Risk Assessment of Verona Township

Presentation to Township
March 3, 2022
Final Project
December 20, 2021

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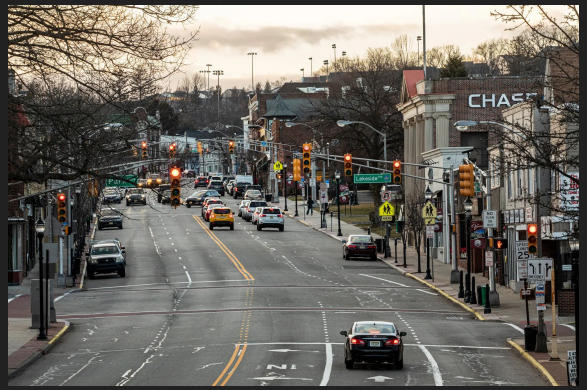
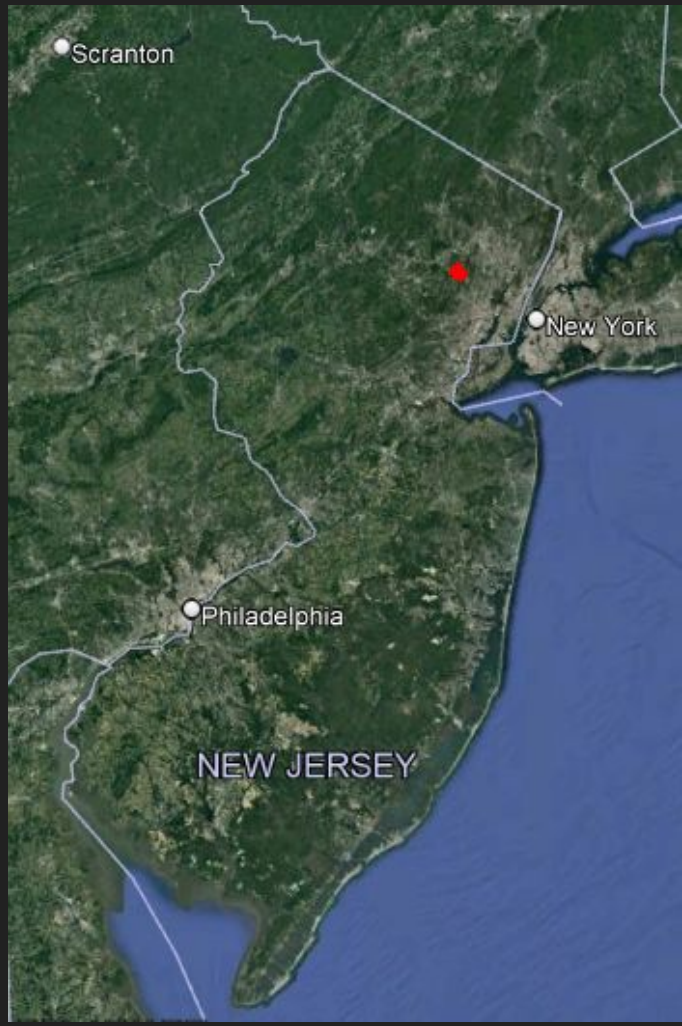


Rutgers University
CEE 556
Methods & Models for Resilient
Building and Infrastructure Systems

Photos from: NY Times



I. Background and Demographics
- Municipality History
- Socioeconomics
- Existing Conditions & Infrastructure
- Topography and Hydrology
- Historical Hazards

II. Flood and Infrastructure Risk
- FEMA and HAND flood maps
- Property Risk
- Evacuation Potential
- Infrastructure Interdependencies and Vulnerability
- ***Highest Risk Areas***

III. Storm Impacts and Damage Metrics
- Site Photos and Media
- Damage Assessment

IV. Hydrology Data & Model

V. LiDAR Model

VI. Recommendations
- Stormwater Management & Other Infrastructure
- Waterway and Lake Modification
- Policy and Programmatic Interventions

Municipality Background

Population (2020) :**14,472**
Population Density: 5,215 *(2.76 sq. mi. Total area)*

Population change between 2010 (pre-Sandy) & 2020 (pre-Ida)
2010:13,329
2020:14,472
Change:1,243 (9.3%)

Demographics / Business / Political Dynamics:

Race Breakdown: 90.9% White // 2% Black // 5.4% Asian // Hispanic or Latino 6.9%

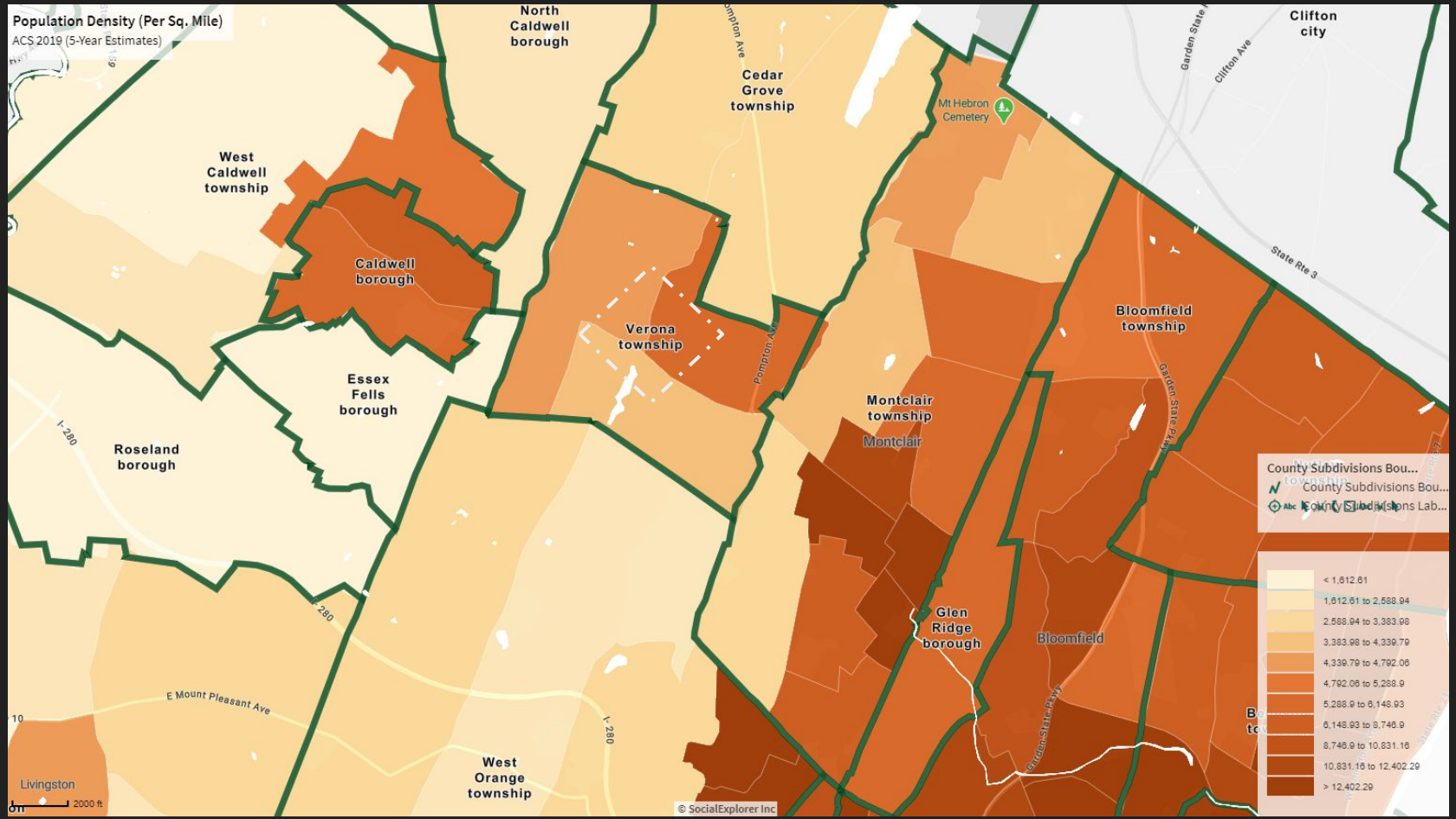
- Median Gross Rent (2015-2019): **$1,672**
- Bachelor's degree or higher education percentage **= 63.6%**
- Mean travel to work time 31.8 minutes *(2015-2019)*
- Minority Owned firms (2012): 258 of 1,875 - **13%**
- **Median Income** *(Household)* - **$128,060** *//* Poverty Percentage **~2.6%**
- Foreign born persons - **12.9 %**

- County of Essex controls the main retention basin in the township AND all of the higher volume roadways that run through the township

Source: US Census Bureau (QuickFacts)

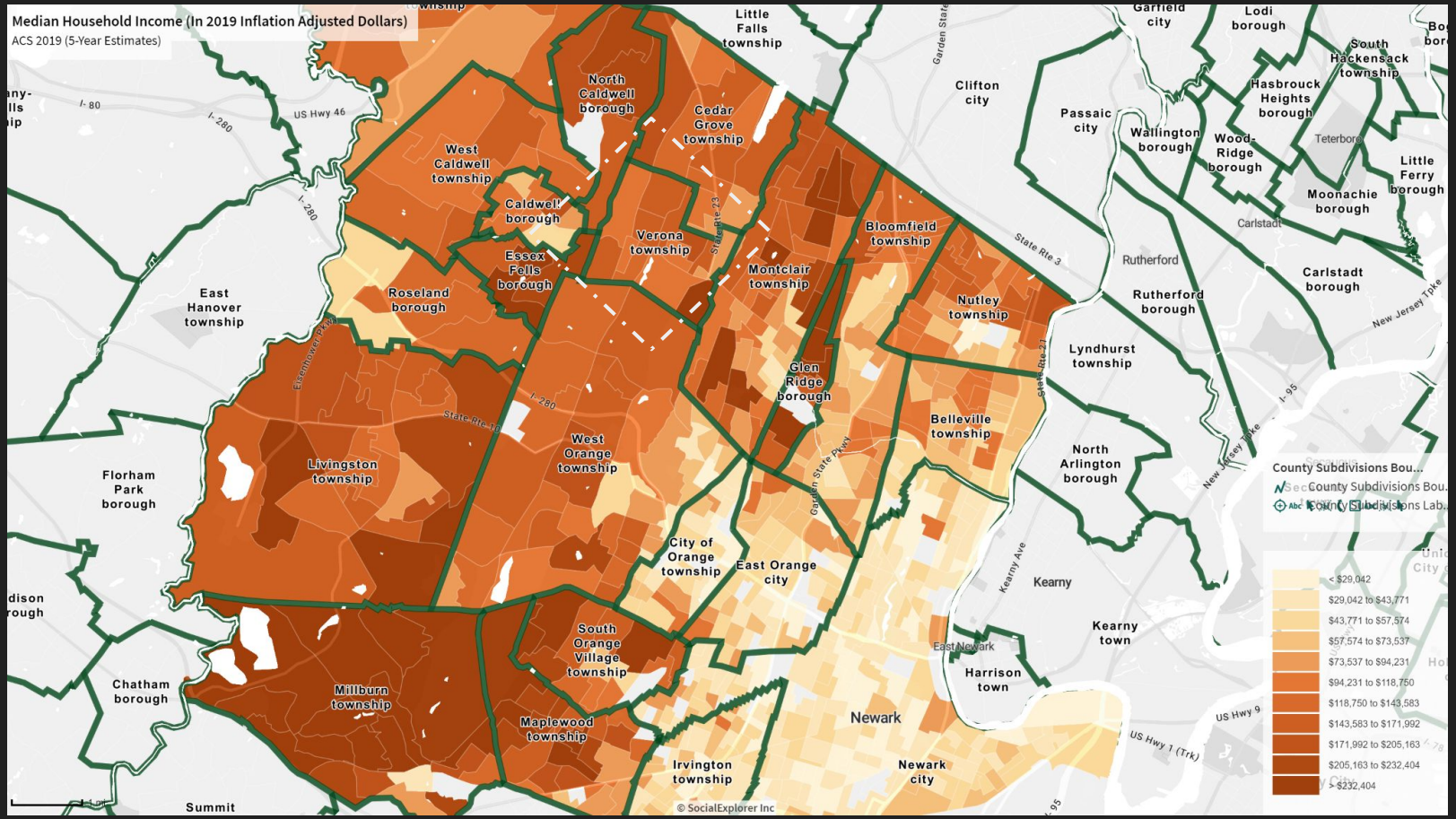
Social Explorer Graphics

Population Density



Socioeconomics

Census data - income compared to County



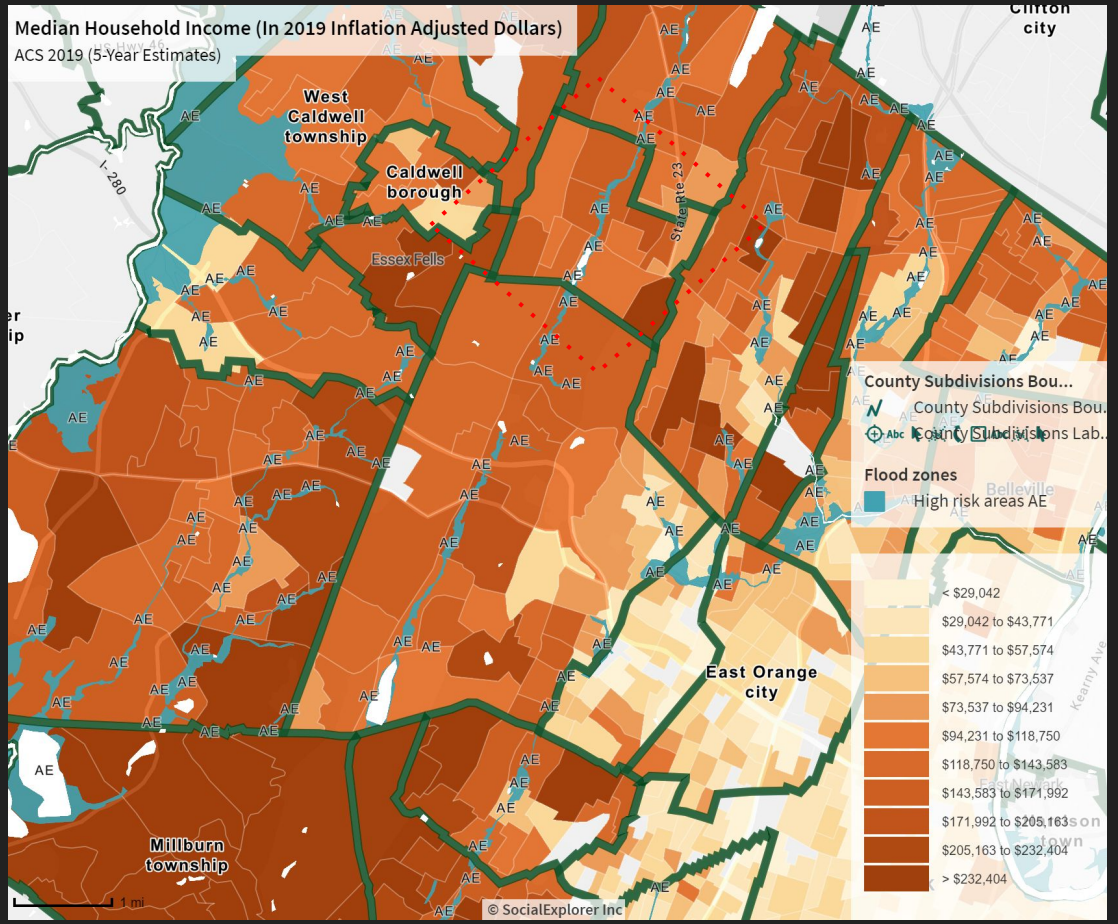
Municipality Background of Risk Factors

High-Level: *consider the types of structures, facilities and population profiles that are at the highest level of risk*

