THE WATER INSTITUTE

THE WEST PARK DRAINAGE IMPACT STUDY

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Produced for the National Park Service

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PREFACE

Hurricanes Laura and Delta, two category-four hurricanes in close succession in August and October 2020, caused a pattern of destruction across southwest Louisiana characterized by a combination of high winds, fallen debris, heavy rains and flooding that extended more than eighty miles inland. When disaster-impacted communities requested National Park Service's (NPS's) Rivers, Trails, and Conservation Assistance Program (RTCA) to assist with long-term recovery with a focus on resource conservation and outdoor recreation, local partners agreed on the need for a planning-level analysis and modeling of potential strategies. Funding was provided through an interagency agreement between the Federal Emergency Management Agency (FEMA) and the NPS via the Stafford Act to conduct the work. The NPS entered into a scope of work with The Water Institute to address the need for modeling and analysis of hydraulic and hydrologic (H&H) resources within West Park in DeRidder, Louisiana to characterize flooding depths and extents across several intensities of rainfall. The results of the analysis are intended to inform DeRidder officials on the capability or proposed mitigation and adaptation alternatives as they look to renovate the park facilities.

ACKNOWLEDGEMENTS

Several persons from both the National Park Service and the City of DeRidder, LA were integral to the development of this report including:

- Helen Siewers and Russell Clark (NPS)
- Ashley Craddock and Tommy Landry (City of DeRidder, LA)

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EXECUTIVE SUMMARY

West Park has long been a center of recreation for residents of the City of DeRidder, Louisiana. Developed in 1942, the park is located on a 48-acre site in the heart of DeRidder along North Pine Street, the city's busiest commercial thoroughfare. Historically, the multi-use park contained heavily forested tracts situated on Hickory Creek. In 2020, the impact of hurricanes Laura and Delta changed much of the park's landscape. Many of the park's trees were uprooted by the winds and rains. The loss of these trees, and the large stump holes left after their removal, not only changed the look of the park, but also threaten the function of the park's natural drainage patterns. In February 2023, the City of DeRidder released the West Park Master Plan to restore the features of the park and provide improved amenities for the community. Developed with assistance from the National Park Service – Rivers, Trails and Conservation Assistance program and CARBO Landscape Architecture, the West Park Master Plan is intended to both provide enhanced opportunities for recreation and improve park drainage. A centerpiece of the plan is the creation of a pond for the temporary detention and permanent retention of stormwater in a low-lying area between two branches of Hickory Creek.

To determine the optimal placement and specifications of this pond, the National Park Service worked with The Water Institute to conduct modeling and analysis of hydraulic and hydrologic resources within West Park and determine flooding depths and extents across several intensities of rainfall. For this study, The Water Institute utilized two United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) models. The HEC Hydrologic Modeling System (HEC-HMS) was used to model local hydrology and the HEC River Analysis System (HEC-RAS) was used to develop a two-dimensional model of the study area, which evaluated the impacts of five different proposed scenarios. The analysis was performed at a planning level, and explored alterations to park hydrology, namely the installation of a detention pond and alterations to the stream banks (widening, adding vegetation for roughness) to explore ways to alleviate flooding within the park under 2-, 10-, and 100-yr average recurrence interval precipitation events.

The final proposed configuration scenario considered the surrounding available right of way and available depth to act as a gravity drained pond. The proposed pond, located south of Park Road, would have a 10 × 2 ft reinforced concrete box inflow culvert mimicking that of multiple 24 in. conduits. The proposed outflow culvert would be a single 24 in. reinforced concrete pipe which constricts flow allowing the pond's volume to be utilized to its full capacity. The adjacent stream had the lowest elevation providing approximately 4 feet of depth and 7 ac-ft of storage capacity. Any depth beyond 4 feet would hold standing water for aesthetic purposes only and would not contribute to flood storage unless water levels were reduced through evaporation or through mechanical extraction/pumping.

Given design recommendations and the low storage capacity of the final selected configuration, the proposed pond will create limited additional storage and is likely to be more effective for smaller, more frequent events, such as the 2-yr rainfall event (Figure ES 1). In such an event, the proposed detention pond would deliver some flood mitigation benefits within West Park, reducing flood depths south of the tennis courts and around the junction of Hickory Branch and North Pine Street. Nevertheless, the total water volume entering the park from upstream for the 2-yr event would still exceed the storage volume of the proposed pond and result in localized flooding within the park. The proposed detention pond would be less effective in reducing flood depths within West Park during more extreme rainfall, such as 10-yr and 100-yr events. With the pond in place, minor reductions in flooding at the junction North Pine Street and

Hickory Branch are observed in the model results for a 10-yr event, while no notable reductions are observed during a 100-year event.

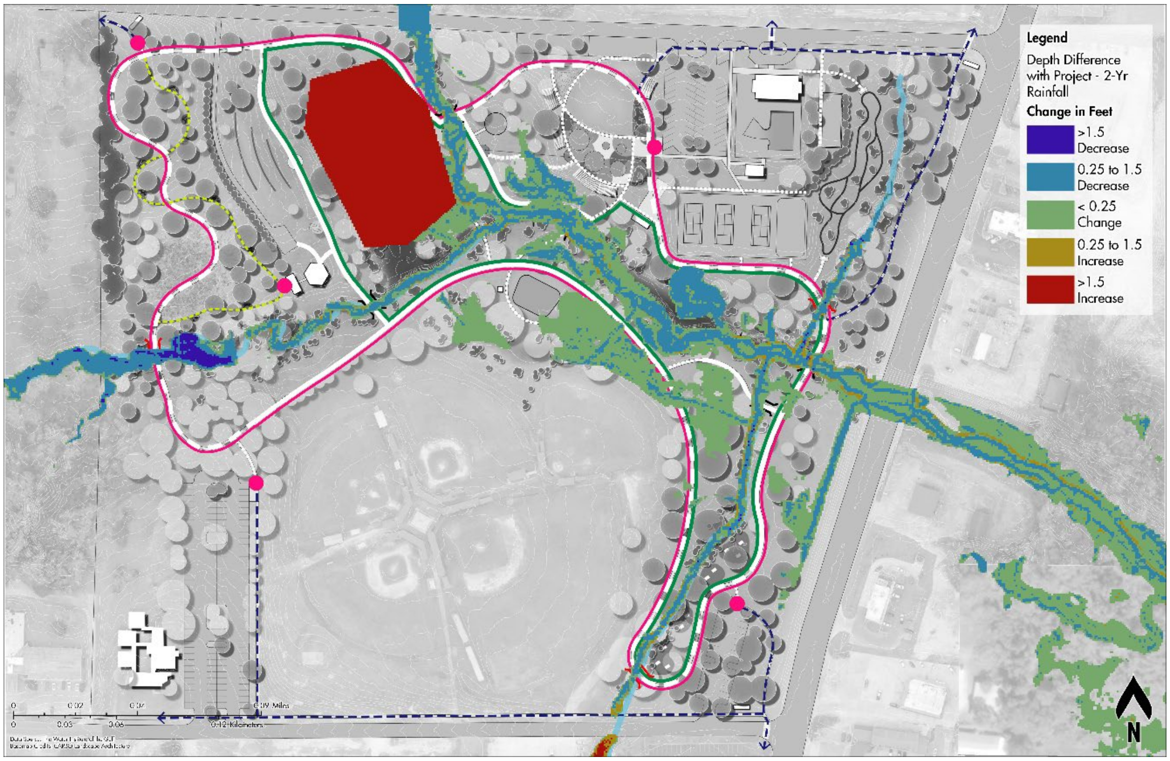

Figure ES 1. Flood depth differences resulting from a 2-year storm event in West Park with the proposed pond installed, showing impacts to the main walking loop (solid pink lines), the accessible walking loop (solid green lines), planned trail expansion (hatched gold lines), and proposed city sidewalks (blue hatched lines) identified in the West Park Master Plan

While the installation of the proposed detention pond within West Park will alleviate flooding during smaller, more frequent events, its primary function would likely be aesthetic. Unless large-scale and expensive engineering projects are constructed, extending beyond the park's borders, the park will likely continue to experience flooding during extreme rainfall events. The flood extent and depth data for the with- and without-project conditions can be used by park planners to alter the locations of park infrastructure, such as shelters, paths, and playgrounds, to reduce flood frequency and magnitude impacts. Finally, while the proposed pond may not consistently reduce flood depths throughout West Park, it also is not expected to induce flooding beyond the park's boundaries or worsen conditions in surrounding neighborhoods.

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LIST OF ACRONYMS

Acronym	Term
ARI	Average Recurrence Interval
BLE	Base Level Elevation
DEM	Digital Elevation Model
FEMA	Federal Emergency Management Agency
GIS	Geographic Information Systems
GPS	Global Positioning System
HEC	Hydrologic Engineering Center
HMS	Hydrologic Modeling System
HUC	Hydrologic Unit Code
LSU	Louisiana State University
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
PAC	Percent Annual Chance
QA/QC	Quality Assurance/Quality Control
RAS	River Analysis System
ROM	Rain on Mesh
ROW	Right of Way
SVG	Spatial Video Geonarratives
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSE	Water Surface Elevation

1.0 INTRODUCTION

West Park is located along the Hickory Branch of the Flat Creek watershed in the City of DeRidder, in Beauregard Parish, LA (Figure 1). Two small tributaries flow into Hickory Branch within the park area (Figure 1), where flows run from west to east and exit the park to flow under the U.S. Highway 171 (North Pine Street) bridge. The watercourses within the park have eroding channel banks, comprised generally of sandy loam soils (Natural Resources Conservation Service [NRCS], U.S. Department of Agriculture [USDA], 2022). Significant portions of the park, as well as commercial properties along U.S. Highway 171 lie within the Federal Emergency Management Agency's (FEMA's) Special Flood Hazard Area and regulatory floodplain (Louisiana State University [LSU] AgCenter, 2018), which extends along the banks of the Hickory Branch creek (Figure 2).

Presently, the National Park Service (NPS) is working with Carbo Architects of Baton Rouge, LA to determine improvement and restoration measures for West Park. NPS has requested that The Water Institute (the Institute) conduct a hydrodynamic modeling study to investigate multiple proposed scenarios for potential flood mitigation if the park were used for the dual purposes of recreation and flood risk reduction. Furthermore, the NPS is working with City of DeRidder officials to determine the best sites and locations for existing and future park infrastructure to make it more resilent to frequent minor flooding.

For this study, two United States Army Corps of Engineers (USACE) Hydrologic Engineering Center (HEC) models were used. The HEC Hydrologic Modeling System (HEC-HMS) was used for hydrology and the HEC River Analysis System (HEC-RAS) was used to develop a two-dimensional (2D) model of the study area and is further explained in Section 2.2 of this report. The modeling software were chosen for several reasons: they are the standard analysis software of FEMA and USACE, are the industry standard for such evaluations, and are also free and open source. From this 2D model, proposed detention configurations were evaluated to determine any impacts to the study area. For this study, the 2-, 10-, and 100-yr average recurrence intervals (ARIs) were evaluated for existing conditions and for all proposed scenarios.

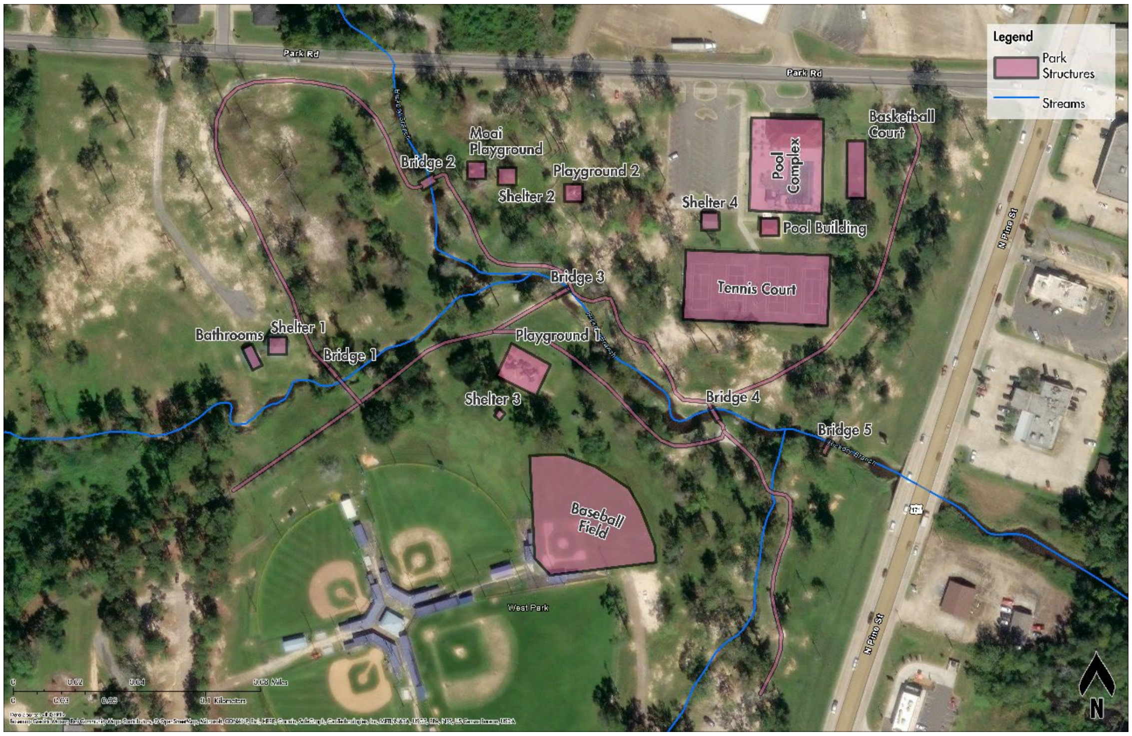


Figure 1. The two tributaries that flow into Hickory Branch within the park area.

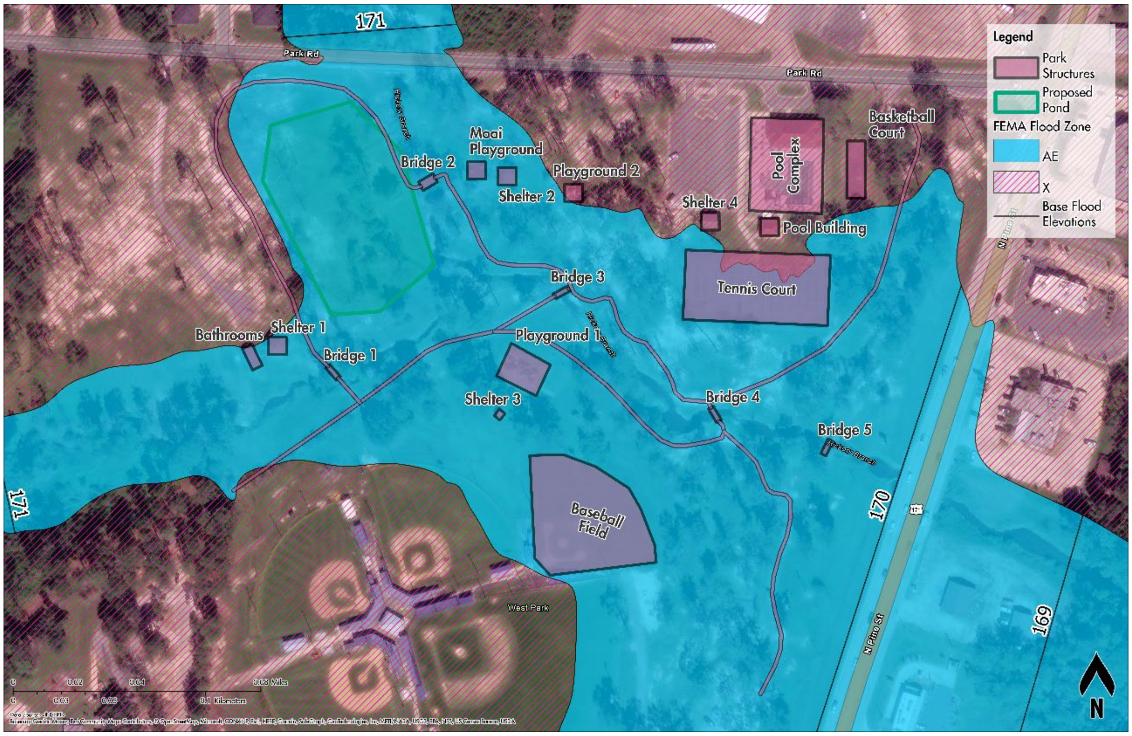


Figure 2. Study area as shown in Figure 1, with FEMA flood zones A (white), AE (blue) and X (hatched magenta), Base Flood Elevations (BFE) and known structures within the park.

2.0 METHODS

2.1 DATA COLLECTION

To inform the modeling approach used for this study, an existing Whiskey Chitto Base Level Elevation (BLE) model and LiDAR dataset was downloaded and reviewed. The existing BLE model was evaluated for use for this study's scope and the LiDAR evaluated to determine if the resolution was suitable for the study, and whether it would allow the delineation of the contributing watershed and represent features within the West Park study area.

