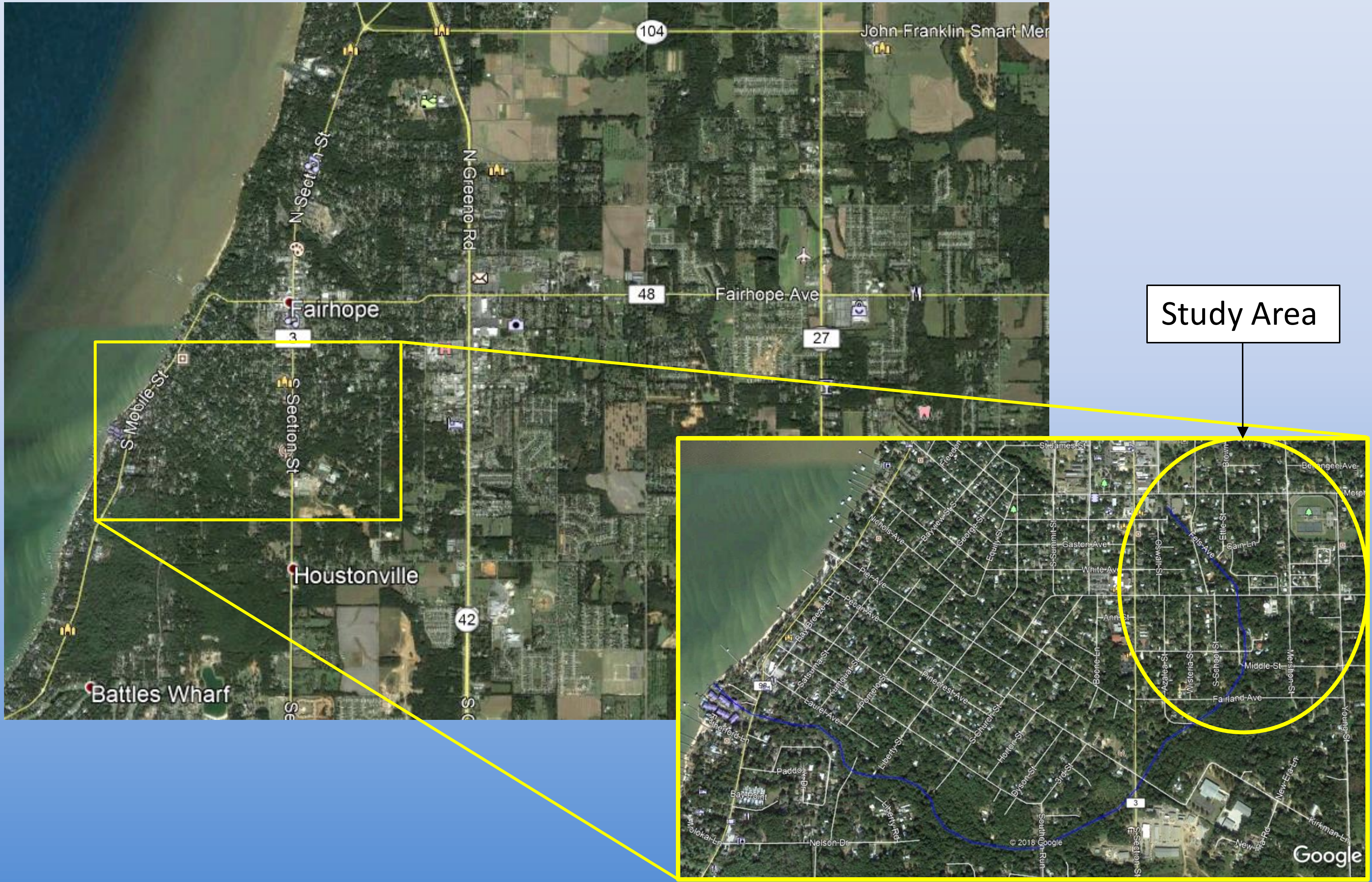
# Location Map – Tatumville Gully



# GSSHA Hydrologic Model

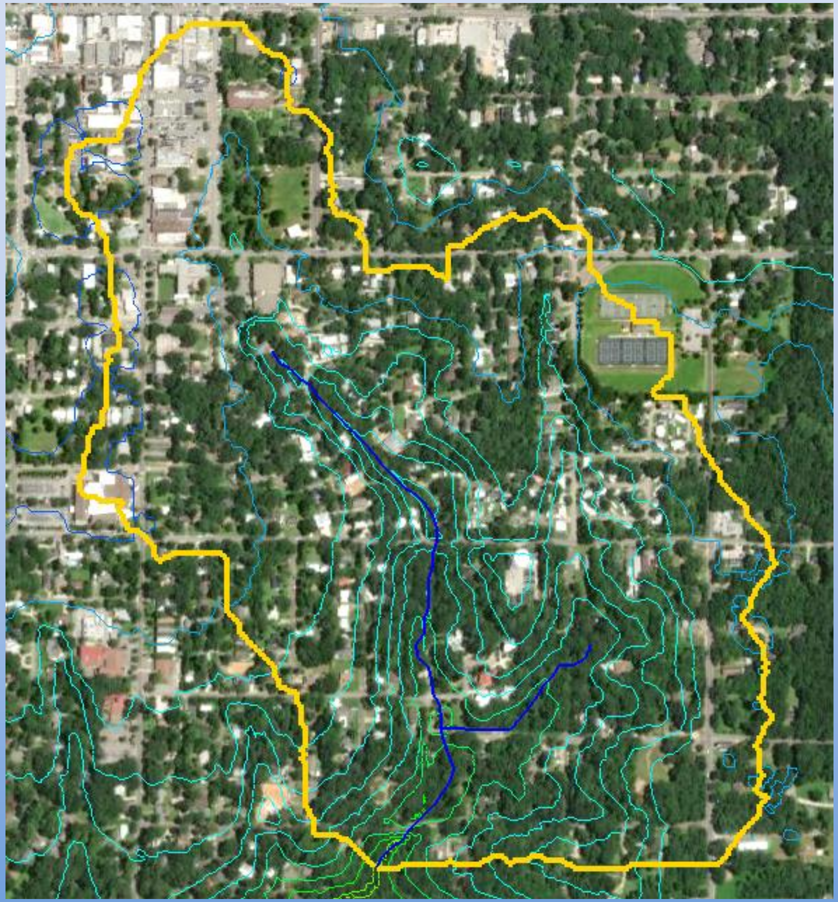
What is GSSHA?

Gridded Surface Subsurface Hydrologic Analysis (GSSHA) is a physics-based, distributed, hydrologic, sediment and constituent fate and transport model.

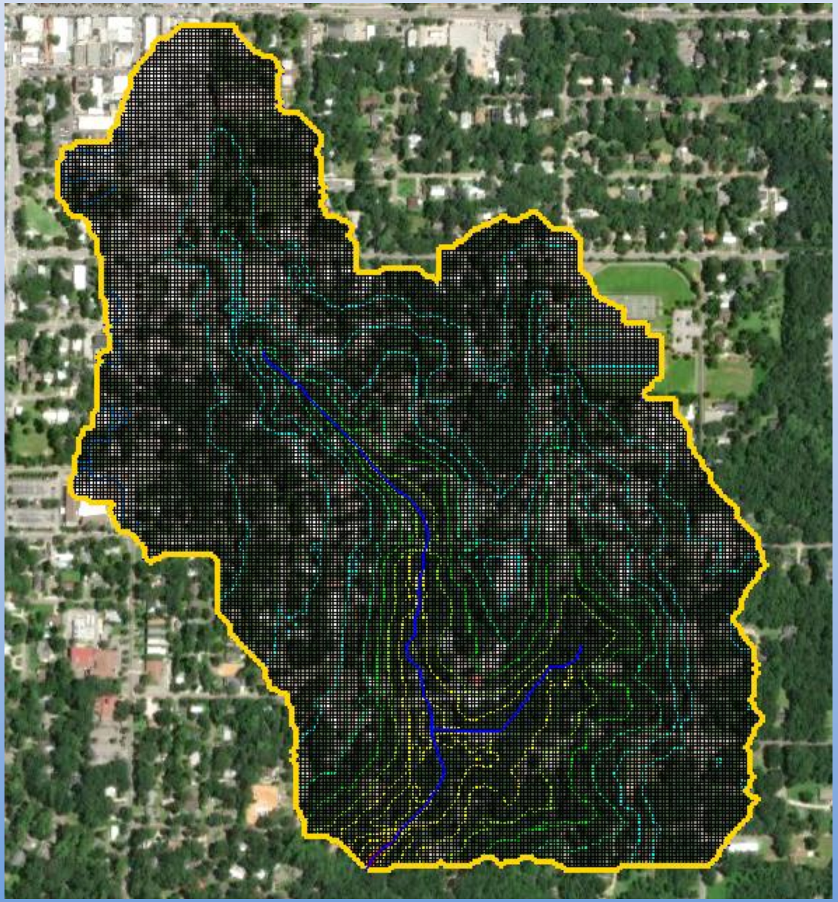
Features include two dimensional (2-D) overland flow, 1-D stream flow, 1-D infiltration, 2-D groundwater, and full coupling between the groundwater, shallow soils, streams, and overland flow.

GSSHA was used for determining the timing and discharge down to Mershon Street, Middle Street and Fairland Avenue.

# GSSHA Hydrologic Model

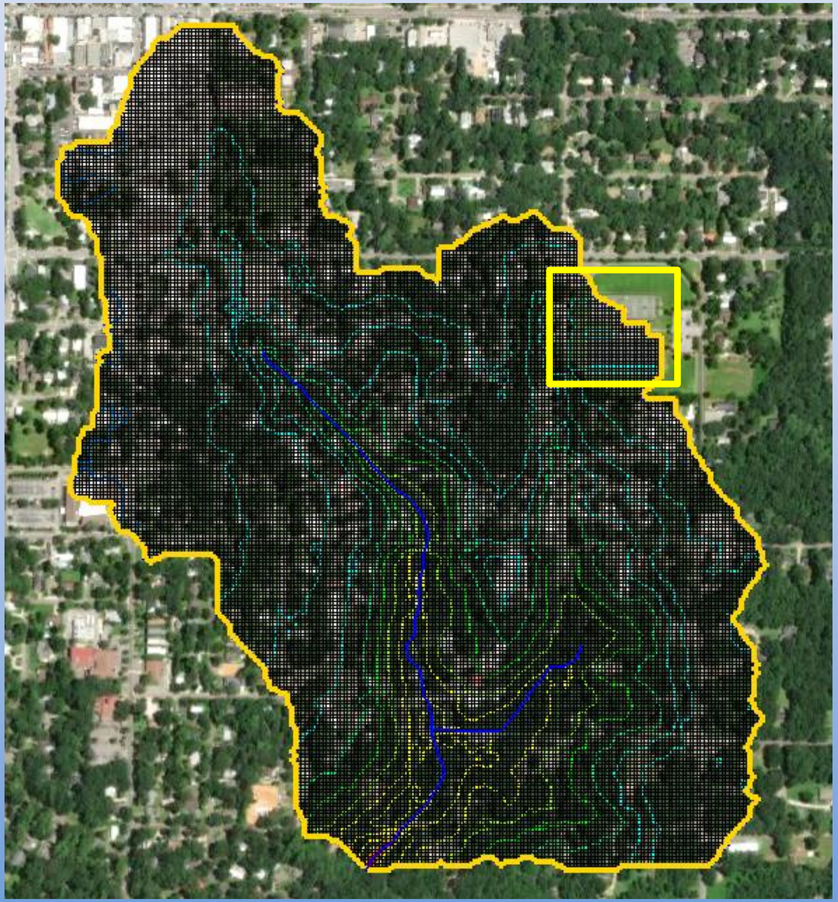


DRAINAGE AREA

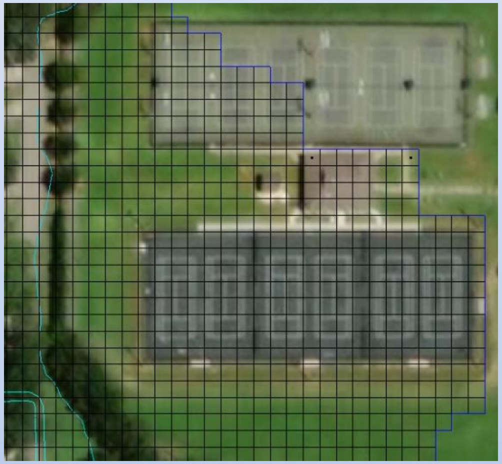


GRIDDED GSSHA MODEL

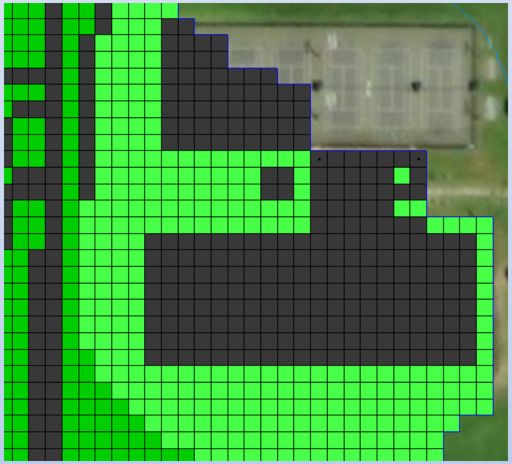
# GSSHA Hydrologic Model
# Gridded Components



