

EVALUATION OF ELLICOTT CITY FLOOD RISK MANAGEMENT STRATEGIES

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USACE Baltimore District
Planning Division
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US Army Corps
of Engineers®



AGENDA

- **Background & Purpose**
- **Study Area**
- **Flood History**
- **County Flood Risk Management (FRM) Alternatives**
- **Key Takeaways**
- **Evaluation Methodology**
- **FRM Measures Reviewed**
- **Additional FRM Strategies for County Consideration**
- **Results and Conclusions**
- **Q&A**





BACKGROUND

- Major floods in 2016 & 2018
- Howard County leadership developed study-driven solutions
- County requested the US Army Corps of Engineers (USACE) to conduct independent review of County studies, modeling and proposed alternatives
- USACE offered additional strategies to be considered by the County





BACKGROUND

- USACE assembled **independent, multi-disciplinary team**
- Solicited **input from** interagency **Maryland Silver Jackets** flood risk management team and **national USACE flood experts**
- **USACE reviewed completed County studies and modeling**
 - *Did not develop new engineering designs or modeling*
- **USACE provided project considerations for the County**
 - *Not recommending specific projects*
 - *Not involved in County decision making*





USACE MULTI-DISCIPLINARY REVIEW TEAM



National team with disciplines in:

- Civil engineering
- Hydraulic & Hydrologic engineering
- Community planning
- Geotechnical engineering
- Cultural / environmental specialties
- Non-structural flood proofing committee member



May 2019 site visit



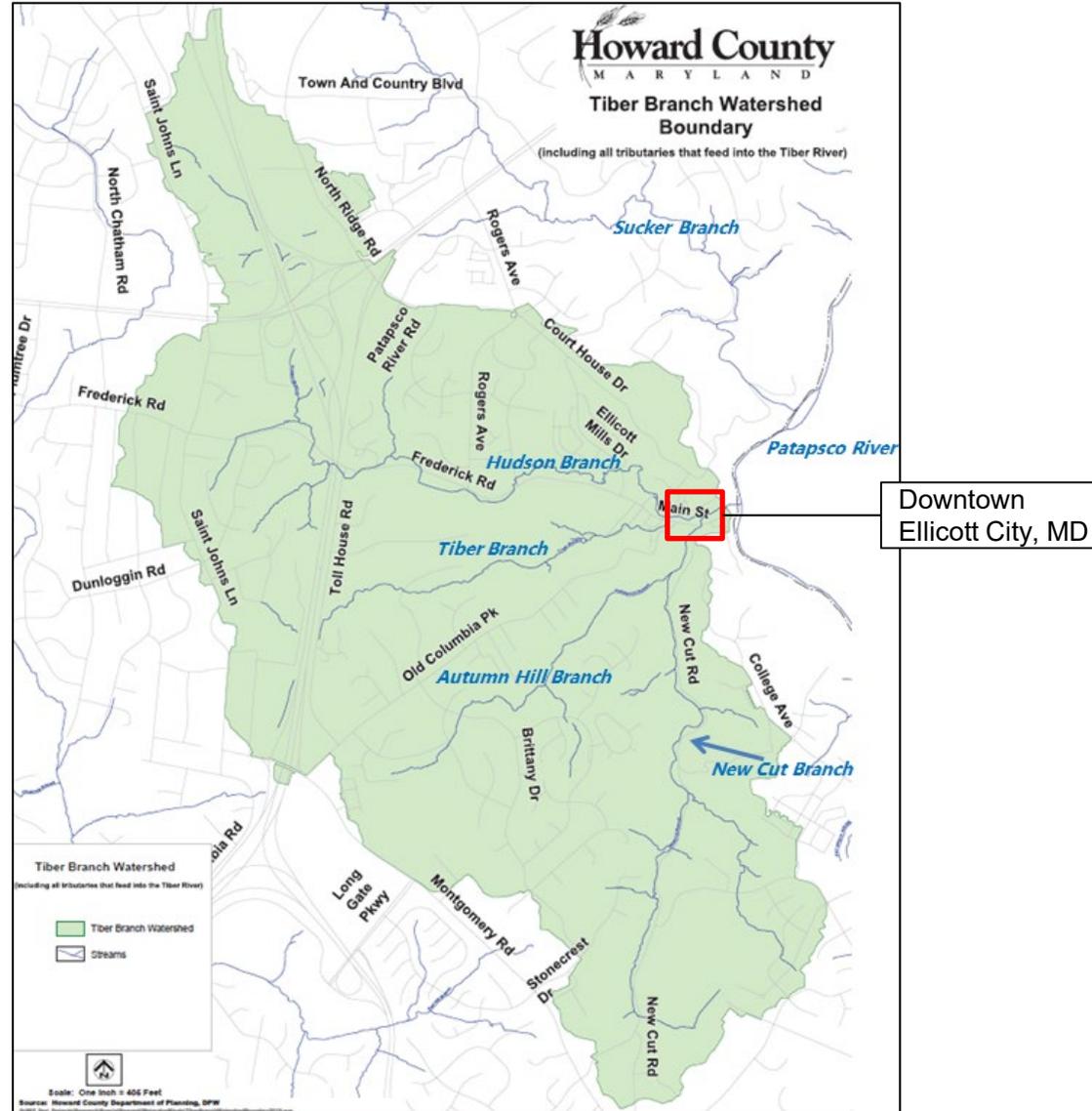
PREVIOUS USACE INVOLVEMENT



- **July 2009** – Updated flood maps
- **July 2016** – Cleared debris from Patapsco River following flood
- **June 2017** – Reviewed McCormick Taylor’s hydrologic and hydraulic model
- **February 2018** – Completed Nonstructural Flood Proofing Study



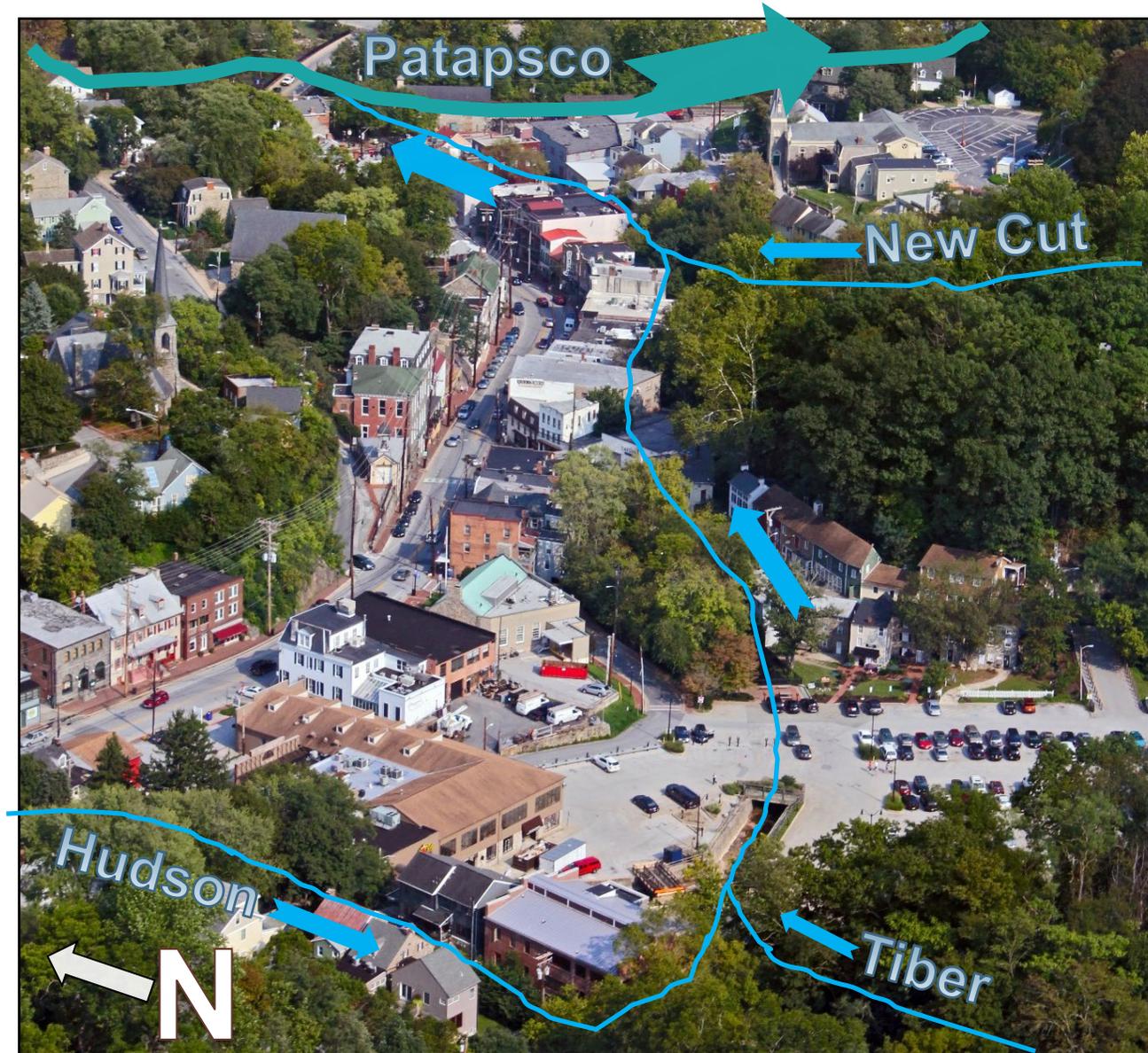
ELLICOTT CITY WATERSHED



Ellicott City is situated at the confluence of three tributaries draining ~3.7 square-mile watershed



ELLICOTT CITY: STREAM DEPENDENT





FLOOD HISTORY

From both “bottom-up” (Patapsco) and “top-down” (steep, flashy watershed) sources

- Since 1868, at least seven recorded major flooding events
- 2016 and 2018 floods were “top-down”



