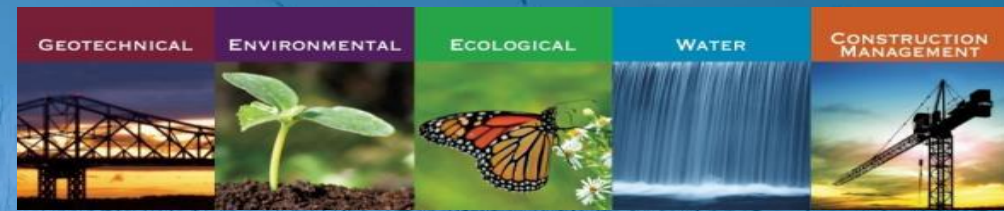


GZA GeoEnvironmental, Inc.

**NEWEA 2018**

January, 2018



# Resilience Plan for the Stratford, CT Water Pollution Control Facility

Stratford, Connecticut

Dan Stapleton, P.E.  
Sam Bell

Proactive By Design.  
Our Company Commitment





## ..... Building Coastal Resiliency

[http://www.townofstratford.com/filestorage/39879/40866/Stratford\\_Coastal\\_Resiliency\\_Plan\\_-\\_Final\\_Report\\_12-21-2016\\_Electronic\\_-\\_optimized.pdf](http://www.townofstratford.com/filestorage/39879/40866/Stratford_Coastal_Resiliency_Plan_-_Final_Report_12-21-2016_Electronic_-_optimized.pdf)



Proactive by Design



### Town of Stratford Coastal Community Resilience Plan

December 2016



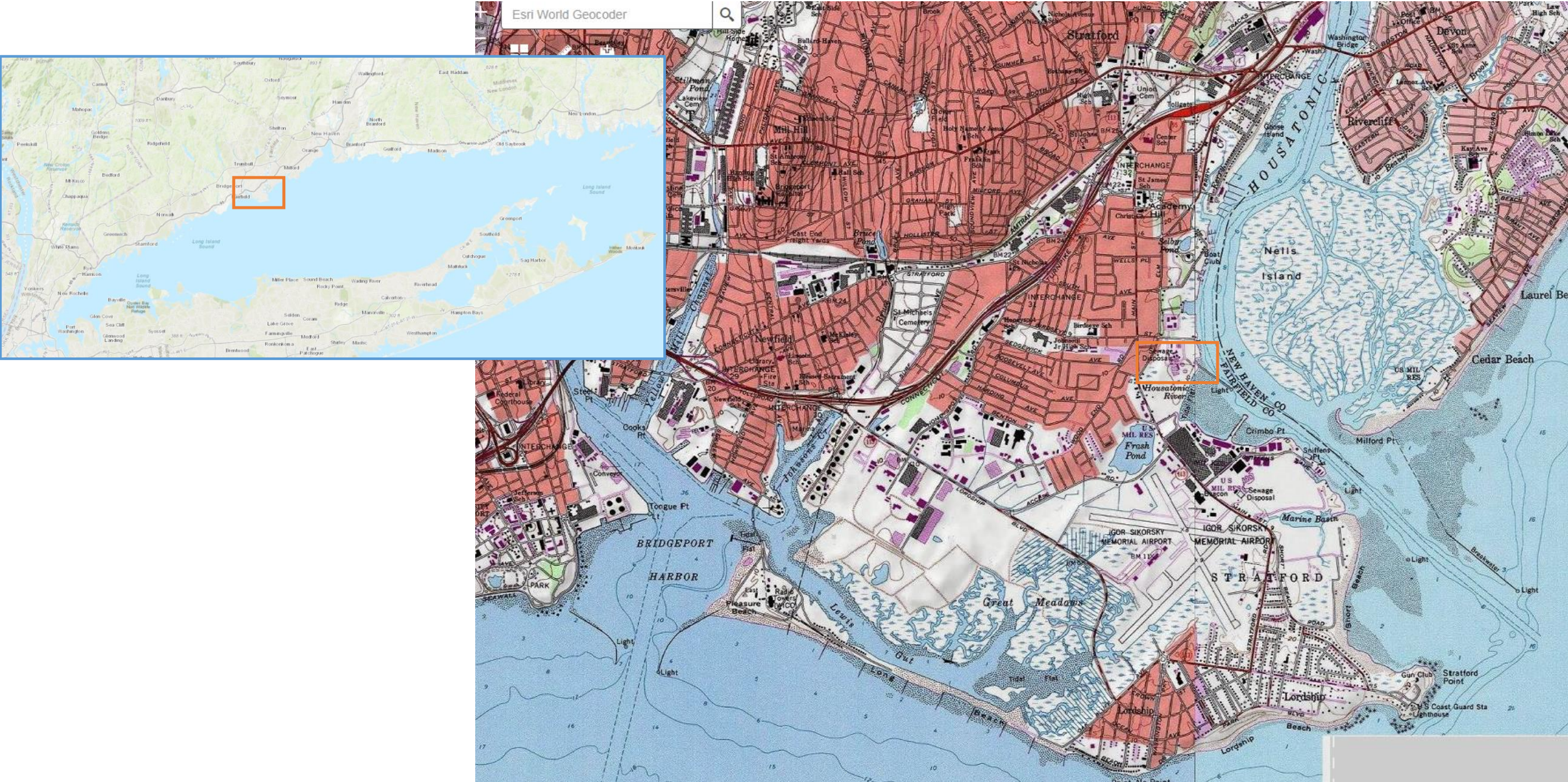
Prepared for:  
**Town of Stratford, Connecticut**