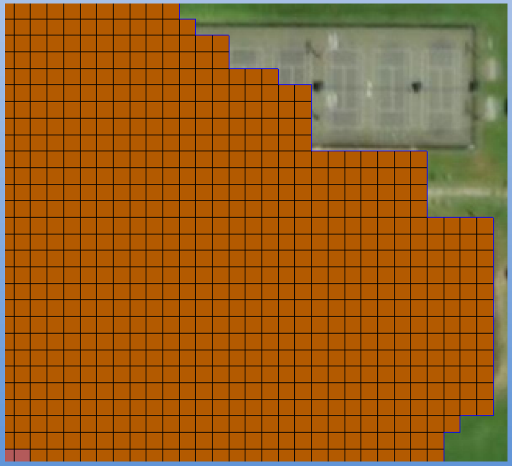
GRIDDED GSSHA MODEL



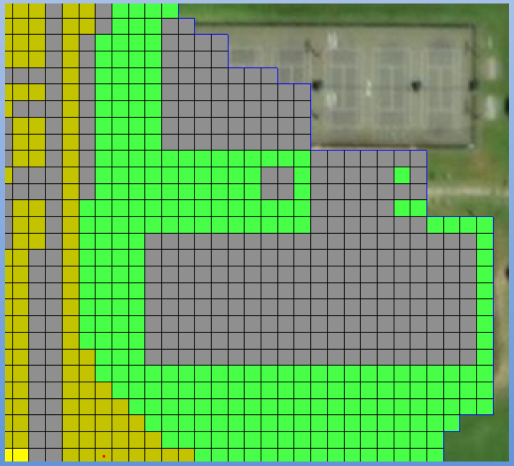
Gridded Model



Gridded Land Use

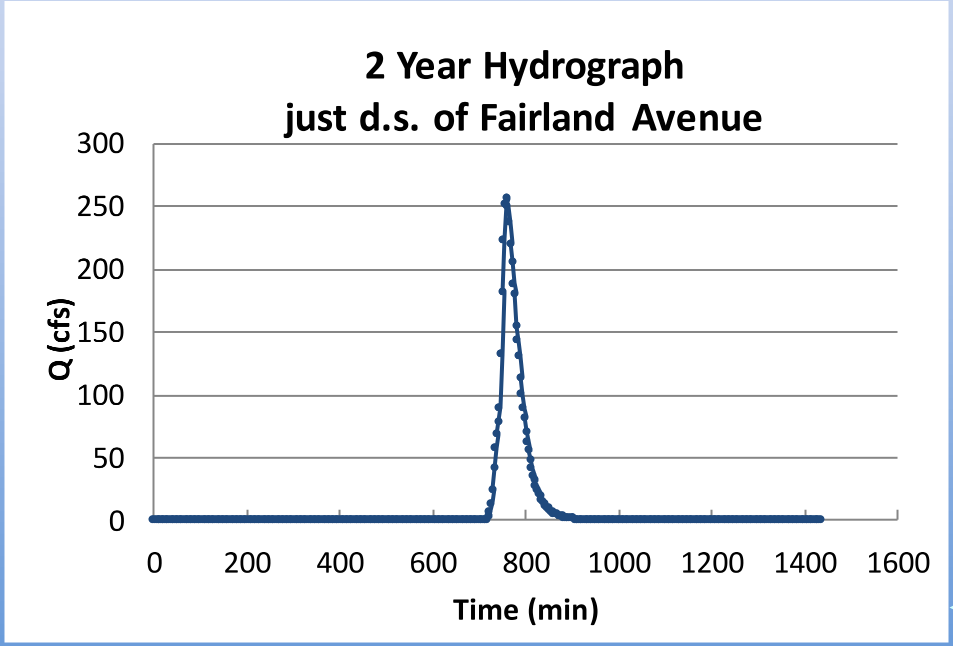


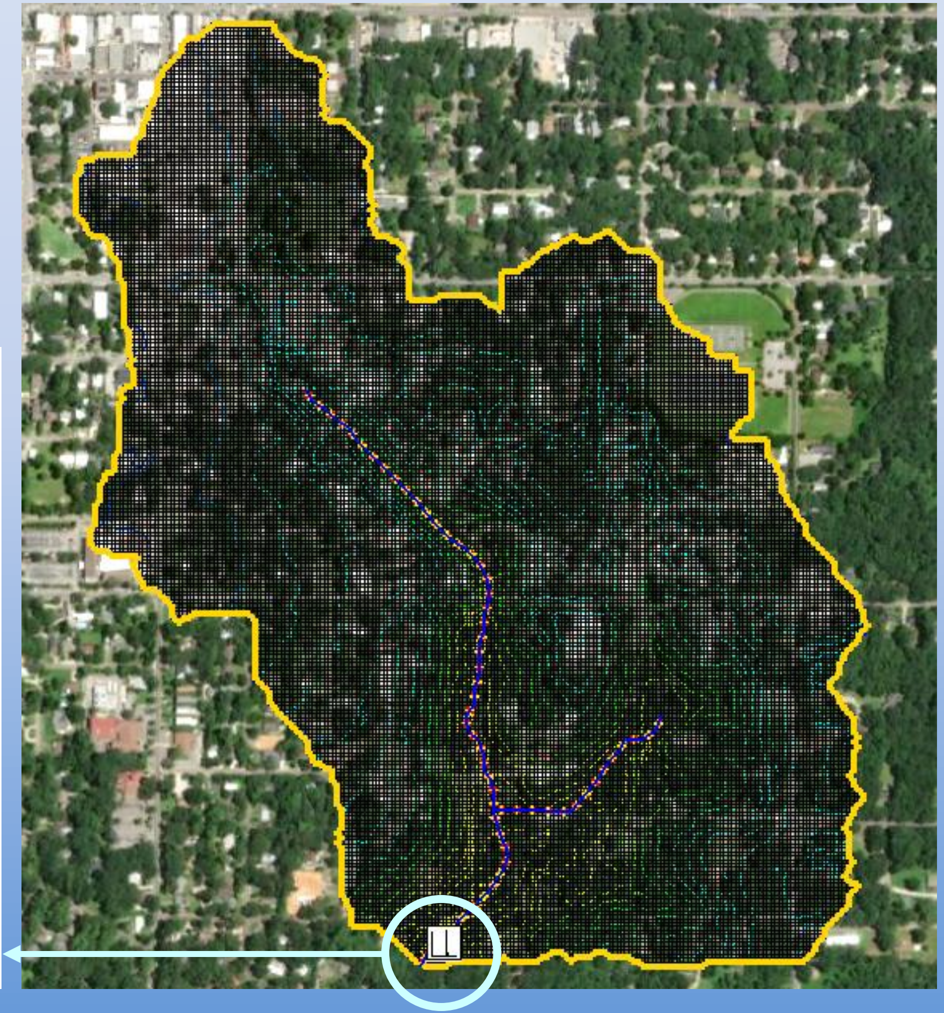
Gridded Soil Type



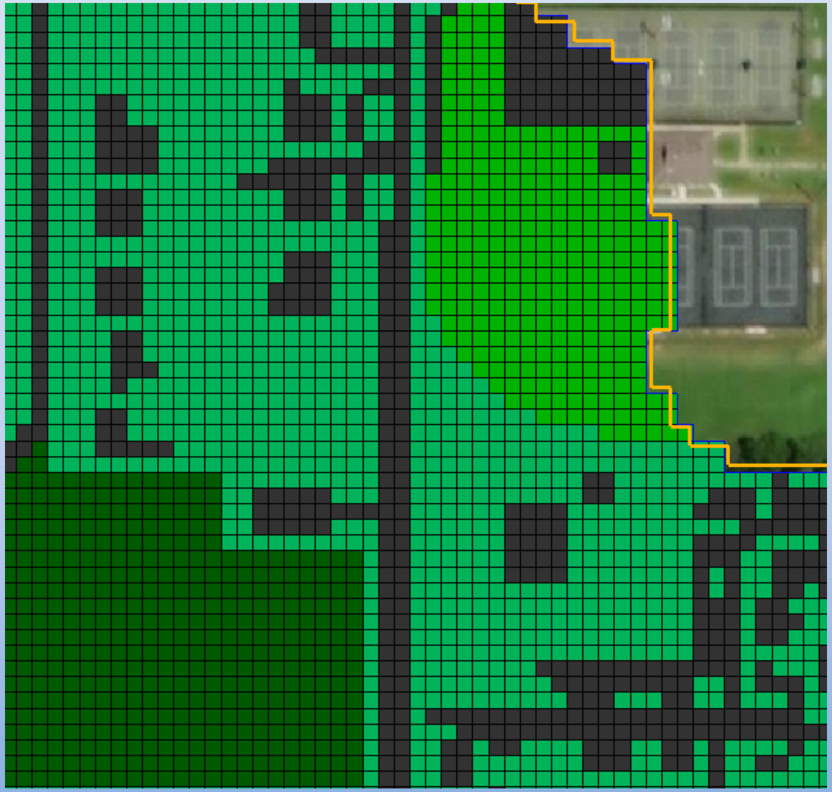
Gridded LU/ST Combined

# 2-Year Hydrograph
## (just downstream of Fairland Avenue)

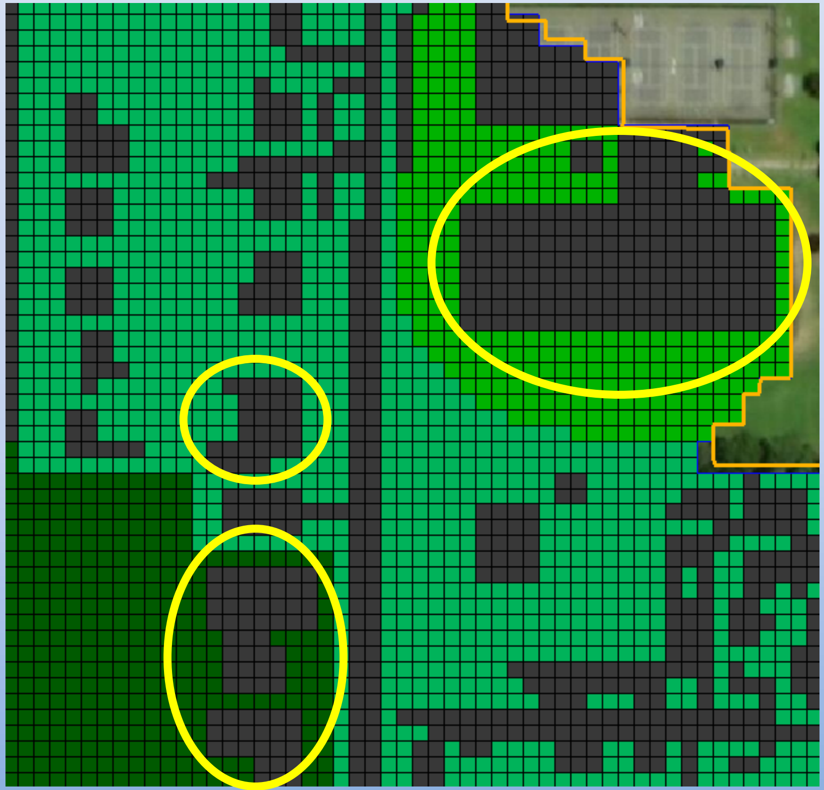


# Land Use Changes Since 2009



Gridded Land Use 2009

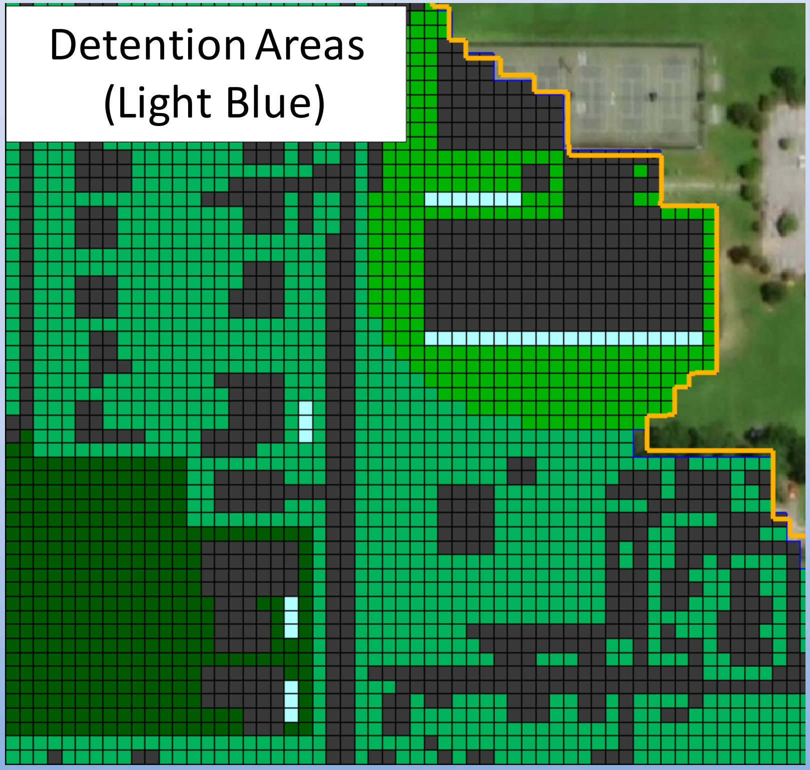


Gridded Land Use 2019

Changes in land use since 2009, indicated by modified land use grid cells

# Individual Home Detention Swales

Gridded Land Use 2019

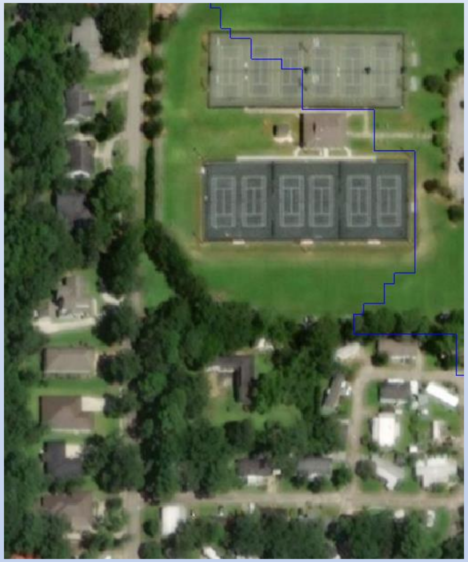



Gridded Land Use 2019 with Graded Swales

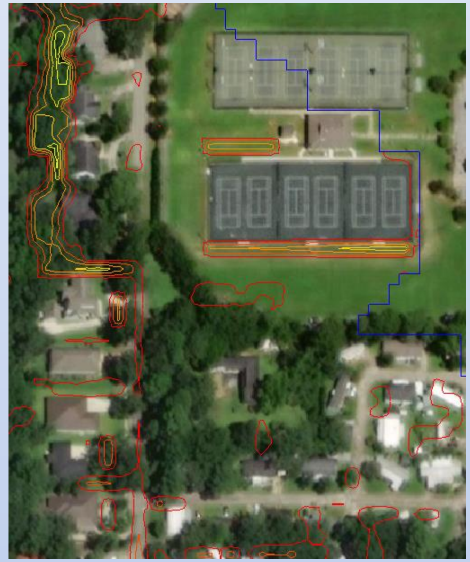
Home detention swales (Approx 15' wide x 50' long x 3' deep)

North Tennis court detention swale (Approx 15' wide x 115' long x 3' deep)
South Tennis court detention swale (Approx 15' wide x 300' long x 3' deep)

