Flood Early Warning System for San Jacinto County

FIF Grant Project No. 40042

San Jacinto River Authority
Flood Management Division

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Not Applicable

List of Acronyms

ACE – Annual Chance Flood Elevation
ALERT – Automated Local Evaluation in Real Time
BLE – Base Level Engineering
DNE – Determination of No Effect
FEMA – Federal Emergency Management Agency
FIF – Flood Infrastructure Fund
FWS – Flood Warning System
HCFCD – Harris County Flood Control District
ILA – Interlocal Agreement
NEMA – National Electrical Manufacturers Association
O&M – Operations and Maintenance
PAS – Path Analysis Study
SJMDP – San Jacinto Regional Watershed Master Drainage Plan
SJRA – San Jacinto River Authority
SWR – Standing Wave Ratio
TPWD – Texas Parks and Wildlife Department
TWDB – Texas Water Development Board
TxDOT – Texas Department of Transportation

INTRODUCTION

Background

The San Jacinto River Authority (SJRA) owns, operates and maintains a network of gauge sites that monitor water level (stage) and/or rainfall in the Lake Conroe and Lake Creek watersheds through the use of rain and stream gauges. Data from these gauge sites is publicly displayed on SJRA's Contrail website (https://sanjacinto.onerain.com). The location of these gauges is depicted below in **Figure 1**.

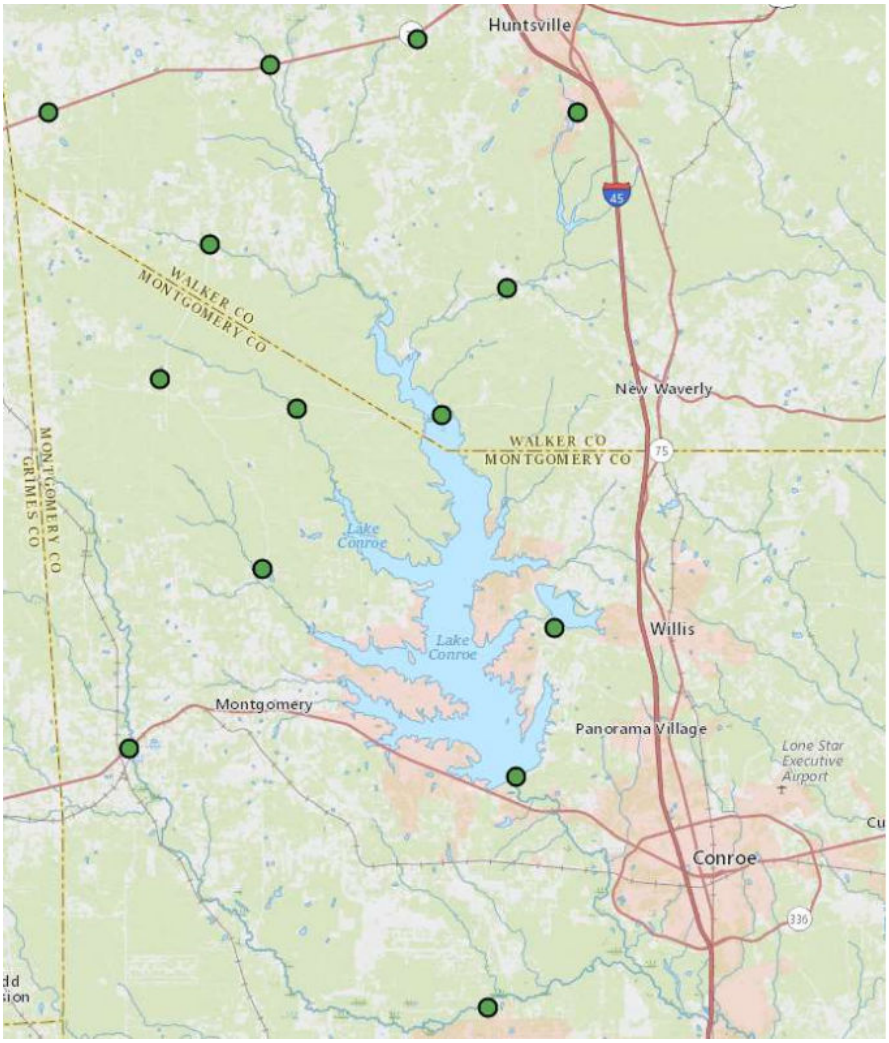

Figure 1. SJRA Existing Gauge Network (Pre-Project)