2.1.1 Existing BLE Model

The Whiskey Chitto BLE model developed by FEMA was downloaded from the U.S. Geological Survey (USGS) Interagency Flood Risk Management website, which included spatial data (FEMA, 2020) and a report summarizing the efforts (Compass PTS JV, 2020).

The model encompasses the Whisky Chitto Watershed and is a full 2D rain-on-mesh (ROM) model. The model does not contain any detailed structures, such as culverts or bridge crossings. Also, a hydrologic model was not completed to accompany the BLE efforts. Instead, hand calculations were completed to calculate excess precipitation from the calculated curve number and used as input into the HEC-RAS model.

Each model takes over 20 hours to run a10-day simulation. For computational efficiency—and given the scope of this study—the BLE model was used to provide boundary conditions for a new sub-regional hydraulic model developed for the study area (Section 2.2) and to inform this new model for the existing terrain and Manning's landcover.

2.1.2 LiDAR

For the delineation of the contributing watershed at the regional scale, a 10-meter resolution digital elevation model (DEM) was obtained from USGS (USGS, 2018), converted to feet, and reprojected to the state plane coordinate system similar to that used in the BLE model. The HEC-RAS BLE model already contained a 3-meter resolution DEM, however, the source LiDAR for the DEM was collected in 2007. To update the DEM locally for the study area, a 1-meter resolution DEM with source data from 2018 was obtained (USGS, 2018) and used for sub-regional hydraulic modeling efforts within study area.

2.1.3 Datum and Coordinate System

For consistency, the datum and coordinate system used was the same that was used in the BLE model as listed below:

- Datum: GCS_North_American_1983
- Coordinate System: NAD_1983_StatePlane_Louisiana_North_FIPS_1701_Feet

2.2 HYDROLOGY AND HYDRAULICS

2.2.1 Watershed Delineation

A 10-meter DEM terrain from USGS was used to delineate the watershed (USGS, 2018); this resolution was sufficient to route rainfall throughout the watershed and develop realistic flow and stage for use in the sub-regional model. The source data has units converted from meters to feet and was re-projected to match the BLE model, which uses a projection of EPSG 3451.

The basin boundary was manually delineated based on the DEM because the study area is smaller than the surrounding 12-digit Hydrologic Unit Code subbasin (HUC12) boundary (Figure 3). HEC-HMS geoprocessing tools were used to delineate the subbasins from this boundary. This includes spatial references for hydrologic elements and tools for delineating a watershed from a DEM. Most of these tools are found in the geographic information system (GIS) menu within the HEC-HMS software interface.

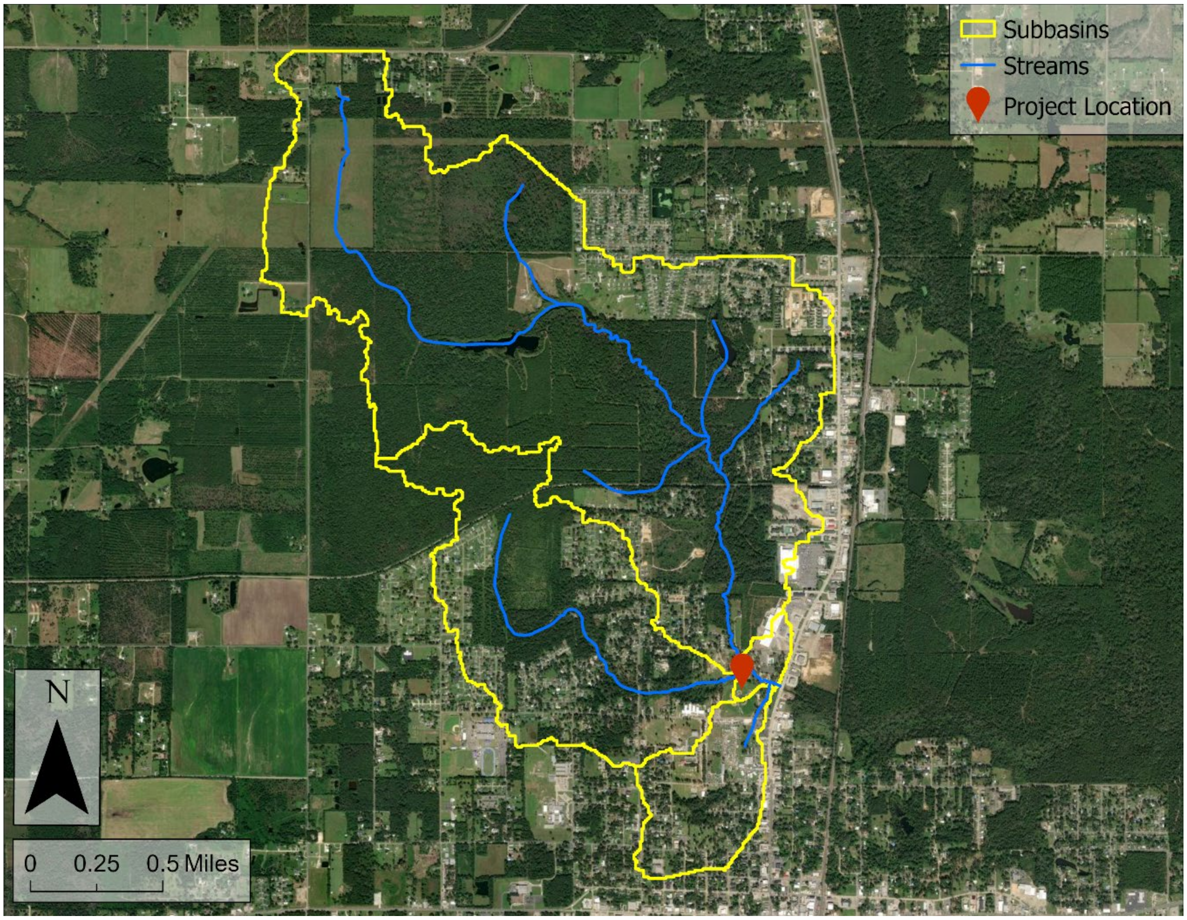


Figure 3. HEC-HMS subbasin delineation

2.2.2 Hydrologic Losses

The hydrology model (HEC-HMS) receives precipitation as input and includes a process through which it can determine how much of the rainfall is turned into runoff via a loss module. The losses in the hydrology model account for soil absorbing precipitation and computes the excess precipitation as runoff that is then routed through river reaches in the model. The Whiskey Chitto BLE model contained a curve number shape file which was converted from a vector to a raster grid. A runoff curve number is an empirical parameter used in hydrology for predicting direct runoff or infiltration from rainfall excess. From the raster grid, zonal statistics were evaluated and applied using each HMS subbasin to obtain a mean curve number to use in the model. The initial loss value for each subbasin was visually calibrated in the BLE model result hydrograph for similar events (Figure 4).

A separate basin was created to represent losses for the 2-yr frequency event, which required lower initial loss rates to obtain reasonable results.

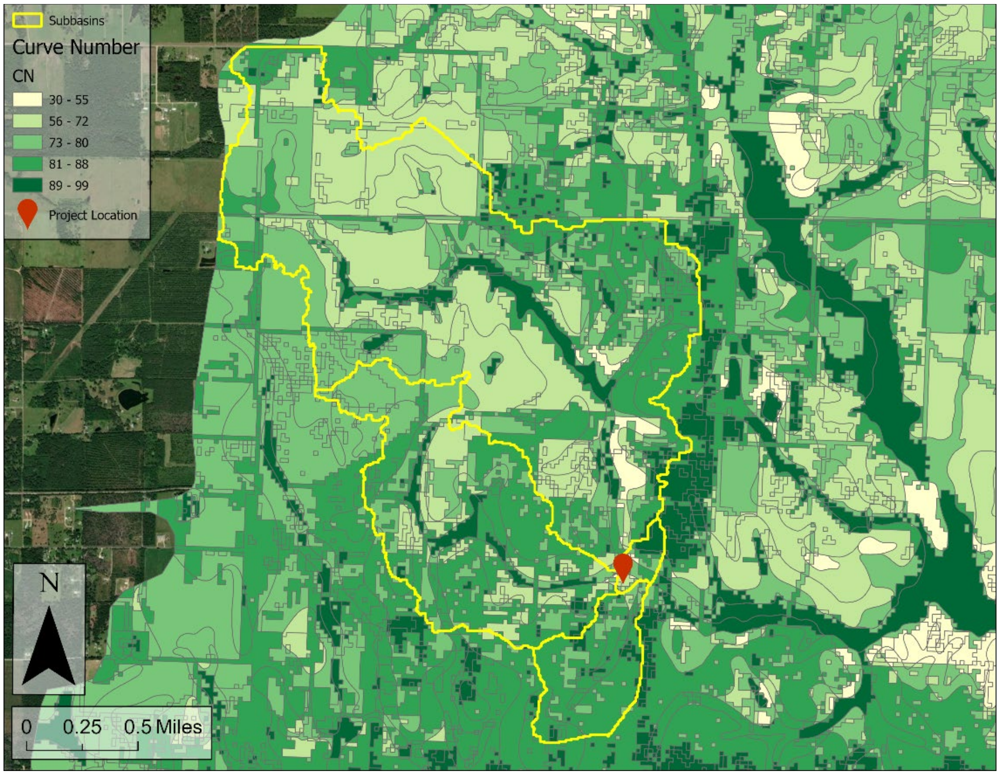


Figure 4. Curve Number feature layer used to get lump subbasin average values.

2.2.3 Transform

While a subbasin element conceptually represents infiltration, surface runoff, and subsurface processes interacting together, the actual surface runoff calculations are performed by a transform method contained within the subbasin.

The modified Clark (ModClark) transform method was selected for converting rainfall to run-off. The ModClark Method is a linear, quasi-distributed transform method that is based on the Clark Conceptual Unit Hydrograph. It fundamentally represents the subbasin as a collection of grid cells. The Clark Method uses a time-area curve and the time of concentration to develop a translation hydrograph. By contrast, the ModClark method eliminates the time-area curve and instead uses a separate travel time index for each grid cell. The travel time index for each cell is scaled by the overall time of concentration. Excess precipitation falling on each grid cell is lagged by the scaled time index and then routed through a linear reservoir. The outputs from the linear reservoirs of the cells are combined to produce the final hydrograph. The ModClark parameter values were estimated from calculated basin characteristics following HEC-HMS geoprocessing procedures (USACE, 2022).

2.2.4 Baseflow

The baseflow is the flow in the stream without accounting for the addition of the excess precipitation runoff (e.g., the portion of the streamflow that is sustained between precipitation events and fed to streams by delayed pathways). The upper portion of the contributing watershed, within s_North on Hickory Branch, contains existing reservoirs (Figure 5). To simulate the reservoir releases, a constant baseflow was used to simulate an expected maximum release value from the reservoirs in the s_North subbasin of 150 cubic feet per second (cfs), which also includes an estimate for local baseflow. This value is informed by information for the largest reservoir, Scaldi Lake, which has a documented maximum release value of 110 cfs (USACE, 2020).

Separate basins within the HEC-HMS model were created both with and without the expected reservoir release baseflow, and additional simulations were run to observe the potential benefit of more control from these flow sources.

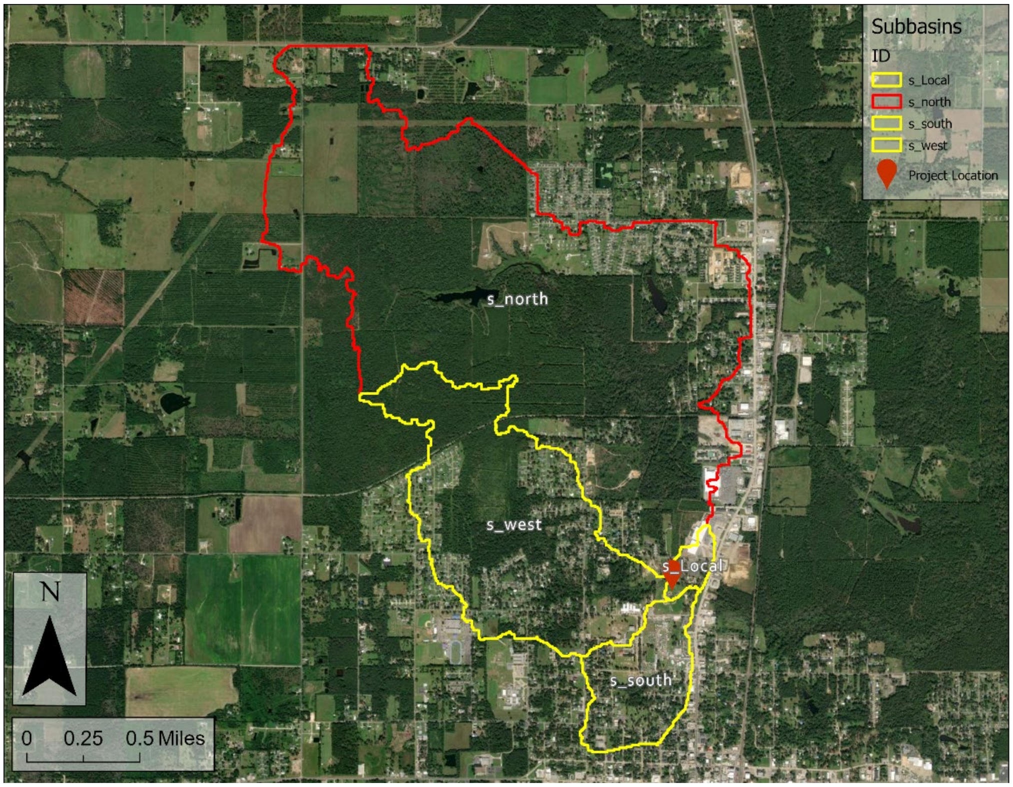
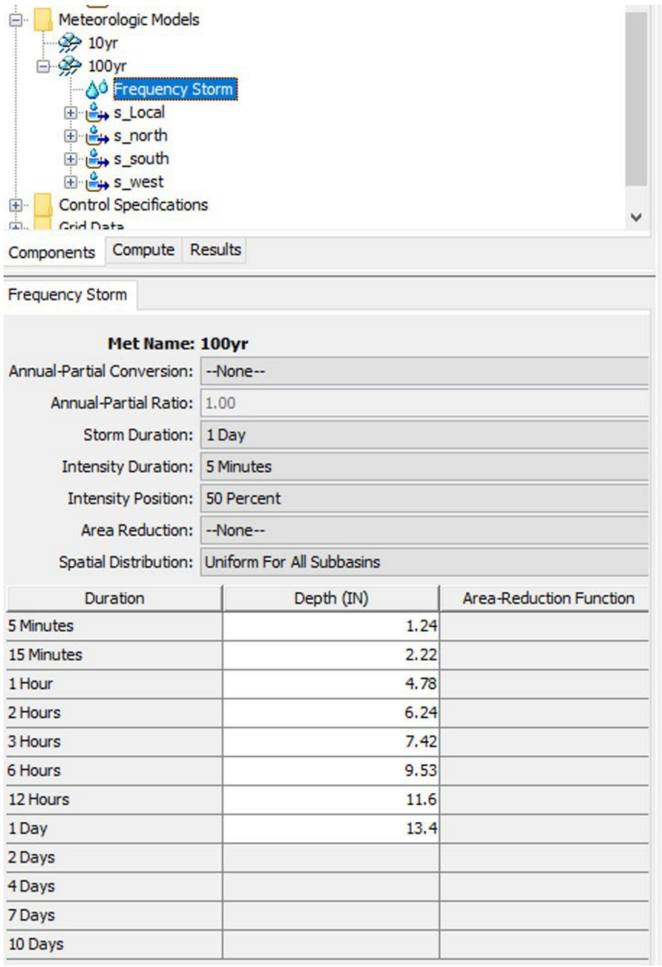


Figure 5. Location of reservoirs (s_north) within the contributing watershed

2.2.5 Meteorology

To simulate frequency return interval precipitation events, National Oceanographic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates were used (Perica et al., 2013). The

ARIs simulated in the model were: 2-, 10-, and 100-yr return intervals. The parameters chosen for the events were: Partial Duration, 90% Confidence Interval, and a 24-hr duration (Figure 6).



Met Name: 100yr

Annual-Partial Conversion: --None--
Annual-Partial Ratio: 1.00
Storm Duration: 1 Day
Intensity Duration: 5 Minutes
Intensity Position: 50 Percent
Area Reduction: --None--
Spatial Distribution: Uniform For All Subbasins

Duration	Depth (IN)	Area-Reduction Function
5 Minutes	1.24	
15 Minutes	2.22	
1 Hour	4.78	
2 Hours	6.24	
3 Hours	7.42	
6 Hours	9.53	
12 Hours	11.6	
1 Day	13.4	
2 Days		
4 Days		
7 Days		
10 Days		

Figure 6. Example meteorological model setup within HEC-HMS

2.2.6 HEC-HMS Calibration

The 2-, 10-, and 100-yr ARI precipitation event simulations were run in HEC-HMS and calibrated to best match the results of the BLE model by adjusting the initial abstraction losses. A single basin model was used across the simulations with one set of calibration parameters. Figure 7 and Figure 8 shows the Whiskey Chitto BLE result hydrograph from HEC-RAS for various percent annual chances (PAC), where the line depicting a 1PAC is the 1% annual chance event. This is equivalent to an ARI value of 1/0.01 = 100-yr ARI. Figure 8 shows the HEC-HMS hydrograph at the same location, near the roadway below West Park.

