

Activity 610 (Flood Warning & Response)

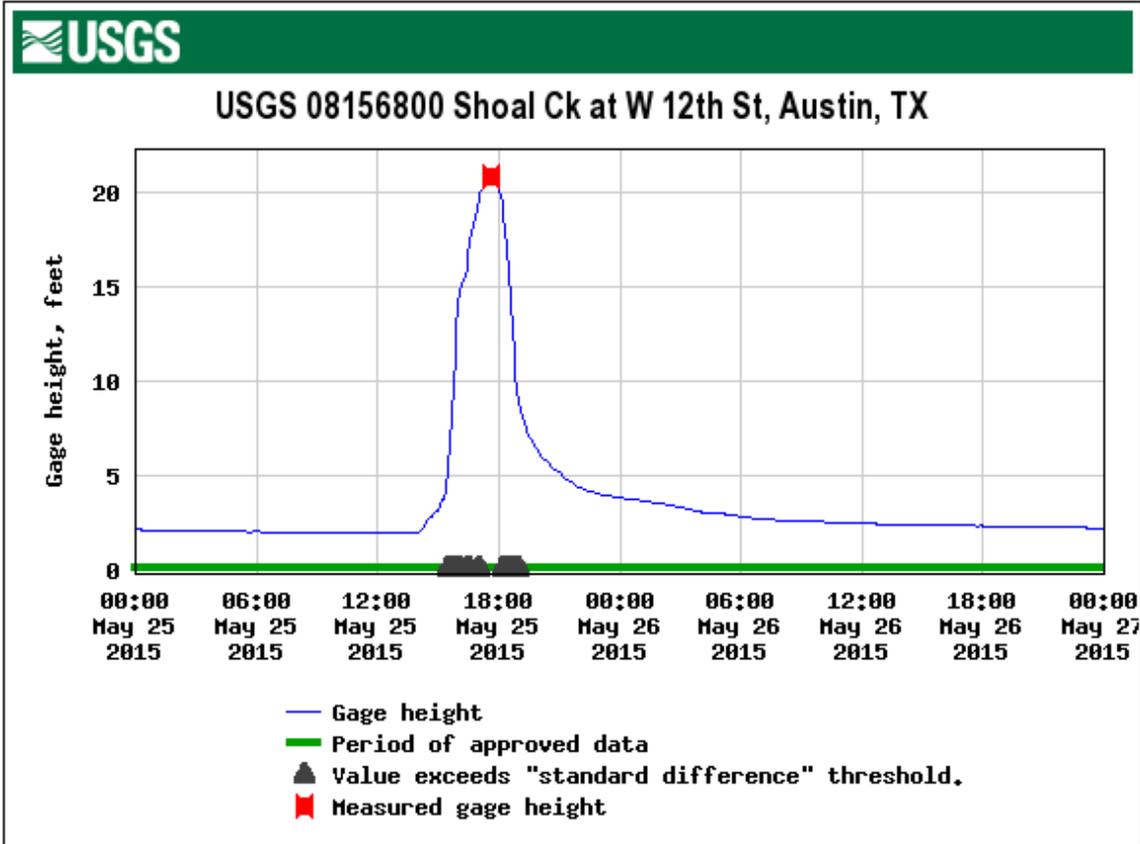
Description of flood hazard

The City of Austin's flood hazards are flash flooding. It is located in one of the most flash-flood prone regions in North America. Flash flooding is the number one natural disaster that is a threat to this area and it is listed as the No. 1 threat within the City of Austin's Emergency Response Plan.

For example, on May 24, 2015, Shoal Creek in Austin experienced approximately 5 inches of rain in about 3 hours. Below are some images received off of Twitter of a swift water rescue that occurred in downtown Austin.



This is the hydrograph from the USGS gauge that is located on W. 12th Street approximately 2 blocks from where the above images were taken. Note that from 3 pm to 5:30 pm the creek rose 17 feet. In some 5 minute time intervals the creek rose approximately 1.5 feet.



There are a total of **5,799 structures** in 46 watersheds are located in the 100yr floodplain in the City of Austin Full Purpose Jurisdiction.

The CFHM Masterplan has identified 5,118 structures in the 100yr floodplain located in 25 watersheds in the City’s Full Purpose Jurisdiction. Out of the 5,118 structures in the 100yr floodplain, 2,561 are inundated during a 100yr flood; 1,152 during a 25yr flood, 539 during a 10yr flood and 48 are inundated during a 2yr flood. The FPO identifies 681 structures in 100yr floodplain in 21 additional watersheds.

A total of **393 roadways** in 26 watersheds are at risk of inundation during a 100yr flood in the City of Austin Full Purpose Jurisdiction. *See Memorandum from Reem Zoun, P.E.; Kevin Smith, GISP to Mapi Vigil, P.E. concerning the “Numbers of At-Risk Structures and Roadways in the City of Austin Floodplain. A geodatabase of this information is contained in the attached Flood_Structures.gdb folder.*

Of those **5799** structures subject to flooding, **4502** of them are within areas that have a Flood Threat program that involves forecast modeling and mapping. The remaining **1297** structures have a Flood Threat program that relies on either inundation levels associated with gate openings at Mansfield or Tom Miller Dam (LCRA controls those gate operations) or are covered by a

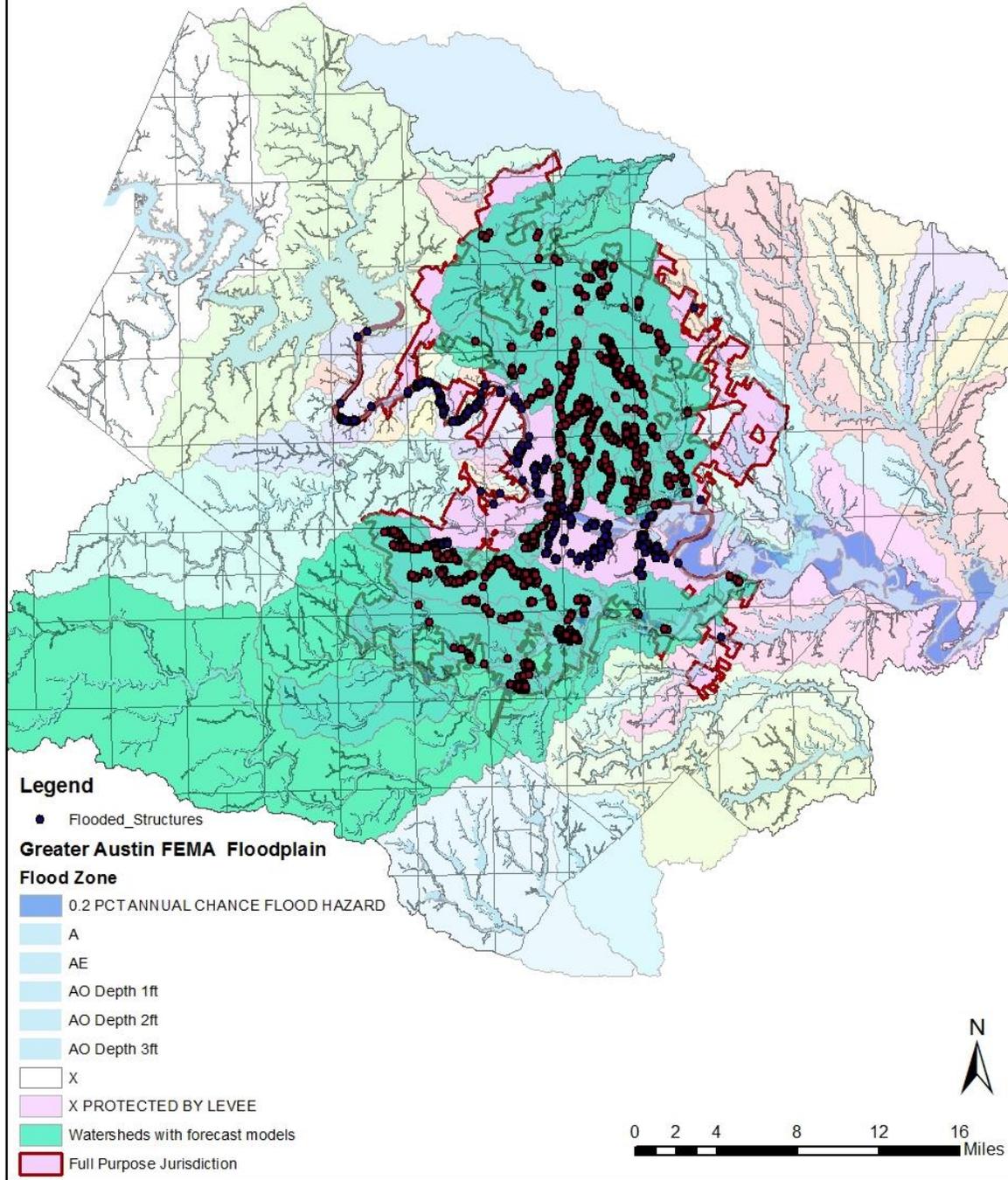
threat score associated with Depth-Duration-Frequency rainfall. This is automatically available to the Flood Warning staff every 15 minutes.

The number of buildings in the floodplain that are covered by emergency warnings issued by the City of Austin is **5,799**.

The number of building in the floodplain that are covered by flood response operations (Austin Fire Department, Austin Police Department, Department of Homeland Security and Emergency Management, Austin Public Works Department, and Austin Watershed Protection Department barricade operations) is **5,799**.

The next page contains a map indicating the extent of the Flood Threat Recognition system available in Austin.

Flooded Structures in Austin, Texas



A CD entitled “ENS Maps” with the inundation maps indicating level of inundation, structures at risk in the area of inundation and gage heights is included in this documentation.

An email that from the City of Austin Homeland Security and Emergency Management Department that Austin has a flood warning and response plan to the CEMP that has been adopted by the City Council is included in this folder.

Community Outreach

See documentation from Section 330.

Evaluation of the Flood Warning and Response Plan

There were no field exercises concerning the Flood Warning and Response Plan. However, two Storm Reports (both of which involved structural flooding) are included as Attachment A to this activity of the CRS.

Flood Threat Recognition System

Flood Threat Recognition System (FTR) 2 a1

Include documentation of early notice of a flood at one or more locations within the community. If appropriate, show how the community provides flood forecasts for areas other than the above forecast points.

