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Memo

To: City of Columbia

From: Steve Godfrey, PE, CFM

Date: July 26, 2021

Subject: Shandon Phase II Downstream Evaluation

SOUTH CAROLINA REGISTERED PROFESSIONAL ENGINEER No. 19415 STEVEN B. GODFREY 7/26/21

SOUTH CAROLINA WOOLPERT, INC. No. C02990 CERTIFICATE OF AUTHORIZATION

Background

Woolpert has been asked by the City to review the current XP-SWMM model for the Shandon Phase II improvements provided by Cox & Dinkins, Inc. on 03/08/2021 and expand the model downstream to evaluate if the proposed improvements will have any adverse impacts to downstream locations. This memo will summarize the updates made to the XP-SWMM model and results of the extended analysis.

FEMA

The Shandon Rosewood drainage systems discharge into a tributary to Gills Creek. This stream is a regulated FEMA stream starting at the outfall of the western pipe system (FEMA Lettered Cross-section H) and extends down to Gills Creek. A FEMA FIRMette of the stream is shown in Figure 1 and the FEMA FIS profiles for the stream are shown in Figure 2 and Figure 3. Woolpert obtained the FEMA supporting hydraulic data for Gills Creek Tributary 1A to be used with this downstream evaluation. The FEMA supporting hydraulic data consisted of a HEC-RAS model as shown in Figure 4 and the model's water surface elevation profiles are shown in Figure 5. The HEC-RAS model only changes flow at 3 locations within the study area, however, discharges at key cross-sections are provided in Table 1 and will be used as comparison values for the downstream evaluation. It is important to note, that a LOMR was approved for this Tributary that drastically reduced the floodplains along this stream.

Shandon XP-SWMM Model

The current Shandon Rosewood XP-SWMM model includes 2 primary pipe systems (East and West) including the channel sections downstream to Edmond Drive. FEMA data from lettered cross sections G and F were used to create pseudo stage hydrographs with the peak water surface elevations occurring between hours 12 and 13 of the simulation. This data was applied as 2D Head Boundaries to adjust the water surface elevations within the 2D channel so the backwater would be similar to the FEMA effective water surface elevations. The current model's downstream boundary setup is shown in Figure 6. The proposed Phase II improvements for the eastern system will pipe the current channel down to the confluence with the channel outfalling the western system. The XP-SWMM model uses an additional DEM dataset to revise the elevation data used by the 2D model in this area once the channel is piped. The 2D zone uses a 12 ft grid cell size and was assigned a roughness value of 0.05 for all overland flow areas and a roughness value of 0.035 for the channel sections downstream of the pipe systems.

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Model Updates

Woolpert used the FEMA HEC-RAS data to extend the Shandon XP-SWMM model down to Gills Creek. The HEC-RAS model included the stream crossings for the Edmond Road bridge, the footbridge near Nephi Street, the Plowden Road bridge, the CSX Railroad culverts and the South Beltline Boulevard culverts. A 1D/2D model network was used down to the CSX Railroad crossing. The HEC-RAS cross sections in this area were truncated to represent only the channel portion of each cross-section, allowing the overbanks to be modeled within the 2D network. The 1D channels were allowed to interact with the 2D grid via a 1D/2D interface along the channel banks. The 2D grid was refined to use a 6 ft grid cell size around the primary channel and both pipe system outfalls for increased model detail. The updated XP-SWMM's downstream section is shown in Figure 7 and a summary of how the 1D/2D model was setup is shown in Figure 8. A 1D network was used for the areas downstream of CSX to Gills Creek that represented the primary stream and bypass system.

With the model being extended down to Gills Creek, approximately 322 additional acres of drainage area also needed to be accounted for. This area was delineated into three new subbasins based on key stream crossings along the Tributary. To calculate Curve Numbers for the new subbasins, the National Land Cover Dataset was used to define the landuse along with a Lookup table for the various landuse categories and hydrologic soil groups. Figure 9 through Figure 11 show this data. Flow paths were defined for each new subbasin using TR-55 methodology to develop approximate Time of Concentrations for these large-scale subbasins. Summary of hydrologic parameters for each of the new subbasins are provided in Table 2, while the Curve Number (CN) lookup table is provided in Table 3 for reference. While the hydrologic source data and methodology for CN development in the provided Existing Conditions and Improved Conditions model was not provided, a composite weighted curve number was computed for the entire drainage area using the NLCD to verify that the original hydrology and this expanded model's hydrology are generally consistent. This composite CN value was found to be within reason of the CN values provided in the original study, so the hydrologic procedures used in this model update are considered reasonably compatible with the original study's CN values.

For the updated model, two additional changes were made to the basic model setup in defining the underlining DEM data. These included the use of an Elevation Shape polygon to fill the portion of the channel required by the eastern pipe system extension instead of using 2 DEM data sources. Building footprint polygons were also used to raise the DEM by 4 feet to represent the blockage the building's foundation would have on the overland flow paths. By including the buildings within the DEM, the overland flow was attenuated more in the 100-year event as the water had narrower paths to flow and as water would pond at slightly higher depth in certain locations.

Results

Figure 12 through Figure 16 compare the 100-year event hydrographs from the Existing Conditions model to the proposed Improved Conditions downstream of the study area. The HEC-RAS peak flows for the 10-, 50-, and 100-year storm events at each location are also shown for reference. As shown in Table 1, the HEC-RAS model assigns flow changes at fewer locations than the XP-SWMM model, so the HEC-RAS flows for multiple cross-sections are identical whereas the XP-SWMM model adds additional hydrology along the Tributary. This updated hydrology results in 100-year peak flows in the XP-SWMM model at cross-section G being closer to the 10-year FEMA peak flows (Figure 12) due to its upstream location. 100-year peak flows in the XP-SWMM model at cross-section D are upstream of the next HEC-RAS flow change location, so its peak flows are more in alignment with the FEMA 100-year peak flow (Figure 15). Overall, the XP-SWMM model shows that the proposed improvements from this study do not increase peak flows in the downstream system.

Figure 17 through Figure 21 compare the 100-year event water surface elevation plots from the Existing Conditions model to the proposed Improved Conditions simulated in the XP-SWMM model downstream of the study area. The HEC-RAS 100-year base flood elevation is shown at each location for reference. The XP-SWMM model shows that the proposed improvements from this study do not increase peak water levels in the downstream system.

Figure 22 through Figure 24 show 1D/2D modeled flooding extents in plan view. They show the Existing Conditions, Improved Conditions, and FEMA-defined flooding extents. The one location where Improved Conditions peak water levels are higher is shown in the 2D flooding map Figure 25 and is the location where the eastern system channel is filled in and piped. In Existing Conditions, the water surfaces are not consistent across the floodplain, where the proposed Improved Conditions does have a more consistent water surface across the floodplain but it does make the water levels higher in the area of the filled channel. The design condition for this pipe system extension under the filled channel is less than the 100-year storm event, so there is still overtopping during the 100-year storm event because the pipe system cannot carry that volume of water. Any overland flow in this original channel section will have a higher water surface elevation simply because the filled ground elevation is higher than the existing channel invert elevation. See Figure 26 for a comparison of computed water levels at specific locations around this filled channel section.

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Table 1: HEC-RAS Model Discharges at Key Locations

FEMA Letter	HEC-RAS River Station	HEC-RAS Q 10-Year	HEC-RAS Q 50-Year	HEC-RAS Q 100-Year	HEC-RAS Q 500-Year
H	8,067	6,68	962	1,092	1,359
East & West Confluence	7,547	1,496	2,065	2,310	2,777
G	7,203	1,496	2,065	2,310	2,777
F	6,447	1,496	2,065	2,310	2,777
E	5,805	1,496	2,065	2,310	2,777
D	4,829	1,496	2,065	2,310	2,777
C	4,295	1,823	2,502	2,794	3,349
B	1,926	1,823	2,502	2,794	3,349

Table 2: Hydrologic Parameters for New Downstream Subbasins

Subbasin	Area (Acres)	CN	Time of Concentration (Mins)
J_6447	104	77.1	30
J_4829	178	75.2	30
J_4295	140	75.8	60

Table 3: Curve Number Lookup Table Used to Derive New Subbasin Parameters From National Land Cover Dataset

NLCD	HSG_A	HSG_B	HSG_C	HSG_D	HSG_AD	HSG_BD	HSG_CD	HSG_U	HSG_W
Open Water	100	100	100	100	100	100	100	100	100
Developed – Open Space	45	65	76	82	64	74	79	76	100
Developed – Low Intensity	63	76	84	87	75	82	86	84	100
Developed - Medium Intensity	80	87	91	93	87	90	92	91	100
Developed - High Intensity	92	94	96	96	94	95	96	96	100
Barren Land	39	61	74	80	60	71	77	74	100
Deciduous Forest	36	60	73	79	58	70	76	73	100
Evergreen Forest	36	60	73	79	58	70	76	73	100
Mixed Forest	36	60	73	79	58	70	76	73	100
Shrub/Scrub	39	61	74	80	60	71	77	74	100
Herbaceuous	30	58	71	78	54	68	75	71	100
Hay/Pasture	49	69	79	84	67	77	82	79	100
Cultivated Crops	67	78	85	89	78	84	87	85	100
Woody Wetlands	75	80	85	90	83	85	88	85	100
Emergent Herbaceuous Wetlands	80	85	90	95	88	90	93	90	100