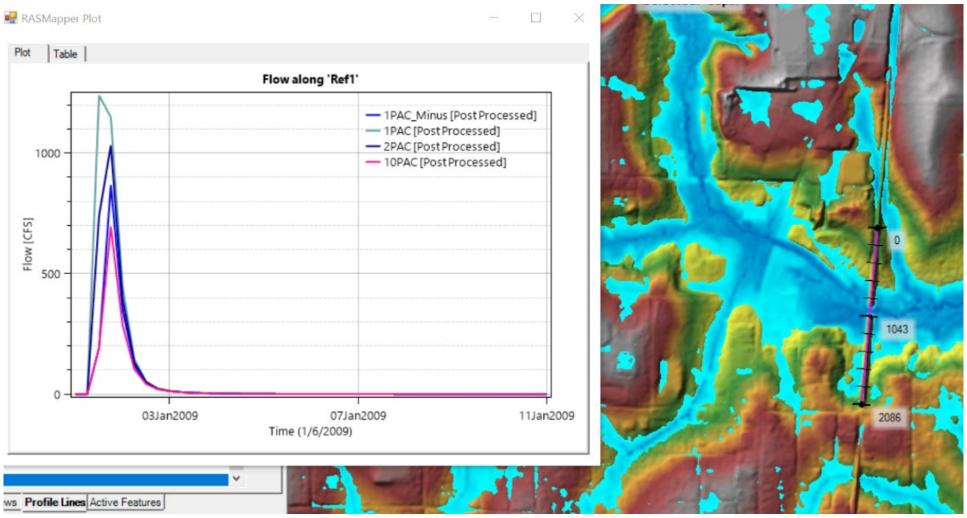


Figure 7. Whiskey Chitto BLE HEC-RAS flow hydrograph flows at the West Park outlet resulting from the 2, and 10-yr events.

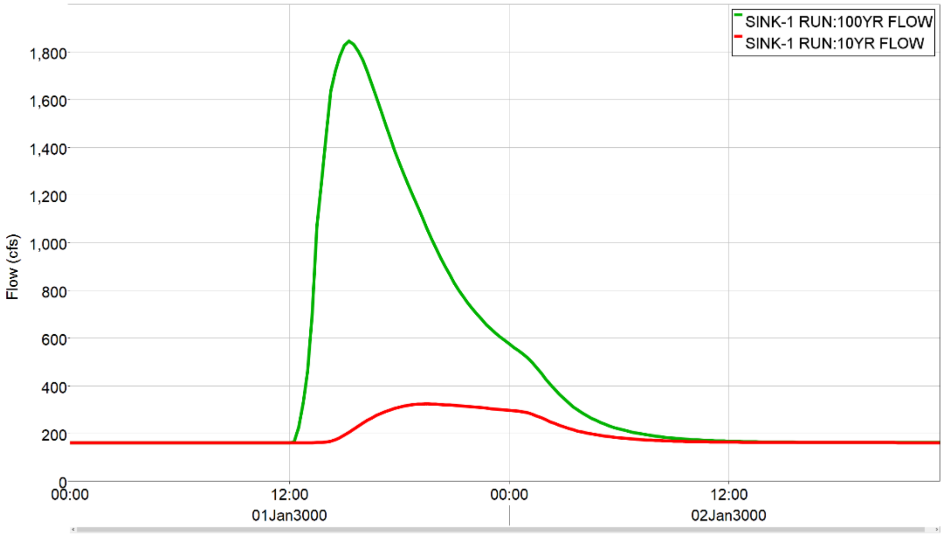


Figure 8. HEC-HMS calibrated flow hydrograph of 10-yr and 100-yr at West Park outlet

The differences in the flow hydrographs in Figure 7 and Figure 8 between the Whiskey Chitto BLE model and the calibrated HEC-HMS are mostly due to the assumption of a constant 150 cfs release from the upstream reservoirs on the main river stem of Hickory Branch. That 150 cfs flow creates a more attenuated hydrograph in the HEC-HMS model versus the peaky/flashy hydrograph seen in the BLE model. This is most noticeable in the 10-yr flow hydrograph. As shown in Figure 8, the red line (10YR FLOW) is compared to the HEC-RAS Whiskey Chitto BLE pink line (10PAC) in Figure 7. The difference between these two flow hydrographs, both representing a 10-yr flow hydrograph, is that the HEC-HMS hydrograph has a lower peak value. The HEC-HMS results are also more attenuated, meaning that the total volume under the curve is similar but has a lower peak and stretches out further over time. This is because the upstream reservoir holds runoff back with controlled releases at a more constant rate and reduces the flood peak.

2.2.7 Hydraulics

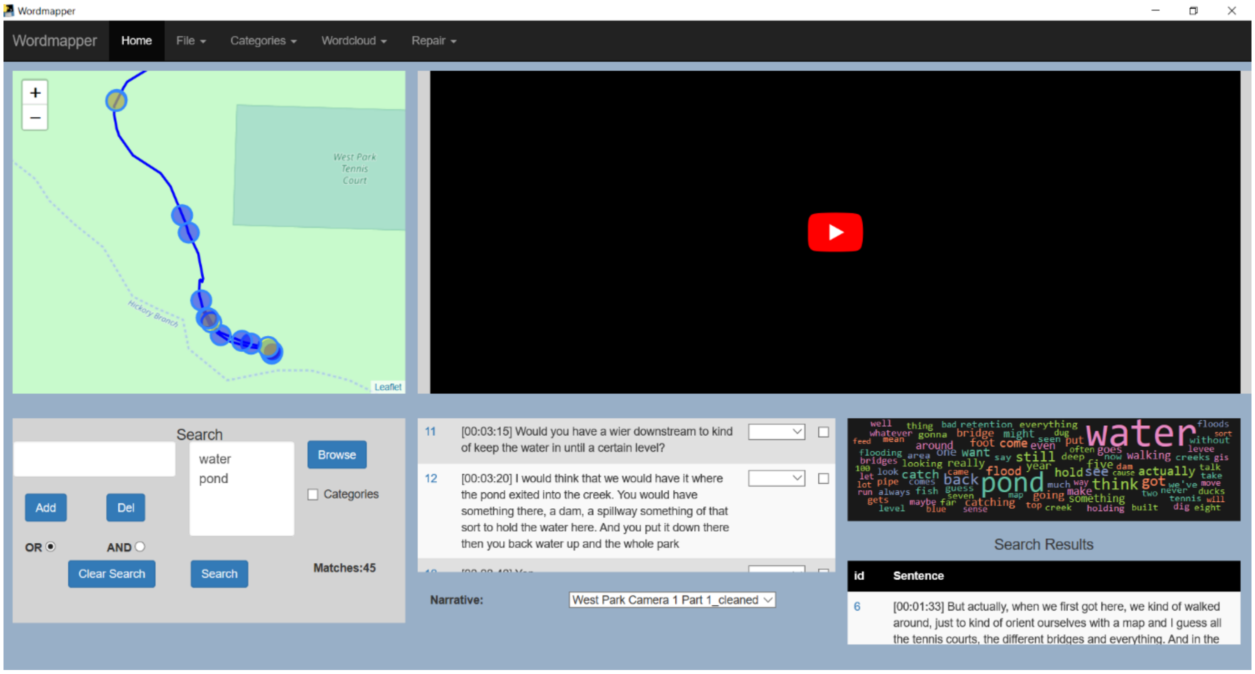
As noted in Section 2.2.2, hydrologic models are designed to estimate the amount of runoff or streamflow generated by individual storm events or by a combination of various storm events. Hydraulic models are then used to compute streamflow characteristics, such as depth and width of water and flow velocity. Input flows are connected to the calculated hydrographs and are distributed across the cells they are connected to. The downstream boundary condition used was assigned as the maximum constant stage extracted from the BLE model for the 10- and 100-yr ARIs. A simulation was not available for a 2-yr ARI in the BLE model to inform the downstream boundary condition. As a result, the 10-yr BLE output was used instead, which is a conservative assumption. The final set of simulations included proposed scenarios that were generated with the intent to decrease localized flooding by evaluating different pond configurations.

Next, breaklines were placed in the model at stream centerlines and elevated terrain features to force model mesh triangulation at a resolution sufficient to evaluate project outcomes. The study area contains multiple bridges and/or culverts; however, these features were not implemented into the 2D model domain because doing so would require each structure to be surveyed, which was not part of this study's scope. Instead, the approximate hydraulic opening was burned into the terrain to allow runoff to pass. Simulations for the 2-, 10-, and 100-yr events were run, using the upstream flows obtained from the hydrologic model as previously discussed (Section 2.2) and corresponding downstream stage derived from the regional BLE model. Existing results were verified and are further explained in Section 3.2.

2.3 QUALITATIVE METHODS AND MODEL GROUND TRUTHING

Following the initial model development phase and the testing of the model under existing conditions, a site visit was conducted to ground truth the model outputs with town officials who possess local and historical knowledge of the actual impacts flooding on West Park. This was conducted to assure the accuracy of the models and identify potential areas for model improvement. The primary qualitative data collection methods used to gather and map local knowledge on West Park included interviews, a review of hard copy printouts of model outputs, and the collection of spatial video geonarratives (SVG), environmentally cued interviews conducted on-the-ground using video cameras capable of pairing high-definition video with precise GPS coordinates. SVG trips are participant-led and yield essential local knowledge and interpretations of experiences and practices as they happen and complement and enhance participant observation of the site (Sunderland et al., 2012). Data derived through the SVG trip were recorded with the permission of participants.

Following the SVG trip, the Water Institute transcribed, coded, and transformed the audio recordings into qualitative data that was then analyzed to detect underlying themes in the dialogue. Otter.ai software (Otter.ai, 2021) created the initial transcriptions of the audio outputs from the engagement activities. To ensure accurate transcription, one research team member listened and re-read the transcripts to ensure accuracy with a selection verified by a second team member. After the interview was transcribed and reviewed, GPS coordinates were retrieved from the video cameras, and were mapped and paired with the transcripts created from the audio using the custom software WordMapper. This approach to gathering environmentally coded geospatial data allowed city officials to identify, describe, and explain sources of flood risk relevant to the study aim and how they are adapting their daily practices to these concerns (Figure 9). The final products of the SVG trips are geospatial datasets and a series of locally informed maps that reveal otherwise unknown patterns of resource utilization and adaptation that will directly inform subsequent intercept survey methods (Curtis et al., 2018). The qualitive data outputs were analyzed and used to refine the models, thereby reducing the level of uncertainty in the model runs that incorporate the planned retention pond on the landscape.



water
pond

Matches:45

11 [00:03:15] Would you have a wier downstream to kind of keep the water in until a certain level? ☐

12 [00:03:20] I would think that we would have it where the pond exited into the creek. You would have something there, a dam, a spillway something of that sort to hold the water here. And you put it down there then you back water up and the whole park ☐

Narrative: West Park Camera 1 Part 1_cleaned

id	Sentence
6	[00:01:33] But actually, when we first got here, we kind of walked around, just to kind of orient ourselves with a map and I guess all the tennis courts, the different bridges and everything. And in the

*Figure **9**. WordMapper software pairs GIS data with the narrative to aid in finding key themes and locations of importance.*

3.0 RESULTS

Results from the HEC-HMS model (the hydrology model) are used to inform boundary condition flows for the sub-regional West Park HEC-RAS model (the hydraulics model). In addition, the runoff volume in the HEC-HMS model resulting from each scenario was computed and compared to various detention pond designs and their corresponding storage volume capacity. Figure 10 illustrates all the HMS simulations run and the timeseries for the cumulative volume, and Table 1 shows the final volumes for each simulation. The final volumes (Table 1) can be compared to the required volume needed by a water storage structure to fully mitigate inundation of West Park. Note that the term "NoResQ" represents each simulation that has reduced baseflow to represent no releases from the upstream reservoirs.

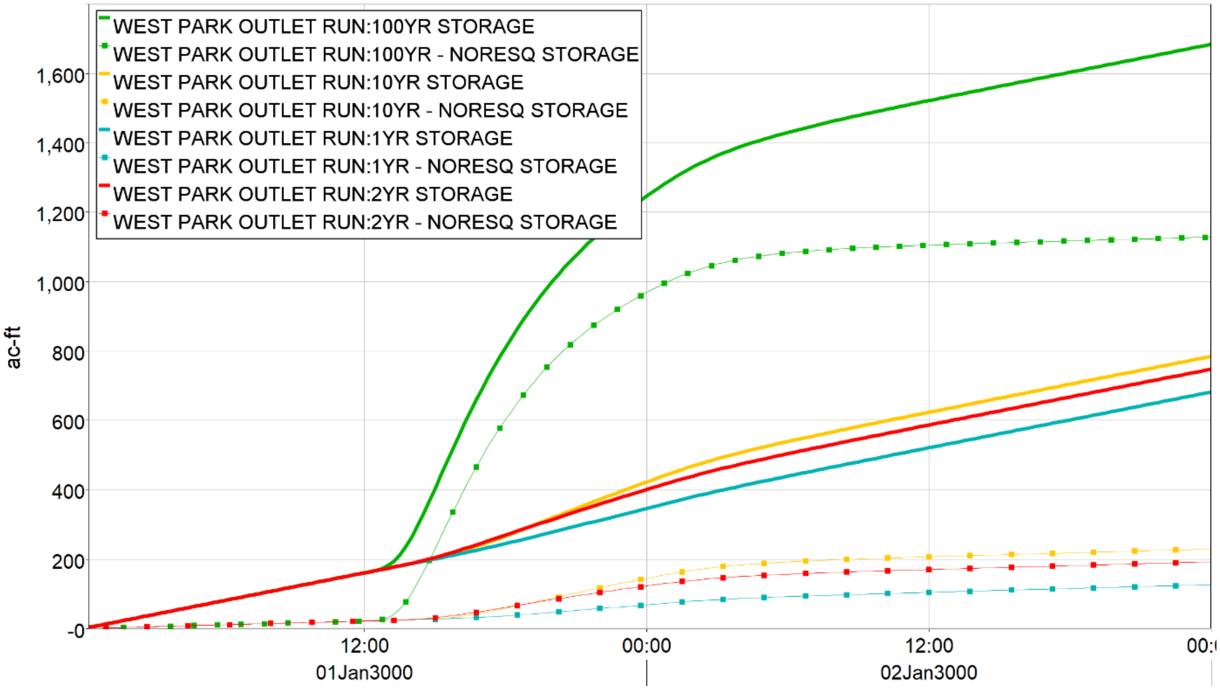


Figure 10. Cumulative volume for each HEC-HMS simulation. Note that the term "NoResQ" represents each simulation that has reduced baseflow to represent no releases from the upstream reservoirs.

Table 1. Cumulative volume value for each simulation. Note that the term "NoResQ" represents each simulation that has reduced baseflow to represent no releases from the upstream reservoirs.

Event	Storage (ac-ft)
1YR	682
1YR - NORESQ	126
2YR	748
2YR - NORESQ	192
10YR	785
10YR - NORESQ	229
100YR	1,684
100YR - NORESQ	1,128

3.1 EXISTING CONDITIONS

A 2D HEC-RAS (V6.3.1) model was developed for this study, referenced in this report as the West Park HEC-RAS model. The model domain encompasses the contributing watersheds and extends approximately 1 mile downstream of the park to ensure the downstream boundary does not influence the hydraulics near the park. The input flows entering the study area (listed in Table 1) were placed within the 2D domain just north of the delineated outlets except for one location which was placed east of N. Pine St. and is shown in Figure 11. The reason for this placement was to avoid flow interference in the vicinity of proposed projects near this respective subbasin which alter the 2D model mesh. To compare existing (without project) and proposed (with project) results, it is common industry practice that the model mesh is uniform where proposed projects are located to avoid manually adjusting input flows for each scenario tested.