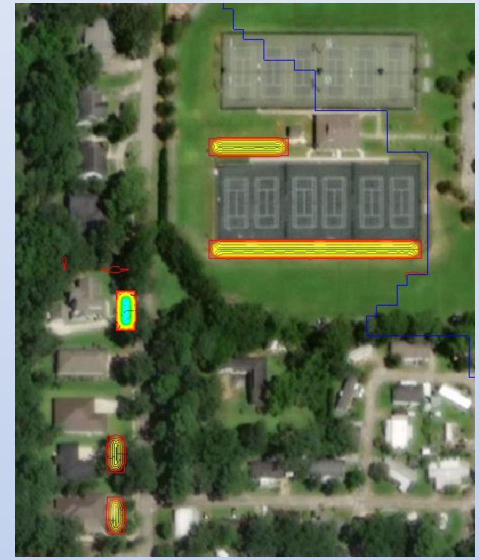
# Water Depth from 24 Hour Rain Event



11:00 am



12:00 pm



2:00 pm

5:00 pm

8:00 pm

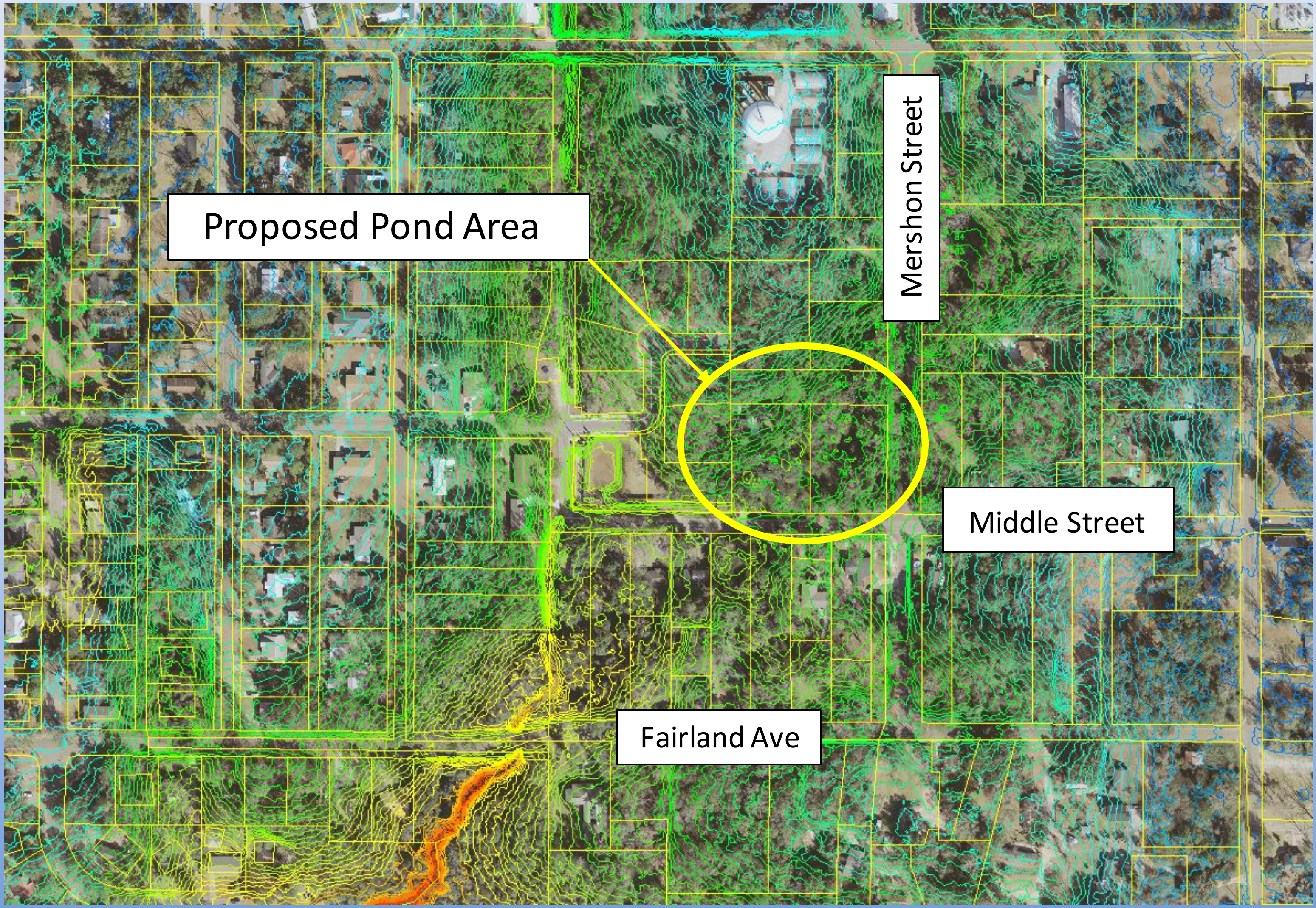
11:00 pm

# Results from Implementing Detention Swales

| Location | 2009 | 2019 | Detention Swales | | |
|---|---|---|---|---|---|
| | | | 3' Deep | 2' Deep | 1' Deep |
| | Q2 (cfs) | Q2 (cfs) | Q2 (cfs) | Q2 (cfs) | Q2 (cfs) |
| Mershon St | 116.1 | 128.1 | 117.3 | 117.9 | 119.2 |
| D.S of Fairfield Ave | 248.9 | 258.6 | 251.2 | 252.1 | 252.7 |
| | | | | | |
| | Q25 (cfs) | Q25 (cfs) | Q25 (cfs) | Q25 (cfs) | Q25 (cfs) |
| Mershon St | 344.1 | 353.0 | 341.5 | 345.2 | 349.3 |
| D.S of Fairfield Ave | 716.0 | 727.3 | 719.3 | 721.7 | 724.8 |
| | | | | | |
| | Q100 (cfs) | Q100 (cfs) | Q100 (cfs) | Q100 (cfs) | Q100 (cfs) |
| Mershon St | 522.1 | 533.2 | 522.3 | 527.3 | 531.6 |
| D.S of Fairfield Ave | 1211.9 | 1219.5 | 1210.6 | 1215.4 | 1218.0 |
| | | | | | |

The addition of detention swales helps reduce peak discharges by holding water and letting the water infiltrate back into the ground

# Local stream erosion in watershed

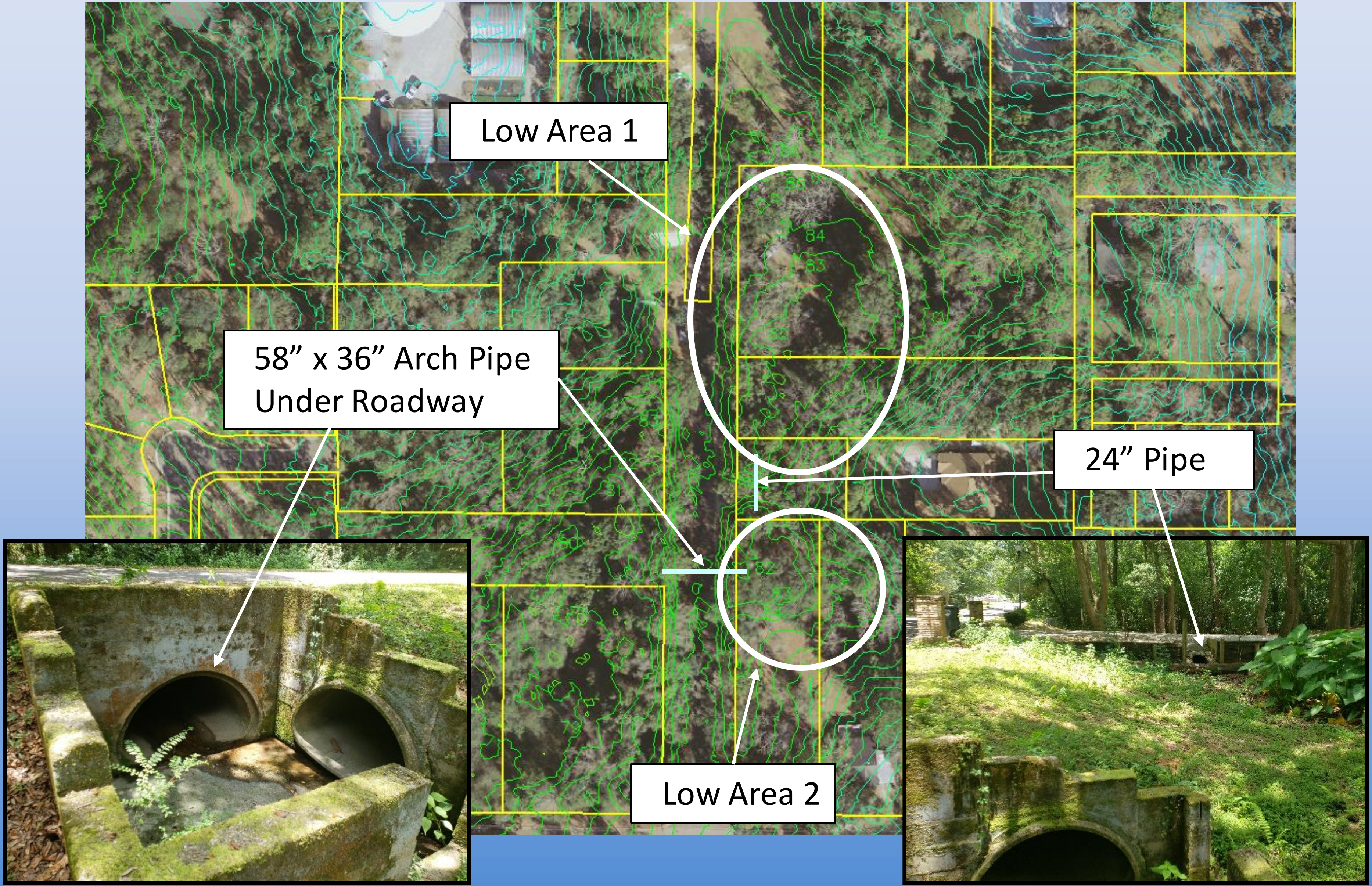



Stream erosion occurs in various areas throughout the watershed.

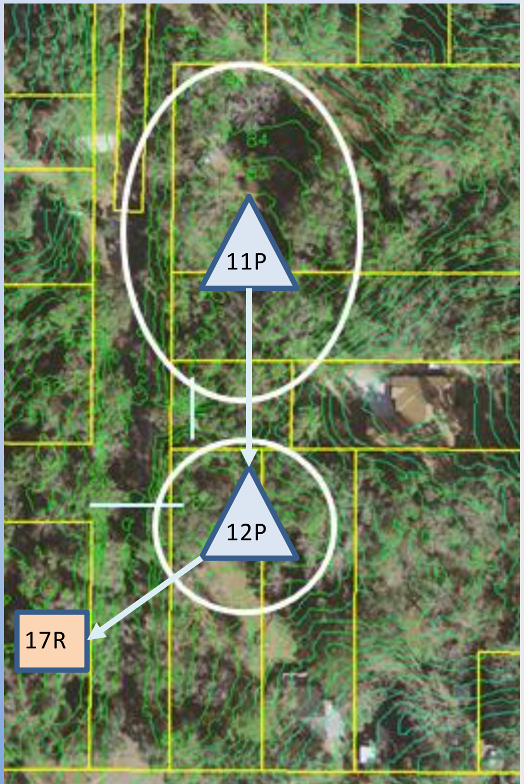
A detention pond at the corner of Mershon St and Middle St has been proposed to determine if it could provided any benefit.

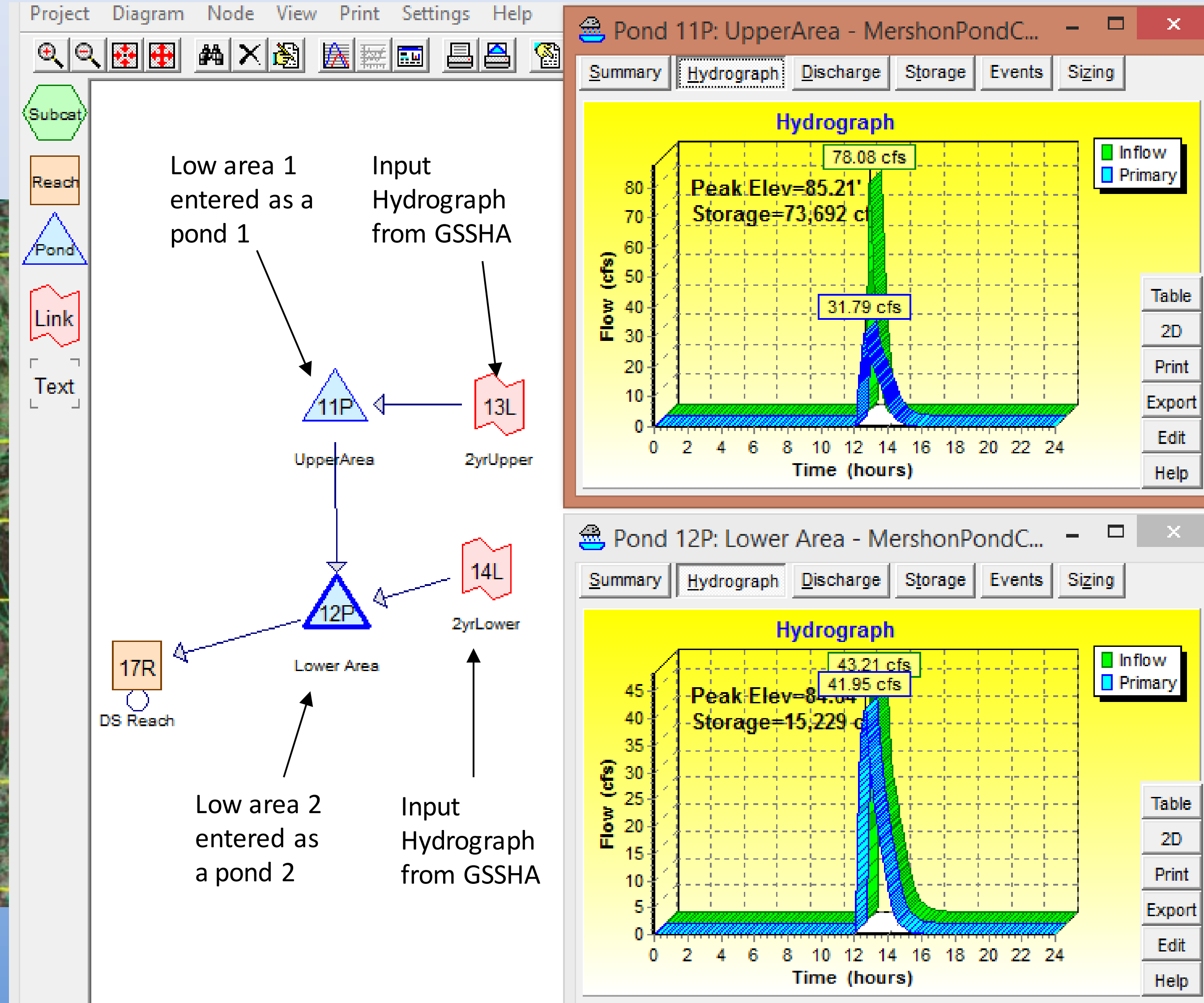
# Low Areas Providing Detention Upstream of Proposed Pond

An initial HydroCAD model of the existing conditions was created to incorporate two low areas upstream