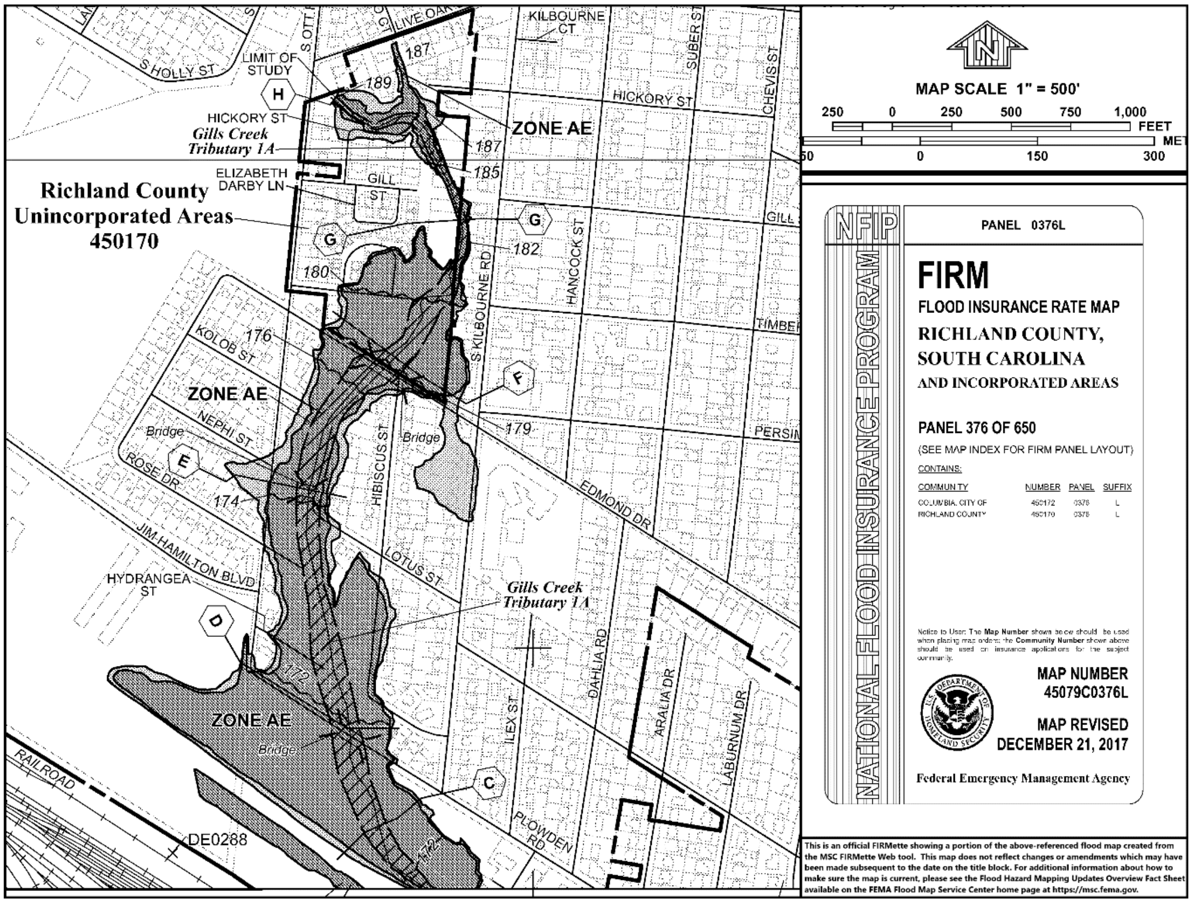

Figure 1: FEMA (FIRMette) for Gills Creek Tributary 1A

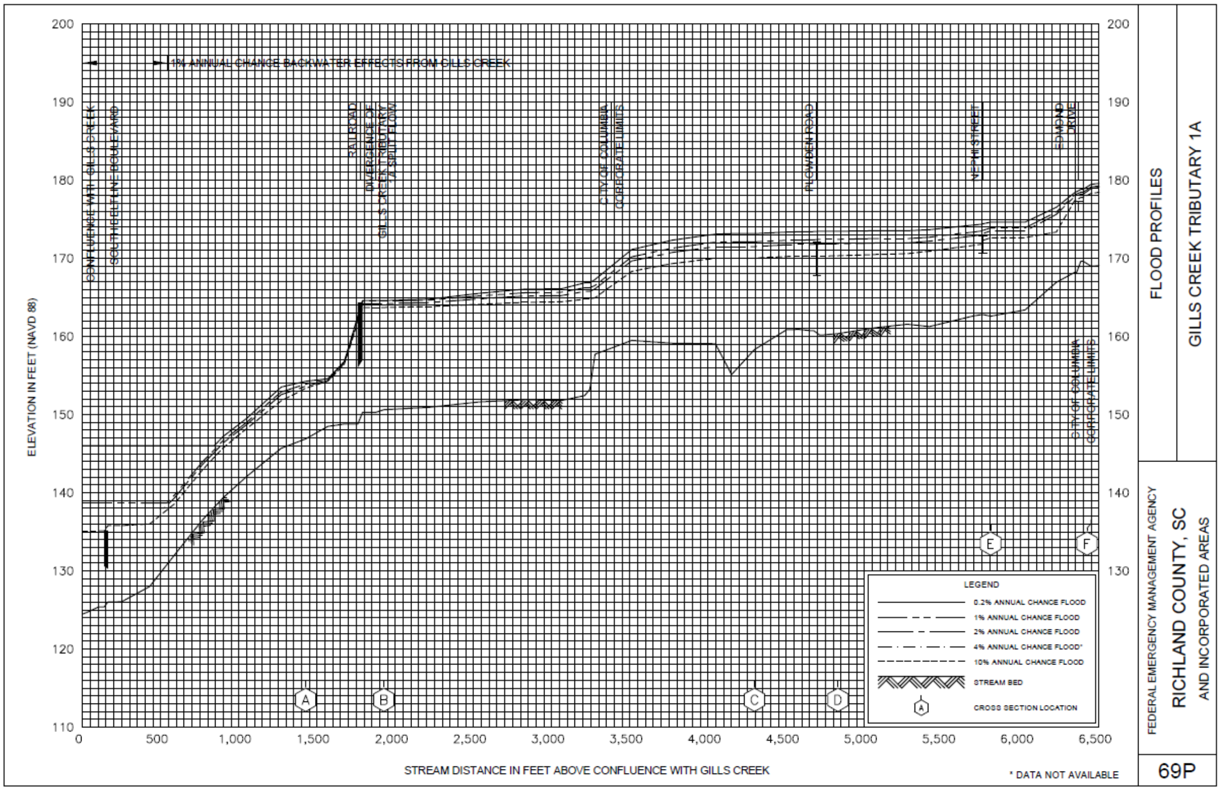

Figure 2: Gills Creek Tributary 1A FIS Profile (69P)

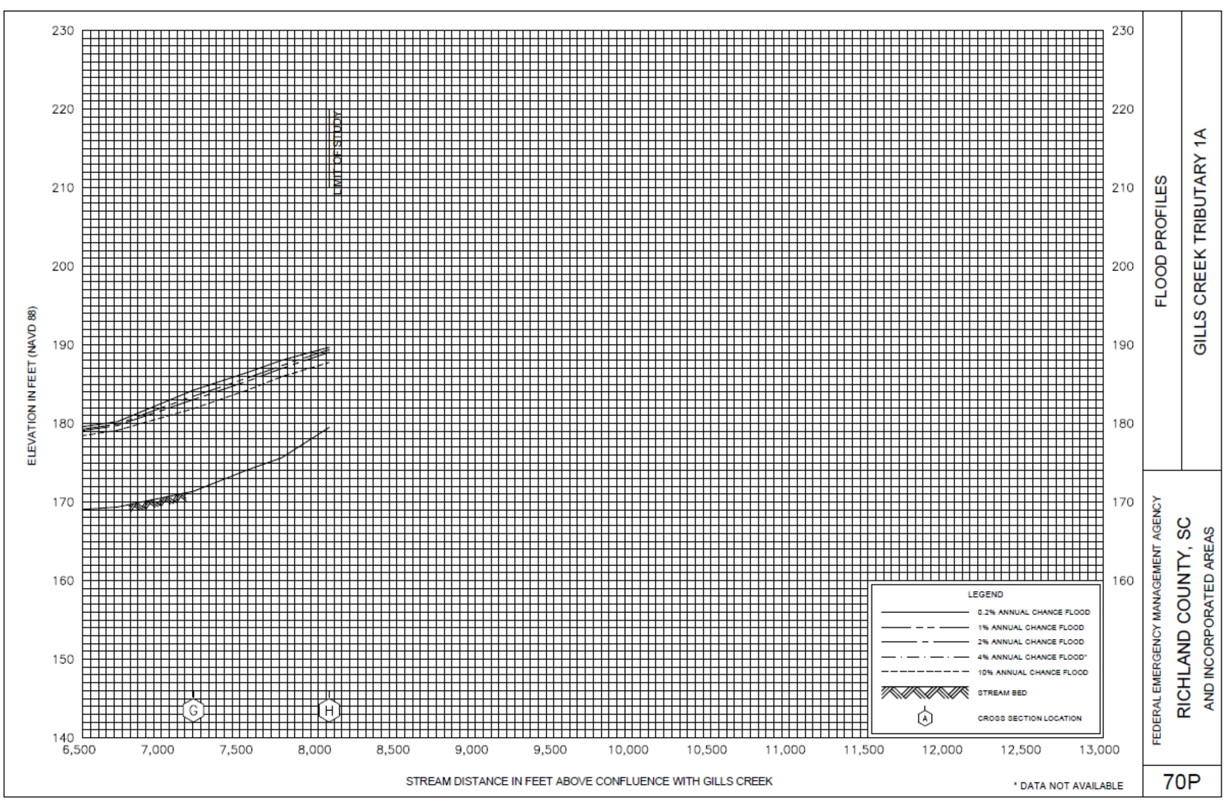

Figure 3: Gills Creek Tributary 1A FIS Profile (70P)


H
G
F
E
D
C
B
Hickory St
Gill St
Valencia Heights
Timberlane Dr
Persimmon St
Edmond Dr
Lantana Dr
Plowden Rd
Boxwood Dr
Loquat Ct
Loquat Dr
S Beltline Blvd
Norfolk Southern
CSX Transportation
Manuey Ct
Legend
FEMA Letter
FEMA XSEC
FEMA 100yr