The City of Austin has an automated flood threat recognition system that relies on several layers of data and services. Flood forecasting models are run on the majority of watersheds within the City of Austin. These flood forecasting models run continuously, provide an output every 15 minutes, incorporate soil moisture, and utilize rainfall from three different sources:

1. NEXRAD Dual Pol radar rainfall (available from two NWS locations – EWX and GRK stations);

2. Gauge adjusted radar rainfall – utilizes data from 196 rain gauges including the City of Austin gauges, the Lower Colorado River Authority gauges, the Upper Brushy Creek WCID gauges, and the USGS gauges; and
3. Forecasted rainfall available from the National Weather Service (High Resolution Rapid Refresh) and a private one-hour forecast rainfall.

The flood forecast models are calibrated using the USGS gauges. The City of Austin is a cooperating technical partner with the USGS at gauge locations in the Austin area. The URL below is a link to the USGS website with the listing of the associated gauges.

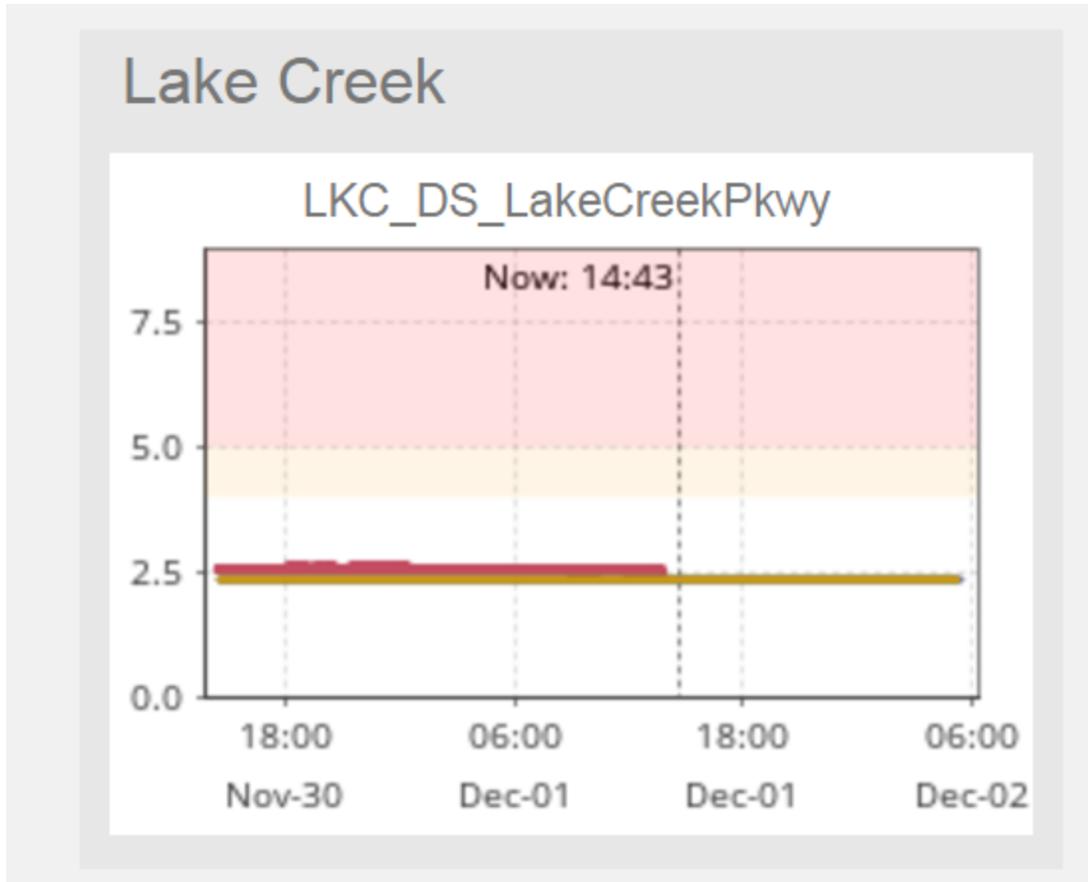
http://waterdata.usgs.gov/nwis/current?multiple_site_no=08105886%2C08154700%2C08155200%2C08155240%2C08155300%2C08155400%2C08155500%2C08155541%2C08156675%2C08156800%2C08156910%2C08158000%2C08158030%2C08158035%2C08158045%2C08158200%2C08158380%2C08158600%2C08158700%2C08158810%2C08158827%2C08158840%2C08158860%2C08158920%2C08158927%2C08158930%2C08158970%2C08159000&index_pmcode_STATION_NM=1&index_pmcode_DATETIME=2&index_pmcode_00065=3&index_pmcode_00060=4&format=station_list&group_key=county_cd&sort_key_2=site_no&html_table_group_key=NONE&rdb_compression=file&list_of_search_criteria=multiple_site_no%2Crealtime_parameter_selection

For these watersheds, the City of Austin utilizes a service through Vieux and Associates, Inc. that runs continuous model simulations. A screen shot of one of the forecast pages is indicated below:



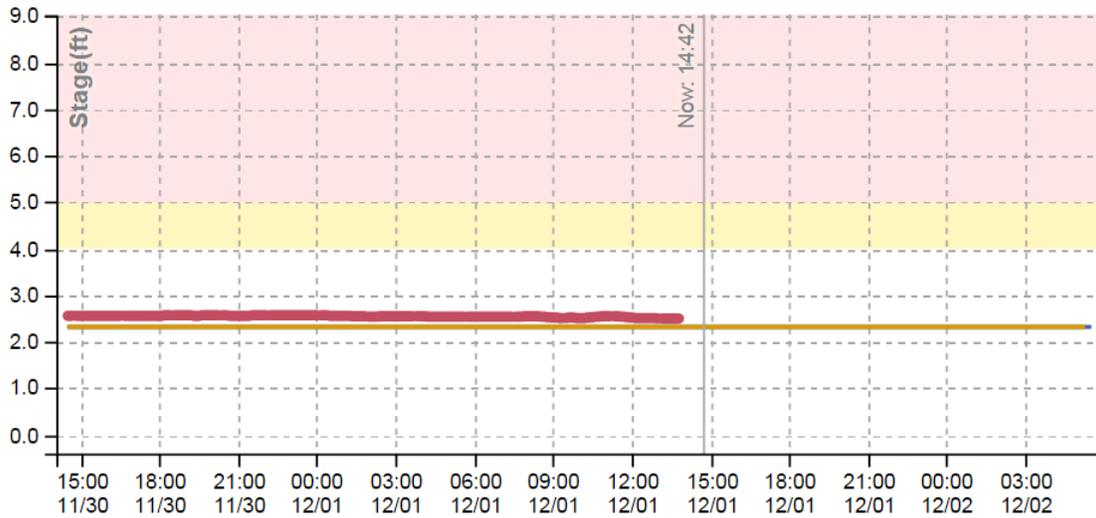
Note that at these USGS gauge locations there are two levels at different stages. The first level is marked in yellow as a “watch” status, and the red level is considered to be a “warning” status. The models are run every 15 minutes with a continuous calculation of soil moisture. The rainfall is based on the Dual Pol rainfall from either the EWX or GRK NWS NEXRAD Doppler radar, gauge adjusted radar rainfall that utilizes the Dual Pol rainfall and adjusts it to 196 ground gauges, or based upon the NWS High Resolution Rapid Refresh Rainfall. This is a 12 hour forecast rainfall product that is produced every 15 minutes.

Note in the screen shot below a picture of the model forecast during a dry period.



LKC_DS_LakeCreekPkwy

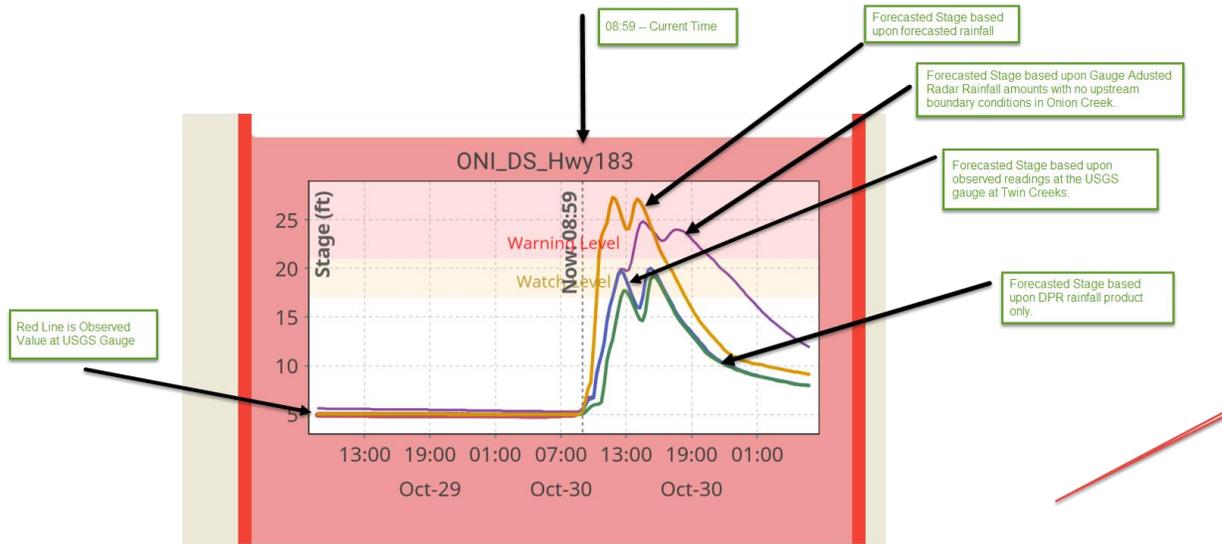
 Save



GARR + QPF Stage **DPR Stage** **GARR Stage** **Observed Stage**

Basin	Lake Creek
ID	08105886
Status	0
DPR Stage (ft)	2.32
DPR Discharge (cfs)	0
Time of Max Future Simulated w/ DPR	2015/12/01 14:45
GARR Stage (ft)	2.32
GARR Discharge (cfs)	0
Time of Max Future Simulated	2015/12/01 14:45
GARR + QPF Stage (ft)	2.32
GARR + QPF Discharge (cfs)	0
Time of Max Future Simulated w/PV+HRRR	2015/12/01 14:45
Observed Stage (ft)	2.50
Observed Discharge (cfs)	1
Time of Most Recent Observed	2015/12/01 13:45

Below is an annotated screen shot from a flood that occurred in Austin on October 30, 2015.