- Property in High Flood Zones
- Low mobility areas
- Non-ambulatory persons
- Repetitive Loss areas

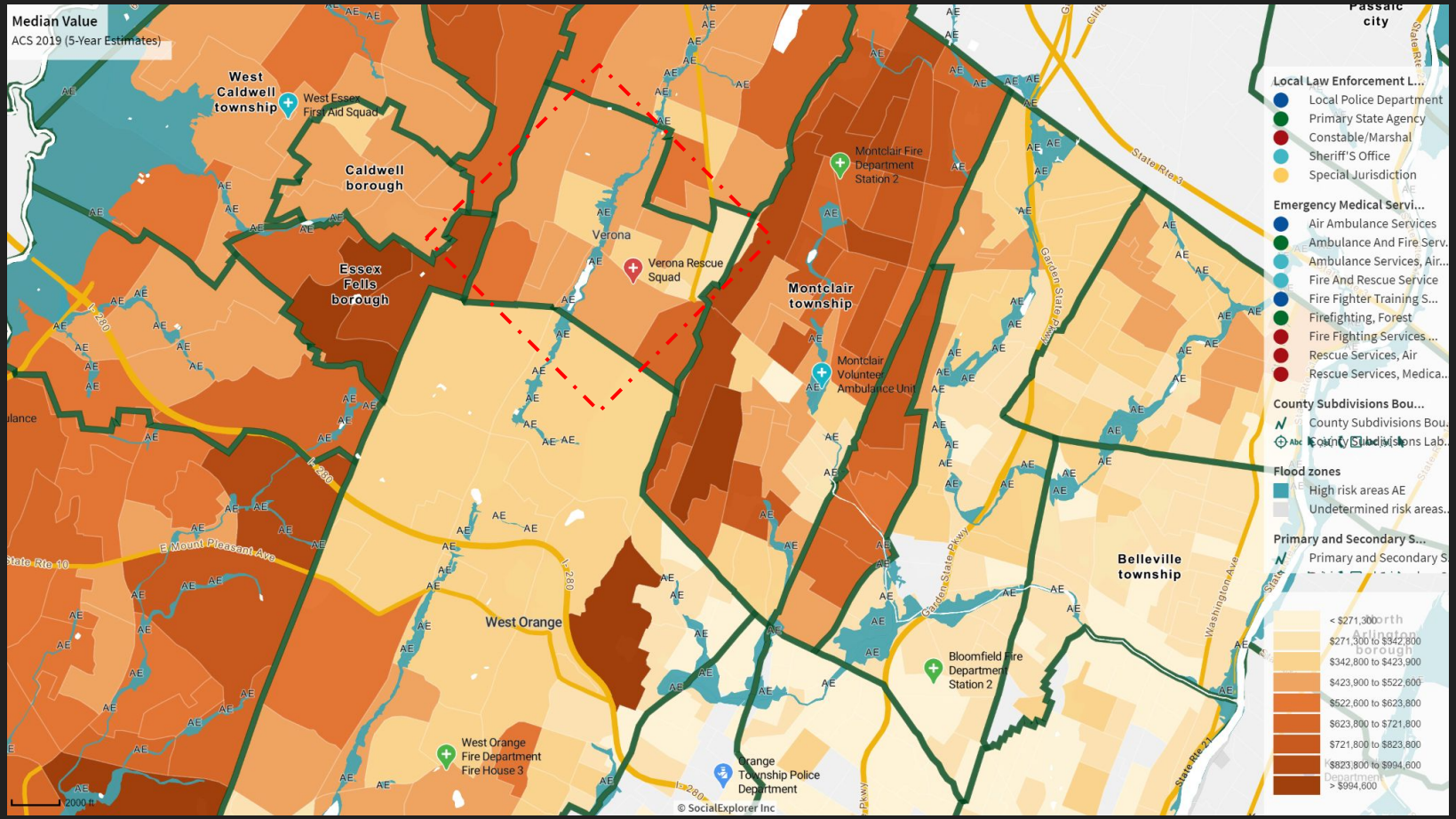
Township of Verona
(data from FEMA Region 2)
65 NFIP Policies
60 Claims Losses
$284,742 in payments

2 Repetitive Loss Properties
1 Severe Repetitive Loss Properties



Social Explorer Graphics

Median Home Value - *For context of risk to real property*



Existing Conditions & Infrastructure

5,130 Total Building Properties (Essex County Parcels)

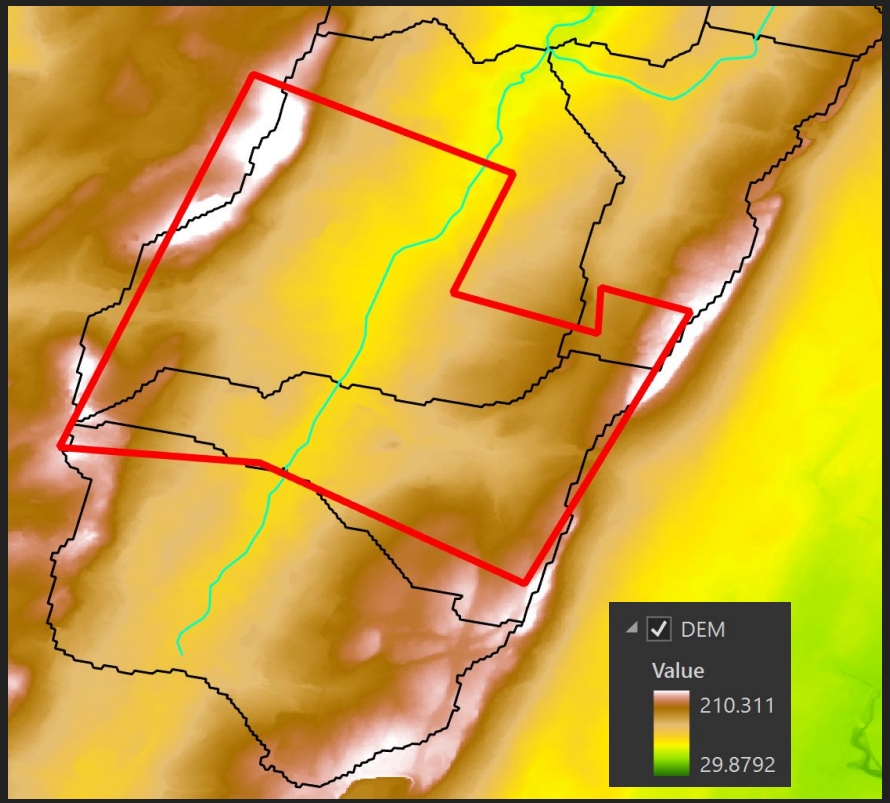
4,870 Residential Buildings (94.9%)
$229,000 = Mean Building Value
74 Years = Mean Age
Building Age ranges from brand new (single digit) to the oldest residential building of 250 years

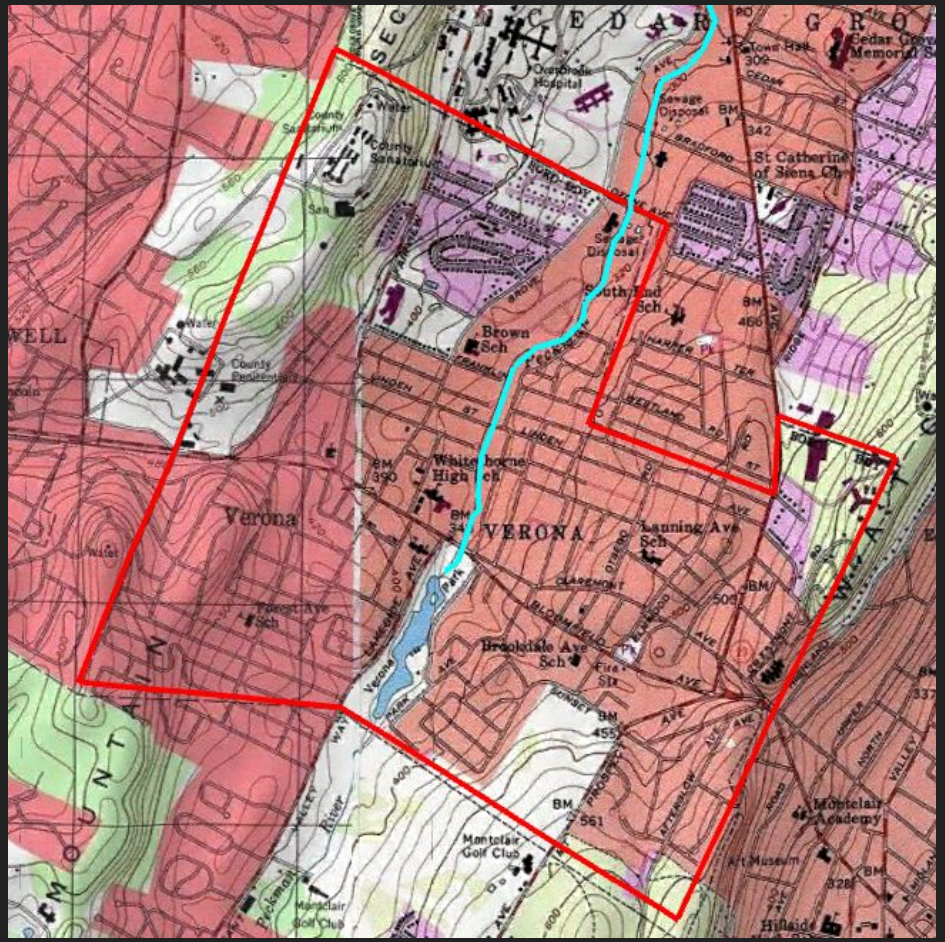
185 Commercial Buildings (3.6%)
$638,000 = Mean Building Value
72.5 Years = Mean Age

Building Classifications:
2 - Residential
4A - Commercial
4B - Industrial
4C - Apartment
15A & B - Public School
15C - Public Property (Park, Municipal Building, etc.)
15D - Church & Charitable
15F - Other exempt properties

Topography & Hydrology

Town spans hills and valley of a small watershed





Hazards

Historical events - August 2018 flooding and Hurricane Ida 2021 of the Peckman River in Verona

- 2018 Flooding: (*From Essex County Hazard Mitigation Plan)*

  August 11th
  4:50pm EDT rose above its flood stage of 3.5 feet
  4:55pm EDT continued to rise above its flood stage of 4.0 feet
  5:10pm EDT major flood stage of 5.0 feet
  5:35pm EDT cresting at a height of 6.4 feet
  6:50pm EDT river fell back below flood stage

  Record crest at this location is 6.6 feet.

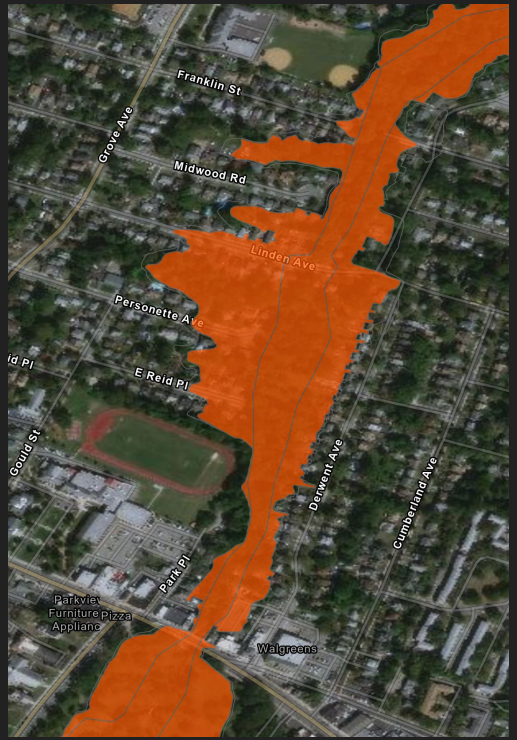
- Hurricane Ida 2021

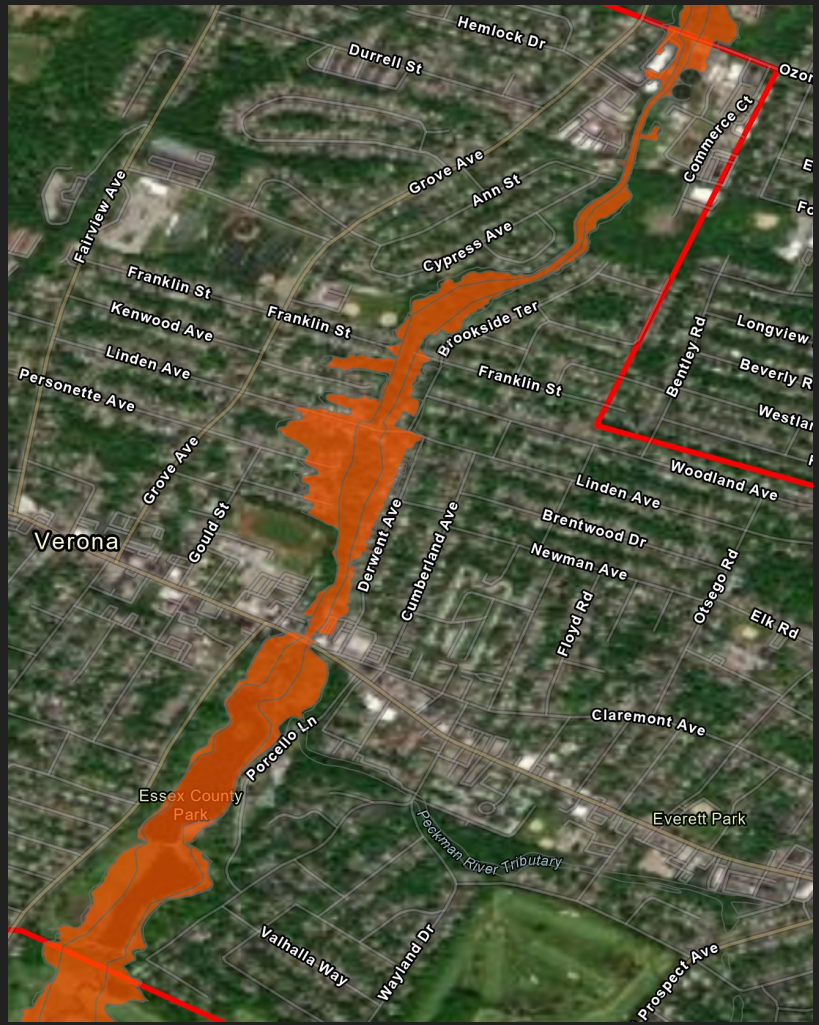
  USGS gage on Ozone Avenue bridge recorded depth of >5 feet for 3 hours, with a peak depth of 6.2 feet

FEMA Flood Maps

Zone AE - 1% Annual Risk determined by detailed methods. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain mgmt standards apply.