Figure 4: FEMA Gills Creek Tributary 1A Supporting HEC-RAS Data

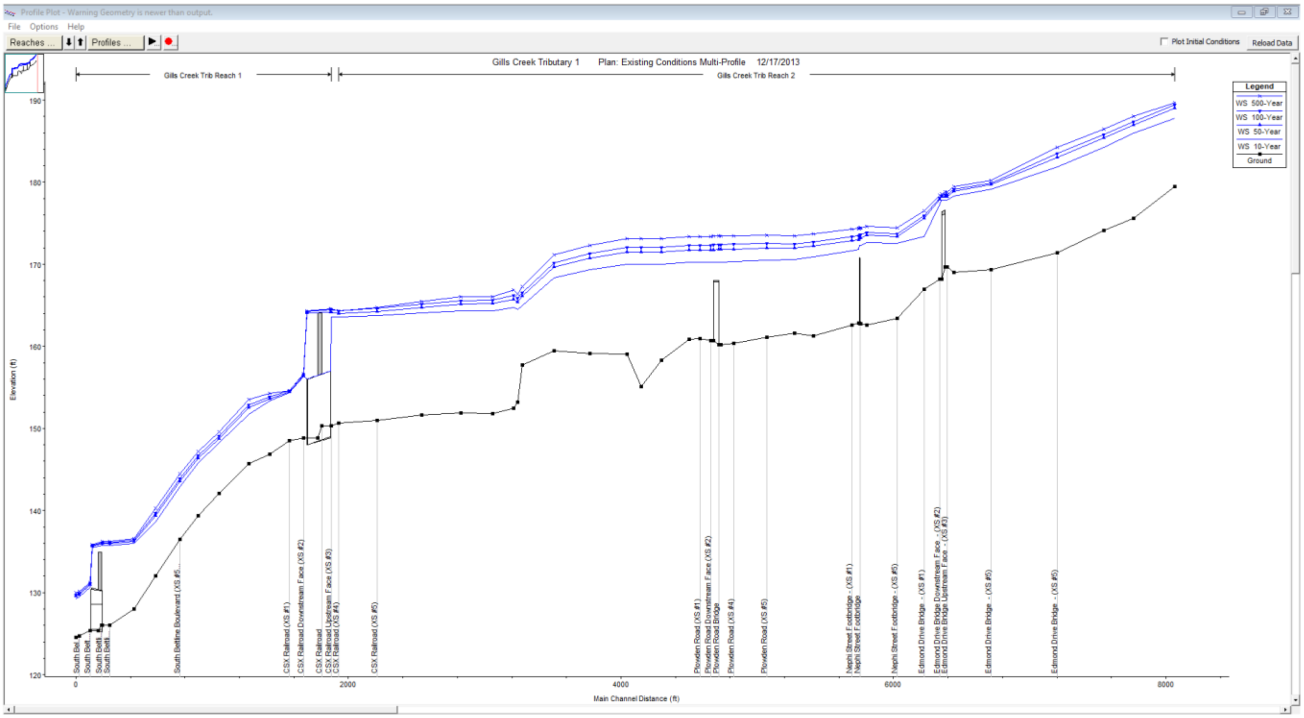

Figure 5: Gills Creek Tributary 1A HEC-RAS Model Profile

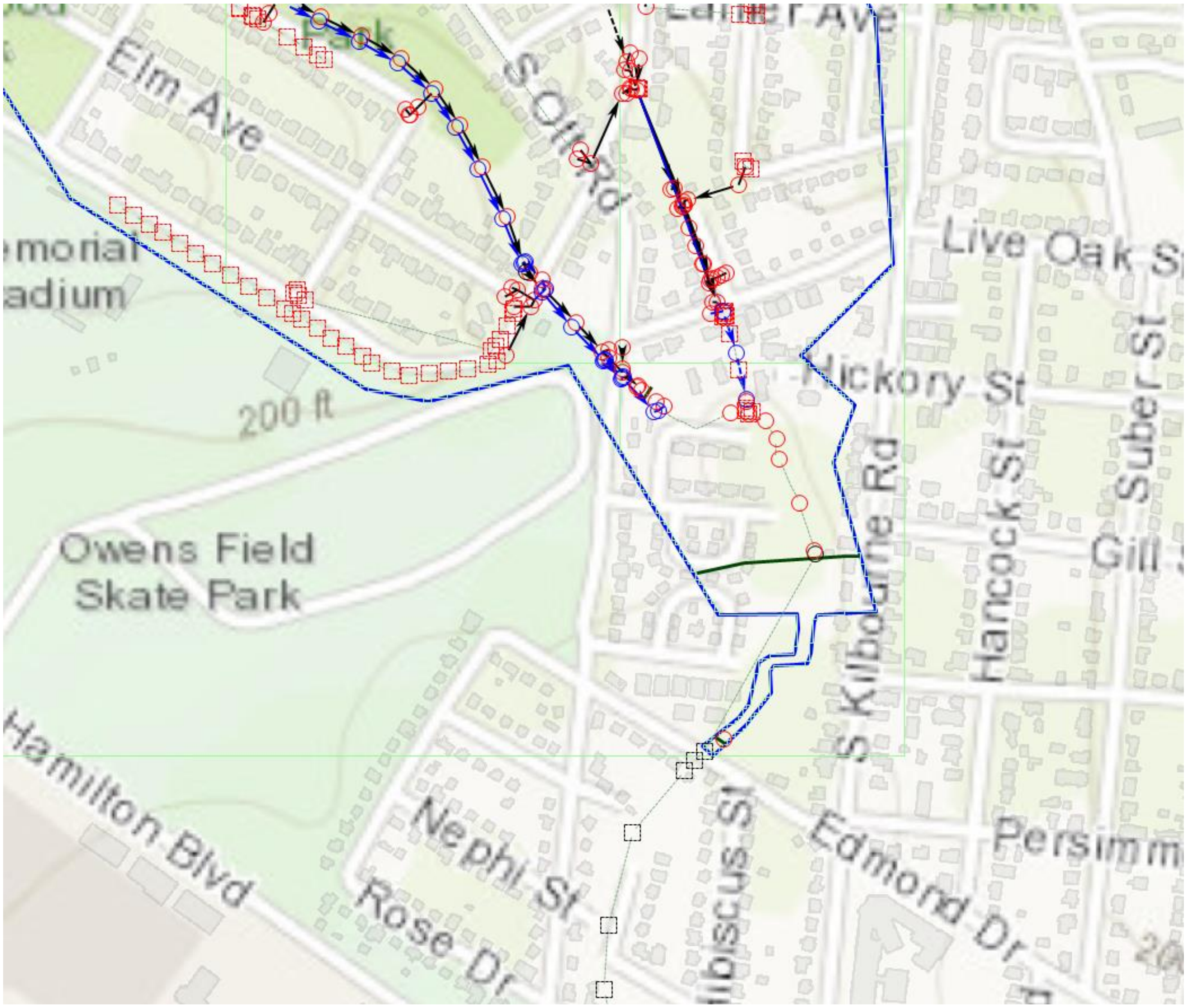

Figure 6: Provided XP-SWMM Model for Shandon Phase II Downstream Boundary (Existing Conditions)

