundary.

Although many factors were supportive of heavy rainfall if storms were to occur, there was not a clear forecast signal that heavy rainfall would persist long enough to produce flooding. For example, the HREF output, an ensemble of numerous high-resolution forecast models, showed very little in the way of thunderstorm coverage, and thus almost no threat for flooding in central Illinois at the time of the flood event.



A)



B)

Figure 2. Surface weather map showing temperatures, dewpoints, and frontal positions at 7:00 AM (1200 UTC; A) and 10:00 AM (1500 UTC; B) on August 12, 2021, as analyzed by the Weather Prediction Center. The Gibson City area is indicated with a gray star.

Data Sources and Data Collection

The official rainfall estimates created by the National Weather Service (NWS) come from the River Forecast Centers (RFCs). Gridded rainfall estimates come from radar estimates adjusted (bias-corrected) to better match observed rainfall at rain gauge locations. Gridded rainfall data is then manually quality controlled each hour. Data becomes available 30-60 minutes after the top of the hour, but may still be reviewed and adjusted by NWS forecasters for a few days after the rainfall occurred due to the availability of additional data. It should be noted that during real-time operations, local NWS Weather Forecast Offices (WFOs) have access to the unadjusted rainfall estimates from radar which are available every few minutes. In some instances, NWS WFOs will have access to near-realtime rainfall observations from automated rain gauges. Only two (2) automated rain gauges in the Gibson City area were available to warning forecasters during the event, and both were from unofficial sources.

A substantial amount of additional rainfall information was collected to perform analysis on the rainfall that occurred on August 12. For the areas hardest hit by rainfall, only two (2) rain gauges would be available to NWS forecasters in real-time operations, and those gauges were operated by private networks with limited information about observation quality. Real-time gauges typically monitored by the NWS include those operated by the FAA (ASOS and AWOS) and the US Geological Survey (USGS). No (0) USGS stations were available in the area and one (1) FAA station was available. Once per day, additional rainfall information is available from manual observations including the NWS Cooperative Observer Program (COOP) and the Community Collaborative Rain Hail and Snow (CoCoRaHS) network. These observations cover a meteorological observation day (24-hour period ending at 7:00 AM CDT or 6:00 AM CST). Data was retrieved for 21 CoCoRaHS stations across the area and two (2) COOP stations. Data was also collected from private weather stations across the area, although these stations often have varying quality and usefulness. Private weather station data was available from six (6) Weather Underground Private Weather Station (WUPWS) sites, of which two (2) were near Gibson City. An additional five (5) rainfall reports were collected from Gibson City residents during a post-event survey by NWS personnel. Jacob Dickey, meteorologist at WCIA-TV, also requested rainfall information from persons in the vicinity of Gibson City and Elliott via social media, which led to an additional 21 rainfall reports. In total, hourly and daily rainfall data was collected for 56 locations (Figure 3). Follow-up with private rainfall observers and review of gauge siting removed some reports from further consideration. The manual rainfall observations from the public were often not tied to a particular calendar day or meteorological observation day, but often began between midnight and 4:00 AM (0500 UTC to 0900 UTC) and ended between 3:00 PM and 5:00 PM (2000 UTC to 2200 UTC), or had an unknown duration.

The different durations covered by the various rain gauges (Figure 4) made direct comparison of rainfall measurements difficult without additional review and analysis. More on the QC review of rainfall reports is discussed in the following section.

Generally, reports of flash flood impacts come from many sources, including law enforcement, local emergency management officials, trained weather spotters, media sources, and sometimes the public. As the flash flood event was developing on August 12, local broadcast media and emergency management reported roadway flooding and structure flooding to the NWS. Due to reports of significant flood impacts and reports of potentially extreme rainfall amounts, NWS personnel conducted a survey of Gibson City and vicinity on August 13. Evidence of recent flooding was collected, including high water marks (debris and mud marks left behind by recent flooding) and accounts from residents (Figure 5). Residents were asked about how floodwaters behaved, including whether water was moving or stagnant. Residents were also asked if any manual rain gauge observations were collected. After the flash flood survey, additional reports of flash flooding were collected from news reports and social media. In total, about 200 reports of flooding were collected across southwest Ford County, far eastern McLean County, and far northern Champaign County.

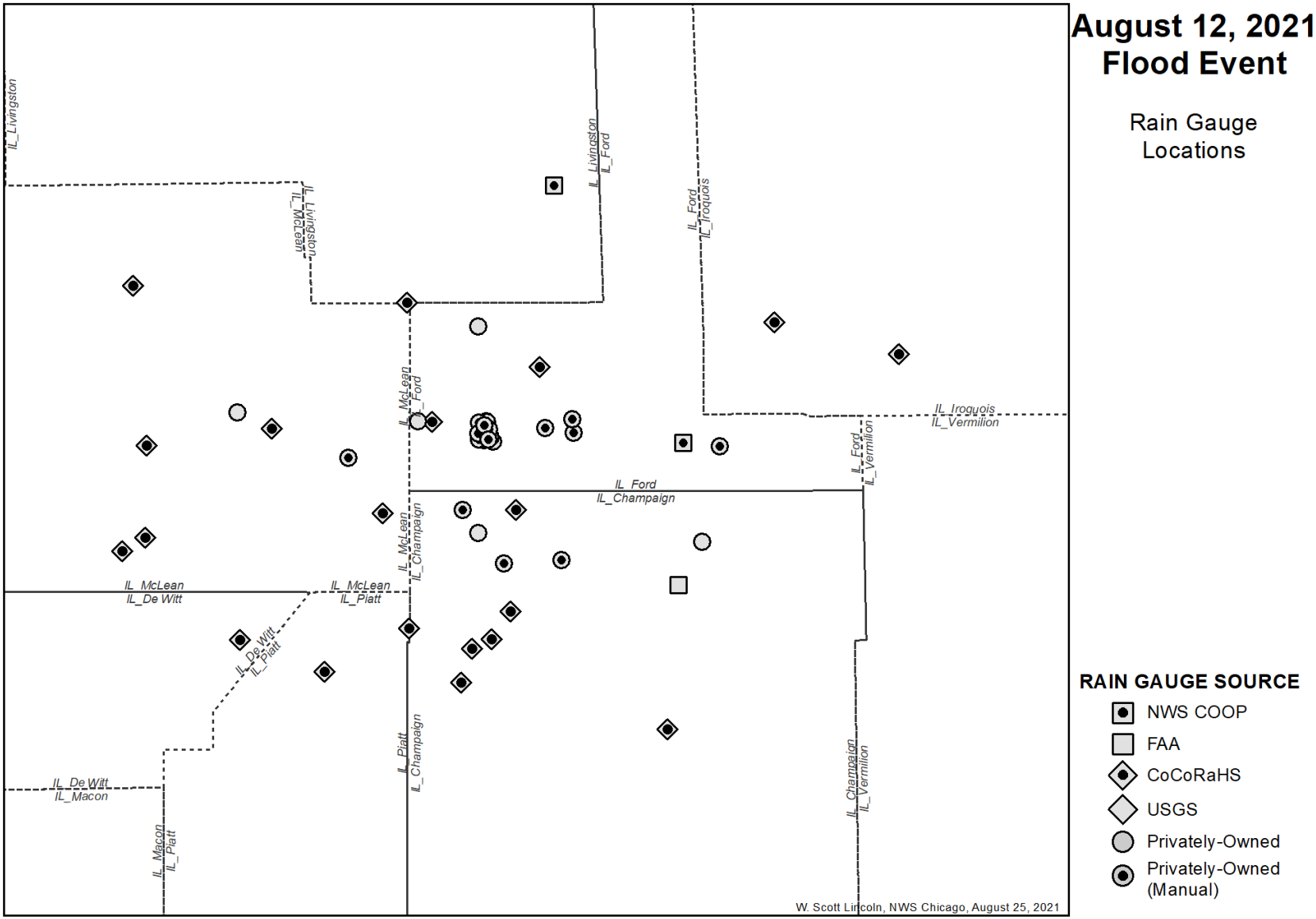


Figure 3. Locations of rain gauge data collected for this analysis. Rain gauges are labeled by the source network (COOP, FAA, CoCoRaHS, USGS, or private) and also whether they are daily, manual observations only (black dot). Not all rain gauges shown above were used in subsequent analyses based upon quality control review.

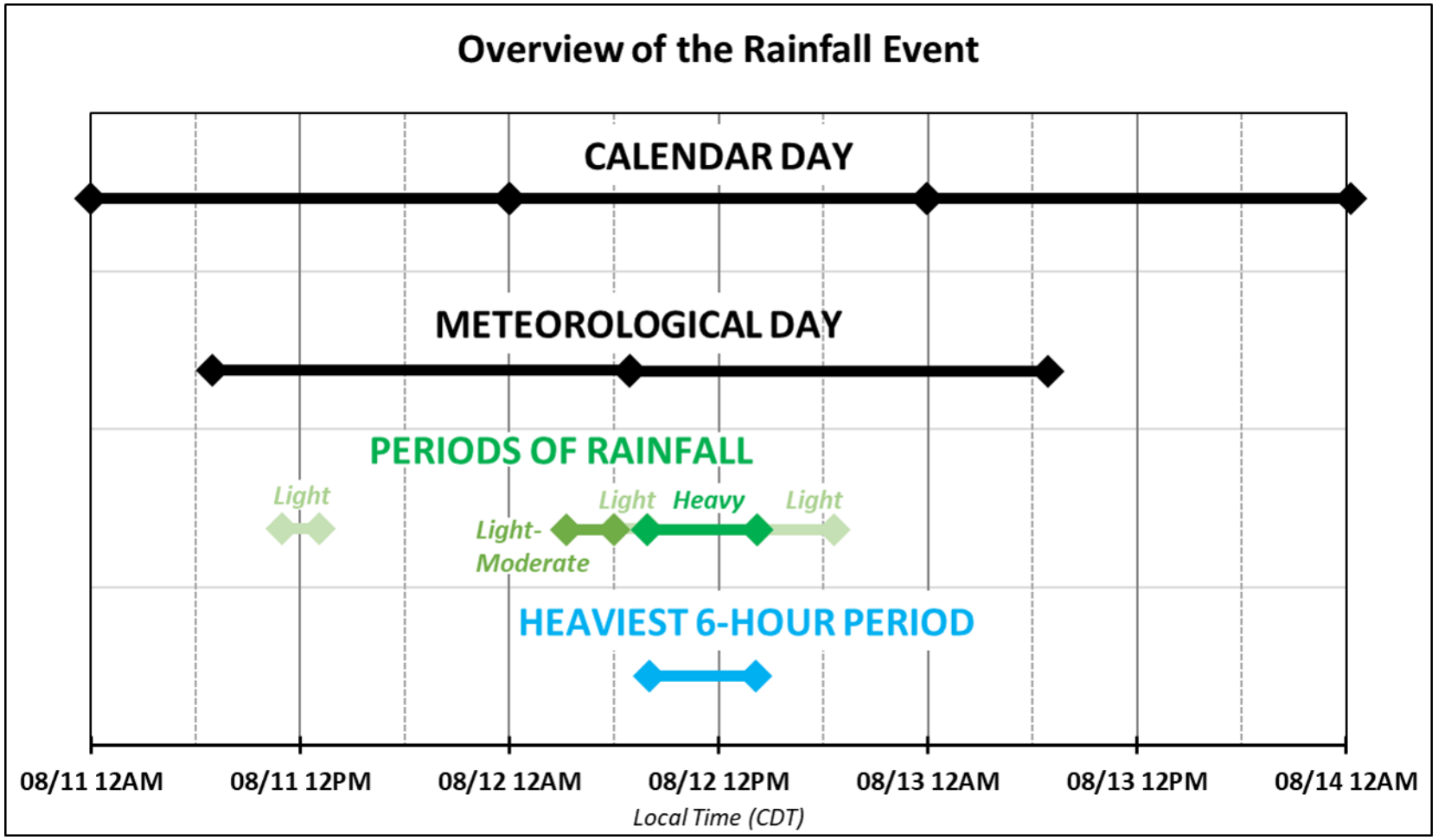


Figure 4. The rainfall making up this event spanned two calendar days and two meteorological observation days. The vast majority of the rainfall, however, occurred within a single calendar day and two meteorological observation days, with the heaviest 6-hour period occurring within the meteorological observation day ending at 1200 UTC August 13, 2021.

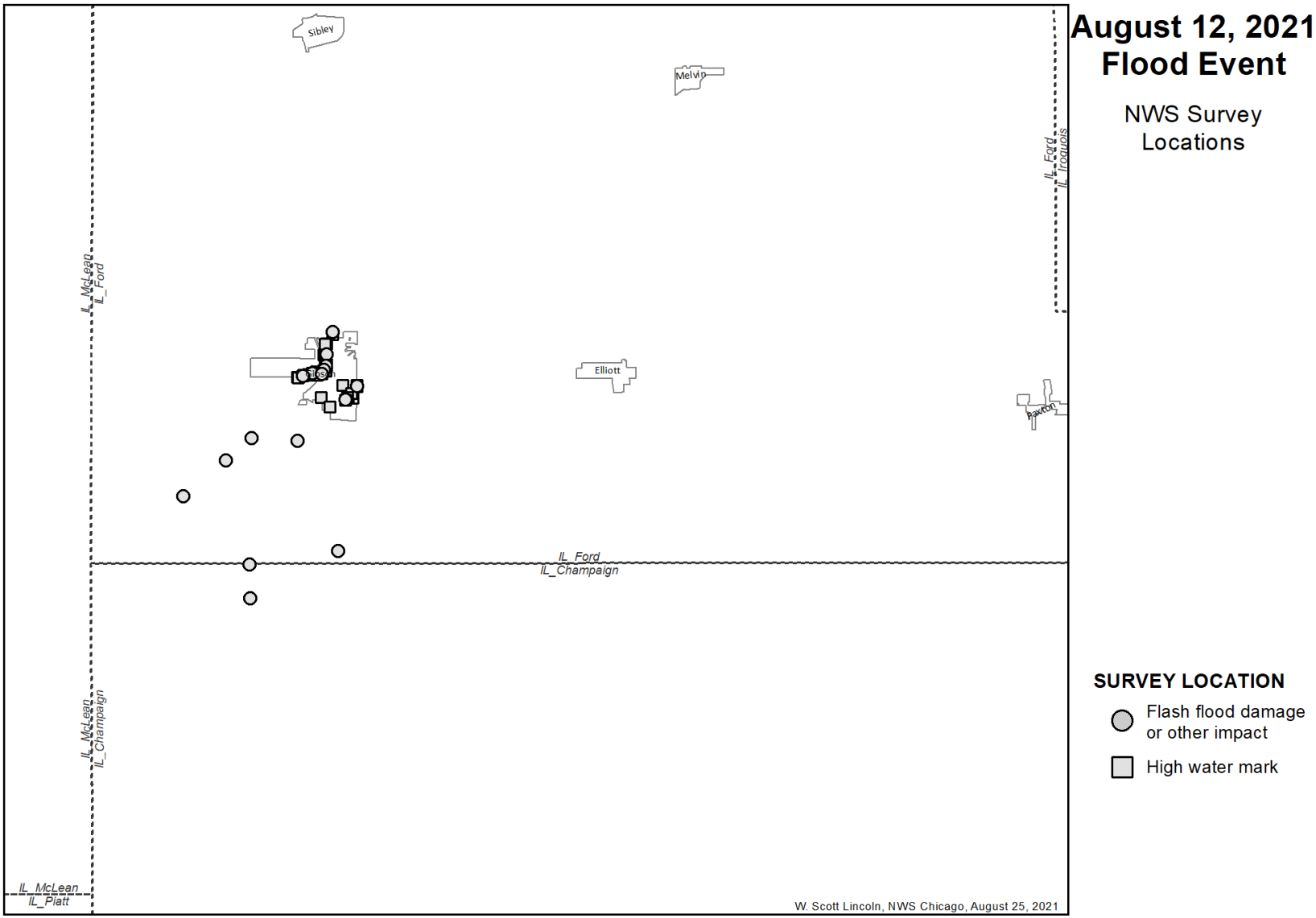


Figure 5. Location of flash flood damage or other flood impacts surveyed during the post-event NWS survey. Some locations had high water marks evidenced by debris or mud which could yield an estimate of peak water level.