# HydroCAD Model for Existing Conditions

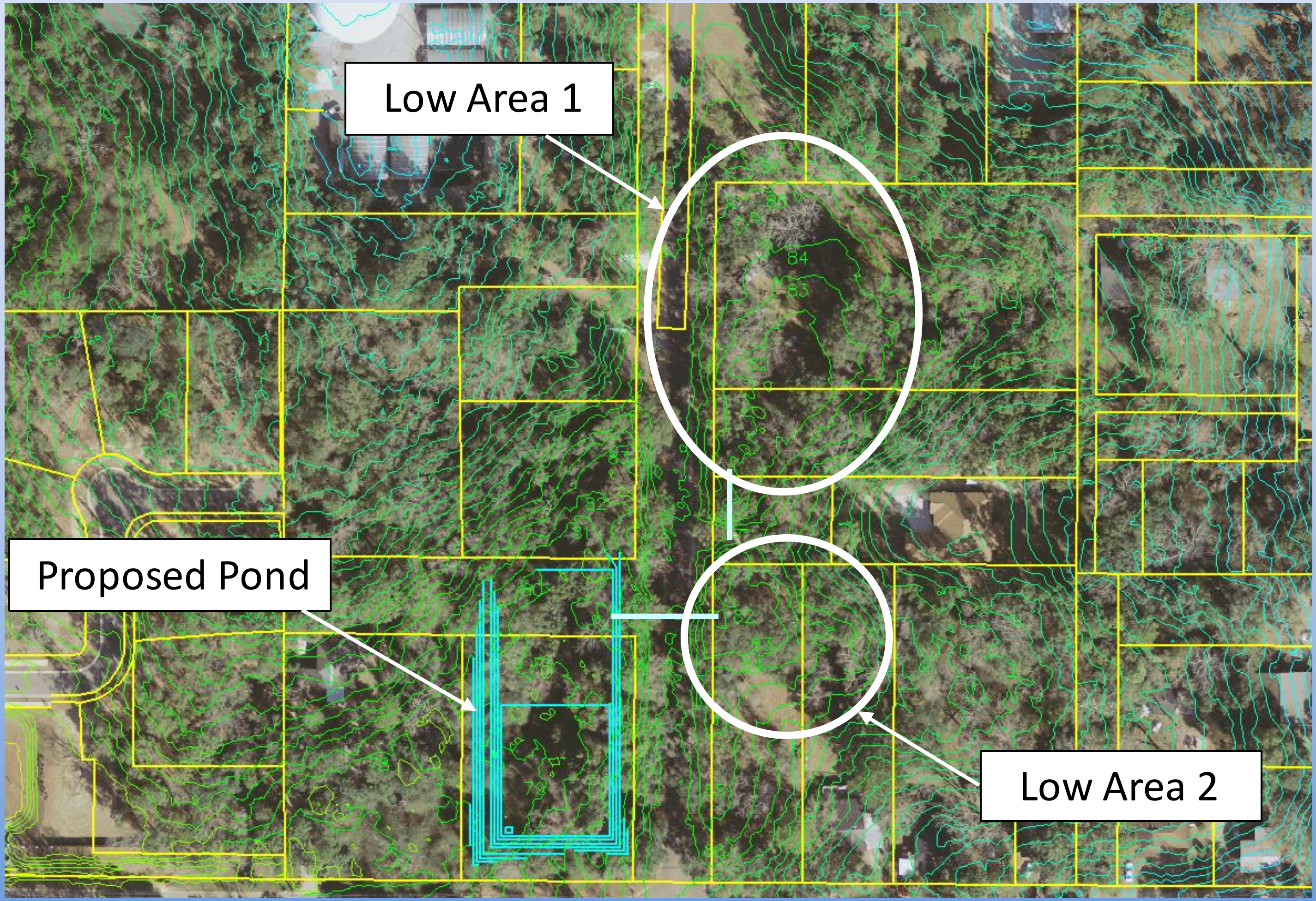



HydroCAD was used to model the low areas as detention areas in series

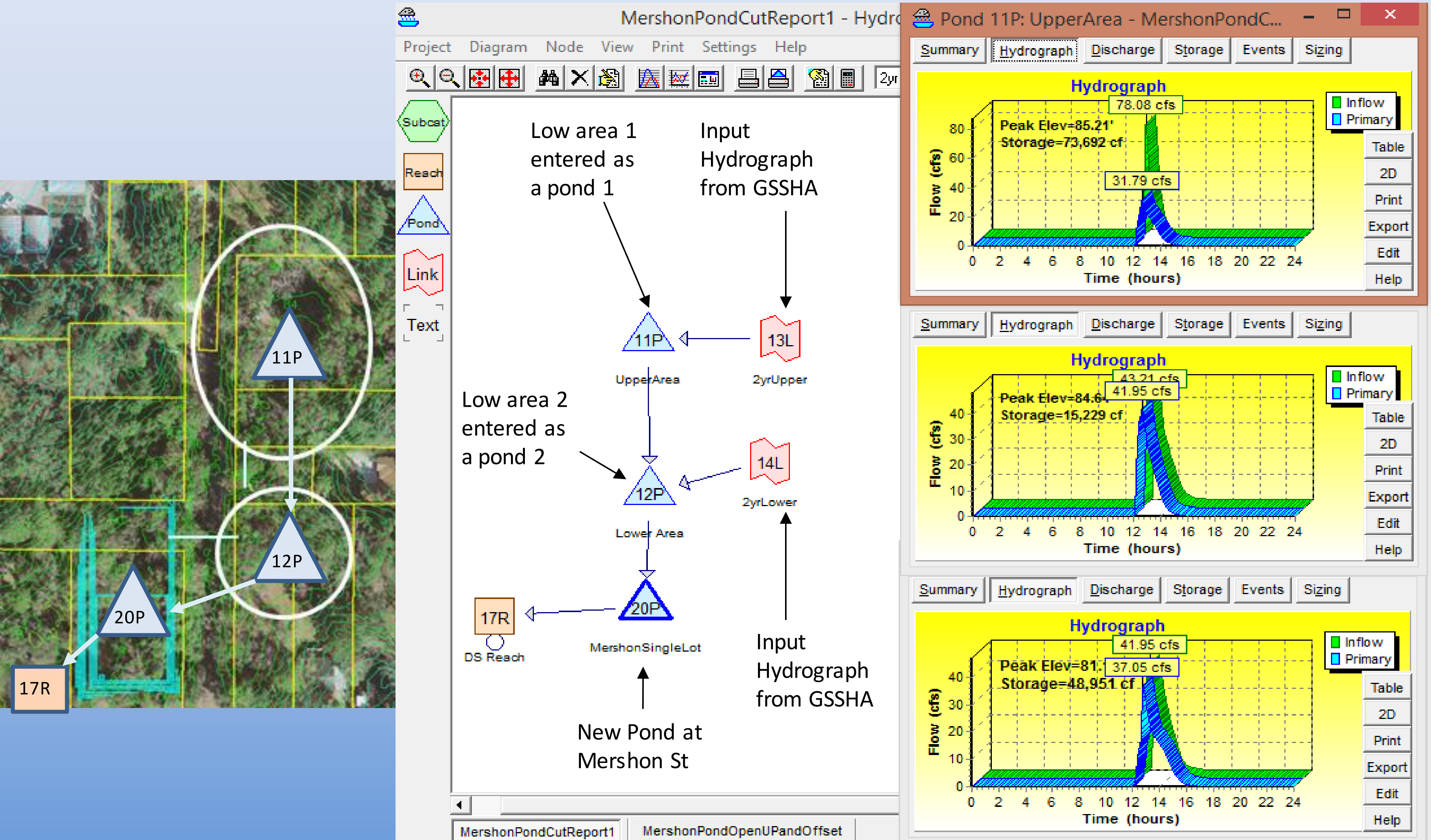
Inflow hydrographs were taken from the GSSHA hydrologic model

# Proposed Pond at Mershon St & Middle St




The initial proposed pond was contained mostly in the empty corner lot with some grading occurring within the property of the city

# HydroCAD Model for Initial Pond




HydroCAD was used to model the low areas as detention areas, along with the new pond

Inflow hydrographs were taken from the GSSHA hydrologic model

# Results from Initial Mershon St Pond

## Existing Conditions

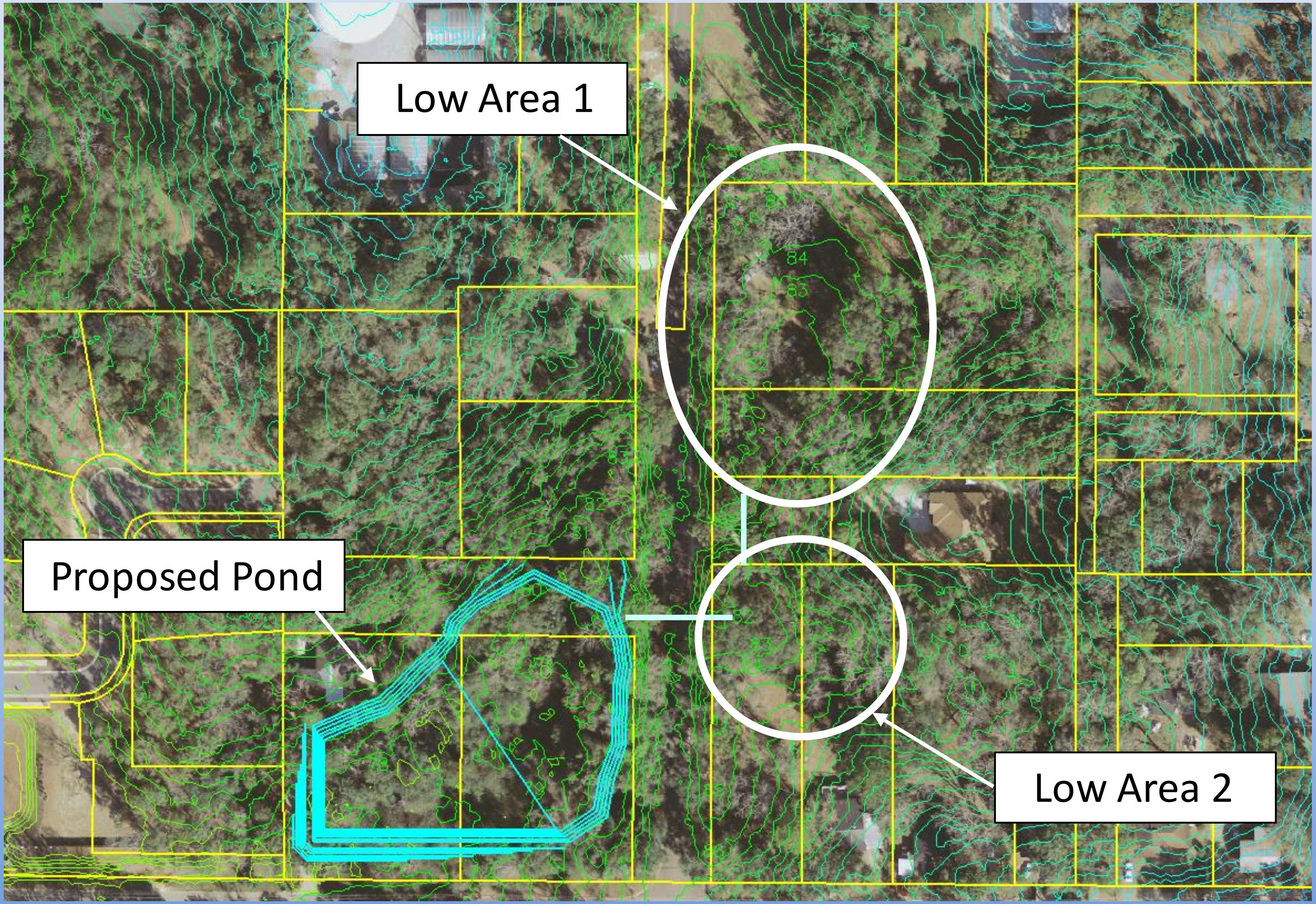
| | LOW AREA 1 | | | | | LOW AREA 2 | | | | | D.S. Reach Flow Q (cfs) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | | |
| 2 year | 24 | 78.1 | 33.4 | 85.36 | | 58 x 36 | 45.6 | 42.3 | 84.65 | | 42.2 |
| 25 year | 24 | 163.9 | 133.9 | 86.35 | | 58 x 36 | 190.5 | 189.5 | 86.29 | | 189.4 |
| 100 year | 24 | 209.8 | 201.0 | 86.55 | | 58 x 36 | 318.0 | 317.5 | 86.47 | | 317.5 |

The conceptual detention pond placed at the corner lot at Mershon St and Middle St provides very little reduction in peak discharges

## Single Lot Pond

| MERSHON ST POND GRADED (SINGLE LOT) | | | | | D.S. Reach Flow Q (cfs) |
|---|---|---|---|---|---|
| Pipe (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | | |
| 24 | 42.3 | 34.6 | 81.15 | | 34.5 |
| 24 | 189.5 | 186.2 | 81.71 | | 186.1 |
| 24 | 317.5 | 313.7 | 82.03 | | 313.6 |

# 2nd Proposed Pond at Mershon St & Middle St




The second proposed pond utilizes two lots and city property in order to provide more storage volume

# Results from Second Mershon St Pond

## Existing Conditions

| | | LOW AREA 1 | | | | | LOW AREA 2 | | | | D.S. Reach |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pipe Size | Inflow | Routed Outflow | Stage | | Pipe Size | Inflow | Routed Outflow | Stage | | Flow |
| | (in) | Q (cfs) | Q (cfs) | (ft) | | (in) | Q (cfs) | Q (cfs) | (ft) | | Q (cfs) |
| 2 year | 24 | 78.1 | 33.4 | 85.36 | | 58 x 36 | 45.6 | 42.3 | 84.65 | | 42.2 |
| 25 year | 24 | 163.9 | 133.9 | 86.35 | | 58 x 36 | 190.5 | 189.5 | 86.29 | | 189.4 |
| 100 year | 24 | 209.8 | 201.0 | 86.55 | | 58 x 36 | 318.0 | 317.5 | 86.47 | | 317.5 |

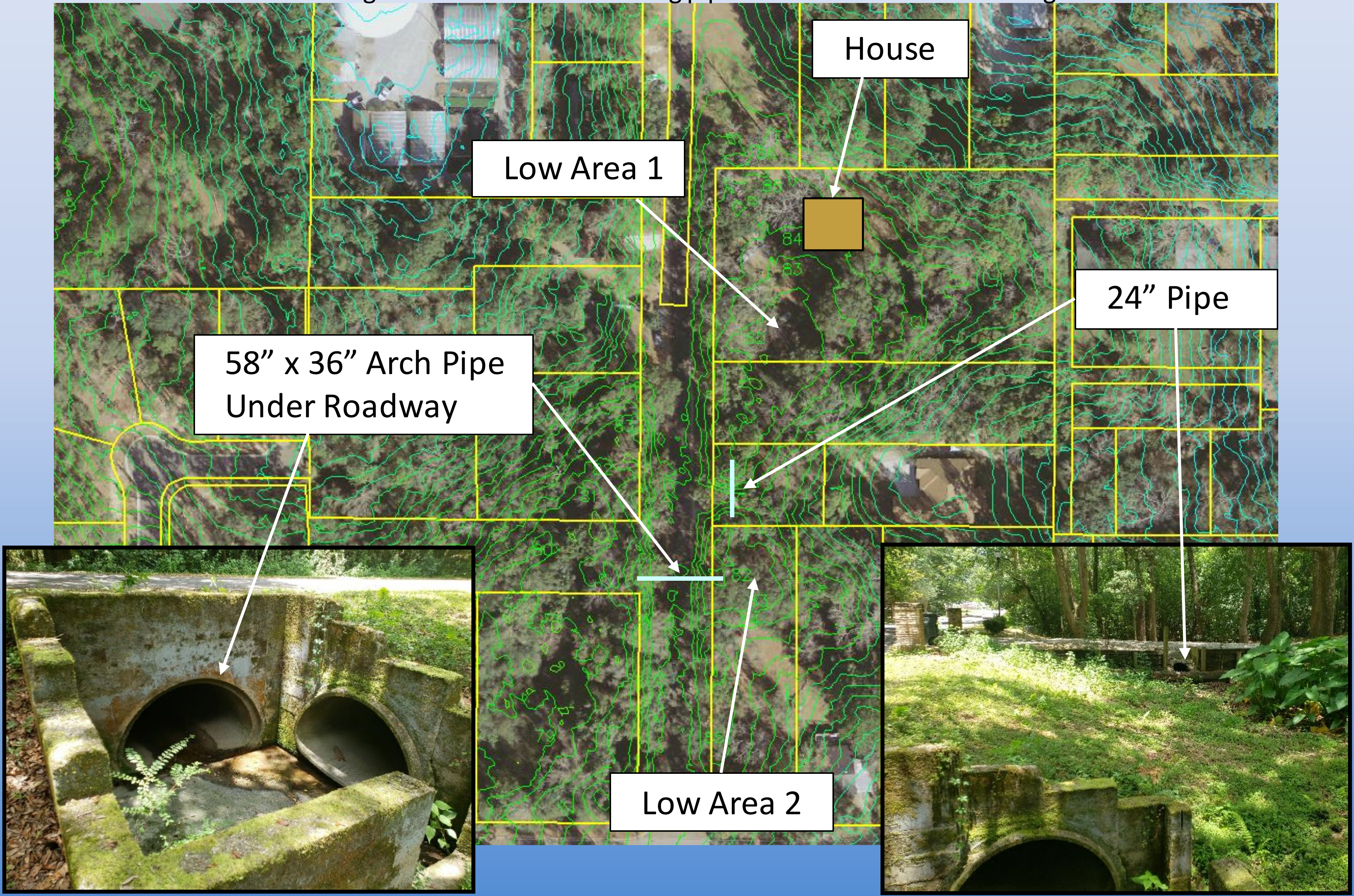
## Double Lot Pond

| | MERSHON ST POND GRADED (TWO LOTS) | | | | D.S. Reach |
|---|---|---|---|---|---|
| Pipe | Inflow | Routed Outflow | Stage | | Flow |
| (in) | Q (cfs) | Q (cfs) | (ft) | | Q (cfs) |
| 24 | 42.2 | 18.3 | 79.02 | | 18.3 |
| 24 | 189.5 | 127.9 | 81.51 | | 127.8 |
| 24 | 317.5 | 265.2 | 81.91 | | 265.1 |