1868



1952



1972



1975



2011



2016



2018



FLOOD HISTORY: 30 JULY 2016

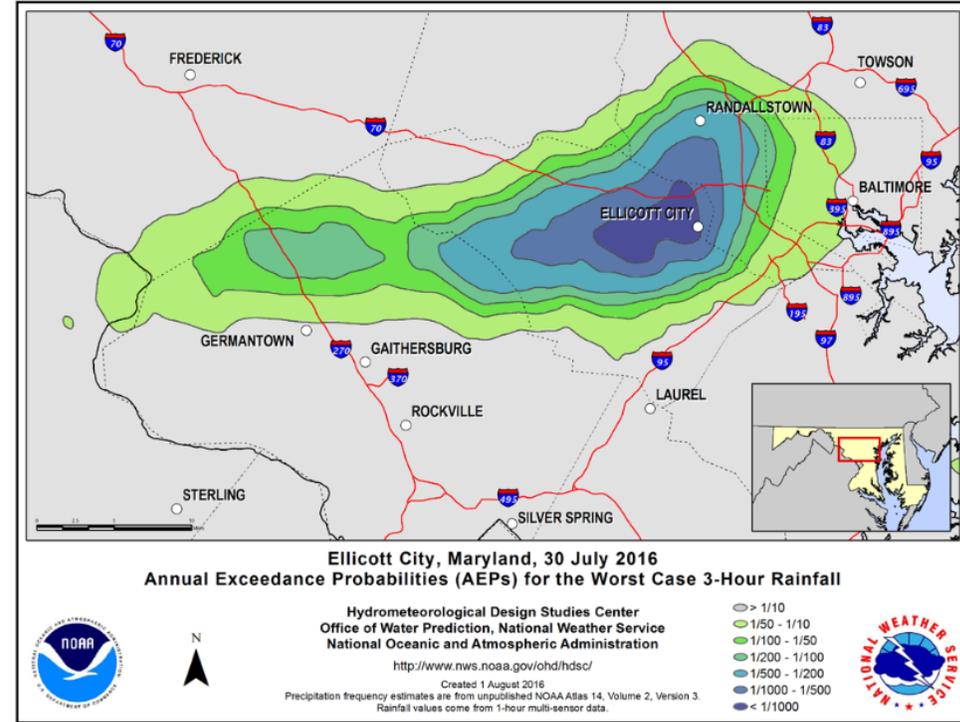
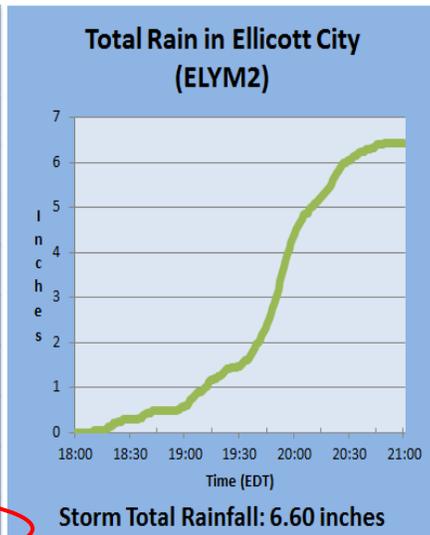


Historic Rainfall in Ellicott City, Maryland – July 30, 2016



Duration	Max Rainfall in Duration	Time of Occurrence
1 minute	0.20"	7:52pm-7:53pm
5 minutes	0.80"	7:50pm-7:55pm
10 minutes	1.44"	7:50pm-8:00pm
15 minutes	2.04"	7:46pm-8:01pm
20 minutes	2.44"	7:44pm-8:04pm
30 minutes	3.20"	7:36pm-8:06pm
60 minutes	4.56"	7:30pm-8:30pm
90 minutes	5.48"	7:00pm-8:30pm
2 hours	5.96"	6:50pm-8:50pm

Information obtained from the Ellicott City (ELYM2) rain gauge. This gauge reports in 0.04" increments.



- Less than 1 in 1,000 exceedance probability for Worst Case 3-Hour rainfall



FLOOD HISTORY: 27 MAY 2018 FLOOD



Ellicott City, MD – May 27, 2018



Duration	Max Rainfall in Duration	Time of Occurrence
1 minute	0.16"	4:15pm-4:16pm
5 minutes	0.56"	4:15pm-4:20pm
10 minutes	0.96"	4:11pm-4:21pm
15 minutes	1.44"	4:06pm-4:21pm
30 minutes	1.84"	3:53pm-4:22pm
	1.84"	5:20pm-5:50pm
60 minutes	2.68"	3:20pm-4:20pm
	2.84"	5:00pm-6:00pm
2 hours	5.00"	3:53pm-5:53pm
3 hours	6.56"	3:15pm-6:15pm

*Information obtained from the Ellicott City (FLYM2) rain gauge.
Data is preliminary and subject to correction. This gauge reports in 0.04" increments.*





REVIEWING MODELED ALTERNATIVES



County identified **60 alternatives**

- Containing 1 to 14 unique Flood Risk Management (FRM) **measures**

Measures include:

- Underground diversion tunnels
- Culvert additions / improvements
- Upstream above ground storage ponds
- Underground storage structures
- Floodplain modifications (includes building acquisitions / modifications)
- Conveyance improvements (includes building acquisitions / modifications)





ADDITIONAL NON-STRUCTURAL FRM MEASURES BEING IMPLEMENTED BY COUNTY



USACE review team made aware of these, but did not review

- Flood Warning System
- Evacuation Planning*
- Flood Proofing Fund



**USACE team provided additional evacuation ideas for Ellicott City*



KEY TAKEAWAYS

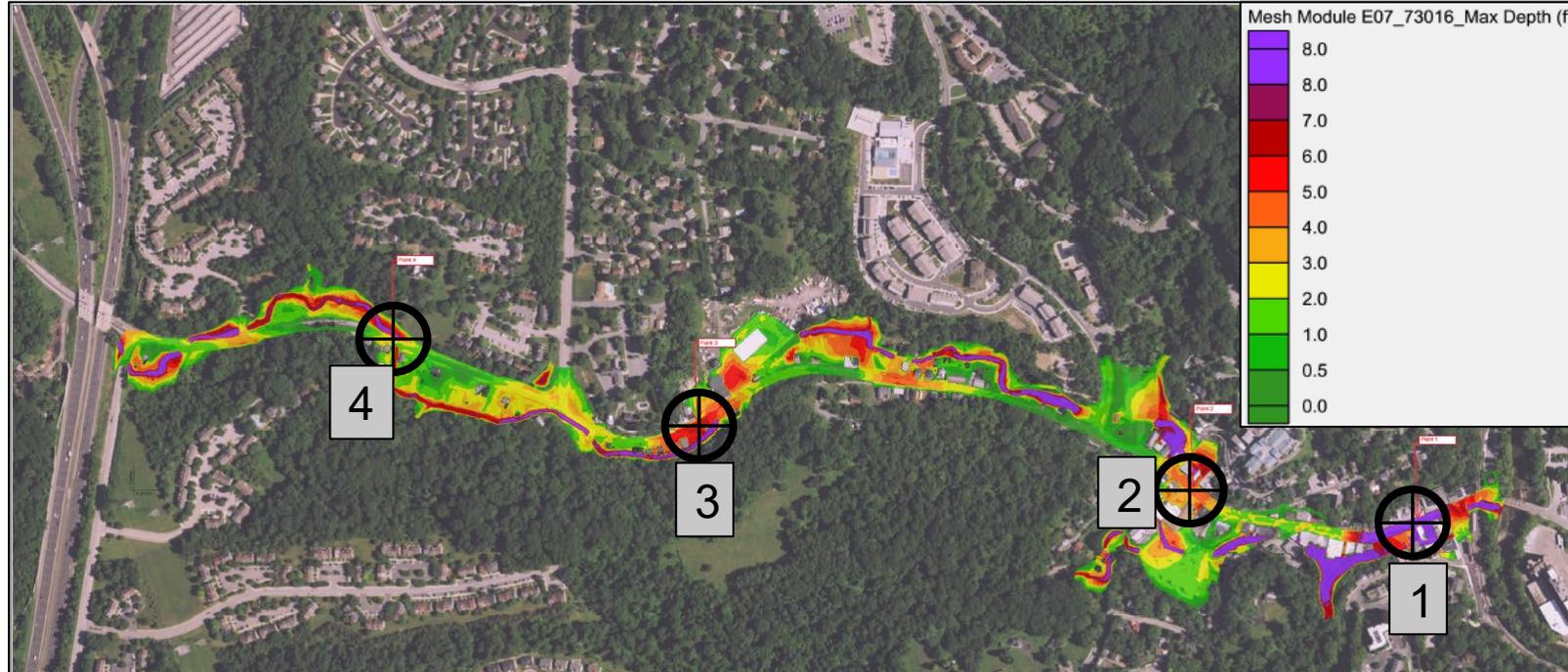
- County considered thorough array of FRM measures backed by modelling
- FRM measures considered by the County can effectively reduce flooding and are the same types considered for USACE FRM projects
- County's plan includes many of the top measures based on USACE criteria
- USACE identified additional FRM strategies for County consideration to further reduce flood risk
- There will still be residual flood risk after construction of measures. County should continue to pursue additional acquisitions, flood proofing of buildings, flood-warning systems and evacuation planning



EVALUATION METHODOLOGY (BASED ON JULY 2016 FLOOD)



- **Flood depths and velocities** reviewed at **four locations**
- Modeled alternatives that **reduced flooding** in the downtown area roadway to **3.5 feet** (or below) **and/or 5 feet/sec** (or below) included for further evaluation
- **Reduced number of alternatives** considered from **60 to 8** with 12 FRM measures



2-D modeled depths (2016 storm)



EVALUATED MEASURES



County FRM Measures Evaluated by USACE:

- 1. North Tunnel
- 2. South Tunnel
- 3. Maryland Avenue Culverts
- 4. Terraced Floodplain
- 5. Lot D Channel Expansion
- 6. Lot F Underground Storage (H1-UG1 & H8-UG1)
- 7. West End Floodplain Conveyance
- 8. West End Underground Storage (H1-UG2)
- 9. H-7 Pond (13 acre-feet)
- 10. T-1 Pond (70 acre-feet)
- 11. H-4 Pond (16 acre-feet)
- 12. NC-3 Pond (63 acre-feet)

Downtown / Upper Main St.