Rainfall Amounts

A review of all available rainfall data showed that a swath of Ford, McLean, and Champaign counties in Illinois received several inches of rainfall between 4:00 AM and 5:00 PM August 12 (0900 UTC to 2200 UTC). The heaviest period of rainfall generally occurred within a 6 hour period from 8:00 AM to 2:00 PM (1300 UTC to 1900 UTC). As seen in Figure 6, gridded radar rainfall estimates from MRMS showed significant portions of eastern McLean County, northern Champaign County, and southern Ford County received greater than 1.0 inch of rainfall. Closer to the McLean-Ford County border and the Champaign-Ford County border, rainfall amounts rapidly increased to nearly 6.0 inches. The heaviest rainfall amounts were estimated to have occurred to the northeast of the McLean-Ford-Champaign County intersection, near the communities of Gibson City and Elliott. In this area, 7.0-8.0 inches of rainfall was estimated by the bias-corrected product from the NWS RFCs, 8.0-9.0 inches of rainfall was estimated by the radar-only product from MRMS, and 7.5-13.5 inches was reported by numerous rain gauges. A steep gradient from lighter rainfall amounts to higher rainfall amounts was evident.

The thunderstorms which produced the flash flooding occurred from about 8:00 AM (1300 UTC) through about 3:00 PM (2000 UTC). Although individual storms were generally moving eastward, continual redevelopment of thunderstorms west of previous thunderstorms caused several hours of heavy rainfall. Prior to the flash flood producing rains, thunderstorms moved through the area between 4:00 AM (0900 UTC) and 6:00 AM (1100 UTC), followed by a period of light rain, which may have contributed to the severity of later flash flooding by increasing soil moisture. Then, around 8:00 AM (1300 UTC), rainfall intensity increased significantly and remained generally heavy until about 2:00 PM (1900 UTC). Some light rainfall also occurred for several hours after 2:00 PM, but generally was not heavy enough to worsen the already significant flooding.

Because of the earlier mentioned differences in rainfall durations between various types of gauges, the relative contribution of rainfall from each of the meteorological observation days was analyzed. For the purposes of this analysis, the 2-day rainfall accumulation ending at 7:00 AM (1200 UTC) on August 13 was used as a reference because it included all the various rainfall measurement durations of the various observations (Figure 4). In Gibson City, rainfall accumulation over the 1-day period ending at 7:00 AM (1200 UTC) August 13 was about 90-95% of the total accumulation, and the heaviest 6-hour period ending at 2:00 PM (1900 UTC) August 12 was about 85-90% of the total accumulation. Several rainfall observations from manually-read rain gauges spanned multiple meteorological observation days and also included no information about the heaviest 6-hour period. The 1-day to 2-day ratio and the

heaviest 6-hour to 2-day ratio were thus used estimate the shorter-duration rainfall amounts for gauges that reported a storm total value only.

Rainfall observations collected from the various rain gauge networks were in general agreement with gridded radar-rainfall estimates (Figure 6). A few gauge observations were slightly lower than gridded radar estimates while a few gauges close to the rainfall maximum were higher than the gridded radar estimates. The manual rainfall observations received via social media or the NWS post-event survey were further evaluated, especially reports of rainfall that far exceeded the radar estimates. Multiple rainfall reports in the Gibson City area ranged from 7.5-13.5 inches (Figure 7). Manual observations were given a unique identifier based upon a nearby intersection with exact locations omitted for privacy. For each of these additional reports that was near or exceeded the radar estimate, NWS personnel tried to collect information about the type of rain gauge, when the rainfall amount was observed and when the gauge was last emptied, where and how the gauge was sited on a property, and reviewed pictures of the gauge location. Many individuals did not reply to requests for additional information. Some individuals also provided information that indicated their gauge overflowed at values far below the likely storm total (such as a 6-inch capacity rain gauge in an area with 9-inches of estimated rainfall). A few other gauges also appeared to be sited poorly, or no information on gauge siting was available, yielding low confidence in the observed value. After filtering out some observations, the 26 rainfall reports from private manual observations were reduced to 13 rainfall reports, reducing the total number of gauges from 56 to 43. Table 1 lists the collected rain gauge observations and also indicates if the gauge was filtered based upon the QC review.

Using the available gauge observations, included the filtered manual reports, gridded rainfall estimates were bias corrected to further improve the gridded estimates. After bias correction, accumulations increased in the area of heaviest rainfall, while accumulations were generally unchanged or decreased slightly elsewhere. In the vicinity of Gibson City, gridded rainfall estimates peaked at near 11.5 inches for the 2-day period ending at 7:00 AM (1200 UTC) August 13, 2021 (Figure 8). For comparison, the highest observed point rainfall amount was about 13.5 inches, possibly higher due to a gauge overflow, at site Gibson_PrairieSmoke_MeadowRue. Multiple other manual observations were available within two (2) miles of this location with values ranging from 7.5 to 12.0 inches and averaging 10.6 inches, although several of these gauges also may have experienced overflows, suggesting that actual amounts may have been higher.

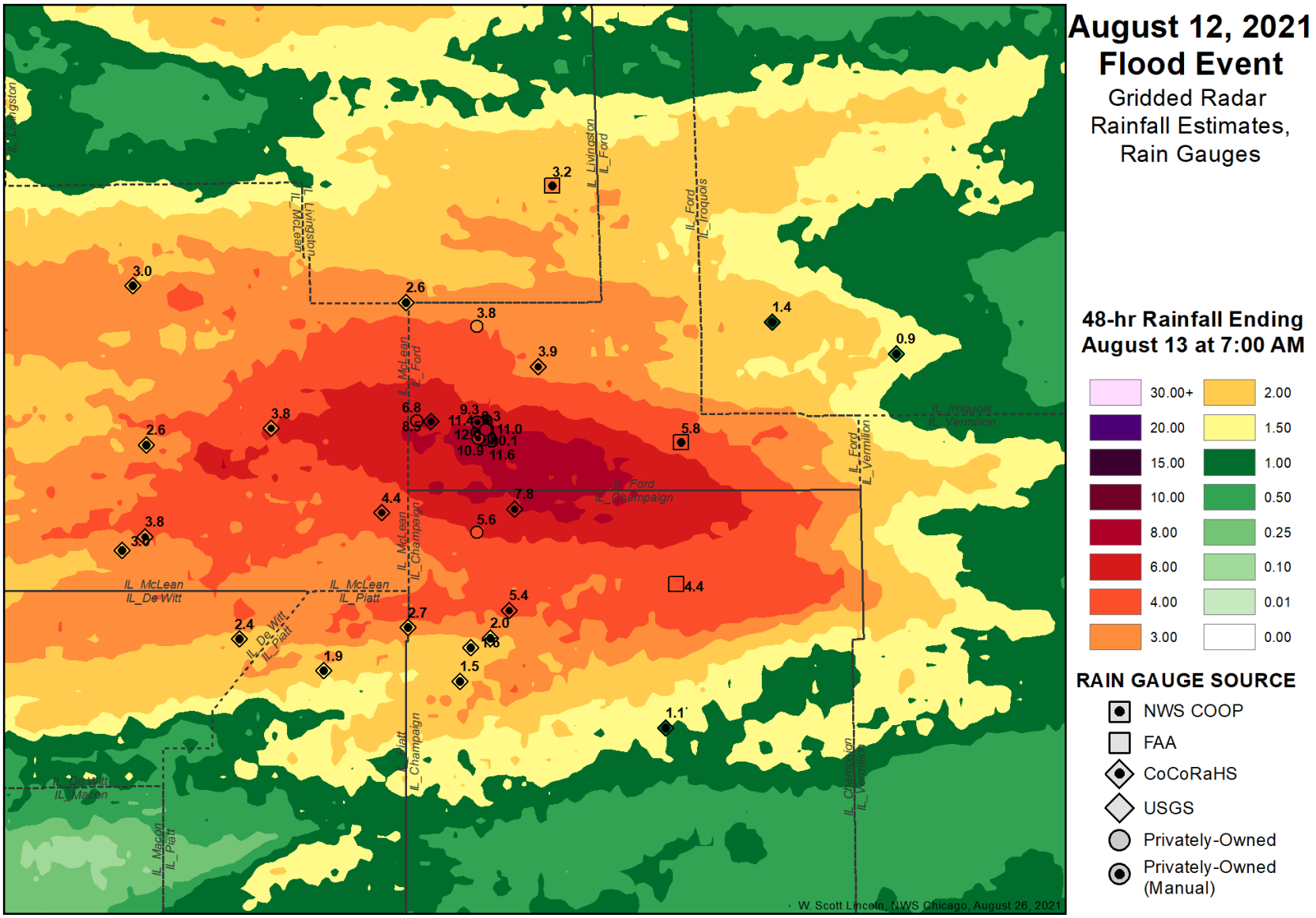


Figure 6. Gridded rainfall estimate from radar covering the 2-day period ending July 13, 2021, at 1200UTC with gauge observations as an overlay. Rain gauges symbolized by source network.

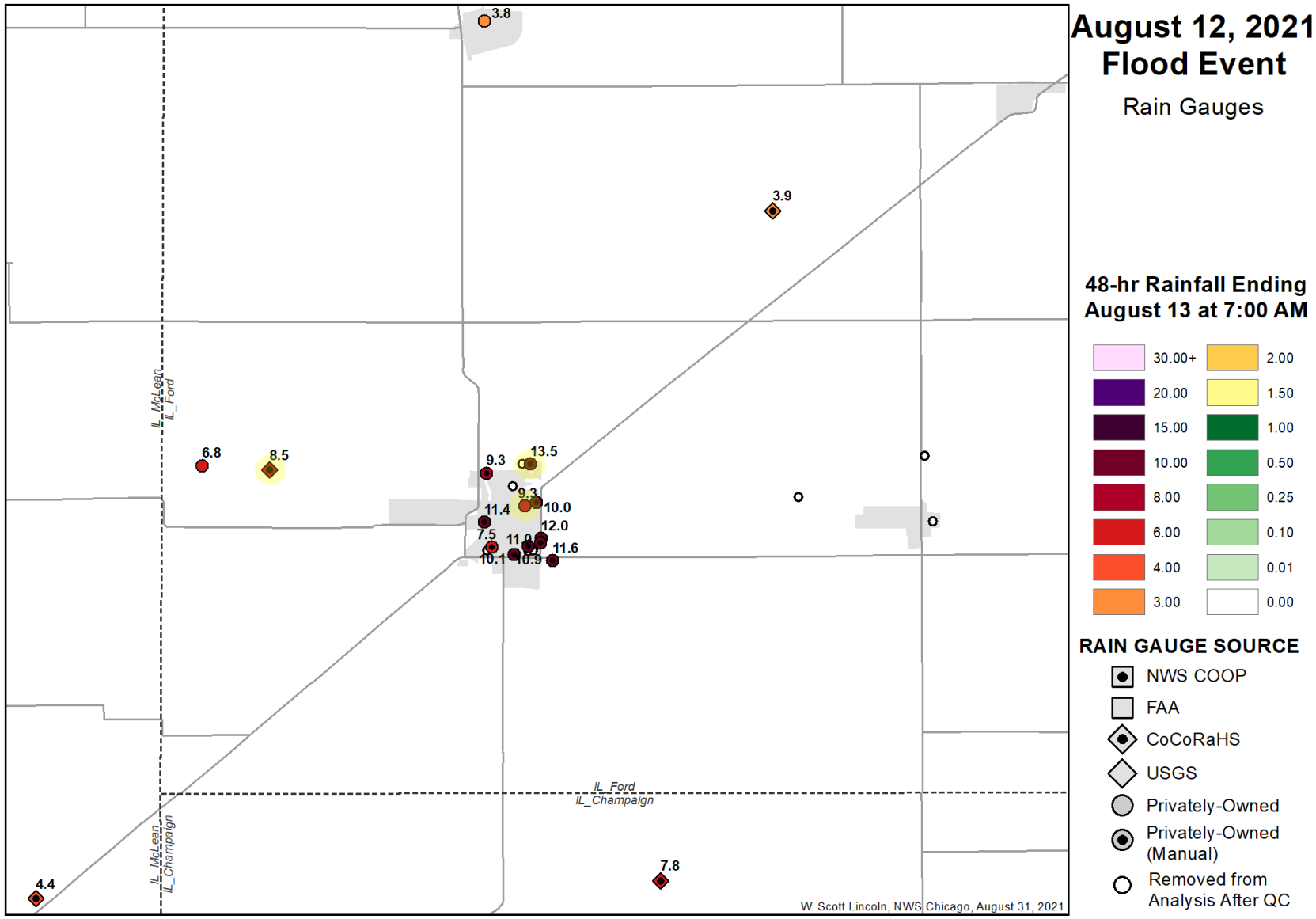


Figure 7. Rain gauges observations covering the 2-day period ending August 13, 2021, at 1200UTC, for the Gibson City and Elliott areas. Rain gauges symbolized by source network. Rain gauges that were removed from further analysis due to concerns found during QC review indicated with smaller symbols but no labels. Sites KILGIBSO9, KILGIBSO6, and Gibson_PrairireSmoke_MeadowRue, which are discussed further in a later section, are highlighted.