Prepared By:  
**GZA GeoEnvironmental, Inc.**



28 Offices Nationwide  
[www.gza.com](http://www.gza.com)

# Stratford Coastal Community Resilience Plan



# Stratford Coastal Community Resilience Plan

## About the Town:

- 19 square miles
- 51,490 people
- 20,290 households
- 2,600 people per square mile
- 65% households are families
- avg 3.18 people per household
- Average Age: 43 yo
- 9,200 people: elderly
- 10,690 people: <17 yo
- Median income: \$66,361



Town Center

## Asset Value Distribution

<b>Occupancy</b>	<b>Exposure (\$1000)</b>	<b>Percent of Total</b>
Residential	4,804,160	71.5%
Commercial	1,184,257	17.6%
Industrial	517,257	7.7%
Agricultural	14,010	0.2%
Religion	102,683	1.5%
Government	33,465	.5%
Education	64,294	1%
Total	6,720,103	100%

# Stratford Coastal Community Resilience Plan

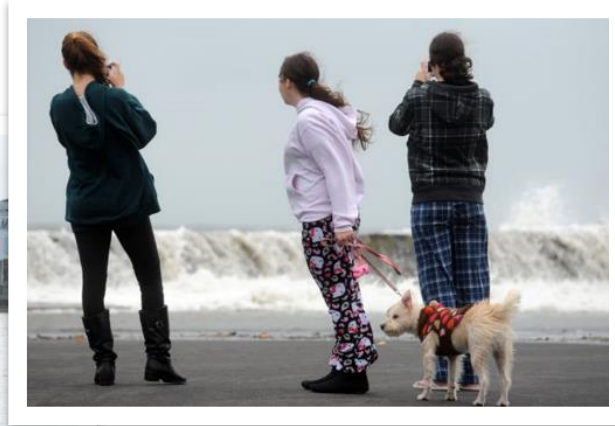
## “Risk-Informed Decision Making”