The second conceptual detention pond placed at the corner lot at Mershon St and Middle St provides reduction in peak discharges

# Possible Stage Reduction by Increasing Pipe Sizes

Due to the benefit of the second conceptual pond, it could possibly offset discharge increases from increasing pipe sizes in order to reduce stages



# Results from Second Mershon St Pond and increasing pipe sizes

## Existing Conditions

| | LOW AREA 1 | | | | LOW AREA 2 | | | | D.S. Reach | NO POND | | | | D.S. Reach |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) | Pipe (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) |
| 2 yr | 24 | 78.1 | 33.4 | 85.36 | 58 x 36 | 45.6 | 42.3 | 84.65 | 42.2 | --- | --- | --- | --- | 42.2 |
| 25 yr | 24 | 163.9 | 133.9 | 86.35 | 58 x 36 | 190.5 | 189.5 | 86.29 | 189.4 | --- | --- | --- | --- | 189.4 |
| 100 yr | 24 | 209.8 | 201.0 | 86.55 | 58 x 36 | 318.0 | 317.5 | 86.47 | 317.5 | --- | --- | --- | --- | 317.5 |

## Increase Pipe Size under the Driveway

| | LOW AREA 1 (INCREASE PIPE SIZE) | | | | LOW AREA 2 | | | | D.S. Reach | MERSHON ST POND GRADED (TWO LOTS) | | | | D.S. Reach |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) | Pipe (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) |
| 2 yr | 58 x 36 | 78.1 | 34.2 | 85.09 | 58 x 36 | 46.9 | 45.9 | 84.74 | 45.9 | 24 | 45.9 | 21.2 | 79.39 | 21.2 |
| 25 yr | 58 x 36 | 163.9 | 132.1 | 86.34 | 58 x 36 | 187.6 | 186.6 | 86.28 | 186.5 | 24 | 186.6 | 127.7 | 81.51 | 127.6 |
| 100 yr | 58 x 36 | 209.8 | 200.0 | 86.54 | 58 x 36 | 316.0 | 315.2 | 86.46 | 315.1 | 24 | 315.2 | 264.2 | 81.90 | 264.2 |

## Increase Pipe Size under the Driveway and Mershon Street

| | LOW AREA 1 (INCREASE PIPE SIZE) | | | | LOW AREA 2 (INCREASE PIPE SIZE) | | | | D.S. Reach | MERSHON ST POND GRADED (TWO LOTS) | | | | D.S. Reach |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Pipe Size (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) | Pipe (in) | Inflow Q (cfs) | Routed Outflow Q (cfs) | Stage (ft) | Flow Q (cfs) |
| 2 yr | 58 x 36 | 78.1 | 42.2 | 84.66 | (2) 58 x 36 | 58.0 | 57.0 | 84.07 | 57.0 | 24 | 57.0 | 23.7 | 79.78 | 23.7 |
| 25 yr | 58 x 36 | 163.9 | 128.8 | 85.98 | (2) 58 x 36 | 190.6 | 180.9 | 85.8 | 180.9 | 24 | 180.9 | 155.6 | 81.6 | 155.6 |
| 100 yr | 58 x 36 | 209.8 | 191.0 | 86.40 | (2) 58 x 36 | 297.1 | 295.4 | 86.29 | 295.2 | 24 | 295.4 | 265.4 | 81.91 | 265.4 |

The second conceptual pond placed at the corner lot at Mershon St and Middle St can offset increases in discharge

# TATUMVILLE GULLY
# HYDRAULIC ANALYSIS
# FAIRHOPE, AL

Tatumville Gully is located in Fairhope, Alabama and drains area from Fairhope Avenue to Mobile Bay (Figure 1). A hydraulic model was created for a portion of the upper part of the gully. The study reach extends from Nichols Avenue to Fairland Avenue; and to the east just past Mershon Avenue (Figure 2). A detention pond at the corner of Middle Street and Mershon Avenue is proposed to determine if peak discharges and velocities can be reduced in the downstream reaches.

## SURVEY AND DATUM

Survey information used for developing the hydraulic model was taken from a cad file provided by Mott MacDonald. Information taken from the topographic survey includes cross-sections, existing road grade elevations, and all drainage structure information within the study reach. The coordinate system provided is in State Plane AL-W and the datum is to NAVD 88 (feet).

## THE STREAM

The drainage area of the stream to Nichols Avenue is approximately 0.12 square miles and is approximately 0.27 square miles at Fairland Avenue. The stream drains an area that is comprised mostly of business and residential areas. The USGS program StreamStats indicates that the basin is 82% developed. The main channel of the stream throughout the reach varies from 20’ wide and 4’ deep upstream to 35’ wide and 10’ deep downstream. The stream slope varies between 0.01 ft/ft upstream to 0.04 ft/ft downstream.

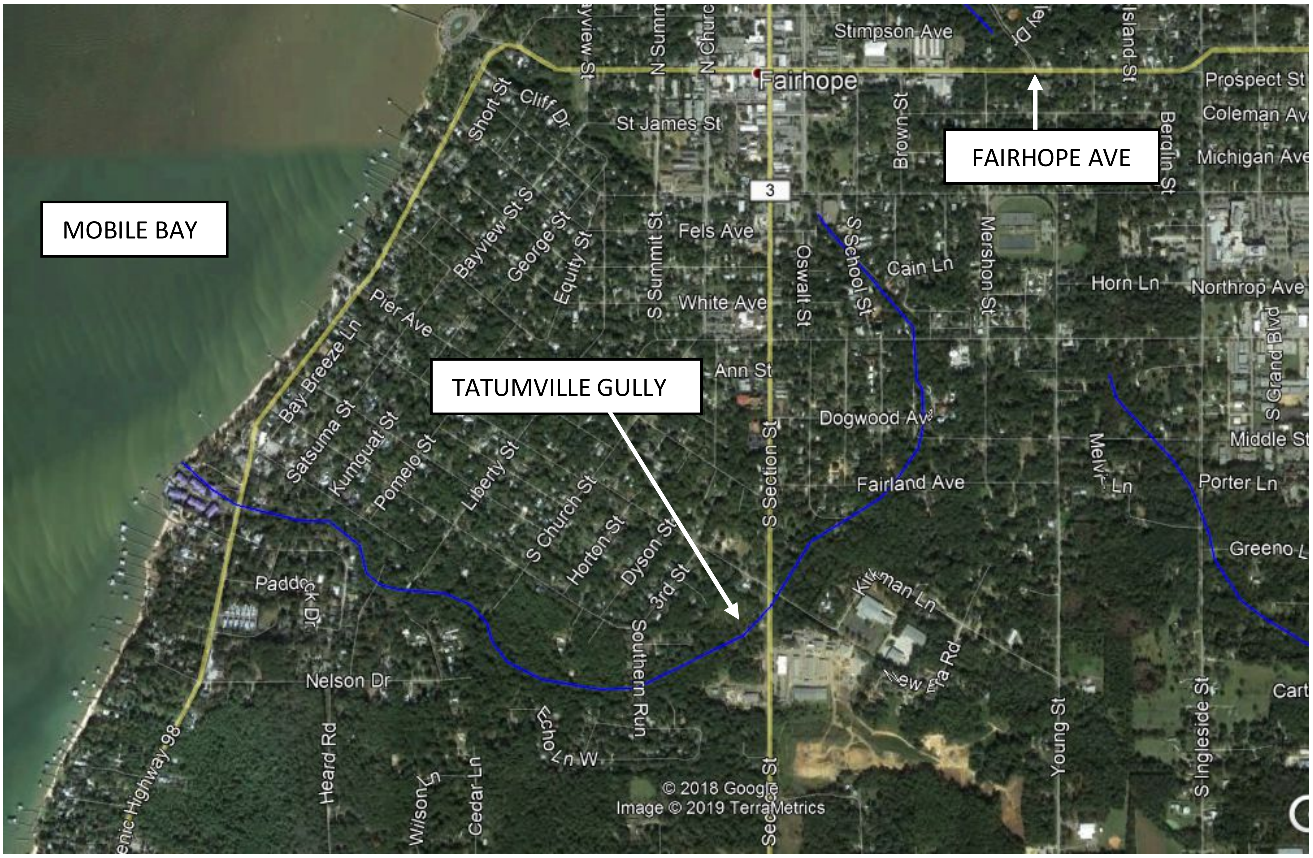



**Figure 1. Aerial image indicating location of Tatumville Gully**

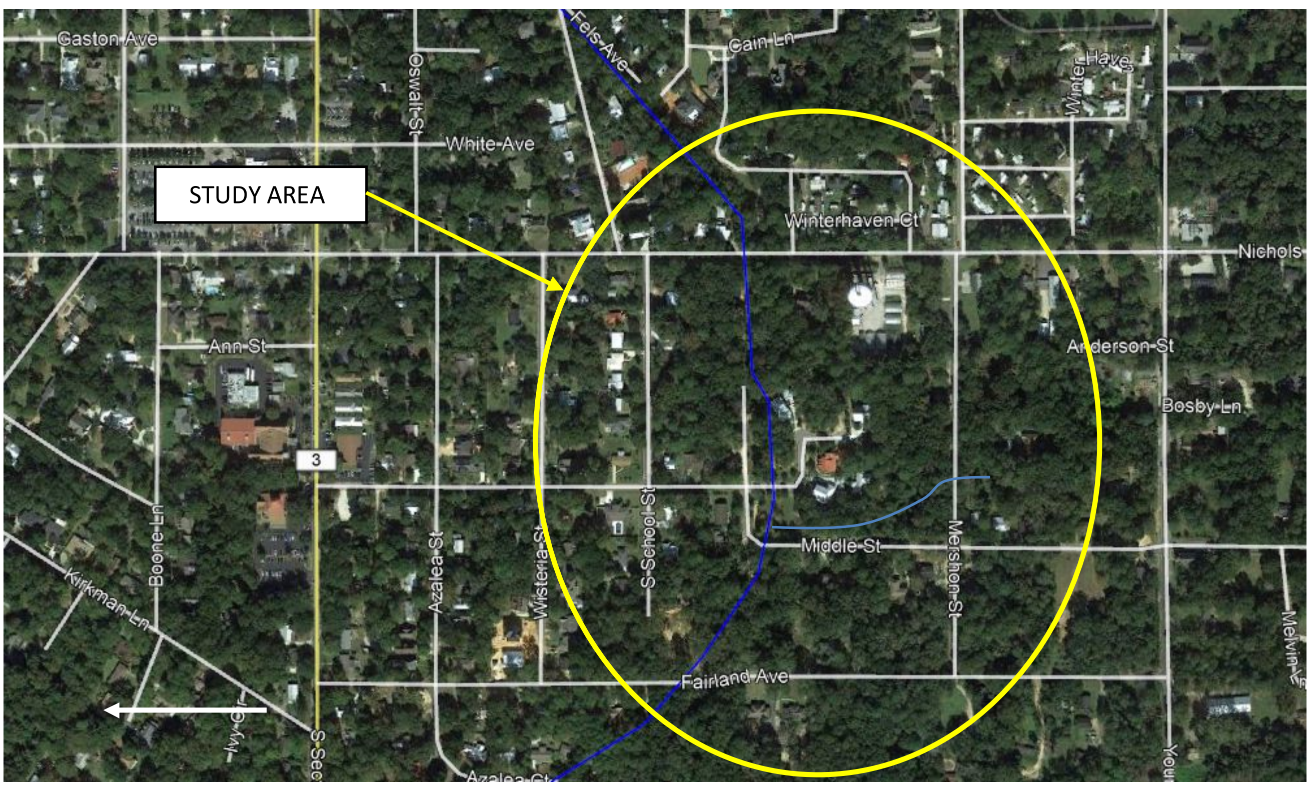



**Figure 2. Aerial image indicating location of study area along Tatumville Gully**

## HYDROLOGIC MODEL

An estimate of peak discharges along the study reach for selected recurrence intervals was determined using the Gridded Surface Subsurface Hydrologic Analysis (GSSHA) model (Figure 3). GSSHA is developed and maintained by the US Army Engineer Research and Development Center (ERDC) Hydrologic Modeling Branch. GSSHA is a physically-based, distributed parameter hydrologic model with 2D overland flow, 1D stream flow, and 1D infiltration. Parameters used to generate a GSSHA simulation include precipitation data, digital terrain data, land use data, and soils data.

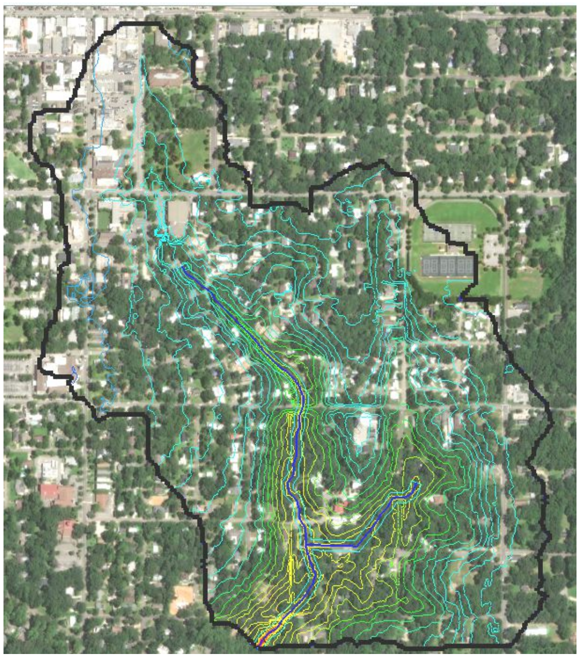


**Figure 3. Aerial image indicating drainage area**

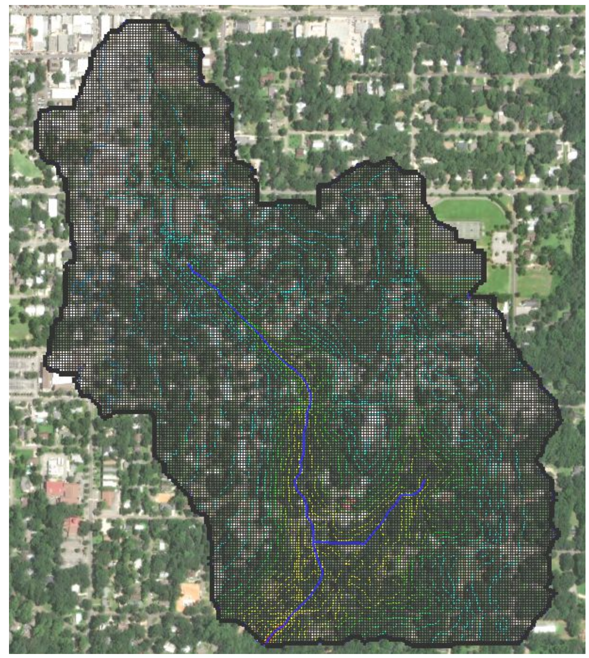


**Figure 4. Aerial image indicating drainage area with grid cells**

Once the data has been incorporated into the model, the model is divided into individual grid cells. The downstream most point of the model was taken approximately 170' downstream of Fairland Avenue. For this model, the basin utilized a 5 meter by 5 meter grid cell size. Over the entire watershed this generates approximately 29,480 grid cells.