West End / upstream improvements



USACE EVALUATION OF FRM MEASURES



Criteria:

1. Prevention of Loss of Life
2. Reduction to Flood Depths and Velocity
3. Economic Impacts
4. Preservation of Historical / Cultural Values / Community Cohesion
5. Environmental Impacts
6. Operations and Maintenance
7. Initial Construction Costs
8. Implementation Duration

Each Measure:

Assigned numbers to rate against criteria

Advantages / Challenges / Considerations

Each measure evaluated relative to the others

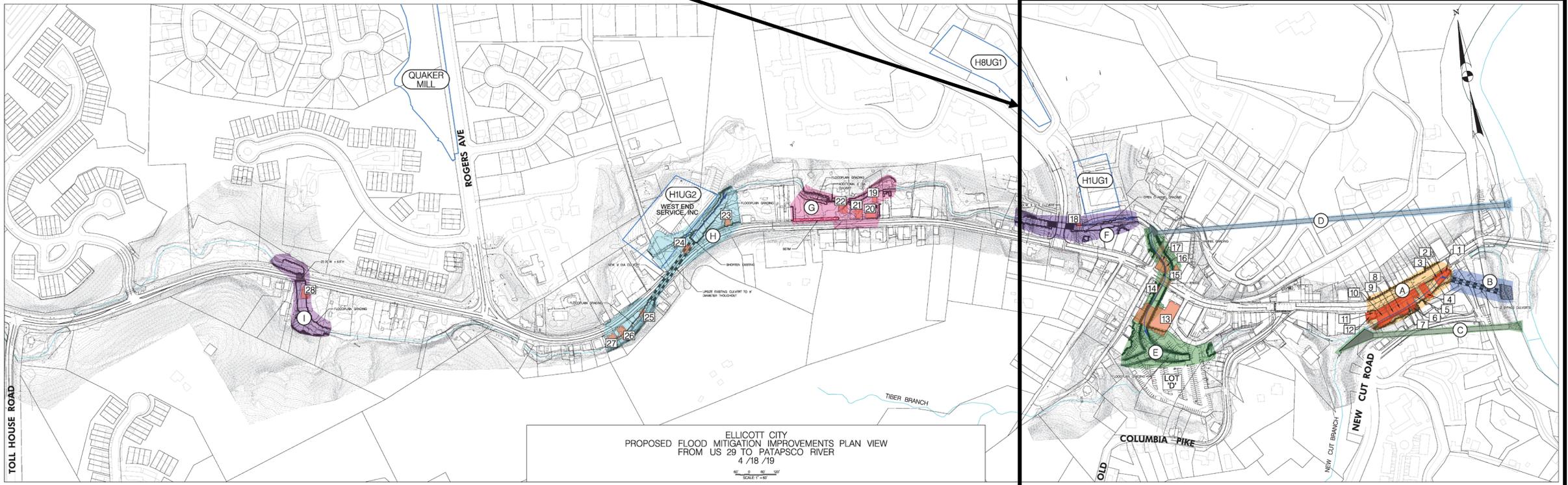
Flood reduction effectiveness based on July 2016 modeled storm



EVALUATED MEASURES



Downtown Main St. Area Measures

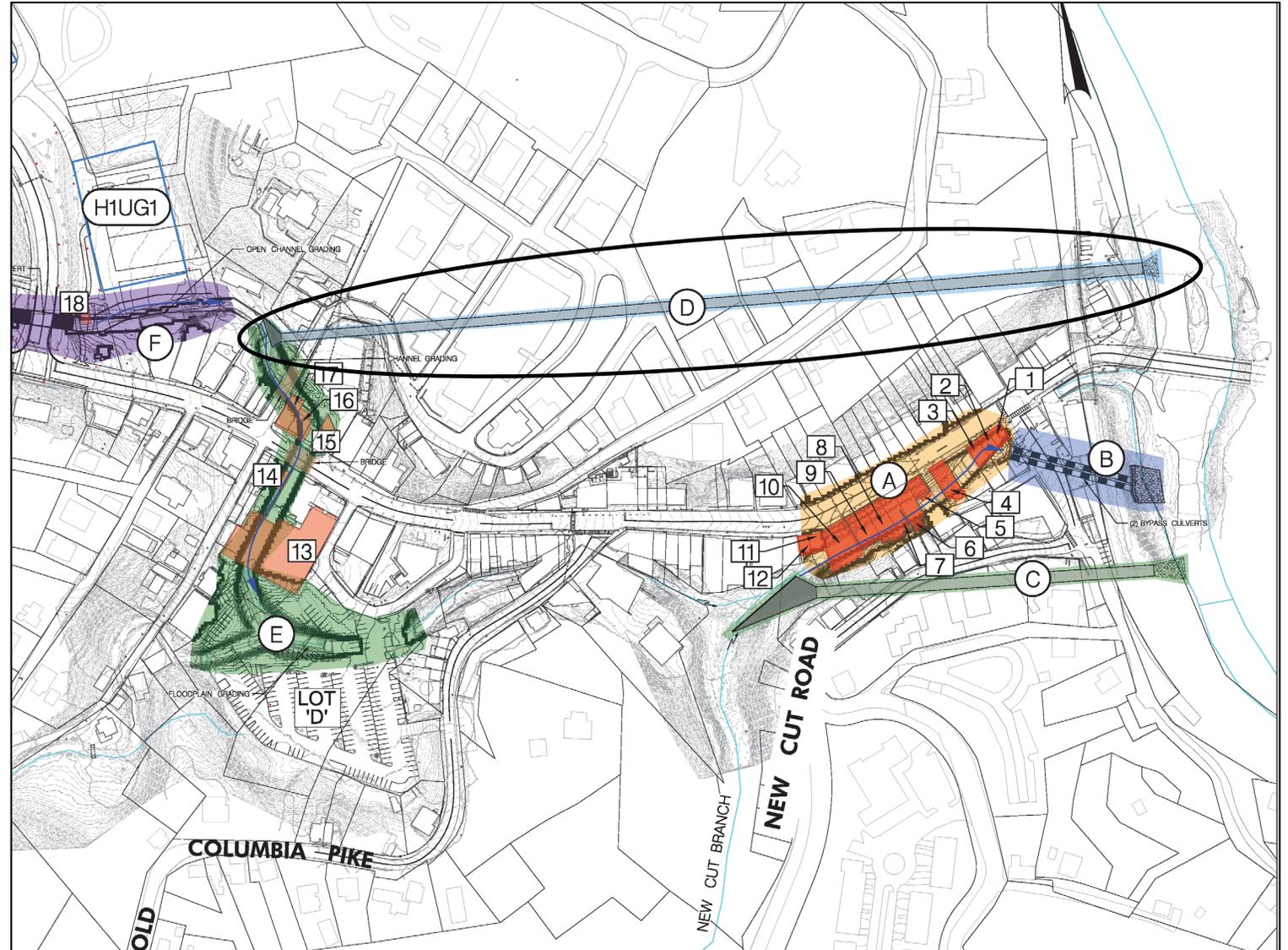


EVALUATED MEASURES



1. North Tunnel

- Approx. 1,600 feet long
- 15' finished diameter
- Active just for storm flows
- Outfalls to Patapsco River, north of Main St. bridge





EVALUATED MEASURES



1. North Tunnel

Advantages:

- Little impact to historic structures
- Would not impact community cohesion
- Minimizes/avoids utility relocation
- Produces most significant reduction to flooding downtown

Challenges:

- Most expensive
- Significant engineering challenges, including constructability and duration (under railroad tracks)
- Potential for debris to block intake or upstream channel and reduce effectiveness

Considerations:

- May be less costly options that achieve similar levels of flood reduction (e.g. Lot D Floodplain Expansion), but require more extensive changes to downtown
- May require Environmental Impact Statement
- Consider program to manage upstream debris
- Outlet structure to Patapsco should be designed to minimize erosion and scouring of bed and banks

2. South Tunnel

- Approx. 600 feet long
- 10' finished diameter (as modeled)
- Up to 20' diameter
- Active just for storm flows
- Outfalls to Patapsco River, south of Main St. bridge





EVALUATED MEASURES



2. South Tunnel

Advantages:

- Little impact to historic structures
- Would not impact community cohesion
- Minimizes/avoids utility relocation

Challenges:

- Significant engineering challenges, cost and duration (under railroad tracks)
- Potential for debris to block intake or upstream channel and reduce effectiveness
- Less effective than North Tunnel

Considerations:

- May require Environmental Impact Statement
- Consider program to manage upstream debris
- Outlet structure to Patapsco should be designed to minimize erosion and scouring of bed and banks
- Effectiveness could be improved with additional hydraulic head on intake via weir structure

3. Maryland Ave. Culverts

- Approx. 275 LF
- 2 x 10' culverts
- Active just for storm flows
- Outfalls to Patapsco River, south of Main St. bridge





EVALUATED MEASURES



3. Maryland Ave Culverts

Advantages:

- Significant reductions to flood depths and velocities on Maryland Ave. and lower Main St.

Challenges:

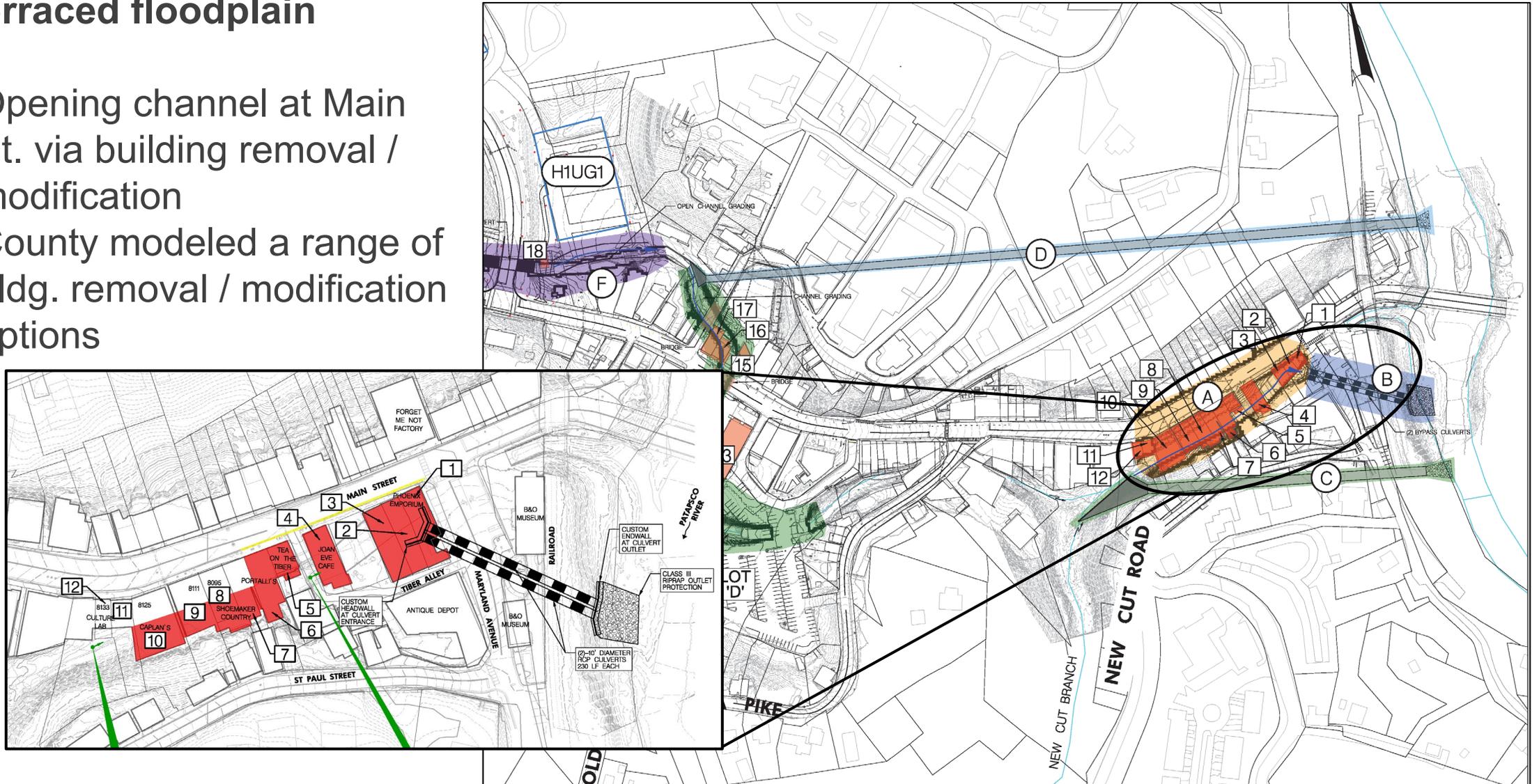
- Installed under CSX railroad and near two historic railway buildings, increasing construction cost and complexity
- Requires removal of some buildings on southwest corner of Maryland Ave and Main St.