This screen shot shows the multitude of rainfall products available for use. Also note the time the forecast was made was at 08:59. At that time, the observed values of the gauge was not reading any flow. However, the forecasts shown on the right of the line describe the rapid flash flooding that occurs on this creek. This was a forecast for a 350 square mile watershed that has its headwaters well outside the City of Austin jurisdiction – Blanco County.

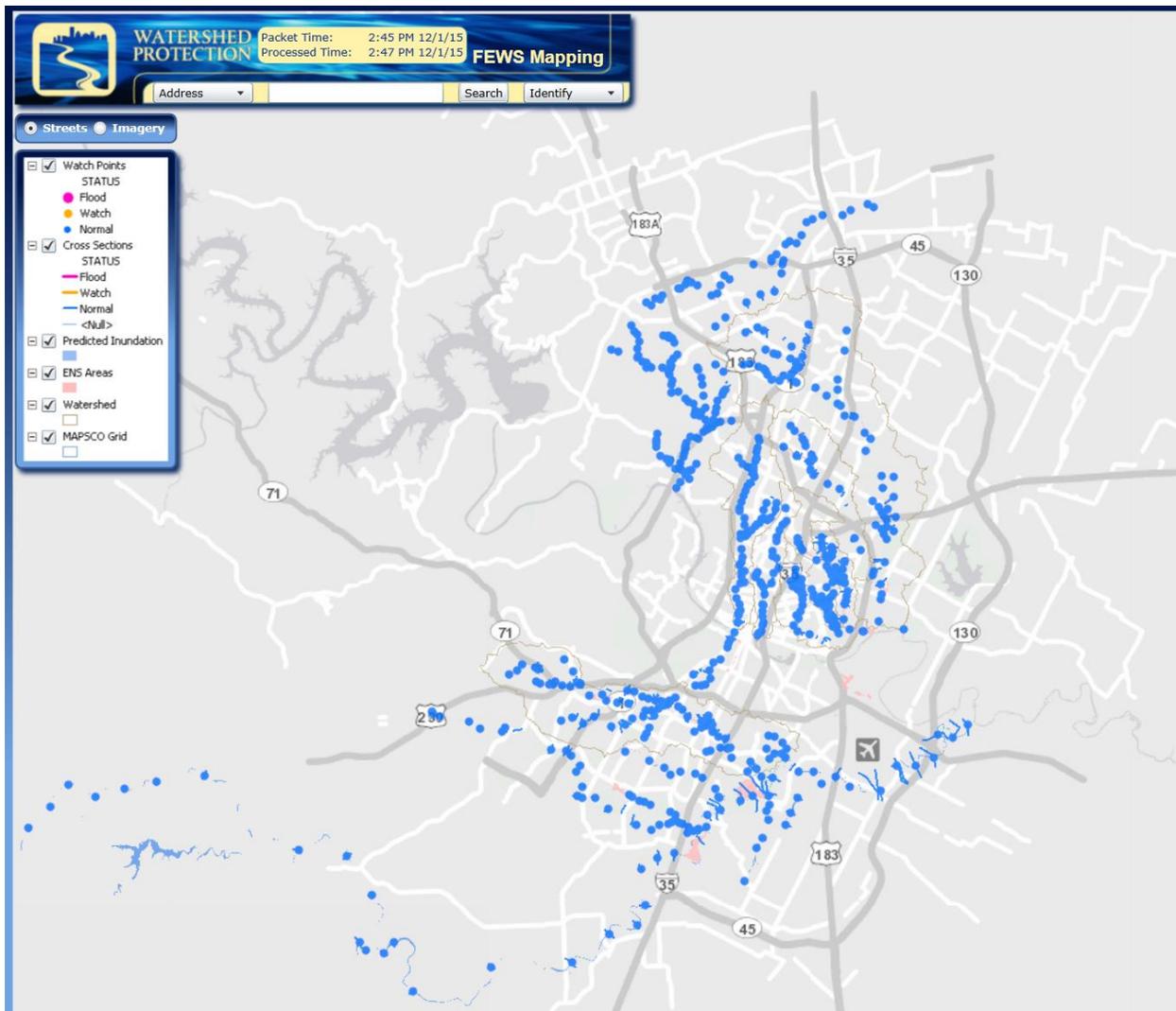
Forecasts are made for multiple points within a watershed. Every 15 minutes, there are two XML files produced – one based upon the gauge adjusted radar rainfall (rainfall that has fallen to the ground) and the other one based upon the HRRR rainfall (forecasted rainfall). Appendix B contains sample XML files. Note that at each line, a forecast is made.

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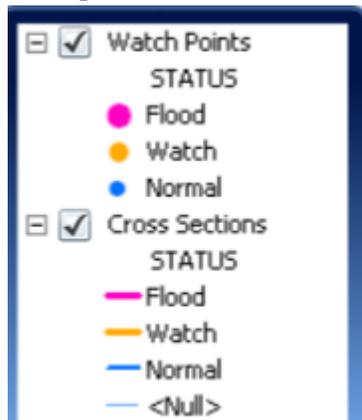
Time forecast was made: 2015-10-30 05:45 CDT
Forecast to occur at 10/30/2015 at 11:45 CDT