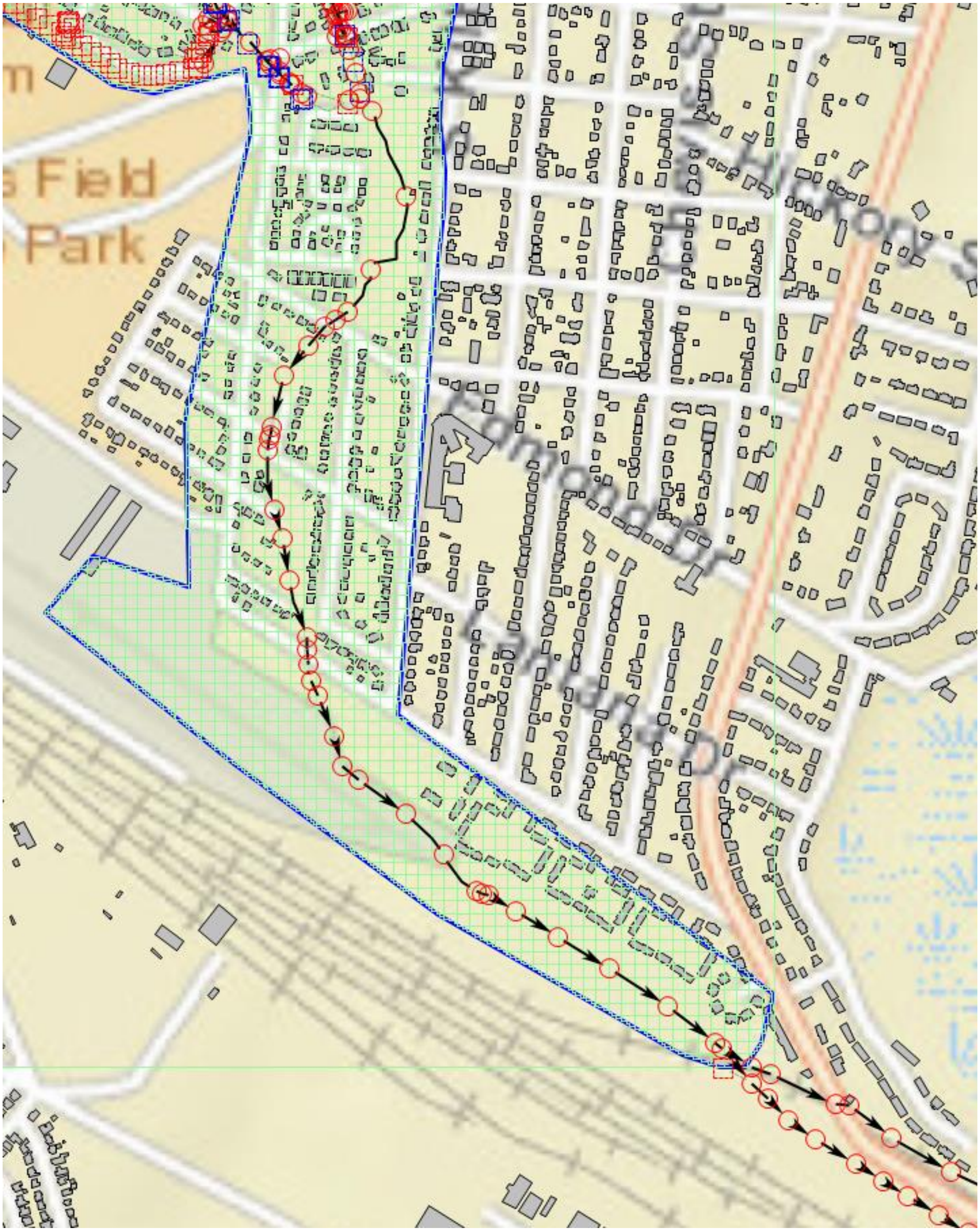

Figure 7: Updated XP-SWMM Model with FEMA Downstream Data

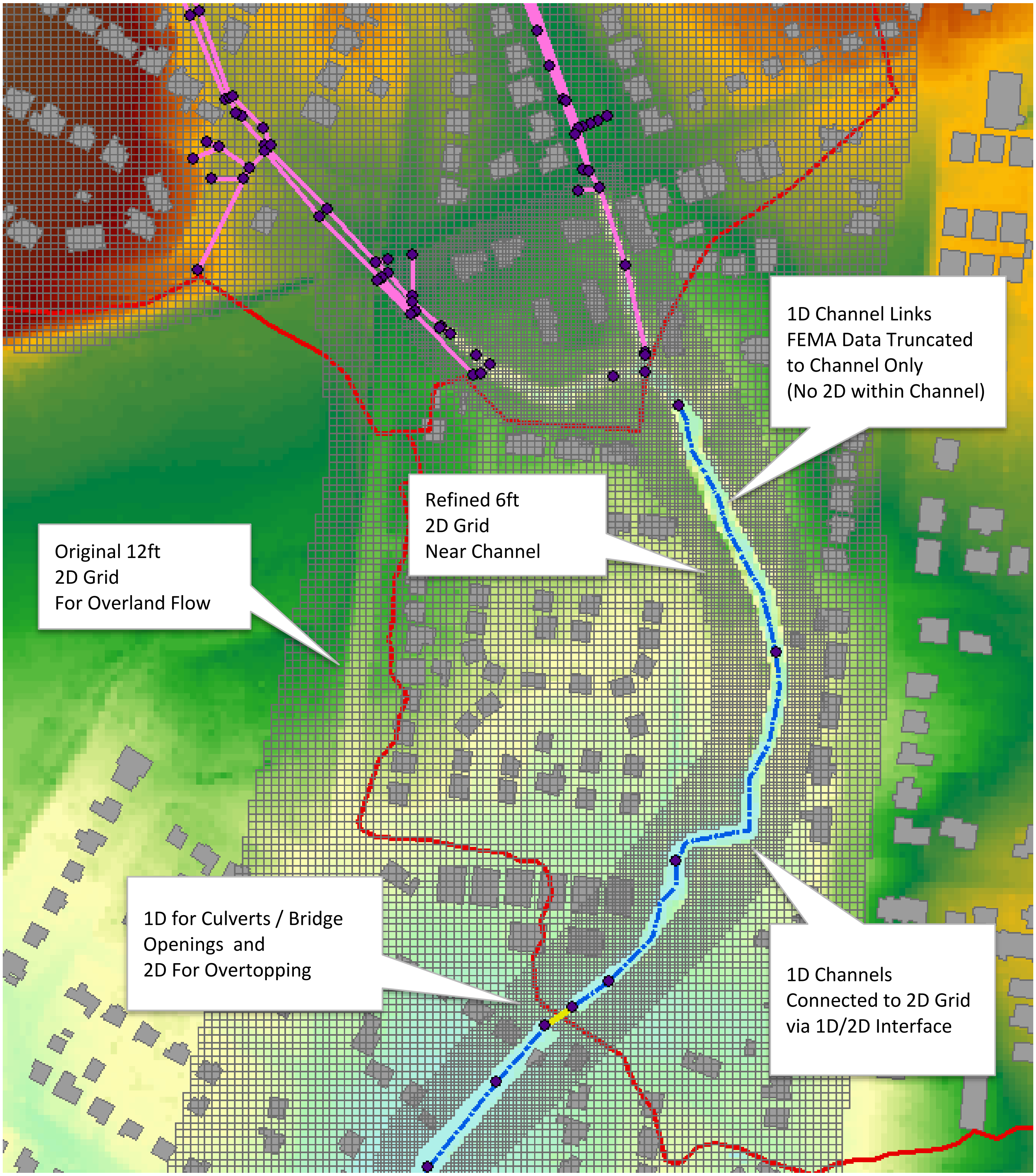

Figure 8: Updated XP-SWMM Model Downstream General 1D/2D Setup

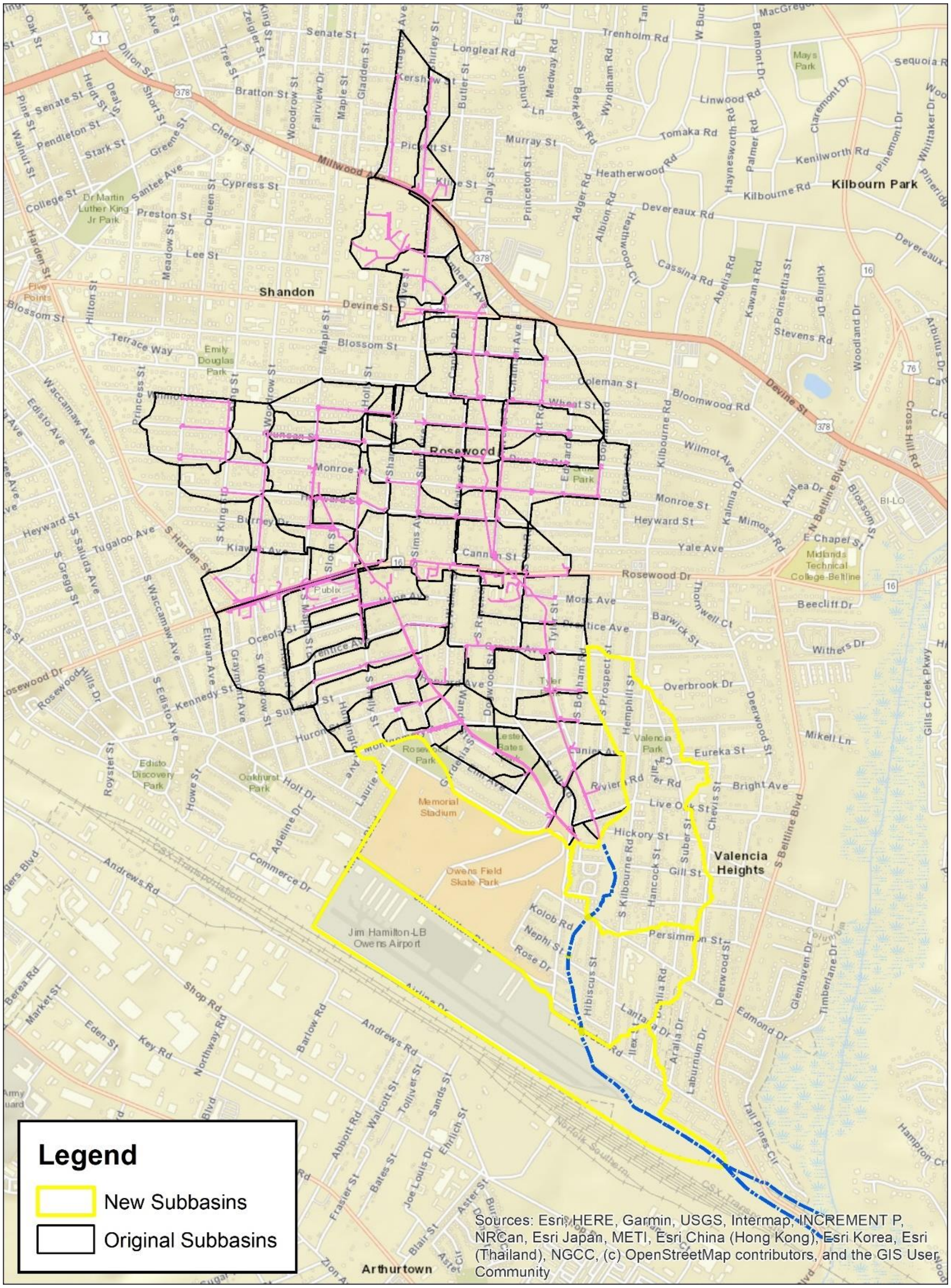

Figure 9: Location of New Subbasins

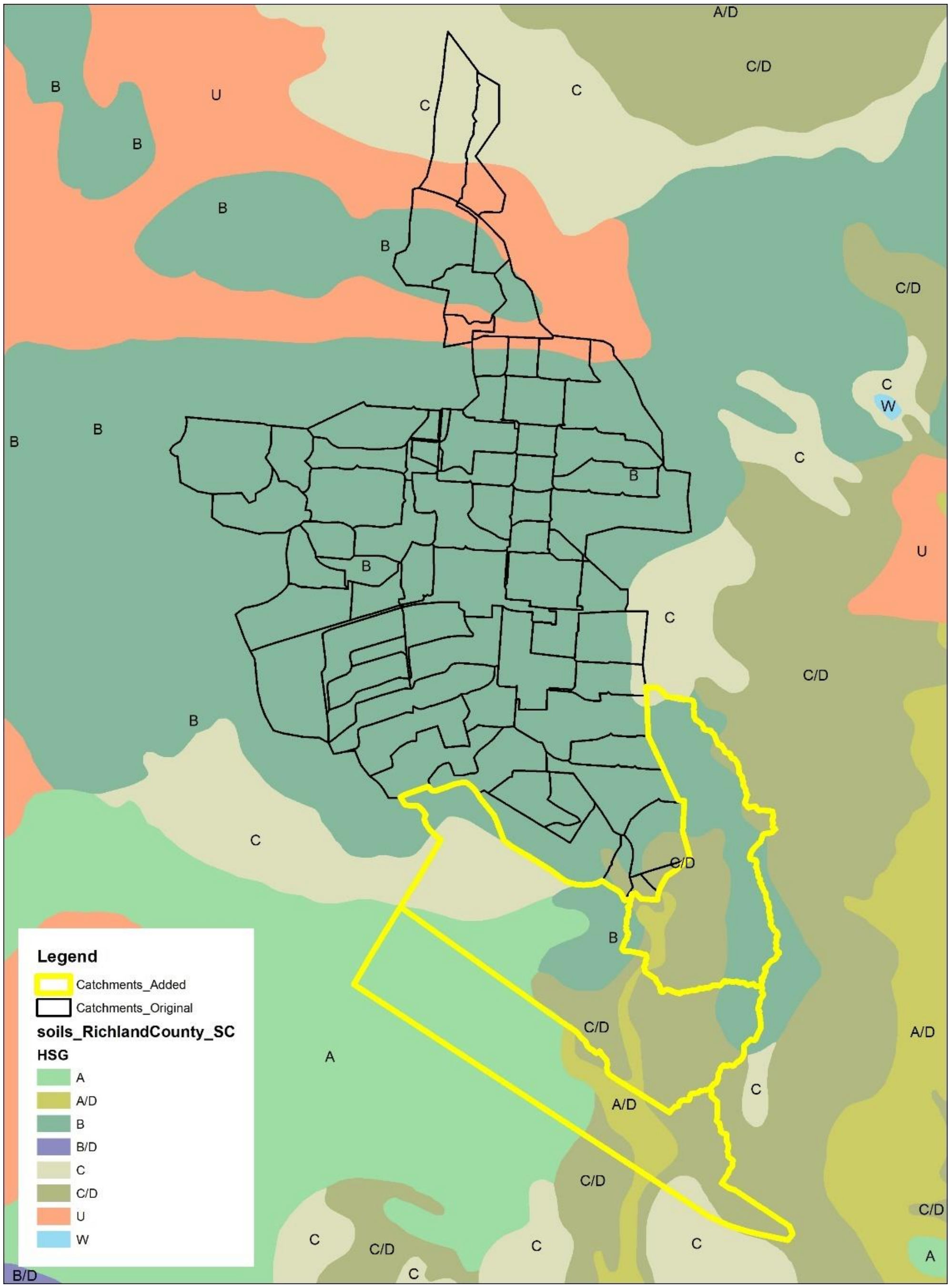

Figure 10: New Subbasin Boundaries with Hydrologic Soil Groups

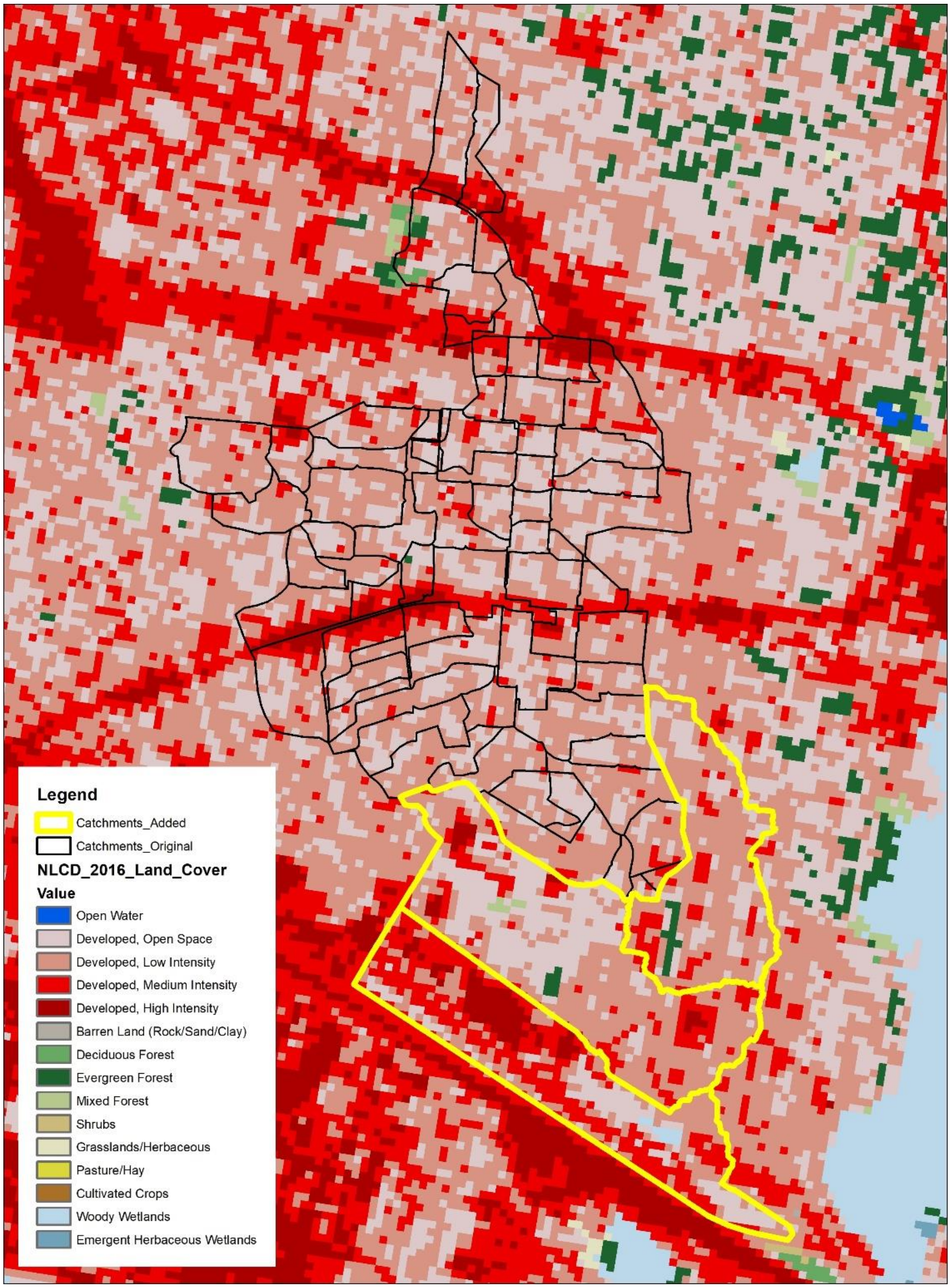

Figure 11: New Subbasin Boundaries with National Land Cover Dataset

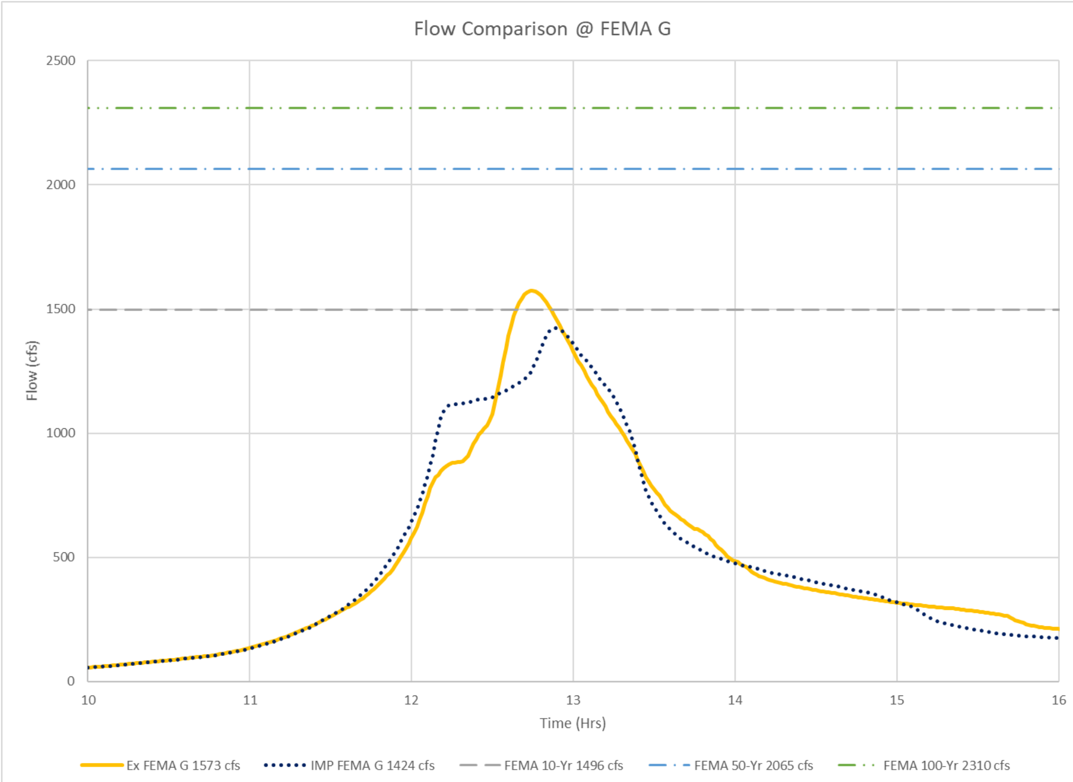