Considerations:

- Outlet structure should be designed to address erosion of Patapsco River bed and banks
- Conversations with CSX Transportation would be required for evaluations of alignment alternatives

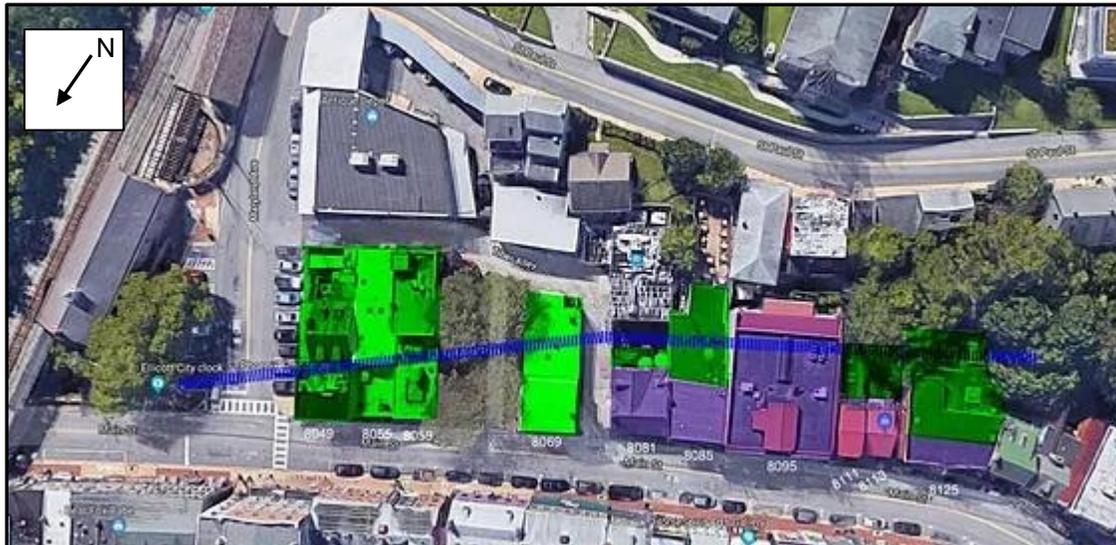
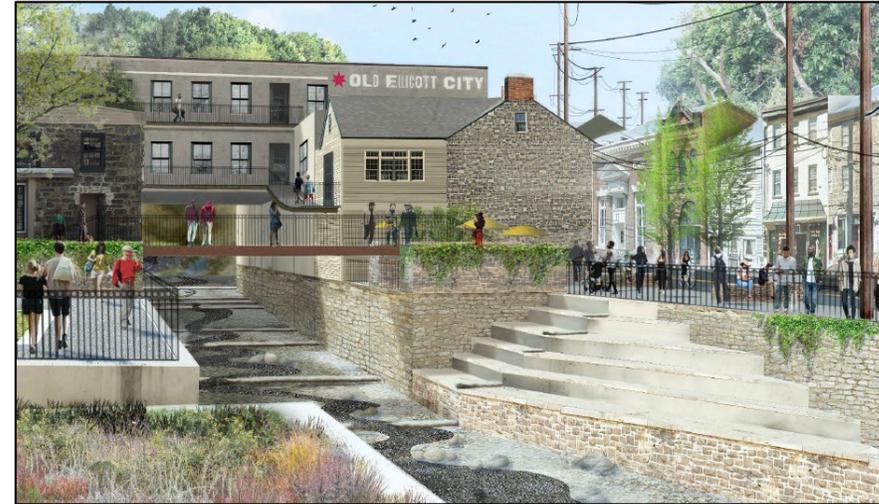
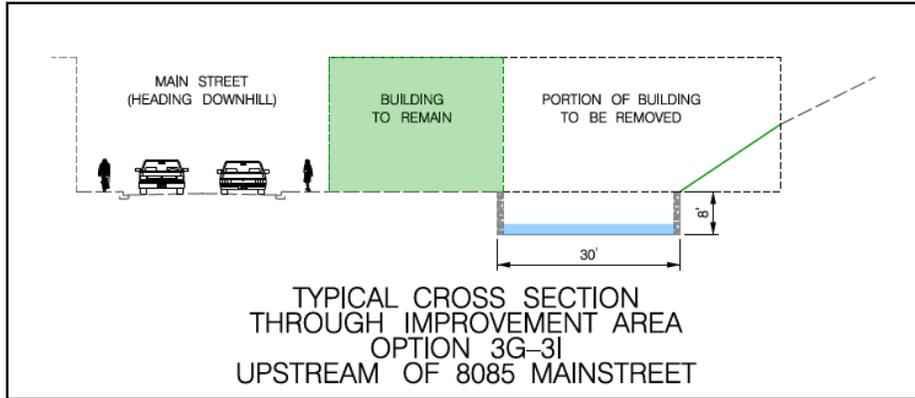
4. Terraced floodplain

- Opening channel at Main St. via building removal / modification
- County modeled a range of bldg. removal / modification options



Red indicates which buildings were modeled as modified / removed under various modeling scenarios

4. Terraced floodplain (cont.)

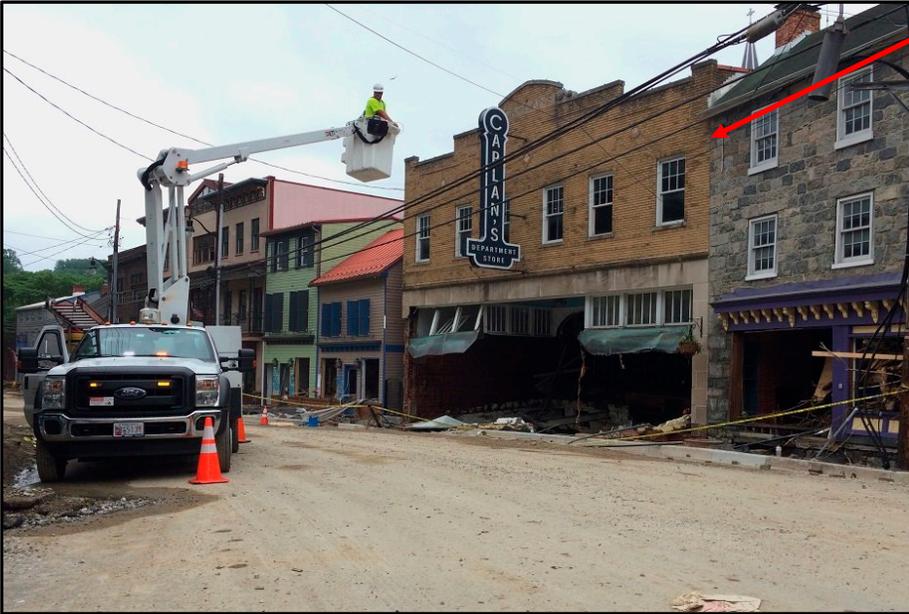


Green buildings/sections removed, purple maintained (County proposed plans)

4. Terraced floodplain (cont.)

- Includes building removal / modifications

Caplan's



Pictured buildings will be maintained



Green buildings/sections removed, purple maintained



EVALUATED MEASURES



4. Terraced Floodplain

Advantages:

- Removal of structures reduces risk of loss of life from upstream flash floods, and potentially bottom-up Patapsco flooding
- Recreational/tourist opportunities
- Opportunity to develop riparian and in-stream habitat

Challenges:

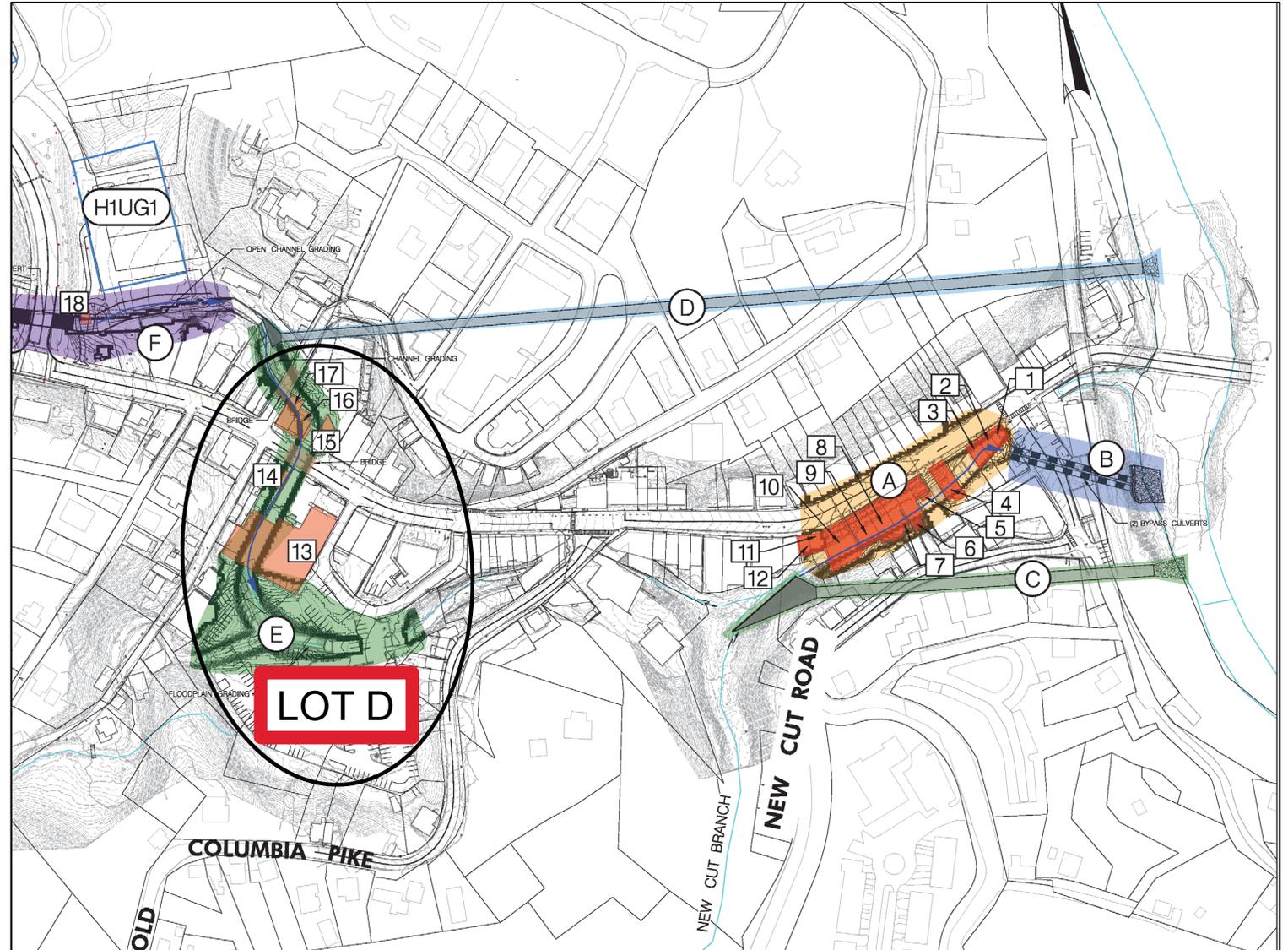
- Real estate acquisitions
- Sediment and debris management required to prevent channel blockages