SJRA utilizes ALERT2 protocol to transmit data collected by the gauges. ALERT stands for Automated Local Evaluation in Real Time, which is a radio protocol developed by the National Weather Service (NWS) in the late 1970s for transmitting hydro-meteorological data. ALERT2, the successor to the ALERT protocol, was introduced in 2010 by the National Hydrologic Warning Council (NHWC). ALERT2 gauges operate similarly to ALERT gauges but transmit information much more efficiently, and as a result the ALERT2 protocol reduces data loss that may occur due to the tremendous load on the system during extreme rainfall events.

SJRA collects the data from its network of gauges and publishes it on SJRA's public-facing Contrail website. The Contrail site provides rainfall totals, flow rates, stage information, weather activity, and historical data. Contrail provides the flexibility to view water related information in a number of different ways, including viewing individual gauge site information on a static map, pan and zoom map, table, or customized dashboard.

Project Need

In 2020, with the goal of applying for Flood Infrastructure Fund (FIF) funding, SJRA reached out to various entities in its service area to determine their interest in partnering with SJRA on installation of new rain and stream gauges. San Jacinto County indicated a desire to partner, requesting the addition of three new gauges at locations deemed critical by the County for flood early warning capabilities based on previous flood and flood response experiences in these areas **(Figure 2)**. The areas downstream of the proposed gauges have been impacted by several previous storm events, including Hurricanes Harvey, Rita, and Ike, as well as storms in 1994, 1998, 2015, and 2016, causing road closures, high water rescues, etc. These have historically been low population areas but are growing rapidly. The three requested gauge locations included:

- Peach Creek at FM 3081
- Winters Bayou at SH 150
- East Fork San Jacinto River at FM 945

In June 2020, SJRA submitted abridged FIF applications for various projects to the Texas Water Development Board (TWDB), including the Flood Early Warning System for San Jacinto County (FEWS) project. In August 2020, SJRA's Board of Directors adopted a resolution approving submittal of a full application to TWDB for the FEWS project. SJRA received an invite from TWDB to submit a full application for the FEWS project, and submitted the application. The application was successful, and a grant contract with TWDB was executed in June 2021.

In March 2021, SJRA's Board of Directors authorized execution of an Interlocal Agreement (ILA) with San Jacinto County related to the project. Per the ILA, San Jacinto County will provide annual funding to SJRA for operations and maintenance (O&M) of the new equipment, and SJRA will use the County's funding to provide the labor, equipment, and materials necessary to operate and maintain the new gauges so long as said gauges remain in place.

Project Objective

The project provides advanced warning information to the public and emergency responders such that they can take appropriate actions and provide appropriate instructions based on the conditions at the time. The advanced warning will also allow emergency responders time to prioritize the dispatch of first responders. This will protect life and allow protection of property which can be moved to a safe location with adequate warning. The early warning system may reduce the burden on County emergency services by reducing the necessary number of high-water rescues during flooding events, and could give emergency responders more time to close roads before they become flooded, therefore benefitting more than just the residents and businesses directly downstream of the new gauges.