Risk = An event x probability of occurrence x resulting consequences

# Stratford Coastal Community Resilience Plan

## Five Steps:

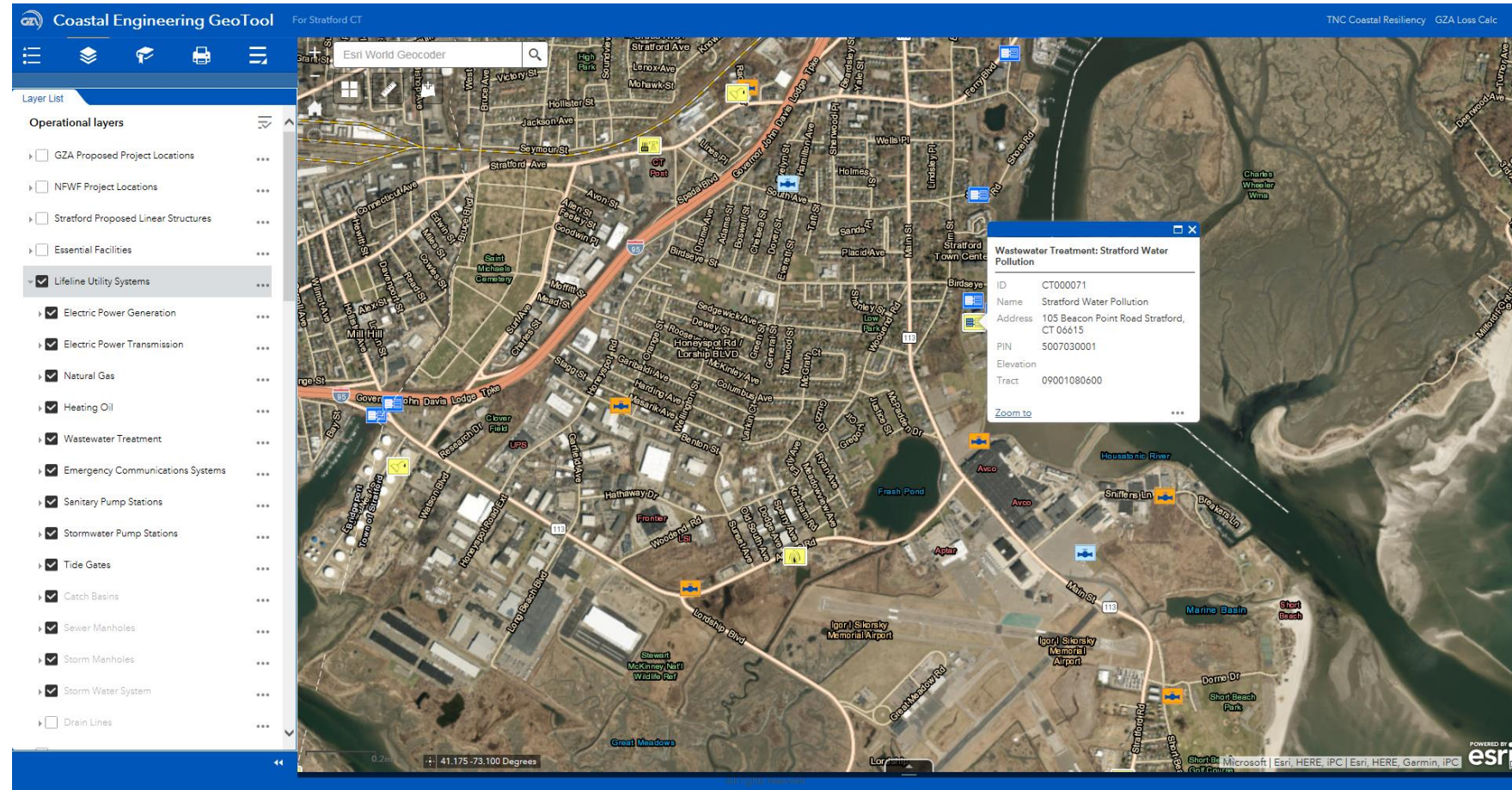
- I. Coastal Hazards Characterization
- II. Vulnerability Assessment
- III. Public and Stakeholder Outreach
- IV. Resiliency Strategies, Actions and Projects
- V. Plan Implementation



# Stratford Coastal Community Resilience Plan

## Town Assets Inventory:

- ✓ Essential Facilities
- ✓ **Lifeline Utilities**
- ✓ Transportation
- ✓ High Potential Loss Facilities
- ✓ Hazardous Material Facilities
- ✓ High Occupancy/Vulnerable Population Facilities
- ✓ Private and commercial property
- ✓ Natural Resources



# Stratford Coastal Community Resilience Plan

## Vulnerability Assessment:

- ✓ Essential Facilities
- ✓ Lifeline Utilities
  - ✓ Water Pollution Control Facility
- ✓ Transportation
- ✓ High Potential Loss Facilities
- ✓ Hazardous Material Facilities
- ✓ High Occupancy/Vulnerable Population Facilities
- ✓ Private and commercial property
- ✓ Natural Resources



