TWDB Contract No. 1600012034
Final Report
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Website and Public Data Feed for Low-Water Crossings

City of Austin
June 10, 2019

City of Austin Watershed Protection Department

The City of Austin's Watershed Protection Department protects lives, property and the environment of our community by reducing the impact of flood, erosion and water pollution.

The Flood Early Warning System monitors rainfall, water levels and low water crossings in Austin 24 hours a day, 365 days a year. During a flood, FEWS works closely with emergency managers for the most effective and timely community response.
http://www.austintexas.gov/department/flood-early-warning-system

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Definition of Acronyms Used

API
Application Programming Interface (API)

ATXFloods
Austin Texas Floods

AWS
Amazon Web Services

CAPCOG
Capital Area Council of Governments

CCP
Waze Connected Citizens Program

CSV
Comma-Separated Values

CTECC
Combined Transportation, Emergency & Communications Center

CTXFloods
Central Texas Floods

EMS
Emergency Medical Services

FEWS
Flood Early Warning System

TWDB
Texas Water Development Board

WCAG
Web Content Accessibility Guidelines

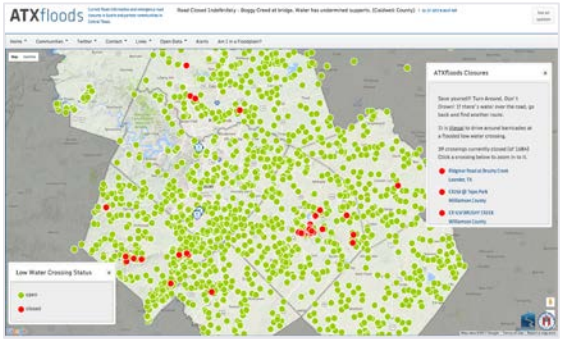
XML
eXtensible Markup Language

Background

Many residents know that Central Texas is part of the Hill Country, but what they may not know is that it is also part of an area known as Flash Flood Alley. This is due to the area's steep terrain, shallow soils, and susceptibility to heavy rainfall events.

Also due to the unpredictable nature of our rains, many creeks and streams are dry more often than they are swollen with rain, so many older roadways have bridges or culverts over these waterways that are considered low-water crossings. A low-water crossing is passable when dry, but during heavy rains they are designed to flood -– and with water rushing over a low-water crossing, it is dangerous to pass by car, truck, or foot. There are many such crossings throughout the Central Texas area.

In 2012, a Code for America Fellow worked with the City of Austin's Watershed Protection Department to create a mapping tool to show whether low-water crossings were open or closed. The project used several free and/or open-source tools, including CartoDB, Google Docs, and JavaScript, allowing it to be expanded and replicated by additional municipalities.



ATXfloods.com in 2017

The service became an extremely popular method of communicating road closure information, with increasing usage by the public as well as television broadcasters. Other communities were added with a corresponding increase in the number of data points, growing from a handful of crossings in the City of Austin in 2011 to its current state, which covers thousands of data points in 15 different jurisdictions, including greater Travis County, Bastrop County, and Hays County. It also grew in scope, showing not just closed low-water crossings but also roadways that are not designed to flood, but frequently do.

By 2017, ATXfloods.com was a victim of its own success, having outgrown the framework upon which it was built. With so many groups now using the tool for key tasks, the Watershed Protection Department's Flood Early Warning System team received a grant from the Texas Water Development Board (TWDB) to improve the performance and usability of this

increasingly important service. This work was completed by the City of Austin's Office of Design & Delivery.

Objectives

The grant contract scope outlines eight primary objectives:

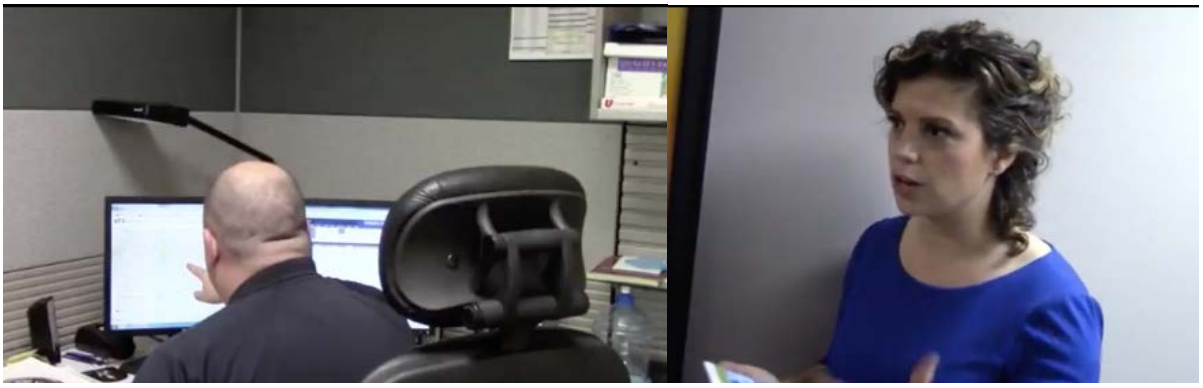
1. Rewrite program code for speed of dashboard users
2. Setup cloud database from open feed eXtensible Markup Language (XML) file
3. Investigate means and methods for audible alerts based upon development of open-source information that can be accessed by third-party application developers for geocoded alerts
4. Notifications for administrators after 24 hours if roads are still listed as closed
5. Include a form for users to use to report incidents based upon location and then set to the appropriate jurisdiction
6. Reorganize the website to display a list of closed roads by jurisdiction
7. Other enhancements as later defined
8. Develop specifications for long-term maintenance of the website

Process

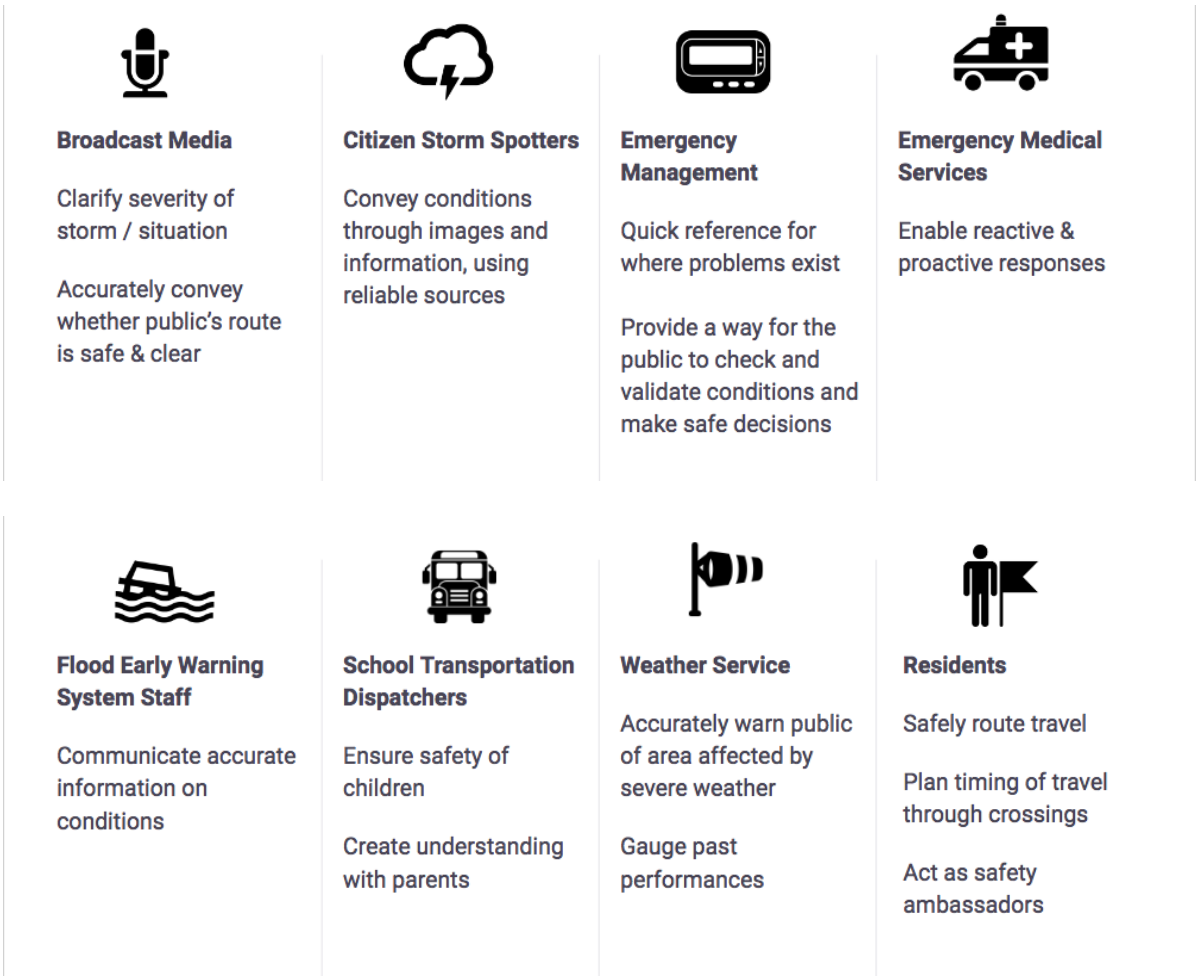
To work toward these objectives, we assembled a multidisciplinary team including researchers, designers, developers, scientists, engineers, emergency managers, and product managers to work in overlapping phases of Discovery, Design, and Iterative Development.

Discovery

In the Discovery phase, we conducted interviews with 25 key stakeholders and end-users of the service to identify key tasks, challenges, and motivations. These included interviews with Broadcast Media, Citizen Storm Spotters, School District Transportation Dispatchers, Emergency Management staff, Weather Services, Flood Early Warning System staff, and Emergency Medical Services (EMS). See detailed insights in Appendix J.



We also conducted a survey for public comment, distributing through email listservs, NextDoor, and Twitter and following up with respondents through 1-on-1 interviews. We attended a Deaf & Hard of Hearing Town Hall on Weather Alerts and held Open Meetings with a local civic technology organization, Open Austin, to share our plans and progress.

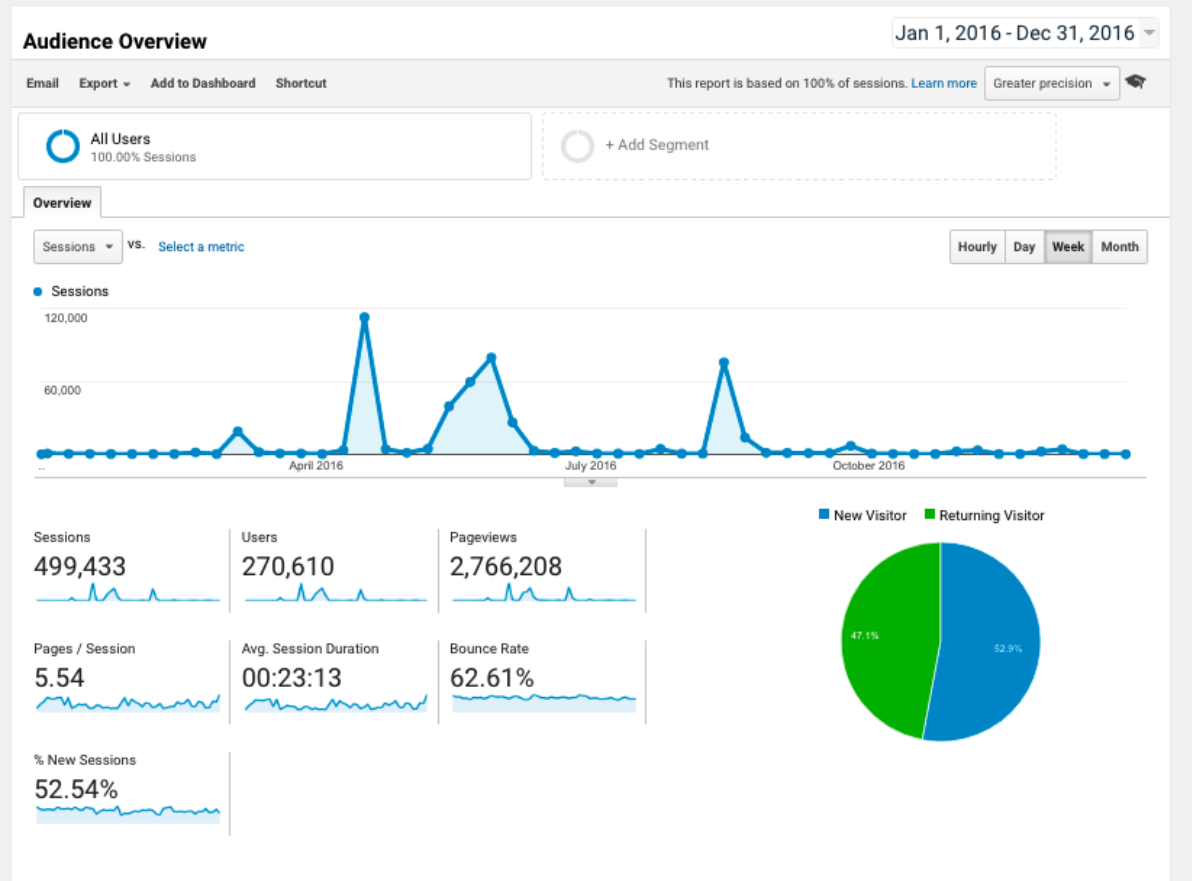


Motivations for using ATXfloods across different types of stakeholders

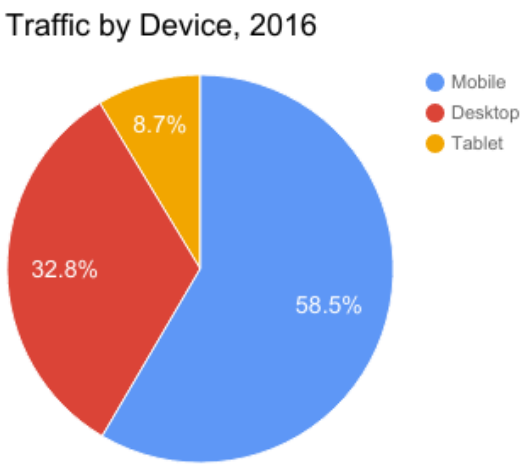
As part of the discovery process with administrative users, we audited the administration fields of the current service to identify opportunities to automate and streamline data entry, and we analyzed the web usage data over the course of 2016.