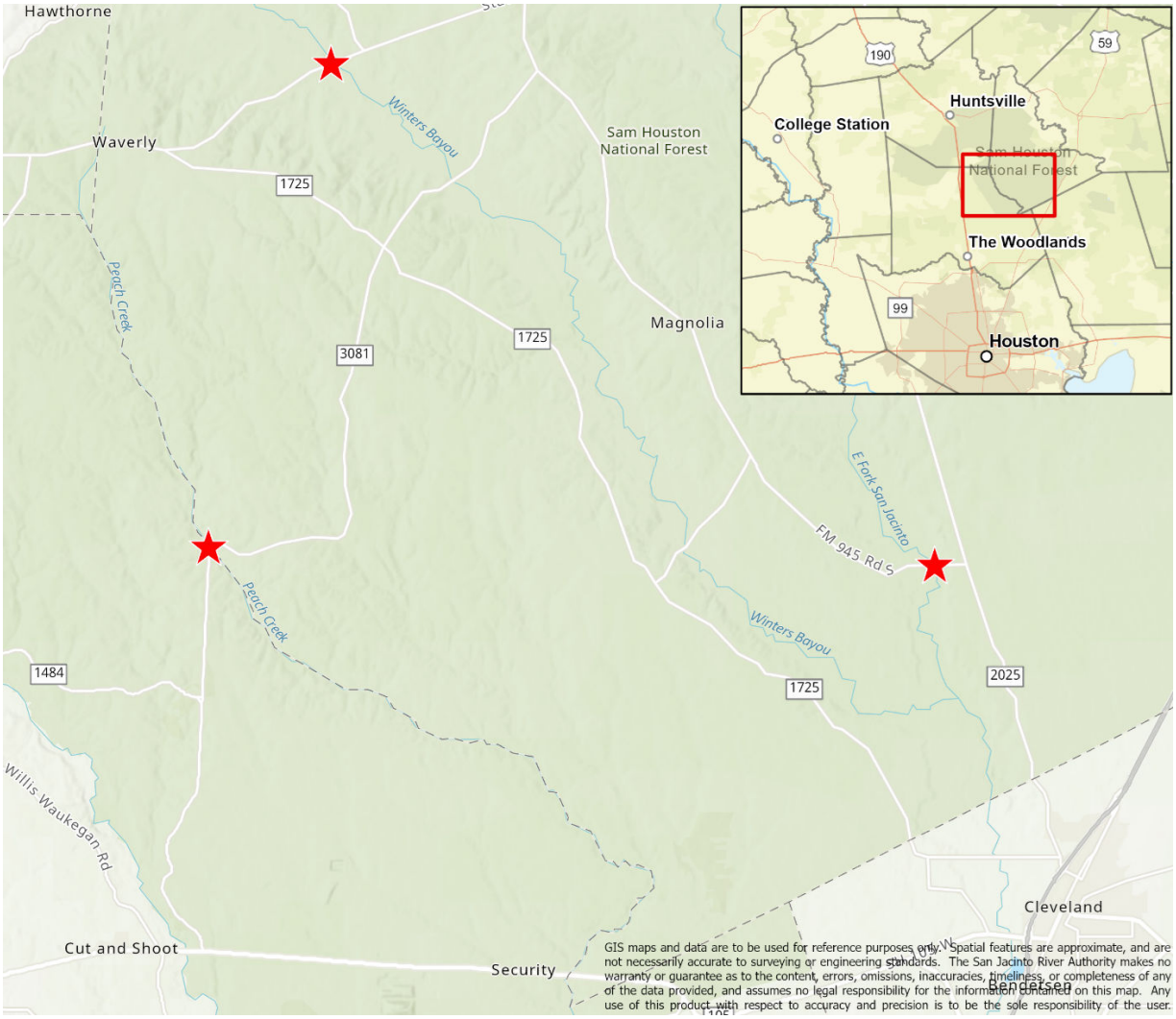

Figure 2. New San Jacinto County Gauge Locations

Communities and Entities Involved in Formulating the Project

The project is located entirely within SJRA's jurisdictional boundary. SJRA has acted cooperatively with other political subdivisions to address flood control needs in the area, including coordinating the project with San Jacinto County and Harris County Flood Control District (HCFCD). San Jacinto County is supportive of the rain and stream gauge additions to better protect the citizens and first responders in the County. SJRA and HCFCD already share rain/stream gauge data with each other, with SJRA's gauge network data displayed on HCFCD's Flood Warning System (FWS) website. HCFCD is agreeable to adding these three proposed gauges to the public-facing side of the FWS website that shows rainfall and stream level information. The need for additional gauges in the Upper San Jacinto River Basin was also addressed in the San Jacinto Regional Watershed Master Drainage Plan (SJMDP), a study led by HCFCD with partners SJRA, the City of Houston, and Montgomery County. The Winters Bayou at SH 150 gauge was recommended specifically in the SJMDP, as it was requested by Montgomery County. The SJMDP was completed in December 2020.