Considerations:

- Could incorporate parapet walls (permanent or automated)
- Bollards placed along lower Main St. could reduce vehicles and other large debris from entering channel during floods
- Potential backwater effects from bottom-up Patapsco River floods

5. Lot D Channel Expansion

- Includes bldg. removals
- Re-configures parking lot D
- Significantly increases conveyance capacity via terraced floodplain, removal of constrictions

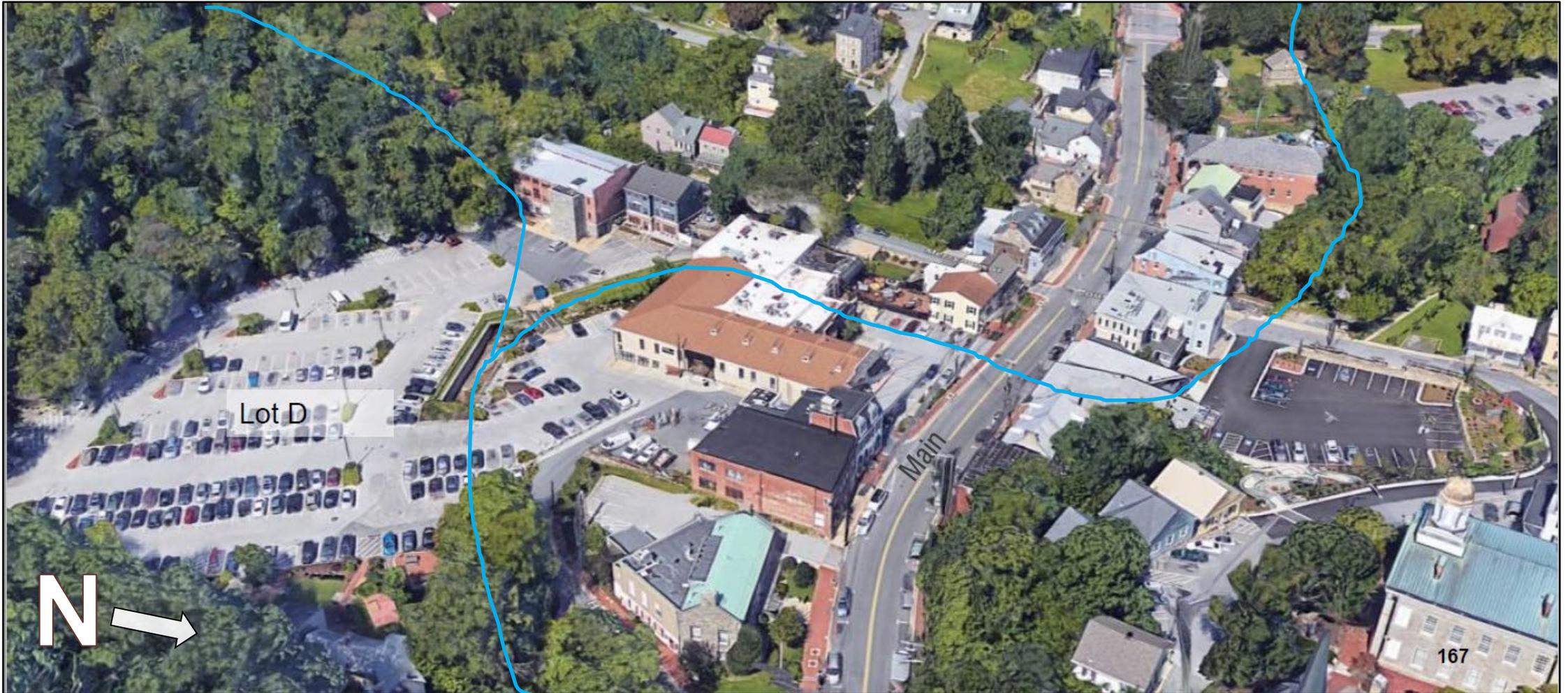




EVALUATED MEASURES



5. Lot D Channel Expansion (cont.)

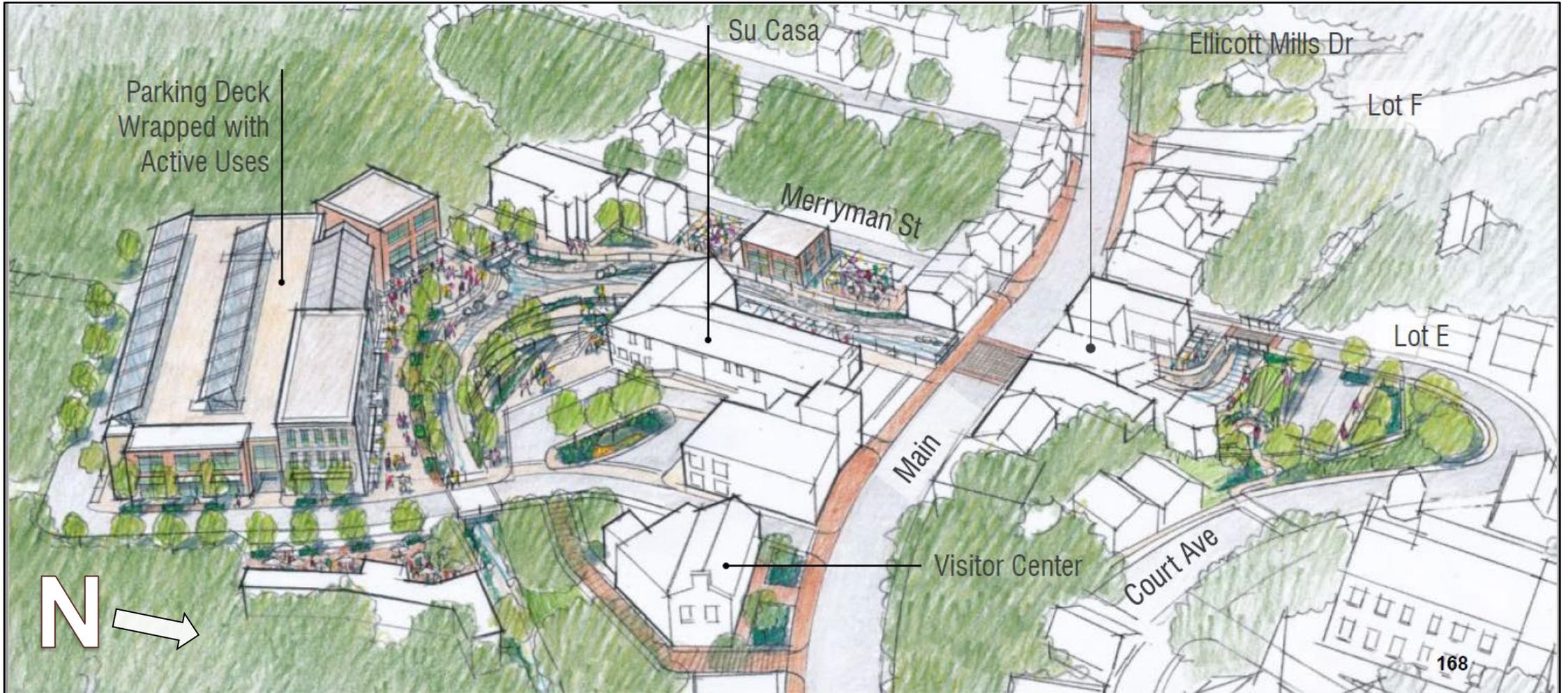




EVALUATED MEASURES



5. Lot D Channel Expansion (cont.)





EVALUATED MEASURES



5. Lot D Channel Expansion

Advantages:

- Significantly reduces flood depths and velocities on lower Main Street
- Less costly than tunnel options
- Opportunities to create in-stream and riparian habitat

Challenges:

- Removal, relocation or modifications to a number of historic structures
- Impacts to Main St./Court Ave. utility corridor
- Loss of parking depending on configuration

Considerations:

- Parking structure or adding parking elsewhere
- Could be highly walkable space for visitors
- Environmental improvements possible (in-stream, riparian habitat)
- Evaluation of impacts to historic structures