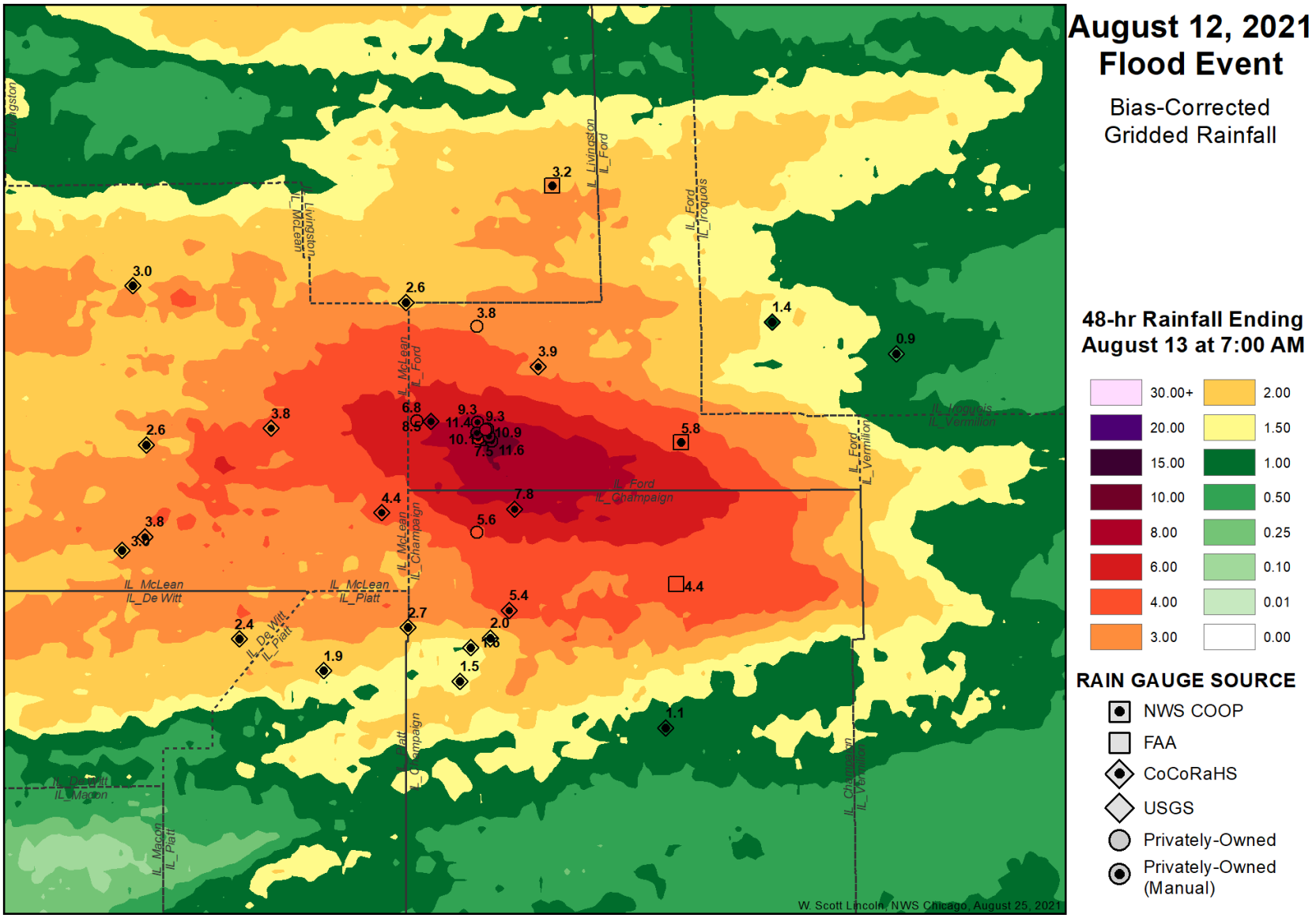


Figure 8. Updated rainfall estimate covering the 2-day period ending August 13, 2021, at 1200UTC with gauge observations as an overlay. Gridded rainfall was bias corrected to better match gauge observations. Rain gauges symbolized by source network.

Table 1. List of collected rainfall reports. Rainfall reports from private observers marked as "other" network had a unique ID assigned to them based upon a nearby intersection, with exact location omitted for privacy. Whether or not a report was considered reasonable indicated by "used in analysis?" column. Rainfall observations not deemed reasonable are display here for general information, but likely do not represent true rainfall at that location. Rainfall observations were reviewed based upon the type of rain gauge, siting of the rain gauge, the times the gauge was emptied, and whether or not the gauge overflowed significantly. Rainfall amounts less than 3.0 inches over the 2-day period ending August 13 at 7:00 AM (1200 UTC) were omitted. Table may contain some estimated values.

ID	Network	Max 1-hr Rain	Max 3-hr Rain	Max 6-hr Rain	Aug 12 7:00 AM 1-day Rain	Aug 13 7:00 AM 1-day rain	Aug 13 7:00 AM 2-day rain	Used in Analysis?
Gibson_PrairieSmoke_MeadowRue	Other		5.5	11.5	1.5	12.0	13.5	Y
Elliott_Poplar_Elm	Other			9.6	0.5	11.5	12.0	N
Gibson_Lawrence_6th	Other			10.2	0.5	11.5	12.0	Y
Gibson_Illinois_IL9	Other			9.9	0.5	11.1	11.6	Y
Gibson_West_9th	Other			9.7	0.5	10.9	11.4	Y
Gibson_Lawrence_5th	Other			9.4	0.5	10.5	11.0	Y
Gibson_Wood_4th	Other			9.3	0.5	10.4	10.9	Y
Gibson_South_Park	Other			8.6	0.5	9.6	10.1	Y
Gibson_Guthrie_13th	Other			8.5	0.5	9.5	10.0	Y
Gibson_Melvin_MeadowRue	Other			8.4	0.5	9.4	9.9	N
KILGIBSO9	WUPWS	2.2	5.8	8.3	0.6	8.8	9.3	Y
Gibson_Bell_19th	Other			7.9	0.5	8.8	9.3	Y
IL-FD-9	CoCoRaHS				0.8	7.6	8.5	Y
Gibson_GCMS_Elem	Other			6.8	0.5	7.5	8.0	N
Saybrook_Courtland_1080	Other						8.0	Y
IL-CP-125	CoCoRaHS				0.6	7.2	7.8	Y
KILGIBSO6	WUPWS	1.6	3.8	5.9	0.9	6.0	6.8	Y
3450N_300E	Other						6.3	Y
Dewey	Other						6.0	Y
Gibson_Gray_Gray	Other			5.1	0.5	5.5	6.0	N
PXNI2	COOP				0.3	5.5	5.8	Y
KILFISHE15	WUPWS	1.5	2.8	5.1	0.4	5.3	5.6	Y
IL-CP-112	CoCoRaHS				0.3	5.1	5.4	Y
KTIP	FAA	2.3	3.7	3.8	0.1	4.3	4.4	Y
IL-MCL-30	CoCoRaHS				0.8	3.6	4.4	Y
IL-FD-10	CoCoRaHS				0.8	3.1	3.9	Y
IL-MCL-61	CoCoRaHS				1.2	2.6	3.8	Y
KILSIBLE9	WUPWS	1.5	1.8	2.1	1.6	2.3	3.8	Y
IL-MCL-2	CoCoRaHS				1.2	2.6	3.8	Y
Paxton_Lane_IL45	Other						3.2	N
CHTI2	COOP				1.5	1.7	3.2	Y
KILRANTO9	WUPWS	1.2	2.1			3.2	3.2	N
IL-MCL-45	CoCoRaHS				0.9	2.1	3.0	Y
IL-MCL-28	CoCoRaHS				1.9	1.1	3.0	Y

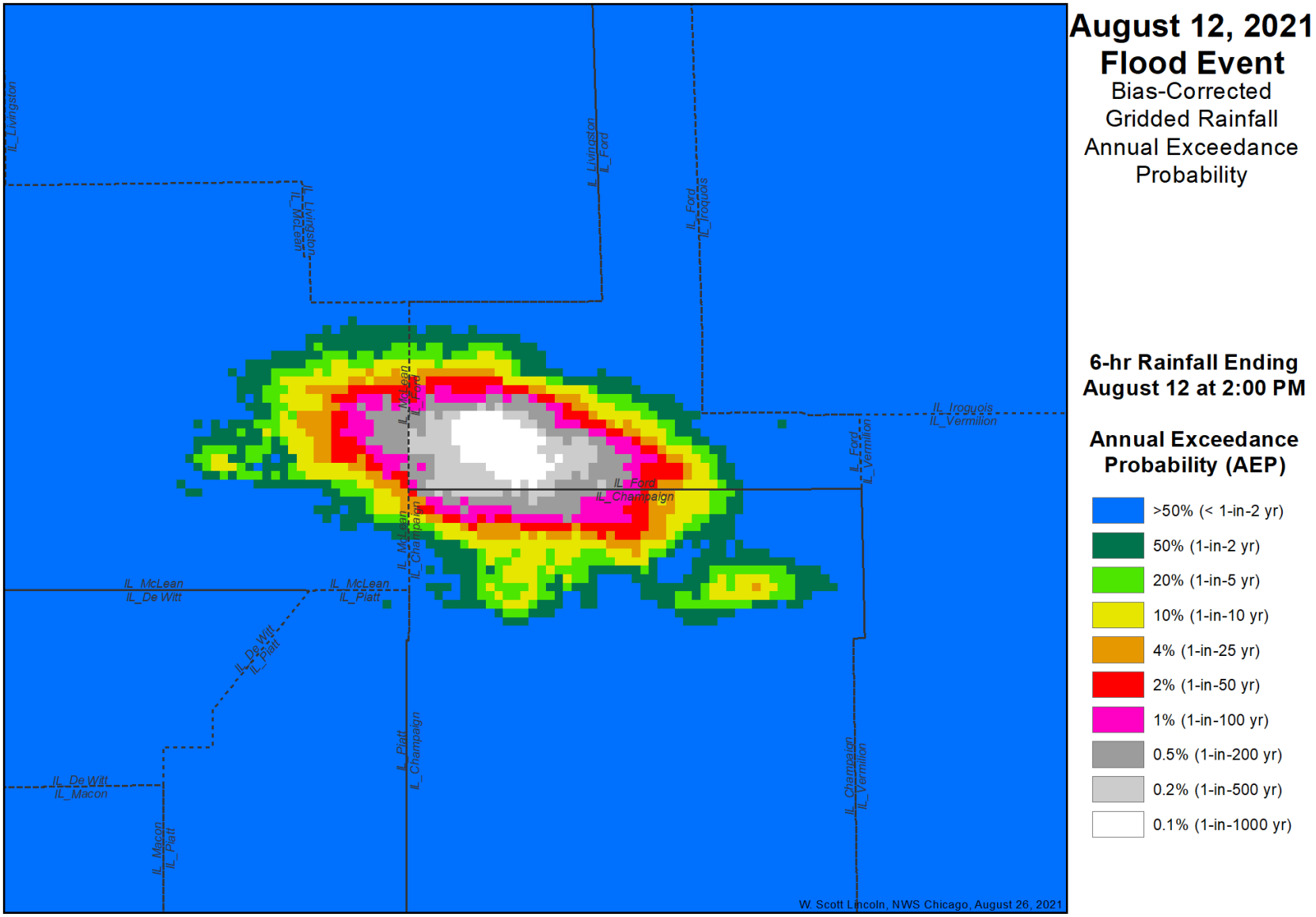
Climatological Context of Rainfall Amounts

The bias-corrected, gridded rainfall estimates were compared to NOAA Atlas 14 which provides estimates of the rarity of a given rain amount. The storm total rainfall spanned two calendar days and two meteorological observation days, but the overwhelming majority of rainfall in most locations occurred within a single 24-hour period and most of that rainfall occurred in a 6-hour period. From NOAA Atlas 14, the annual exceedance probability (AEP) was calculated for a given rain amount. AEP is related to the more widely (and often inaccurately) used term "average recurrence interval" (ARI). For example, a so-called "100-year event" has about a 1% chance of occurring in a given year (AEP).

Observed storm total rainfall ranged from typical to extreme. When looking at the heaviest 6-hour rainfall period, portions of Ford, McLean, and Champaign counties received rainfall with less than a 50% chance of occurring in a given year (Figure 9). Rainfall amounts rapidly became rarer closer to the rainfall maximum near Gibson City. Extreme rainfall amounts (<1% AEP) were recorded in southwest Ford County, portions of far eastern McLean County, and portions of far northern Champaign County, covering an approximately 150 square mile area. Near and just to the southeast of Gibson City, an approximately 30 square mile area experienced rainfall with less than a 0.1% AEP (1-in-1000 annual chance). Rainfall of this magnitude is almost always associated with significant flood impacts. Also notable was the sharp gradient between extreme rainfall and typical rainfall; typical rainfall occurred within just 10 miles of the analyzed maximum rainfall location.

Due to the extreme rainfall observed, rain gauges in the vicinity of Gibson City and Elliott were analyzed more closely. The hourly rain gauges with the highest 2-day totals (ending August 13 at 1200 UTC) included WUPWS site KILGIBSO9 with 9.33 inches and WUPWS site KILGIBSO6 with 6.84 inches. The location of these gauges is highlighted on Figure 7. Hourly data confirmed that the majority of the 2-day rainfall total occurred within an approximately 6-hour long period. Rainfall was extreme (exceeding the 1% AEP) for the 6-hr, 12-hr, and 24-hr durations (Figure 10). The rainfall observation from the private observer Gibson_PrairieSmoke_MeadowRue of 13.5 inches included a few additional details which allowed for the analysis of shorter duration accumulations. The location of this site is highlighted on Figure 7. This observer reported 5.9 inches over a 3-hour period (greater than 1% AEP) and 11.4 inches over a 6-hour period (greater than 0.1% AEP). Even if no additional rainfall was recorded, the accumulated rainfall trace for Gibson_PrairieSmoke_MeadowRue would have remained above the 1% AEP value for about 20 days and above the 0.1% AEP for about 10 days. This means the accumulated

255 rainfall amount would have been extreme even if it had occurred over that much longer period, but it
256 instead occurred over just a few hours.



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258 Figure 9. Annual Exceedance Probability (AEP) of the gridded rainfall estimate covering the 6-hr period ending August 12, 2021, at 2:00 PM (1900 UTC).

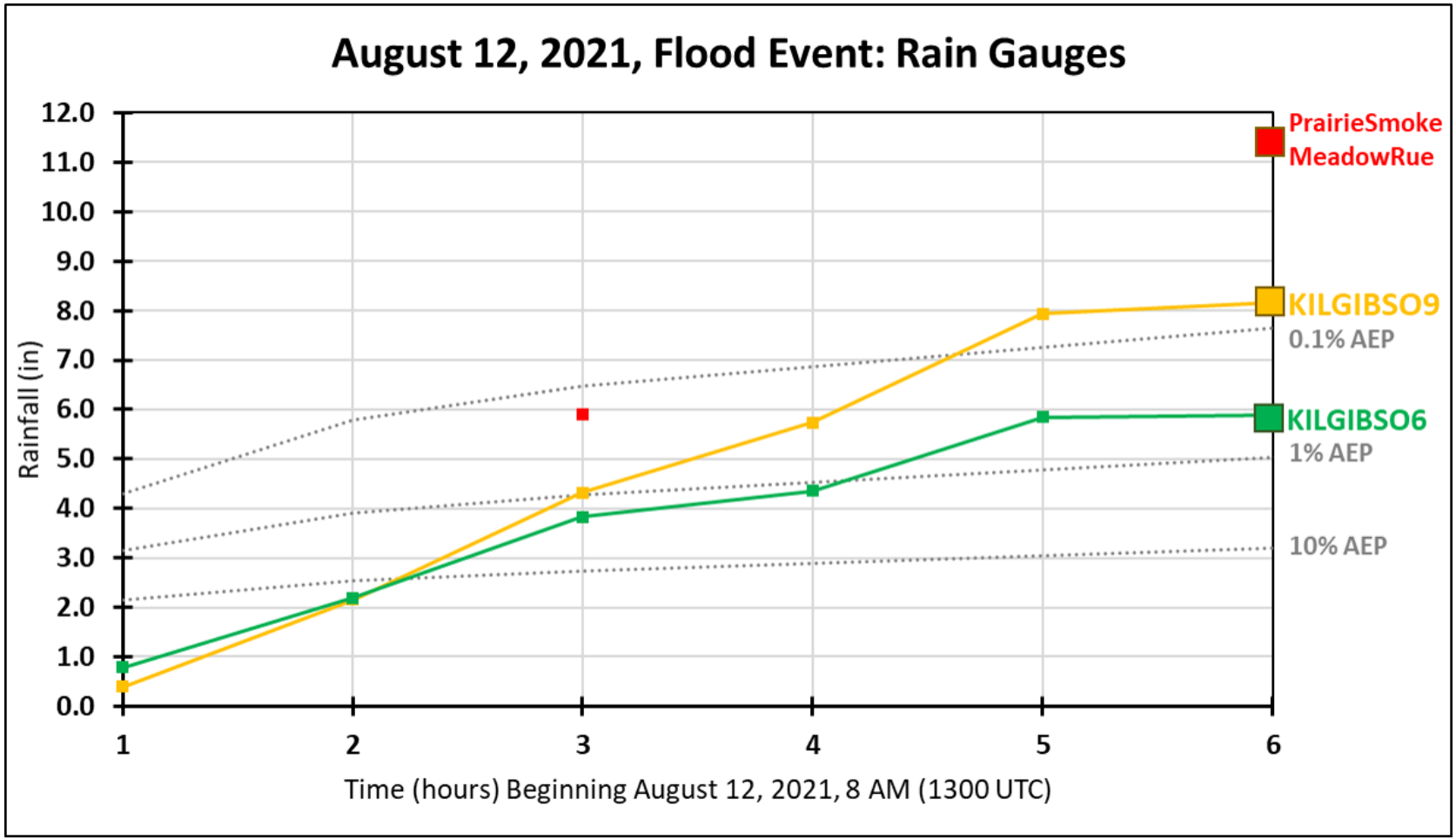

Figure 10. Total accumulated rainfall for two WUPWS sites and one manual observation near Gibson City beginning at 8AM (1300 UTC) August 12, 2021. NOAA Atlas 14 data are shown by dotted lines. The manual observation taken by a Gibson City resident, collected after the event (Gibson_PrairieSmoke_MeadowRue), was the highest rainfall observation collected in the area.