Figure 12: XP-SWMM Flow Hydrograghs Compared to FEMA Steady State Flows @ FEMA G

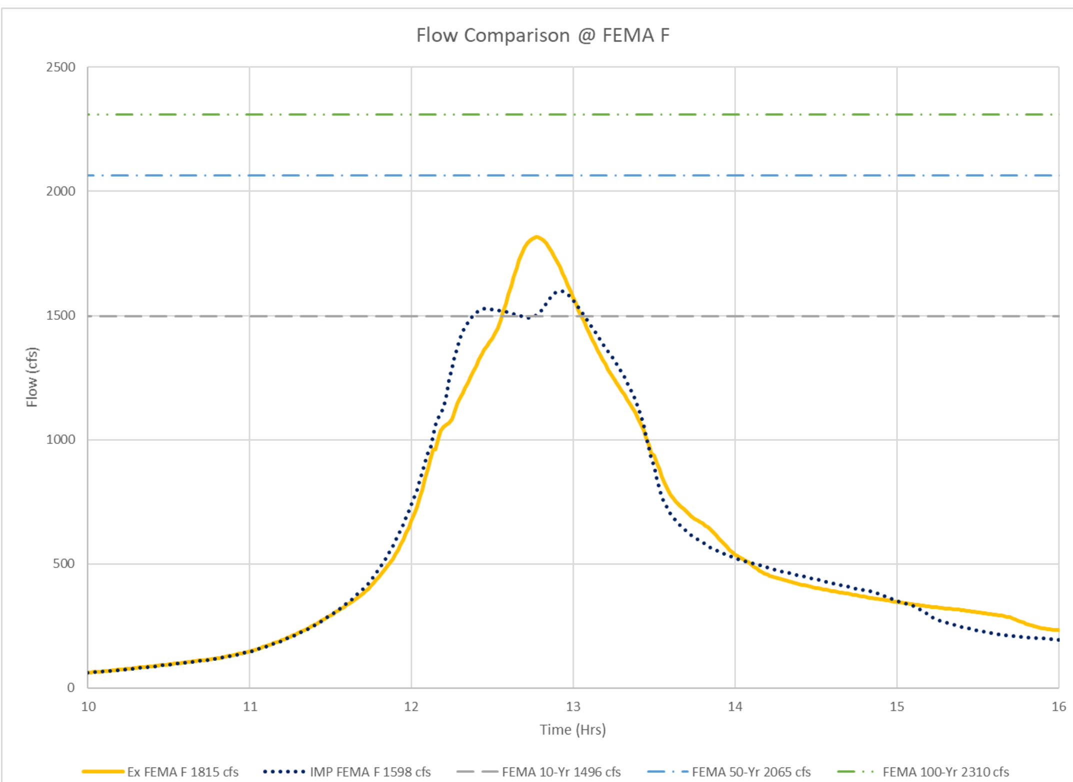

Figure 13: XP-SWMM Flow Hydrogragh Compared to FEMA Steady State Flows @ FEMA F

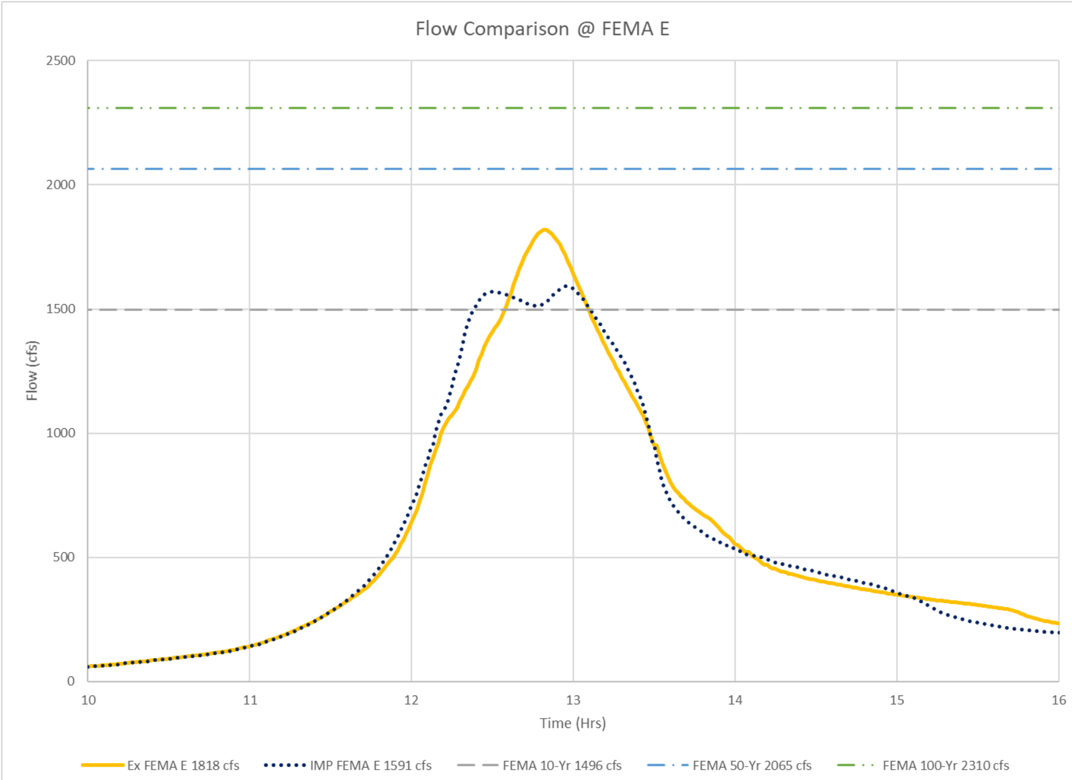

Figure 14: XP-SWMM Flow Hydrogragh Compared to FEMA Steady State Flows @ FEMA E

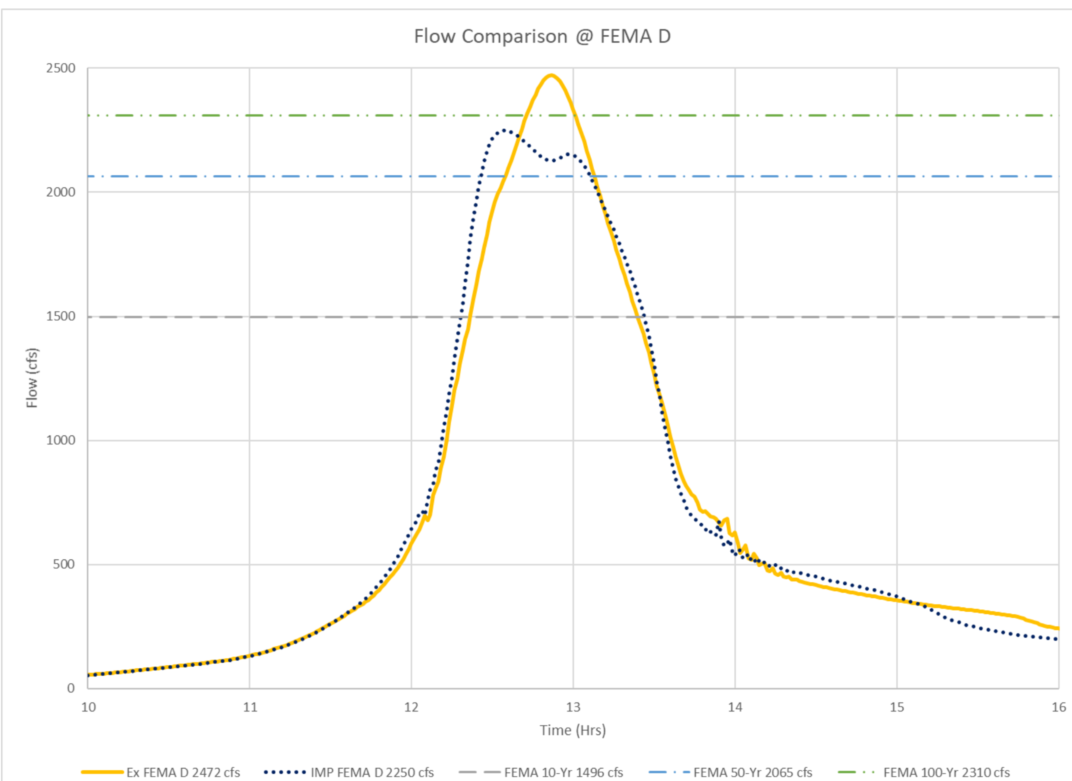

Figure 15: XP-SWMM Flow Hydrogragh Compared to FEMA Steady State Flows @ FEMA D

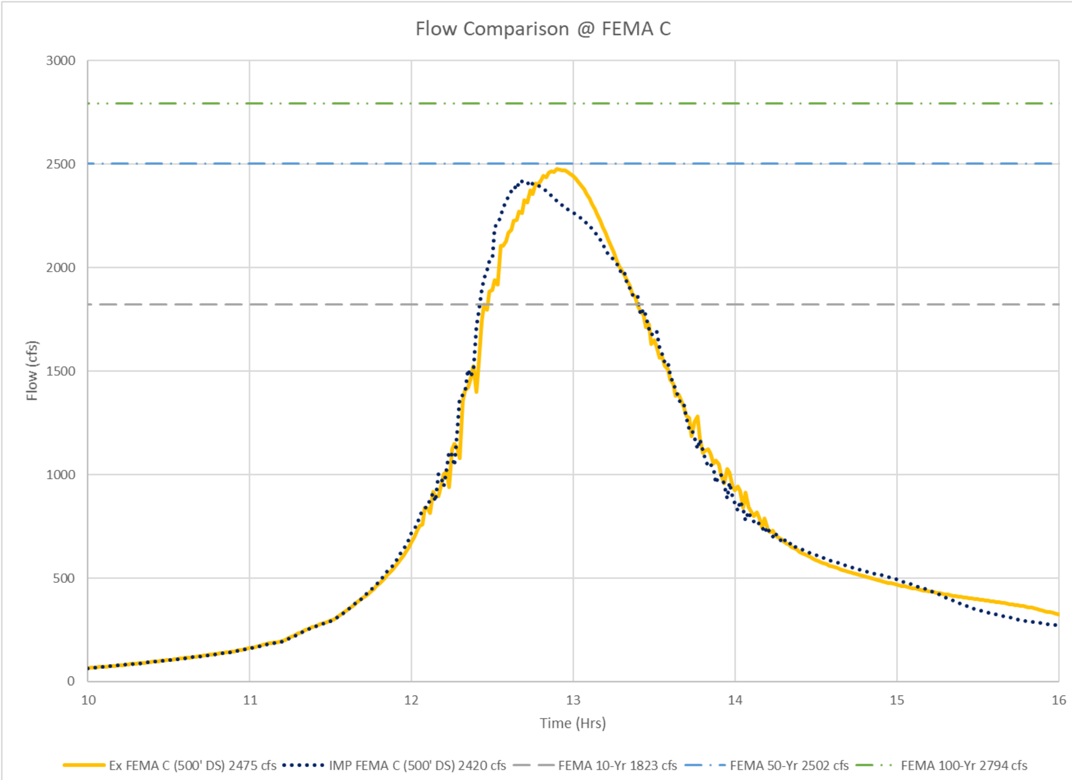