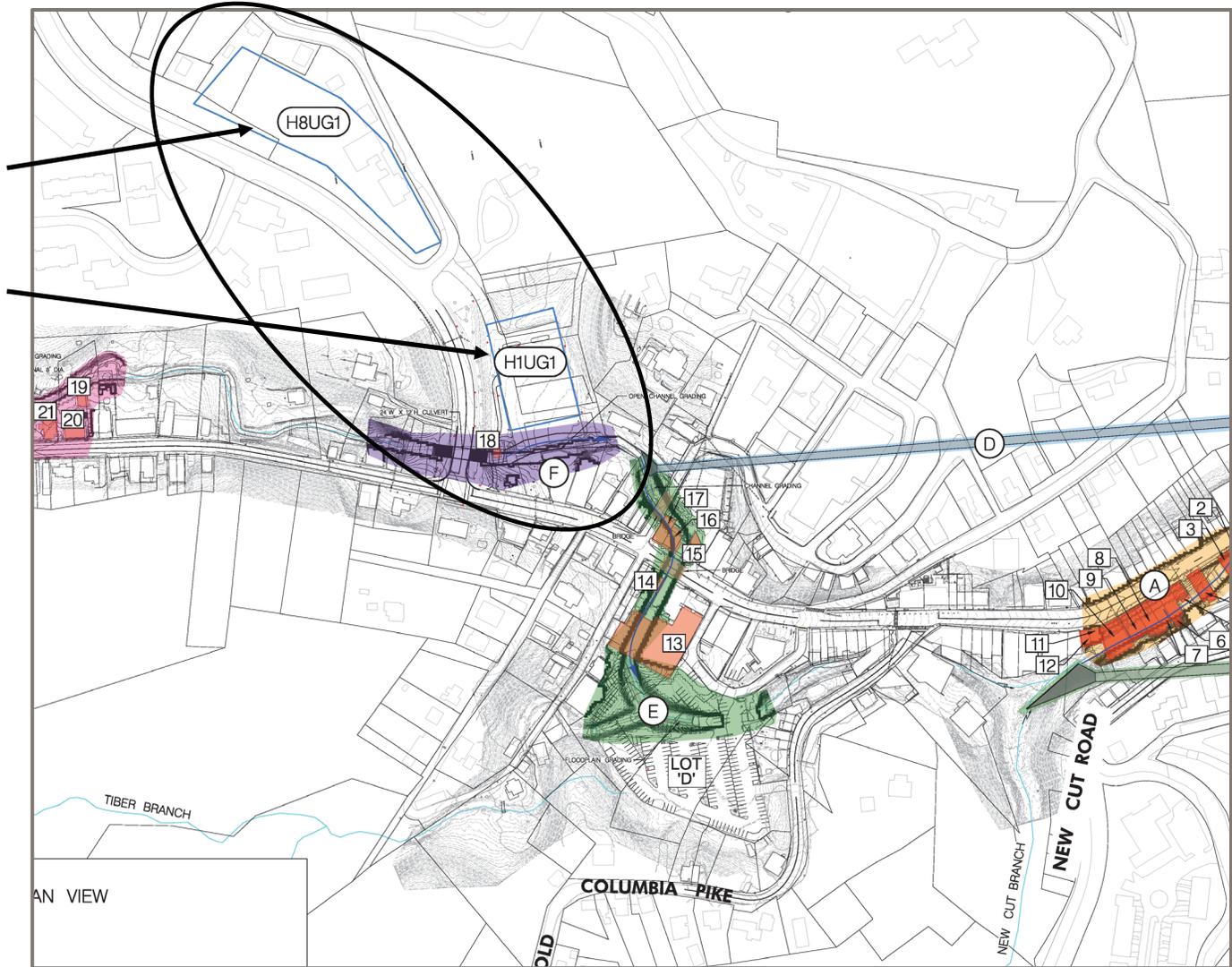


EVALUATED MEASURES



6. Lot F Underground Storage

- H1-UG1 & H8-UG1
- 33 acre-feet of storage combined





EVALUATED MEASURES



6. Lot F Underground Storage

Advantages:

- Water quality benefits after construction from captured sediments
- Little negative impacts to local economy or historic feel

Challenges:

- Once storage structure fills, no further benefits to flood reduction
- More costly than aboveground storage structures of similar capacity
- Excavation activities may impact archaeological resources
- Regular cleaning of sediment required

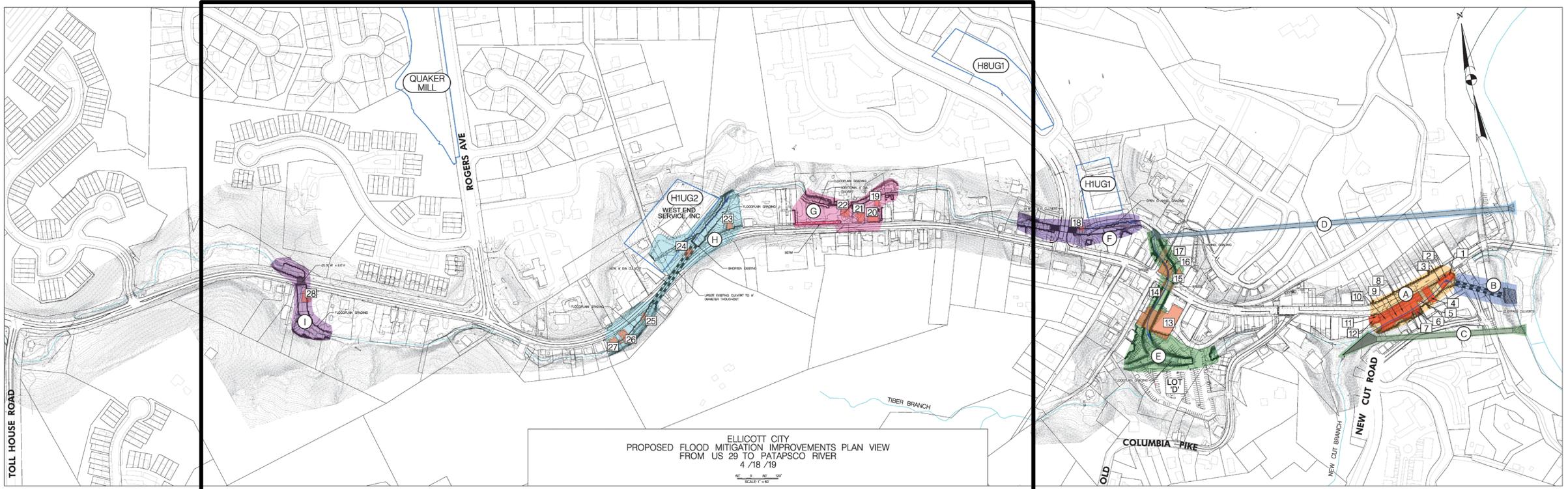
Considerations:

- Structure outlet sized to avoid overflowing too quickly during large storm

EVALUATED MEASURES



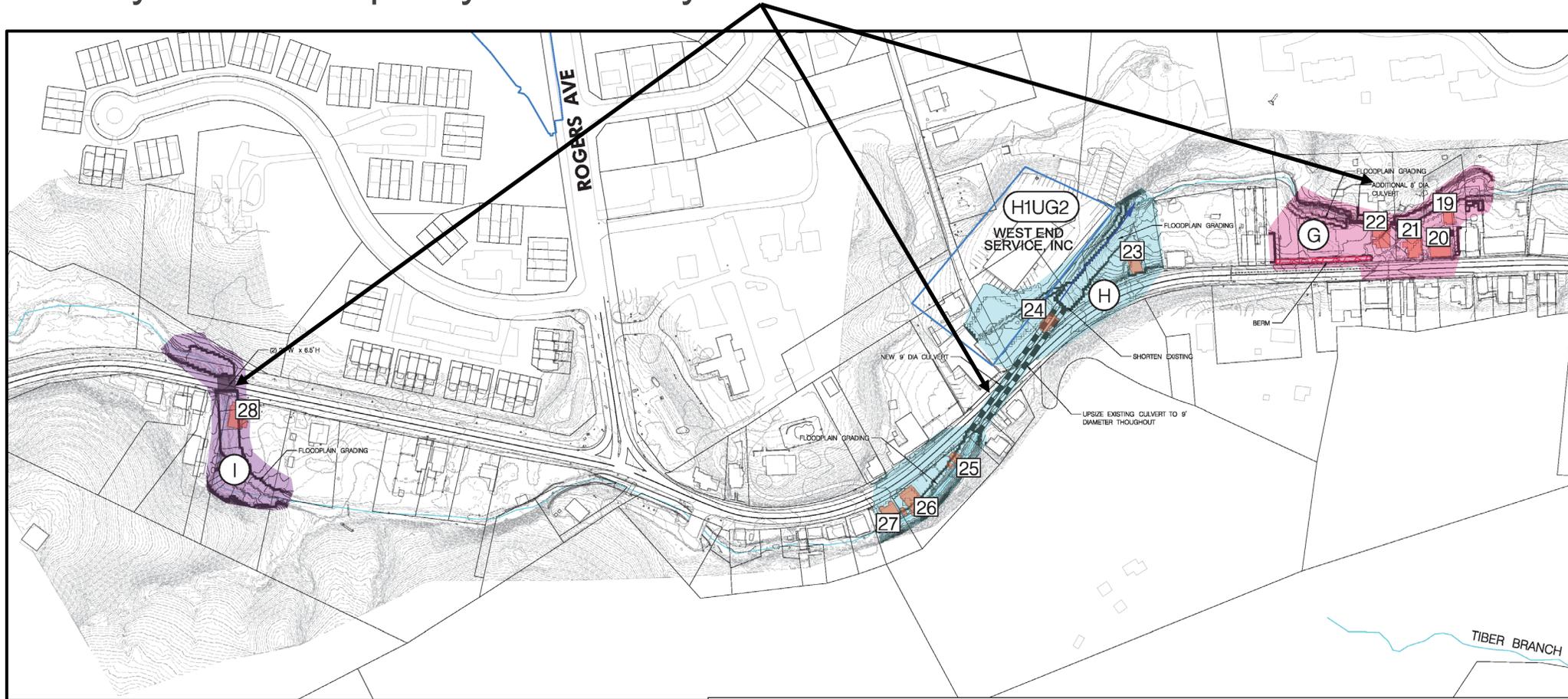
West End and Upstream Measures



EVALUATED MEASURES

7. West End Conveyance Improvements

- From Ellicott Mills Drive upstream
- Generally doubles capacity of roadway culverts below Main St/Frederick Rd.