Flash Flood Impacts

Rainfall of the magnitude that occurred August 12, 2021, in portions of Ford, McLean, and Champaign counties is almost always associated with significant flash flood impacts. Preliminary reports received by the NWS indicated that multiple roadways were flooded and structures were impacted, possibly by surface flow. A ground survey was conducted on August 13, 2021, to look for evidence of flash flooding in the impacted area. The survey confirmed significant impacts in the Gibson City area, including evidence of dozens of structures and roadways flooded by overland flow. The location of all known flood impacts, included those collected by the survey and those collected from news reports and social media, are shown by Figure 11. The number of known impacts is likely smaller than the true number of impacts as it only reflects the impacts seen by the survey or shared by news media and social media.

Based upon the fact that the heaviest rainfall occurred right over the Gibson City and Elliott areas and the horizontal distances between rainfall and impacts were short, highest water levels likely occurred shortly after the heaviest rainfall. While water levels may have risen very quickly during the period of heaviest rainfall, anecdotal information suggested that inundation in some areas drained slowly, taking up to a few days to completely drain. Some of this behavior was likely due to the terrain of Gibson City. In northern Gibson City, along and north of 19th Street, the general overland flow path is from east to west (Figure 12). Runoff overwhelmed canals and waterways near Gibson City Melvin Sibley Middle School, filled relative low spots with water, flowed through yards, knocked down a portion of fencing, and entered structures as it headed toward Drummer Creek. Along North State Street in Gibson City, the general overland flow path is from east to west until reaching a railroad embankment, then it turns sharply south (Figure 13). Runoff overwhelmed the storm sewer network and surface ditches, then accumulated in relatively lower spots as it moved toward Drummer Creek. The most significant inundation was noted in the areas of lower terrain. The railroad embankment to the west greatly impeded overland flow, possibly contributing to higher water levels, and forced water southward toward West 9th Street where the embankment was eventually overtopped and significant erosion caused a partial washout. If any culverts or other man-made storm drainage features were built to allow for westward flow underneath the railroad embankment, they were overwhelmed by the extreme rainfall. Along West 8th and West 9th Streets in Gibson City, the general overland flow path is from east to west toward Drummer Creek (Figure 14). Runoff overwhelmed storm sewers and drainage ditches, and accumulated in the lower terrain centered on Lowery Park. Additional runoff came from the east as the railroad embankment was overtopped at West 9th Street. Without underground drainage such as storm sewers, substantial inundation would remain in this area as it is surrounded on all sides by higher

terrain, including the embankment for IL-47 near Drummer Creek. The lack of a natural path for surface water to exit this area may have contributed to the prolonged inundation noted during the storm survey, although evaluation of manmade drainage structures that drained this area, such as storm sewers, was beyond the scope of the NWS post-event survey. In eastern Gibson City, along IL-54, the general overland flow path is from east to west, with an unnamed ditch turning south along IL-54 (Figure 15). Runoff overwhelmed the unnamed ditch, caused overtopping of IL-54, and moved to the west into portions of town. Numerous roadways and structures were impacted, with the most serious impacts in areas of relatively lower terrain, as the runoff moved westward through eastern and southern portions of Gibson City. In southern Gibson City and along IL-9/IL-54, the general overland flow path is from east to west (Figure 16). The unnamed drainage ditch running along IL-54 turns west toward Drummer Creek after flow south of town. Runoff overwhelmed the ditch in this area, causing flooding of numerous structures and large areas of property. Surface flow from the north and east also entered this area, flooded structures, flooded numerous roadways, and accumulated in the relatively low terrain areas near the IL-47/IL-9/IL-54 intersection. A railroad embankment to the west may have impeded overland flow westward toward Drummer Creek, possibly contributing to higher water levels or more prolonged inundation.

Near Lakeview Drive southeast of Gibson City, the general overland flow path is from north to south along Dickerson Slough, with some tributaries entering the area from the east (Figure 17). Flow from one tributary enters a lake along Dickerson Slough before then entering the larger stream. Based upon anecdotal reports, runoff overwhelmed this small tributary, flooded structures and property along Lakeview Drive, and then contributed to the filling of the small lake. It is also likely that flooding from Dickerson Slough contributed to filling the lake and prevented water from the small tributary from leaving the area.

The area around Elliott sits on relatively higher ground, causing the general overland flow path to be from west to east in the eastern portion of town, and from east to west in the western portion of town (Figure 18). Runoff overwhelmed ditches and creeks in this area, inundated nearby property, and overtopped multiple roadways. The most significant flood inundation was noted in areas of relatively lower terrain.

At the time of this report, limited information was available about the costs associated with the flash flood event. Because of the large number of impacted structures and due to the unavailability of flood

325 insurance coverage for Gibson City and Ford County (Marilyn Sucoe, Illinois NFIP coordinator, personal
326 communication, August 18, 2021), damage costs are assumed to be significant.

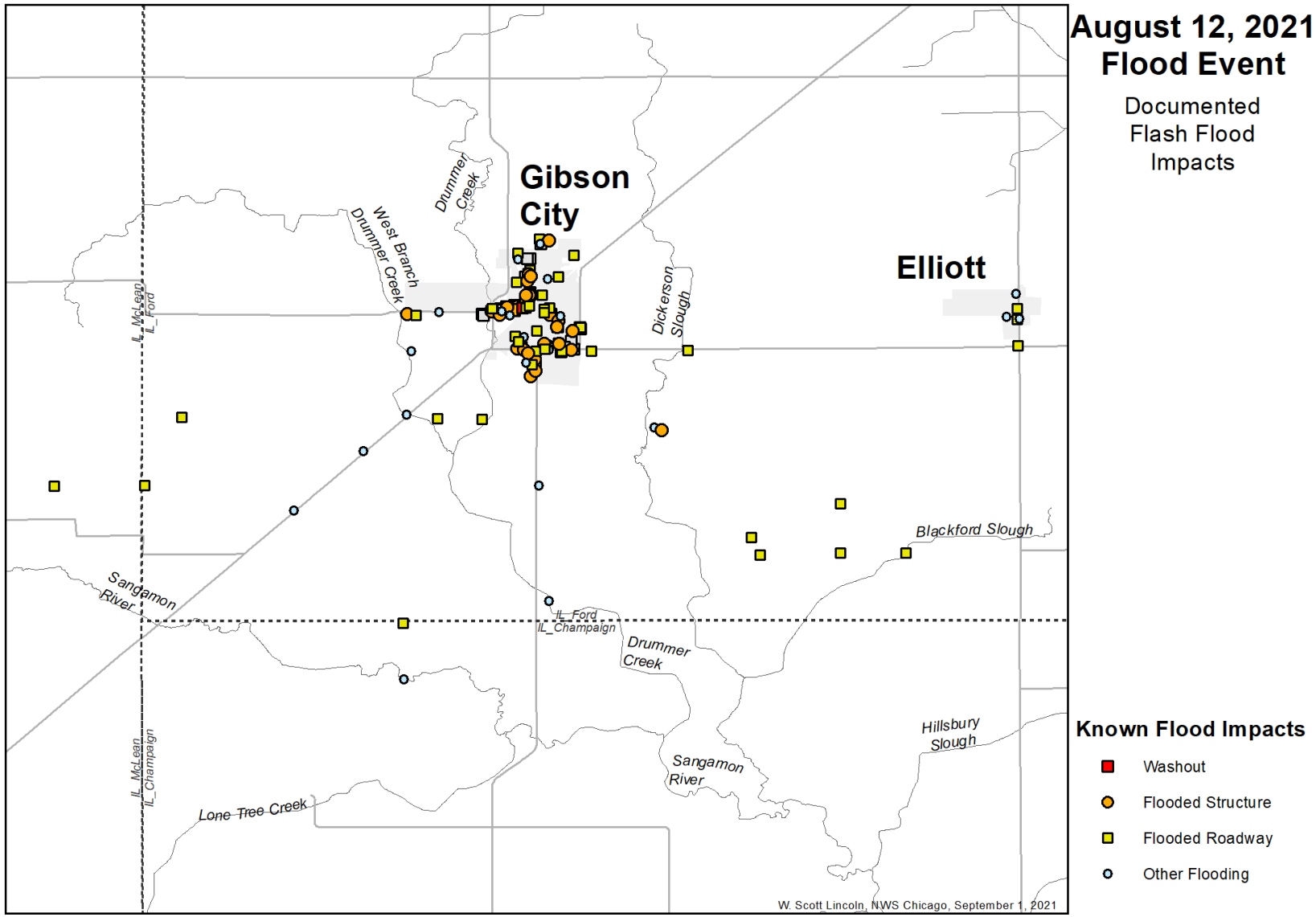

Figure 11. Documented impacts from the flash flood which occurred on August 12, 2021. Reports came from a National Weather Service survey conducted on August 13, and the additional reports of flash flooding collected from news reports and social media.

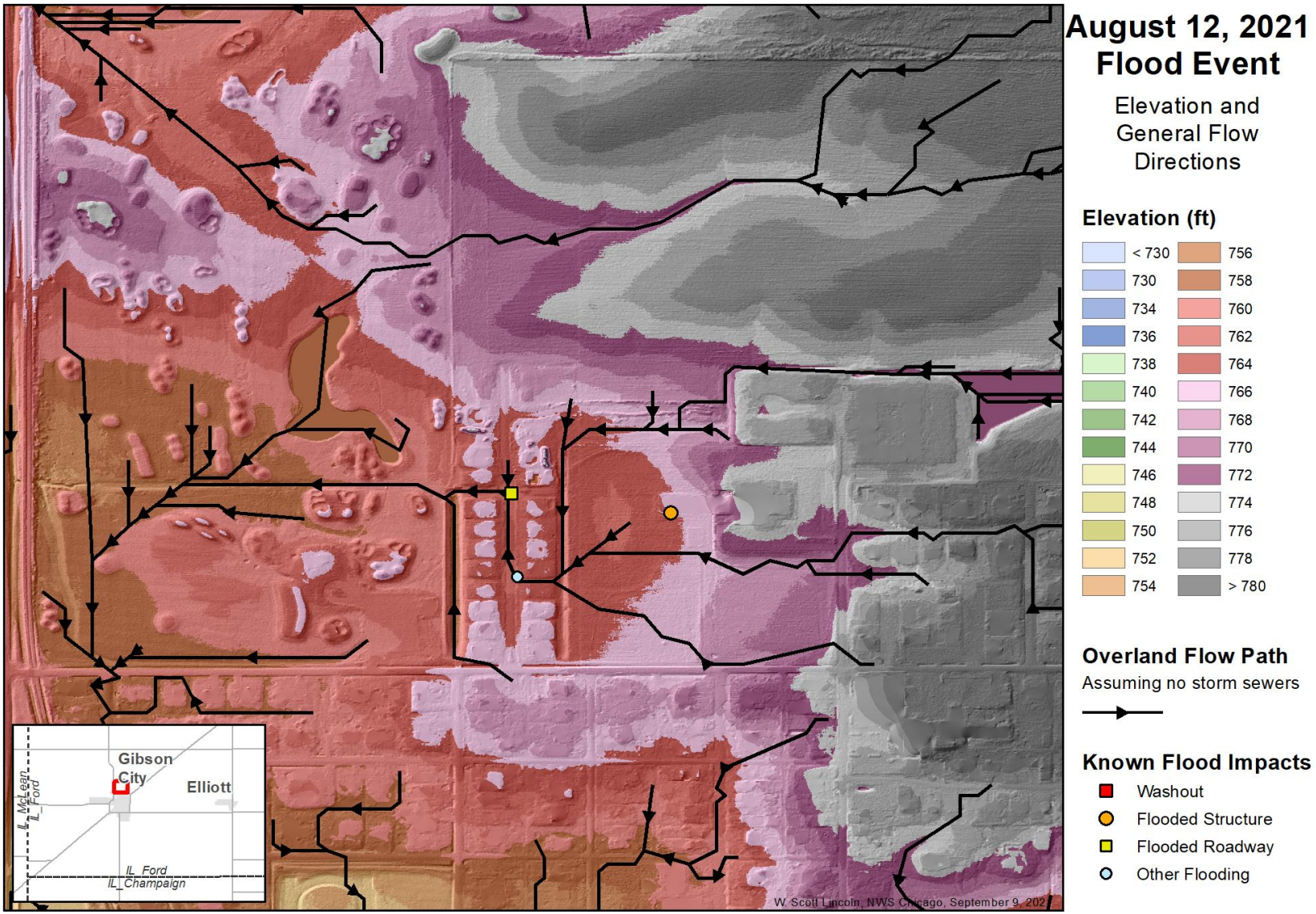

Figure 12. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the 19th Street area of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