Once the model is built and run, discharges can be determined at any point along the stream arc. For use in the hydraulic model, discharge locations were located at the following locations: Nichols Avenue, Dogwood Avenue, Middle Street, Fairview Avenue, Mershon Street, and at a driveway culvert (Figure 5). Peak discharges for selected recurrence intervals (2-, 10-, 25-, and 100-year floods) are provided in Table 1.

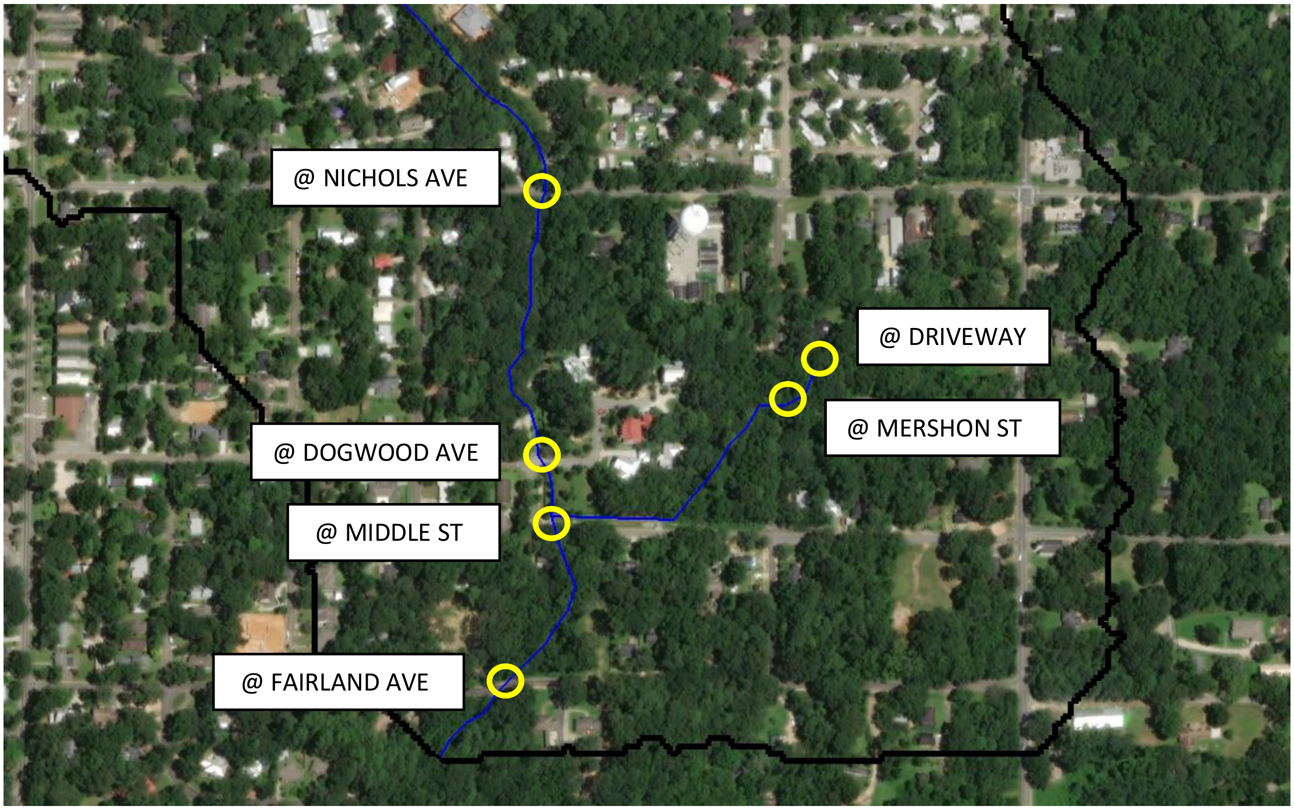



**Figure 5. Schematic indicating the discharge locations in GSSHA model for use in the hydraulic model**

## HYDRAULIC MODEL

The Hydrologic Engineering Center – River Analysis System (HEC-RAS) software developed by the U.S. Army Corps of Engineers Hydraulic Engineering Center was used to create the hydraulic model. HEC-RAS is a water surface profile computation model used to analyze one-dimensional steady flow in open channels. The HEC-RAS model utilizes stream discharge, floodplain cross-section conveyance and slope and an integral part of its modeling routine. Information used to develop the model includes floodplain cross-sections, Manning's n values, structure information, and discharges. The limits of the hydraulic model extend from Nichols Avenue to Fairland Avenue; and to the east just past Mershon Avenue (Figure 6).

It was determined during the development of the HEC-RAS model there appeared to be enough storage volume behind some of the culverts to attenuate flow. In order to detail the routing component, the computer program HydroCAD was used. HydroCAD is a Computer Aided Design system for modeling the hydrology and hydraulics of stormwater runoff. For the analysis, each structure (Nichols Avenue, Dogwood Avenue, Middle Street, Fairview Avenue, Mershon Street, and at a driveway culvert) was coded into the model as a detention pond (Figure 7). The model was set up to act as ponds in series where the backwater from each structure has the ability to affect the upstream structures. Figure 8 indicates the areas that have enough storage volume to impact discharges.

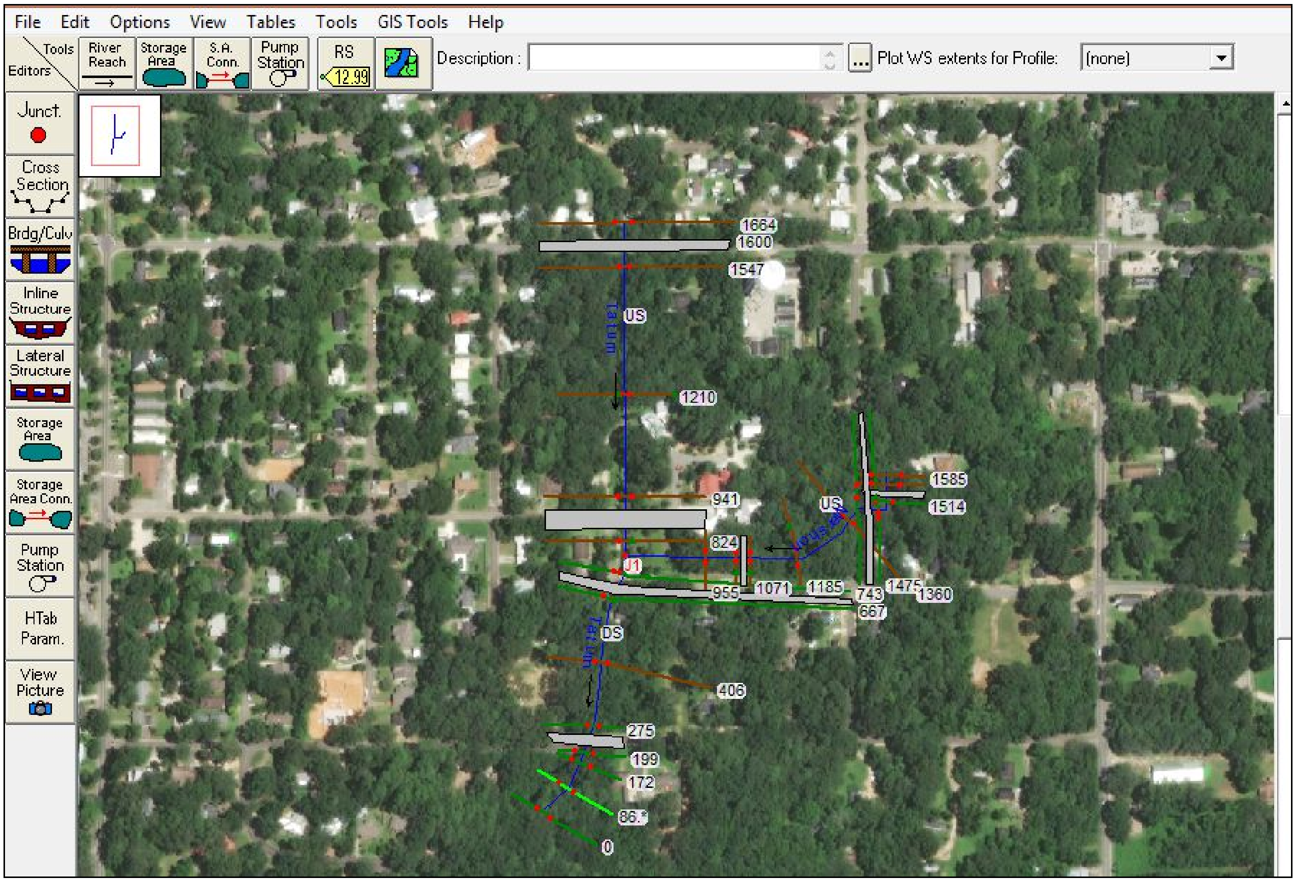


Figure 6. Schematic indicating HEC-RAS model layout

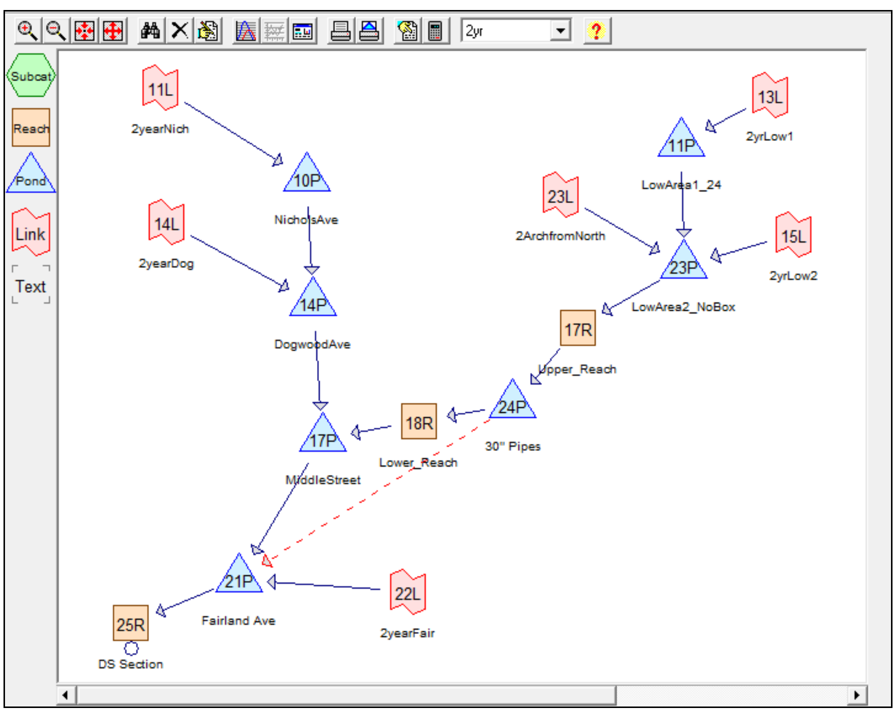


Figure 7. Schematic indicating HydroCAD model layout

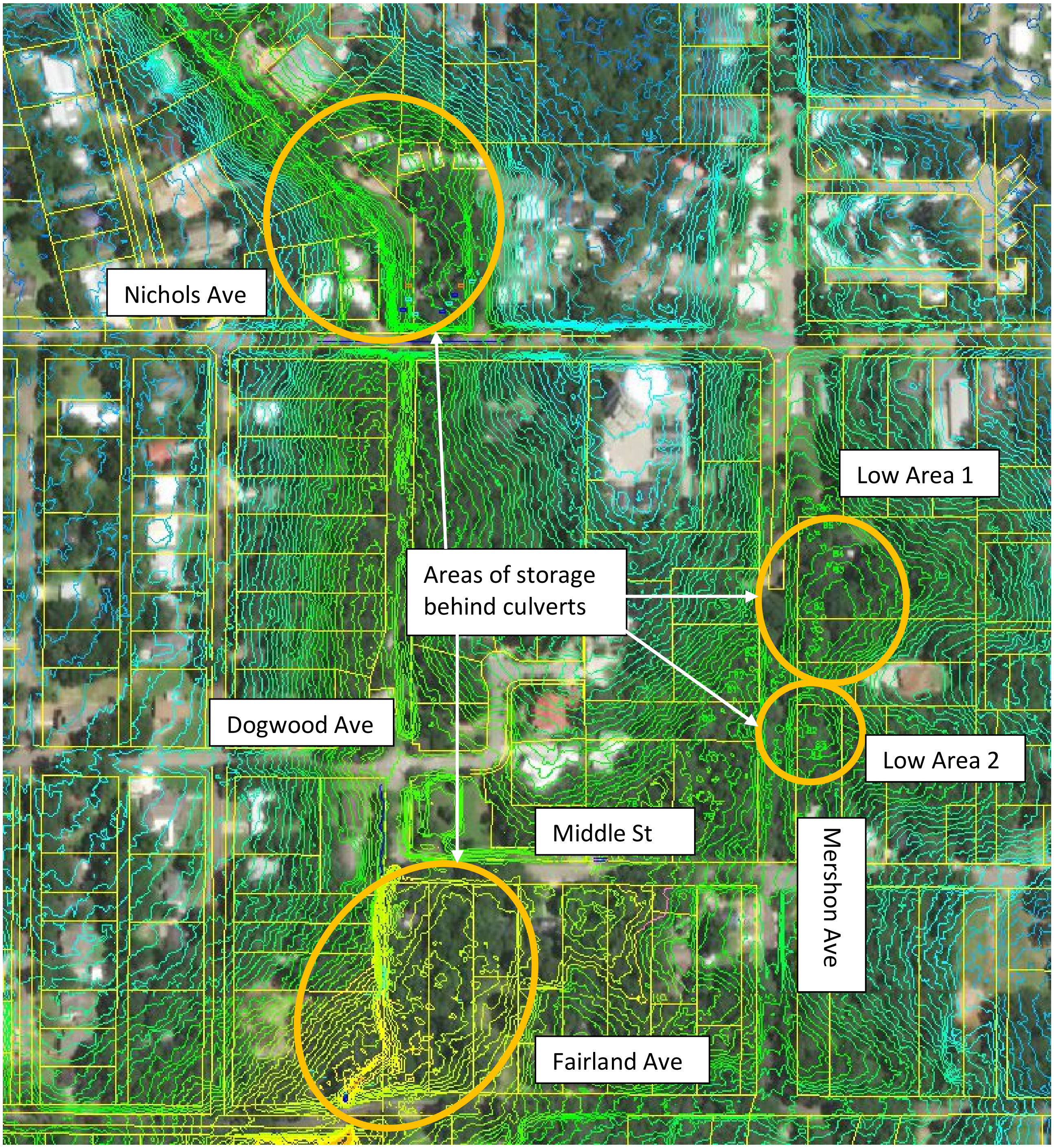


**Figure 8. Schematic indicating areas of storage**

Once the drainage structures and input hydrographs were entered into the HydroCAD model, the routed discharges could then be taken and input into the HEC-RAS model. The HEC-RAS model could then be used to determine velocities and stages in the downstream reaches. Table 1 is a summary of the routed flows at each drainage structure for the 2-, 10-, 25-, and 100-year flood events. Figures 9 and 10 indicate the water surface elevation profiles for the different flood events.