Jurisdiction	Address	Usage	Example ID #	Example of use	Notes	Can map to:
Bastrop / Caldwell County	Address	Block of street address	615	500 Blk	This area is interesting - Pettytown is a shared jurisdiction, so it looks like there are mult people (maybe somebody from Bastrop & someone else from Caldwell?) who maintains overlapping data points?	Point description
Marble Falls	Address	Clarification of location + jurisdiction	405	Between US-281 & Commerce St., Marble Falls,		Point description
Lockhart	Address	GPS coordinates	707	29.8607278,-97.7411527777 7778		Point description
Austin	Address	Jurisdiction	35	Austin, TX	Helpful to understand who entered the waypoint, less helpful to communicate exact location?	Point description
Travis County	Address	Jurisdiction	42	Travis County, TX		Point description
Sunset Valley	Address	Jurisdiction	113	Sunset Valley, TX		Point description
Leander	Address	Jurisdiction	193	Leander, TX		Point description
Round						Point

Administrative fields in the original version of ATXfloods and the data they generate



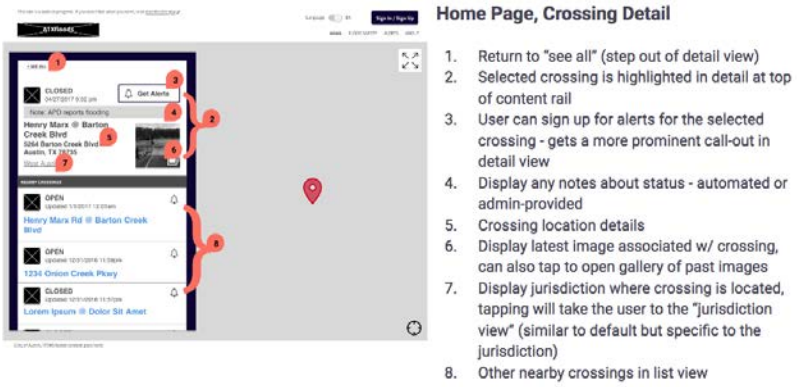
Audience overview of ATXfloods.com usage over the course of 2016



Usage of ATXfloods.com across Mobile, Desktop, and Tablet devices in 2016

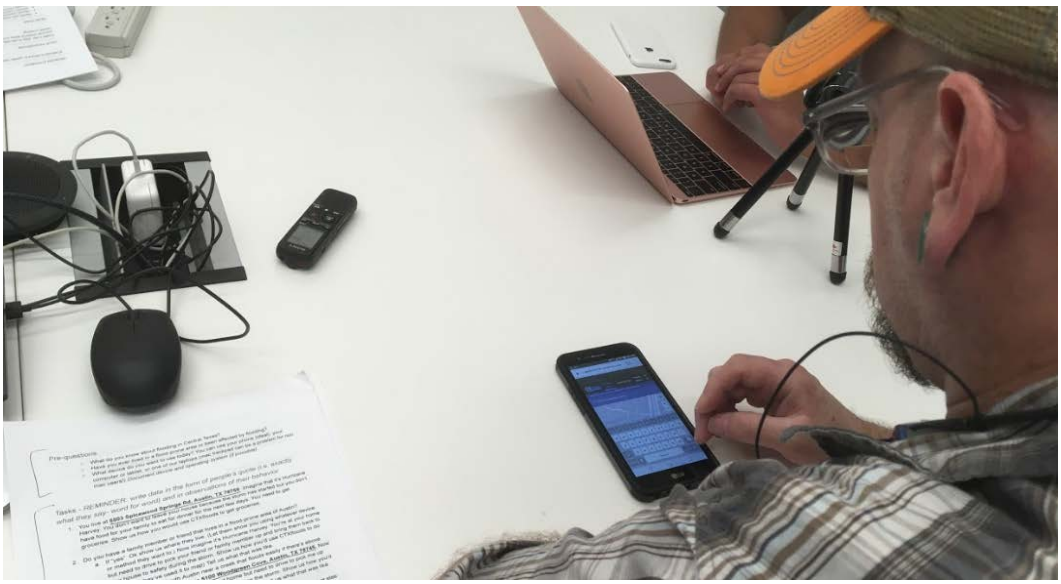
Design & Iterative Development

In the Design & Iterative Development phase, we sought to design and build a scalable framework and user interfaces to meet the needs of both residents and staff using the tool. For residents, this meant a tool that helps them gather the information they're looking for quickly and easily. For staff, it meant a tool that can help them update information quickly and easily. The resulting interface would improve our ability to provide timely, accurate data for the residents, broadcast media, school bus dispatchers, and emergency response staff.



Specification document with wireframe of early design

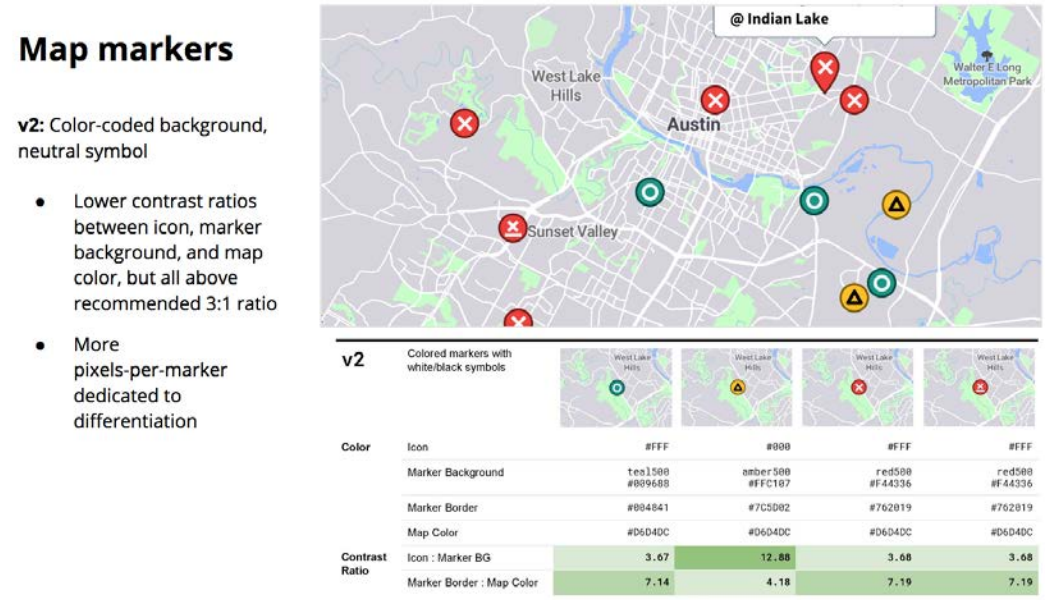
For both audiences, ease of use was a high priority. We assessed ease of use through an ongoing process of *usability testing*, which evaluated the effectiveness of design directions through feedback sessions with representative users.



Usability testing a version of ATXfloods on a mobile device

As a government service, we prioritized accessibility in our design and development to support a wide range of browsers, devices, and screen sizes, as well as users of all abilities. A core

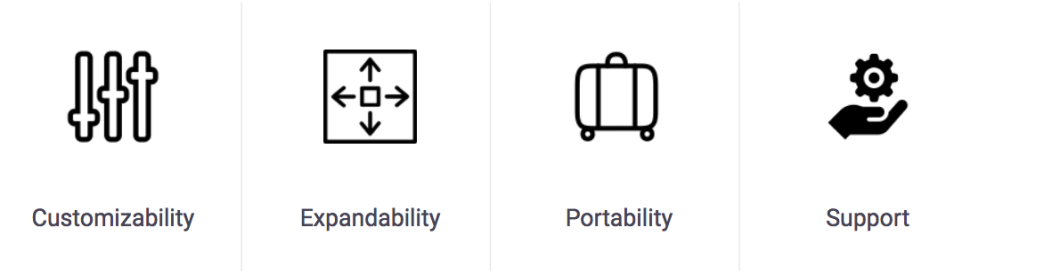
component of accessibility was support for mobile devices, which made up 58.5% of all visits to ATXfloods in 2016. Another component involved the design of our maps and pointers, which previously were difficult to discern for users with colorblindness (around 8% of the population).



Assessment of color options to maximize accessibility for users with colorblindness

Technology Selection

To ensure that our platform could grow and adapt with changes in technology and user behavior, we evaluated potential frameworks based on customizability, expandability, portability, and the size and activity of communities for ongoing support.



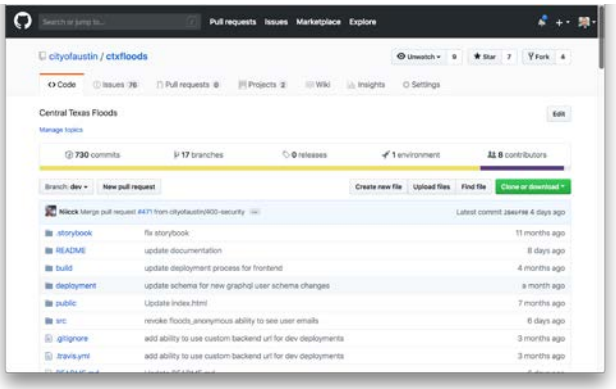
Assessment criteria for technology frameworks

Among databases, we evaluated PostgreSQL, ElasticSearch, GraphQL, and DyanamoDB. We ultimately selected PostgreSQL for its well-established place in the industry, thorough documentation, ease of use, and its ability to integrate with Node.js and the Serverless Framework for the back-end of the application. For our front-end framework, we selected React, the open-source framework developed by Facebook, which is also being used for the

future version of Austin.gov. For mapping libraries, we selected Mapbox GL for its significant improvements in the speed of presenting maps online (resulting in an almost 4x improvement in performance), with the open-source framework Leaflet for devices that aren't able to access WebGL technologies.

Toward the grant's objective of providing open-source information that can be accessed by third party application developers for geocoded alerts, we worked the City of Austin's Transportation Department to support integrations with existing mapping applications so that the data can be made accessible to all, regardless of application or device. See Appendix C for more information.

We also made the data from this service more accessible to researchers and members of the public by including a web-based tool that uses the popular GraphQL query language. This data service is now available at floods.austintexas.io/data. More information about data feeds is available in Appendix B.



Throughout the development process, we managed our tasks, code, and progress in a public repository at https://github.com/cityofaustin/ctxfloods.

Findings

Through our research, design, and iterative development, the team developed several findings around the availability and accessibility of data from ATXfloods, its growing coverage area, and possible requirements for ongoing iteration and maintenance. These informed and guided our deliverables throughout the project, though several relate to areas outside of the scope of the grant and may need to be addressed through additional and/or adjacent efforts.

Availability and accessibility of data

1. Most residents want to see road closure data in the apps that they're already using for mapping and wayfinding (e.g., Google Maps, Waze), which has the potential to reach the largest proportion of residents. Our work in supporting these integrations is detailed in Appendix C.

2. Closer integration with the emergency response teams, systems, and processes at CTECC (Combined Transportation, Emergency & Communications Center) and CAPCOG (Capital Area Council of Governments) has significant potential for improving response times and increasing operational efficiencies. Currently, emergency response teams need to balance information from multiple systems on different screens as situational awareness applications do not share data across systems.

3. Lack of robust data availability from the existing system creates recurring administrative burden for staff as basic reporting requests require manual processes that could otherwise be automated. In Appendix B, we provide details on how our work supports modern and flexible data feeds with a web-based user interface for running queries.

Growing coverage area

4. With the increase in usage of ATXfloods across jurisdictions in Travis County, Bastrop County, and Hays County, the Austin-focused name "ATXfloods" doesn't adequately describe the breadth of the service provided. Our team has recommended using the name "CTXfloods" to be more inclusive of all of the communities served.

5. As the growing coverage area aligns with an increasing reliance on the service for critical public safety applications, the completion of this grant marks a point at which stakeholders across the participating cities and counties can assess the specific responsibilities of their members in managing security, permissions, infrastructure, and data quality for this service.