On October 7, 2020, SJRA sent over 200 letters to entities within the Upper San Jacinto River Basin regarding this and other grant project applications. One letter of support was submitted to SJRA for this project, from Commissioner David S. Brandon, Precinct 3 Commissioner, San Jacinto County.

Public Comment

SJRA made a presentation regarding the funding application and project at the San Jacinto County Commissioners Court meeting on October 7, 2020, which included the opportunity for public input. No public comments were submitted at the meeting.

SJRA has held two public meetings to inform the public of the project. Opportunity was provided for the public to provide questions in advance of each meeting, as well as to make comments or ask questions at each meeting.

- September 1, 2021 – A public meeting was held at the San Jacinto County Shelter in Coldpsring, Texas, and also broadcast virtually. The meeting presentation included information on the grant award, an overview of the project, and a demonstration of the equipment proposed for installation. Staff of SJRA and TWDB were present, however no members of the public attended. No questions or comments relevant to this project were received from the public.

- May 26, 2022 – A public meeting was held at the San Jacinto River Authority, General & Administration (G&A) building in Conroe, Texas, and also broadcast virtually. The meeting presentation included a project overview and update on project progress. SJRA and TWDB staff attended the meeting, along with a small number of public participants. No questions or comments relevant to this project were received from the public.

A final public meeting will be held on December 14, 2023 at the SJRA General & Administration (G&A) building in Conroe, Texas, and will also be broadcast virtually.

METHODOLOGY

Site Evaluation and Equipment Selection

For years SJRA has operated and maintained a robust network of gauging sites and ALERT/ALERT2 systems. SJRA O&M staff have a wealth of experience with gauging equipment and the ALERT systems, and stay current on the latest developments in technology and equipment, enabling SJRA to effectively operate and maintain the current network and modify or expand it as necessary. This includes the ability to add new equipment and sites to the network.

For this project, SJRA contracted with Distinctive AFWS Designs, Inc. to conduct a Path Analysis Study (PAS) to evaluate each of the proposed gauging sites, determine site constraints, and recommend equipment. The PAS took into consideration site conditions, ability of radio signals to travel from each site to SJRA's existing radio receiver and repeater locations, data accuracy, and overall usefulness of the new data. The most significant result of the PAS was the recommendation for radar sensor gauges in lieu of instream gauges at all three sites. A site-by-site summary of the results of the PAS is as follows:

Peach Creek at FM 3081

- Recommended gauge shelter location on southeast (downstream) corner of bridge; on-site radio test was successful for this location;
- Recommended mounting sensor gauge above the 1% annual chance (100-year) flood elevation;
- Due to shifting path of the creek, potential impact of flood debris, and general reliability and durability concerns regarding instream pressure transducer stream gauges, a radar sensor was recommended over an instream pressure transducer stream gauge;
- Solar coverage is limited by nearby tree line; recommended trimming nearby trees for improved rain measurements and accurate data collection. [NOTE: SJRA employed a contractor to perform tree trimming at this location due to proximity of trees to overhead power lines; SJRA obtained right of entry from neighboring landowner to obtain access to trim trees]

Winters Bayou at SH 150

- Recommended gauge shelter location on southwest (downstream) corner of bridge; on-site radio tests found that signals did not reach both of SJRA's receiver/repeater sites at optimal levels; [NOTE: SJRA mitigated by use of a directional antenna at this site]
- Recommended mounting sensor gauge above the 1% annual chance (100-year) flood elevation;
- Due to general reliability and durability concerns regarding instream pressure transducer stream gauges, a radar sensor was recommended over an instream pressure transducer stream gauge;
- Recommended clearing trees near the channel for a clear radar path. [NOTE: Rather than clear trees, SJRA trimmed trees/brush along the channel at this site; no full trees, shrubs, etc. were removed]