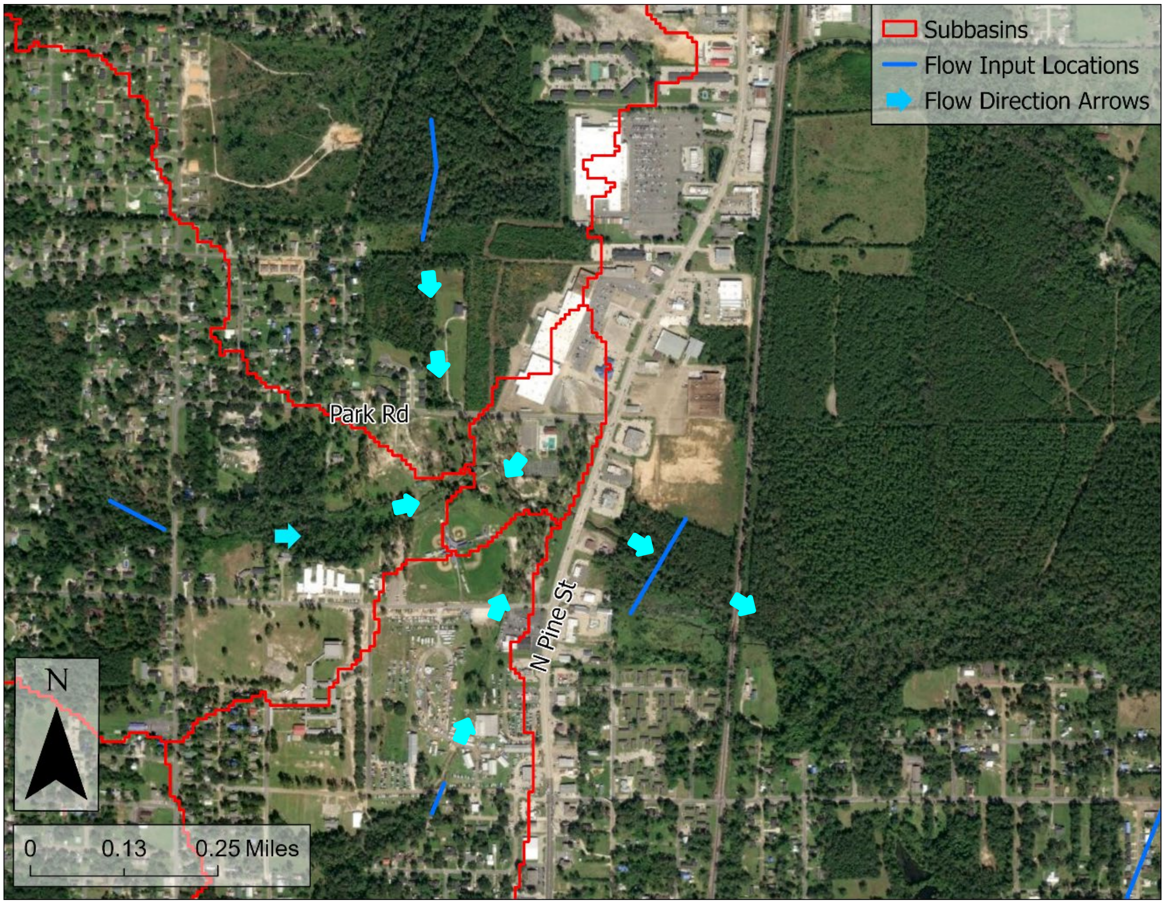


Figure 11 The blue lines represent the flow input locations within the study area. Flow input locations are placed about 25% north of their outlet to not double account calculated the time of concentration.

The existing 2-, 10-, and 100-yr inundation extents are shown below in Figure 12, Figure 13, and Figure 14 respectively. Please note, in each of these figures, water appears to flow across roadways. In actuality, water would pass underneath them. This depiction may be interpreted as if the roadway was not present, since the watercourses were burned into the model mesh as described above.

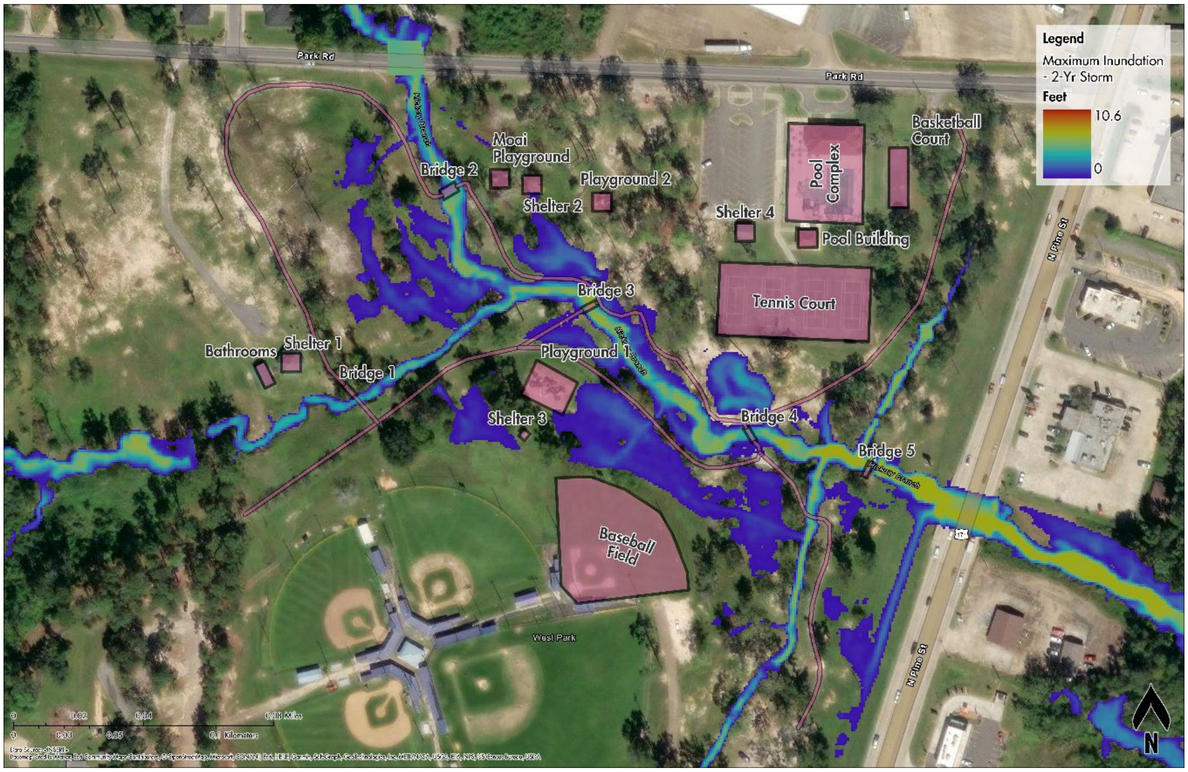


Figure 12. 2-yr existing inundation boundary

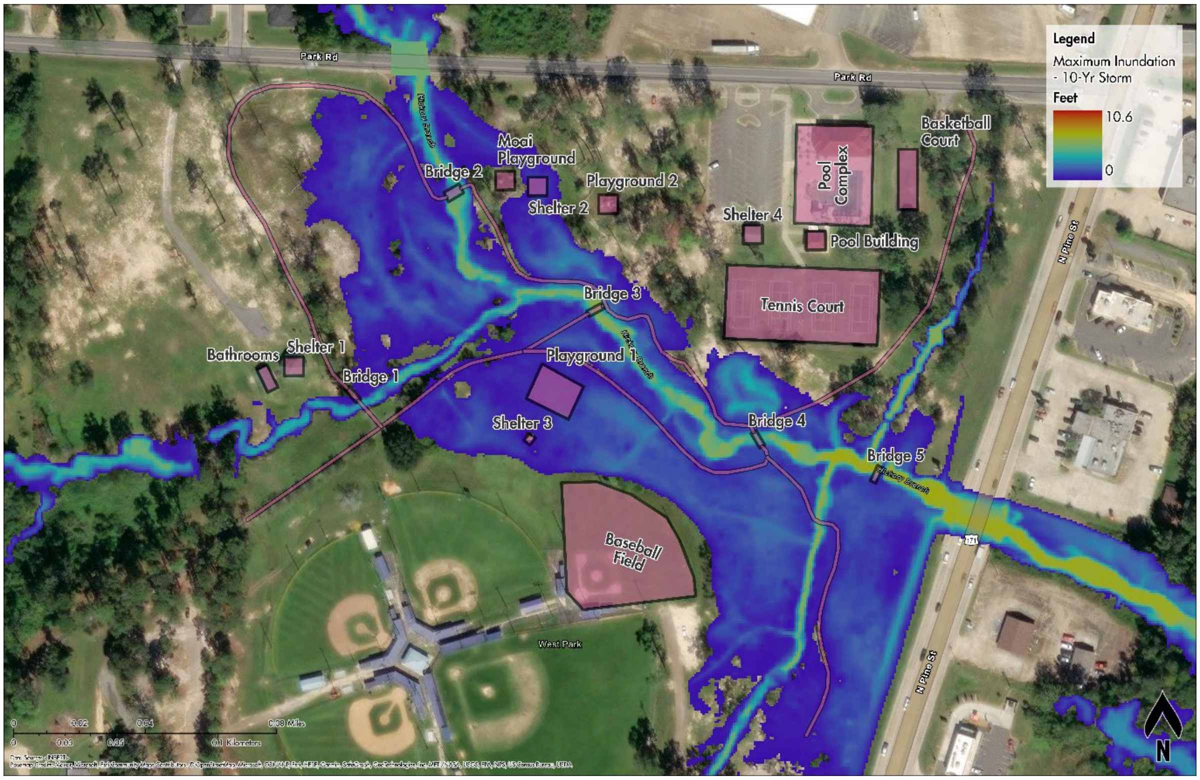


Figure 13. 10-yr existing inundation boundary

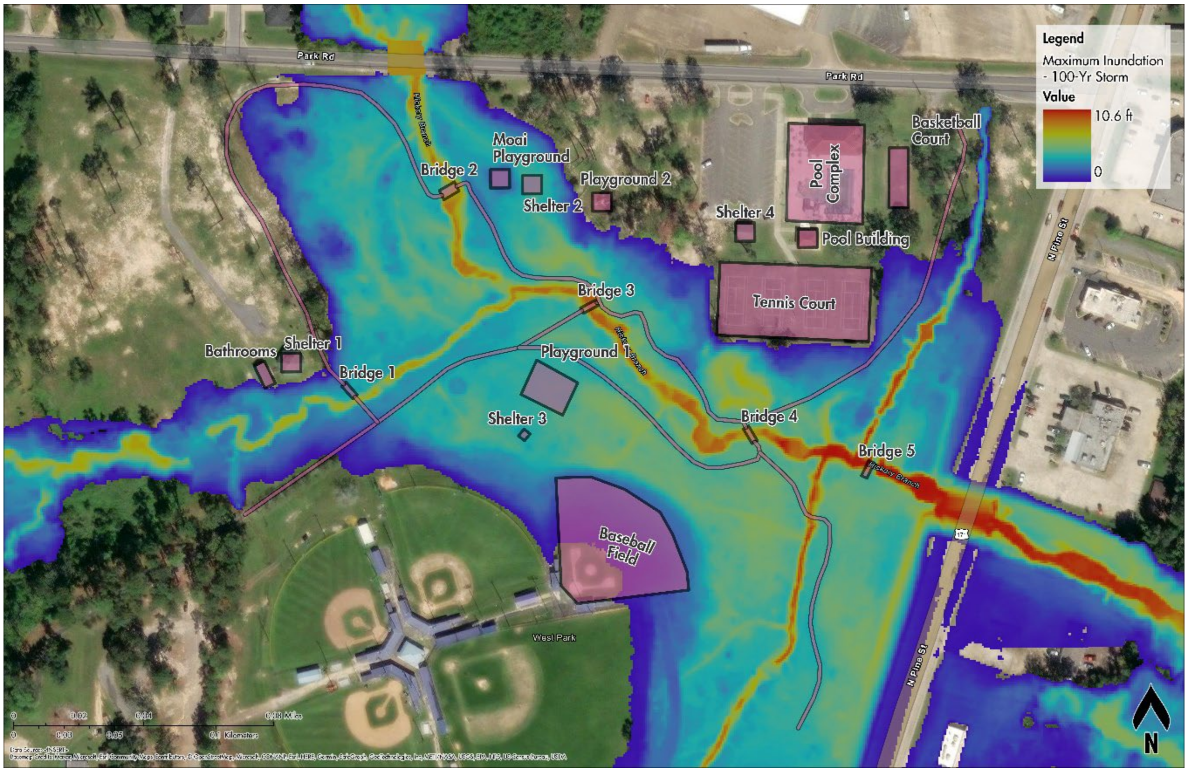


Figure 14. 100-yr existing inundation boundary

Results show that both N. Pine St. and Park Rd. constrict flow for larger storm events. The existing flood maps were shown to two officials from the City of DeRidder during a site visit, which were verified to historical flooding within the park.

3.2 GROUND TRUTHING RESULTS

To ground truth the model outputs, The Water Institute conducted a site visit with two officials from the City of DeRidder who possess local and historical knowledge of the impacts flooding on West Park. Data collection took place on June 6, 2023, and was explicitly designed to provide contextualized environmental geospatial data that was used to perform Quality Assurance and Quality Control (QA/QC) and refine the 2-, 10-, and 100-yr inundation boundaries under existing conditions and with the proposed pond feature installed on the landscape. In reviewing the preliminary modeling outputs under existing conditions for these inundation events, the City of Deridder representatives remarked that the modeling results seemed accurate, based on storm impacts that they have observed. In reviewing all three storm events, they specifically noted that the maps for the 10-yr storm appear to closely mirror the highest levels of inundation that they have observed in West Park during their time working with the city. The city representatives remarked that flooding has never gotten up to the park bathrooms near the tennis courts, which is on elevated ground. One representative noted on the map how close the modeled flood depths matched his experiences in the park during storm events, noting that the tennis courts and park bathrooms have come close to flooding, but have never taken on water. “That's the tennis courts and there's a little bathroom right here somewhere it's never gotten up to into that bathroom…I've seen it up pretty close to that but not quite there.”

In addition, while looking at the 100-yr event images, the city representatives remarked that flooding has never gotten onto the baseball fields. According to one, “water normally will backup on a heavy flood, water backs up so gets into the playground here and kind of feathers off before it gets to the ball field. It never got up high enough to get into the ballfield area…I've seen this (looking at the map). It's never gotten high enough.” Overall, the 10-yr event most closely resembles what has been observed during past park floods with water covering walking trail and up to past the trail bridges, to the point that after the water recedes, crews need to clean out debris (Figure 15). He later noted that “the walking trails, the bridges here, most of those go under… Yeah, they go under because we have to send some people and clear the debris off the bridges and clean them. So the walking trails are usable. A lot of times we have to send a crew up and clean the track because it's already been flooded, and it's left debris on the track.” He continued, noting that this level of inundation within the park can be caused by 4–5 inches of rainfall, depending on time of year and the ground conditions. “And that happens quite often. Just…a shower won't do…don't get me wrong. But you know, a 4- or 5-inch rain will definitely [flood the park]. And then it always depends on the middle of summer is all creeks low.”

Discrepancies between the model outputs and the experiences of the city representatives were identified along High School Drive which runs to the south of the park area and along North Pine Street which runs along the eastern edge of the park. According to one representative, “I've seen it 2 or 3 foot from coming up on the highway. You know, I mean, it's been that bad before…So I've seen it come up, [but] it's never flooded the highway.” He continued, identifying key locations where he has observed flooding during storm events. “Okay, so to give you give you a few of what I've seen about 3 foot from High School Drive and there's a manhole right there and I've seen it come up and around back to the creek from back into like it is just around that ball field there. But I've never seen it cross High School Drive or Pine Street.” When examining the 10-yr inundation map, he noted that “that's what I would say is probably the worst I've seen it looked like this.”

Figure 15. Bridges along walking trails in West Park.

Following the qualitative phase of the research, the results were presented to the modeling team. It was discovered that the breaklines representing those roadways were not triangulating correctly, impacting how runoff crosses the roads during the simulations. The model was adjusted to assure that breaklines at high elevations on the road were placed in the mesh and enforced in the model. The updated model results show inundation reaching, but not crossing, the roadways around the park (Figure 16).

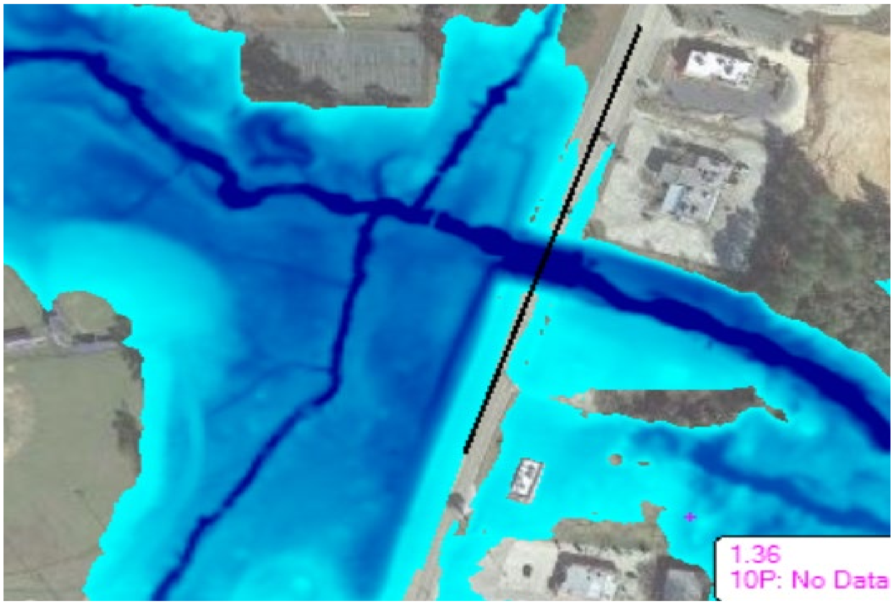


Figure 16. Updated model results showing the breakline along North Pine Street, near its junction with Hickory Branch.