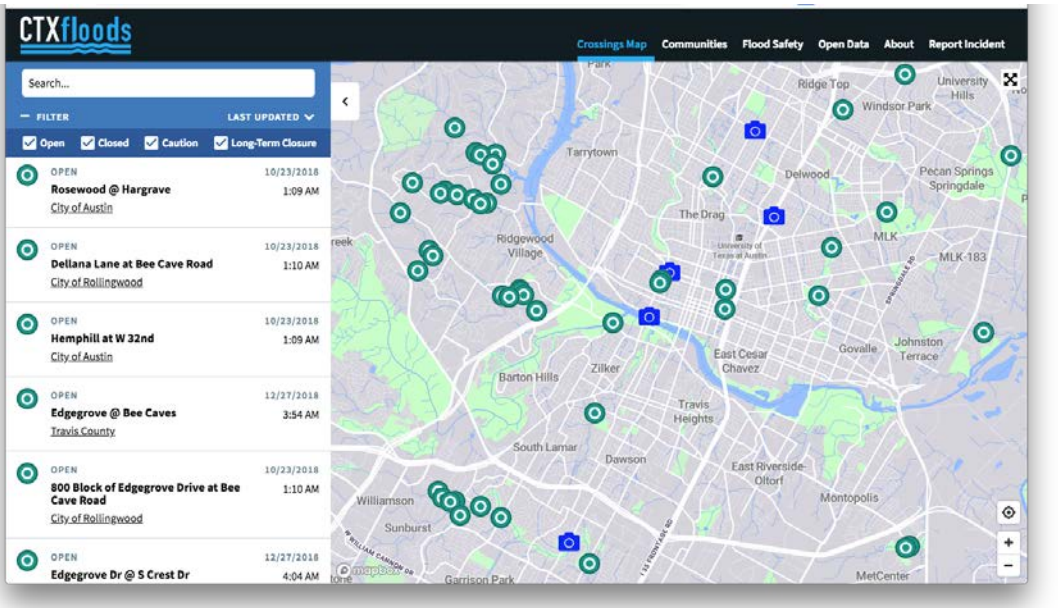
Requirements for ongoing iteration, maintenance, and administration

6. Following major flooding events, the work of adjusting information to show that crossings have been re-opened can be seen as a lower priority for emergency staff, leading to data quality issues and a reduction in trust of the service by both residents and third-party applications. Improvements to the design of the back-end system should mitigate some of this latency, though the highest level of accuracy may require resourcing additional staff.

7. As noted in the recommendations in Appendix G, the work of maintaining a digital service should include the ability to make ongoing improvements based on inevitable changes in technology, administrative processes, and user behavior. These may include features to support integrations with additional systems or the use of data modeling to predict road closures in advance.

8. In all cases, ongoing iteration and maintenance will require resourcing staff to support industry practices for automated testing, continuous integration, and software development. Our recommendations for ongoing support are included in Appendix G.

Deliverables



In completion of this grant, we have prepared the following deliverables:

1. Production-ready code for a new version of ATXfloods, now renamed “CTXfloods.” This is available in online repositories at https://github.com/cityofaustin/ctxfloods and https://github.com/cityofaustin/ctxfloods-backend. The code will also be delivered to the TWDB on a flash drive.

2. Documentation to assist in launching, maintaining, and improving the CTXfloods service, included in Appendix H.

3. Additional details on work completed in each of the grant’s objective areas is included in following appendices:

    Appendix A: Software Improvements
    Appendix B: Data Feeds
    Appendix C: Support for Third-Party Services (e.g., Google Maps, Waze)
    Appendix D: Notifications
    Appendix E: Crossing Addition and Reporting Functionality
    Appendix F: Public and Administrative Views
    Appendix G: Recommendations for Long-Term Iteration and Maintenance
    Appendix H: Documentation for Launching this Service
    Appendix J: Detailed Insights from User Research

Appendix

Appendix A: Software Improvements

1. **Ability to easily search for crossings.**
   As the existing system does not have the ability to search for crossings, we developed full-text search for all crossings in both the public-facing and administrative views (see Appendix F for screenshots), including support for location-based searches.

2. **Improved data fetching speed.**
   The time to load all crossings in the new system is 3.8x faster than the existing system, from an average of 4.96 seconds (current system) to an average of 1.29 seconds (new system). This difference in load time is particularly significant for residents and administrators relying on slower networks.

3. **Made it easier and faster for administrators to find and update crossings, eliminating barriers of page refreshes and scrolling.**
   These improvements are detailed in Appendix F.

4. **Additional types of crossings.**
   Instead of simply labeling a crossing as “Open” or Closed”, we now have more descriptive statuses of “Caution”, “Closed”, and “Closed Long-term”, each with their own rules and impact on push notifications. This sets a foundation for machine learning and AI to inform the “Caution” state based on data of flooding activity over time.

5. **Interactive data portal.**
   Included a web-based tool for residents and other members of the public to access crossing data using the popular GraphQL query language. More information about data feeds is available in Appendix B.

6. **Created more granular administrative privileges.**
   As the existing system had a single level of permissions for all users, we developed three levels of permissions for Contributors, Community Admins, and System Owners. These are detailed in Appendix F.

7. **Email push notifications for administrators.**
   These are detailed in Appendix D.

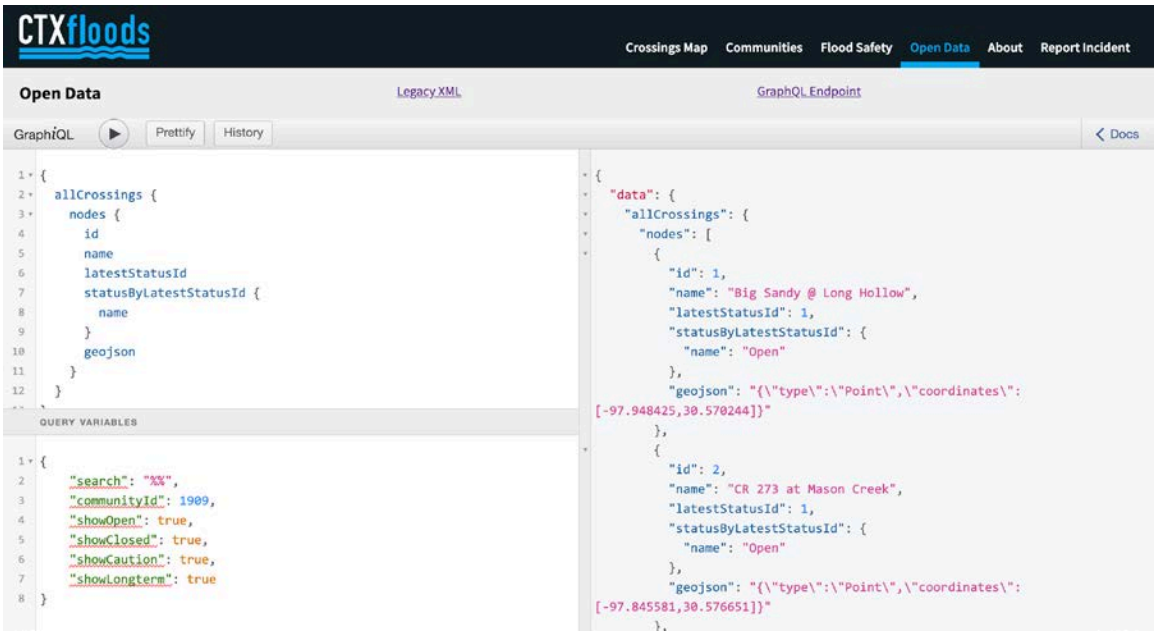
The full list of software improvements can be found in our Github repository:
https://github.com/cityofaustin/ctxfloods/issues?q=is%3Aissue+is%3Aclosed

Appendix B: Data Feeds

As noted in the report, the team worked to develop a solution that is accessible across devices, external applications, and other views that currently do not exist. To support current and future functionality, our solution supports accessing road closure data through an API Endpoint, XML Feed, and an Interactive Data Portal.

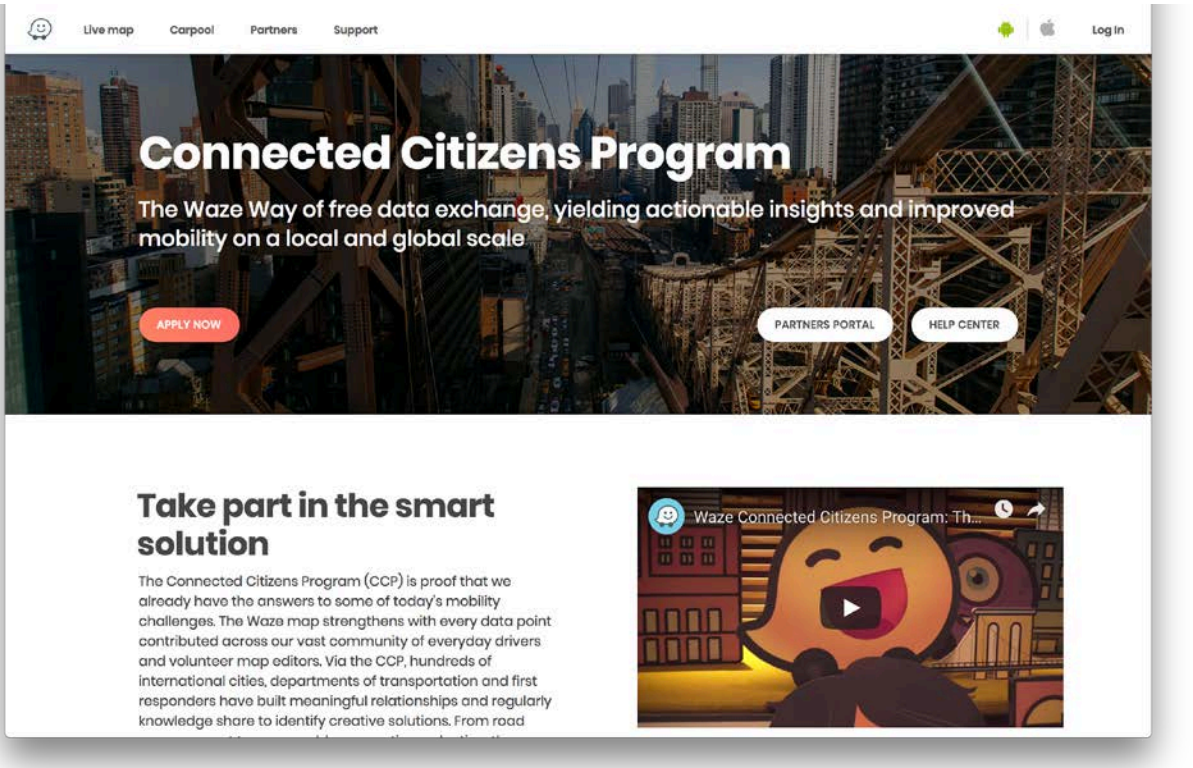
Our solution for the API Endpoint and XML Feed matches the format of the existing ATXfloods data feed, allowing for a seamless transition for existing third-party services. In the images below, you'll see the feeds from the existing and future tools, which have the exact same format for supporting both legacy and future integrations.

We also wanted to make querying the data easier for administrators and members of the public, so we included an interactive tool for writing queries using the popular GraphQL query language.



Appendix C: Support for Third-Party Services (e.g., Google Maps, Waze)

The service has been developed to integrate with the Waze Connected Citizens Program (CCP), which is detailed at https://www.waze.com/ccp.



With our real-time data model, we were able to implement a Partner Feed according to the Waze specifications, which runs as a scheduled process through the back-end of the system with a custom Node.js handler, wazeFeedHandler.js.

The Waze Partner Feed allows the service to automatically report road closures to Waze, helping users find alternate routes. This allows closure data within CTXfloods to get directly into the hands of drivers even if they don't know it exists.

Once implemented, the flexibility in this real-time data model and API will enable any future integrations to be developed, tested, and integrated smoothly.

Additional information about the Waze Connected Citizens Program:

CONNECTED CITIZENS
by waze

The Waze Connected Citizens Program is a free, two-way data exchange empowering municipal decisions to achieve concrete community impact. Launched in October 2014 with 10 city partners, the program has expanded to 450 partners including city, state and country government agencies, nonprofits and first responders.

WAZE provides real-time, anonymous, proprietary incident and slow-down information directly from the source: drivers themselves

PARTNERS provide real-time and advance information on government-reported construction, crash and road closure data

BENEFITS

TO WAZERS

The Waze map evolves with every driver and data point added. The Connected Citizens Program yields more data, giving Wazers a greater ability to circumvent road closures and traffic jams.

TO PARTNERS

SITUATIONAL AWARENESS: Partners receive real-time incident information faster than other reporting methods and accurately pinpoints where incidents occur, creating faster response and clearing times and potentially saving lives

TWO-WAY DRIVER COMMUNICATION: Partners leverage Waze as a two-way communication channel: Partners use Waze to inform drivers of major traffic events and drivers communicate back real-time road insights through the app

INFRASTRUCTURE PLANNING: Insights into locations with frequent congestion or hazards yields smarter urban planning

BRIDGING CONNECTIONS WITH OTHER PARTNERS: Waze gathers partners via in-person summits and an online forum to discuss case studies and exchange ideas to further impact communities globally

STREAMLINING DATA INPUTS: Partners can utilize data standards designed by Waze for closure and incident reporting to reduce data fragmentation and promote transport and government data aggregation.

REAL-LIFE CONNECTED CITIZENS DATA EXCHANGE CASES

RIO DE JANEIRO (COR)

Analyzed traffic and incident data from Waze to identify neighborhoods that experience the most congestion on election days (FIG. 1).

Rio later used this analysis during a secondary election to test transit management personnel staffing within neighborhoods. The right image shows a decrease in reported heavy congestion (dark red) as a result of this test.

FIG. 1

FIG. 2

CITY OF BOSTON

Analyzed three months of Waze data to determine locations with the most double parked car reports. Issued month-long test where Bike Strike Team was dispatched to alleviate traffic conditions.

In one month, issued more than 240 move-alongs and 36 parking tickets. Test has led to additional mobility experimentation by the city.

To get more information on Waze Connected Citizens Program and to hear more case studies from partners, please watch our latest program video on www.waze.com/ccp.

Appendix D: Notifications

In our research and in the documentation for the initial grant, we saw an interest from administrators for receiving email notifications about closed crossings that may need to be updated and marked as open.

To support this functionality, the service automatically sends administrators an email with a list of any crossings in their jurisdiction that have been marked as “Closed” or “Caution” for longer than 18 hours.

Here is a screenshot of the text from an automated email, which explains the situation, requests their review, and lists out the individual crossing name, status, and reason for closing. Tapping or clicking on the name of the crossing will take the administrator directly to the crossing detail page on CTXfloods, where they can edit the status with one tap or click.