East Fork San Jacinto River @ FM 945

- Recommended gauge shelter location on southwest (downstream) side of bridge; on-site radio tests found a power amplifier was required to reliably receive data from this site; use of a power amplifier and/or use of a directional antenna instead of an omnidirectional antenna (as was used in the PAS) was anticipated to be required to improve the signal at this site;
- No tree trimming or clearing required for the site;
- A rain gauge was NOT recommended at the site due to overhead vegetation likely blocking precipitation and leading to inaccurate measurements.
- Recommended mounting sensor gauge above the 1% annual chance (100-year) flood elevation;
- Due to the tendency for the stream to move and difficulty of access to the bridge for maintenance, as well as general reliability and durability concerns regarding instream pressure transducer stream gauges, a radar sensor was recommended over an instream pressure transducer gauge.

Flood Hardening

When the San Jacinto River Authority (SJRA) submitted its abridged application, the intention was to place each of the gauges such that any equipment susceptible to water damage would be elevated above the 0.2% (500-year) annual chance flood elevation (ACE). Since that time, SJRA obtained data incorporating Atlas 14 rainfall into flood water surface elevations. The 0.2% ACE elevations are much higher than SJRA anticipated. In some cases, the elevations are as high as 10 feet above the top of the roadway/bridge, which creates maintenance difficulties and safety concerns for maintenance staff. Therefore, SJRA made the decision to locate sensor gauges above the 1% (100-year) ACE. Equipment susceptible to water damage would be placed in watertight compartments for protection against the elements.

SJRA determined the appropriate elevations for each of the sites by leveraging existing data. Water surface elevations determined in the San Jacinto Regional Watershed Master Drainage Plan using Atlas 14 rainfall were used to determine the appropriate elevation for Peach Creek at FM 3081 and East Fork at FM 945. The elevation for the sensor gauge at Winters Bayou at SH 150 is based on the FEMA recent Base Level Engineering (BLE) study of Winters Creek. While the BLE study did not use Atlas 14 rainfall, the study did incorporate existing gauge data.

TWDB Environmental Requirements

Pursuant to the environmental assessment requirements of 31 Texas Administrative Code (TAC) § 363.14, TWDB staff determined that the project was exempted from formal environmental review requirements. A “Determination of No Effect” (DNE) was issued by the TWDB for the project in May 2021. The requirements of the DNE were considered in the evaluation of sites and equipment for this project.

PROJECT IMPLEMENTATION

Equipment

For equipment installed at all sites, SJRA generally followed the equipment recommendations described in the PAS. Although the PAS recommended a power amplifier at the FM 945 site only, SJRA

installed power amplifiers at all three sites to ensure robust connectivity with the network. **Photos of the completed installations are shown in Figure 3, Figure 4, and Figure 5.** The following equipment was installed as part of the project:

Peach Creek at FM 3081 **(Figure 3)**

- Gauge Shelter – transmitter in NEMA 4X aluminum telemetry cabinet, tipping bucket rain gauge, power amplifier and directional antenna, mounted on a breakaway aluminum pole on a concrete base; located off road shoulder on southeast (downstream) corner of bridge;
- Stream Gauge – radar sensor, mounted from the bridge structure, with sensor located above the 1% annual chance (100-year) flood elevation;
- Wiring and conduit between gauge shelter and radar sensor, with conduit mounted to bridge structure.

Figure 3. Completed Installation, Peach Creek at FM 3081

Winters Bayou at SH 150 **(Figure 4)**

- Gauge Shelter – transmitter in NEMA 4X aluminum telemetry cabinet, tipping bucket rain gauge, power amplifier and directional antenna, mounted on a breakaway aluminum pole on a concrete base; located off road shoulder on southwest (downstream) corner of bridge;
- Stream Gauge – radar sensor, mounted from the bridge structure, with sensor located above the 1% annual chance (100-year) flood elevation;

- Wiring and conduit between gauge shelter and radar sensor.

Figure 4. Completed Installation, Winters Bayou at SH 150

East Fork San Jacinto River @ FM 945 **(Figure 5)**

- Gauge Shelter – transmitter in NEMA 4X aluminum telemetry cabinet, power amplifier and directional antenna, mounted on a breakaway aluminum pole on a concrete base; located off road shoulder on southwest (downstream) corner of bridge [Note: No rain gauge installed at this site because of overhead vegetation];
- Stream Gauge – radar sensor, mounted from the bridge structure, with sensor located above the 1% annual chance (100-year) flood elevation;
- Wiring and conduit between gauge shelter and radar sensor.