The review of the model outputs and the SVG tour of the park provided valuable data on the accuracy of the models. Beyond this, however, the DeRidder representatives voiced some concerns with the design of the planned retention pond in the park. One concern was that it did not appear that the modeling showed the proposed pond area capturing the two streams that come in from the north and the west. This is a feature that is necessary for the project in that the pond is meant to have standing water year-round, but also act as a retaining pond during heavy rain so that the water can be released more slowly.

Noting the location of the pond on the map, one noted that "the pond does not have this tying in into it (pointing to one stream). Nor does it have this tying into it (pointing to another stream). It's keeping the creeks going around it. See what I'm saying. So if those creeks would run into the pond, now you're catching the water and holding it. So if I could hold, let's say, the pond was 10-foot deep and it can hold five foot of water. And then when it rains, this water would run into the pond and hold five foot of water or whatever, I'm just using numbers before it started spilling out and dropping into the creek. Now, you're catching water and holding it." Following the SVG trip, this concern was noted to the modeling team. The modeling team responded that the pond will be hydrologically connected to Hickory Branch in two locations, one upstream and one downstream (Figure 17) at only the unnamed east tributary. The reason the pond was only connected to one tributary is due to the timing of the inflow of the tributary on the west. By the time runoff enters the vicinity of the pond from the tributary on the west, the eastern tributary has already filled the pond. This information was provided to the city representatives who took part in the qualitative research in West Park.

Figure 17. Location of hydrological connections between the planned pond and Hickory Branch.

In addition, city officials want to know at what depth this pond should be conceptualized, so that planning can be done around levees and trail elevation around the proposed pond. According to one, “I would think you’d want it no less than 6 (feet deep). I think 5, 6 foot of water would get too hot and you'd start losing fish and then you have a fish kill to clean up and so forth so you’ve got to keep it deep enough. Aeration, I think, is gonna be a must, just for your fish to survive. We've got we've got a pond over in Twin Lakes and it's not aerated but it has natural spring in it, so it's always getting refreshed.”

Finally, the city representatives noted the importance of the modeling efforts and the final design of the pond for park planning efforts. One noted the necessity to repair several sections of the walking trails in West Park, including several segments around the location of the proposed pond. These efforts are heavily reliant upon the construction of the proposed pond. “And that's one of the reasons it hasn't been repaired yet. I mean, we still got, I don't know, seven, eight breaks all along the walking trail. And we're kind of waiting to redo the walking trail until we get all this sorted out. We don't want to spend $100,000 redoing the walking trails and then cut a big section out to put the pond in.”

Despite the need for flood control within the park and other recreations co-benefits in West Park, the primary concern of city and park officials is that that creating a pond in the area won’t make flooding worse upstream, particularly on the Hickory Branch which flows into the park and proposed pond area from the north. As one park official noted, “you want to make sure it's viable before…you don't want to go say ‘hey, we're gonna do this’ And then find out, oh we can't, because then the public will say ‘well, why ain't we getting our pond’ you know? So I don't I can't foresee anybody complaining about having a pond there. As long as we're not backing water up on somebody.”

3.3 CONDITIONS WITH PROJECT

The existing conditions model was updated based upon the results of the field visit and used as the basis for comparison with the selected proposed conditions scenarios. Multiple proposed scenarios were evaluated to reduce flooding within the study area. However, after multiple meetings with NPS and the City of DeRidder, proposed detention ponds that would require minimal maintenance and no pumping operations were the only scenarios best fit for their operations. However, additional scenarios were also evaluated to determine the magnitude of change required to decrease inundation extents regardless of maintenance requirement plans and/or pumping needs; these results are briefly summarized in Appendix A. The final proposed scenario selected by NPS and the City of DeRidder to evaluate is the following:

- **Proposed Scenario – 1**: A proposed detention pond located south of Park Road (Figure 18).

The location of the proposed pond was determined by considering the surrounding available right of way and available depth to act as a gravity drained pond. The adjacent stream had the lowest elevation providing approximately 4 ft of depth and 7 ac-ft of volume (any depth beyond 4 ft deep would hold standing water for aesthetic purposes only and would not contribute to flood storage unless water levels were reduced through evaporation or through mechanical extraction/pumping). The proposed pond configuration has a 10 × 2 ft reinforced concrete box inflow culvert mimicking that of multiple 24 in conduits. The outflow culvert is a single 24 in reinforced concrete pipe which constricts flow allowing the pond's volume to be utilized to its full capacity. Based on the existing bank elevations, an inflow culvert with a depth greater than 2 ft is not feasible. The proposed pond configuration is shown in Figure 18.

Figure 18. Proposed detention pond location

3.3.1 Impact Analysis

Impacts throughout the study area were evaluated for two metrics: flood depth reduction and inundation extent reduction. Flow rates and stage were also evaluated at the North Pine Street bridge. The volume produced by the contributing watersheds and directed into the park (Table 1) is much greater than the 7 ac-ft provided by the proposed pond. Because of this, the impact of the proposed pond on localized flooding is minor for the larger and less frequent ARI events. A comparison of the Proposed Scenario - 1 results to existing conditions (previously discussed) is shown in Figure 19 through Figure 21, and the simulated flood inundation extent with the proposed pond on the landscape is shown in Figure 22 through Figure 27.

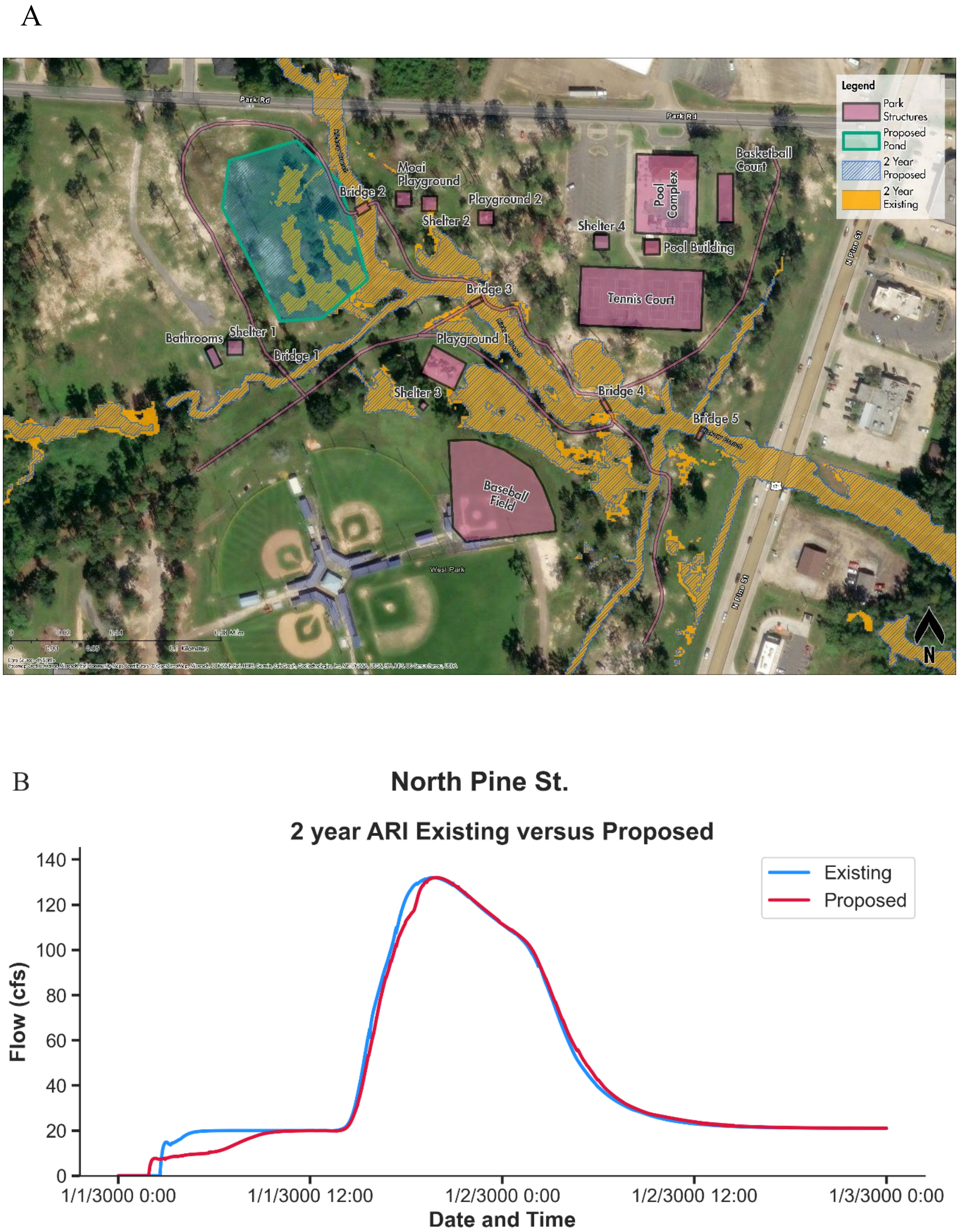


Figure 19. A) 2-yr proposed minus existing inundation extents B) Flow rates at North Pine St.

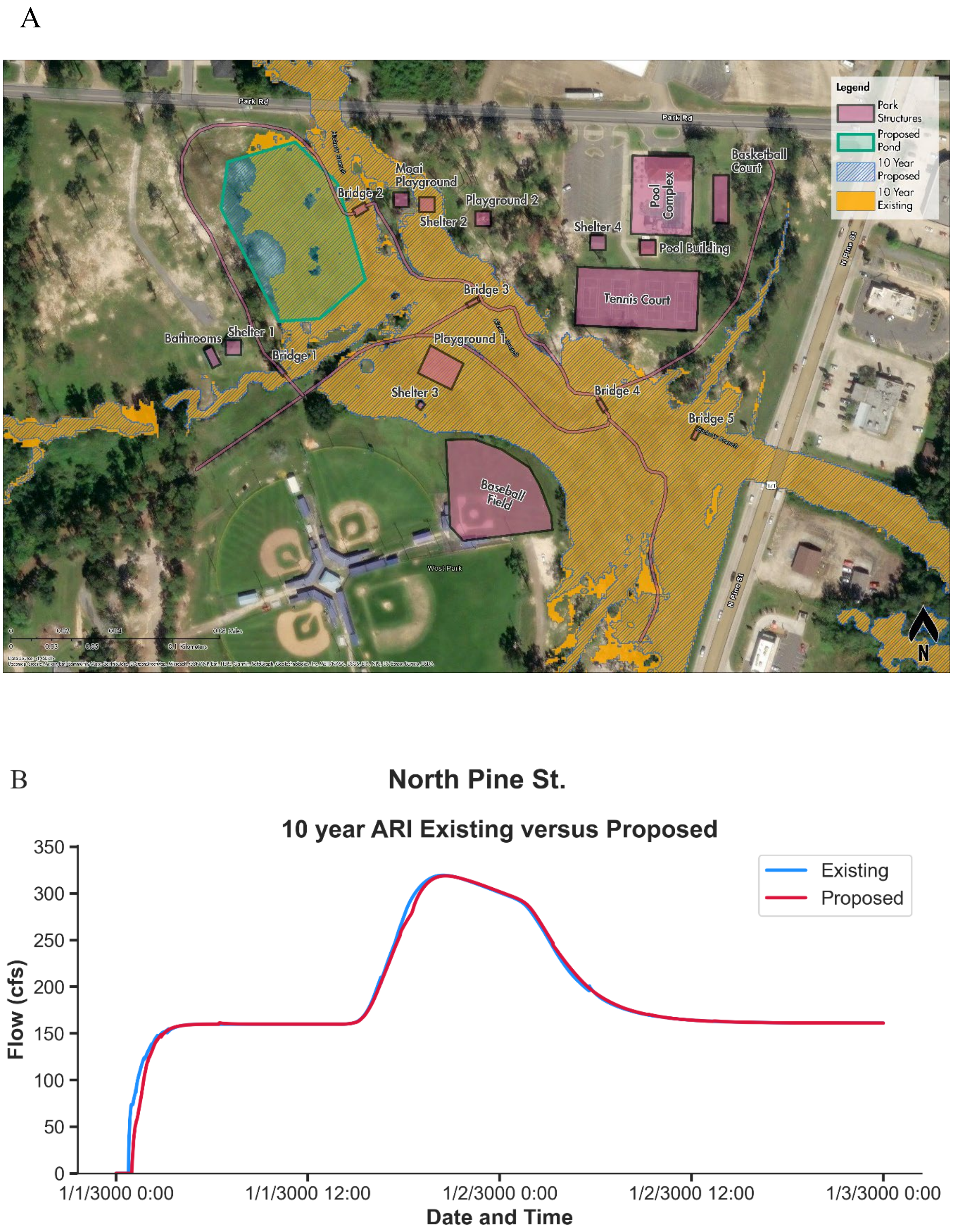


Figure 20. A) 10-yr proposed minus existing inundation extents B) Flow rates at North Pine St.

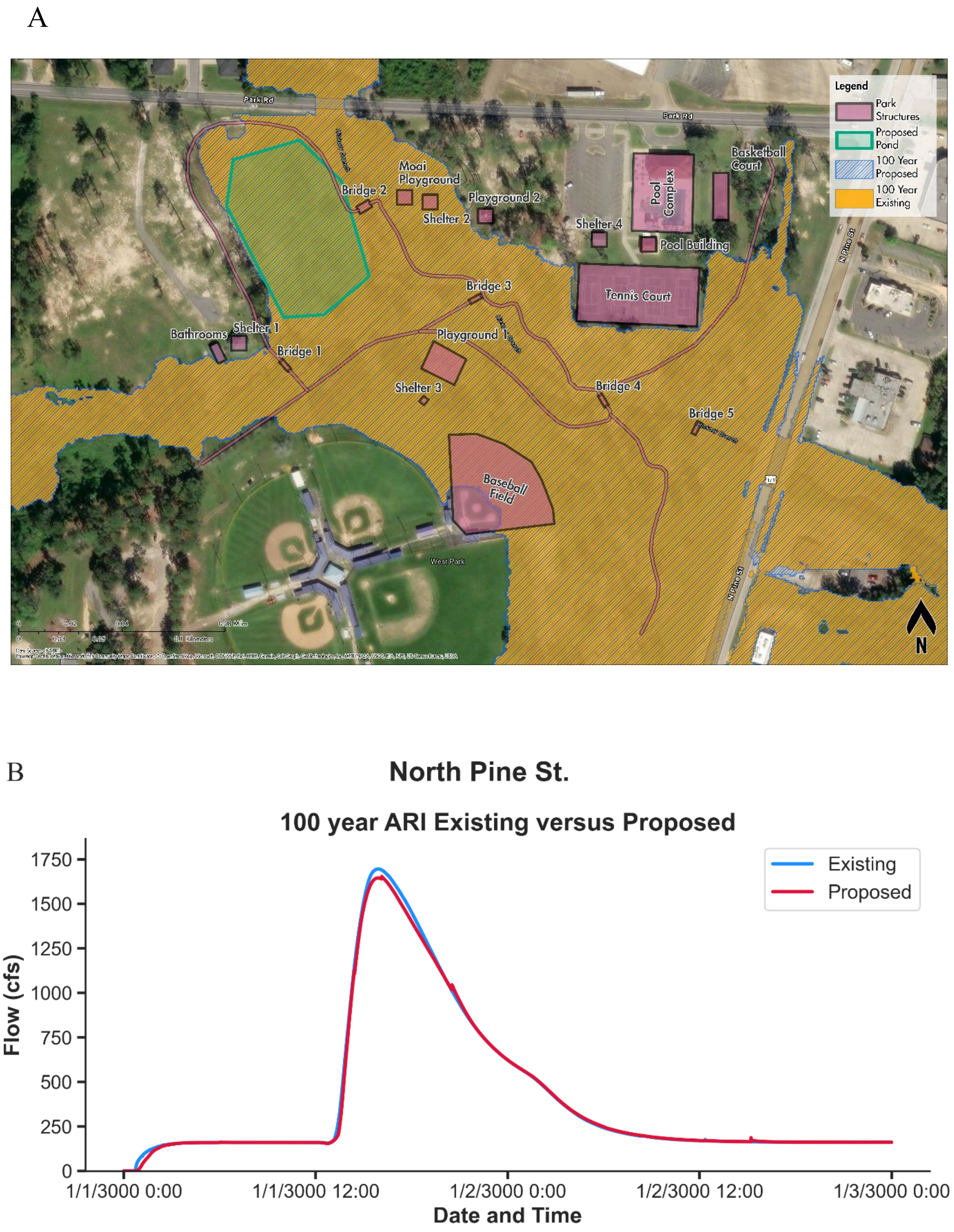


Figure 21. A) 100-yr proposed minus existing inundation extents B) Flow rates at N. Pine St.