<DataPacket Agency="City of Austin Flood Early Warning" PacketDateTime="2015-10-30 05:45:00 CDT">
  <Watershed Name="Lake Creek" Wshed_ID="LKC">
    <Tributary Name="Lake Creek" Trib_ID="LKC_Main">
      <Point Name="LKC_DS_LakeCreekPkwy" WP_HydroID="15125" XS_HydroID="2881" Stage="2.602" Discharge="2.116" ForecastDateTime="10/30/2015 11:45:00 AM CDT" Status="0"/>
      <Point Name="LKC_DS4_SH45" WP_HydroID="15112" XS_HydroID="2815" Stage="0.032" Discharge="0.985" ForecastDateTime="10/30/2015 11:45:00 AM CDT" Status="0"/>
      <Point Name="LKC_WillowWay" WP_HydroID="15101" XS_HydroID="2757" Stage="0.257" Discharge="2.015" ForecastDateTime="10/30/2015 11:45:00 AM CDT" Status="0"/>
      <Point Name="LKC_US_WillowWay" WP_HydroID="15102" XS_HydroID="2759" Stage="0.098" Discharge="2.139" ForecastDateTime="10/30/2015 11:45:00 AM CDT" Status="0"/>
    </Tributary Name="Lake Creek" Trib_ID="LKC_Main">
  </Watershed Name="Lake Creek" Wshed_ID="LKC">
</DataPacket Agency="City of Austin Flood Early Warning" PacketDateTime="2015-10-30 05:45:00 CDT">
  
```

The XML files are read by an internal ArcGIS application that produces floodplain polygons and anticipated annotation. Below is a screenshot of that application. The points on the map are where the forecasts are made.



Note that for each of the cross sections and points that there are three status indicators available



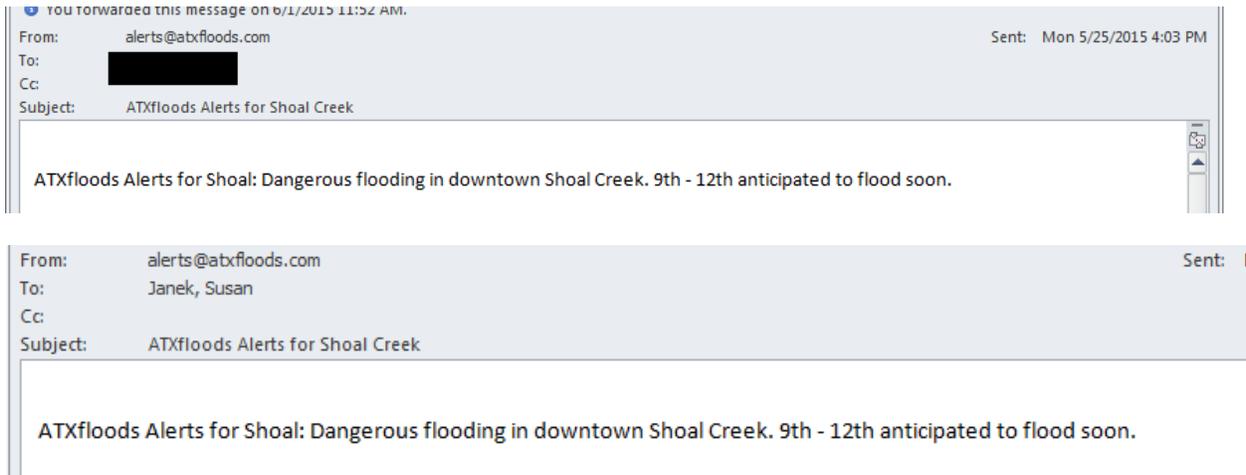
They are Flood, Watch, and Normal.

This information is used by City of Austin Flood Warning Staff, Emergency Manager, and First Responders during a flood event.

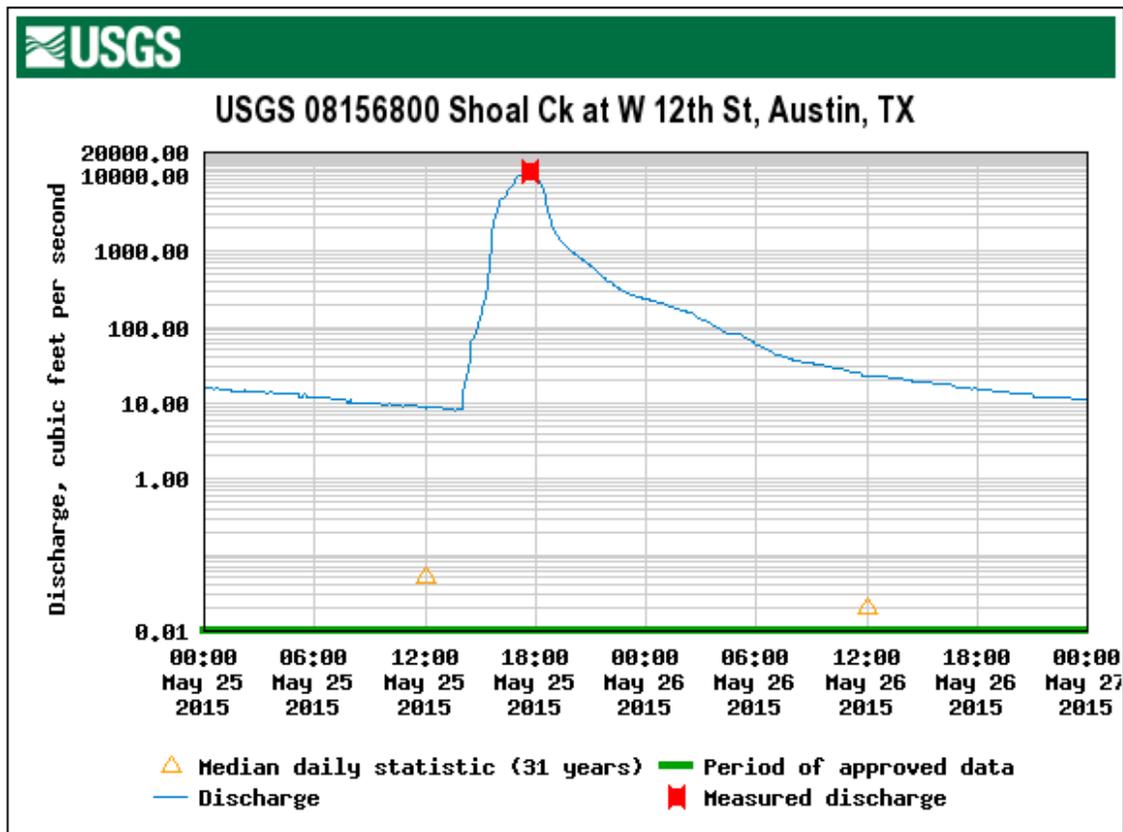
Using this information, City of Austin Flood Warning staff can issue public “watches” using a subscription service known as ATX Floods Alerts. Below is a link to that website.

<https://www.atxfloods.com/alerts.php>

An example of an email alert from this site is as follows:



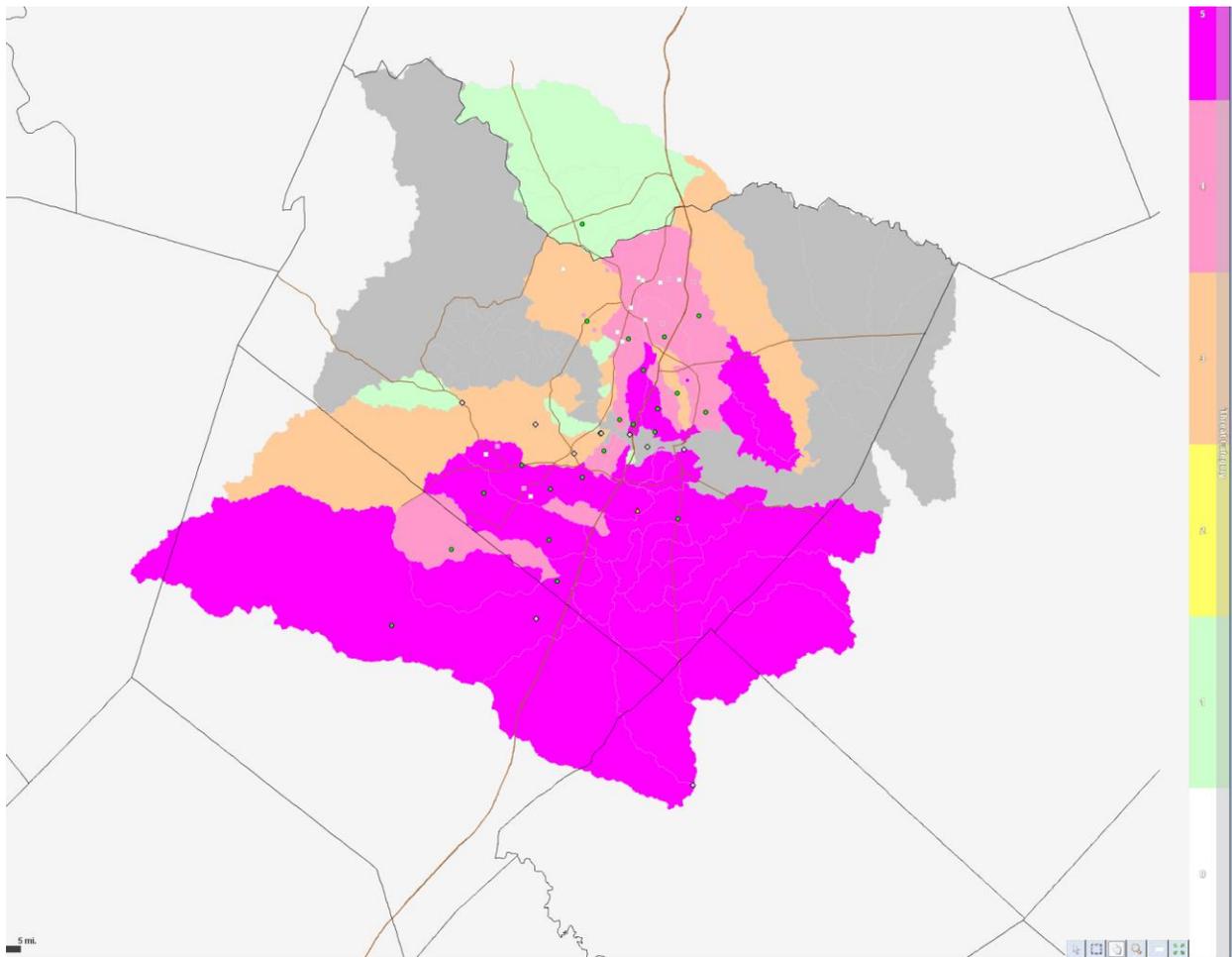
Note that the peak occurred was at 17:40 and the ALERT was issued at 16:03.



In addition to flood forecast models, the City of Austin provides information to the public concerning flooded roadways from a publicly available website www.atxfloods.com. This website relies on inputs from many different jurisdictions. During the October 30, 2015 floods, this website saw 207,489 visits from 135,207 users during the storm. Web traffic spiked in the middle of the day on October 30, 2015 with approximately 20,000 visitors on the site at the time.

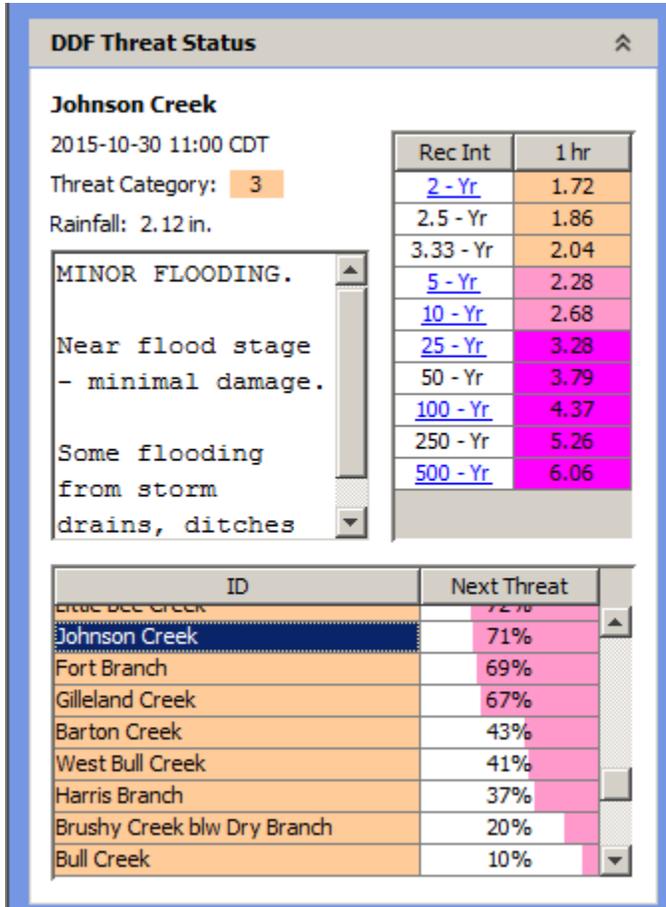
For more information on warnings, please see the draft Storm Report for 10/30/15.