Figure 16: XP-SWMM Flow Hydrogragh Compared to FEMA Steady State Flows @ FEMA C

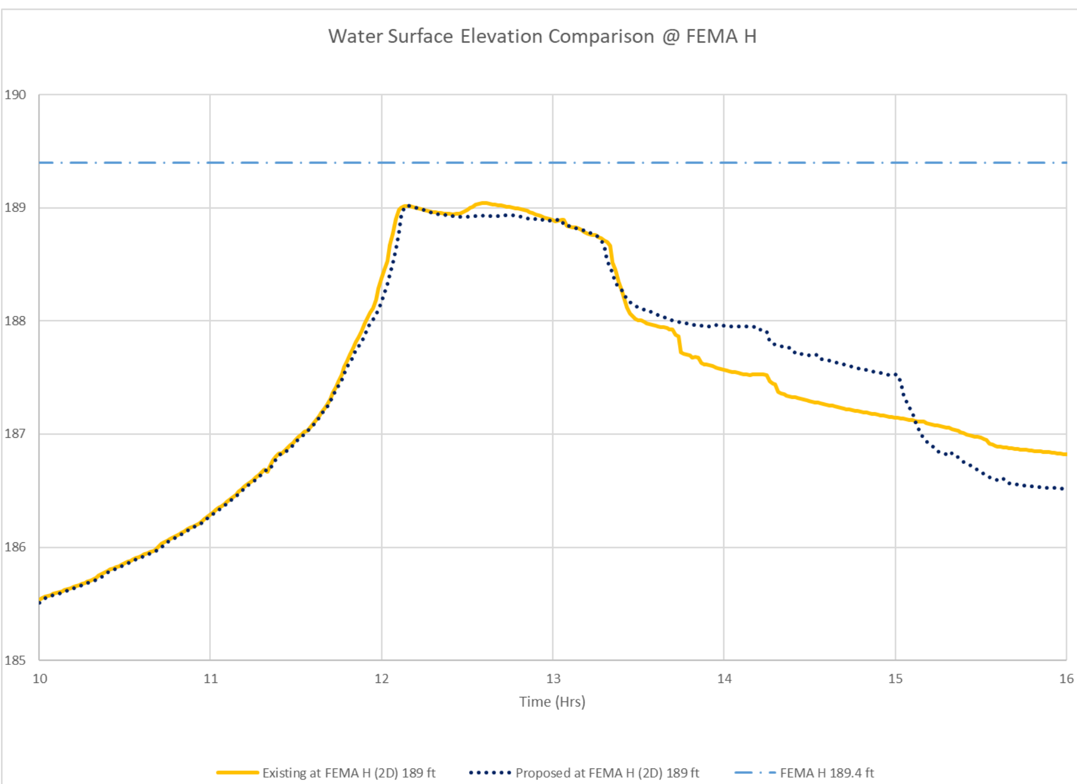

Figure 17: XP-SWMM Water Surface Elevation Hydrograph Compared to FEMA Steady State HEC-RAS Elevation @ FEMA H

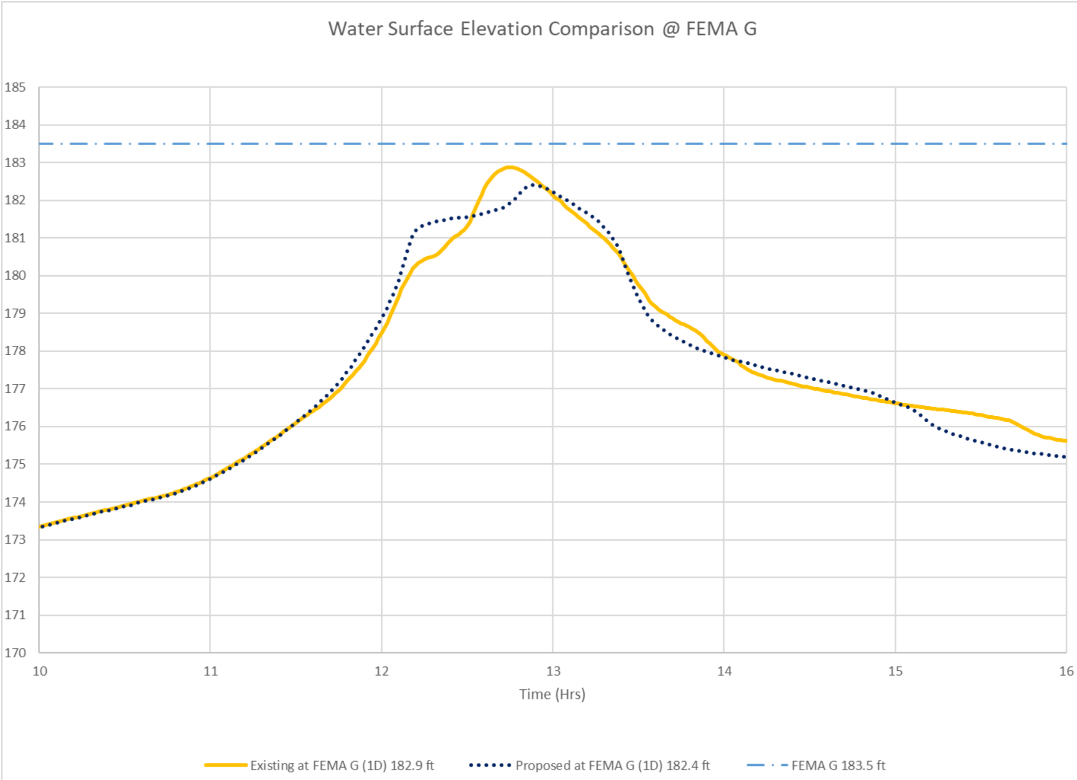

Figure 18: XP-SWMM Water Surface Elevation Hydrograph Compared to FEMA Steady State HEC-RAS Elevation @ FEMA G

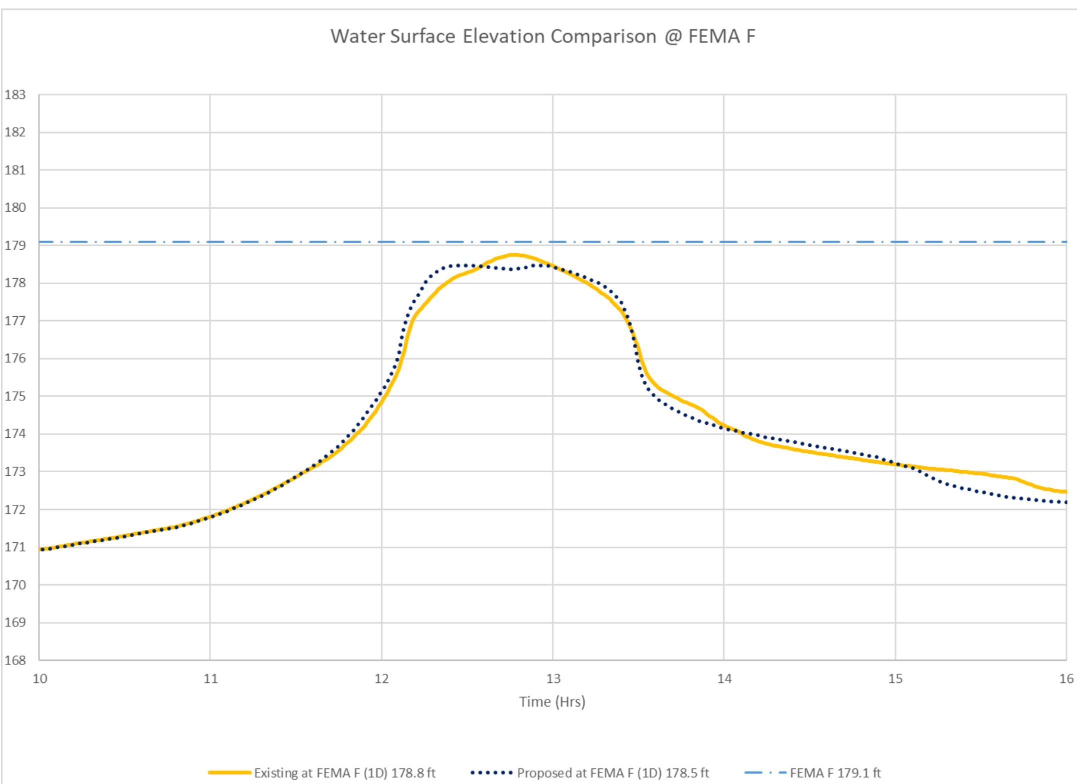

Figure 19: XP-SWMM Water Surface Elevation Hydrograph Compared to FEMA Steady State HEC-RAS Elevation @ FEMA F