EVALUATED MEASURES



7. West end Conveyance Improvements

Advantages:

- Reductions to residential and roadway flood depths (most effective for smaller storms)
- Significant potential for aquatic habitat improvements

Challenges:

- Large number of real estate acquisitions
- Crossing utility corridors and disruption to traffic flows during construction

Considerations:

- Significant opportunity for improvements to in-stream and riparian habitat
- Bio-engineering/nature-based FRM measures possible

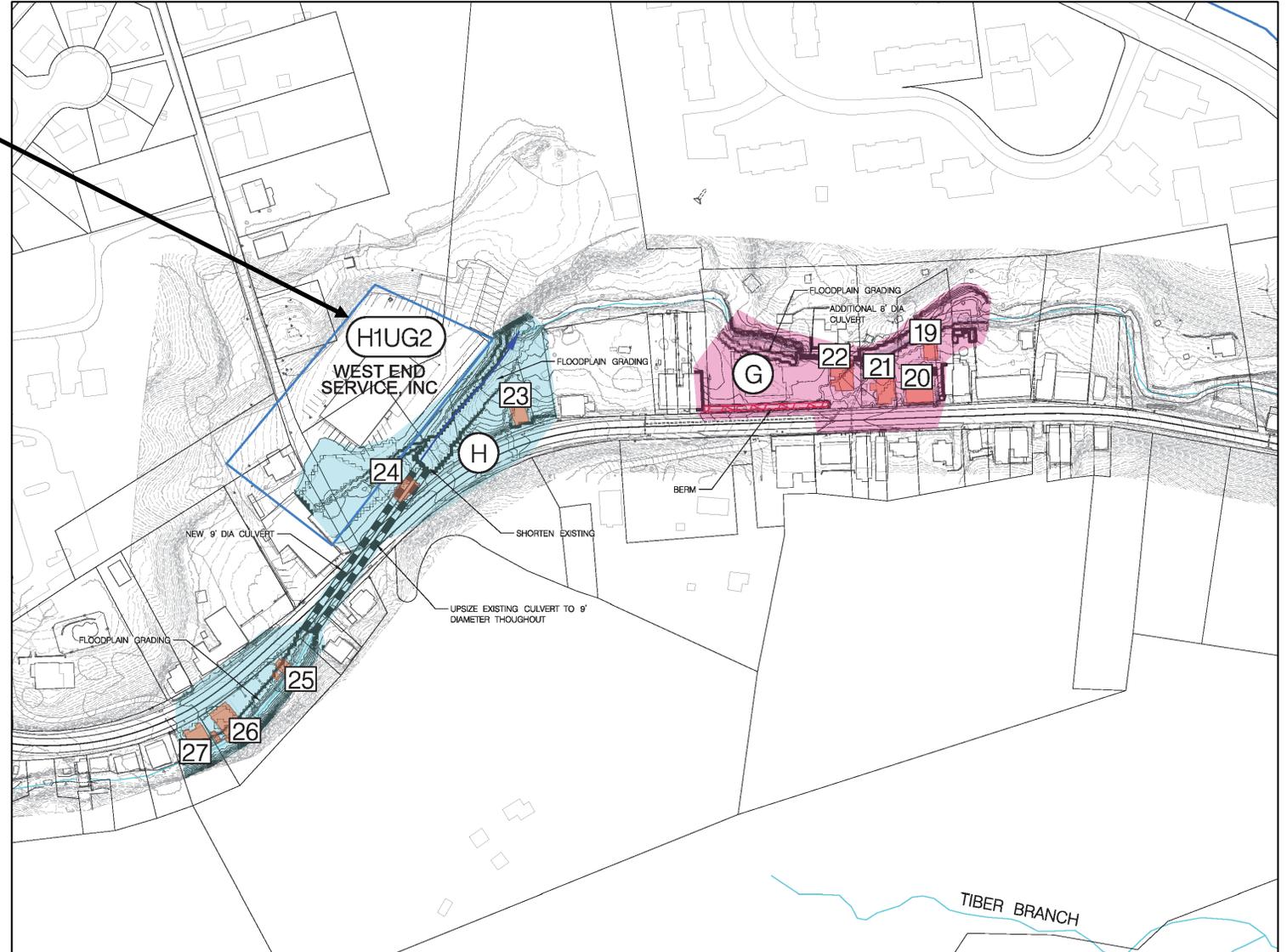


EVALUATED MEASURES



8. West End Underground Storage (H1-UG2)

- 30 acre-feet of storage





EVALUATED MEASURES



8. West End Underground Storage

Advantages:

- Water quality benefits from capture of sediments
- Little negative impacts to local economy or historic feel

Challenges:

- Once storage structure fills, no further benefits to flood reduction
- More costly than aboveground storage structures of similar capacity
- Regular cleaning of sediment required

Considerations:

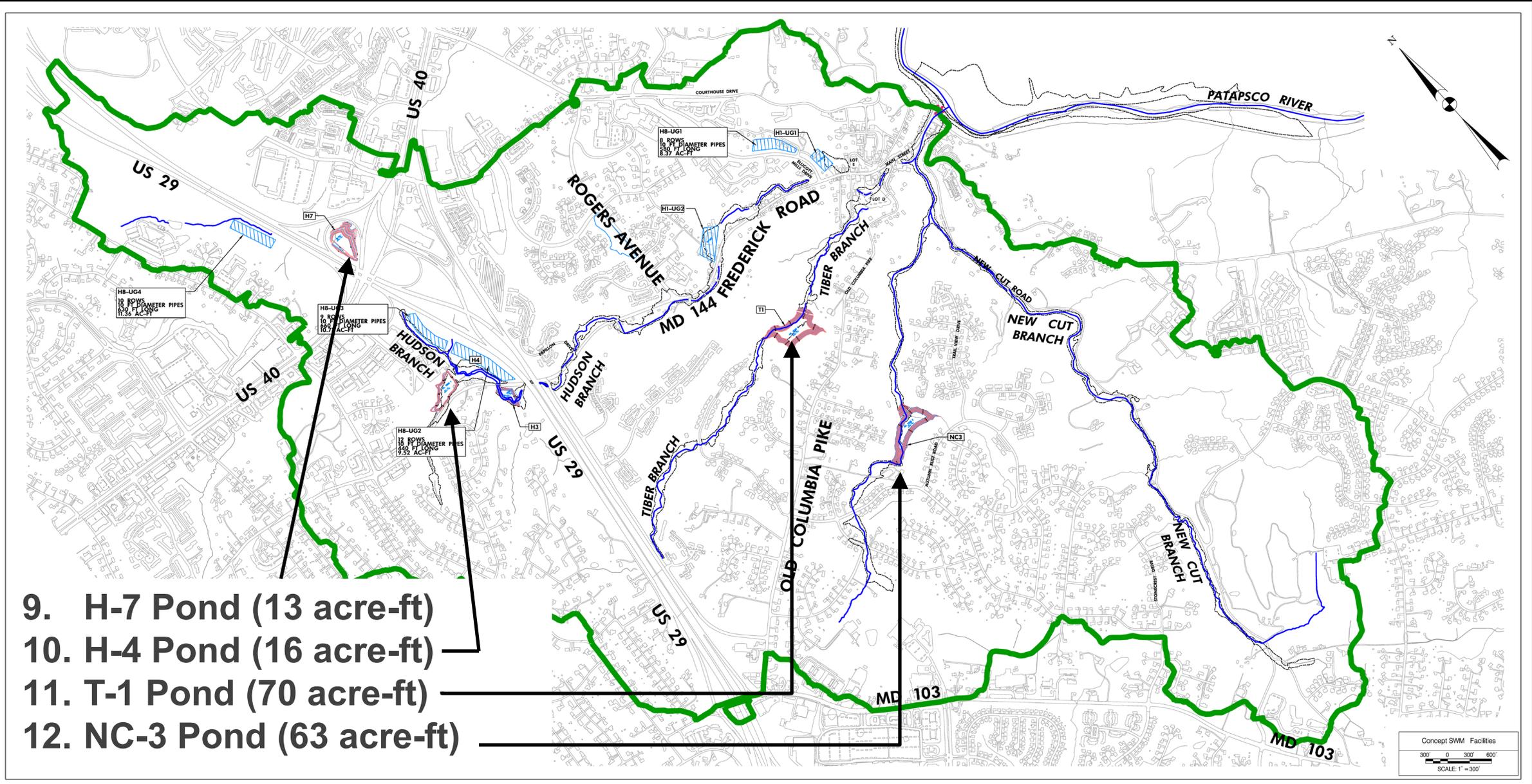
- Structure outlet sized to help avoid overflowing too quickly during a large storm



U.S. ARMY



EVALUATED MEASURES



- 9. H-7 Pond (13 acre-ft)
- 10. H-4 Pond (16 acre-ft)
- 11. T-1 Pond (70 acre-ft)
- 12. NC-3 Pond (63 acre-ft)

Concept SWM Facilities
 300' 0 300' 600'
 SCALE: 1" = 300'



FRM STRATEGIES IDENTIFIED BY USACE FOR COUNTY CONSIDERATION

Targeted Conveyance Increases

- Throughout channelized downtown sections, increase conveyance via **channel lowering / widening + small floodwall**





FRM STRATEGIES IDENTIFIED BY USACE



Targeted Conveyance Increases

Advantages:

- Could allow for conveyance for 2016 storm flows
- Might not disrupt downtown setting, depending on design, as streams already channelized

Challenges:

- Geotechnical investigations required, as channel modifications could impact building foundations
- Structural reinforcement of some buildings may be required
- Additional permitting if archaeological resources present
- Extensive use of parapet walls could impact downtown setting

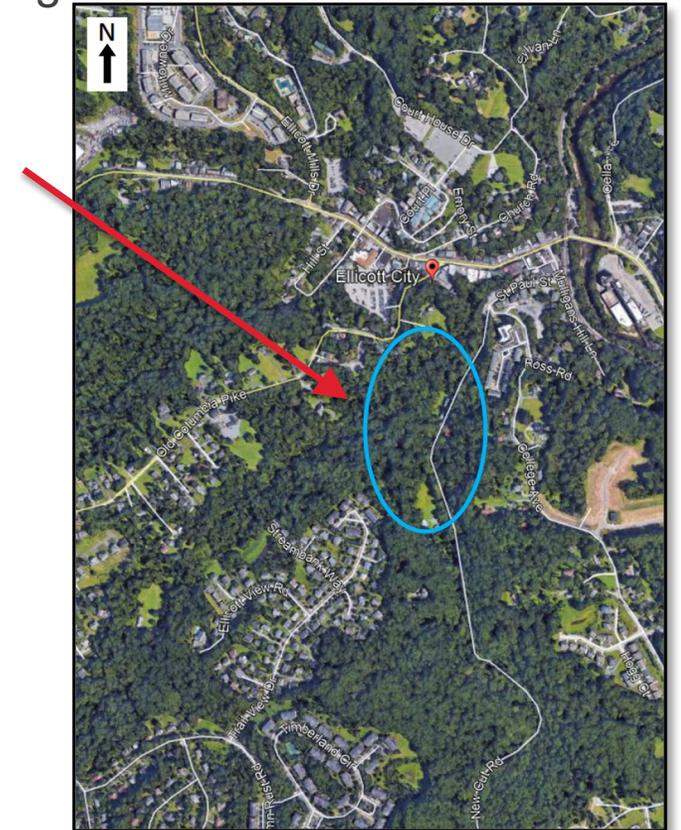
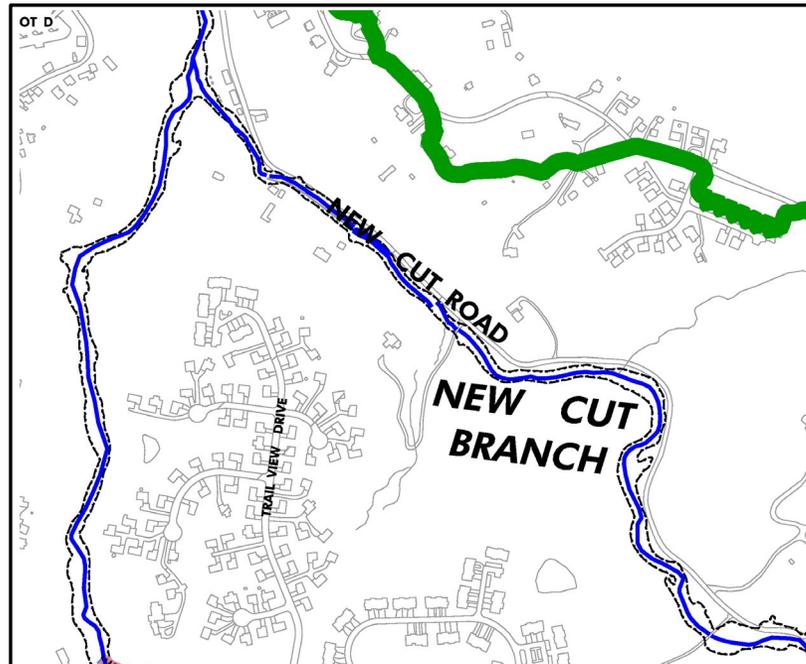
Considerations:

- Projects should begin at downstream channel confluence and proceed upstream
- Existing channel walls may be considered historic structures requiring permitting for modification

FRM STRATEGIES IDENTIFIED BY USACE

New Cut Dry Flood Mitigation Structure

- New Cut flows contributed significant portion of floodwaters to downtown (during both 2016 and 2018 floods)
- Located upstream of the New Cut Branch confluence, a dry flood storage structure could be sized to reduce peak flows from this sub-watershed





FRM STRATEGIES IDENTIFIED BY USACE

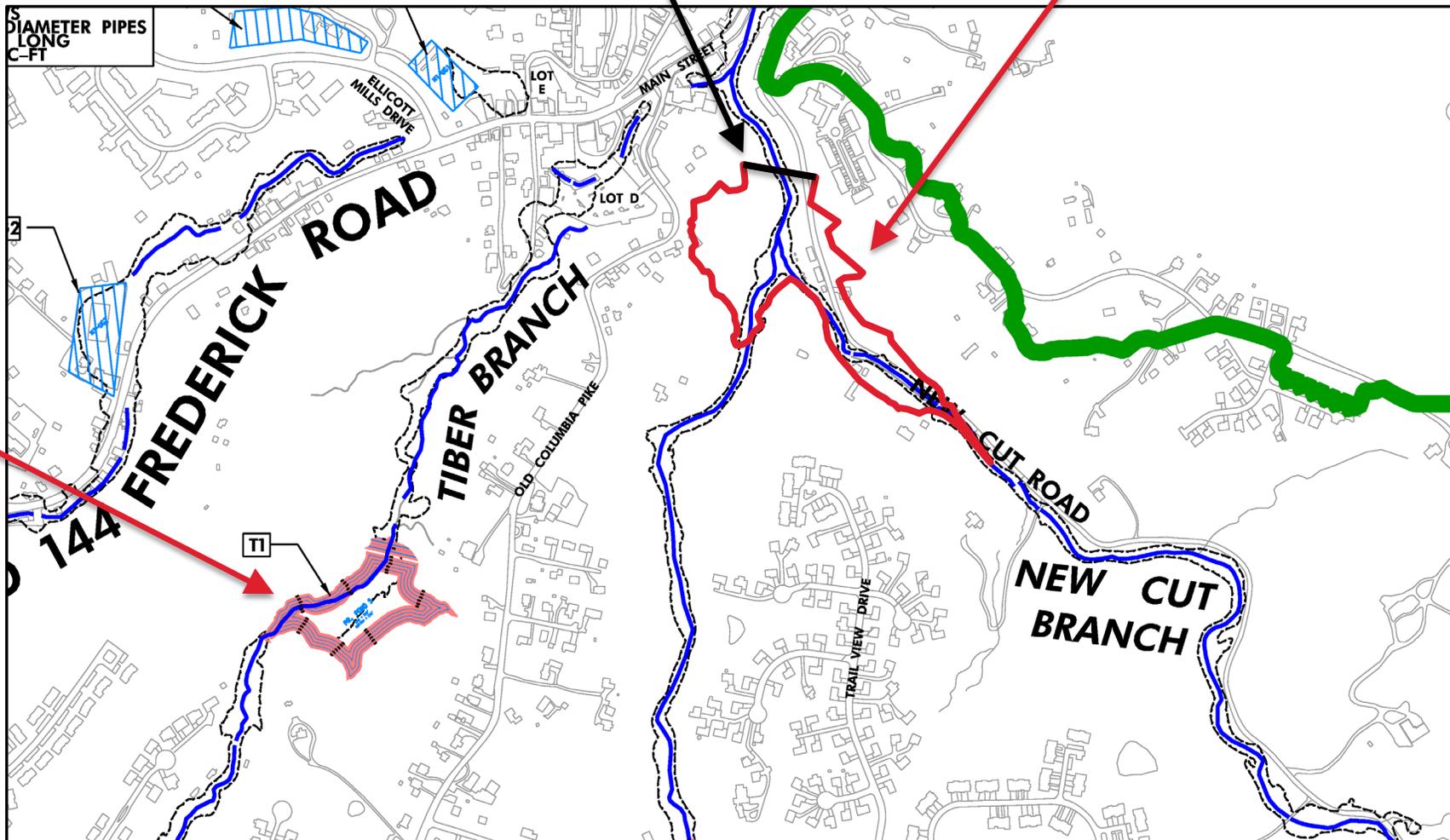


New Cut Dry Flood Mitigation Structure

Possible embankment location (black)

Possible extent of ponding area (red)

T1 Pond
(for comparison)





FRM STRATEGIES IDENTIFIED BY USACE



New Cut Dry Flood Mitigation Structure

Advantages:

- Could significantly reduce peak flows from New Cut Branch watershed
- Embankment/reservoir would retain rock, wood and other debris

Challenges:

- Likely require relocation or closure of New Cut Road
- Acquisitions for numerous properties along New Cut Road required
- Likely be classified as a high-hazard dam requiring permitting
- Possible utility relocations

Considerations:

- Environmental Impact Statement may be required
- Property acquisition challenges
- Placement considerations could be prioritized to minimize visibility from downtown
- Stream mitigation potentially required
- Embankment could be a large concrete structure, depending on size
- Ponding area would remain dry and could potentially remain forested. Would only fill with water during significant storms



FRM STRATEGIES IDENTIFIED BY USACE



Environmental Improvements

- In-stream and riparian improvements
- In-stream challenges from high velocity/debris loads

Parking Restrictions for Downtown Main St.

- New parking structure out of flood plain
- Shuttle service to alleviate loss of street parking
- Vehicles on street increase risk to loss of life

Debris Removal Program

- Annual aggressive program to clear debris along stream reaches including rocks/boulders

Elevated Egress Walkways

- Installed in highest risk areas





FRM STRATEGIES IDENTIFIED BY USACE



Vertical Evacuation Plans for Buildings

- Property / business owners in higher risk areas
- All relevant persons trained to execute

Modeling Analysis

- Model each measure separately to determine impacts and benefits
- Combine measures to see increased effectiveness
- Model different storm scenarios

Interagency Collaboration

- Example: Coordinate with National Weather Service to further improve forecasts and warning systems





EVALUATION OF MEASURES

North Tunnel Approx. 1600LF, 15' finished diameter smooth concrete diversion tunnel
South Tunnel Approx. 600LF, 10-20' finished diameter smooth concrete diversion tunnel
New Measure: Further conveyance increase via targeted excavation (channel lowering / widening) plus a potential parapet wall to increase height of floodplain terraces
Lot D Channel Expansion
Maryland Ave Culvert(s) Approx. 275 LF, 2 x 10' diameter culverts
T-1 Pond - 70 acre-feet
NC-3 Pond - 63.0 acre-feet Technically located on Autumn-Hill Branch (trib to New Cut)
Terraced Floodplain
H-7 Pond - 13 acre-feet.
WE Floodplain & Conveyance
New Measure: Dry flood storage structure upstream of NC Branch confluence
Roberts Prop (H4) - 16 acre-feet
H1-UG1 & H8-UG1 Lot F Roger Carter (25+8) - 33 acre-feet Underground storage structure
H1-UG2 (West End) - 30 acre feet Underground storage structure

Top Tier

- North Tunnel
- South Tunnel
- **USACE Identified:** Targeted conveyance increases (downtown)
- Lot D Channel Expansion
- Maryland Ave. Culvert
- T-1 Pond
- NC-3 Pond

Middle Tier

- Terraced Floodplain
- H-7 Pond

Lower Tier

- West End Floodplain & Conveyance
- **USACE Identified:** Dry flood storage structure (NC Branch)
- H-4 Pond
- H1-UG1 & H8-UG1
- H1-UG2



EVALUATION OF MEASURES

North Tunnel Approx. 1600LF, 15' finished diameter smooth concrete diversion tunnel
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Top Tier

- **North Tunnel**
- South Tunnel
- **USACE Identified:** Further downtown conveyance increases
- Lot D Channel Expansion
- **Maryland Ave. Culvert**
- **T-1 Pond**
- **NC-3 Pond**

Blue/bold are projects County has selected for implementation – Alt. 3G7.0

Middle Tier

- **Terraced Floodplain**
- **H-7 Pond**

Lower Tier

- **West End Floodplain & Conveyance**
- **USACE Identified:** Dry flood storage structure (NC Branch)
- **H-4 Pond**
- H1-UG1 & H8-UG1
- H1-UG2



CONCLUSION

- County considered thorough array of FRM measures backed by modelling
- FRM measures considered by the County can effectively reduce flooding and are the same types considered for USACE FRM projects
- County's plan includes many of the top measures based on USACE criteria
- USACE identified additional FRM strategies for County consideration to further reduce flood risk
- There will still be residual flood risk after construction of measures. County should continue to pursue additional acquisitions, flood proofing of buildings, flood-warning systems and evacuation planning



QUESTIONS?



Report and Evaluation Matrix will be posted at:
<https://www.ecsafeandsound.org/>