Regarding watersheds with **no forecast models available**, the flood threat levels are based upon rainfall depth-duration-frequency amounts. Below is a screen shot from the October 30, 2015 storm indicating how these threats are conveyed by color.



Depending on the time of concentration of the watershed and the amount of rainfall, each watershed within Austin has a threat level assigned to it. ‘

Below is a threat score for Johnson Creek. Note that Johnson Creek does not have a forecast model available to it.



By clicking onto the available floodplains for the Recurrence Interval, a KML file appears of the approximate floodplain (based upon the DFIRM FEWMA models).

In conclusion, the Austin Flood Warning program determines threat automatically for all watersheds within its jurisdiction.

Flood Threat Recognition 2.a.2

Provide documentation that demonstrates that the community is prepared to receive flood warnings on a 24-hour basis from what federal, state, or other agencies.

The City of Austin is a National Weather Service documented StormReady community. Flood warnings for Homeland Security and Emergency Management are received from the federal government (National Weather Service and FEMA), the state (State Department of Emergency Management), and the Lower Colorado River Authority.

Will the HSEM Flood Plan capture this?

In addition, Watershed Protection Development Review Flood Warning Staff receive automated alerts from iNWS, the USGS, and the LCRA.

Below are screen shots from the National Weather Service, the USGS, and the LCRA.

Messages (461)

561-49

Edit

Nov 6, 2015, 6:08 AM

Event cancelled. Areal Flood Advisory from 11/6/2015 6:07 AM to 6:45 AM CST for Bastrop County.

[http://inws.wrh.noaa.gov/
weather/alertinfo/2671892](http://inws.wrh.noaa.gov/weather/alertinfo/2671892)

[0](#)



Nov 6, 2015, 11:46 AM

New event. Areal Flood Advisory from 11/6/2015 11:46 AM to 2:45 PM CST for Blanco County.

[http://inws.wrh.noaa.gov/
weather/alertinfo/2672096](http://inws.wrh.noaa.gov/weather/alertinfo/2672096)

[3](#)



Text Message

Send

Messag...(467)

1 (410) 100-...

Edit

Call

FaceTime

Add Contact

Text Message

Nov 27, 2015, 4:06 AM

FRM:WaterAlert@usgs.gov
MSG:119 cfs Streamflow,
2015-11-27 04:00:00 Bull
Ck at Loop 360 nr Austin,
TX
[http://water.usgs.gov/hns?
QStjx:08154700](http://water.usgs.gov/hns?QStjx:08154700)



Text Message

Send

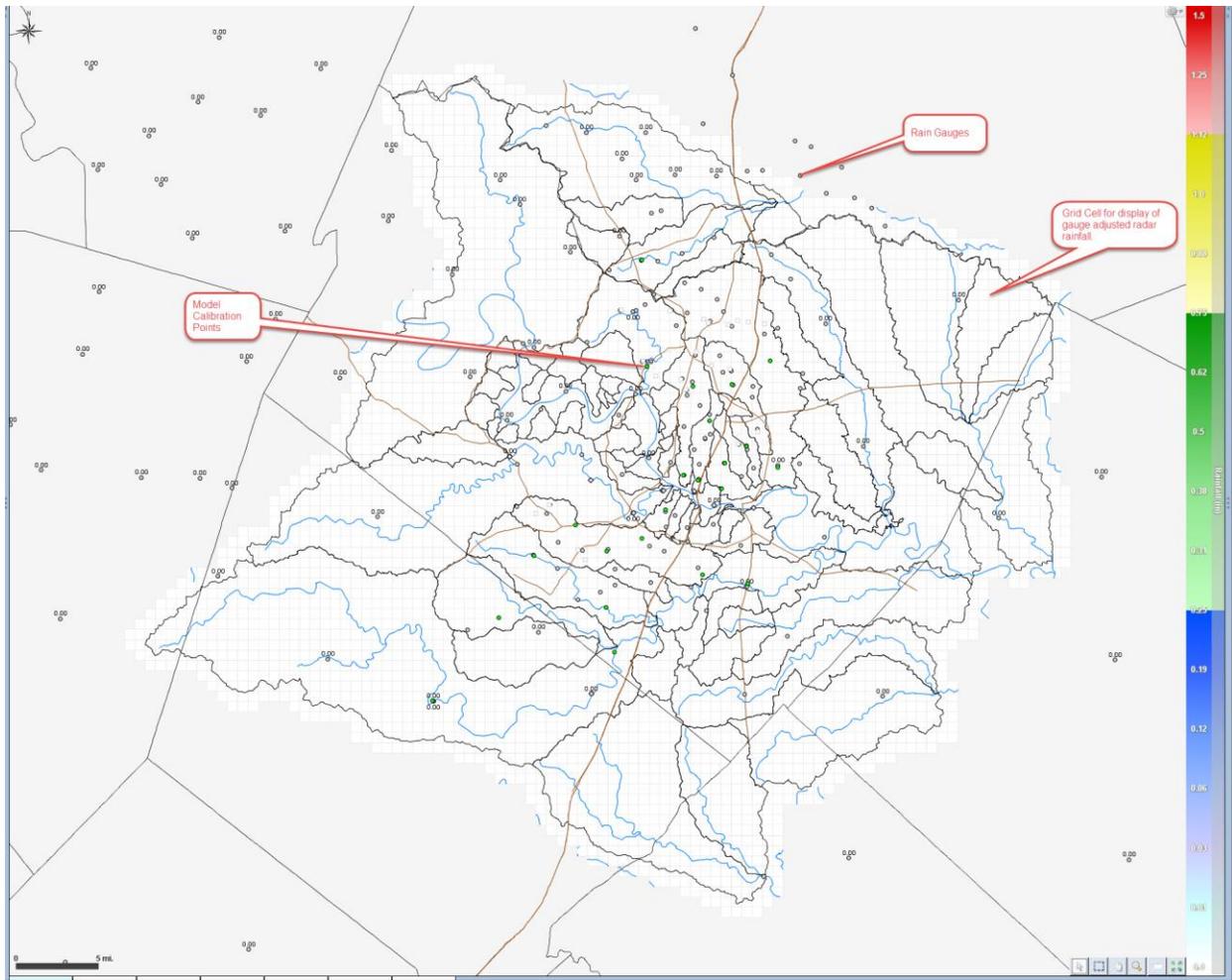
Flood Threat Recognition 2.a.3.

If the community or other local agency uses rainfall and/or runoff data on a real-time basis and makes flood forecasts from these data, provide a description of the system.

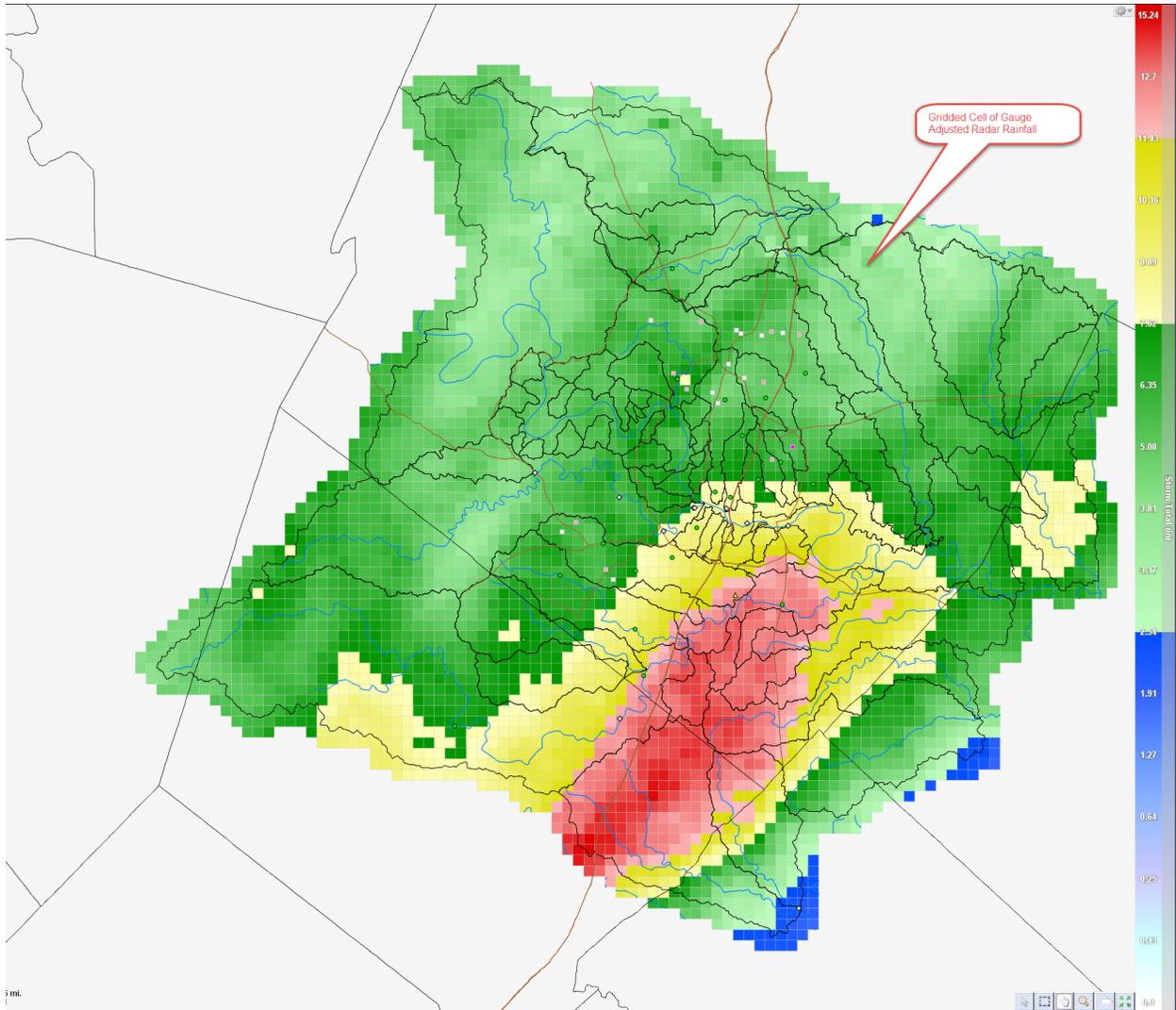