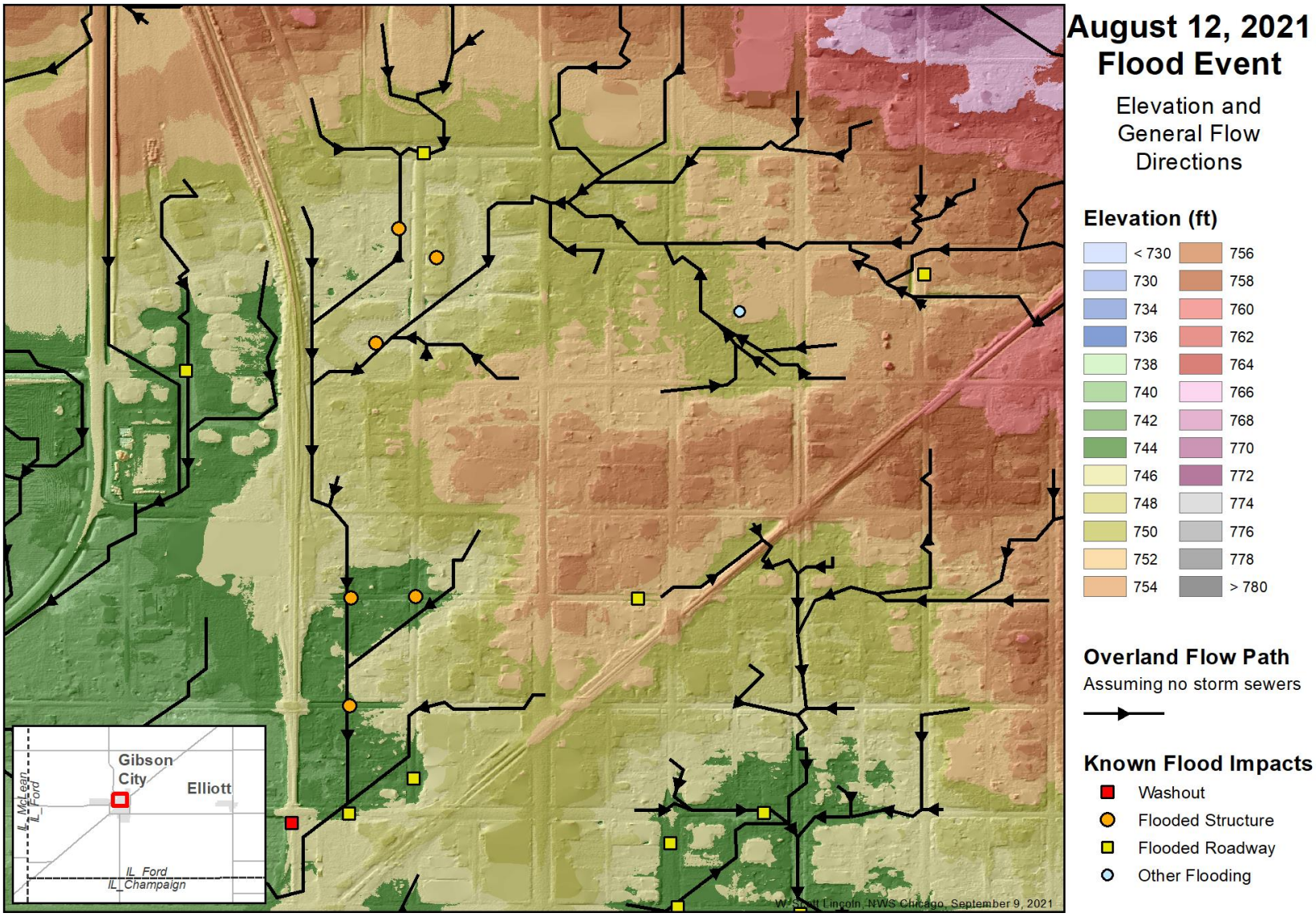

Figure 13. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the North State Street area of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

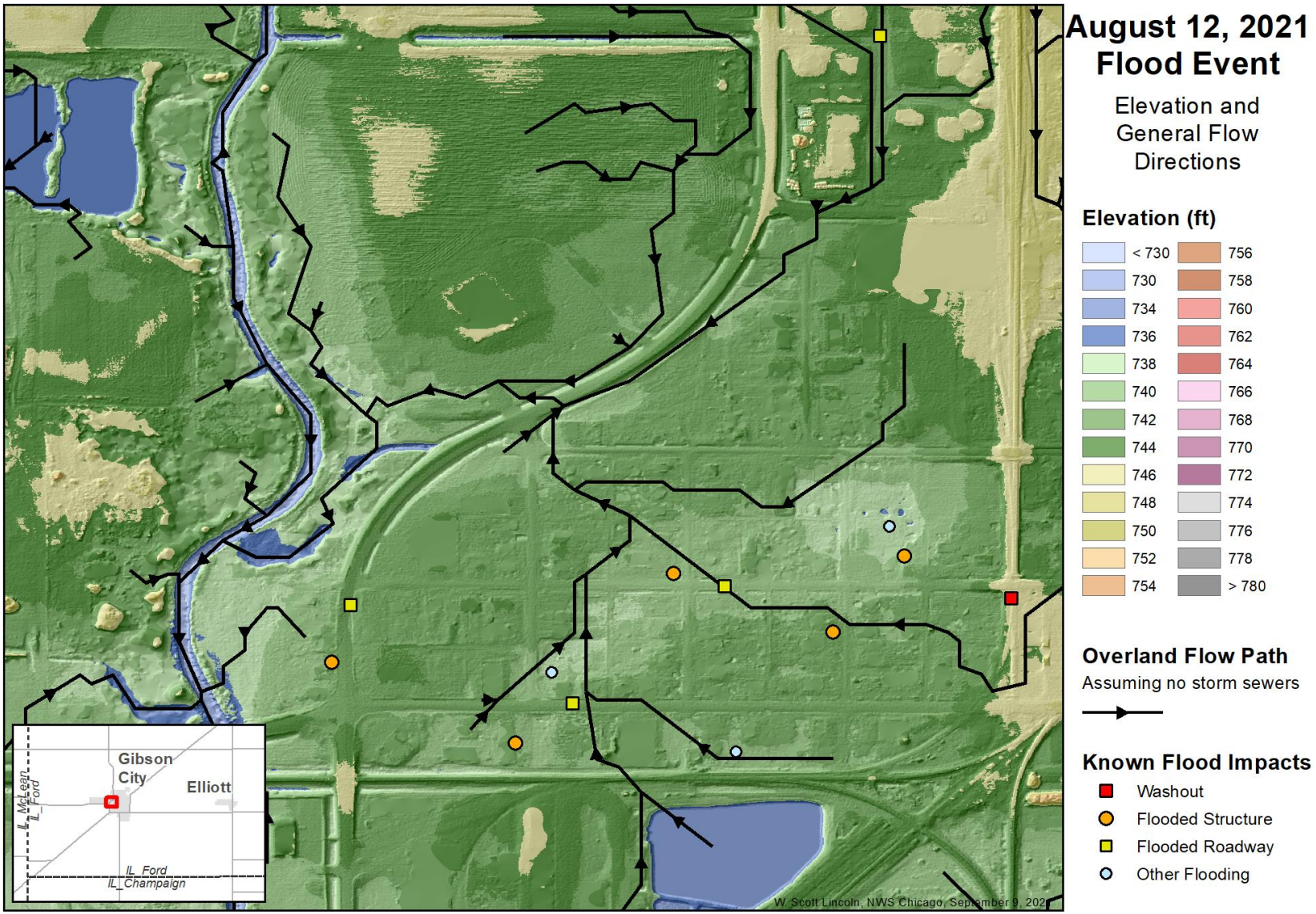

Figure 14. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the West 9th Street area of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

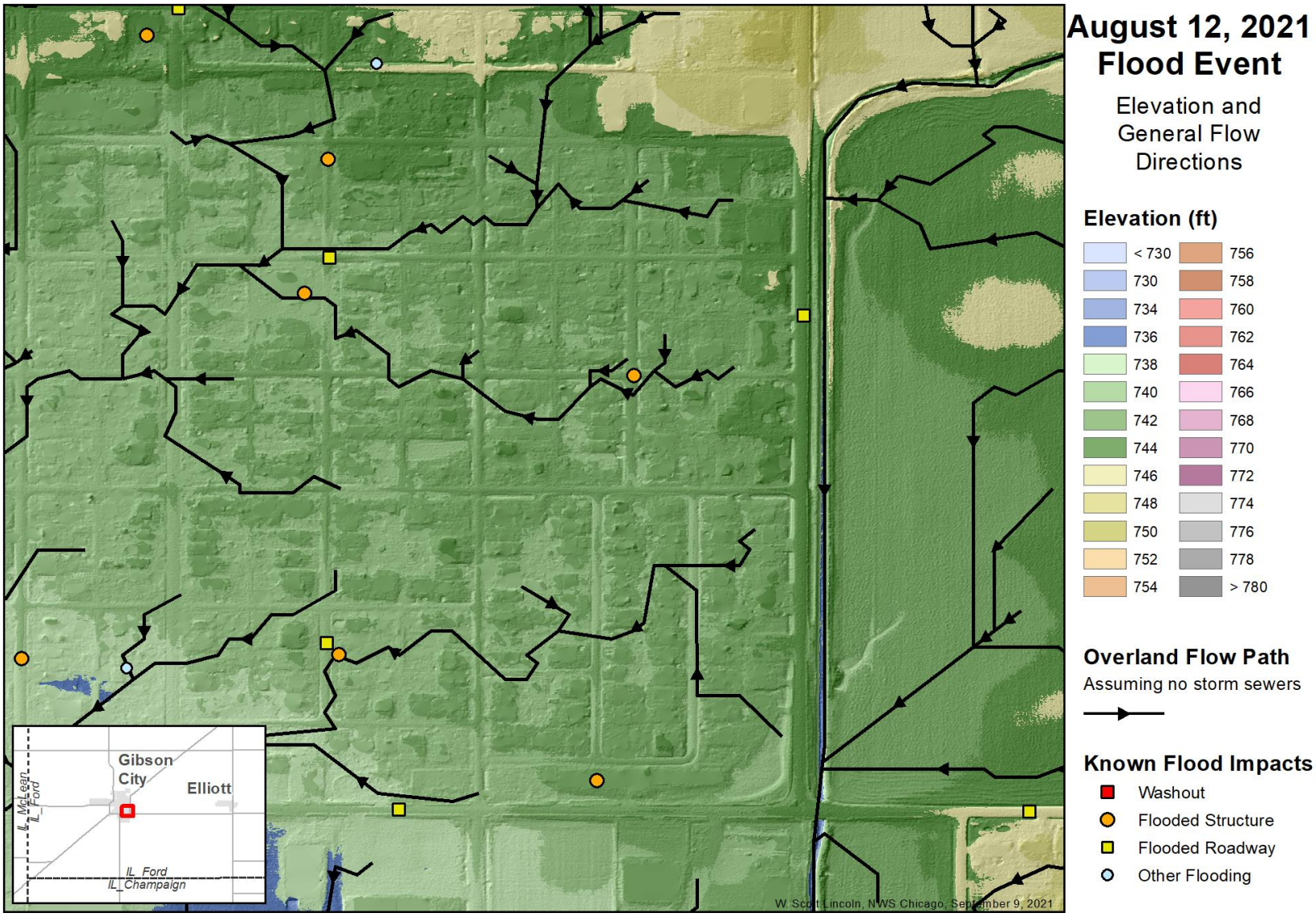

Figure 15. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the IL-54 area of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

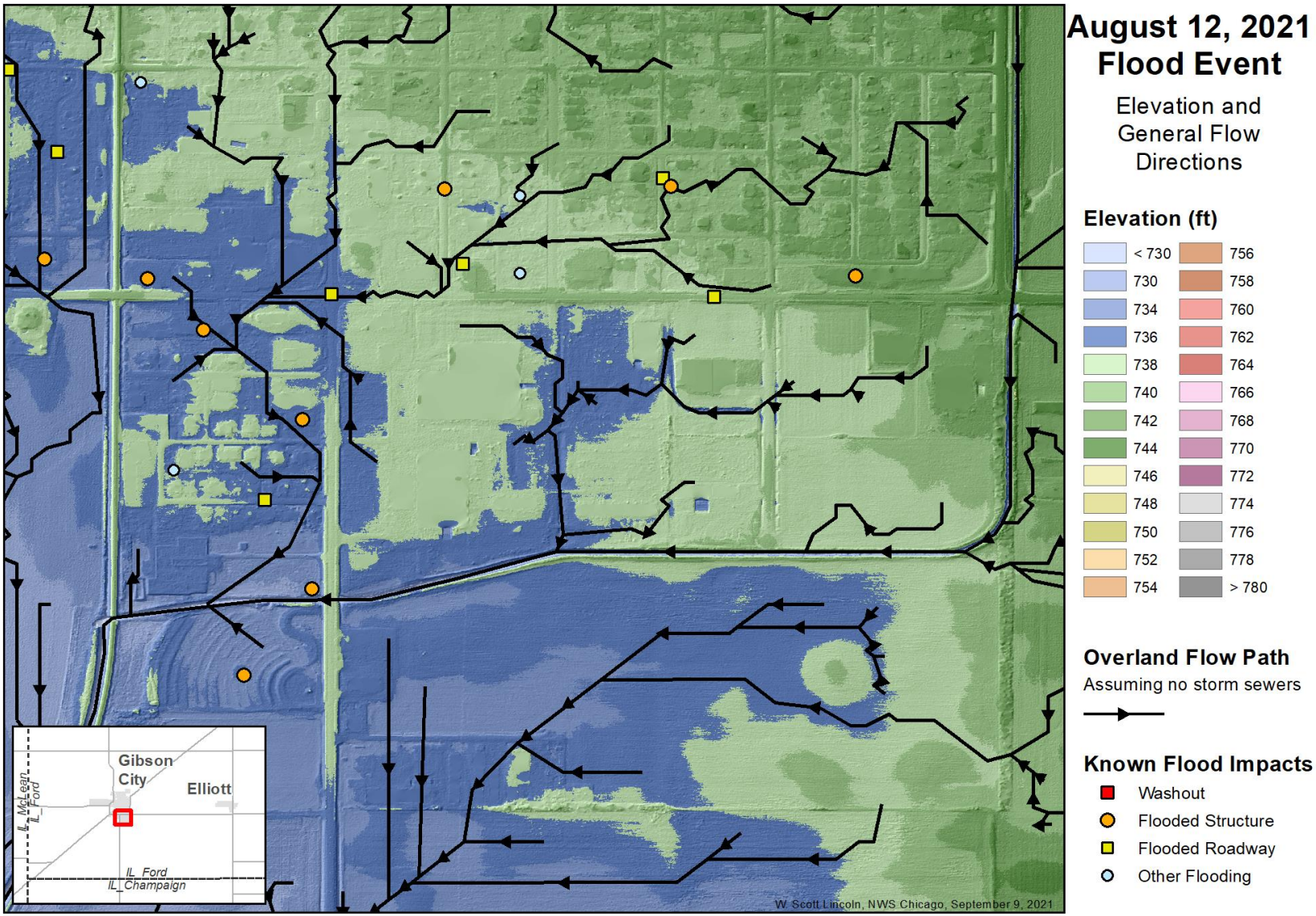

Figure 16. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the IL-47/IL-9 area of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