High-risk regions
- Central Verona
- Sewer Treatment Plant





Height Above Nearest Drainage (HAND) Flood Maps

The FEMA AE zone for central and northern Verona corresponds to ~8.5 feet (2.6m) of flood depth.

By mapping this with HAND (Height Above Nearest Drainage) and adding several additional feet of flooding, we can see what increased flooding may look like.

Generally, the increase in possible flood depth only results in small increases in flooded area up to 11.4 feet (3.5m) of flood depth.

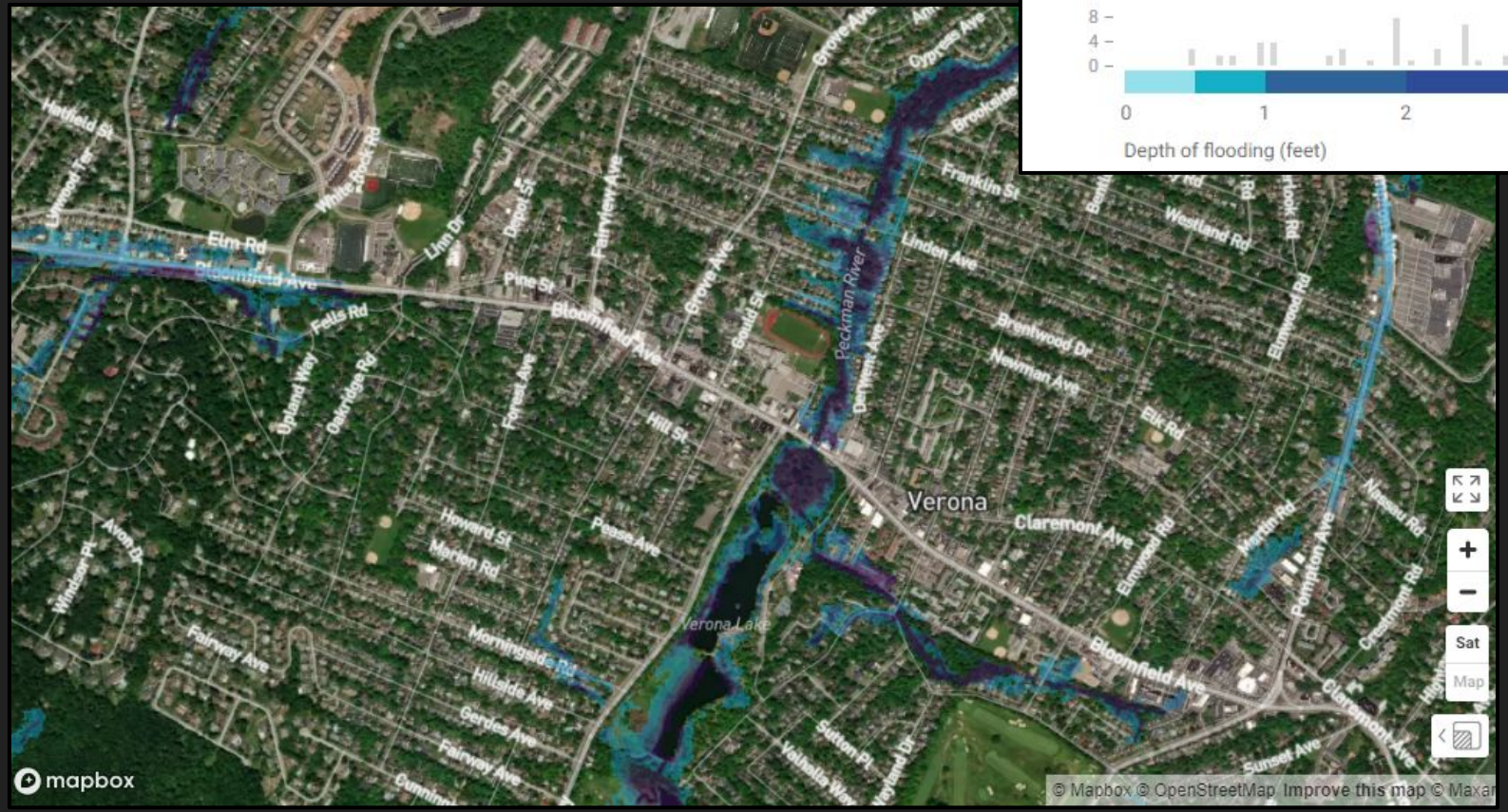
Property Risk in Downtown Verona

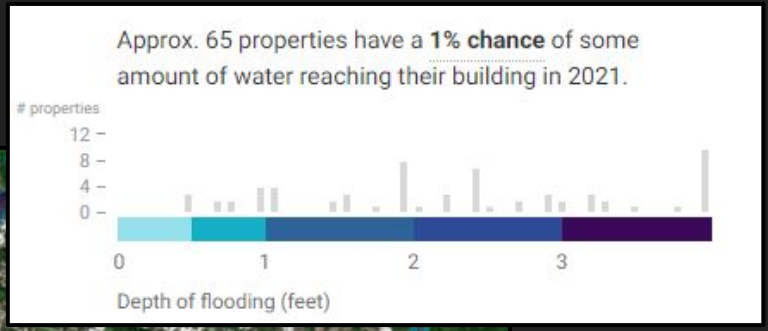
- Appx. 70 properties in downtown Verona have >26% chance of being *severely* impacted by flooding in the next 30 years
  - *Severe impact* - water level reaches to building edge, at least
    - Increases possibility of lower-level damage to residential properties
    - Reduces employee, customer accessibility to government and commercial properties

- Number of properties at flood risk:
  - ~17% of residential properties
  - ~18% of commercial properties
  - ~33% of schools, worship centers, govt. properties
  - ~25% of roads

Source: FloodFactor.com

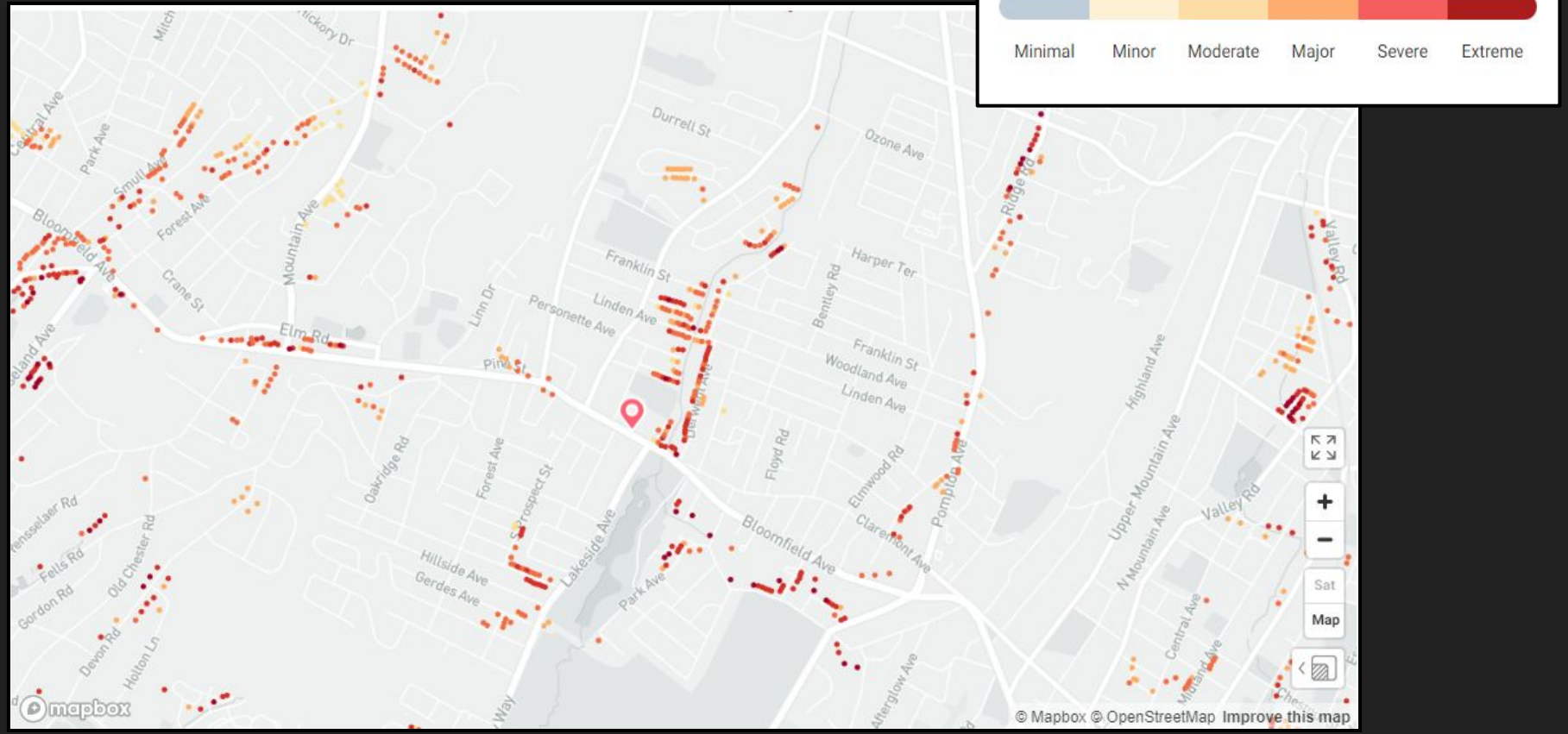
Flood Risk





Source: FloodFactor.com

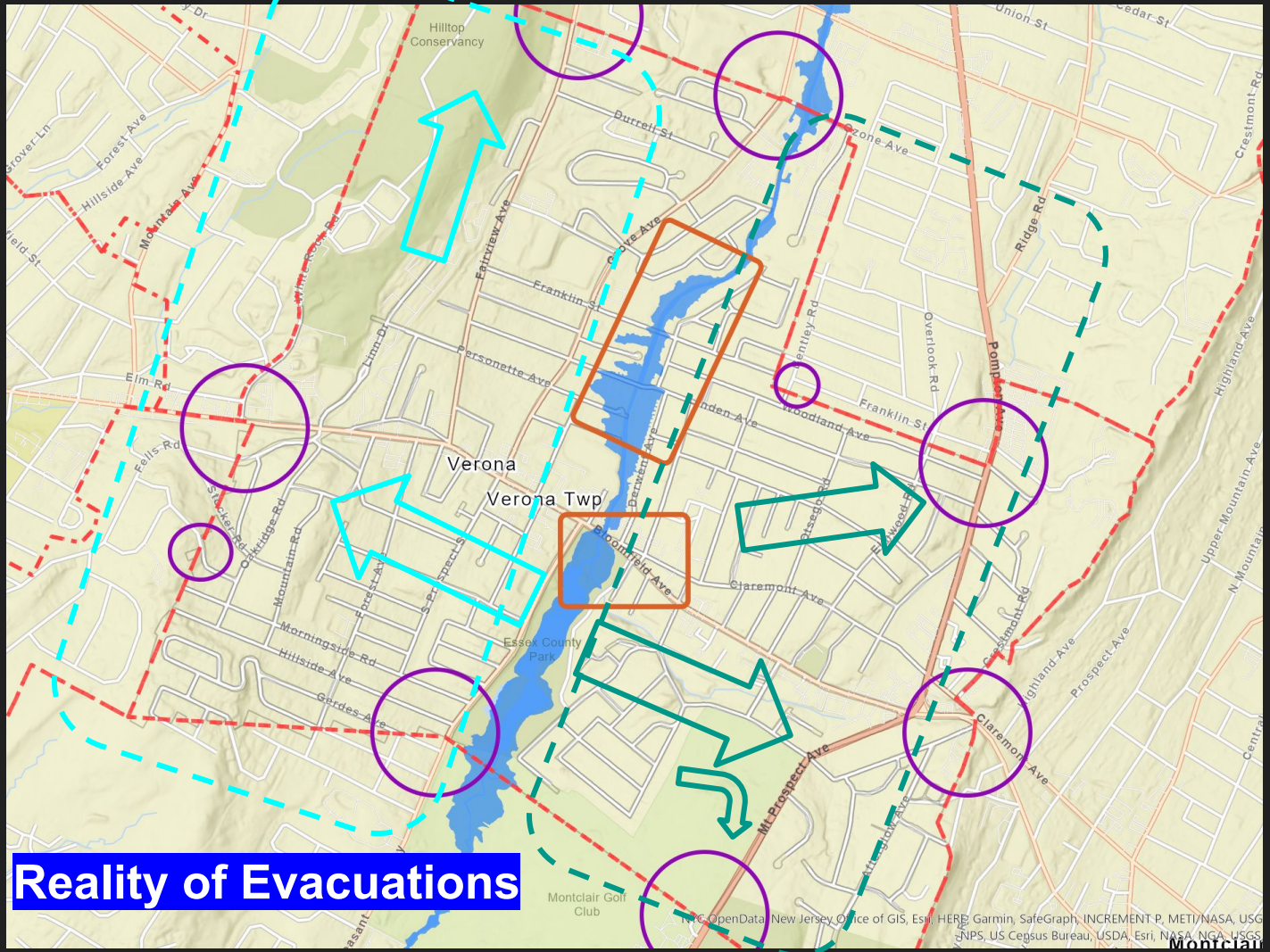
Flood Severity



Source: FloodFactor.com

Evacuation Potential

Reminder: Population Density *(for potential evacuation procedures)*


Hilltop Conservancy
Verona
Verona Twp
Essex County Park
Montclair Golf Club
Reality of Evacuations
Road Access Points
East - West Loss of Access
Priority Evacuation Roads
- Pompton Ave (US-23)
- Bloomfield Ave
- Mt. Prospect Ave
- Claremont Ave.
- Pleasant Valley Way
- Grove Ave.
- Fairview Ave

Infrastructure Interdependencies

How does a natural occurrence impact a variety of sectors?