**Table 1. Recurrence Intervals, peak discharges, and routed discharges**

| Location | Q2 (cfs) | | Q10 (cfs) | | Q25 (cfs) | | Q100 (cfs) | |
|---|---|---|---|---|---|---|---|---|
| | Inflow | Routed | Inflow | Routed | Inflow | Routed | Inflow | Routed |
| Low Area 1 | 39 | 14 | 78 | 25 | 110 | 52 | 153 | 121 |
| Low Area 2 | 79 | 73 | 147 | 106 | 200 | 191 | 334 | 333 |
| | | | | | | | | |
| Nichols Ave | 149 | 146 | 230 | 218 | 357 | 301 | 593 | 403 |
| Dogwood Ave | 160 | 158 | 243 | 243 | 388 | 388 | 569 | 569 |
| Middle St | 217 | 213 | 327 | 325 | 506 | 503 | 727 | 719 |
| Fairland Ave | 238 | 224 | 335 | 304 | 547 | 432 | 840 | 715 |

*Locations can be found on Figure 8

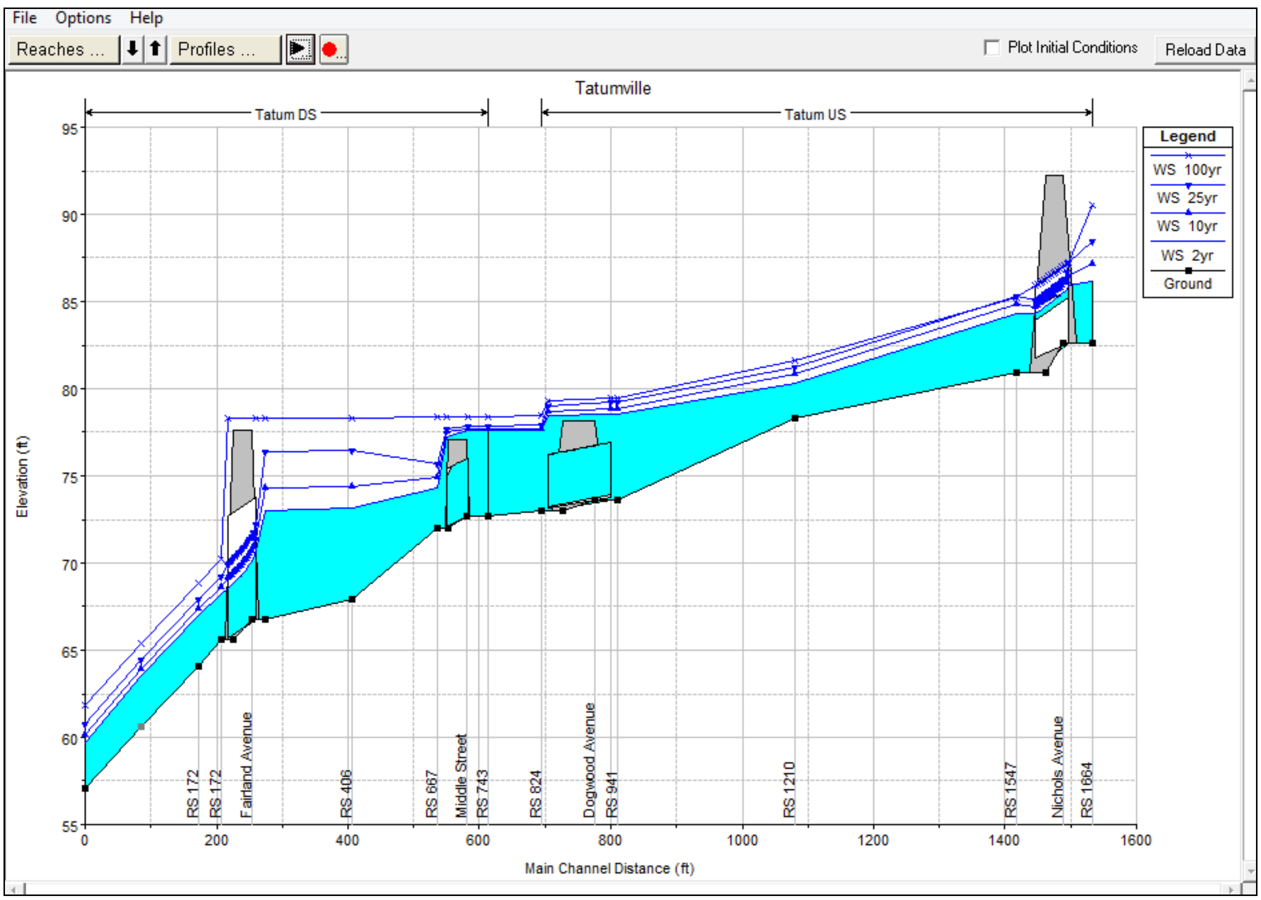



**Figure 9. Schematic indicating water surface profiles from Fairland Ave to Nichols Ave**

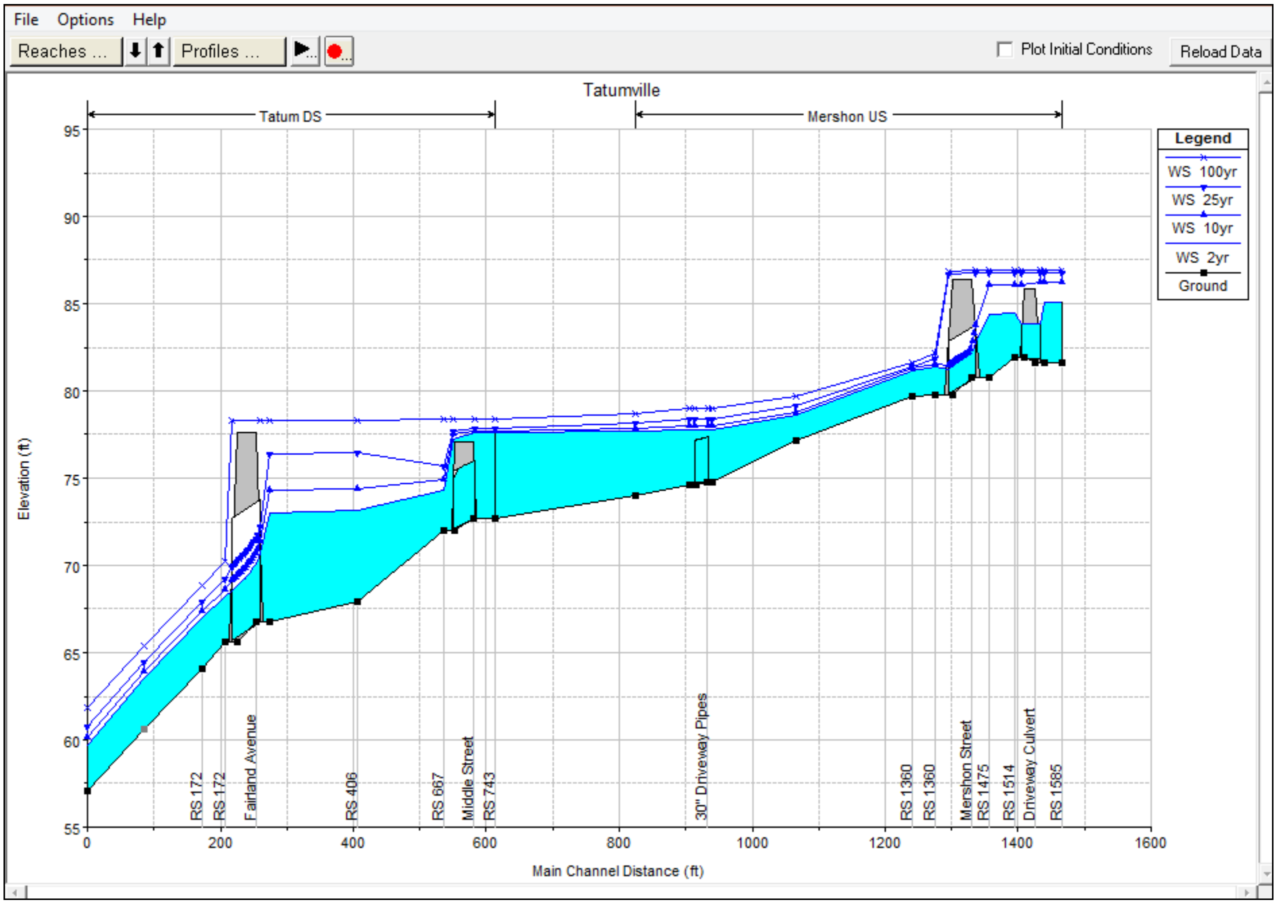



**Figure 10. Schematic indicating water surface profiles from Fairland Ave to Mershon St**

After the routed discharges were entered into the hydraulic model and water surface elevations were generated, a conceptual pond at the corner of Middle St and Mershon Ave was analyzed. Initially the pond was contained within a single lot, however, results indicated that this would not provide enough storage volume to be beneficial. The other conceptual pond utilizes 2 lots and a portion of the city's property (Figure 11). Once the conceptual grading was completed, the pond was entered into the previously built HydroCAD model (Figure 12). Table 2 is a summary of the routed flows at each drainage structure for the 2-, 10-, 25-, and 100-year flood events including the implementation of the conceptual pond. Figure 13 indicates the water surface elevation profile differences downstream of Middle Street based on the existing conditions and with the conceptual pond. Table 3 indicates the velocity changes in the stream sections downstream of Middle Street and Fairland Avenue.

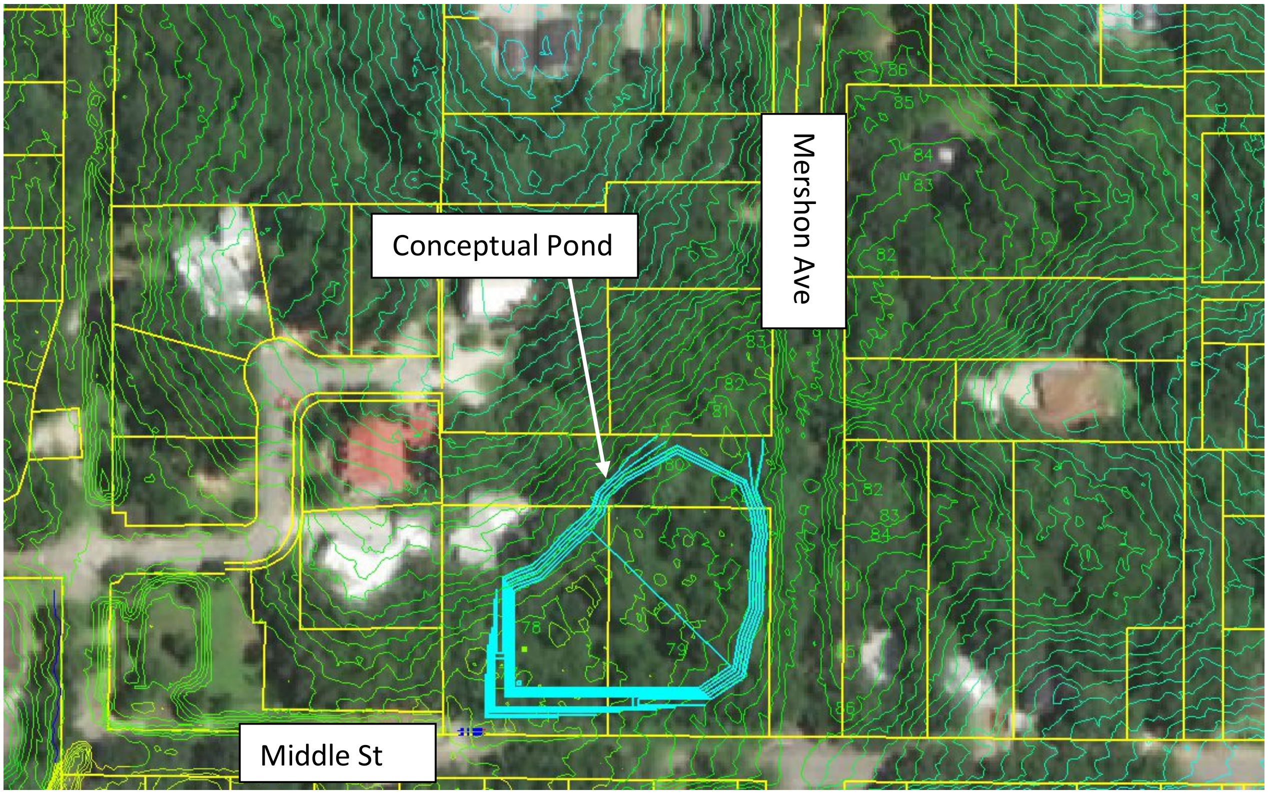



**Figure 11. Schematic indicating conceptual pond at Middle St and Mershon Ave**

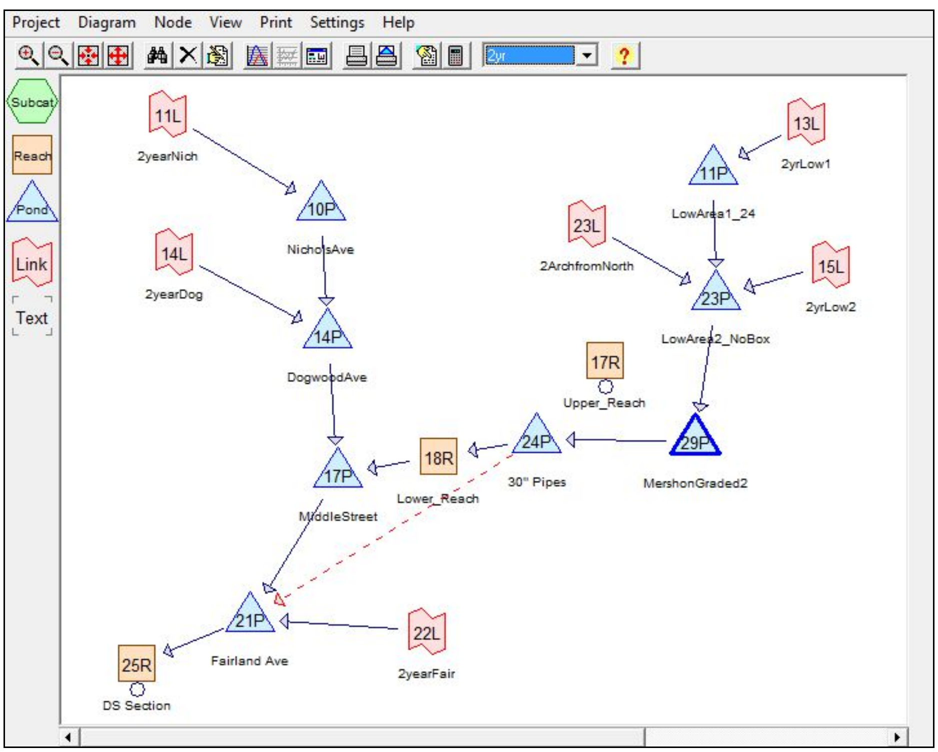



**Figure 12. Schematic indicating conceptual pond at Middle St and Mershon Ave**

**Table 2. Recurrence Intervals, peak discharges, and routed discharges**

| Location | Q2 (cfs) | | | Q10 (cfs) | | | Q25 (cfs) | | | Q100 (cfs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Inflow | Routed | w Pond | Inflow | Routed | w Pond | Inflow | Routed | w Pond | Inflow | Routed | w Pond |
| Low Area 1 | 39 | 14 | 14 | 78 | 25 | 25 | 110 | 52 | 52 | 153 | 121 | 121 |
| Low Area 2 | 79 | 73 | 73 | 147 | 106 | 106 | 200 | 191 | 191 | 334 | 333 | 333 |
| | | | | | | | | | | | | |
| Nichols Av | 149 | 146 | 146 | 230 | 218 | 218 | 357 | 301 | 301 | 593 | 403 | 403 |
| Dogwood Av | 160 | 158 | 157 | 243 | 243 | 241 | 388 | 388 | 388 | 569 | 569 | 569 |
| Middle St | 217 | 213 | 177 | 327 | 325 | 313 | 506 | 503 | 503 | 727 | 719 | 719 |
| Fairland Av | 238 | 224 | 196 | 335 | 304 | 290 | 547 | 432 | 426 | 840 | 715 | 699 |