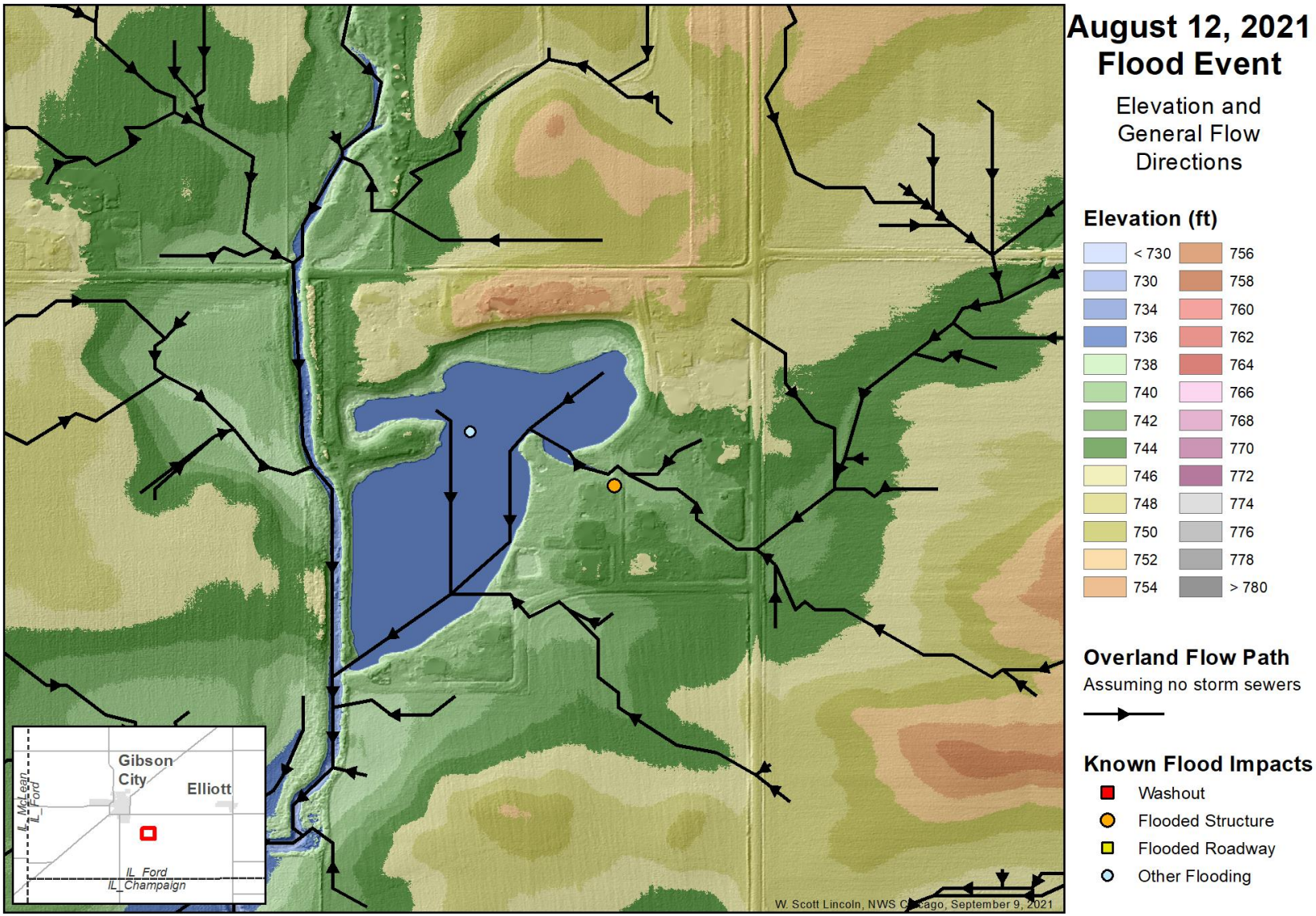

Figure 17. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the Lakeview Drive area southeast of Gibson City, Illinois. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

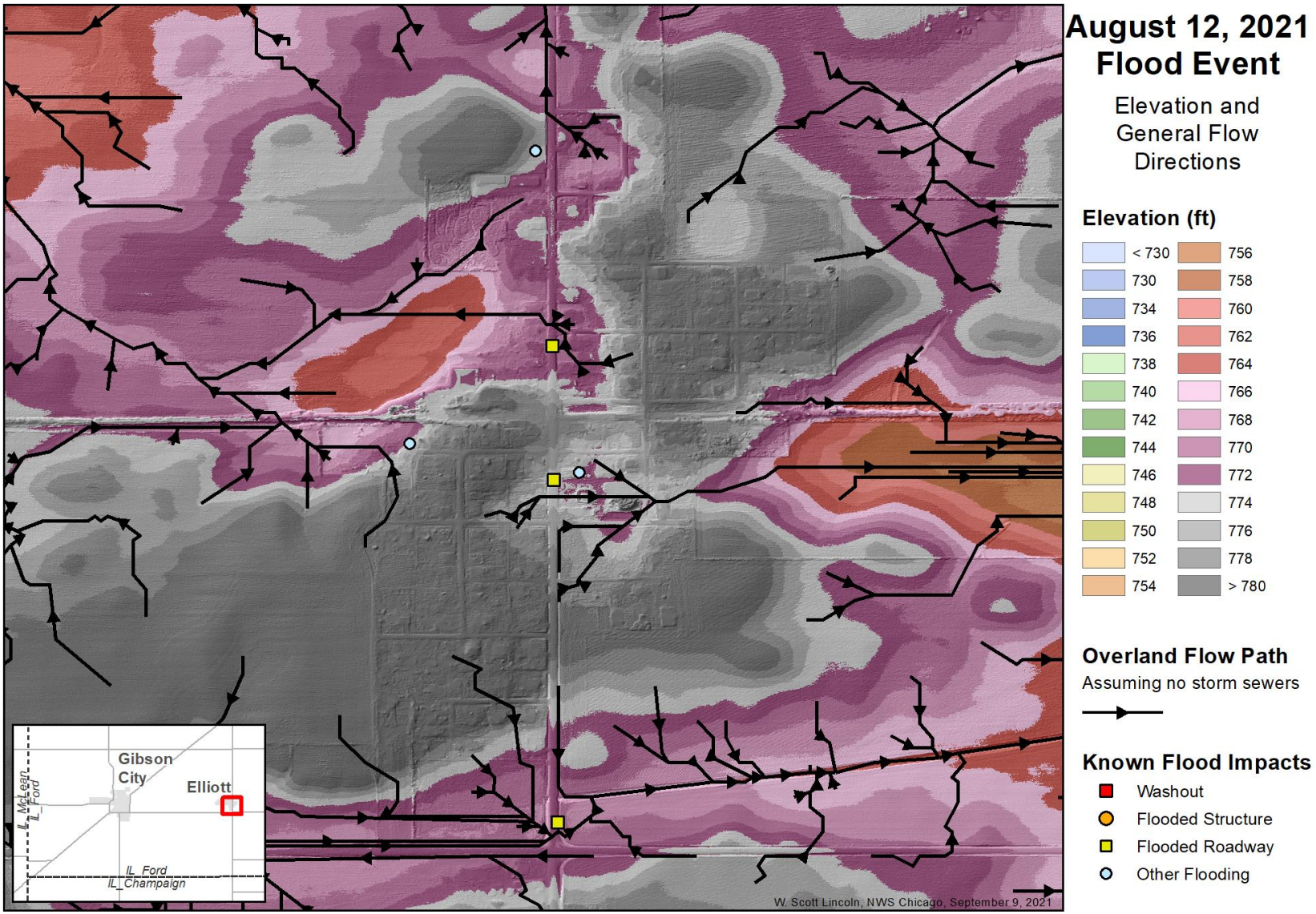

Figure 18. High resolution elevation data, estimated overland flow paths, and documented flood impacts from the August 12, 2021, flash flood event in the Elliot, Illinois, area. Overland flow paths are estimated from elevation data and do not take into account underground storm sewer drainage or other man-made drainage structures.

Hydrologic and Hydraulic Modeling

A hydrologic model was developed to simulate the rainfall runoff processes that occurred during the event across the Gibson City and Elliott areas. For modeling purposes, 16 basins were defined covering portions of Drummer Creek, Dickerson Slough, and multiple other unnamed waterways (Figure 19). Rainfall inputs for each model basin were based upon the 10-min rainfall accumulations from the MRMS radar-only estimates, but with magnitudes adjusted such that storm total rainfall matched the rainfall estimates bias-corrected to gauge observations. Canopy cover in the model was simulated as a simple abstraction ranging from 0.00 to 0.01 inches, depending on GIS estimates of tree cover. Land surface abstractions ranged from 0.10-0.25 inches based upon GIS land cover information. Infiltration was simulated with the Curve Number method. Curve Number values were derived from GIS analysis of 2011 NLCD land cover and STATSGO soil type. Lag time for simulated basins and routing between basins were estimated based upon GIS analysis of land cover and slope.

A hydraulic model was also developed to simulate the surface overland flow behavior of runoff. Multiple 2D flow areas were created corresponding to the different drainage basins covering Gibson City and Elliott. Cell spacing for these 2D flow areas ranged from 125 meters to 300 meters, with the highest resolution used in the vicinity of Gibson City. The model terrain was derived from high resolution LiDAR elevation data, resampled to 10-meter spacing. Manning's n values (surface roughness) were derived from the 2011 National Land Cover Database. The north-south railroad, northeast-southwest railroad, IL-54 on the east side of Gibson City, and IL-9 west of Gibson City, were each added to the model as barriers with specific elevations indicated to improve model performance. The boundary condition input to the hydraulic model was the runoff calculated for each basin, as derived from the hydrologic model.

Based upon output from the hydrologic model, basin runoff ranged from 3.8 inches to 8.4 inches, corresponding to 61-82% of the 5.7-10.3 inches of basin-averaged rainfall (Table 2). Peak modeled streamflow on Drummer Creek at 200N Road about 2 miles downstream of Gibson City reached 16,700 cfs at 5:30 PM (2230 UTC). Based upon estimates from the USGS StreamStats application (Soong, Ishii, Sharpe, & Avery, 2004; Over, et al., 2021), the peak streamflow with only a 0.2% (1-in-500 year) chance of occurring in a given year is approximately 8,900 cfs (uncertainty range 3,900-20,500 cfs) for this location. Because no stream gauges exist on the waterways near Gibson City, no direct verification of output from the hydrologic model could be performed.

The hydraulic model indicated widespread inundation up to 1 foot depth across Gibson City at the peak of the flood (Figure 20) with isolated areas experiencing inundation up to approximately 4 feet in depth,

especially along North State Street. The model also indicated ponding of water in numerous relatively lower locations in the vicinity of Elliott during the peak of the flood (Figure 21). Modeled water levels were extracted for a few locations across the Gibson City area, including State Street near 14th Street (Figure 22 a), Pine Street at 9th Street (Figure 22 b), the IL-9/IL-54/IL-47 intersection (Figure 22 c), the unnamed creek on the south side of town just downstream of IL-47 (Figure 22 d), and Drummer Creek at IL-9 (Figure 22 e). Modeled water levels were compared to the high water mark elevations collected in the vicinity. In general, modeled peak water elevations were similar to observed high water marks, with differences ranging from 0.3 feet to 1.6 feet. The largest difference was for the North State Street location where model output was about 1.6 feet higher than the average elevation of high water marks collected in the vicinity, and was about 0.3 feet above the maximum high water mark in the vicinity. Differences between the model output and the high water marks could be due to many different factors, including uncertainty in the estimation of water depths for high water marks, uncertainty in the calculation of elevation from high water mark depth, high water marks suggesting a different elevation than the true peak water level, limitations with the simple hydraulic modeling approach that was utilized, and general model uncertainty. Despite the differences, the model output from both the hydrologic and hydraulic models still yields helpful information that could not be determined through the post-event survey. Notably, high water marks cannot indicate the approximate time of crest, nor the general flow direction of water, nor other flood behaviors such as flow direction. Output from the hydraulic model suggests the highest water levels occurred in Gibson City from about 11:20 AM to 1:00 PM (1620 UTC to 1800 UTC) on August 12th, just before the heaviest rainfall began to subside. The last of the locations to crest was Drummer Creek at IL-9, which may have taken a slightly longer time to crest because of the substantially larger upstream area.

It is important to note that the models developed for this report were not detailed enough to use for engineering study purposes. The models also did not take into account the underground storm sewer network, which could convey water in different directions than suggested by the surface elevation. Because the extreme rainfall that occurred at Gibson City far exceeded the design capacity of storm sewers, any errors due to their omission from the models is expected to be relatively small. Despite this, uncertainty in crest elevation and timing still exists, and high water mark elevations and modeled elevations should not be assumed to have high precision.

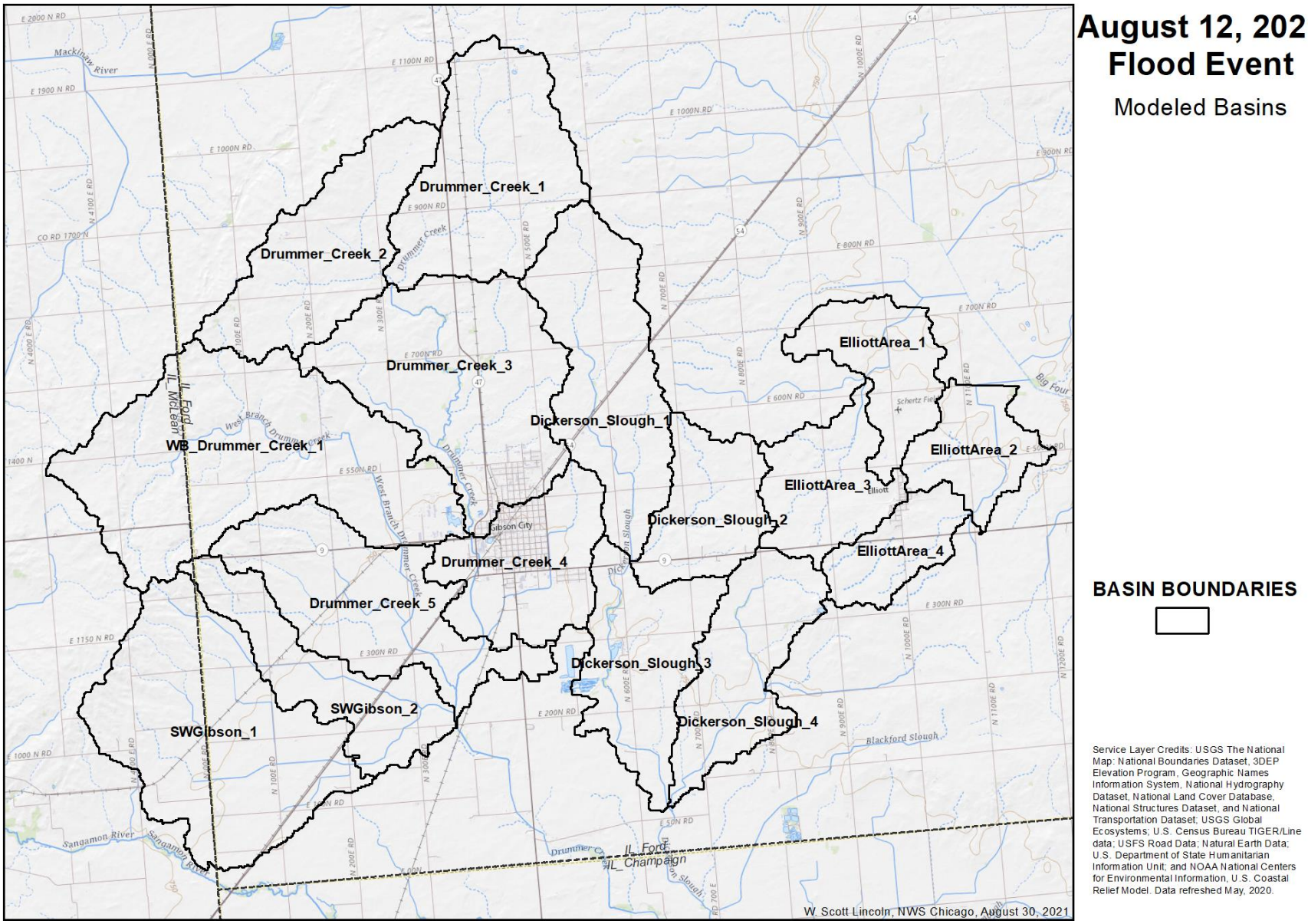

Figure 19. Basins defined for the hydrologic and hydraulic models.

421 Table 2. Average rainfall and runoff estimated from the hydrologic model for each basin in the vicinity of Gibson City and Elliott.