1. Stormwater drains
    a. Severe Ida downpour over 5-hour stretch
    b. Caused overloaded drains and water systems

2. Sewer plant
    a. Heavy rains caused high flooding levels
    b. Sewer plant underwater

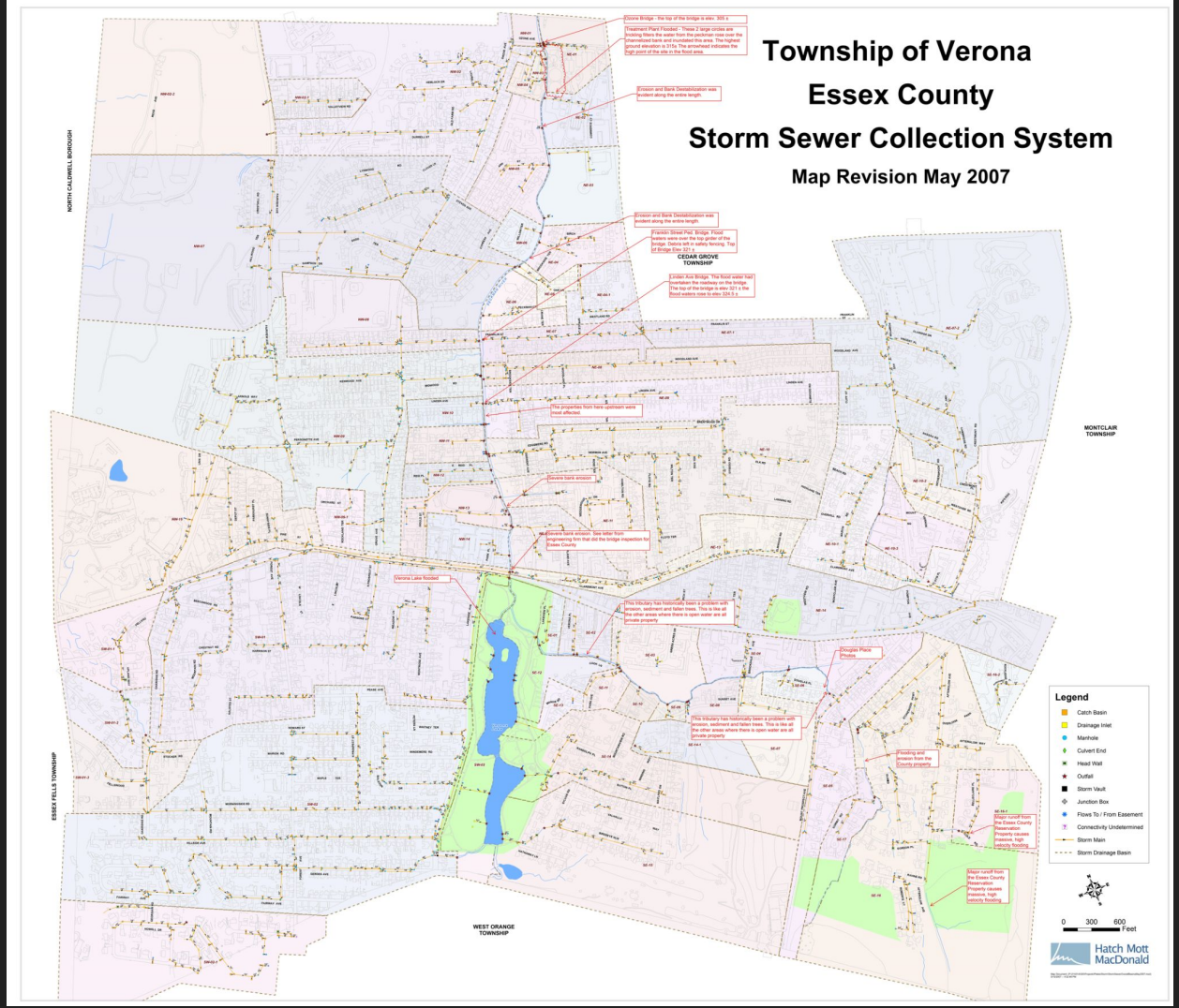
3. Waste collection services
    a. Water infiltration caused widespread property damage
    b. Mass disposal, strain on waste pickup services

4. Inundated call center
    a. Emergency calls from Verona and neighboring towns
    b. Over 700 calls answered

Source: MyVeronaNJ

High Risk Areas

Township provided us a map of impacted regions

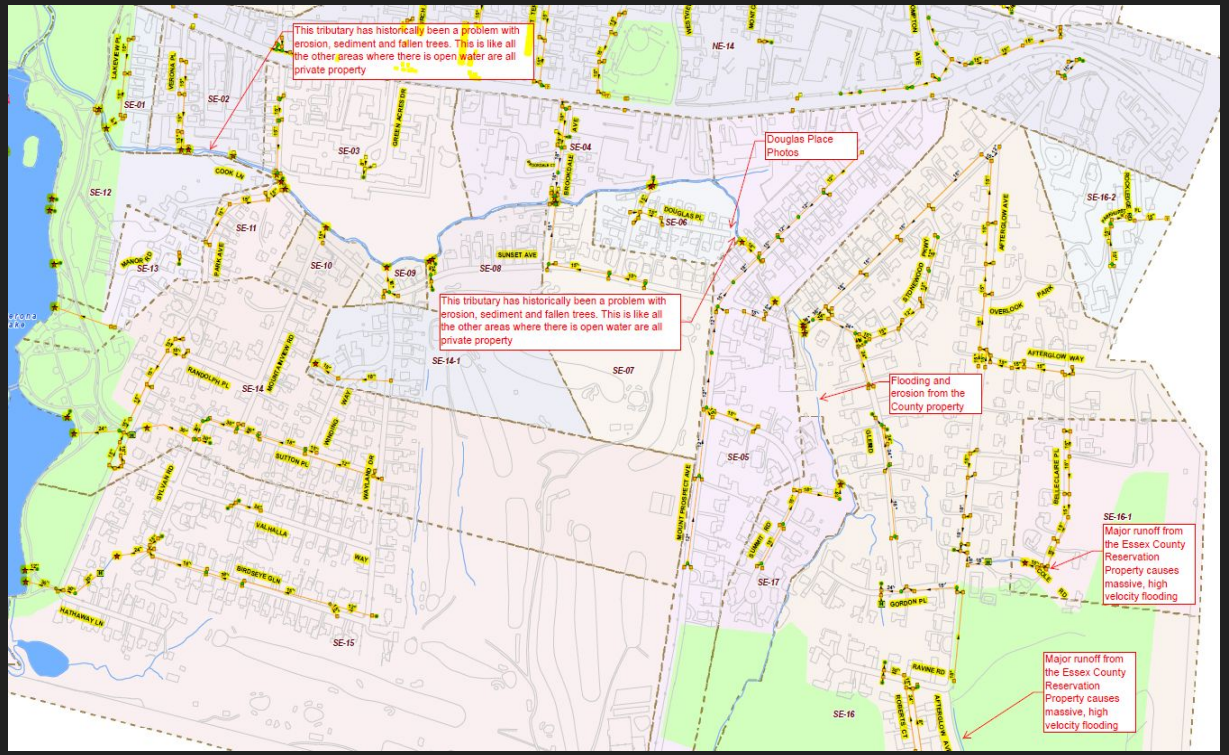


High Risk Areas: Tributary Erosion

The major issues with the tributary are historically erosion, sediment and fallen trees

Tributary erosion and sedimentation have happened constantly. However, no permanent solutions have been attempted

Major runoff from the Essex County Reservation Property causes massive, high velocity flooding



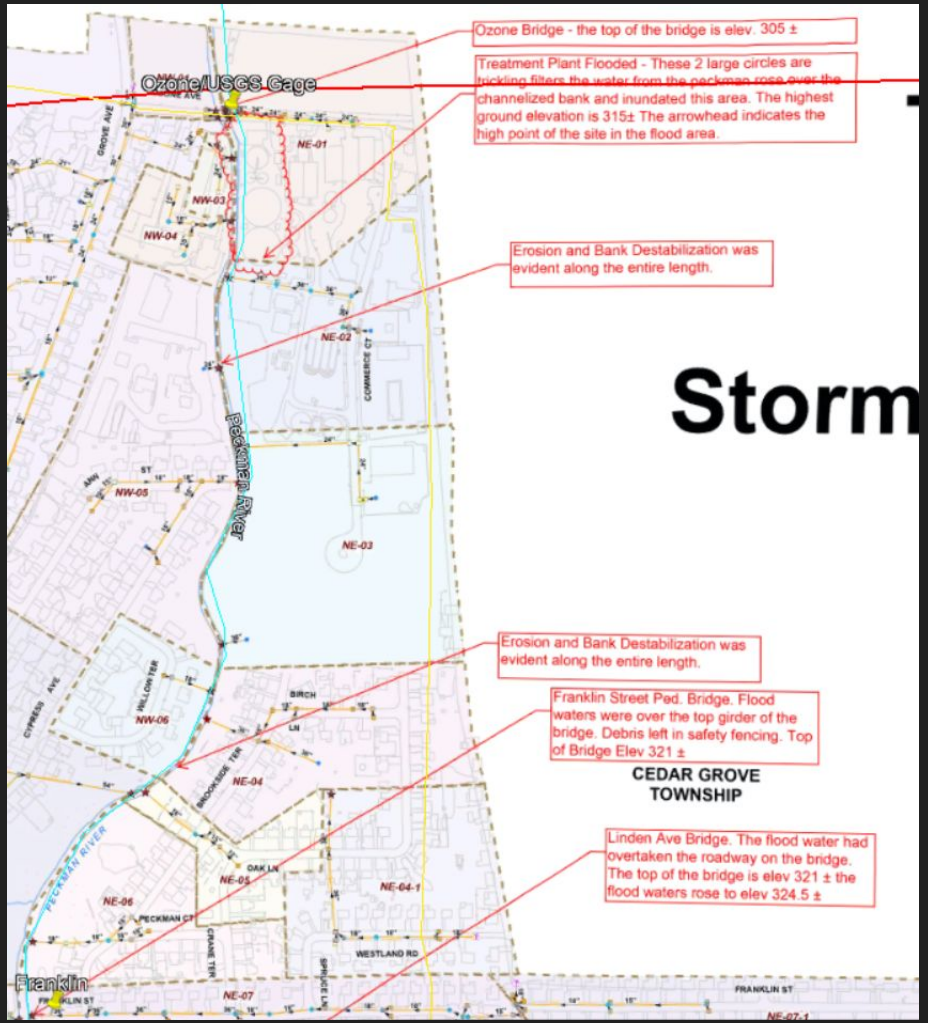
High Risk Areas: Tributary Erosion

Severe erosion of the banks has left many areas where sediment has formed high shoals

Shoals have forced the water courses to split and create new areas of flow/erosion

High Risk Areas:
Peckman River Erosion

Erosion and bank destabilization are along the entire length of Peckman River after Hurricane Ida

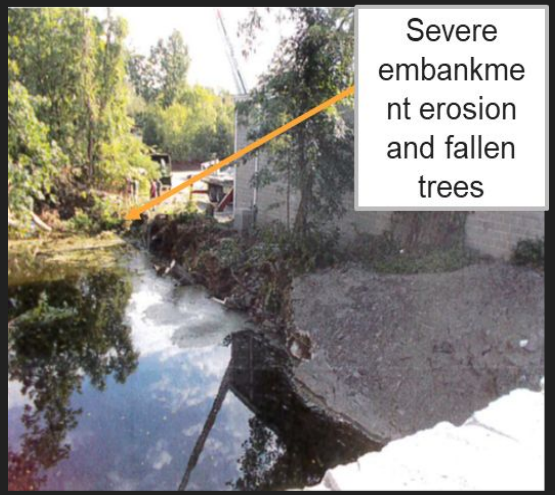


High Risk Areas:
Peckman River Erosion

Severe embankment erosions on the northeast embankment 25’ to ±70’ downstream of the bridge on Bloomfield Ave.

Grouted riprap on northeast and northwest embankment protection was damaged 25’ from the bridge on Bloomfield Ave.

The edge of the northeast embankment of bridge on Bloomfield Ave. is 5’-10’ away from the building adjacent to the bridge



High Risk Areas: Erosion

Channel re-shaping
- To prevent further embankment erosion and shoaling
- Creates stable river channel

Riprap and filter fabric
- Effective erosion control practice
- Easy-to-use method for decreasing water velocity and protecting slopes from erosion
- Cost $5-$10 per square foot (est. from ~$100/ton)

Gabion Basket
- Ease of handling and transportation
- Speed of Construction
- Flexibility (Gabions tolerate movement)
- Easy-to-use method for decreasing water velocity and protecting slopes from erosion
- Cost $20-$40 per square foot (est. from ~$100/ton)

Concrete walls
- Can work well in tight areas where slope must be steep

High Risk Areas: Tributary Erosion

For a region of river 100 feet long needing
4ft high stabilization on both banks:

100 ft * 4ft * 2 banks = 800 sf

@ 10 $/sf for riprap = ~$8,000

@ 40 $/sf for gabion = ~$32,000

High Risk Areas:
Bridges act as bottlenecks

High flows under the bridges exceed what the openings can convey.