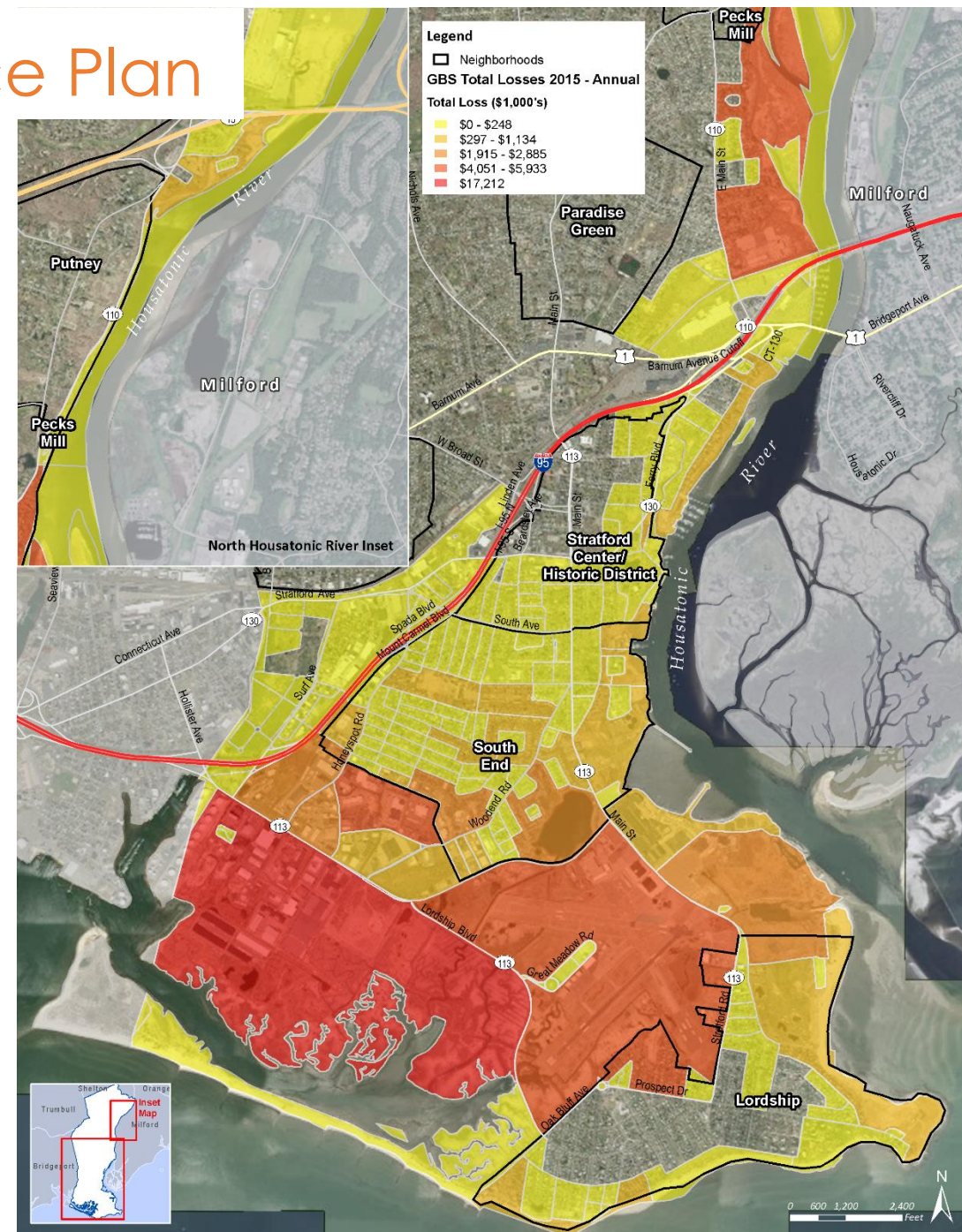


# Stratford Coastal Community Resilience Plan



POTENTIAL LOSS ESTIMATES ANALYZED IN HAZUS :