Figure 5. Completed Installation, East Fork San Jacinto River at FM 945

Installation/Construction

All work on the project was performed in accordance with the TWDB environmental and cultural requirements described in the DNE.

One unique requirement of the project was regarding endangered species. As per agreement with Texas Parks and Wildlife Department (TPWD Project No. 45531) and to ensure compliance with Texas Parks and Wildlife Code and the Endangered Species Act, all staff who performed field efforts were provided training regarding the State-level threatened alligator snapping turtle (Macrochelys temminckii).

Tree/brush trimming and tree removal for the project was scheduled and completed outside of the migratory bird nesting season. SJRA coordinated with a private landowner and a power utility company for removal and trimming of trees for this project, including obtaining access/right-of entry.

Texas Department of Transportation (TxDOT) standards were followed for design and installation of the project. TxDOT standard traffic control measures were utilized when required during construction.

A post-construction survey was completed to obtain elevations of existing features and the newly installed equipment. A permanent benchmark with elevation information was installed at each site.

Other Considerations

TxDOT notified SJRA that the bridge at the East Fork San Jacinto River site is scheduled for replacement in May 2024. If the bridge is replaced, SJRA will coordinate with TxDOT to remove stream gauge equipment from the existing bridge prior to construction, and SJRA will re-permit with TxDOT and re-install equipment on the new bridge. SJRA will also coordinate with San Jacinto County during this process.

For future required maintenance trimming of trees, SJRA will coordinate with the appropriate land/easement/right-of-way holders, utilities, etc., including obtaining access/right-of entry.

SCHEDULE OF EQUIPMENT MAINTENANCE AND MONITORING

Monthly Site Inspections

As part of established O&M procedures, SJRA will visit each site once per month to conduct the following maintenance activities:

- Assess site conditions and check for visual signs of damage from high wind, vegetation, trees, vandalism and/or motor vehicle accidents
- Check and clean rain tipping buckets
- Update software, if applicable
- Document maintenance activities performed
- If maintenance or repair needs are identified, SJRA will determine the appropriate course of action.

Bi-Annual (twice per year) Site Inspections

As part of established O&M procedures, SJRA will visit each site bi-annually (twice per year) to conduct the following maintenance activities:

- Assess site conditions and check for visual signs of damage from high wind, vegetation, trees, vandalism and/or motor vehicle accidents
- Conduct full cleaning of equipment (panels/boxes, rain sensors, and radar sensors)
- Perform full calibration of all sensors
- Check batteries (discharge and charge check)
- Standing Wave Ratio (SWR) check on antennas (checks for correct frequency and power level)
- Update and Record any software changes
- Document maintenance activities performed
- If maintenance or repair needs are identified, SJRA will determine the appropriate course of action.

RESULTS

Challenges

The project had several challenges. Because the sites are in remote, forested areas far from SJRA's existing network sites, sight lines and tree cover presented obstructions that could affect rainfall measurement and transmission of radio signals. Due to the COVID19 pandemic, supply chain issues resulted in delivery delays for equipment and materials. Finally, there were multiple challenges during equipment installation, including obtaining right-of-entry for tree trimming and removal, inclement weather causing poor site conditions and elevated stream levels that caused delays.

Conclusions

SJRA will continue to work with neighboring jurisdictions to develop solutions to better inform and warn the public and first responders of potential flooding conditions. The newly installed rain and stream gauges in San Jacinto County will provide much-needed flood warning information for the County, as well as for downstream stakeholders. The public and first responders will have real-time gauge data to aid in making decisions regarding public and property safety with notice during a flood event. The current population of the County will benefit from the project, as will the future population because the gauge sites will be operated and maintained for the long-term.

ACKNOWLEDGEMENTS

SJRA would like to thank the Texas Water Development Board, San Jacinto County, the Texas Department of Transportation, and all of the professional engineering and surveying consultants involved with the project.