The City of Austin utilizes a private service with Vieux and Associates, Inc. for a hosted solution that provides the following:

- Capture of gauge rainfall from the City of Austin, the Lower Colorado River Authority, the USGS, and Upper Brushy Creek WCID;
- The Dual Pol rainfall products from two NWS NEXRAD Doppler radar sites (EWX – New Braunfels, TX and GRK – Granger, TX)
- Continuous forecasting of models using real-time and forecasted rainfall (this includes the rainfall products from gauge adjusted radar rainfall, Dual Pol NEXRAD Doppler Rainfall, and the NWS HRRR 24 hour forecasted rainfall)
- Display of Depth-Duration-Frequency anticipated threats based upon rainfall
- Automated alerts based upon forecasted flood threats
- Mobile application of system

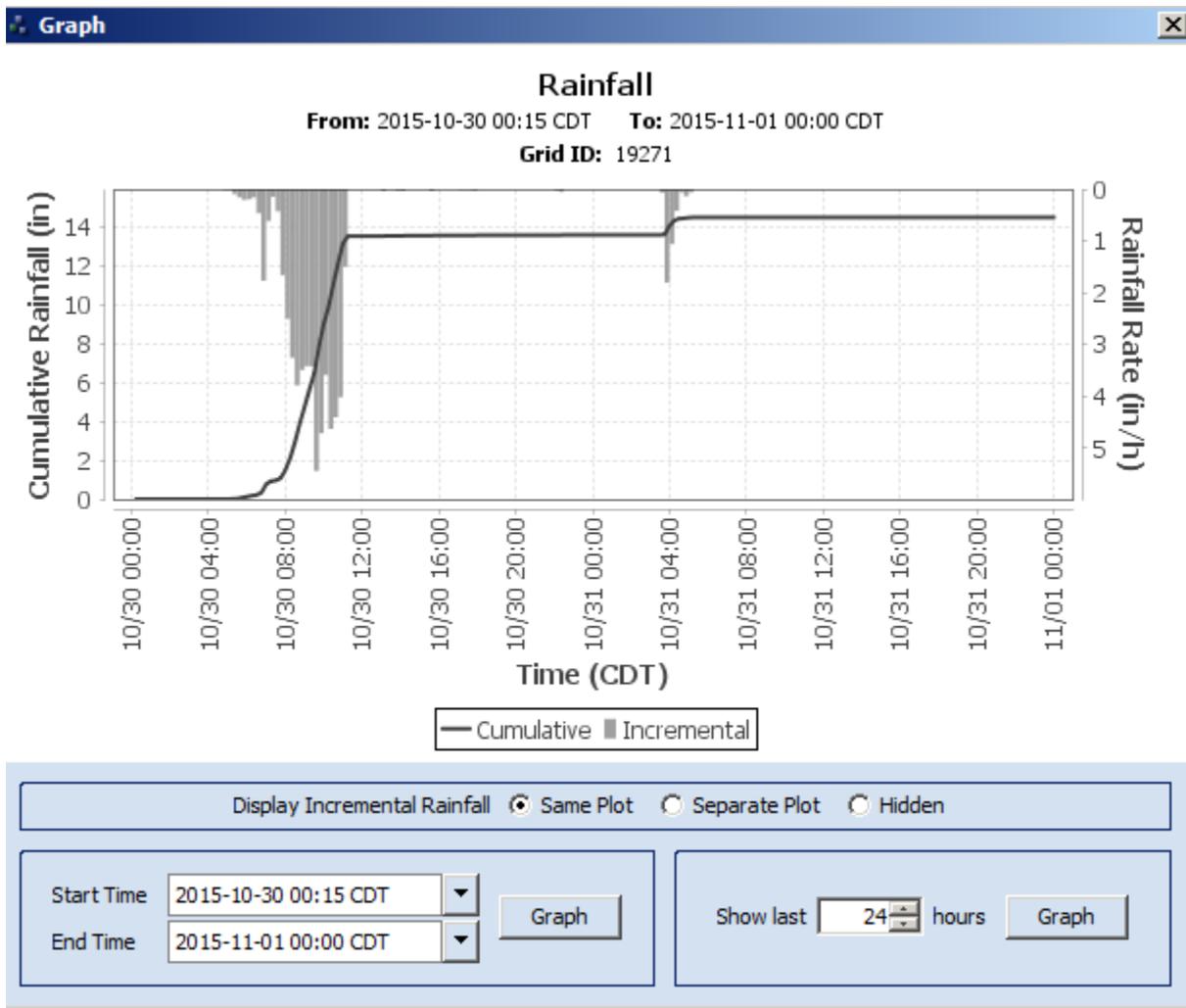
Below are some screen shots from the system.



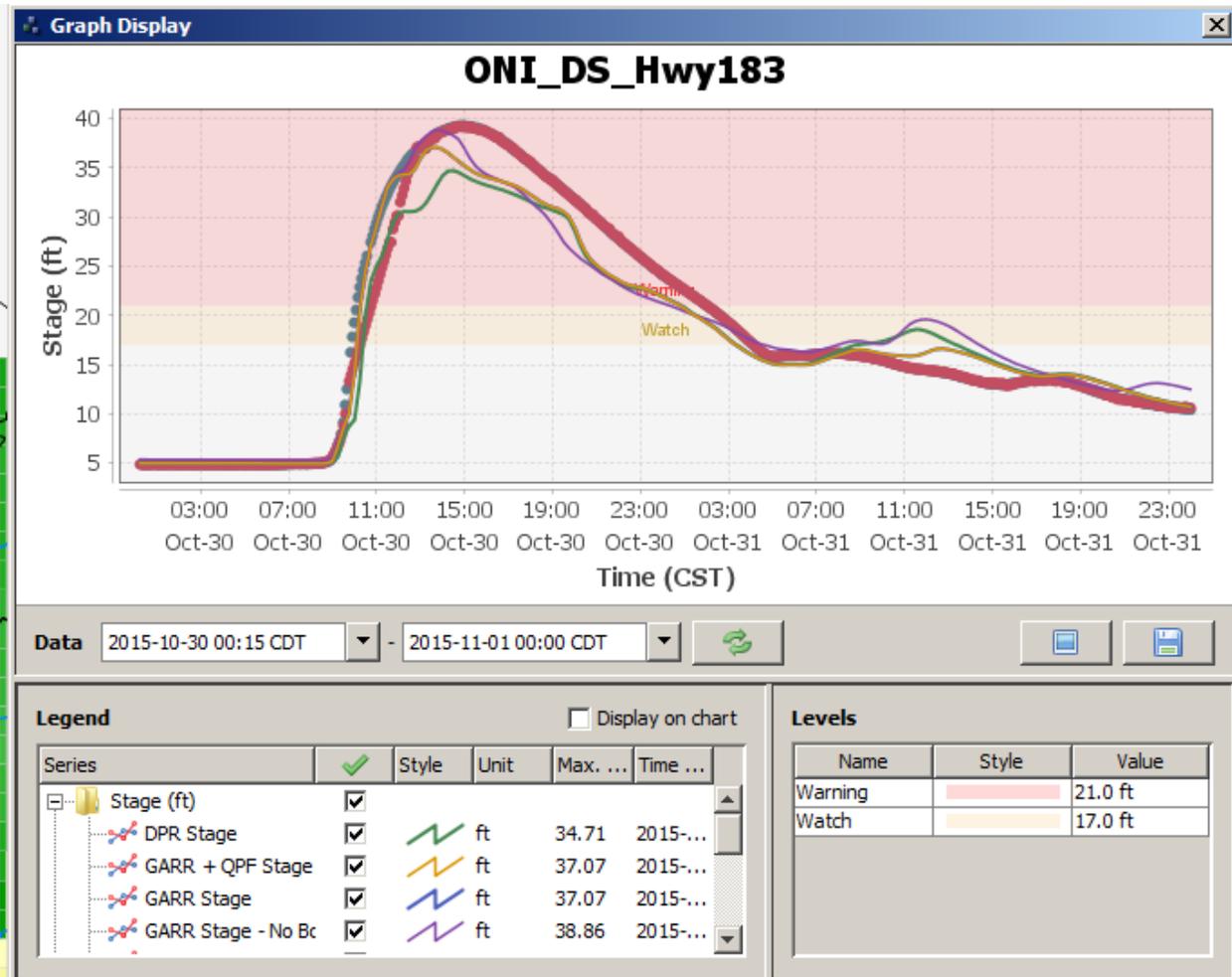
This screen shot shows the product from the October 30, 2015 flood.



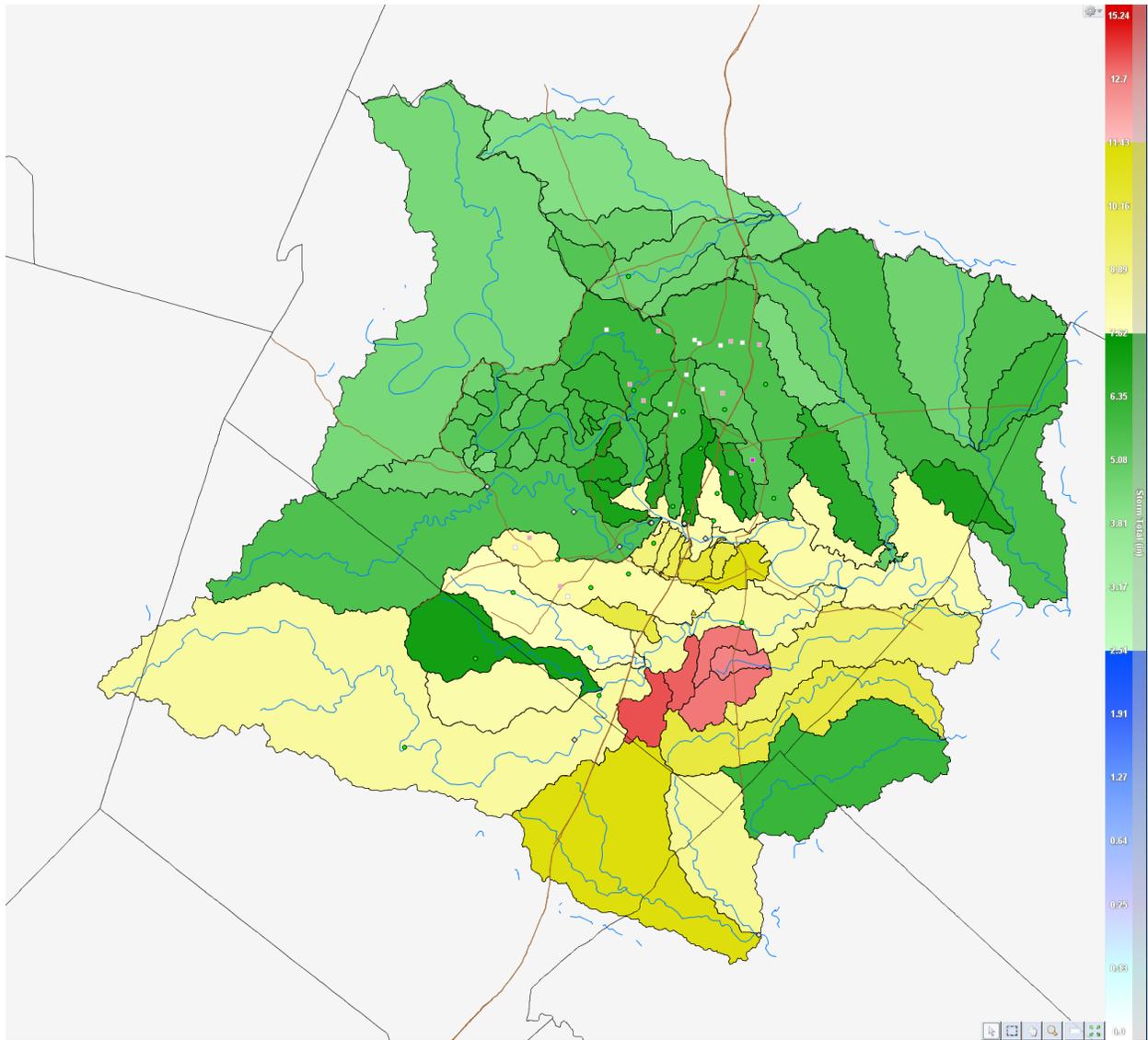
This screen shot shows the rainfall hyetograph for a one square kilometer gauge adjusted rainfall cell.



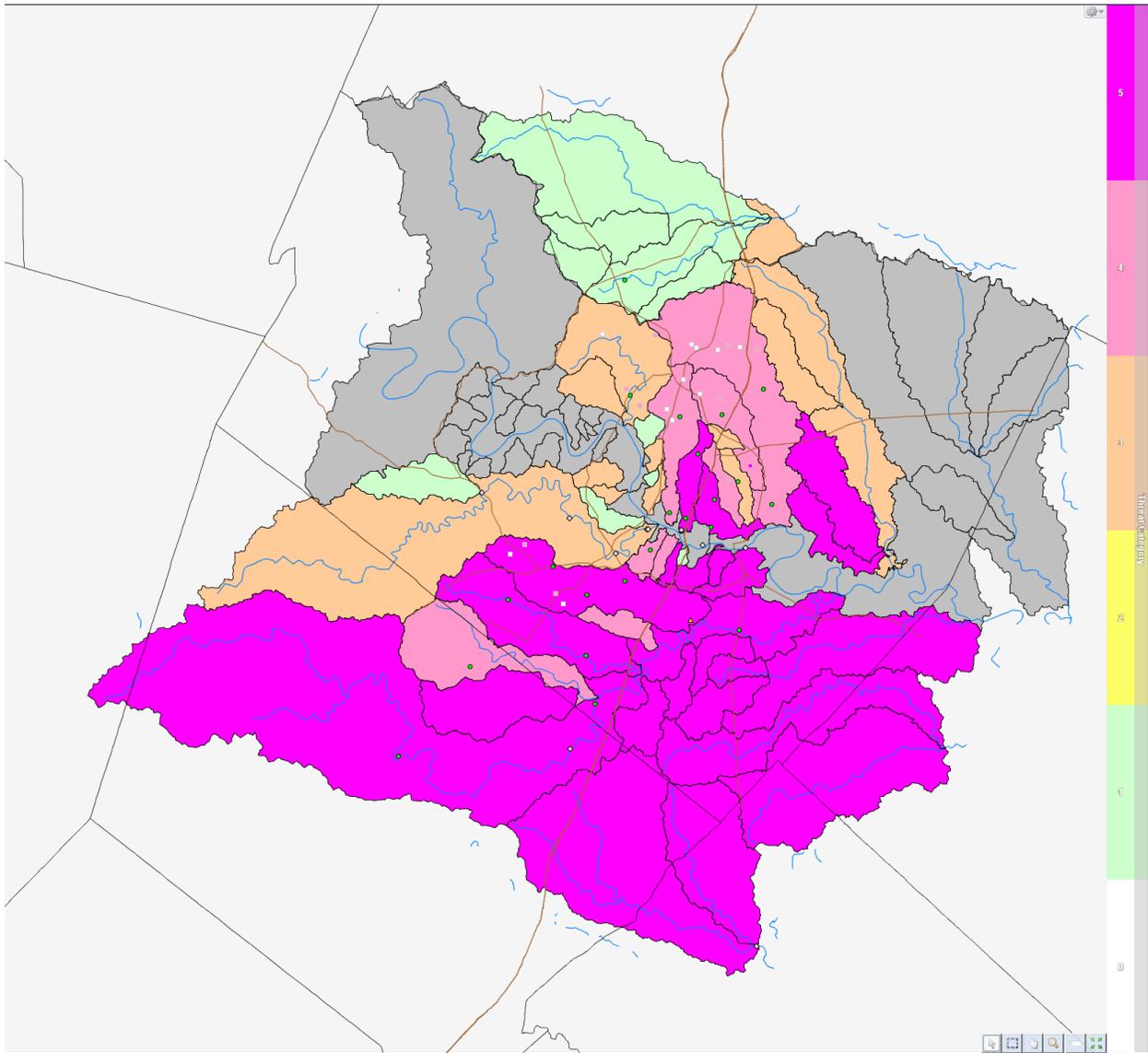
This screen shot shows the model forecast made during the storm.



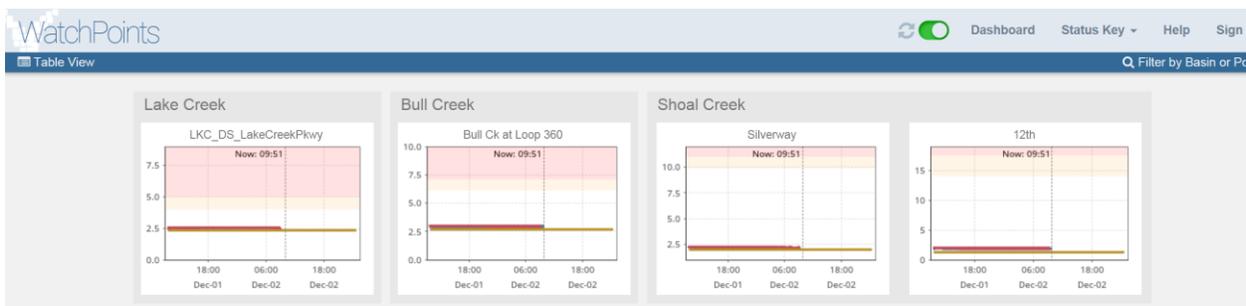
This screen shot shows the basin averaged rainfall from the storm.



This screen shot shows the Depth-Duration-Frequency analysis that was made during this rain storm.



This screen shot shows an over view of the forecasts at the location of the USGS gauges.



This product is password protected. There is also a mobile internet device that is available.

As mentioned earlier, information from the models is brought together in an XML file that is then read by the City’s ArcGIS mapping server for production of maps for forecasted flooding to first responders.

Appendix C contains documentation used for putting together the forecast models and setting up the ArcGIS files for automated mapping.

Flood Threat Recognition 2.a.4

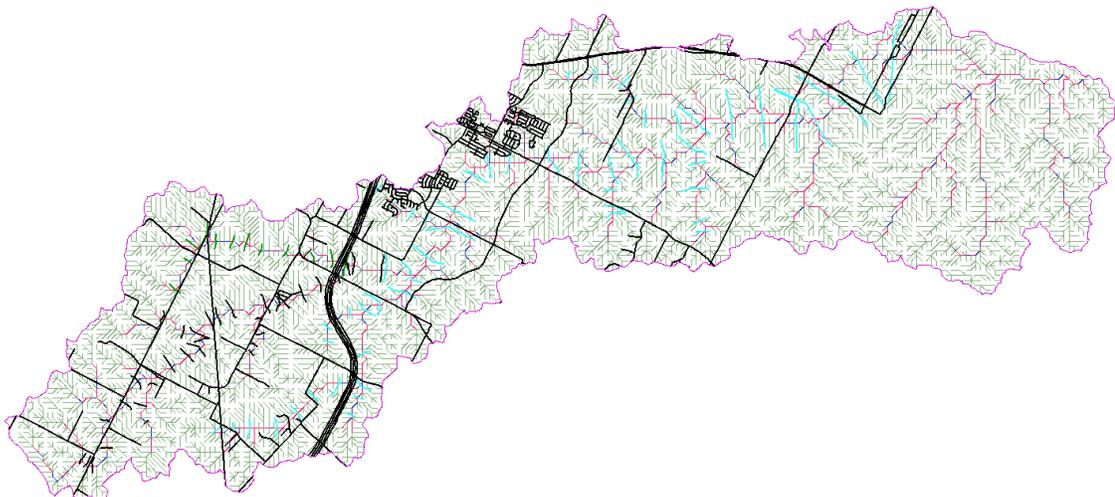
Provide documentation showing the method used to predict downstream arrival time and peak flow or elevations.

The City of Austin uses the Vflo model (<http://www.vieuxinc.com/vflo.html>) The City has two desktop licenses available for the model development. Model development and calibration is internal to the City of Austin. Hosting is considered a “service.”

This model is a gridded, physics-based hydrologic model that can simulate stormwater runoff based on geospatial data to model interior locations in the drainage network.

Where there are physical observations made of stage and discharge (either USGS gauges or City of Austin gauges), forecast models are developed.