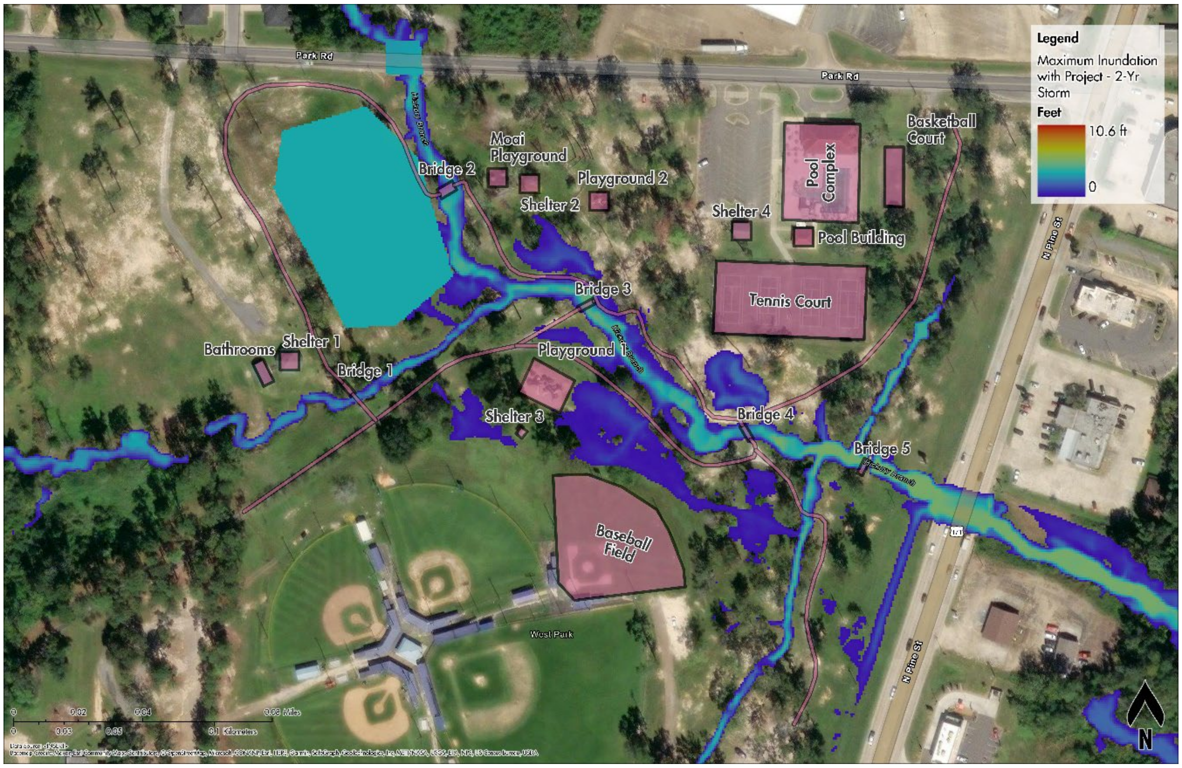


Figure 22: 2-yr Water Surface Extent and Depth with Proposed Pond

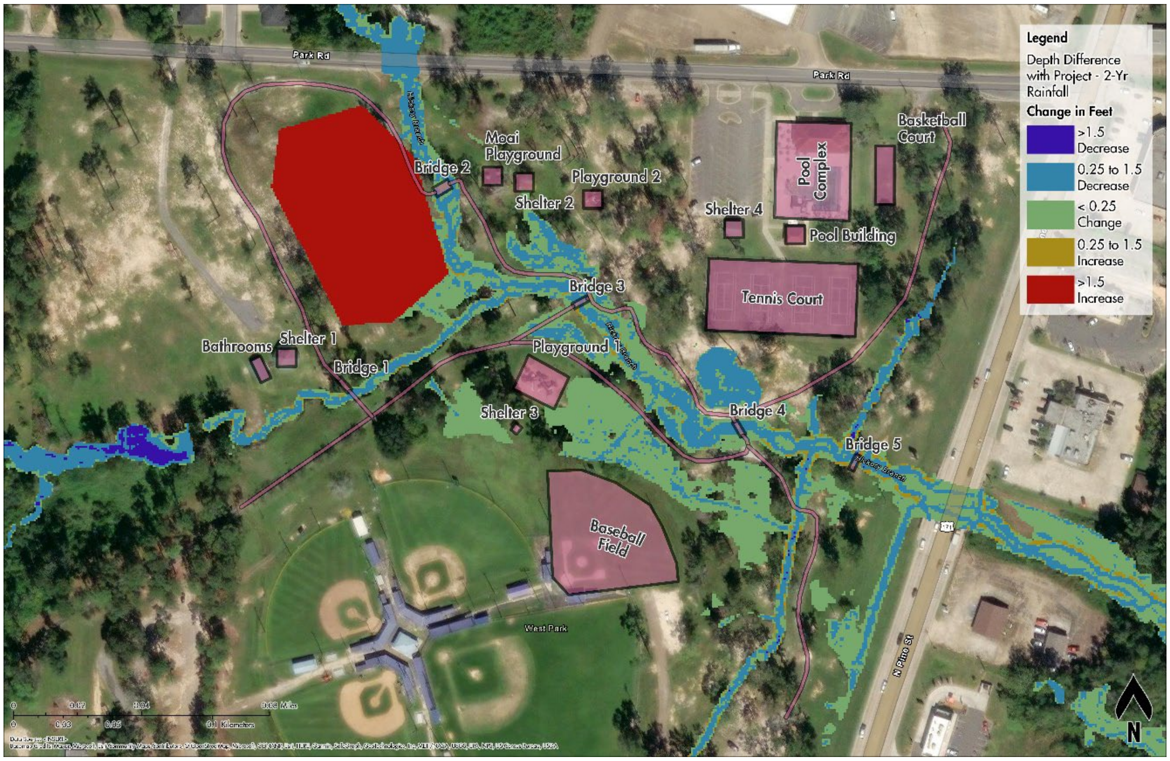


Figure 23: 2 Year Depth Difference of Proposed Pond at West Park

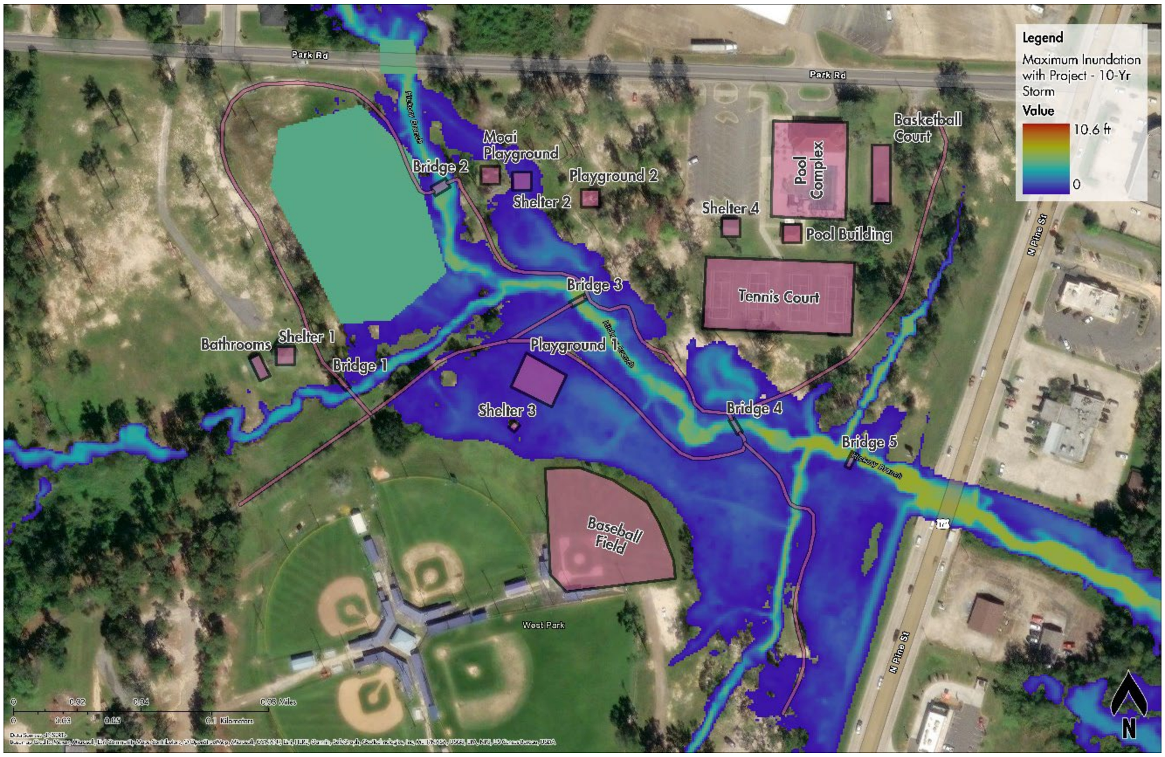


Figure 24: 10-yr Water Surface Extent and Depth with Proposed Pond

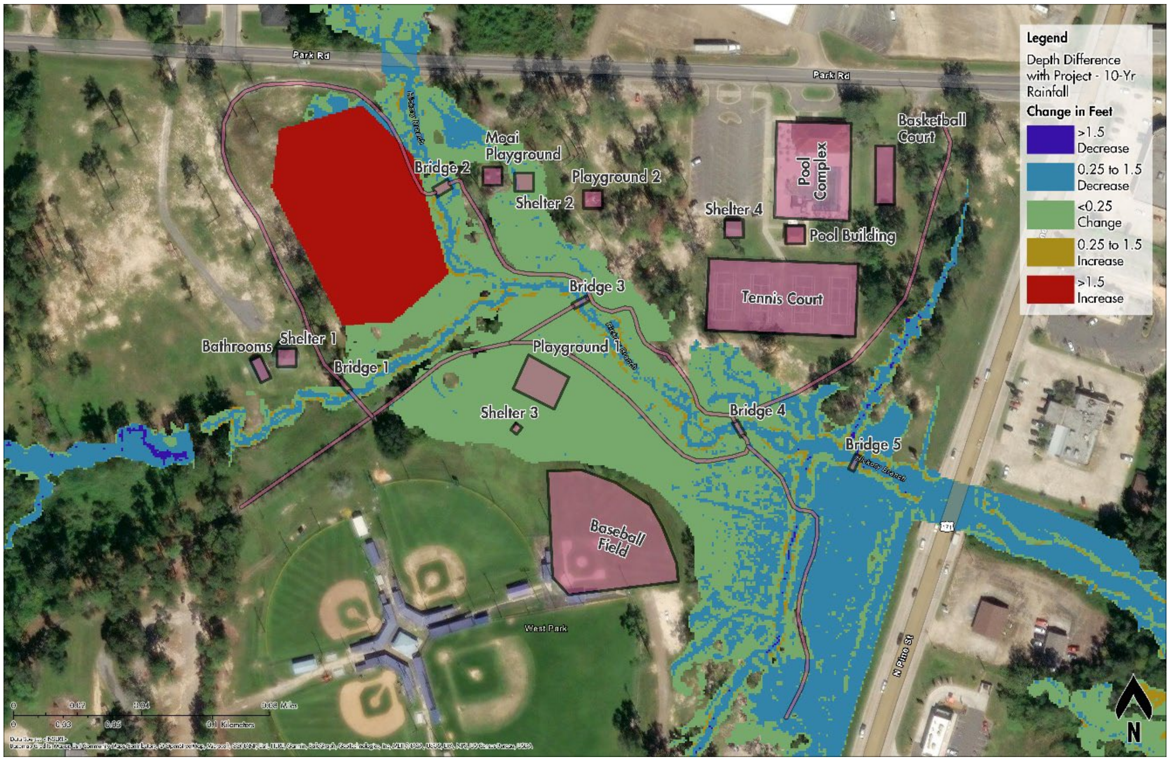


Figure 25: 10 Year Depth Difference of Proposed Pond at West Park

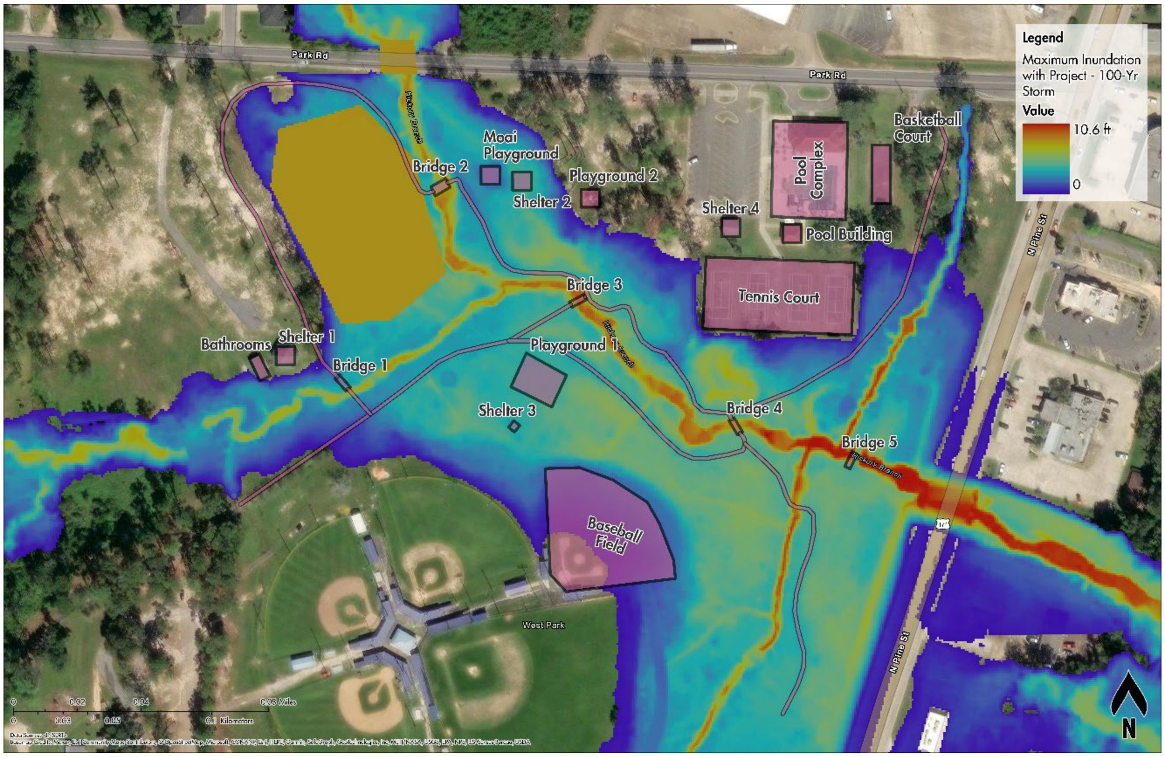


Figure 26: 100-yr Water Surface Extent and Depth with Proposed Pond

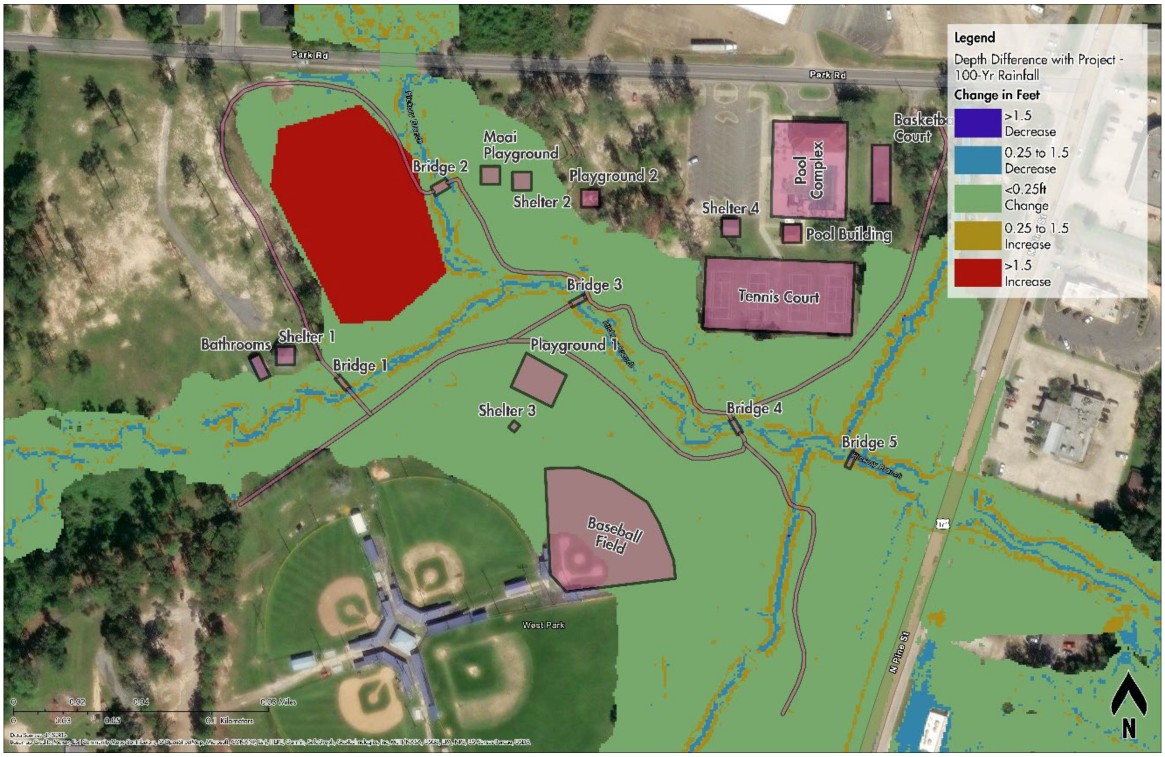


Figure 27: 100 Year Depth Difference of Proposed Pond at West Park

In addition to the results shown as figures in this report, hydraulic model results can also be viewed through a website made available online at: https://westpark.onrender.com/. The results map online web viewer enables users to take a closer look at the differences between the scenarios and to view time series of Water Surface Elevations (WSEs) at particular points of interest as shown in Figure 28 illustrating the 10-year Proposed versus 10-year Existing WSE timeseries and inundation extents within the map viewer.