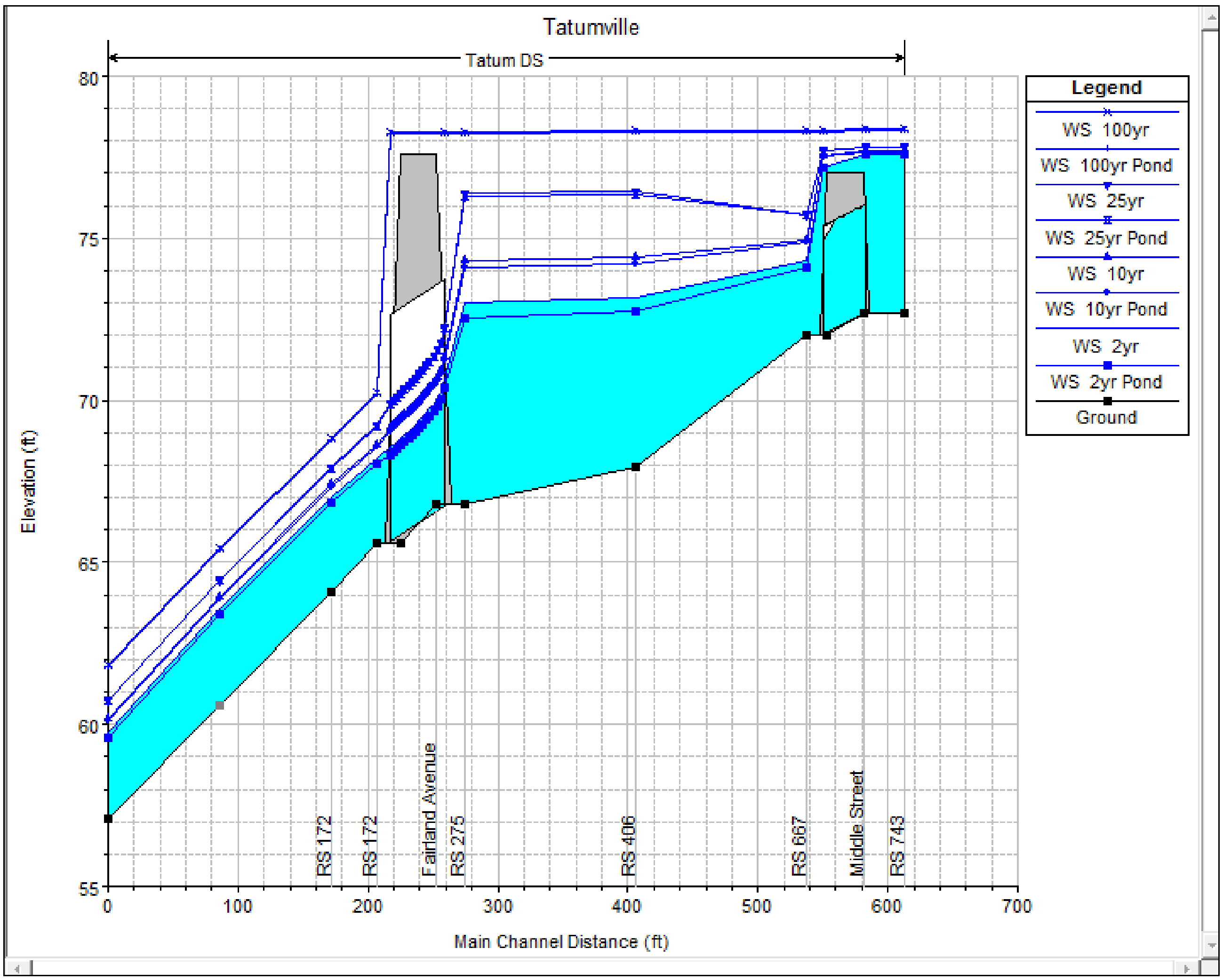



**Figure 13. Schematic indicating water surface profile differences downstream of Middle Street**

**Table 3. Velocity comparisons downstream of Middle St and Fairland Ave**

| Location | V2 (ft/s) | | V10 (ft/s) | | V25 (ft/s) | | V100 (ft/s) | |
|---|---|---|---|---|---|---|---|---|
| | Ex Cond | w Pond | Ex Cond | w Pond | Ex Cond | w Pond | Ex Cond | w Pond |
| DS of Middle St | 7.3 | 7.0 | 8.1 | 8.0 | 8.9 | 8.9 | 1.4* | 1.4* |
| DS of Fairland Ave | 6.5 | 6.2 | 7.0 | 6.9 | 7.7 | 7.6 | 8.7 | 8.7 |

* Lower due to backwater effects from Fairland Avenue

Finally, a scenario was analyzed to see if the stages could be lowered upstream of Mershon Avenue and not impact any of the downstream reaches. Currently a 58" x 36" concrete arch pipe runs under Mershon Avenue. Adding a conceptual second pipe under the road was analyzed. Adding the second pipe will reduce stages, but will increase discharges at the outlet of the pipes. An analysis was performed to see if the conceptual pond at Middle St and Mershon Av could offset the increases in discharge. Table 4 indicates the routed discharges at each drainage structure for the existing conditions, with the conceptual pond added, and with the conceptual pond and additional pipe added. Figures 14-17 indicate the water surface elevation profile differences upstream of Mershon Ave based on the existing conditions and the addition of the extra pipe under Mershon Ave. Figure 18 indicates the water surface elevation differences plotted on a contour map.

**Table 4. Recurrence Intervals and routed discharges for existing, w/ pond, and w/ pond and pipe**

| Location | Q2 (cfs) | | | Q10 (cfs) | | | Q25 (cfs) | | | Q100 (cfs) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ex | w Pond | w Pond w Pipe | Ex | w Pond | w Pond w Pipe | Ex | w Pond | w Pond w Pipe | Ex | w Pond | w Pond w Pipe |
| Low Area 1 | 14 | 14 | 13 | 25 | 25 | 24 | 52 | 52 | 50 | 121 | 121 | 119 |
| Low Area 2 | 73 | 73 | 82 | 106 | 106 | 129 | 191 | 191 | 184 | 333 | 333 | 329 |
| | | | | | | | | | | | | |
| Nichols Av | 146 | 146 | 146 | 218 | 218 | 218 | 301 | 301 | 301 | 403 | 403 | 403 |
| Dogwood Av | 158 | 156 | 157 | 243 | 243 | 243 | 388 | 388 | 388 | 569 | 569 | 569 |
| Middle St | 207 | 175 | 178 | 326 | 319 | 312 | 503 | 503 | 502 | 720 | 720 | 733 |
| Fairland Av | 223 | 196 | 198 | 304 | 289 | 292 | 433 | 427 | 424 | 716 | 700 | 725 |

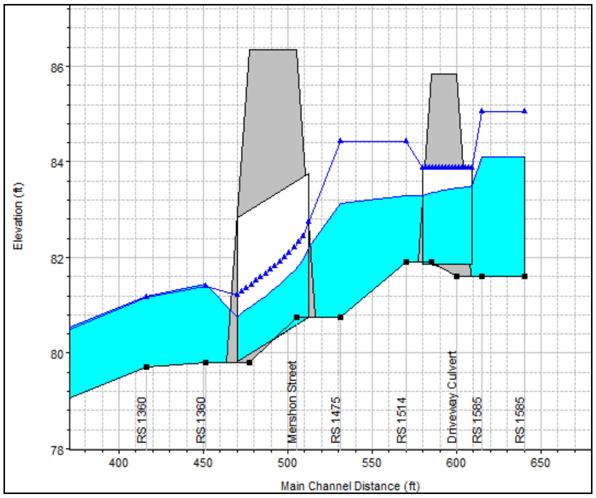



**Figure 14. Profile plot of the 2yr water surface elevation difference for existing conditions and addition of new pipe under Mershon Ave**

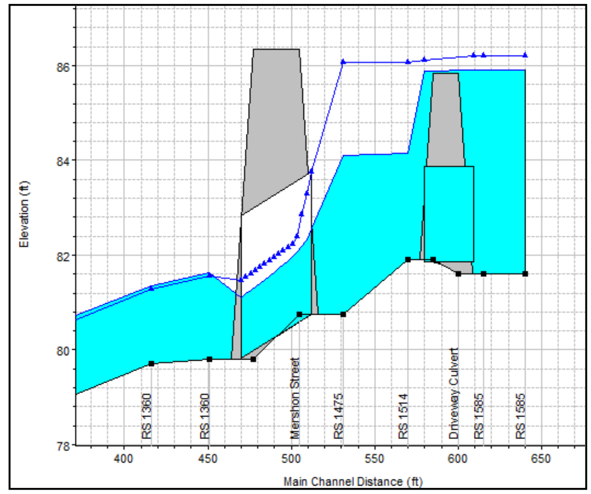



**Figure 15. Profile plot of the 10yr water surface elevation difference for existing conditions and addition of new pipe under Mershon Ave**

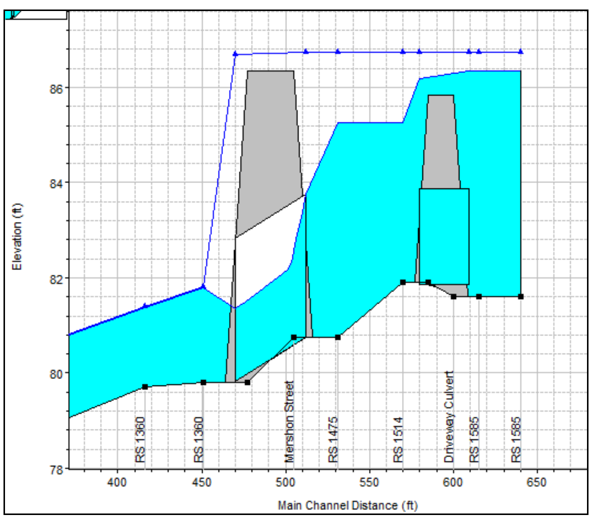



**Figure 16. Profile plot of the 25yr water surface elevation difference for existing conditions and addition of new pipe under Mershon Ave**

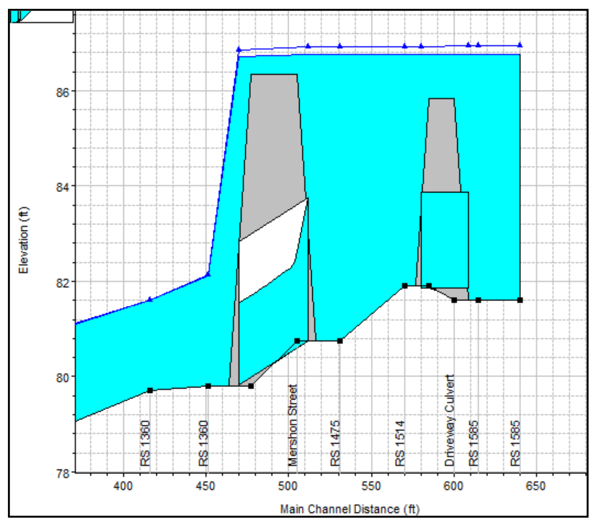



**Figure 17. Profile plot of the 100yr water surface elevation difference for existing conditions and addition of new pipe under Mershon Ave**

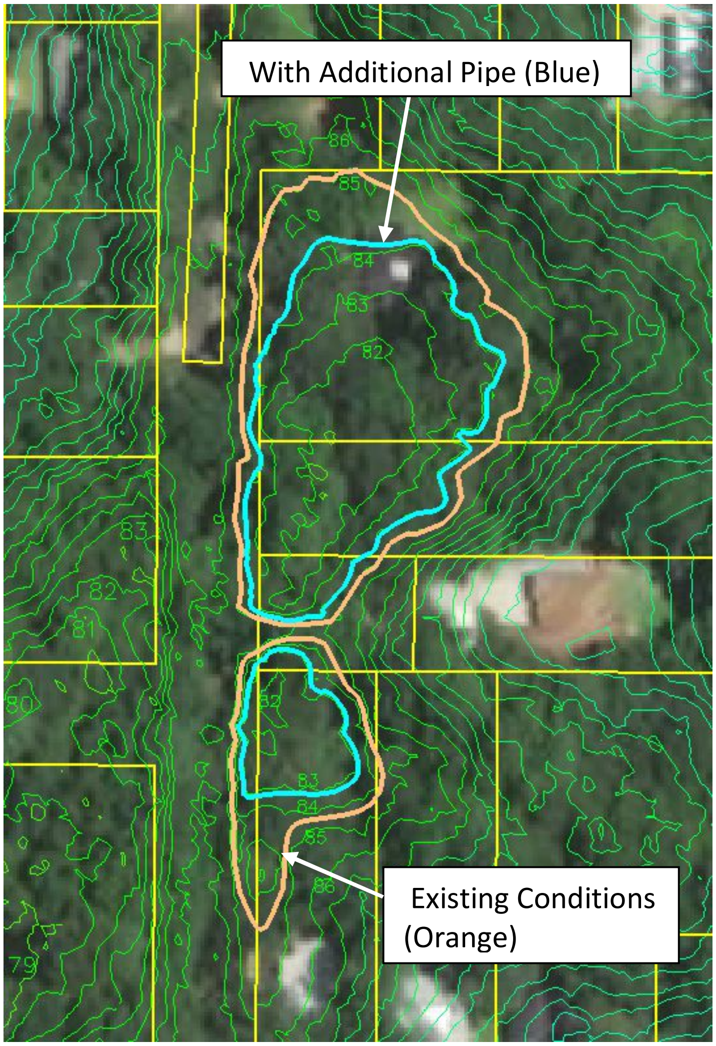
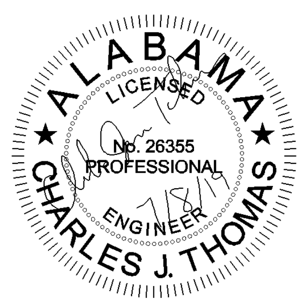



**Figure 18. Water surface elevations for existing conditions and with additional pipe added for the 2yr event**




07 / 08 / 2019
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Date

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Charles J Thomas, P.E.
Senior Engineer