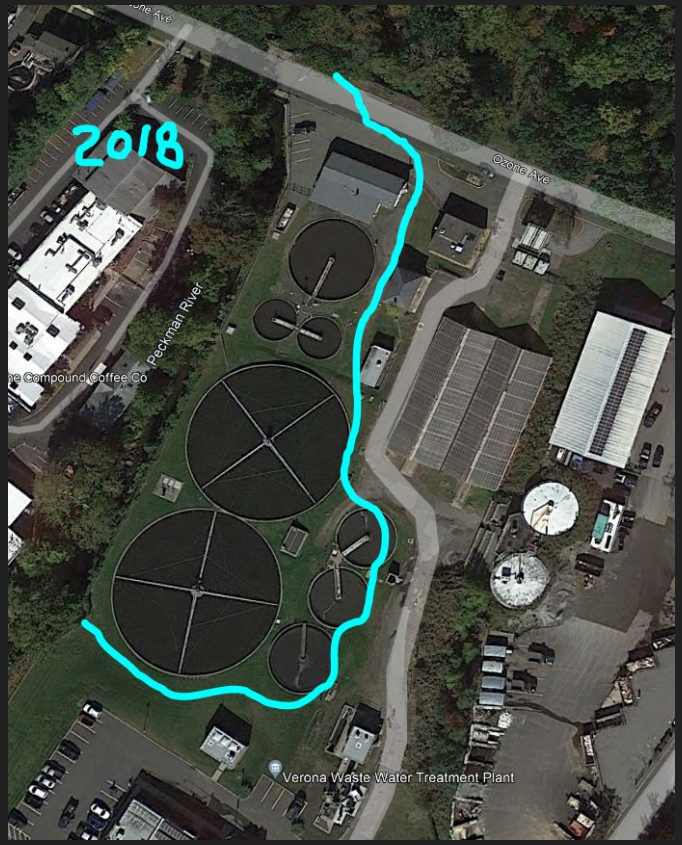
Generally, it is not possible to increase the opening size under the bridge. The width is fixed by the foundations and the depth is fixed by the depth of the deck and streambed below.

It may be possible to excavate a few feet down to make the channel deeper near bridges. This may destabilize the footings - further investigation is needed.

Remove small dam at Linden Bridge?

Angled wingwalls on the upstream side of the bridge can channel the water through and increase capacity.

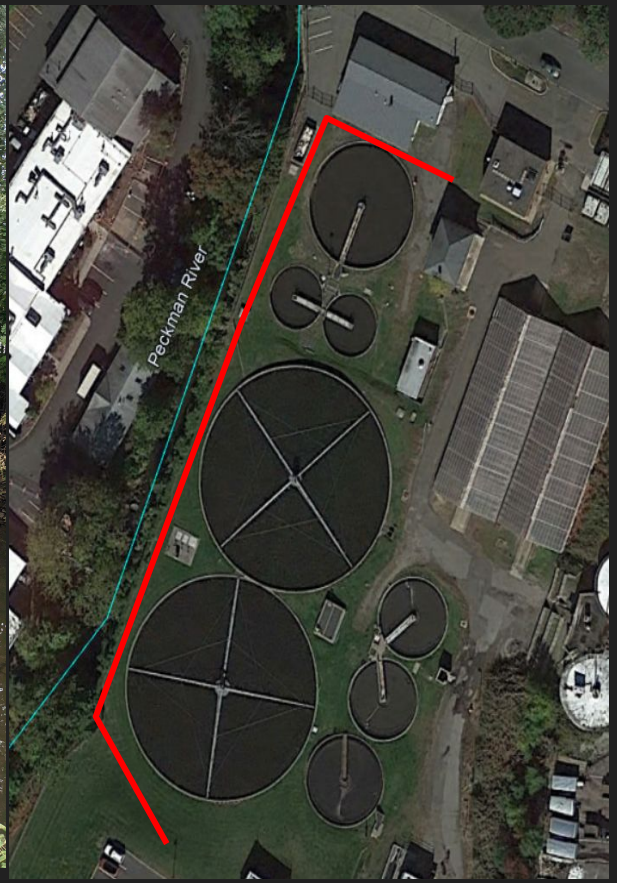
High Risk Areas:
Flooding at WWTP



High Risk Areas: Flooding at WWTP

Due to the varying severity of flooding from Hurricane events, permanent flood walls would not be necessary. It is very likely it would not be feasible to build a permanent wall due to the close proximity of the WWTP and the Peckman River.

Temporary flood barriers, sandbags, or flood wrapping systems are more suitable for emergency events for non-residential buildings.



High Risk Areas:
Flooding at WWTP

Using **sandbags** and taking a conservative approach, would need roughly 5,000 to 6,000 units.

Purchasing filled sandbags would cost between $40 to $50k in total.

They need to be stored properly during cold weather, otherwise they will be unusable.

The disadvantages of sandbags are high disposal costs as the sandbags will be contaminated after use.

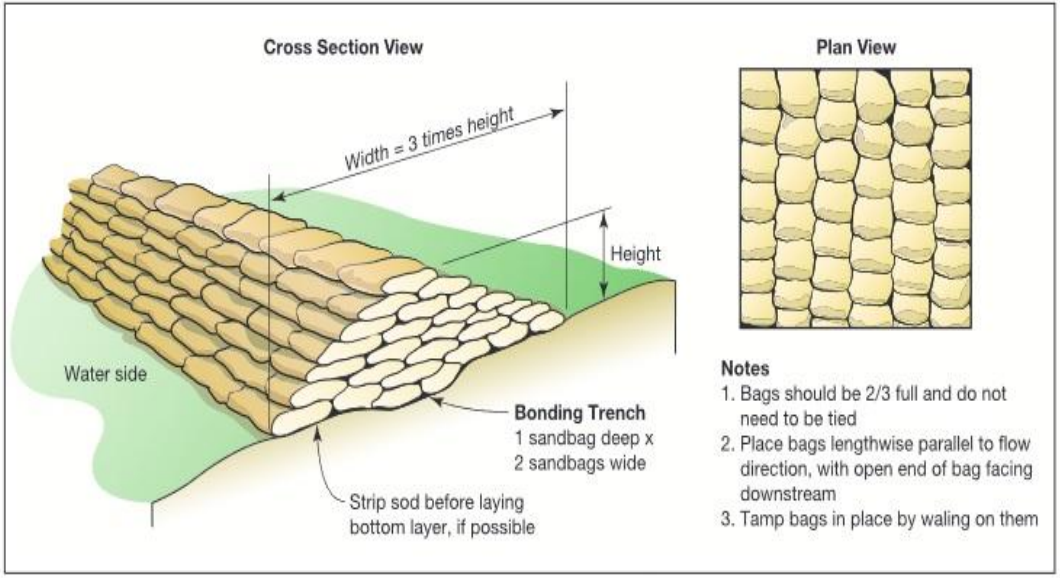


Figure 4-22. Techniques for proper placement of sandbags (source: USACE St. Paul District)

High Risk Areas:
Flooding at WWTP

Temporary flood barriers are more resilient and can be used multiple times with proper storage and cleaning after deployment. They can be filled with water (Fig 4-23), or sand/gravel (Fig 4-24). Tests show these barriers are designed to protect against riverine flood depths up to 3 feet.

The barriers have to be sized for the site. Annual drills and training will be required to ensure adequate time to prepare and setup. These barriers are only suitable for non-coastal flooding applications, as saltwater may hinder the performance.

Costs vary depending on quality and manufacturer, a PIG water-filled flood barrier (empty) of 3 ft tall and 20 ft wide is $461. For 600 LF, the total cost would be ~ $14,000.

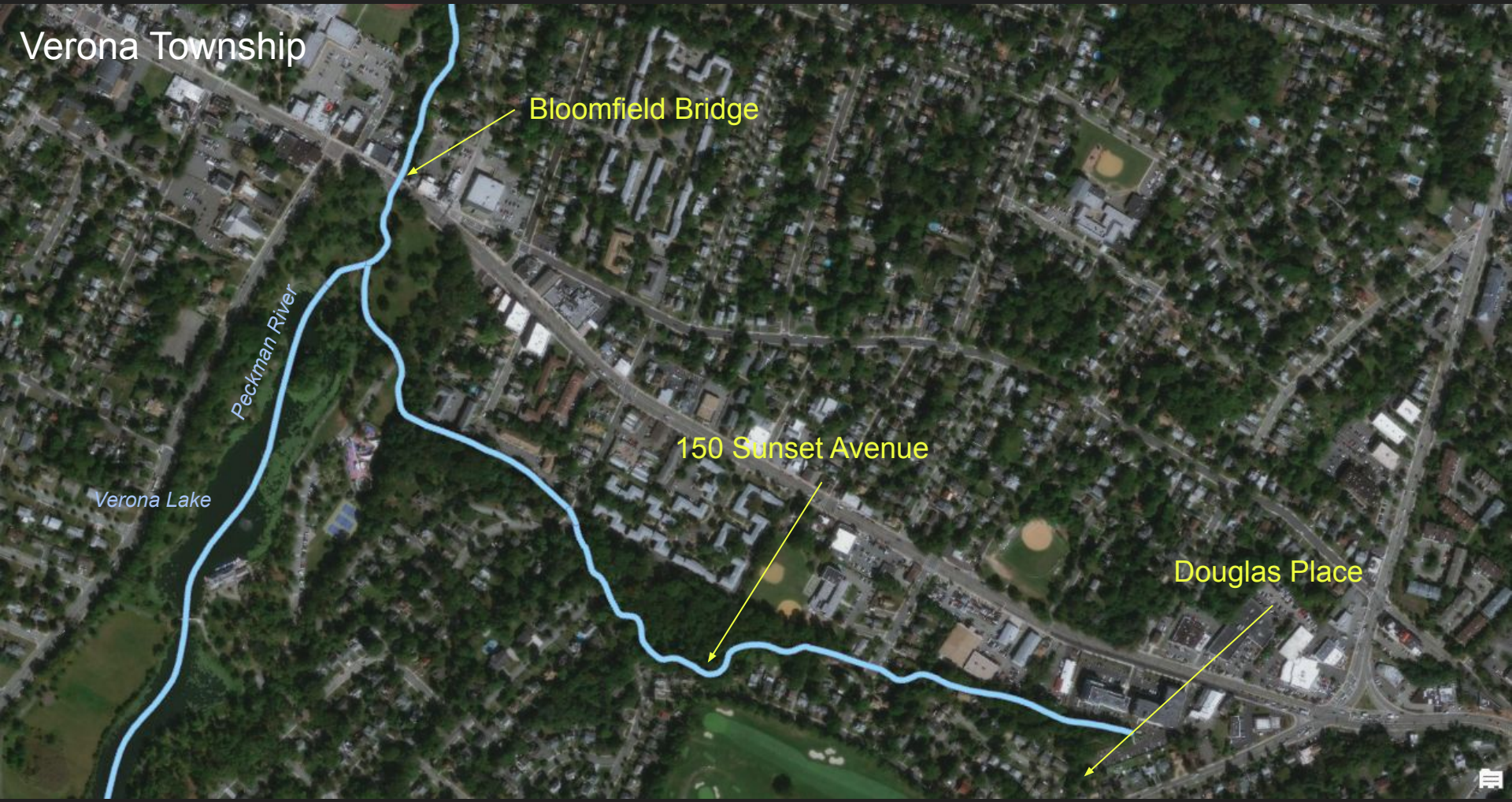
Figure 4-23. Three-foot-high water-filled temporary barrier protecting a structure in Tunica, MS (source: Hydrological Solutions, Inc.)

Figure 4-24. Gravel-filled containers that formed a barrier to protect the University of Iowa (2008)

How severe is the Erosion?

Tools:

- Faro Focus laser scanner
- GPS
- New Jersey Airborne LIDAR (2014)
- ArcGIS Pro


Verona Township
Bloomfield Bridge
Peckman River
Verona Lake
150 Sunset Avenue
Douglas Place

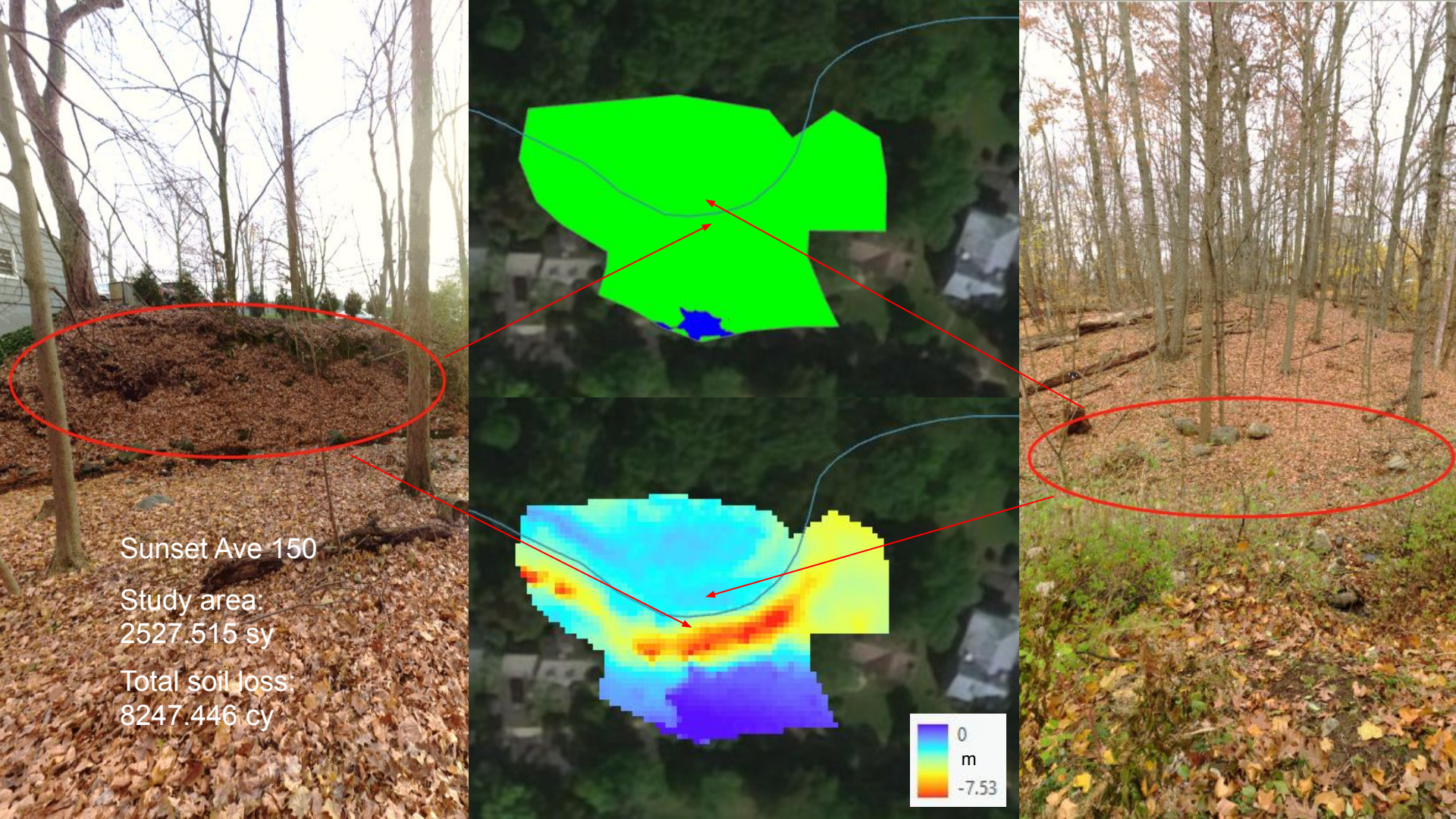

Building Foundation
Erosion
6.5


Ground Points
(Airborne LIDAR)
Field-scanned
point cloud
Georeferencing
Overlay with
airborne LIDAR
Ground point
classification
Ground Points
(Laser-scanned data)
Difference between
surface