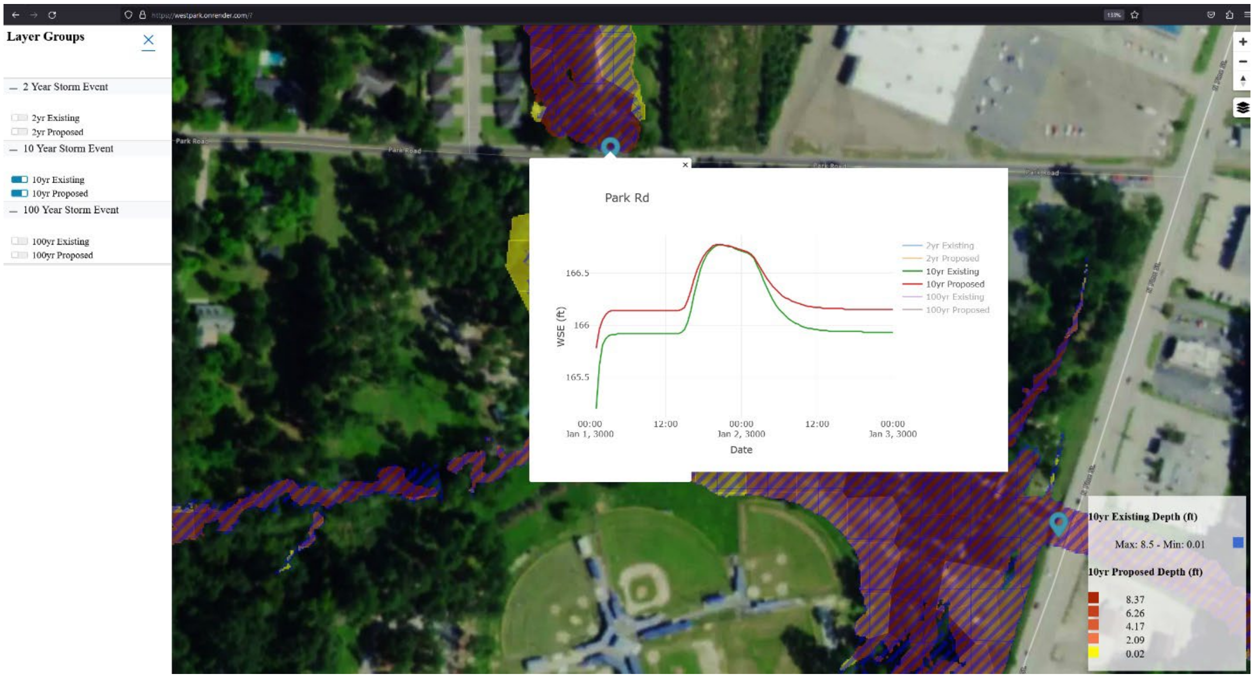


Figure 28: West Park Results Online Map Viewer

4.0 SUMMARY AND CONCLUSIONS

Rainfall events for the 2-, 10-, and 100-year precipitation events were analyzed for West Park in DeRidder, LA. The analysis was performed at a planning level, and explored a series of alterations to park hydrology, namely the installation of a detention pond and alterations to the stream banks (widening, adding vegetation for roughness) to explore ways to alleviate flooding within the park. Since the park was constructed in a natural floodplain, it has a natural propensity to become inundated. Many of the park's features are entirely inundated during infrequent events, such as the 100-yr rainfall event. Due to the low storage capacity of the proposed pond (7.0 ac ft) and based on design recommendations from NPS, the volume of runoff from the frequency events analyzed (as shown in Figure 9), the pond only provides minor flooding relief for the storms analyzed as shown in Figure 19 through Figure 27. The pond will create storage and likely be more effective for smaller, more frequent events. However, those smaller events were not modeled as part of this study so the resulting benefits cannot be quantified in this report without additional effort. The only adaptation measures which could alleviate such amounts of flooding would be large engineering projects exterior to the park or alternatives that were communicated by city representatives to be undesirable, such as pumping in conjunction with deeper retention or detention features or installation of larger detention ponds in areas outside the park.

For more frequent events, such as the 2-year rainfall event, which has a 50% chance of occurring in any year, the proposed detention pond would deliver some flood mitigation within the park's confines. However, the water volume entering the park from upstream for the 2-year event would still exceed the storage volume of the proposed pond. In this case, the proposed pond is shown to reduce flood depths south of the tennis courts and around the junction of Hickory Branch and North Pine Street. The pond is not expected to worsen conditions or induce flooding anywhere within the modeling's focus area in any event considered.

While the pond installation would alleviate flooding during smaller, more frequent events, its primary function would likely be aesthetic. The flood extent and depth maps for the with- and without-project conditions can be used by park planners to alter the locations of park infrastructure, such as shelters, paths, and playgrounds, to reduce flood frequency and magnitude impacts. Table 2 depicts the occurrence likelihood and the corresponding depth of flooding at key park infrastructure.

*Table 2. Flood depths at park infrastructure locations across the 2-, 10-, and 100-year rainfall events. Non-values should be interpreted as no flooding occurring for a given event. *Bridges were not modeled in detail for this study. Only the approximate hydraulic opening of the bridge was imposed into the terrain.*

Park Structure	2-Yr Rainfall Event		10-Yr Rainfall Event		100-Yr Rainfall Event	
	Without Project	With Project	Without Project	With Project	Without Project	With Project
Baseball Field	-	-	-	-	0.9	1.0
Basketball Court	-	-	-	-	-	-
Bathrooms	-	-	-	-	0.4	0.5
Bridge 1*	0.6	0.4	0.9	0.8	3.1	3.2
Bridge 2*	2.2	2.1	3.2	3.1	6.3	6.4
Bridge 3*	3.8	3.6	4.7	4.6	8.0	8.0
Bridge 4*	2.2	1.9	3.4	3.2	6.8	6.8
Bridge 5*	3.1	2.9	3.1	2.7	6.6	6.6
Moai Playground	-	-	-	-	2.2	2.2
Playground 1	0.1	-	0.6	0.6	3.9	4.0
Playground 2	-	-	-	-	-	-
Pool Building	-	-	-	-	-	-
Pool Complex	-	-	-	-	-	-
Shelter 1	-	-	-	-	-	-
Shelter 2	0.05	-	0.9	0.7	4.1	4.1
Shelter 3	-	-	0.2	0.1	3.3	3.4
Shelter 4	-	-	-	-	-	-
Tennis Court	-	-	-	-	-	-

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APPENDIX A.

Additional mitigation scenarios were also investigated and are summarized below with a figure showing the location within the study area. All proposed scenarios described below were not considered feasible design options but are shared for reference.

PROPOSED POND – SCENARIO 2

This scenario contains the same proposed pond footprint as Scenario 1, however, the pond has an average depth of 14 ft and would require a maintenance plan and a pump/pump station to allow the pond to drain (Figure A-1). NPS relayed that this was not a preferred option because of the maintenance it would require. The proposed Scenario 2 pond provides approximately 27 ac-ft of mitigation volume. A preliminary model was run for the 100-yr analysis and results showed that after a 2-day simulation, the pond still had 14 ft of standing water as no pump was modeled. Comparing the volume provided (27 ac-ft) with the volume of the 100-yr input runoff (1,684 ac-ft), the amount of volume provided in the proposed pond is still not enough to make impacts to the inundation boundary (Figure A-2).

Figure A-1. Proposed Pond - Scenario 2

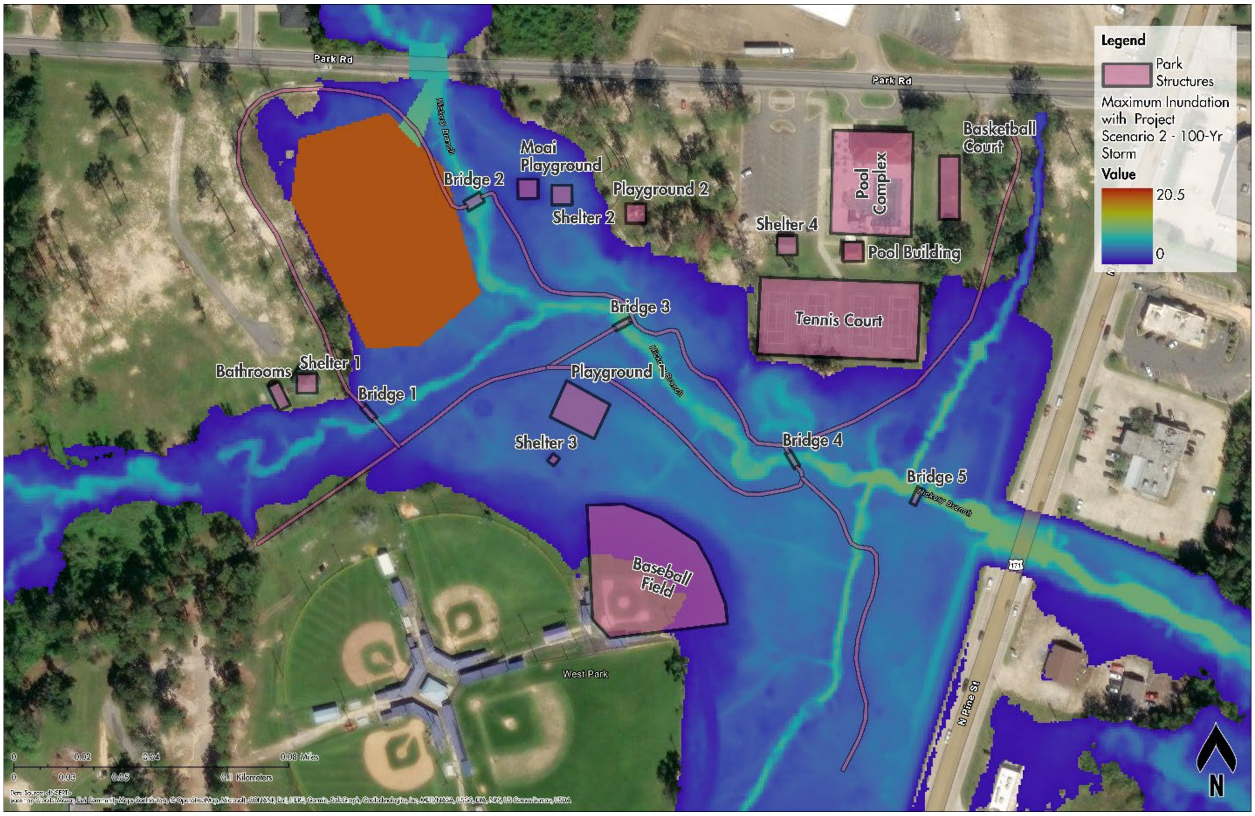

Figure A-2. 100-yr Water Surface Extent and Depth with Proposed Pond - Scenario 2

PROPOSED POND – SCENARIO 3

This scenario contains a proposed inline detention pond. Similar to Scenario 2, this was not a desired mitigation scenario due to the requirement of a maintenance plan and a pump/pump station. The location of the proposed Scenario 3 pond is shown below in Figure A-3and provides approximately 9 ac-ft of mitigation volume. A preliminary model was run for the 100-yr analysis and results showed that after a 2-day simulation, the pond still had 9 ft of standing water as no pump was modeled. Comparing the volume provided (9 ac-ft) with the volume of the 100-yr input runoff (1,684 ac-ft), the amount of volume provided in the proposed pond is still not enough to make impacts to the inundation boundary `(Figure A-4).

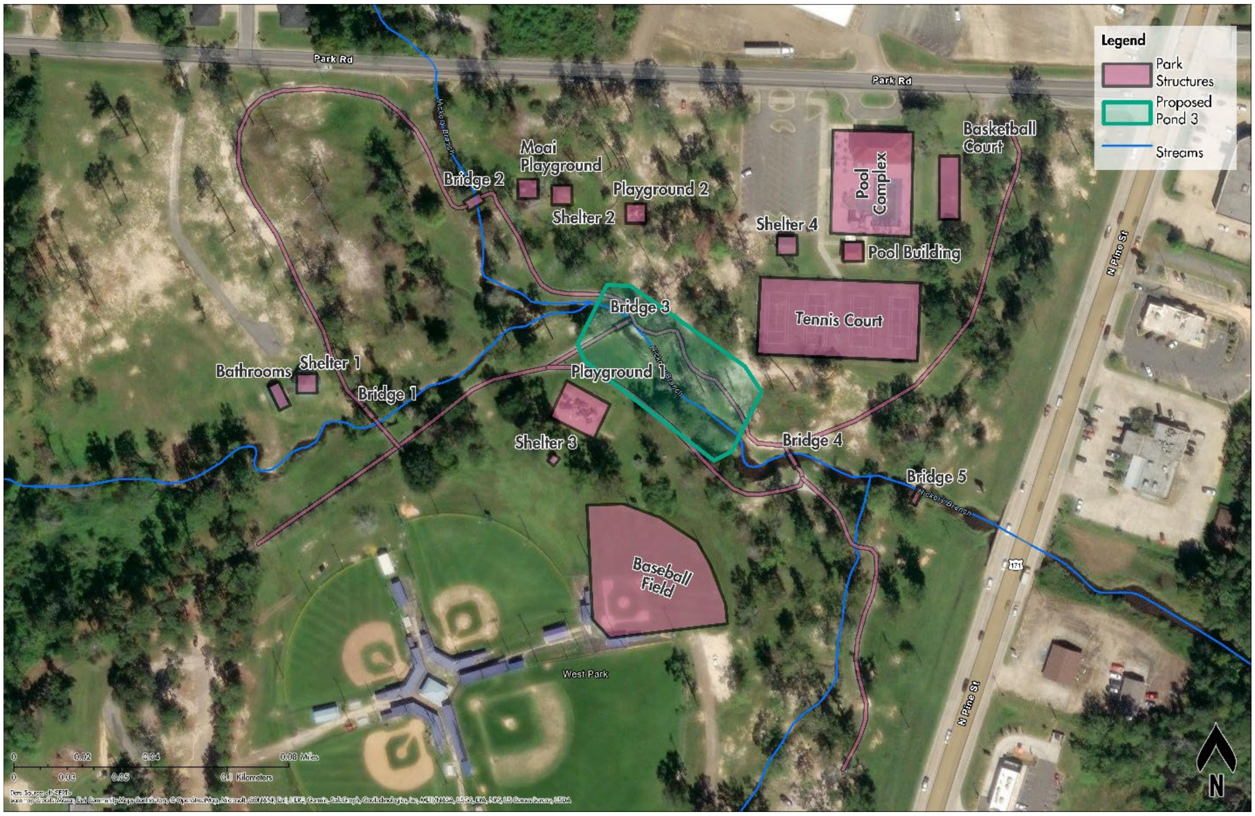

Figure A-3. Proposed Pond - Scenario 3

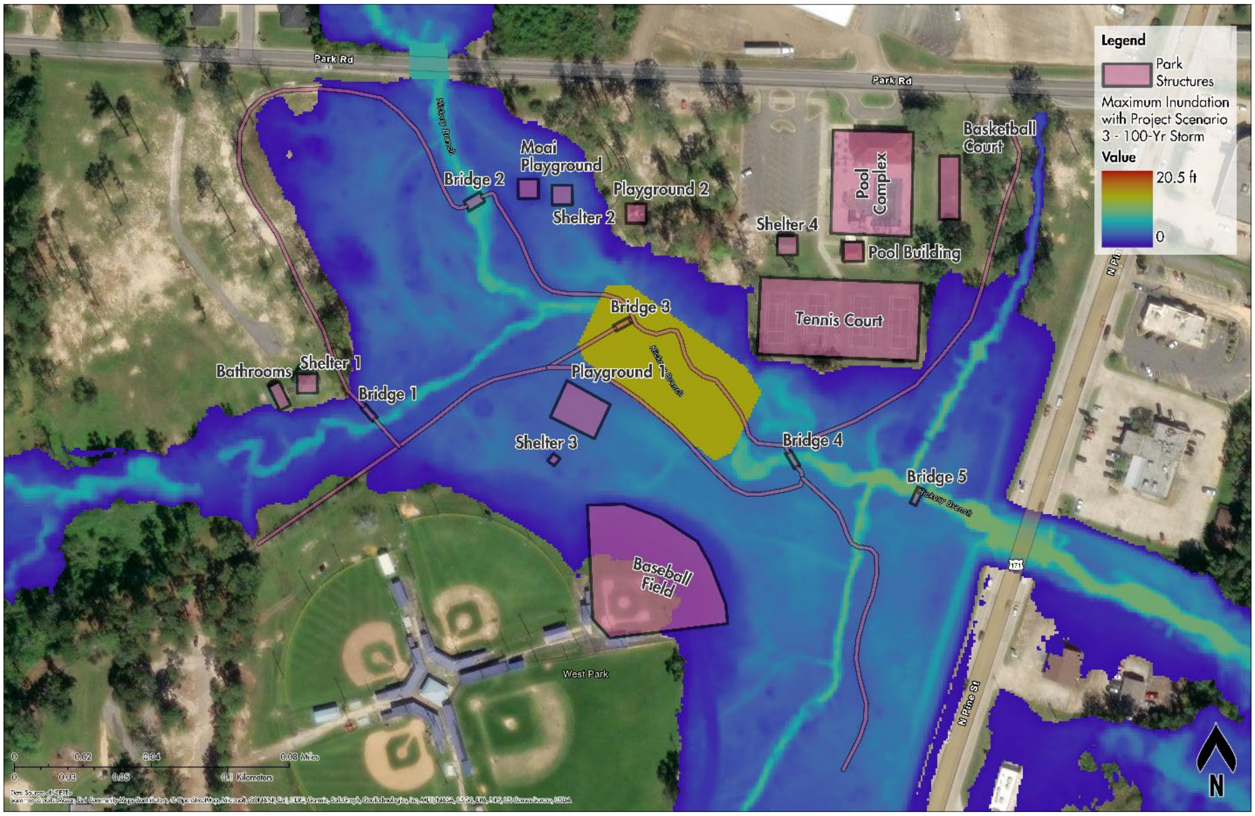

Figure A-4. 100-yr Water Surface Extent and Depth with Proposed Pond - Scenario 3