> Action is required for 5 crossings. Please make sure that their statuses are up to date.
>
> Please "Open" any crossing set to "Closed" or "Caution" if they are safe. Or escalate them to "Long-Term Closure".
>
> Please "Open" or update the date of any crossing set to "Long-Term Closure" that is past its estimated reopen date.
>
> 1: Fred Hartman Bridge
>
> Status: Caution
> Reason: Unconfirmed Flooding
>
> 2: Washburn Tunnel
>
> Status: Closed
> Reason: Flooded
>
> 3: Pasadena River
>
> Status: Closed
> Reason: Flooded

Appendix E: Crossing Addition and Reporting Functionality

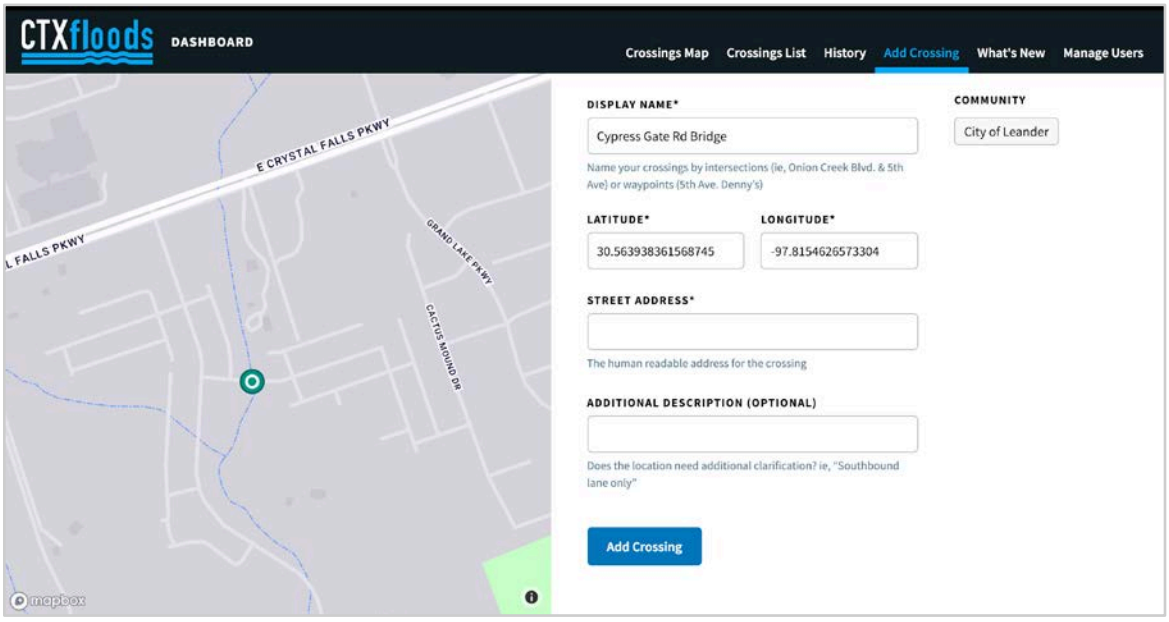
The service also includes functionality for adding additional crossings, tracking the historical status of a crossing, and exporting crossing history for reporting and compliance purposes.

In the Dashboard View, administrators can select “Add Crossing” from the top navigation to pull up a simple web form where they can enter the following information:

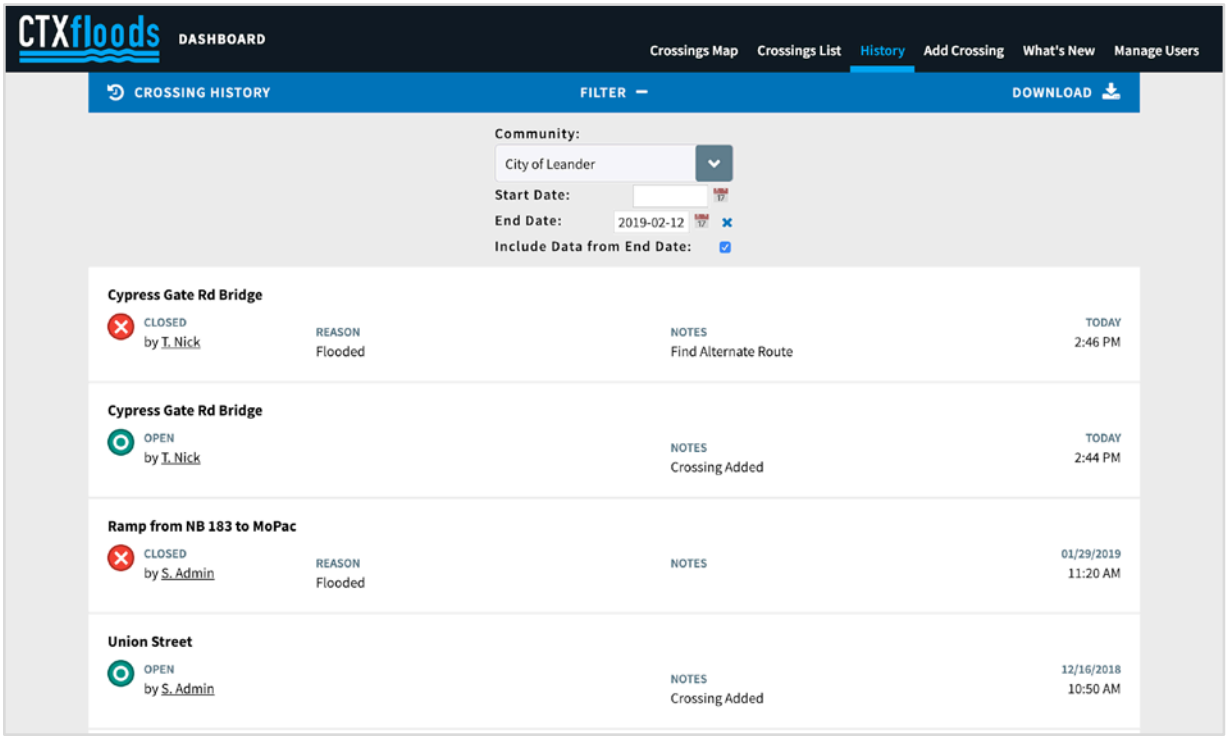
- Display Name
- Community, such as City or County (Optional)
- Latitude
- Longitude
- Street Address
- Additional Description (Optional)

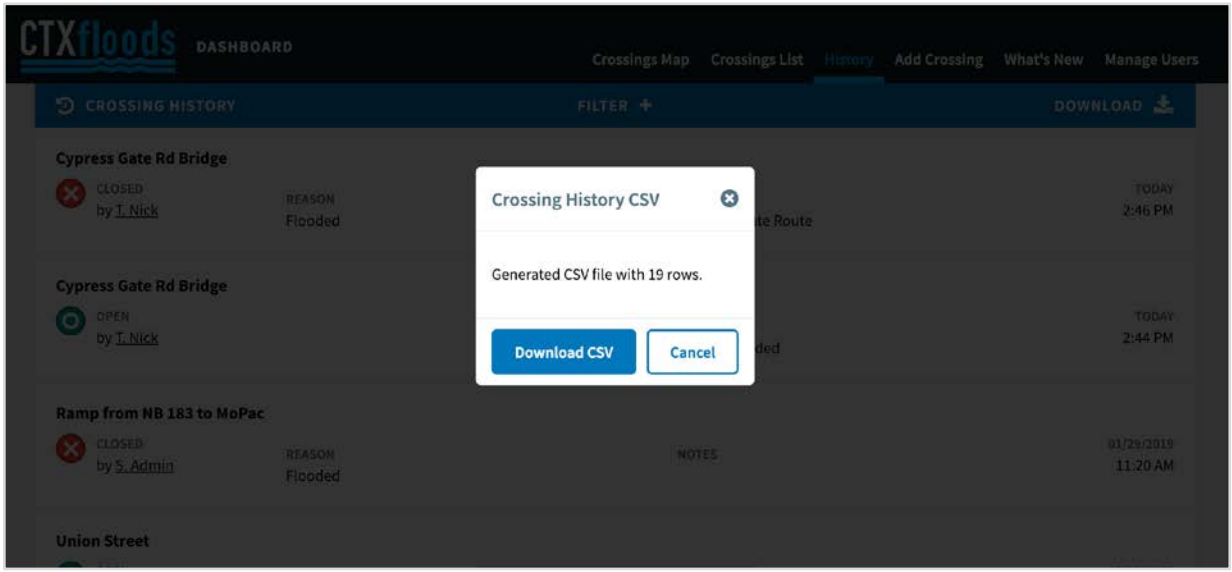
This view also includes a map of the location entered so that the administrator can verify the location before creating the crossing, reducing the risk of errors from mistyped addresses or flipped Latitude/Longitude pairs.

The Crossing Marker in the map is also draggable, meaning that administrators can use their mouse (or finger, on a touch screen) to drag the Marker to a more precise location on the map, and the system will automatically adjust the latitude and longitude entered on the form.



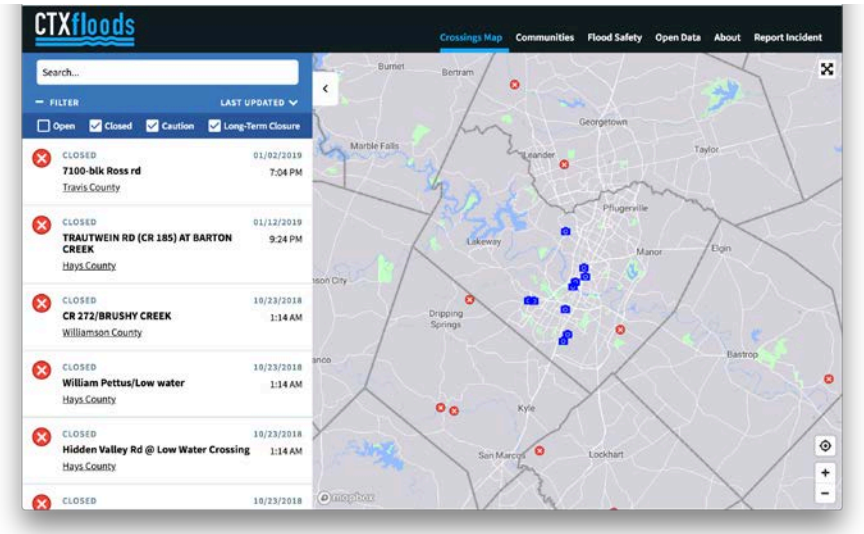
In the Dashboard view, administrators can select “History” from the top navigation to filter crossing history data by community, date, and individual location. When administrators have filtered the list to their desired set of data, they can select “Download” at the top right of the page to create and download a Comma-Separated Values (CSV) file that is viewable in all modern spreadsheet and data analysis tools (e.g., Excel, Tableau, Qlik, Power BI, MicroStrategy).



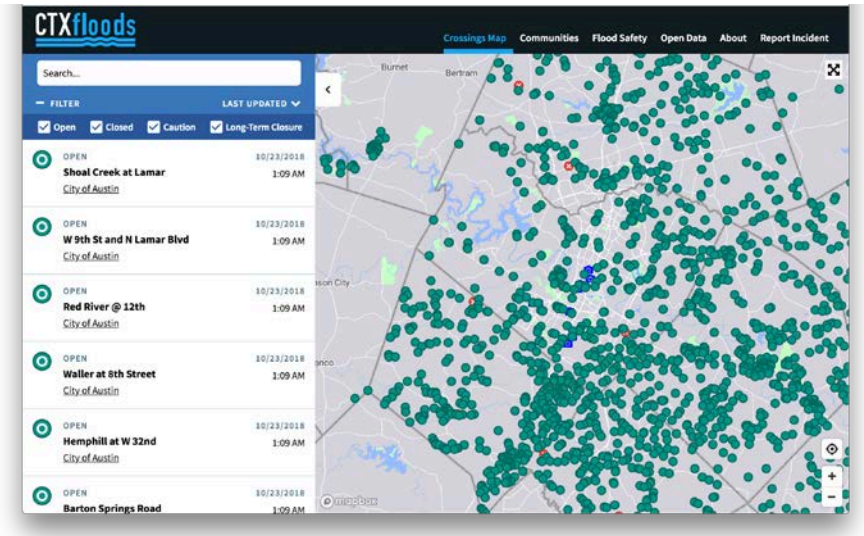


Appendix F: Public and Administrative Views

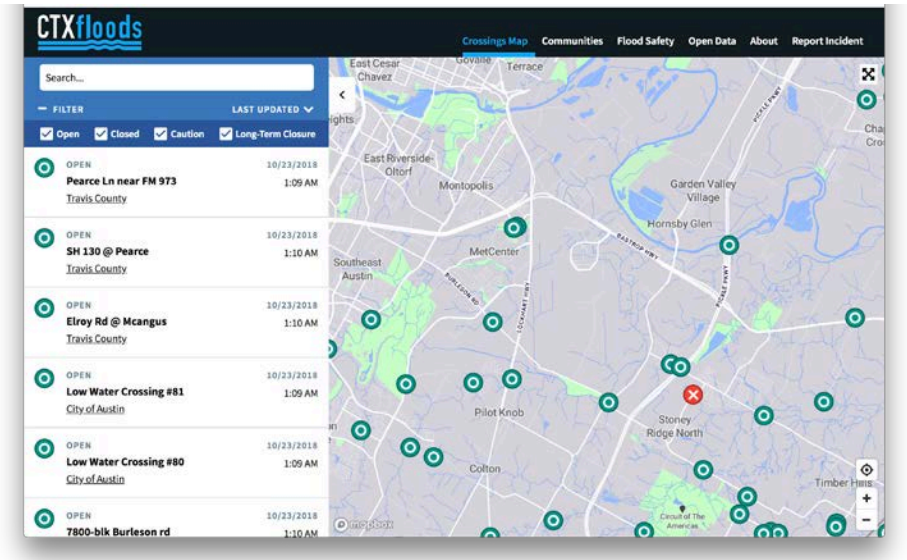
Members of the public can navigate to homepage of the service, which is available for demonstration at floods.austintexas.io. This view displays a map with all Closed, Caution, and Long-Term Closure crossings shown by default, with a list of these crossings shown in the left rail.