Bloomfield Bridge

Study area:
1030.59 sy

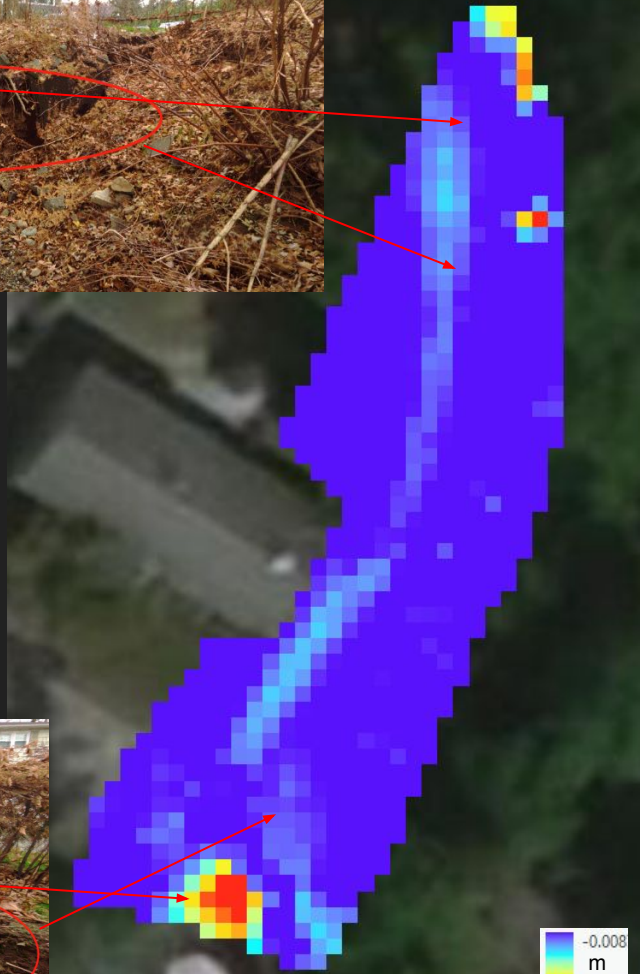
Total soil loss:
2304.1 cy


Sunset Ave 150
Study area:
2527.515 sy
Total soil loss:
8247.446 cy
0
m
-7.53

Douglas Pl

Study area:
1007.059 sy

Total soil loss:
263.57 cy



Future Improvements for Quantifying Flood-related Erosions

Data collection

- 3D modeling to erosion-prone area pre-disaster
- Hardware: drones vs. static laser scanner
- River bed profile

Methods

- Fine-scale flood data (e.g. 1 meter)
- SRH-2D (2D depth-averaged hydraulic & sediment transport model) (Lai et al 2015)
- Lateral bank retreat simulation (Lai et al 2017)

Hydrology

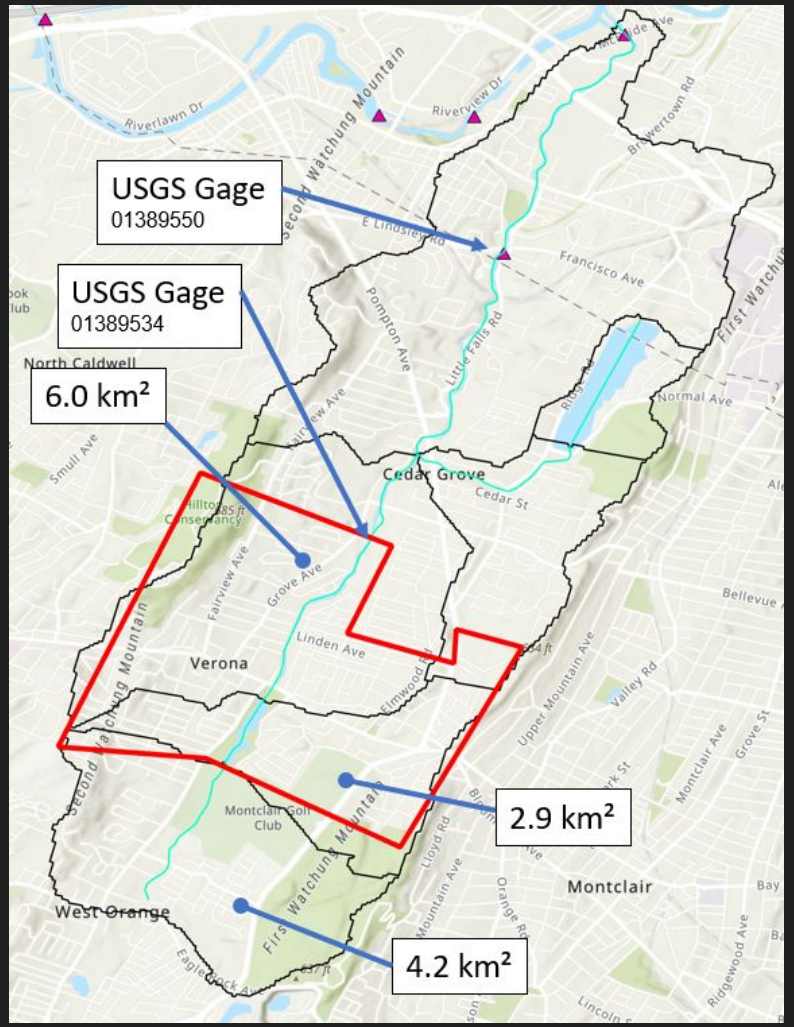
Verona is upstream in a small catchment area that flows into the Passaic River.

The area in the catchment is mostly developed - working with existing stormwater systems. Bylaws for new development will not address existing problems.

Ideally - distributed network of detention basins, infiltration ponds, green infrastructure.

However, hard to mandate the addition of these improvements on private property.

Need to add green or gray infrastructure to mitigate flood risks and control flow in the Peckman River.



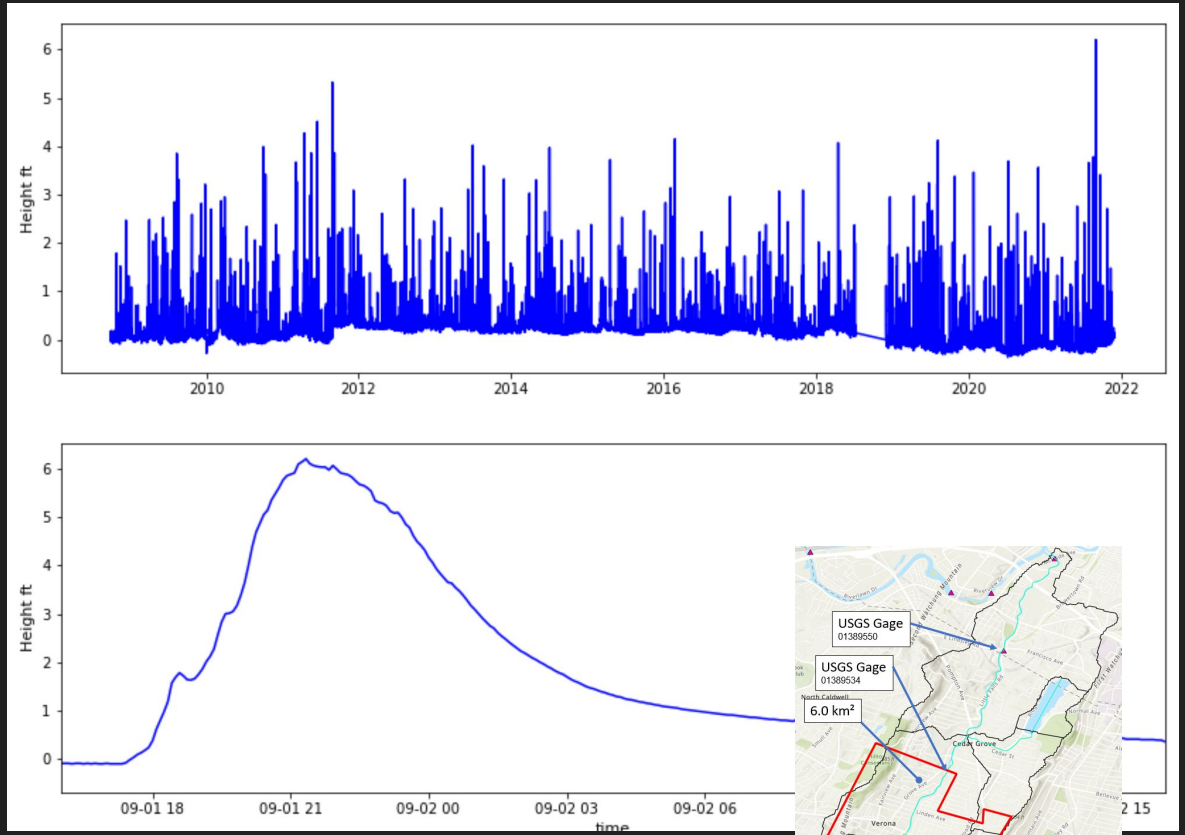
Hydrology

USGS gage 01389534 is near the Verona sewer plant on Ozone Ave

Height data 2008-2018, 2018-present
15 minute to 5 min resolution

Hurricane Ida is the largest recorded event at this location since Irene (2011)

Peak height of 6.2 feet during Ida
- Height above 6 feet for 30 minutes
- Height above 5.5 feet for 2 hours
- Height above 5.0 feet for 3 hours



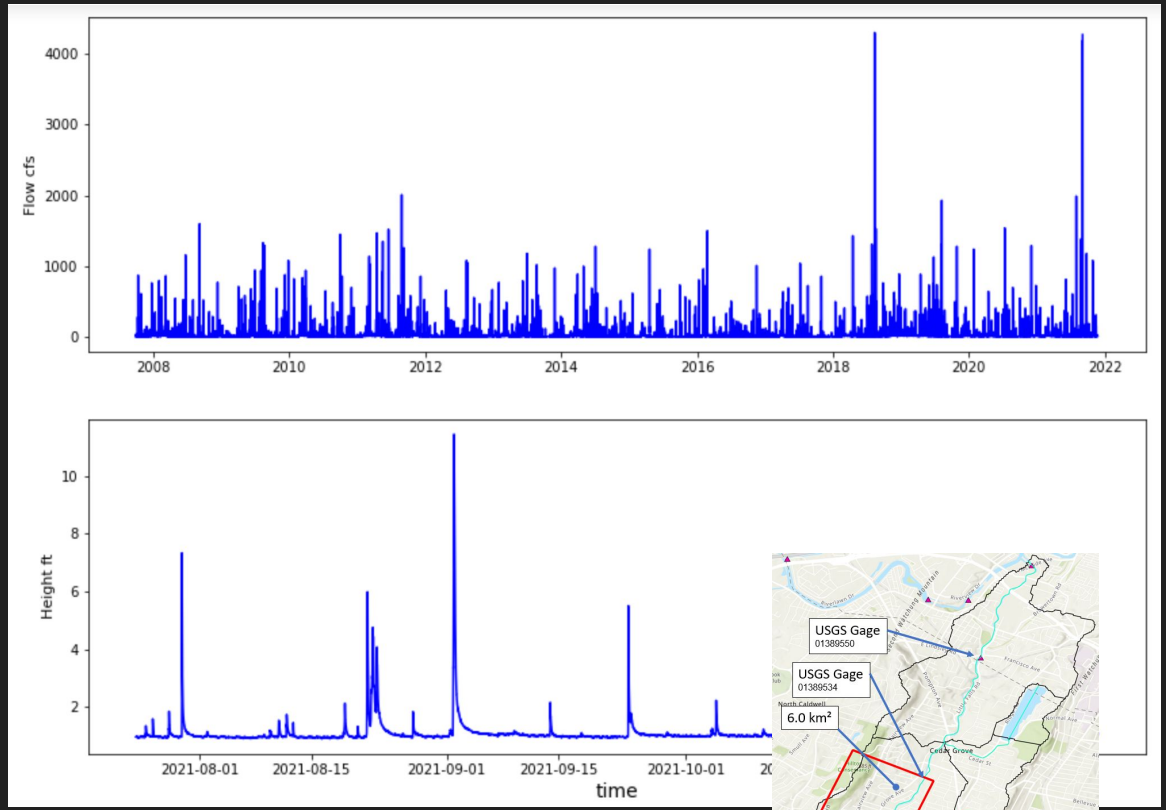
Hydrology

USGS gage 01389550 is 2 miles downstream of Verona sewer plant

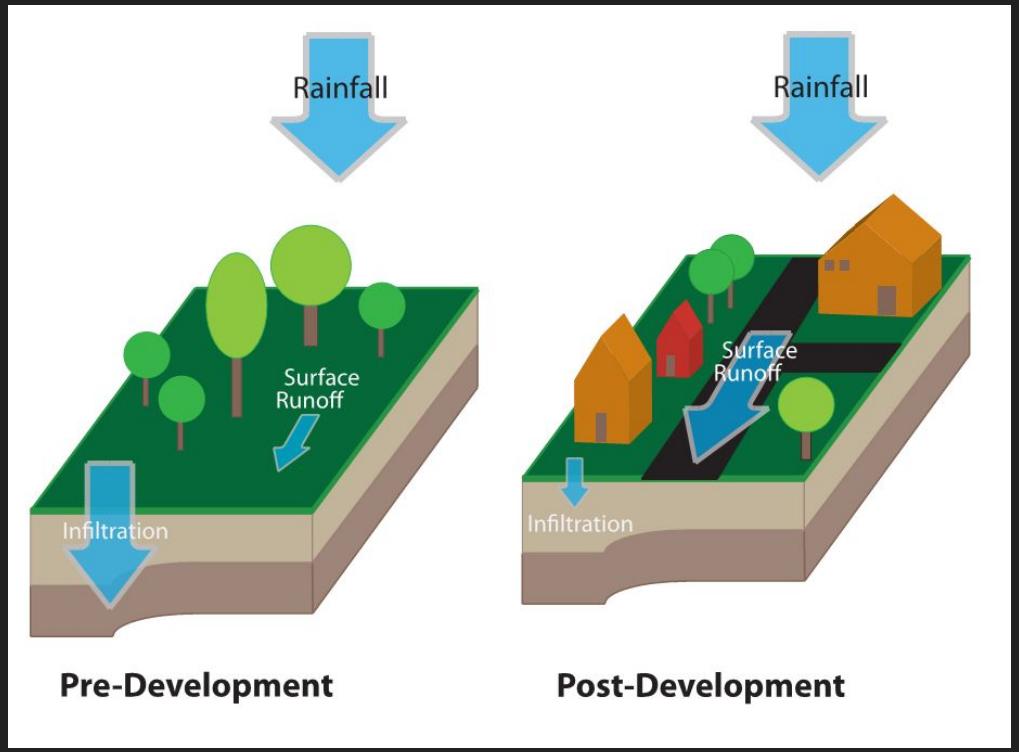
Flow data 2007-present
Height data 2021-present
15 minute resolution