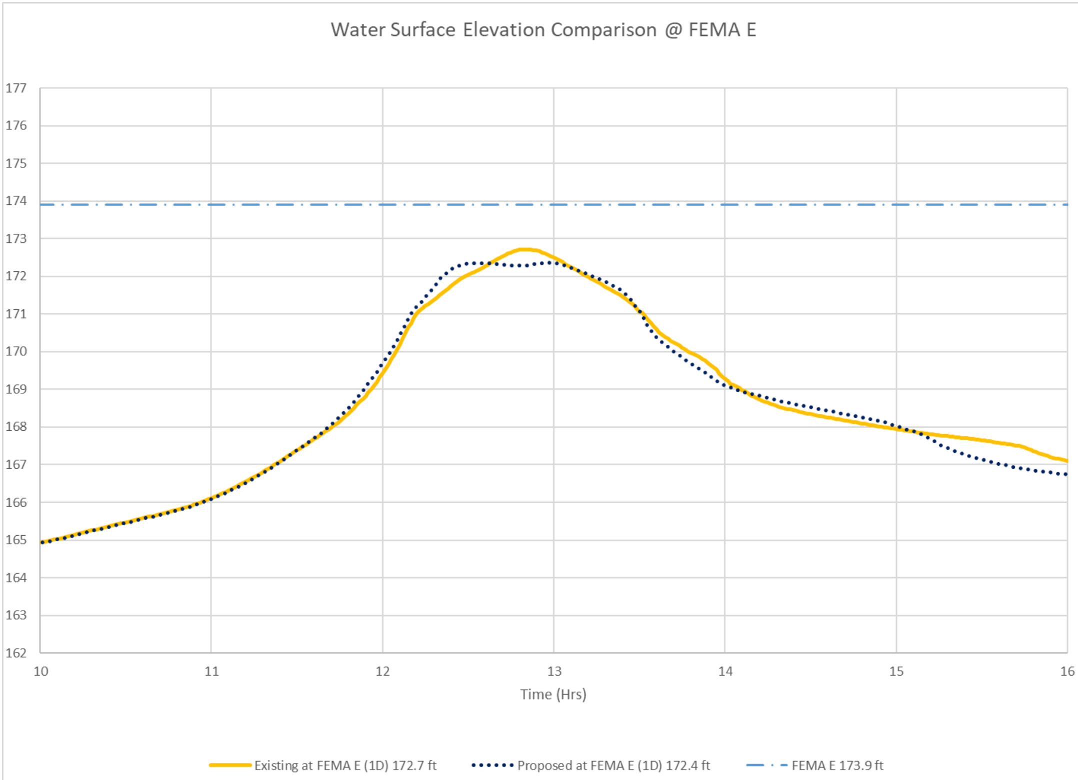

Figure 20: XP-SWMM Water Surface Elevation Hydrograph Compared to FEMA Steady State HEC-RAS Elevation @ FEMA E

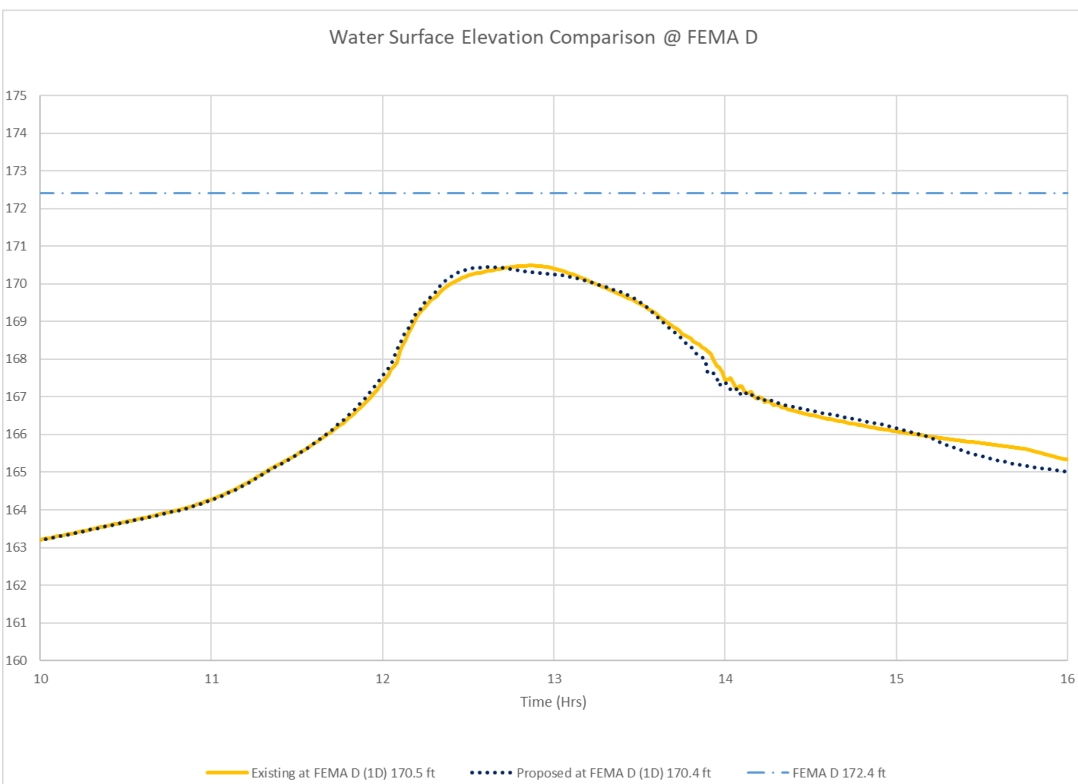

Figure 21: XP-SWMM Water Surface Elevation Hydrograph Compared to FEMA Steady State HEC-RAS Elevation @ FEMA D

Figure 22: Comparison of FEMA 100-yr Floodplain and the Existing 1D/2D XP-SWMM Floodplain