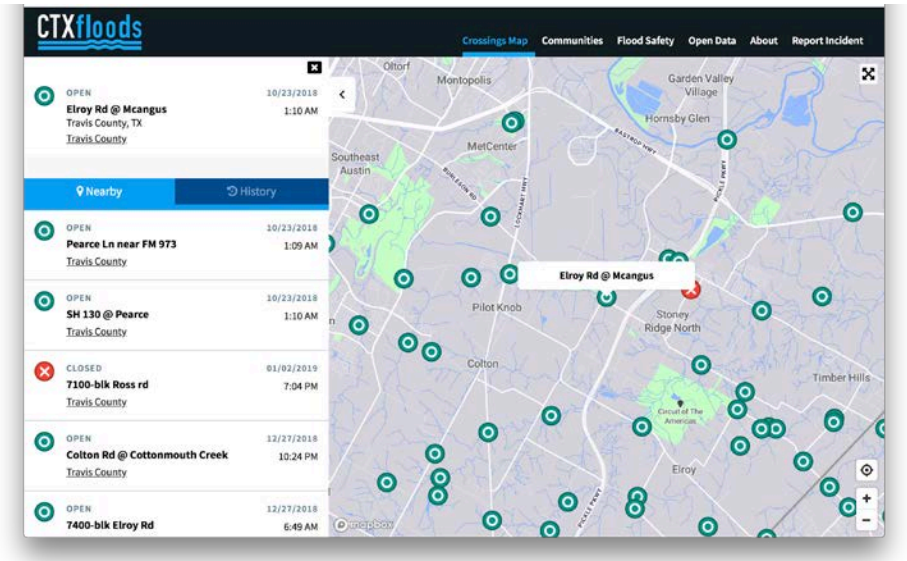
Residents can select a checkbox at the top right of the list to show “Open” crossings as well. This shows a significantly larger number of crossings, which show up without icons at this zoom level.



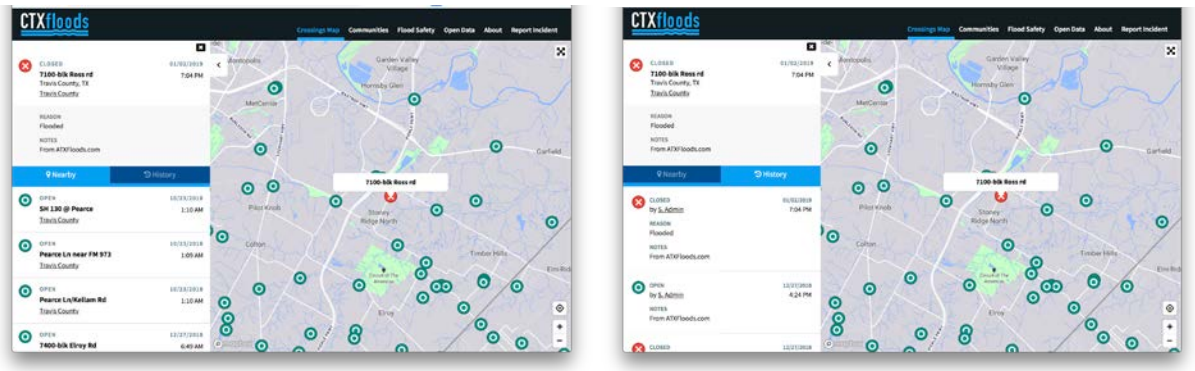
When residents zoom in, they'll see a version of the crossing markers that includes icons as an additional visual indicator for the "Open" crossings.



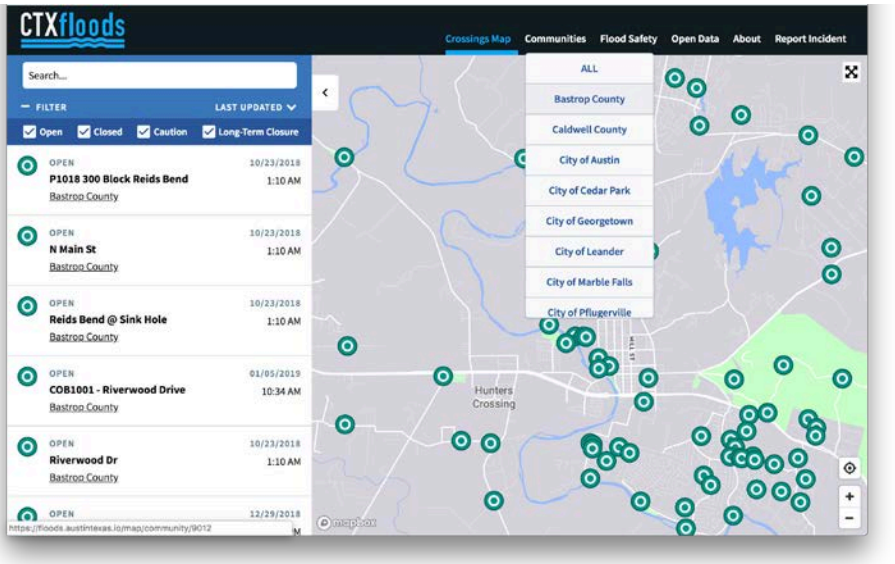
When residents tap or click on a crossing marker, the viewport will center on that crossing and more detailed information will be provided in the left rail of the page.



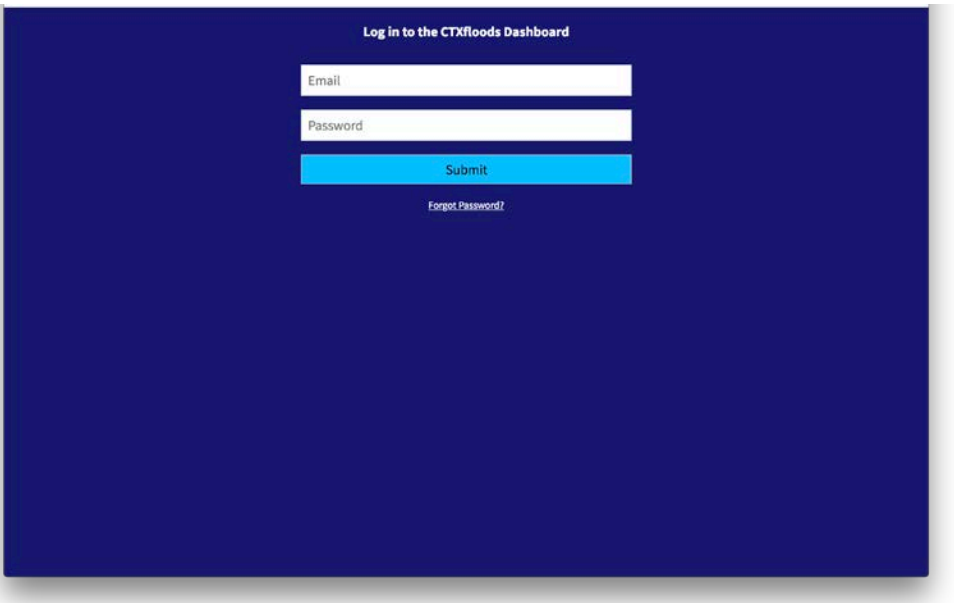
The left rail also features a tab to view the status history of the selected crossing.



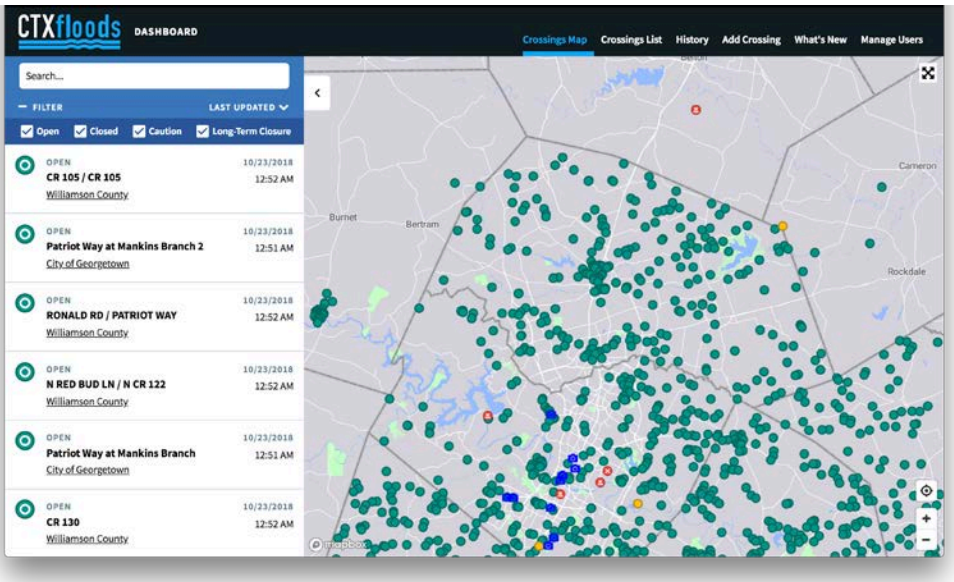
Residents can select from the “Community” dropdown to zoom in on a specific community.



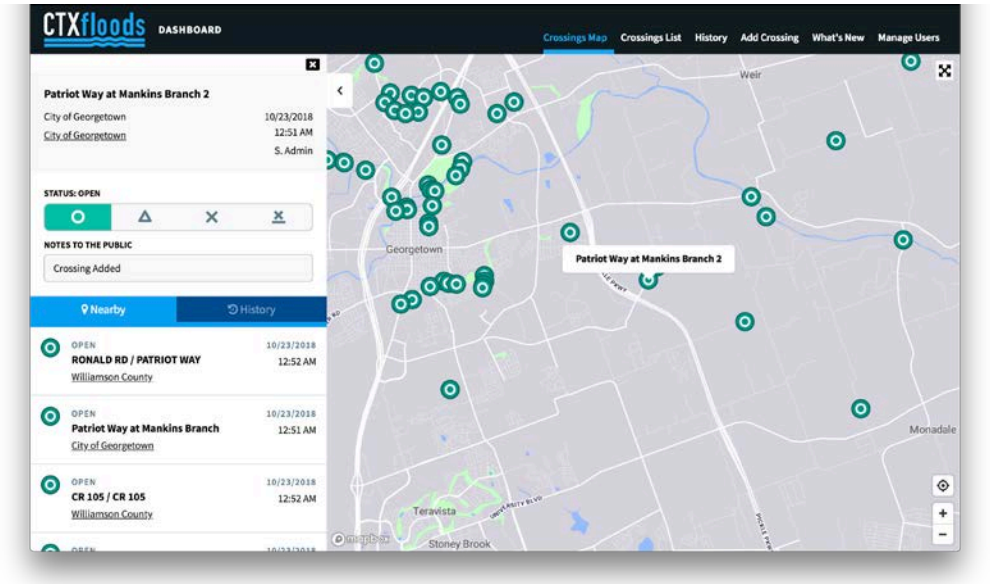
Administrators can log in to the Dashboard view to manage crossing data for this service. A demonstration version of this view is available at https://floodstest.austintexas.io/dashboard/



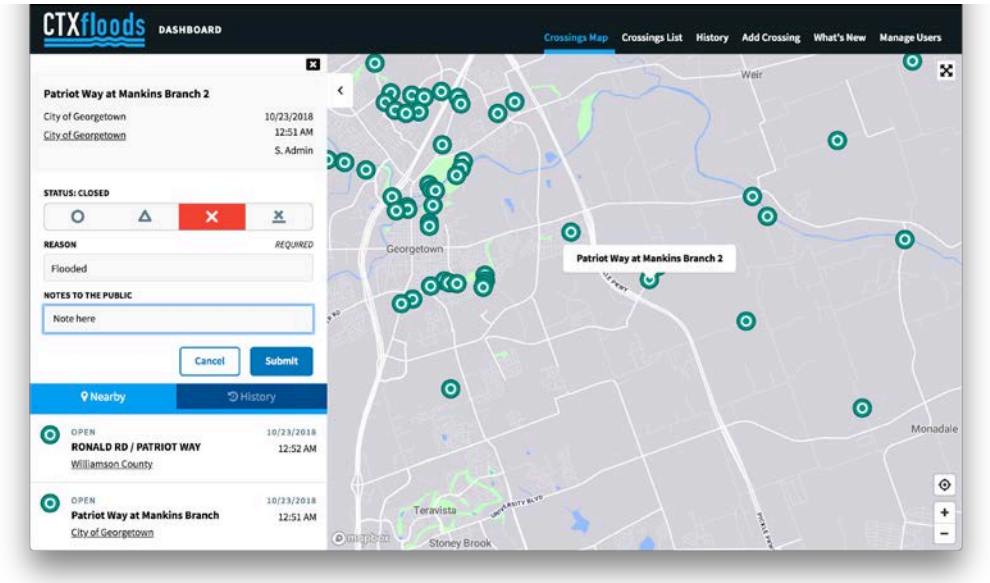
Upon logging in with their username and password, administrators will see a map view that is similar to the public view, but with additional functionality available, as noted in the navigation options shown below:



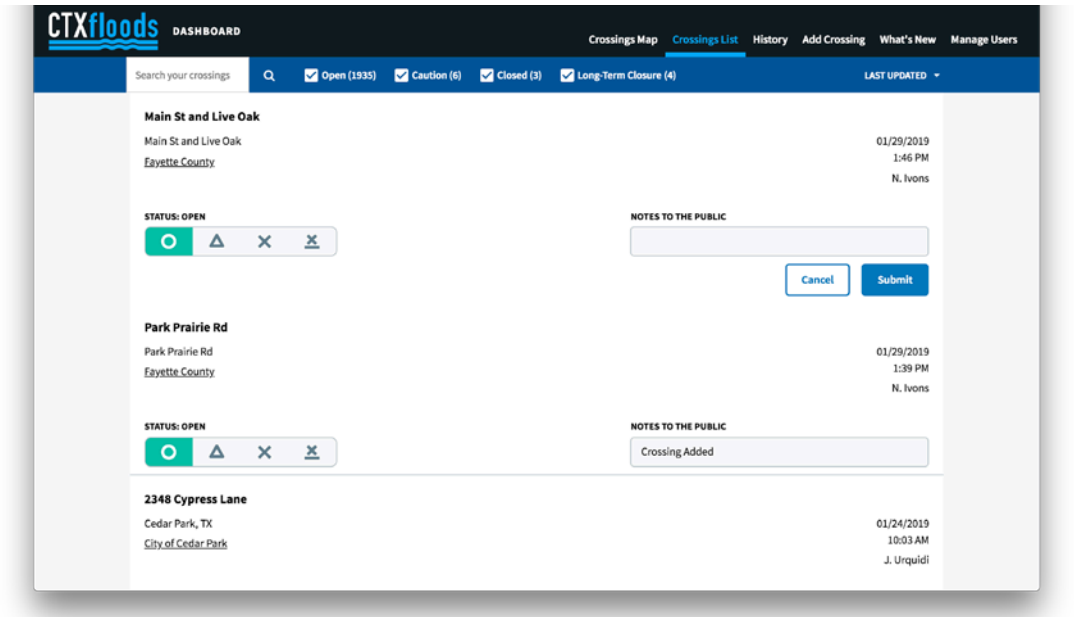
When an administrator taps or clicks on a crossing in their jurisdiction, they'll see a detail view on the left side of the page where they can quickly change the status of the crossing.