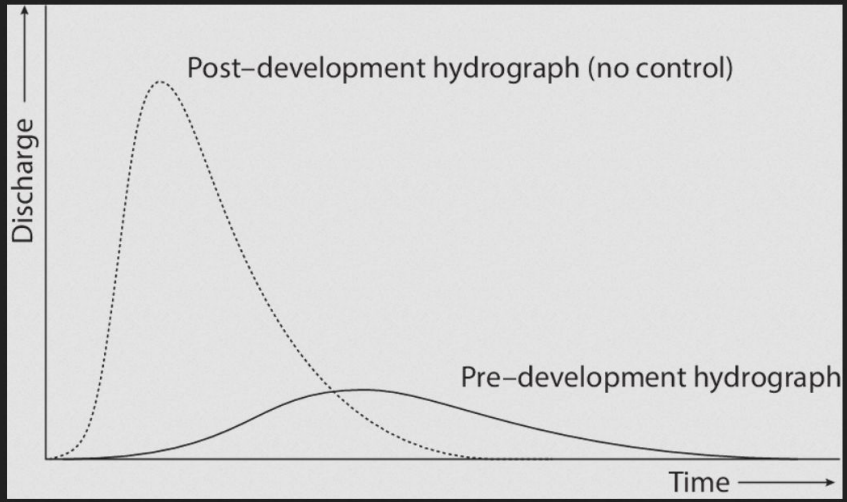
Hurricane Ida is not the only large event - similar flows during 2018 summer flooding of 4400 cfs, flood depth of ~11.4 feet (3.5 m) during Ida

Central Verona catchment is 40% of this gage catchment, max flow of 1,800 cfs during Ida?