Below is a screen shot of one of the watersheds within Travis County.



This particular model is built using 400 ft X 400 ft grid cells. This is a basin that is approximately 55 square miles. Below is a network analysis of the basin. Note that model inputs include the Digital Elevation Model (DEM), information from SURRGO for the soils (this includes roughness, saturated hydraulic conductivity, wetting front, porosity, and soil depth), existing impervious cover, and a calculated boundary condition of the initial saturation.

Similar to RAS, this model cuts cross sections through the DEM and develops flow paths. Forecast points are user defined. For this particular model, there are greater than 70 forecast points developed.

The model is calibrated using gridded rainfall data that is obtained either by the NWS or from Vieux and Associates (gauge adjusted radar rainfall). Weighted gauge only data (Theissen method) can also be used.

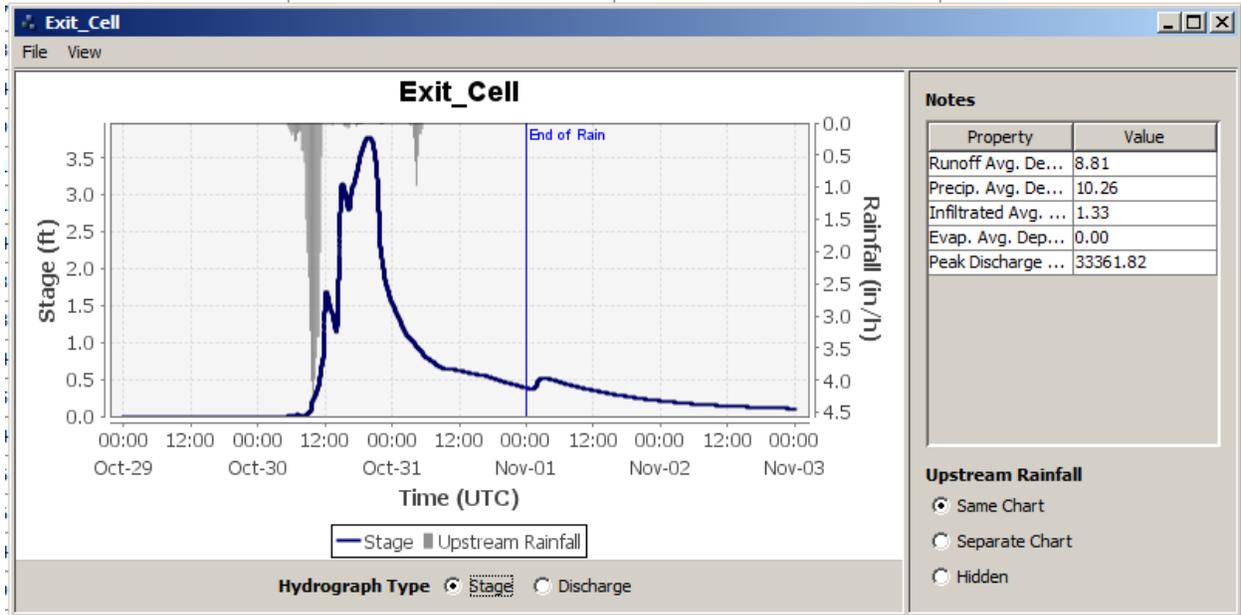
Models are calibrated using the result of the model run with the observed stage and discharge values from the field gauges. Models are calibrated using gridded rainfall that has been made available since November 2004. The desktop version of this model has the ability to set up long-term (one-year and longer) simulations for calibration purposes.

Once the model calibration has been made, the models are version checked and sent of continuous hosting.

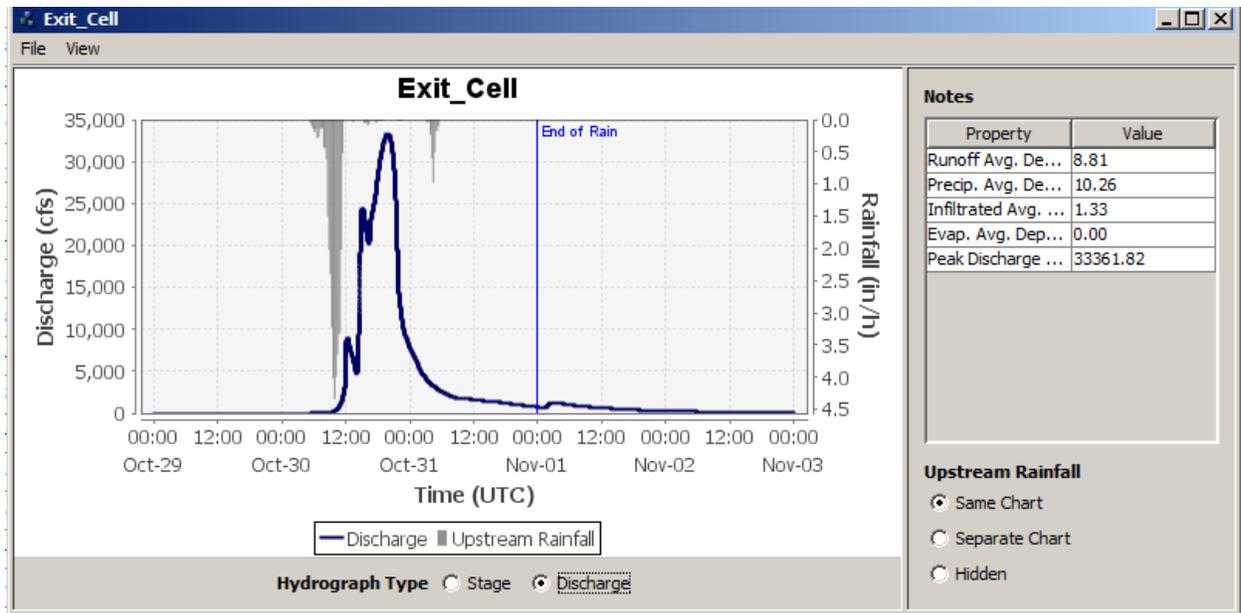
Outputs from this model includes information on the time of the model run, the rainfall input file, the location of the forecast point (cell), the runoff depth (inches), the Flood Time, Stage Peak, Time of Stage Peak, Flow Peak (cfs), and Time of Flow Peak. See the screenshot below.

Device	Time	Notes	Cell	RunoffDepth (in)	Flood Time	Stage Peak (ft)	Time of Stage Peak	Flow Peak (cfs)	Time of Flow Peak
	2015/12/02 16:11:08	202015_DRE_400ft_Assumed_LUTC	Out_Cell	9.81	2015/10/20 09:30:00	3.8	2015/10/20 18:56:59	32361.8	2015/10/20 18:56:59

Below shows a Stage Hydrograph for a particular forecast point.



Below shows the Discharge Hydrograph for that same forecast point.



Information on how to set up the forecast models and the associated forecast maps are included within Appendix C.

Flood Threat Recognition 2.a.5

If flood warnings are received from another agency, include a

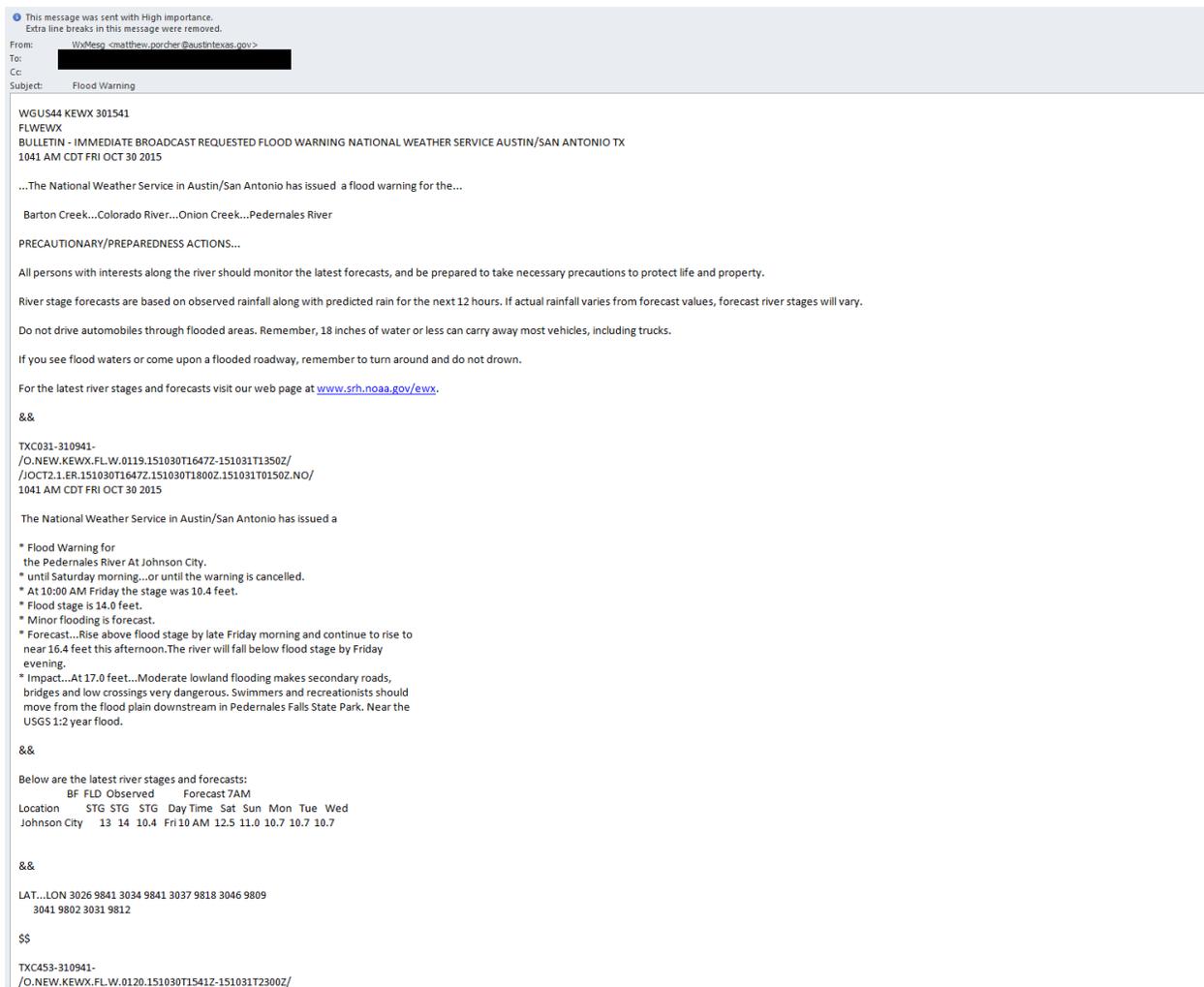
■ **Description of how the notice is received.**

There is only one National Weather Service Advanced Hydrologic Prediction Service forecast point in Austin. It is ATIT2

<http://water.weather.gov/ahps2/hydrograph.php?wfo=EWX&gage=ATIT2>