Basin	Rainfall	Runoff
Dickerson_Slough_1	8.3	6.4
Dickerson_Slough_2	10.2	8.4
Dickerson_Slough_3	10.2	8.2
Dickerson_Slough_4	9.9	8.0
Drummer_Creek_1	5.7	3.8
Drummer_Creek_2	6.4	3.9
Drummer_Creek_3	8.4	6.1
Drummer_Creek_4	10.3	8.4
Drummer_Creek_5	8.3	5.9
ElliottArea_1	6.6	4.5
ElliottArea_2	7.5	5.7
ElliottArea_3	8.6	6.8
ElliottArea_4	9.3	7.4
SWGibson_1	6.7	4.2
SWGibson_2	7.8	5.4
WB_Drummer_Creek_1	7.6	5.0

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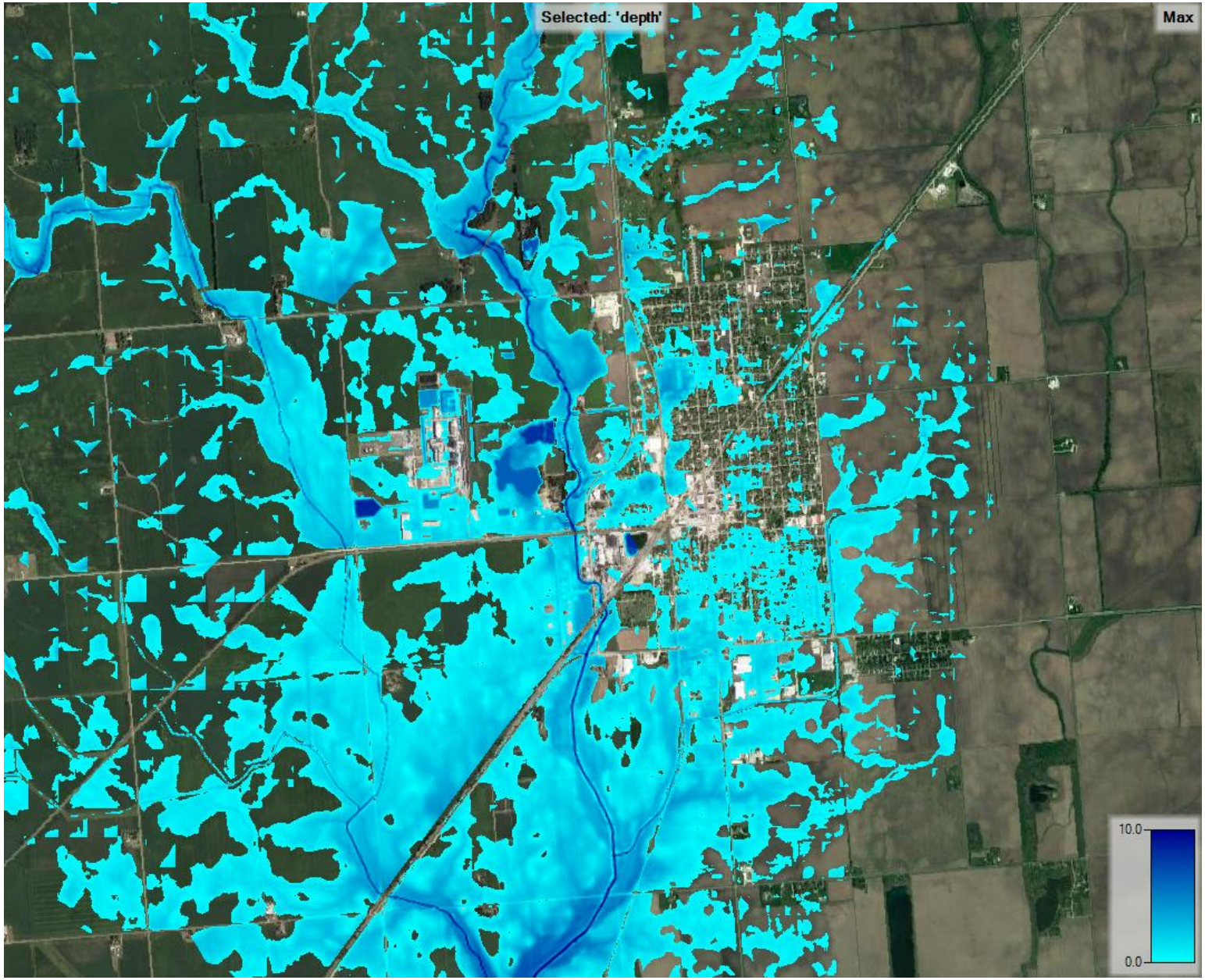
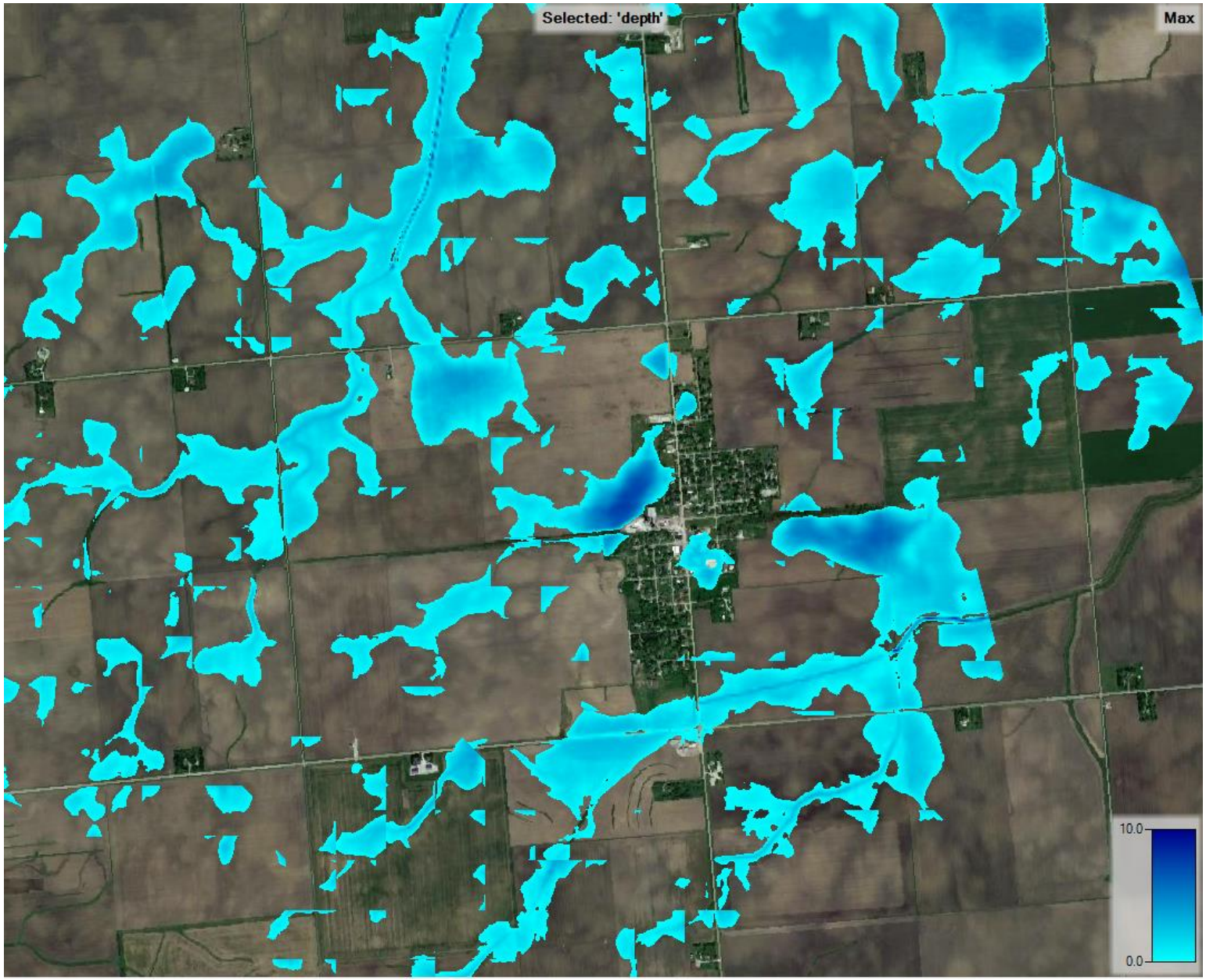


Figure 20. Estimated peak water depth for the Gibson City area from the hydraulic model.



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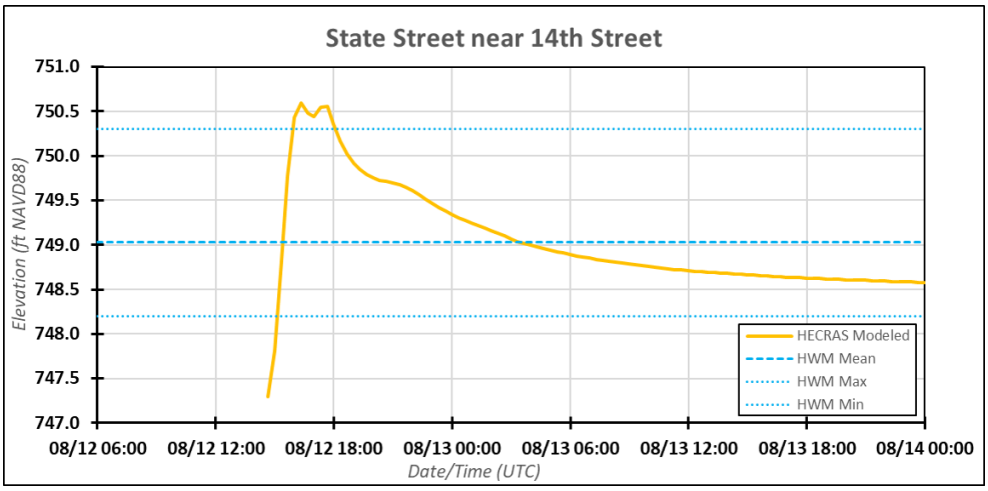
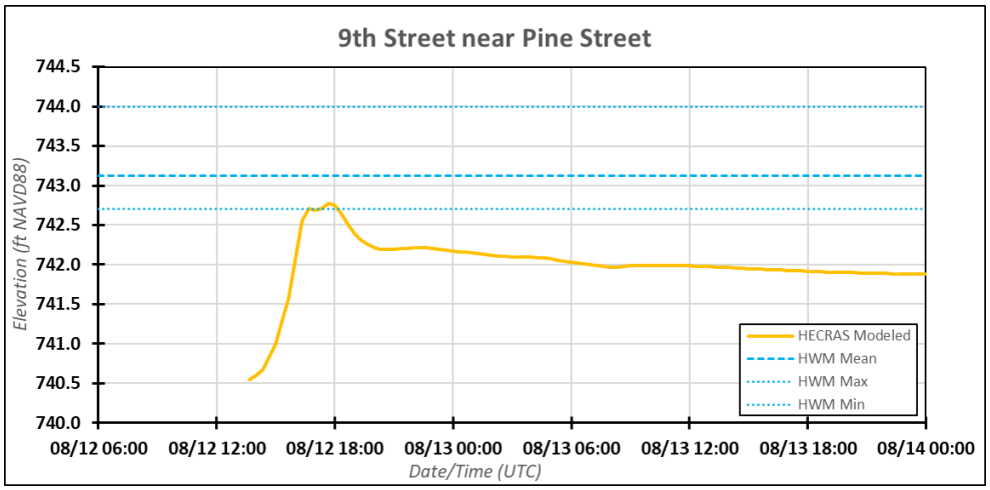
426 Figure 21. Estimated peak water depth for the Elliott area from the hydraulic model.

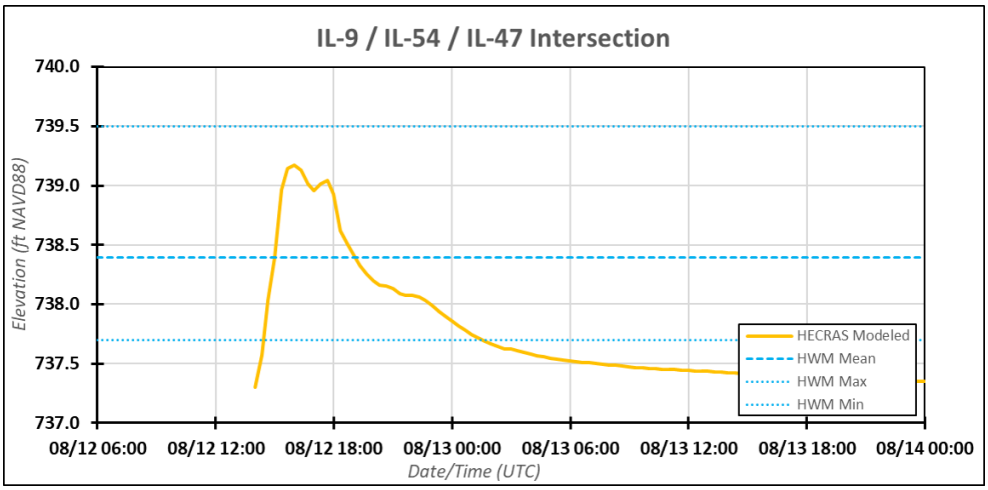
A)

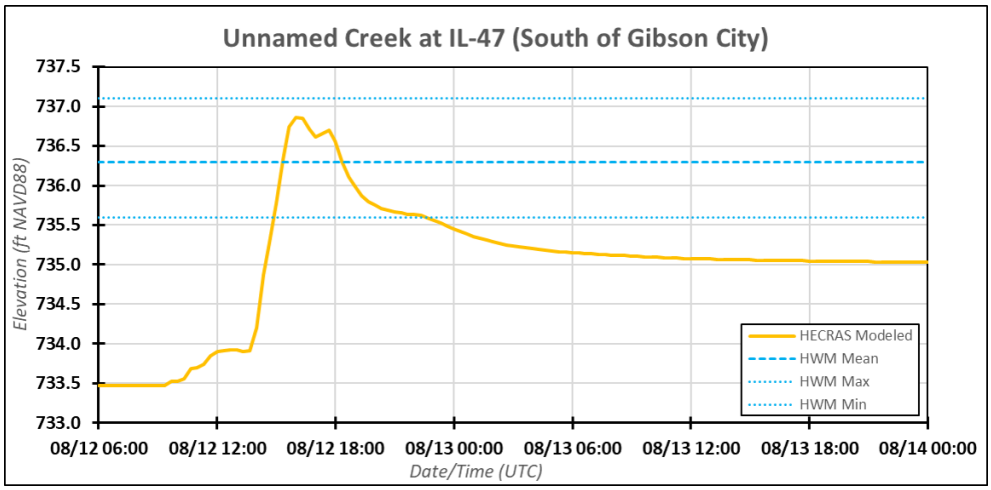

State Street near 14th Street
751.0
750.5
750.0
749.5
749.0
748.5
748.0
747.5
747.0
Elevation (ft NAVD88)
08/12 06:00
08/12 12:00
08/12 18:00
08/13 00:00
08/13 06:00
08/13 12:00
08/13 18:00
08/14 00:00
Date/Time (UTC)
HECRAS Modeled
HWM Mean
HWM Max
HWM Min

B)