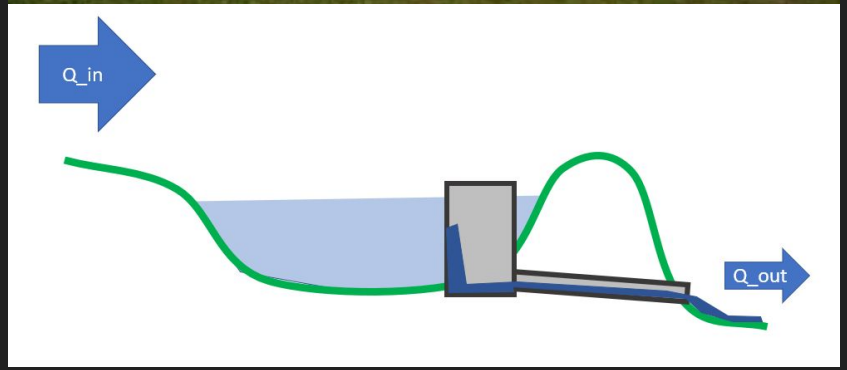


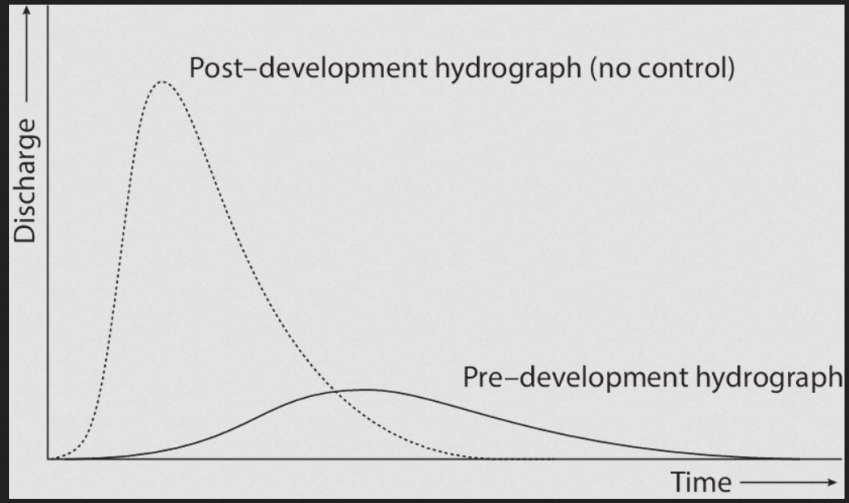
Hydrology - Detention Basin Principal



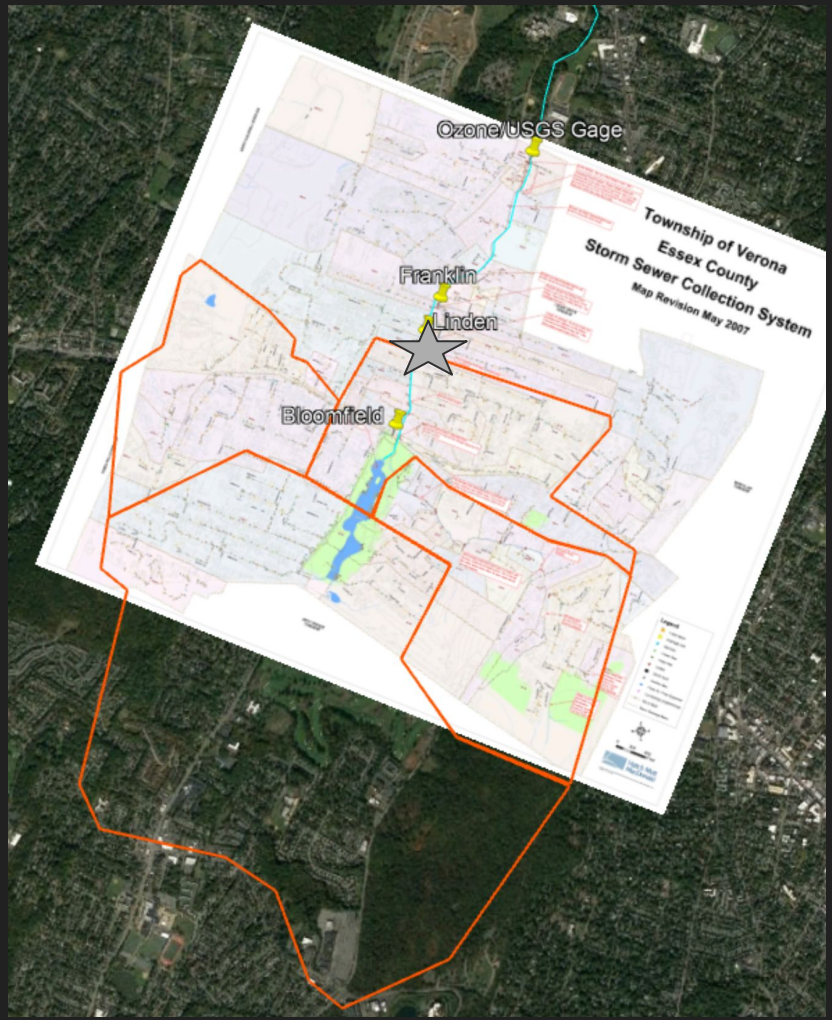


Hydrology - Detention Basin Principal

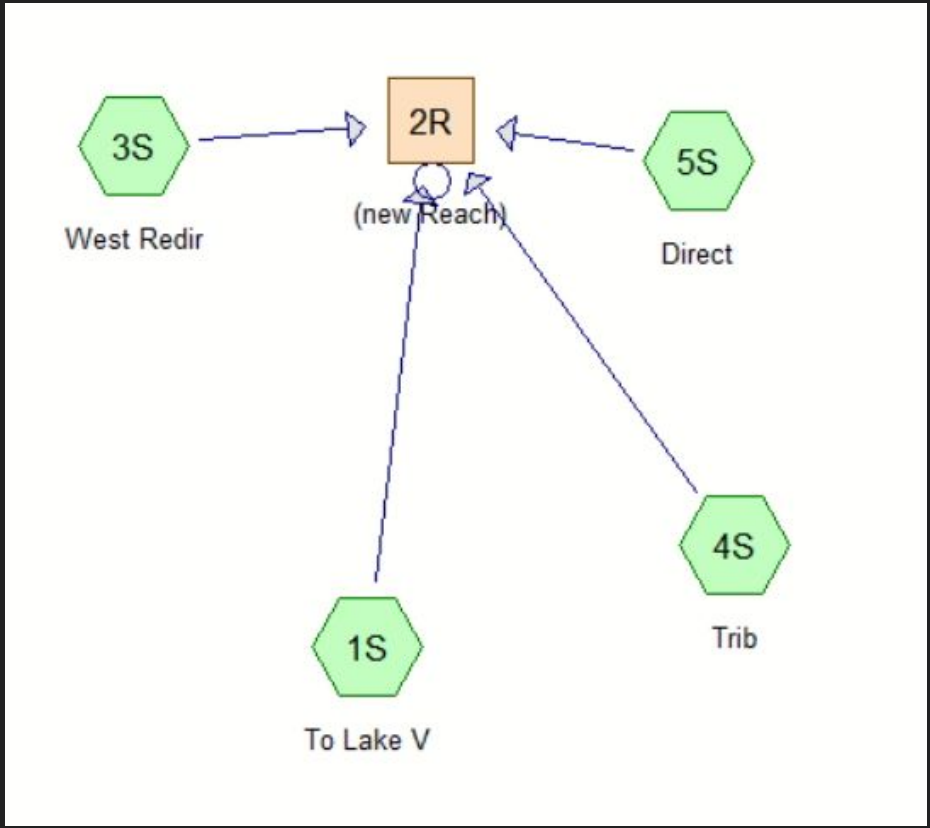


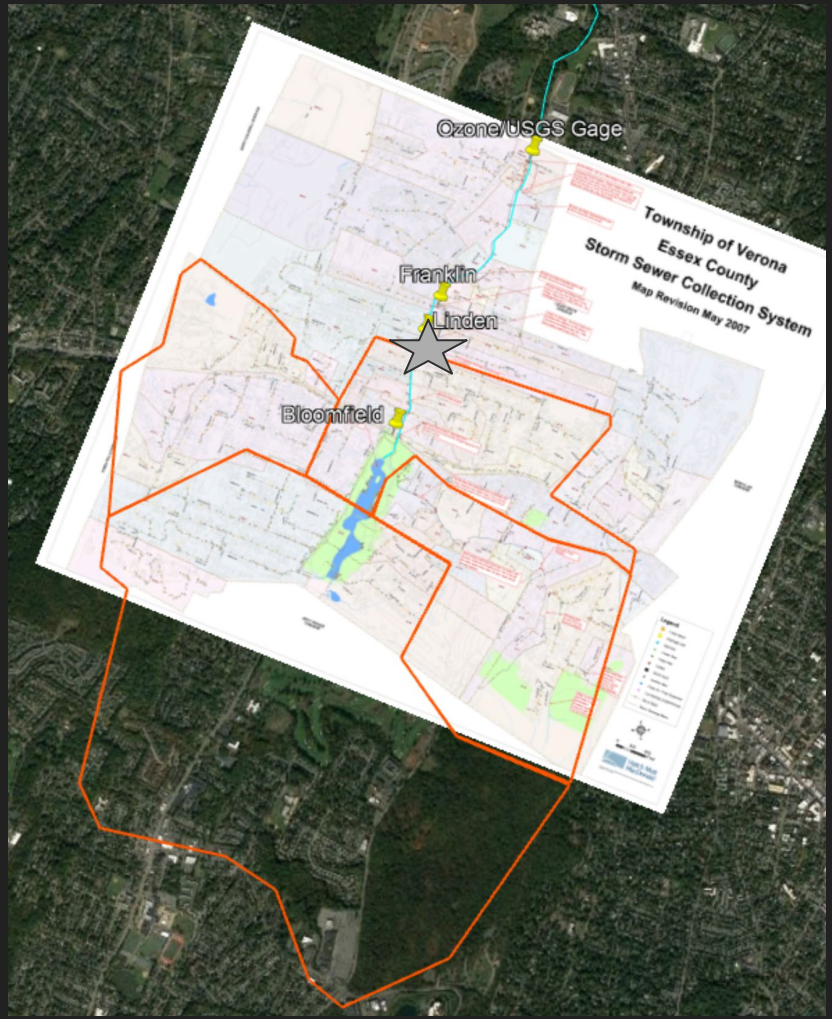


Hydrology - HydroCAD Model of Verona



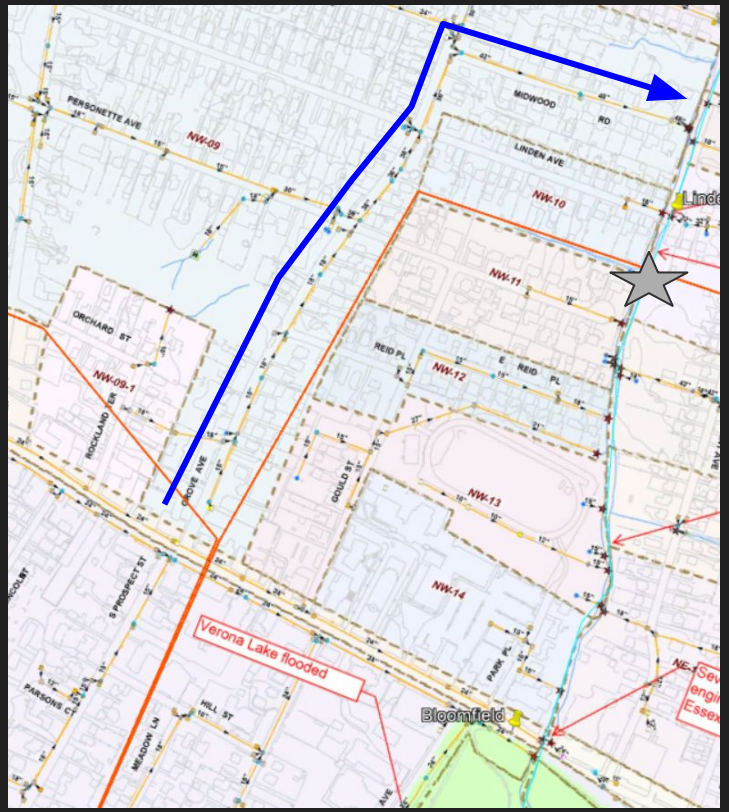
Hydrology - HydroCAD Model of Verona

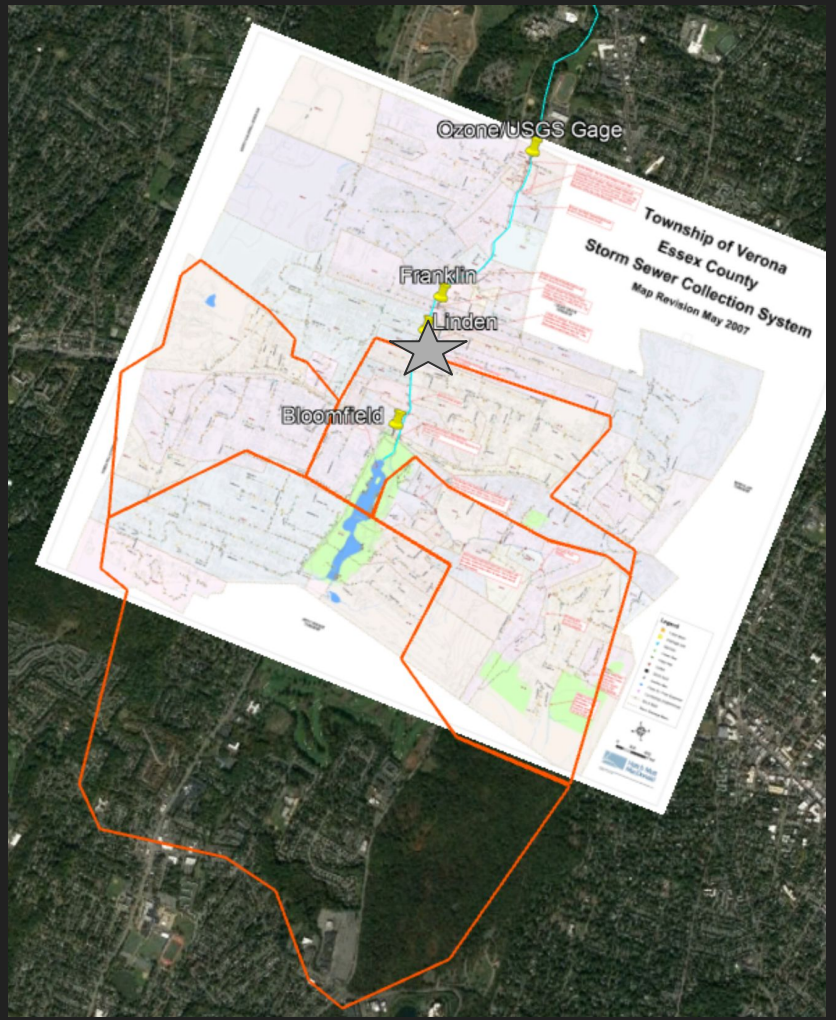




Hydrology - HydroCAD Alternative #1

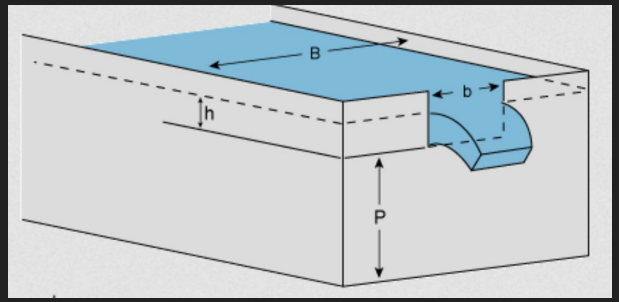
1300 ft of pipe replaced - 15” upsize to 24”





Hydrology - HydroCAD Alternative #2

Convert Lake Verona into a Detention Basin,
2 feet of storage * 500,000 sf area = 1M cf storage

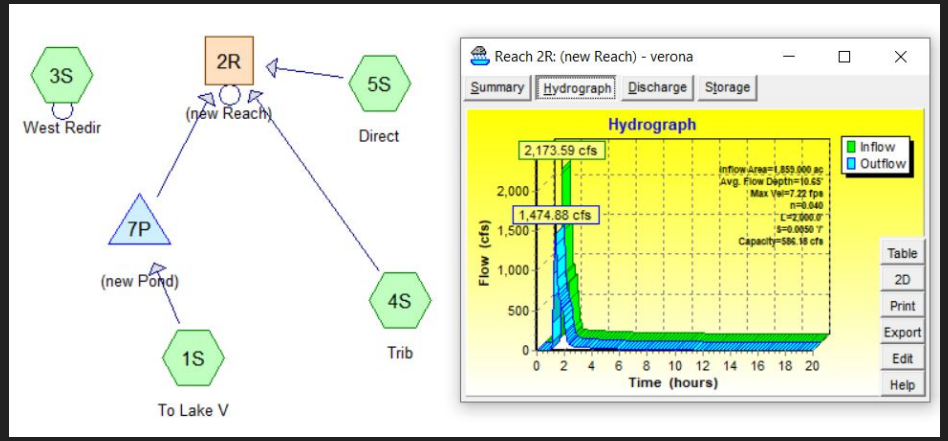


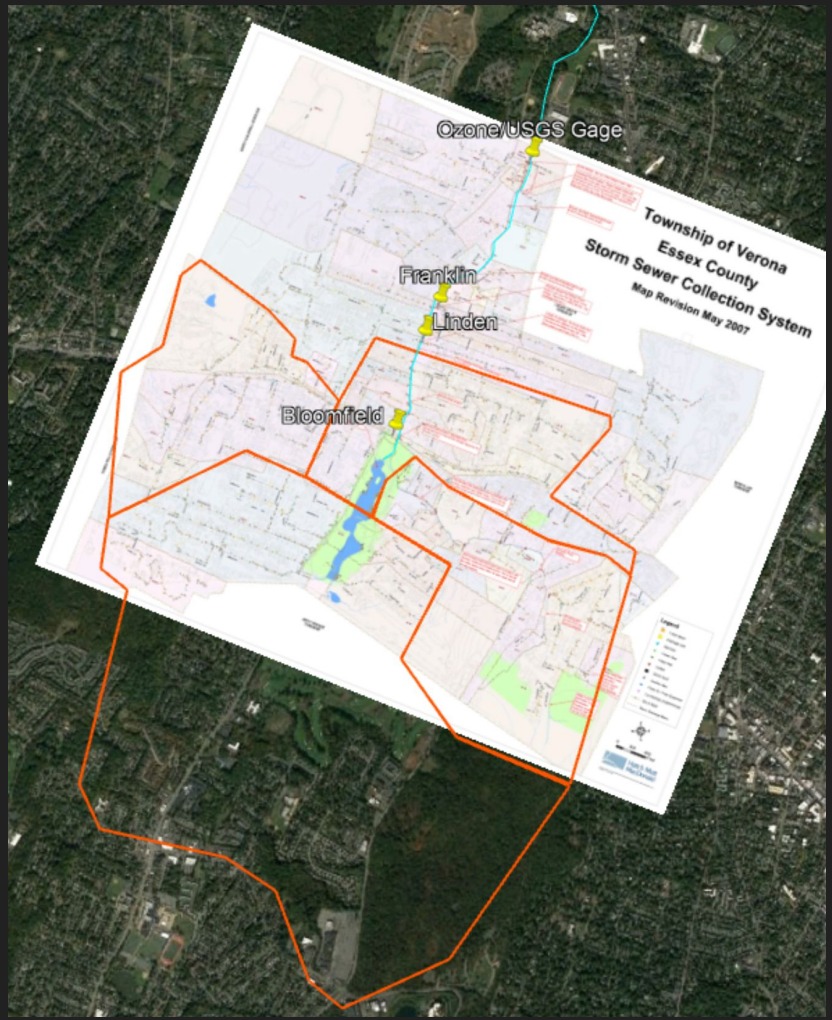
Hydrology - HydroCAD Results

Results are approximate, and more detailed modelling should be performed to validate results

Existing Conditions Discharge	3540 cfs	
Alt #1 - West Tributary Reroute	2990 cfs	16% reduction
Alt #2 - Modify Lake Verona	2460 cfs	30% reduction
Both Alt #1 and Alt #2	2170 cfs	39% reduction

Alt #1 only helps downtown
Alt #2 may help entire watershed & WWTP





Hydrology - HydroCAD Results

Alt #1 - West Tributary Reroute 2990 cfs 16% reduction

1200 LF of pipe @ $150/LF = $200,000

Mostly construction cost, some engineering

Alt #2 - Modify Lake Verona 2460 cfs 30% reduction

Cost unknown - estimate $200,000?

Mostly engineering, some construction

IV. Recommendations

- Stormwater Management Infrastructure
- Waterway and Lake Modification
- Policy and Programmatic Interventions

Stormwater Management (& other) Infrastructure Recommendations

Consider Independently or Cooperatively:

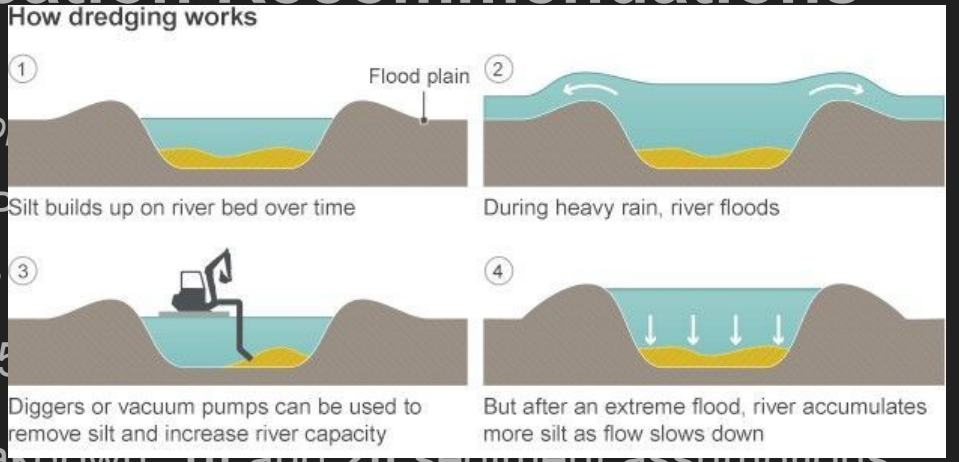
1) Stormwater Pipe Rerouting
2) Modifications to Lake Verona to become an emergency use detention basin
    a) +/- Re-engineering County Park an Overall Lake as a more advanced retention basin
3) Deploying more water level gages (preferably low cost/maintenance)
    a) Goal of having “real-time” flow data
4) New location(s) for stormwater retention basin or floodwater delay
5) Additional Green Infrastructure deployed in areas with considerable impervious coverage AND high flood risk

Waterway and Lake Modification Recommendations

- Sounding of Riverway and Lake Verona
  - *(cost usually covered in quotes for dredging o*
- Dredging Lake Verona and or areas of P
  - To regain retention potential and or add mass

Area of lake: 500,000 Square Feet - 11.5

Hydraulic Dredging - Average Cost Breakdown: **1ft** and **2ft** sediment assumptions



Unit Cost Estimate	**1 Foot** *(x 11.5 acres)* *1613 cyd/acre x 11.5 =* ***18,549.5 cyd***	**2 Foot** *(double 1 foot calculation)* *1613 x 2 = 3,226 cyd/acre x 11.5 =* **37,100 cyd**
$5 per cubic yard	**Est. $92,747**	**Est. $185,500**
$15 per cubic yard	**Est. $278,243**	**Est. $556,500**

Consider feasibility of expanding the lake boundaries to add flood water retention capacity
1612 cubic yards per acre foot added = (43,524 cubic feet) = (325,582 gal)

Policy and Programmatic Interventions

Municipal Level

- Reassess Zoning and Stormwater-related ordinances
- Flood Elevation Certificates
- Localized notification system of street closures due to flash flooding (ex: neighborhood specific reverse 9-1-1)

County Level

- Evacuation Plans set up by neighborhood for use of county roads
- Coordinate prioritized service of county road storm drains and stormwater retention and control systems

Regional Coordination +/- State Level

- Seek cooperative mutual aid agreements with neighboring municipalities to coordinate emergency response and recovery preparedness (i.e. emergency housing, fire/rescue/EMS response, flash flood rescue task force)
- NJ DEP Bureau of Flood Engineering offers a generous amount of services (from technical assistance for modeling to Local Ordinance assistance to draft and redraft more comprehensive flood prevention ordinances and programs)

Federal Level

- Further USGS Coordination
- Seeking federal funding for projects → Possible Sources:
    - Department of Homeland Security / FEMA + related NFIP resources
    - US Department of Agriculture → Natural Resource Conservation Service
    - National Dam Safety Program

Acknowledgement

Cynthia Holland, Councilwoman of Verona Township, NJ

Michael DeCarlo, Engineering Manager, Verona Township, NJ

Sun Ho Ro, PhD candidate, School of Engineering, Rutgers University

Data Source: USGS Airborne Lidar Explorer: https://prd-tnm.s3.amazonaws.com/LidarExplorer/index.html#/

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