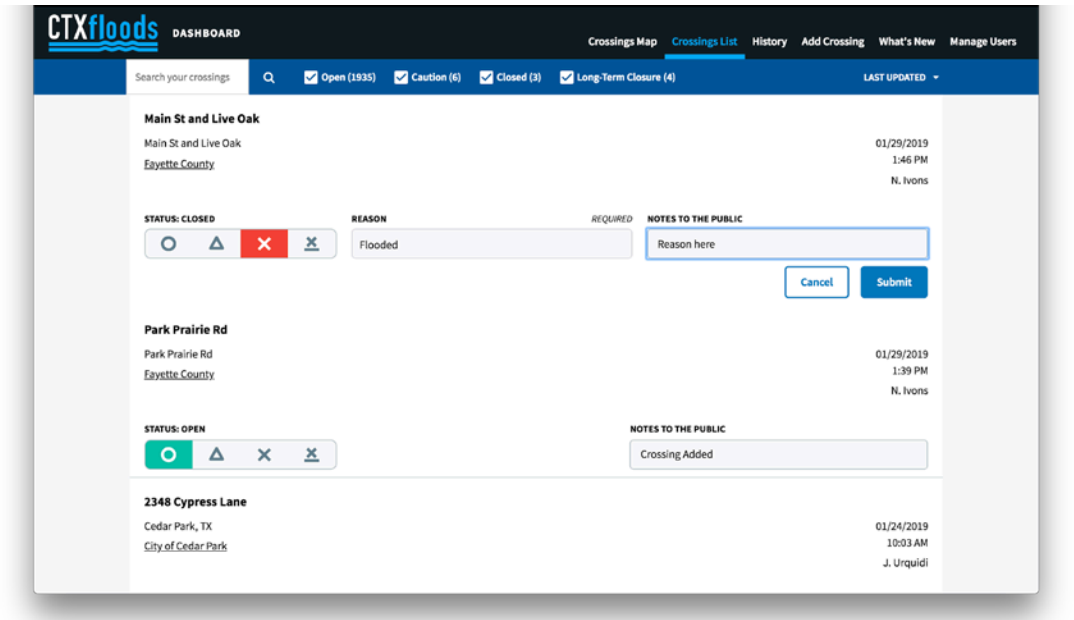


This allows administrators to use the map to navigate through the crossings in their jurisdiction, quickly seeing the locations in front of them and being able to adjust as necessary.

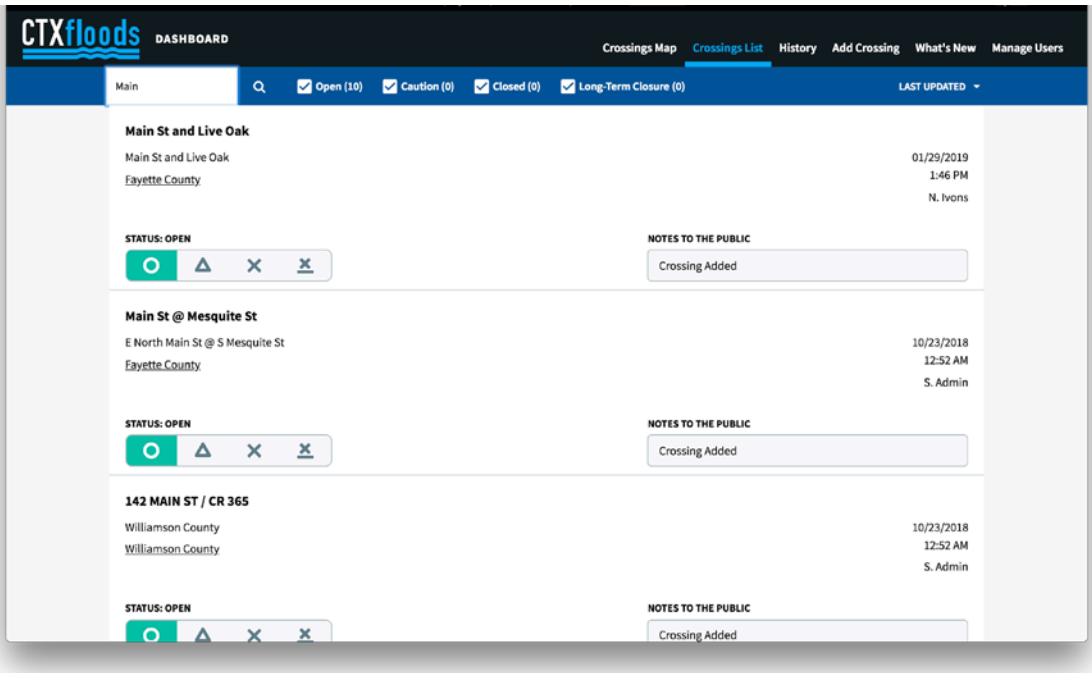


When an administrator selects **“Crossings List”** from the top navigation, they’ll see a list of all crossings in their jurisdiction, with the ability to quickly change the status of each crossing directly on the page.

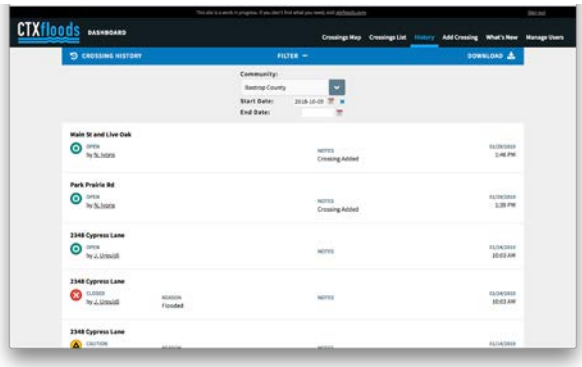


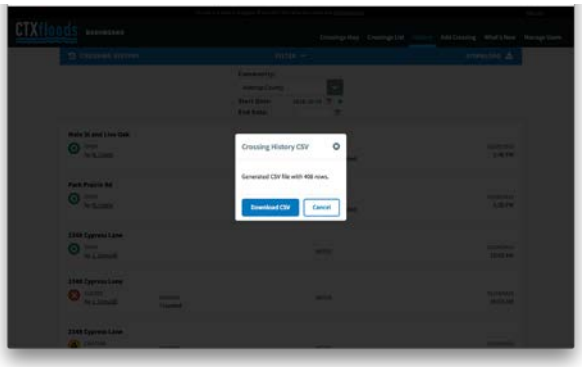


Within the **“Crossings List”** section, administrators can also search among the crossings in their jurisdiction. In this example, the administrator has searched for all crossings with the word “Main”.



As noted in Appendix E, the **“History”** section allows administrators to filter crossing history data by community, date, and individual location. When administrators have filtered the list to their desired set of data, they can select “Download” at the top right of the page to create and download a Comma-Separated Values (CSV) file that is viewable in all modern spreadsheet and data analysis tools (e.g., Excel, Tableau, Qlik, Power BI, MicroStrategy).

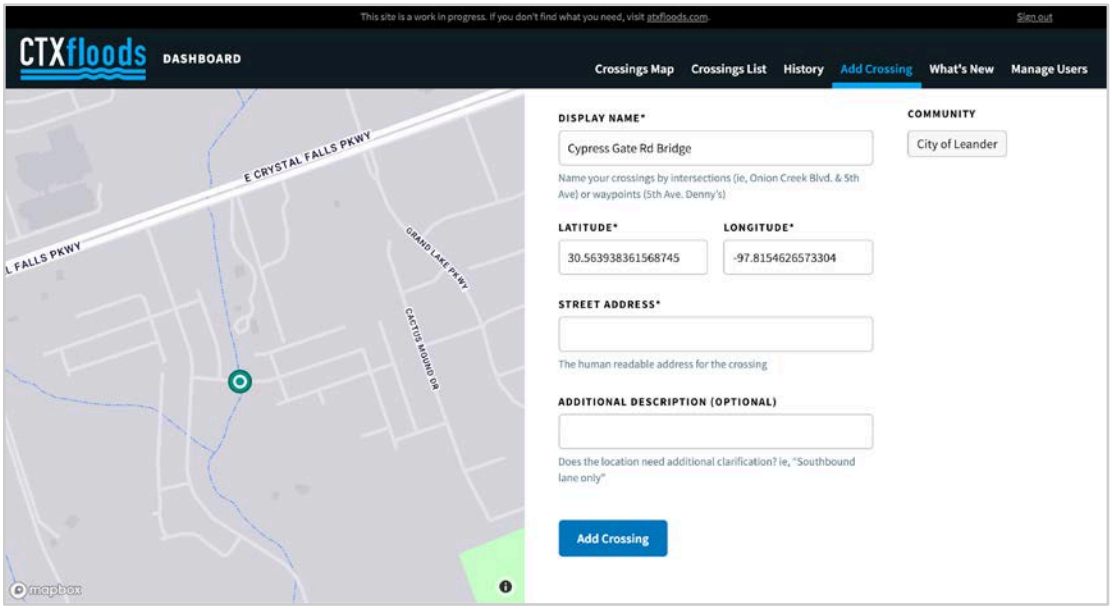




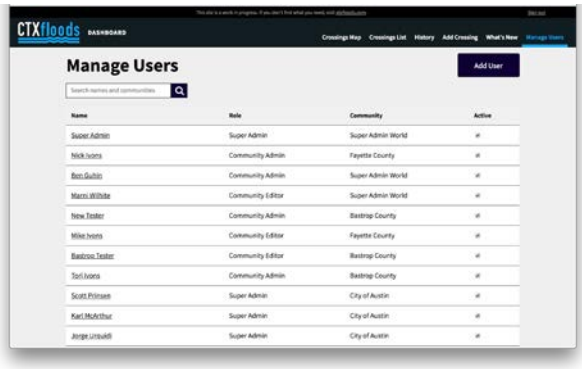
When an administrator selects **“Add Crossing”** from the top navigation, it opens a simple web form where they can enter the Display Name, Community, Latitude, Longitude, Street Address, and an optional Additional Description.

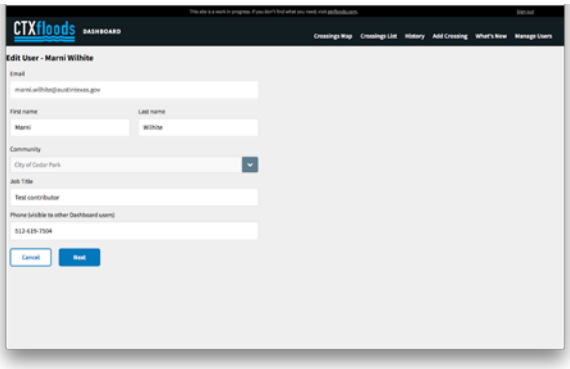
This view also includes a map of the location entered so that the administrator can verify the location before creating the crossing, reducing the risk of errors from mistyped addresses or flipped Latitude/Longitude pairs.

The Crossing Marker in the map is also draggable, meaning that administrators can use their mouse (or finger, on a touch screen) to drag the Marker to a more precise location on the map, and the system will automatically adjust the latitude and longitude entered on the form.



Based on the administrator's permissions, they can select **"Manage Users"** from the top navigation to see a list of users in the system, with the ability to manage user information.