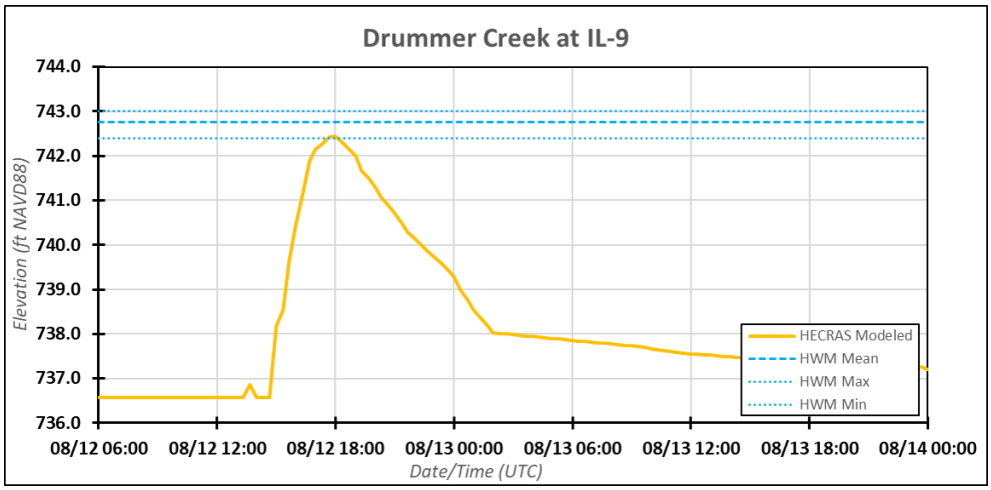

9th Street near Pine Street
744.5
744.0
743.5
743.0
742.5
742.0
741.5
741.0
740.5
740.0
Elevation (ft NAVD88)
08/12 06:00
08/12 12:00
08/12 18:00
08/13 00:00
08/13 06:00
08/13 12:00
08/13 18:00
08/14 00:00
Date/Time (UTC)
HECRAS Modeled
HWM Mean
HWM Max
HWM Min

C)


IL-9 / IL-54 / IL-47 Intersection
740.0
739.5
739.0
738.5
738.0
737.5
737.0
Elevation (ft NAVD88)
08/12 06:00
08/12 12:00
08/12 18:00
08/13 00:00
08/13 06:00
08/13 12:00
08/13 18:00
08/14 00:00
Date/Time (UTC)
HECRAS Modeled
HWM Mean
HWM Max
HWM Min



D)



E)

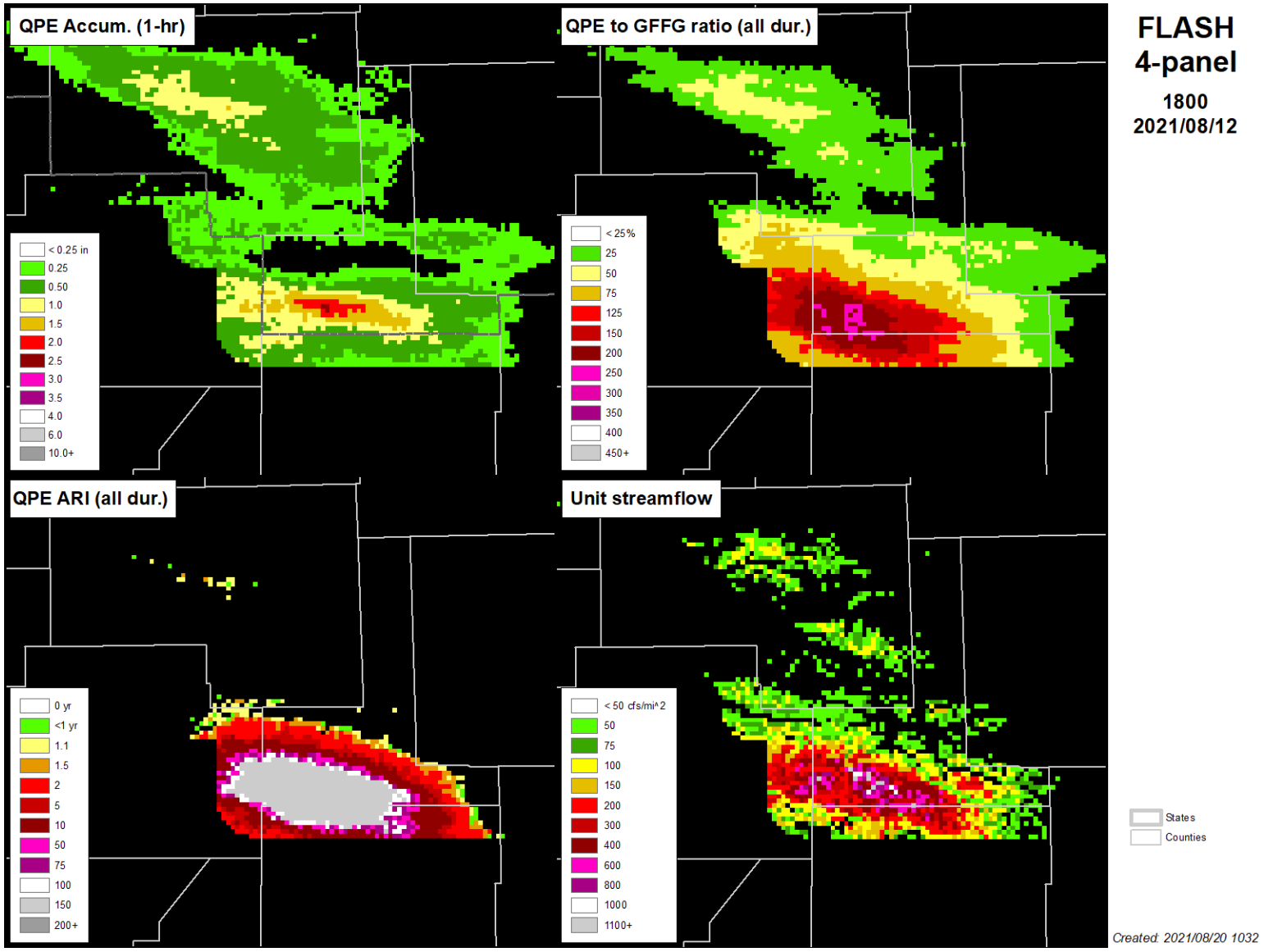
Figure 22. Modeled water surface elevations for locations in Gibson City compared to the high water marks collected in the vicinity. Model output shown for State Street near 14th Street (A), Pine Street at 9th Street (B), the IL-9/IL-57/IL-47 intersection (C), the unnamed creek on the south side of Gibson City at IL-47 (D), and Drummer Creek at IL-9 (E). Model output is indicated with an orange line, the average of the high water marks in the vicinity are indicated with a solid blue line, and the minimum and maximum high water mark elevation in the vicinity are indicated with dashed blue lines.

National Weather Service Hazard Products

National Weather Service forecasters typically use a combination of products to assess flash flood potential, including radar reflectivity, rainfall rates, accumulated rainfall to gridded flash flood guidance (GFFG), accumulated rainfall compared to depth duration frequency (DDF/ARI) information, and modeled unit streamflow from the Flooded Locations and Simulated Hydrographs (FLASH) project. Four (4) of these indicators make up a standard 4-panel procedure to assist with warnings – 1-hr rainfall rates, accumulated rainfall compared to GFFG, accumulated rainfall compared to DDF/ARI, and modeled unit streamflow. Archived data from these products was collected and reviewed. When two (2) of the four (4) panels show the same level of flood impact, a flood hazard product is considered; when all four (4) panels show the same level of flood impact, a flood hazard product is strongly recommended. The output from these MRMS and FLASH products are guidance only and their usefulness may vary from event to event. NWS forecasters make a professional judgement in realtime as to the usefulness of these products, including comparison of radar-estimated rainfall to gauge observed rainfall, when available. The first hints of the need for a Flood Advisory for the impacted area were indicated by these products at about 8:50 AM (1350 UTC), with a strong recommendation by 9:10 AM (1410 UTC). A Flash Flood Warning was hinted at by about 9:10 AM (1410 UTC) with a strong recommendation by 9:40 AM (1440 UTC). A considerable impact Flash Flood Warning was hinted at by about 10:10 AM (1510 UTC) and strongly recommended by 11:50 AM (1650 UTC). An example of output from the 4-panel procedure near the peak depicted severity is illustrated by Figure 23.

The National Weather Service issued numerous hazard products during this event. The first product issued was a Flood Advisory at 9:27 AM (1427 UTC) August 12, 2021. This was followed by a Flash Flood Warning at 9:59 AM (1459 UTC) and a Flash Flood Warning with considerable damage tag at 10:57 AM (1557 UTC). Reports received by the NWS include minor flooding (a few inches of inundation) on IL-9 near Gibson City at 9:27 AM (1427 UTC), at least 1-ft of water on IL-9 and IL-47 with stalled vehicles at 10:44 AM (1544 UTC), and water entering structures at 11:58 AM (1658 UTC). Based upon the time that reports were received, it seems likely that NWS flood hazard products provided lead time of flood impacts and significant flood impacts (Figure 24). This includes almost 45 minutes of lead time between the initial Flash Flood Warning and warning-level flood impacts, and about 1 hour of lead time between the Flash Flood Warning with considerable damage indicated, triggering phone wireless emergency alerts, and the report of water beginning to enter structures. It should be noted, however, that the time of reports often corresponds to the time that the information was received, not necessarily the time

that the impact began. Lead time for the issued flood hazard products was similar to the lead time provided by the MRMS/FLASH guidance products. For the Flash Flood Warning with considerable damage indicated, NWS warning forecasters provided more lead time than guidance provided by the MRMS/FLASH products.



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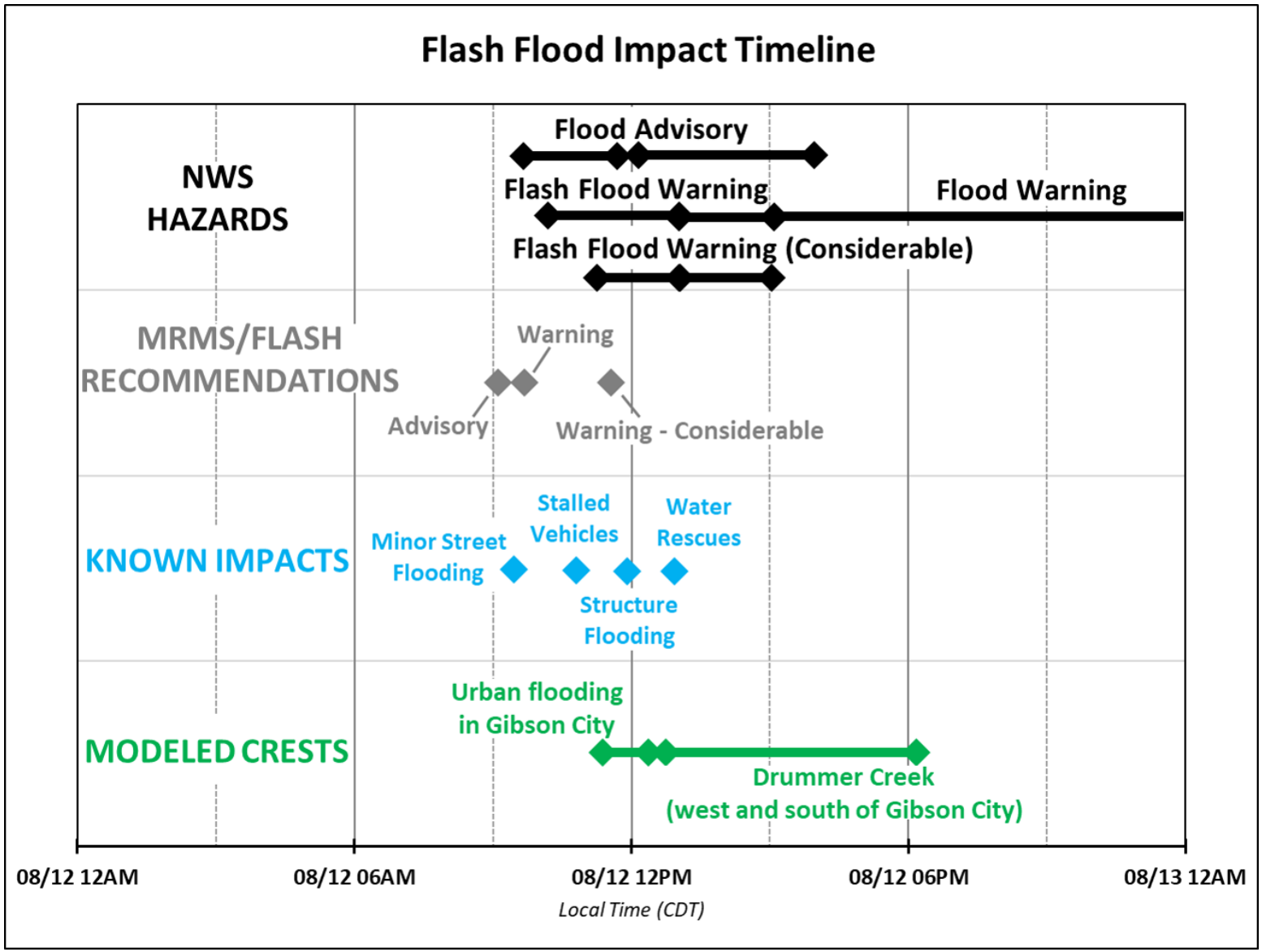
475 Figure 23. Values depicted by various MRMS and FLASH products near their peak during the event at approximately 1:00 PM (1800 UTC) August 12.



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477 Figure 24. Timeline of NWS hazard products, MRMS/FLASH output, known impacts, and modeled crests for the event.

478

Conclusions

Very heavy rainfall occurred in the vicinity of Gibson City and Elliott, Illinois, on August 12, 2021. Gridded rainfall estimates and rain gauges indicated that areas of Ford, McLean, and Champaign counties received heavy rainfall, with the peak rainfall occurring near Gibson City. Over the 2-day period ending at 7:00 AM (1200 UTC) August 13, 2021, bias-corrected radar rainfall estimates indicated about 11.5 inches of rain fell in and near Gibson City. Manual rainfall observations in Gibson City ranged from 7.5 to 13.5 inches, with several rain gauges overflowing at some point in time. The majority of the rainfall (85-90%) occurred in a single 6-hour period ending at 2:00 PM (1900 UTC) on August 12. The amount of rainfall observed was extreme in southwest Ford County, far eastern McLean County, and far northern Champaign County, with AEP values exceeding 1% (1-in-100 year) annual chance. Peak rainfall AEP was estimated at 0.1% (1-in-1000 year) annual chance in the vicinity of Gibson City. This extreme rainfall led to widespread flash flood impacts, included numerous flooded structures and roadways, and water rescues. Fortunately, no reports of injuries or fatalities were received by the National Weather Service despite the significance of the event.

A post-event survey was conducted by NWS personnel on August 13 where the reports of significant flooding were confirmed and numerous high water marks were collected. A hydrologic model and a hydraulic model were developed to simulate the behavior of runoff in the affected areas. Model output indicated that peak water levels likely occurred during and just after the heaviest rainfall, between 11:00 AM (1600 UTC) and about 6:00 PM (2300 UTC). Although most parts of Gibson City were inundated up to a depth of about 1 foot, some isolated areas experienced inundation up to approximately 4 feet. Some of the behavior of floodwaters in the Gibson City area can be explained by the terrain of the area, including the multiple railroad and roadway embankments that cross the town. Runoff did not always follow the natural flow paths one would expect from elevation.

It is likely that the National Weather Service provided lead time with flood hazards issued for flood impacts in the area, especially for the significant flood impacts. It is estimated that 45 minutes of lead time was provided for warning-level flood impacts, and about 1 hour of lead time was provided for significant warning-level flood impacts. Modeling suggested that peak water levels began to occur across the area 30-60 minutes earlier than suggested by the reports received by the NWS. The amount of lead time that could be provided was limited by the short distance between impacted areas and the heaviest rainfall.

Acknowledgements

The author would like to thank the people of the Gibson City, Illinois, area who provided flood impact and rainfall information during the post-event survey. Jacob Dickey of WCIA-TV should also be credited for his assistance in acquiring additional flood impact and rainfall reports via social media. The author would also like to acknowledge the numerous comments and suggestions provided by colleagues at the National Weather Service Weather Forecast Office Chicago, Illinois, which greatly improved this technical report.

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