PROPOSED POND – SCENARIO 4

This scenario proposes inline detention by deepening the channel approximately to an average depth of 10 ft by channelizing the stream to a trapezoidal channel (Figure A-5). The channel trapezoidal dimensions are 60 ft bottom width, 100 ft top width and 3 to 1 side slopes and provides approximately 31 ac-ft of mitigation volume. Similar to the previous proposed scenarios, this was not a desired mitigation scenario due to the requirement of a maintenance plan and a pump/pump station. A preliminary model was run for the 100-yr analysis and results showed that after a 2-day simulation, the pond still had 13 ft of standing water as no pump was modeled. Comparing the volume provided (31 ac-ft) with the volume of the 100-yr input runoff (1,684 ac-ft), the amount of volume provided in the proposed pond is still not enough to make impacts to the inundation boundary (Figure A-6).

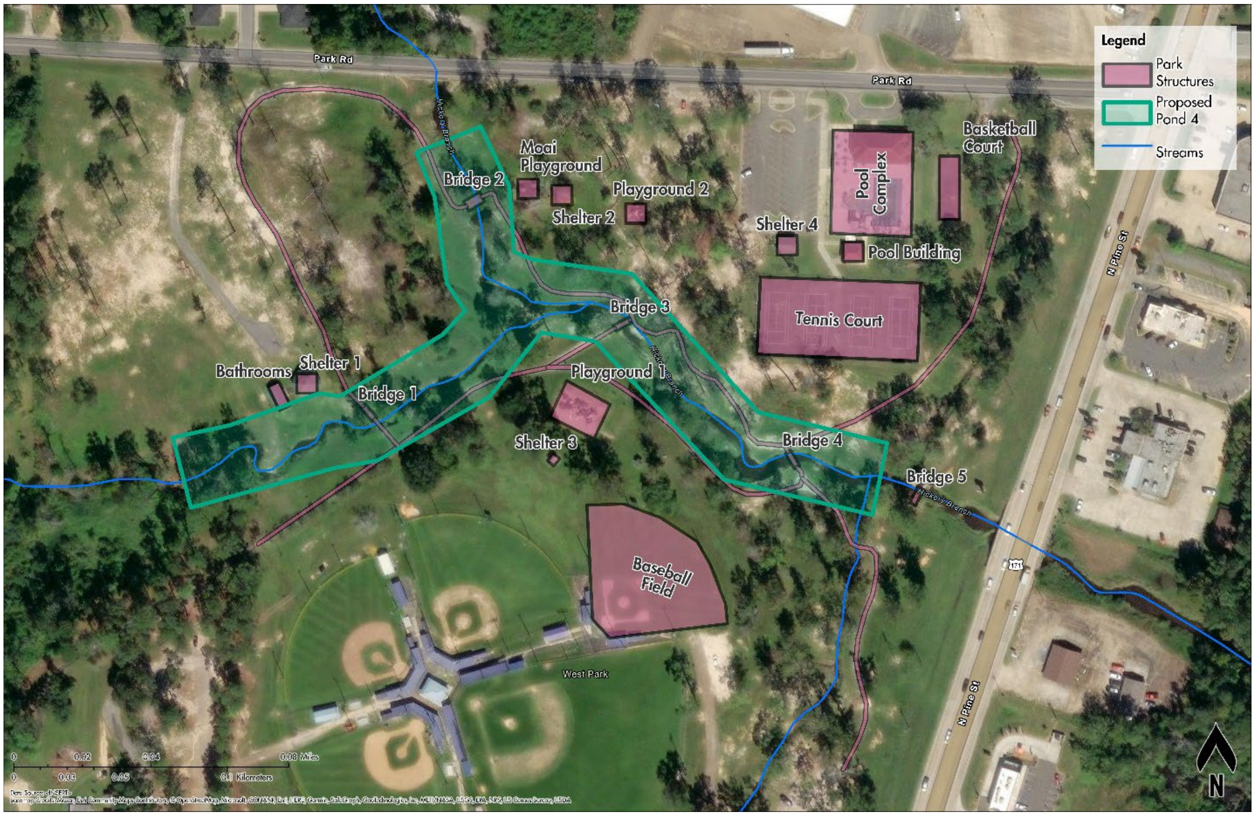

Figure A-5. Proposed Pond - Scenario 4

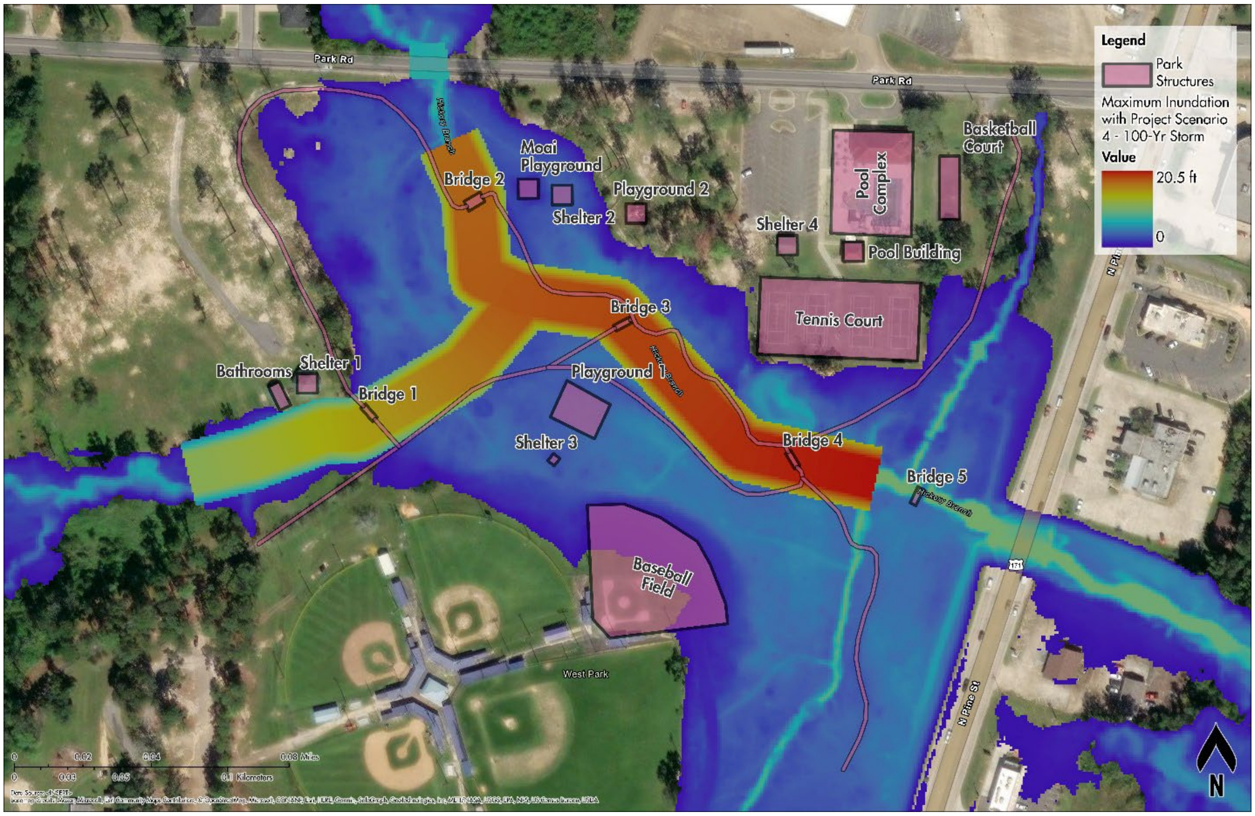

Figure A-6. 100-yr Water Surface Extent and Depth with Proposed Pond - Scenario 4

PROPOSED ADDED VEGETATION – SCENARIO 5

This proposed scenario contains a vegetation addition to the perimeter of the stream with the expectation that the increased roughness would theoretically increase drag, dissipate water velocity and reduce WSE. It is understood that the streams would require access points for the public, however, by modeling the entire region as an added vegetation region (Figure A-7) would show maximum benefits. Results showed that the added vegetation caused backwater effects due to the reduction of flow velocity through the channel and was not considered a feasible proposed design. A preliminary model was run for the 100-yr analysis and results showed that the representation of added brush slowed runoff down creating backwater effects and an increase in WSE's north of Park Rd. (Figure A-8).

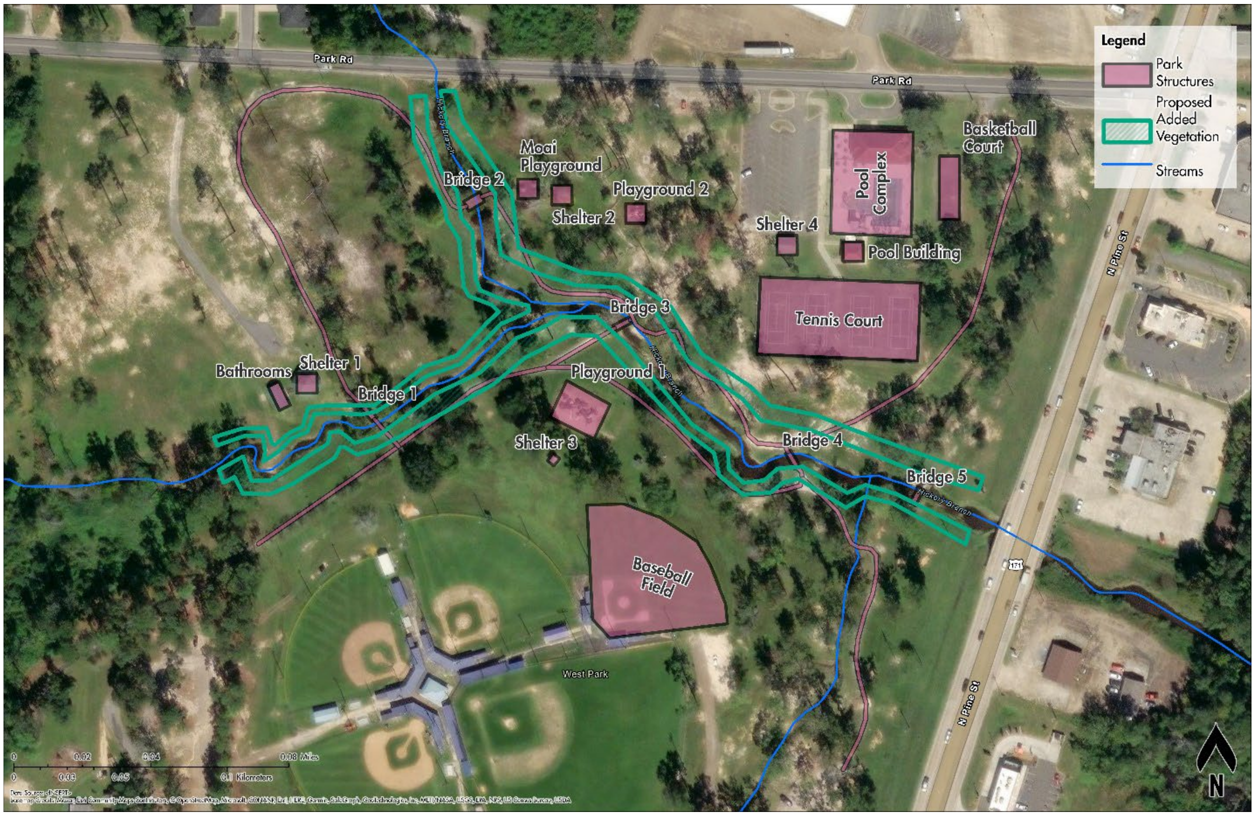

Figure A-7. Proposed Added Vegetation - Scenario 5

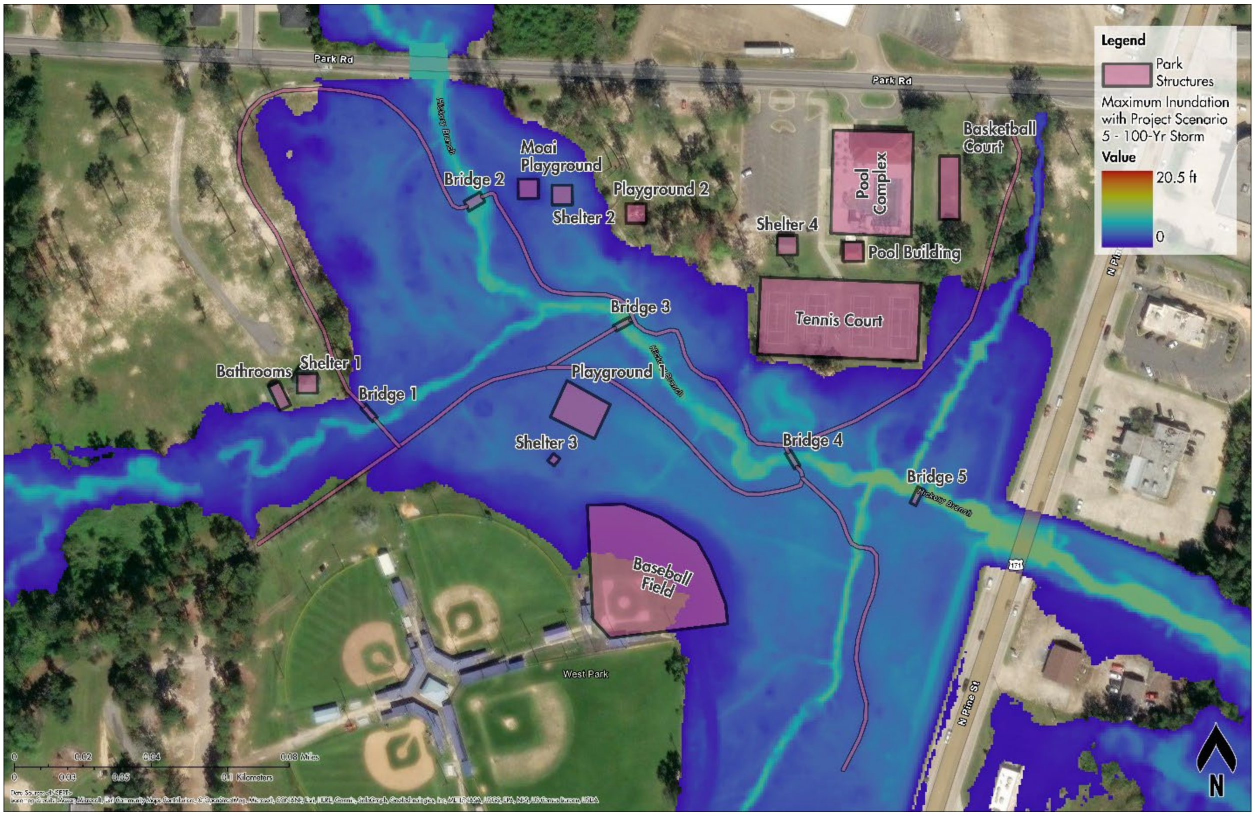

Figure A-8. 100-yr Water Surface Extent and Depth with Proposed Added Vegetation – Scenario 5

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