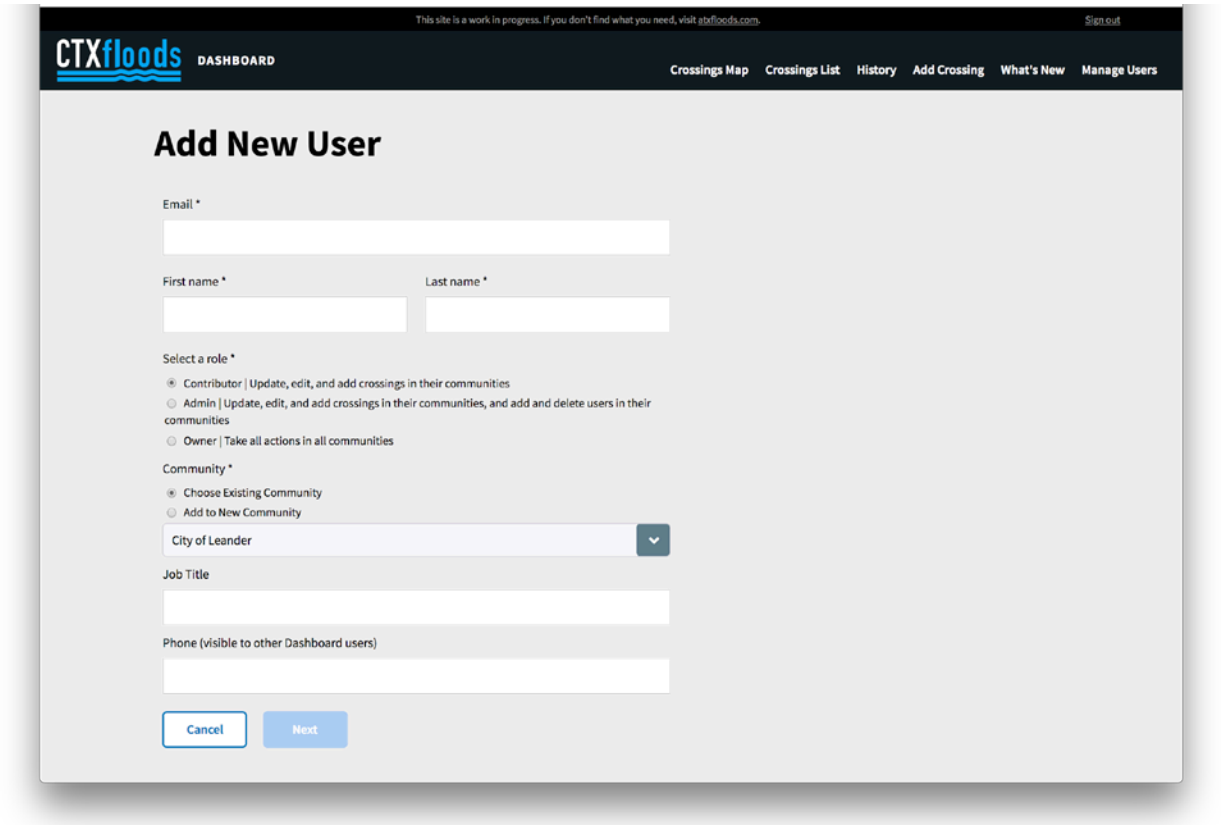


There are three levels of user permissions in the system. The first two are restricted to specific *communities,* which can be any boundary for a group of crossings, such as a City, County, or other type of jurisdiction. Note that individual crossings can belong to multiple communities.

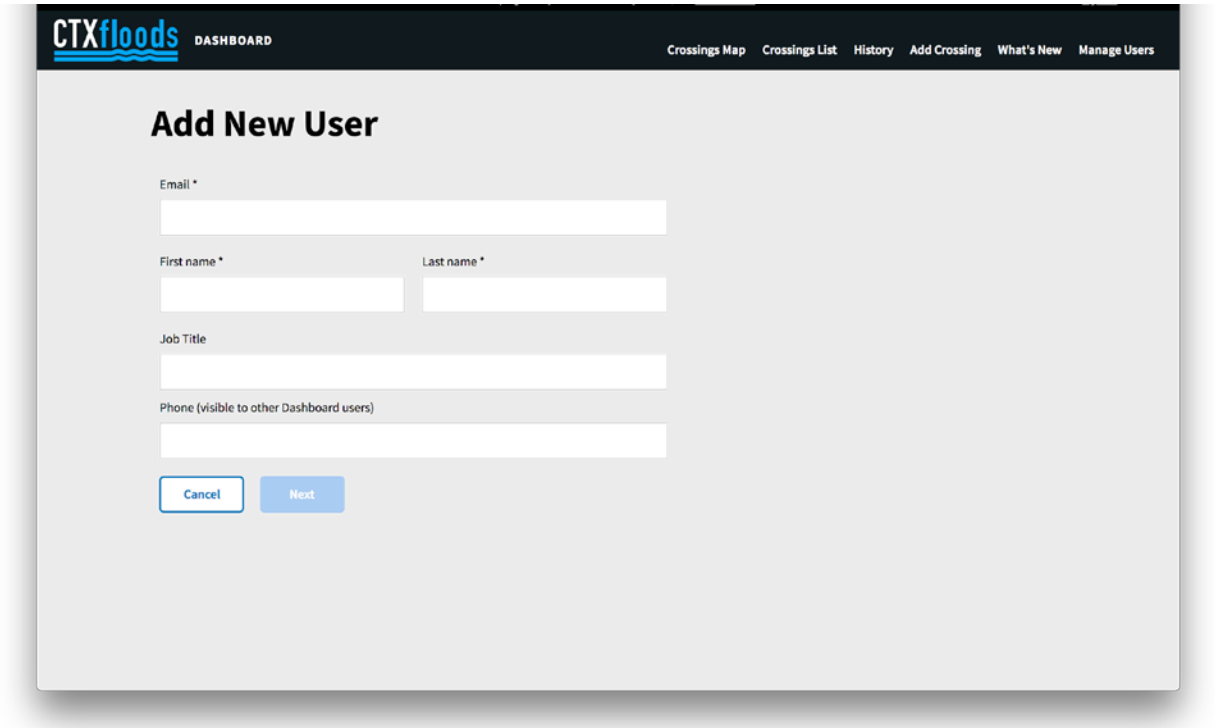
1. The most basic level of user is a ***Contributor***. Contributors can update, edit, and add crossings in their assigned communities.
2. The next level is an **Admin**. Admins can update, edit, and add crossings in their communities, and add and archive users in their communities.

3. The highest level is a Super Admin, or **Owner**. Owners can create new communities, and create new Admins.

When an Owner selects “Add User” in the Manage Users section, they’ll see a simple web form that requests the new user’s email address, first name, last name, permissions level, community, job title, and phone number.



As an Admin can only create users at the contributor level within their assigned community, their version of the “Add User” form does not include options for setting permissions or community.



When the Admin selects “Next,” the new user is sent an email to set their password, and their work begins!

Appendix G: Recommendations for Long-Term Iteration and Maintenance

As noted in the project background, the original version of ATXfloods was developed quickly as a proof of concept and found success over the following years as an increasingly important tool for residents, broadcasters, and public safety personnel during flooding events in Central Texas.

The success of this concept did not bring additional staffing to support the increasing importance of the tool, and the changes implemented through this grant will require ongoing support from experts in product management and full-stack web development to continually operate the service for residents and first responders, and to grow and improve its functionality over time.

In this section, we have listed the core staffing and tasks that will need to be allocated so that this service can be both successful and sustainable over time.

1. Necessary Staffing and Resources

To support a successful deployment, organizations will need to establish a product development team to be responsible for initial launch and ongoing iteration and maintenance of the product. In keeping with the US Digital Services Playbook (https://playbook.cio.gov/), this team should contain members with the following areas of responsibility and expertise:

a. **Executive Leadership.** The team should have single executive sponsor with sufficient level of authority to support resourcing, budget, and collaborations with external partners.

b. **Product Leadership.** The executive sponsor will assign a single person with the knowledge and authority to make day-to-day decisions about the future of the product. More details are included in Play #6 (https://playbook.cio.gov/#play6) of the US Digital Services Playbook.

c. **Full-Stack Web Development.** The team should include at least one person with experience developing web applications using modern languages, MVC frameworks, continuous delivery, continuous integration testing, and cloud platforms. The City of Austin's Position Description website (http://projects.austintexas.io/projects/becoming-odd/recruiting-and-hiring/position-descriptions/) can provide guidance on hiring for these positions, as well as other resources published by the City of Austin's Office of Design & Delivery. Contact information is available at http://odd.austintexas.io

d. **Quality Assurance and Testing.** The team should include at least one person with responsibility for monitoring and testing the quality and functionality of this service as it is continually operated and improved.

Note that these do not need to be full-time assignments, but we strongly recommend assigning separate individuals to each area of responsibility. Development and support staff will need to be on-call during the time leading up to and during flood events in order to address any issues with the service that may arise.

2. Tasks

To support a successful deployment, the following operation and maintenance tasks will need to be performed by the support team.

a. Maintenance

i. Maintain processes for security, continuous delivery, and continuous integration testing.
ii. Maintain Application Programming Interface (API) access to road closure data for critical integrations with internal tools and consumer applications for navigation and wayfinding (e.g., Google Maps, Apple Maps, Waze).
iii. Maintain accessibility of front-end implementation at Web Content Accessibility Guidelines (WCAG) 2.0 Level AAA.
iv. Manage provisioning and administration of the host server environment (Austin's version uses Amazon Web Services (AWS)).

b. Iteration and Improvements

i. Support improvements based on feedback from residents and administrators. We anticipate that this will require approximately 40 hours of work from the product development team every three (3) months.

c. On-Call Support during Weather Events

i. The product development team must establish procedures to ensure staff availability for on-call support during extreme weather events. During a typical year Flood Early Warning System staff monitor approximately 17 rainfall events and close roads during approximately 9 of these events.

2. Integrations with Third-Party Services

To support a successful deployment, the development team will need to ensure continuous access to the third-party services that are part of the system.

a. **Map Hosting and Styling.** The service uses a third-party tool, Mapbox (https://www.mapbox.com), to host map styling, which also provides the significant speed increase for performance across modern devices. Its current pricing is free until 50,000 map views per month, and then $.50 monthly for each additional 1,000 views.
b. **Geocoding for Search Queries.** We are using the HERE Maps API (https://developer.here.com) to geocode search queries for improved usability. It is free for the first 250,000 transactions, then $1 for each additional 1,000 transactions.

Appendix H: Documentation for Launching this Service

As noted in Appendix G, a region and/or municipality wishing to launch this service will need to provide executive leadership and staffing for product leadership, front-end web development, and quality assurance to ensure that the service continues to iterate and improve over time.

A Product Development Team with these competencies will have the expertise to set up the development environment for launching this service in a matter of days, which will include creating a PostgreSQL server and deploying the CTXfloods backend code, which is built with Node.js, GraphQL, and the Serverless Framework.

The front-end of the system is built with React, one of the world's most commonly-used Model-View-Controller (MVC) frameworks for building user interfaces. The full technical stack is designed to work with TravisCI for continuous integration, meaning that new code changes can automatically be applied to your version of the system, with security and functionality tests being deployed automatically.

The code for CTXfloods consists of two repositories, which have also been provided to the Texas Water Development Board on a flash memory drive:

1. https://github.com/cityofaustin/ctxfloods contains the code and Readme documentation for launching the front-end of the service
2. https://github.com/cityofaustin/ctxfloods-backend contains the code and Readme documentation for launching the back-end of the service

A demonstration version of this website is available at floods.austintexas.io, and a version of the admin interface is available at floodstest.austintexas.io/dashboard/.

How to Launch this Software for Your Region

This software was designed to be modular, scalable, and customizable for the Central Texas region as well as other regions throughout Texas and around the world. The following are instructions for launching an additional installation of this software for a new region – for example, if the North Central Texas Council of Governments wanted to launch an installation and call it "NTXFloods."

Part 1: Clone and Launch Locally (for initial testing and customizations)

The easiest way to create new instance of CTXfloods is to clone the GitHub repository to a local machine (such as a laptop, to use for testing and customizations before going live) and follow the instructions listed in the README.
https://github.com/cityofaustin/ctxfloods/blob/dev/README.md#set-up-development-environment and https://github.com/cityofaustin/ctxfloods-backend/blob/dev/README.md#set-up-development-environment

1. Install yarn and nodejs. https://yarnpkg.com/en/docs/install
2. Clone CTXFloods backend.
3. Install Postgres v10.6
4. Seed test data by running "yarn setup-local"
5. Run "yarn start-local" for the backend.
6. Clone CTXFloods frontend.
7. Run "yarn start-local" for the frontend
8. Your local CTXFloods site can be viewed at localhost:3000/map

Part 2: Launch with TravisCI (for automated deployments)

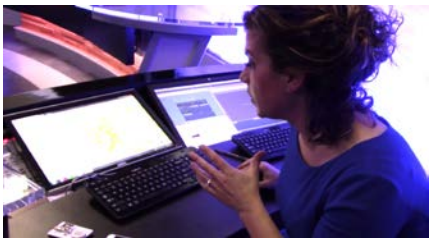
1. Fork CTX Floods frontend and backend.
2. Connect TravisCI to your forked CTX Floods github repos.
3. Plug in values for "TRAVIS_" environment variables in Travis's environment variables settings.
4. Run a build on the master branch.