Information on this gauge is received by email to Flood Warning System Operators, by text to Flood Warning System Operators, or through communication directly with the National Weather Service Weather Forecast Office.

Below is a screen shot of the email message.



Below is an example of a text message that is received.

Clear All

1 (410) 100-192

Cancel

1 of 3

FRM:

SUBJ:TX - Travis County

MSG:

The flood warning continues for the Onion Creek At Hwy 183.

* At 12:36 PM Friday the stage was

(Con't) 2 of 3

35.6 feet.

* Flood stage is 17.0 feet.

* Major flooding is occurring and Major flooding is forecast.

* Forecast. The river will



Delete



Forward

- ***Identify local agency procedures for monitoring the system.***

Flood Warning System Operators receive automated alerts are required to operate on a 24 hour/7 day basis at all times. See Appendix D for FEWS Operating Procedures.

- ***Provide examples of one or more flood forecast notices issued to the community.***

See information in the two Storm Reports found in Appendix A.

- ***If the community has its own gage system, such as an ALERT system, a copy of the maintenance procedures for the system and records showing that the system is being maintained.***

See Appendix E for information pertaining to gauge maintenance as well as a report of gauge maintenance for the past year.

See <http://hydromet.lcra.org/coa/coa.aspx#> for real-time information from the Flood Warning System.

Flood Threat Recognition 3

The flood threat recognition system must be correlated to the flood inundation map, so that the emergency manager can see what areas will be affected by the predicted flood.

The real-time mapping system provides polygon forecasts with attributes of time and date, stage, and discharge for watersheds in Austin. In addition, these maps are made available to first responders during a storm. After the flood event, information from those polygons is cross-referenced with the Flood geodatabase that was created for buildings and for road structures that may be impacted by flooding. This geodatabase is included in Appendix F.

The geodatabase was created by using the FEMA DFIRM models, the elevation data from the City of Austin, and using either Elevation Certificates or estimates from the elevation data set to identify lowest elevations of buildings. The elevation of the bridges was based upon surveyed data that occurred during the development of the FEMA DFIRM maps.

After the storm, the water surface elevations from the forecasts and/or measured high water marks are used to determine the depth of flooding in a building.

Below is a screen shot of the forecast modeling program.