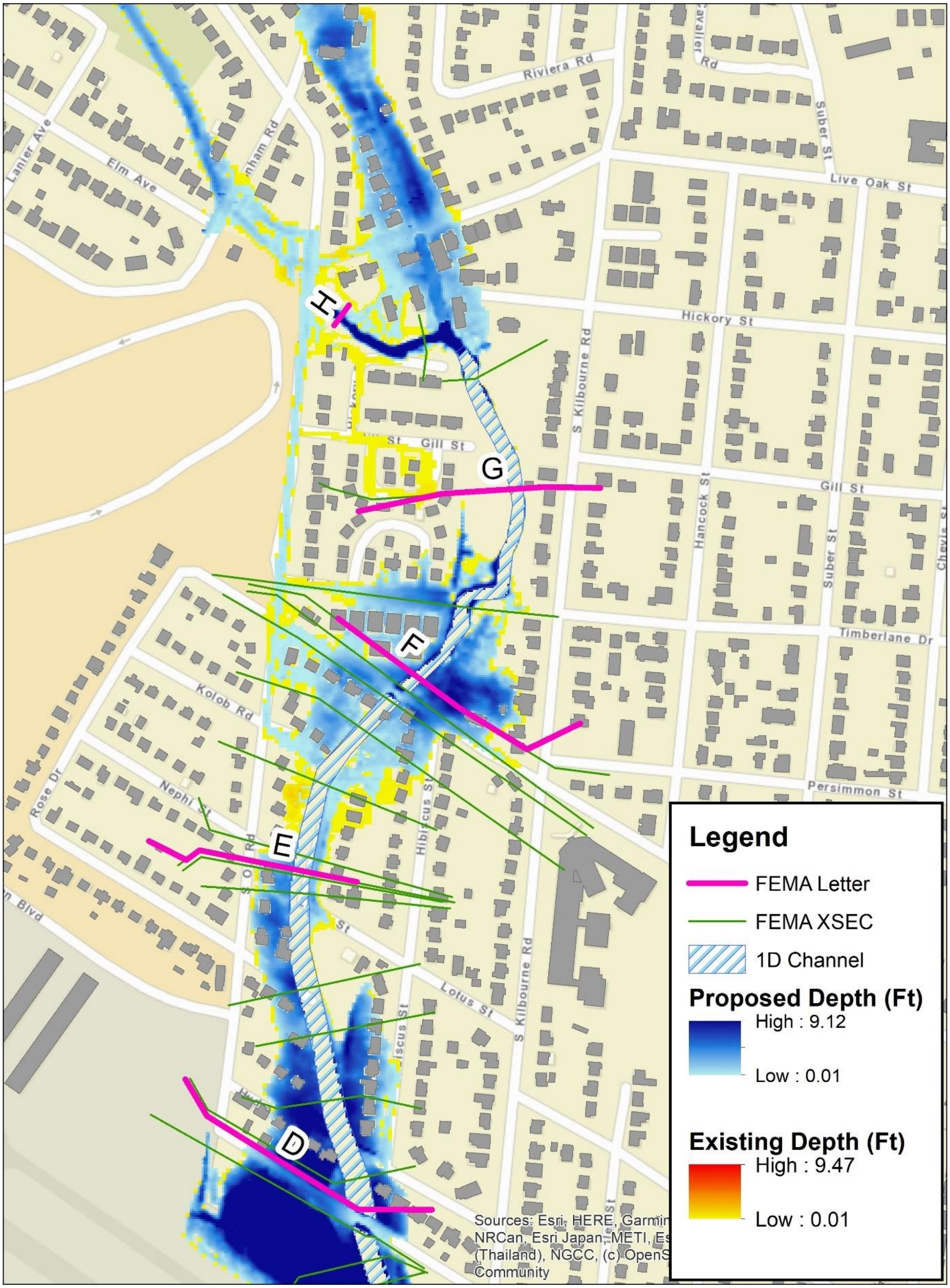

Figure 23: Comparison of Existing and Proposed 100-Year Floodplains

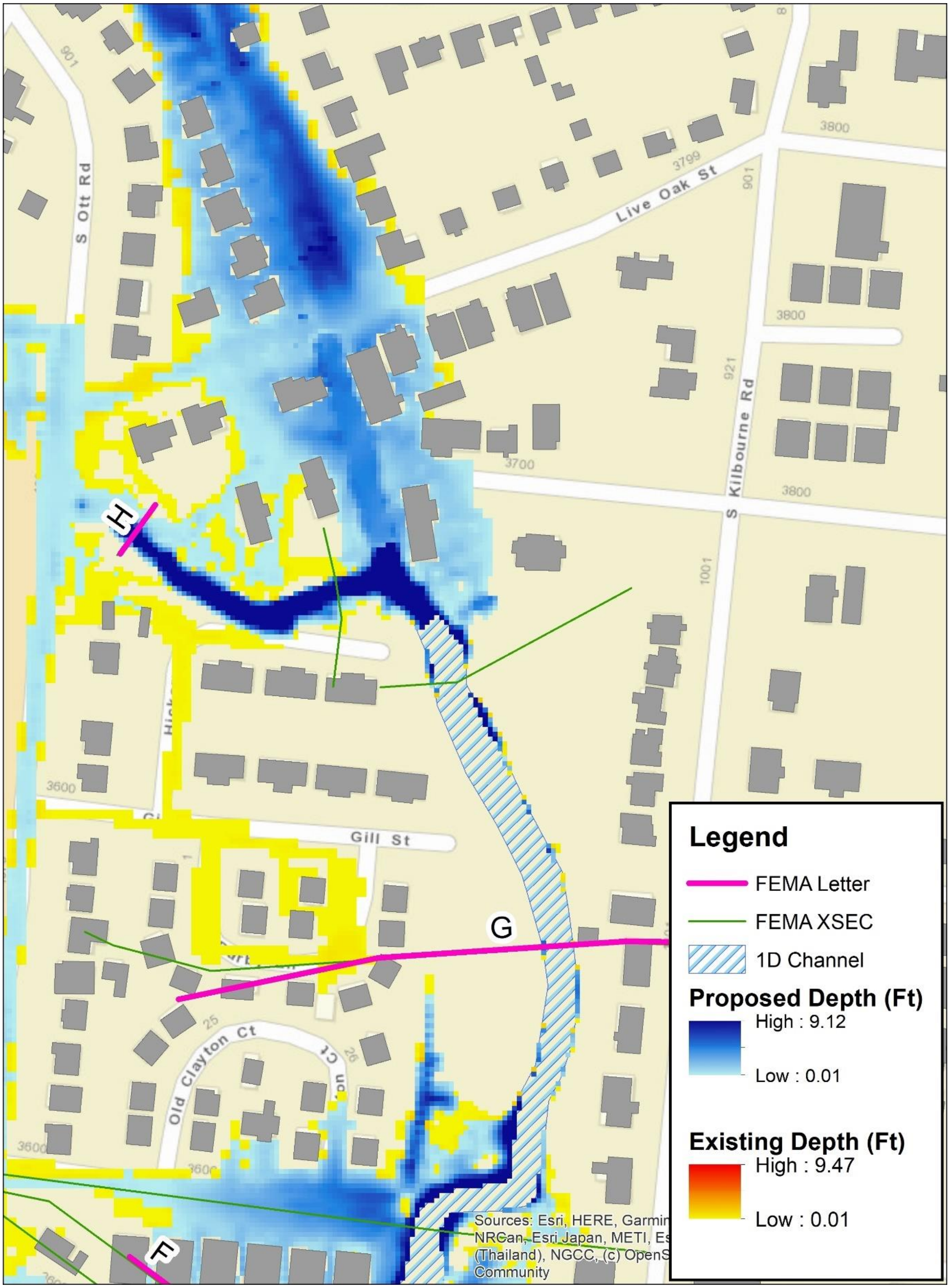

Figure 24: Comparison of Existing and Proposed 100-Year Floodplains (Upper Section)

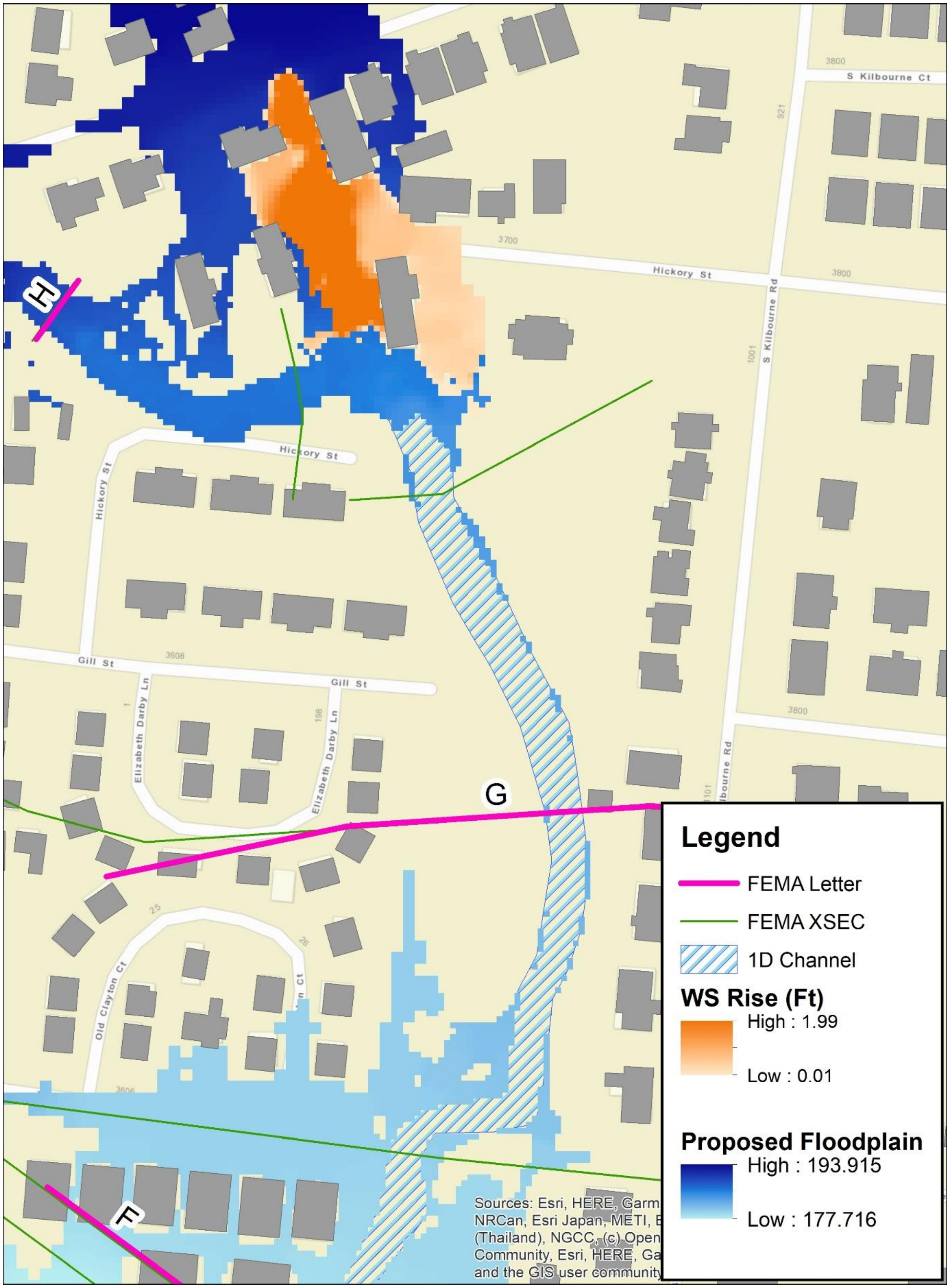

Figure 25: Location of Increased Water Surface Elevations with Proposed Improvements

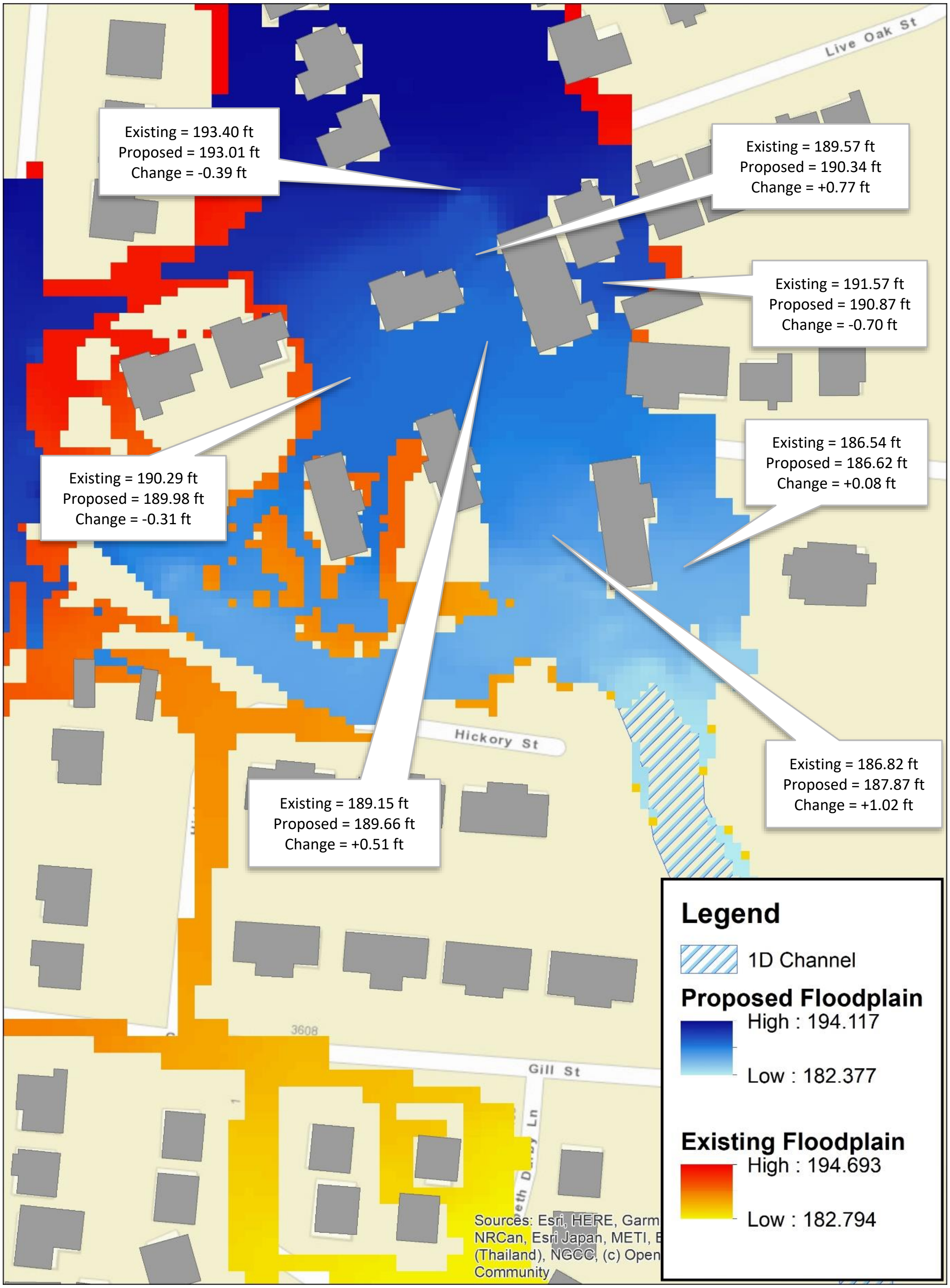

Figure 26: Sample Changes In Water Surface Elevations Along Filled Channel Section