Part 3: Launch Manually (for public deployment)

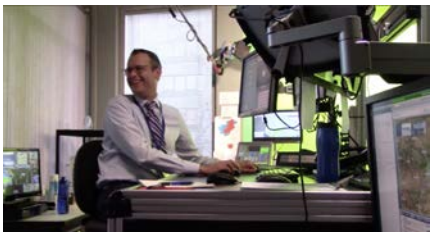
1. Create and store credentials for Amazon Web Services or other hosting environment
2. Plug in values for "TRAVIS_" environment variables in "deployment/vars/prod.sh".
3. Run "deployment/deploy.sh prod"

Appendix J: Detailed Insights from User Research

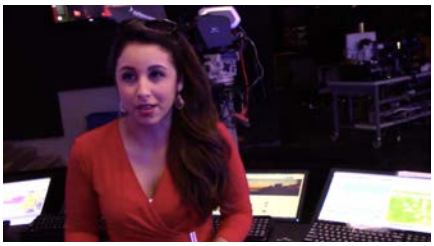
Broadcast Media - Interview Participants



Amanda Dugan
KXAN - Traffic Reporter



Burton Fitzsimmons
Spectrum News - Chief Meteorologist



Natalie Ferrari
KXAN - Meteorologist

Emily Borchard
Spectrum News - Meteorologist

David Yeoman
KXAN - Meteorologist

Scott Fisher (Phone Interview)
FOX 6 News - Chief Meteorologist

Broadcast Media - Insights

Tools and Technology

- Maps
    - USGS streamflow
    - LCRA Hydromet***
    - DriveTexas.org **
    - Viewer reports
- Mirroring tools**
    - BrightEye
- Viewer reports
- Storm reporters
- APD Twitter

Workarounds

- Zooming in jurisdiction-by-jurisdiction
- Need to do mental math to subtract long-term closures from current closures
- Visual
    - Avoids hovering over nav / main menu
    - Closes the legend / key immediately
    - Closes list of closures
    - Do not refresh!
    - Resizes to capture ATXFloods logo + CoA logo

Broadcast Media - Insights

Satisfiers

- Control over display of info
- Show changes over time
- More organized = more on-air use?
- Cameras - more visual
  "People are very visual, they need to see proof of conditions"
- Easy to publish to social media
- Custom display areas - by jurisdiction
- Alternate indications of long-term closures

Motivators

- Clarify severity of storm / situation
- Accurately convey whether public's route is safe & clear

"It conveys urgency too. We can sit in the studio all day and say that it's raining, but if we say ten minutes ago there were 40 crossings closed and now there are 60, it's happening really rapidly."

"This is probably my major tool. I can't think of any other websites that tells me how weather is affecting the roads."

"Sometimes we're coming in and there's so much crap going on, there's so much information… And you're like, 'wait, was that road…' Maybe I'm not following everything that's ha- maybe I haven't paid full attention to what's happening at Driftwood? Oh, well we know that those three crossings have been closed since last night, now we know that this one just happened five minutes ago, ten minutes ago. We missed it before but now we know."

Amanda Dugan, KXAN

Broadcast Media - Insights

Challenges / Constraints

- Difficult interactivity for broadcast
- Transitioning from one jurisdiction to another
- No clarity of time data was updated
- Controls that cover data means ATXFloods gets pulled off-air
- Not allowed to show / drive traffic to
- Focus on KXAN's own tool

"People are very visual - they want to see proof." - Emily Borchard

"That would allow us to …. Heighten the awareness of users" - Burton Fitzsimmons

Confusion

- Unsure of conditions leading into shift
- Can't click photo icons to show crossing-specific images
- Long-term closures vs. closures due to current conditions ***
- Unsure of what drives list order

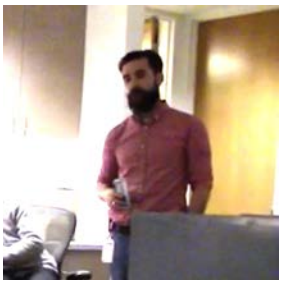
"It's the last thing I would think of before flooding started, to check this to get the starting number to subtract from active closures." - David Yeomans

"People are fascinated by the numbers" - S. Fisher

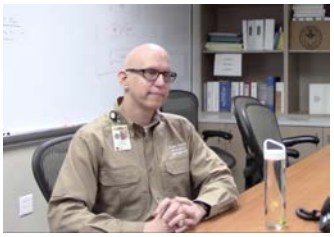
Emergency Management - Interview Participants

Tanner Hunt
Homeland Security, Emergency Management of Austin
Senior Emergency Plans Officer

Roger Thompson
Homeland Security, Emergency Management of CAPCOG
Crisis Information Systems Coordinator

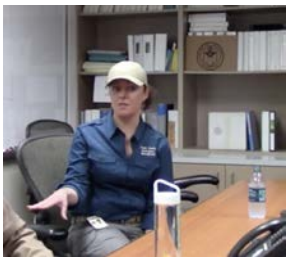


John "Donny" Cummings
Homeland Security, Emergency Management of Austin
Emergency Plans Officer



Blake Clampffer
Homeland Security, Travis County
Assistant Emergency Plans Coordinator

Eric Carter
Director of Homeland Security, Emergency Management of CAPCOG



Stacy Moore
Homeland Security, Travis County
Emergency Plans Coordinator

Steven Long, Homeland Security, Bastrop County, Wireless Systems Manager

Emergency Management - Insights

Decision-making

- Important factors:
  - Frequency
  - Severity
  - Volume
- Are there major damages?
- When are things winding down?
  - Rain stops
  - Water recedes
  - No more calls to emergency services
- When roads that rarely flood are closed, EOC stays open

Workarounds

- Point people ingesting info from social media
- Relay system from HAM radio operators

Tools & Technology

- Maps
  - NWS Radar
  - LCRA Hydromet
  - WAZE
  - DriveTexas.org
- Public Notification Systems
  - IPAWS
  - EAS
  - WEA
  - CodeRed
- Forecasting - NWS email
- Sensors - direct input of data
- Inter-team communication
- Radio
- Pagers (re: EOC activation)
- Cell phones (call, text)
- WebEOC
- Email distribution list (emergency managers)
- Ground conditions
- Social media
- Radio

Emergency Management - Insights

Satisfiers

- Mobile first
- Automation
    - Data flowing in
- Additional closure types
- Realtime
- Reliable
- Regional
- Geo-location

Motivators

- Quick reference for where problems exist
- Capture hourly summaries
- Provide a way for the public to check and validate conditions so they can make good, safe decisions

Challenges / Constraints

- Overnotification
- Public expectation vs. inaccurate info
- Roads outside of zone of control
    - I-35 & 183 (TXDOT)
- Dependency on other agencies
    - County precincts
    - TXDOT
- Keeping staff engaged in recovery mode
- 12 hour shifts can stretch into 30 hours
- Recovery: “That’s where the wheels fall off. Everybody goes back to their daily duties and we can’t get anybody to answer.”

Challenges / Constraints

- Risk: Woman rescued from roadway that was not marked closed
- “Can take 1-2 minutes to input one crossing” (re: system speed)
- Incentive not to mark a road closed so they don’t have to go back and mark it open
- Flat data - not exportable, sortable

Confusions

- Low water crossings are NOT flooded roadways
- Permanent road closures lead to misinterpretation of data

Emergency Management - Insights

[Re: The role that ATXFloods plays in the EOC] ...supplemental information that helps inform a decision rather than basing the decision on that piece of information alone."

"Seeing pictures of any recognizable monuments, in any state [or in context of flooding], it does amplify that perception of 'something serious is going on.'"

- Tanner Hunt

"[Re: site performance] A victim of its own success."

"[Re: hopes for the redesign] ...data is near real time as possible, indicates when something ISN'T current, so they have a way to check and validate their information so [the public] can make good decisions about their safety."

- Eric Carter

"[Re: getting real-time information] ..."Right now, the only way to do this right is to have 240 people sitting at 240 locations staring at them waiting to be able to indicate closures."

"[Re: marking closures as open] That's when the wheels fall off. Everybody goes back to their daily duties and we can't get anybody to answer what the conditions of the roads are."

- Steven Long

Emergency Medical Services - Interview Participants

Keith Noble
ATC - EMS Commander

Adam Johnson (Phone interview)
ATC - EMS

Emergency Medical Services - Insights

Decision-making

- Routing / dispatching resources w/ realtime info
- Place resources based on historical data
- Mobile site - make decisions in commute from Bastrop
- Responses that may modify how we access a neighborhood / area

Tools & Technology

- Restricted internet - blocked Google Maps server affects ATXFloods map
- Maps
    - LCRA Hydromet
    - CAD - Computer Aided Dispatching
    - ESRI - ARC/GIS maps (see: FireViewer)
    - Google Maps - good for waypoints like businesses
- WarnCentralTexas

Motivators

- Get people the EMS response that is needed
- Enable reactive & proactive responses

Workarounds

- Personal phones

Emergency Medical Services - Insights

Satisfiers

- Photos / cameras
- Safer way to check if road is passable
- Residents take closure seriously
- Automated / more effective notifications

“[Re: getting a visual]... real time intelligence, if I can see a crossing and see if it’s closed or not closed but it looks like it should be and I’m wondering why. The markers on the Onion Creek camera - being able to click a dot on the map and see what are the actual conditions on the ground right now.”

“There are times that we’re trying to determine whether this road is passable or not. Sometimes the FEWS guys will go out and drive around to check that out. Having the cameras just makes that a more automated, streamlined, safer process.”

“We can only have about a dozen sites authorized in the emergency vehicles, and ATXFloods is one that came up over and over again, and so we put it on the list. “

- Adam Johnson

Flood Early Warning System - Interview Participants

Matthew Porcher
Austin Watershed Protection - Sr. Systems Admin
Flood Early Warning System (FEWS)

Scott Prinsen
Austin Watershed Protection - Public Information Specialist
Flood Early Warning System (FEWS)

Flood Early Warning System - Insights

Satisfiers

- Create eye-truth via
  - TXDOT cams
  - FEWS cams
  - Social media
  - Employees / field ops
- Show public that data is fresh / site is actively maintained
- Easier to use on big screen
- Plays well with 3rd party services
- Improved speed

Motivators

- Communicating accurate information on conditions to the media

Tools & Technology

- Social Media
  - Public
  - Storm Spotters
  - APD
- Texted photos
- Weather service chat
- GeoJSON (output)
- Radio
  - APD
  - Field crews

Confusion

- Do field crews use this tool to determine openings to check / close?

Flood Early Warning System - Insights

Workarounds

- Data fields - some jurisdictions have repurposed to fit needs
- Plots multiple data points in one spot - red goes on top

Challenges / Constraints

- Tired after an event - managing closure data gets hard
- Each jurisdiction is responsible for own closures - inconsistent timing / process
- Not same person performing opening as who closed it
- #atxfloods gets hijacked at critical mass
- Refresh rate

“We see this [the photo of Stevie Ray Vaughn statue walking on water] and we were like oh my god, this is really really bad bad.”

“[Re: how accurate & timely the openings data are] Every jurisdiction does this differently - we say this is a platform, it’s free, just please do your best to keep it updated and accurate” - Matt Porcher

School Transport Dispatch - Interview Participants

Derek Hay (Phone Interview)
Ride GST Bastrop County - Bus Dispatch Supervisor

Lacey Evans (Phone Interview)
Ride GST Bastrop County - Bus Dispatcher

School Transport Dispatch - Insights

Challenges / Constraints

- Rural roads often not travelled before buses
- Pickup points are spread out
- Visibility - dark in early morning
- Inaccurate data - not updated early enough
- If encounter flooded road, must back out for miles / result in delay

Motivators

- Safety of children
- Create understanding with parents

Tools & Technology

- Communicate w/ email, phone, text
- Mobile ATXFloods - if routing afterschool buses from home

Workarounds

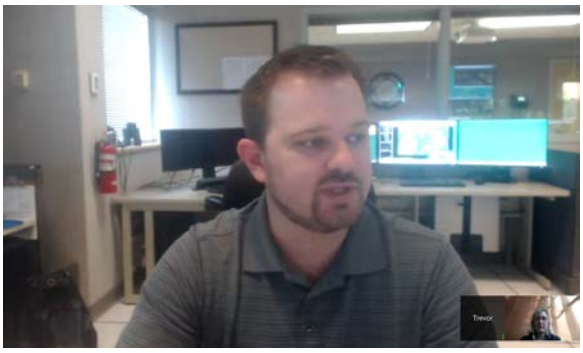
- Create lists of road closures & route affected
- Drive & check on roads that are

frequently problematic

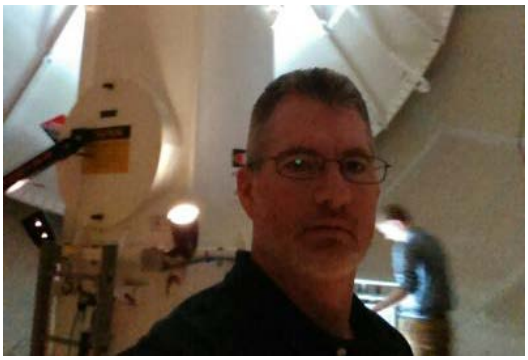
"In the morning, it's more difficult. It's dark, you can't see how much water is on the road. In the afternoon, esp. If we have had rain, we'll use it to see if something has been opened. "
- Lacey Evans

"I don't think a lot of the public knows about it." A lot of the time they'll be telling a parent about it and they'll say 'ATXFloods? What's that?'"
- Derek Hay

Weather Services - Interview Participants



Trevor Boucher
NOAA Meteorologist



Eric Platt
NOAA Meteorologist

Weather Services - Insights

Decision-making

- Situational awareness
- Push Flash-Flood alerts
- Aerial advisories
- Spatial impact

Motivators

- Accurate flash-flood warning maps
- Gauge past performances - estimate event time vs. actual closures time

Confusion

- Permanent / indefinite road closures

Challenges / Constraints

- Zoom buttons are blocked out

Tools & Technology

- Maps
  - Open Street Map
  - NOAA Radar Map
  - LCRA Hydromet
- Navigation
  - Drivetexas.org
  - GoogleMaps
  - WAZE
- Google Hangouts - video & screen share

Satisfiers

- Hone in on certain zones
- Improved mobile interaction
- Use GPS for location detection
- Extra context re: data points (non-binary)
- Cameras
- Timestamp

Weather Services - Insights

“The public must infer that because it’s binary, off/on, they are probably assuming that it’s automated. “

“[Re: spatial extent of what LWC is impacted] Depending on what county it is we might get more proactive emergency managers”

“If we learned anything in our research in weather, it needs to be very responsive and quick.
If the solutions aren’t, people will readily abandon them.”

-Trevor Boucher