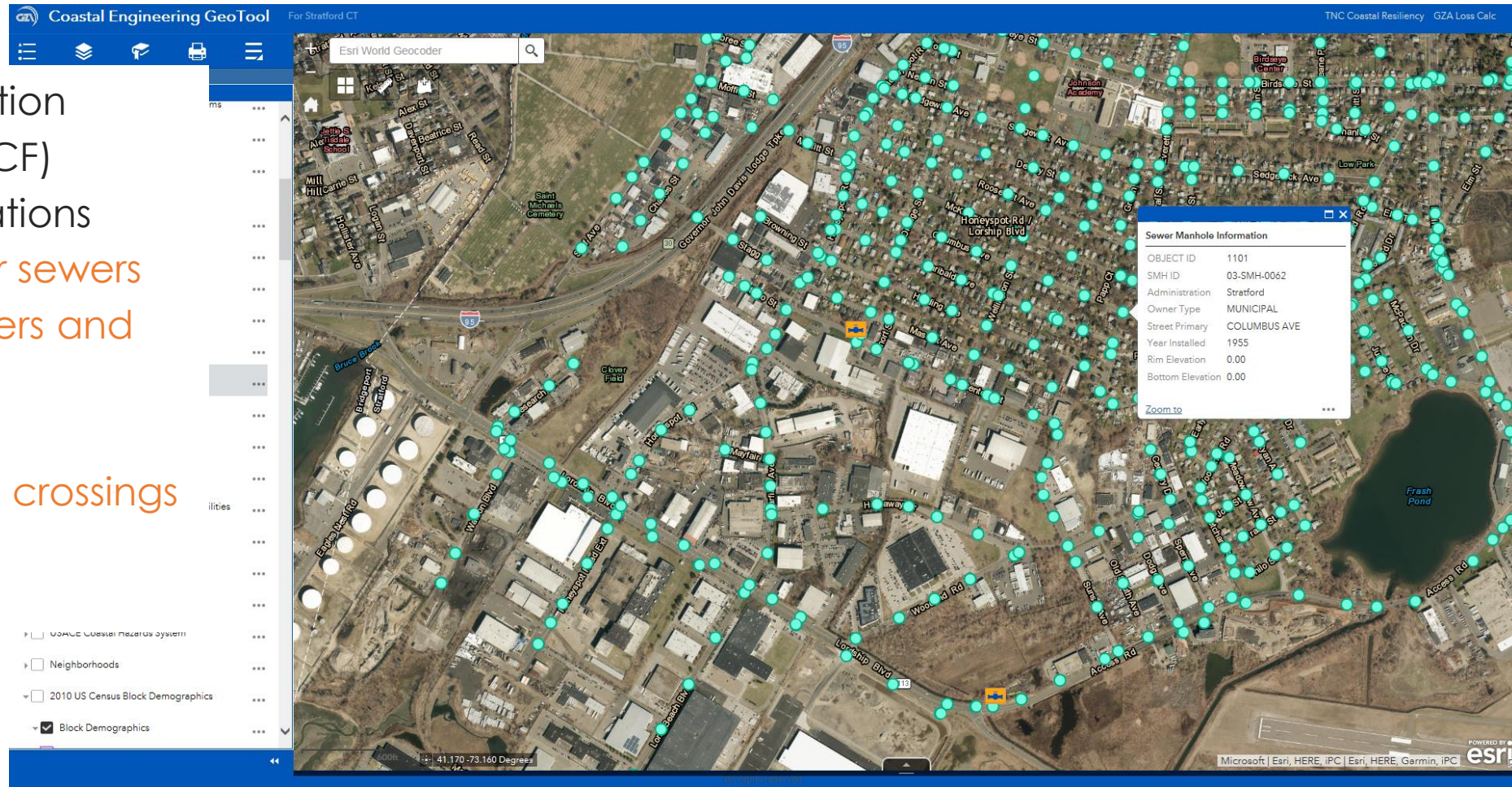
- ✓ DIRECT COSTS
  - Physical damage to critical facilities and infrastructure.
- ✓ CONSEQUENTIAL COSTS
  - Economic loss including lost jobs, business interruptions, repair and reconstruction costs;
  - Social impacts, including estimates of shelter requirements and displaced households
  - Environmental impacts, including loss of wetlands, riparian and open space.



# Waste Water Treatment System

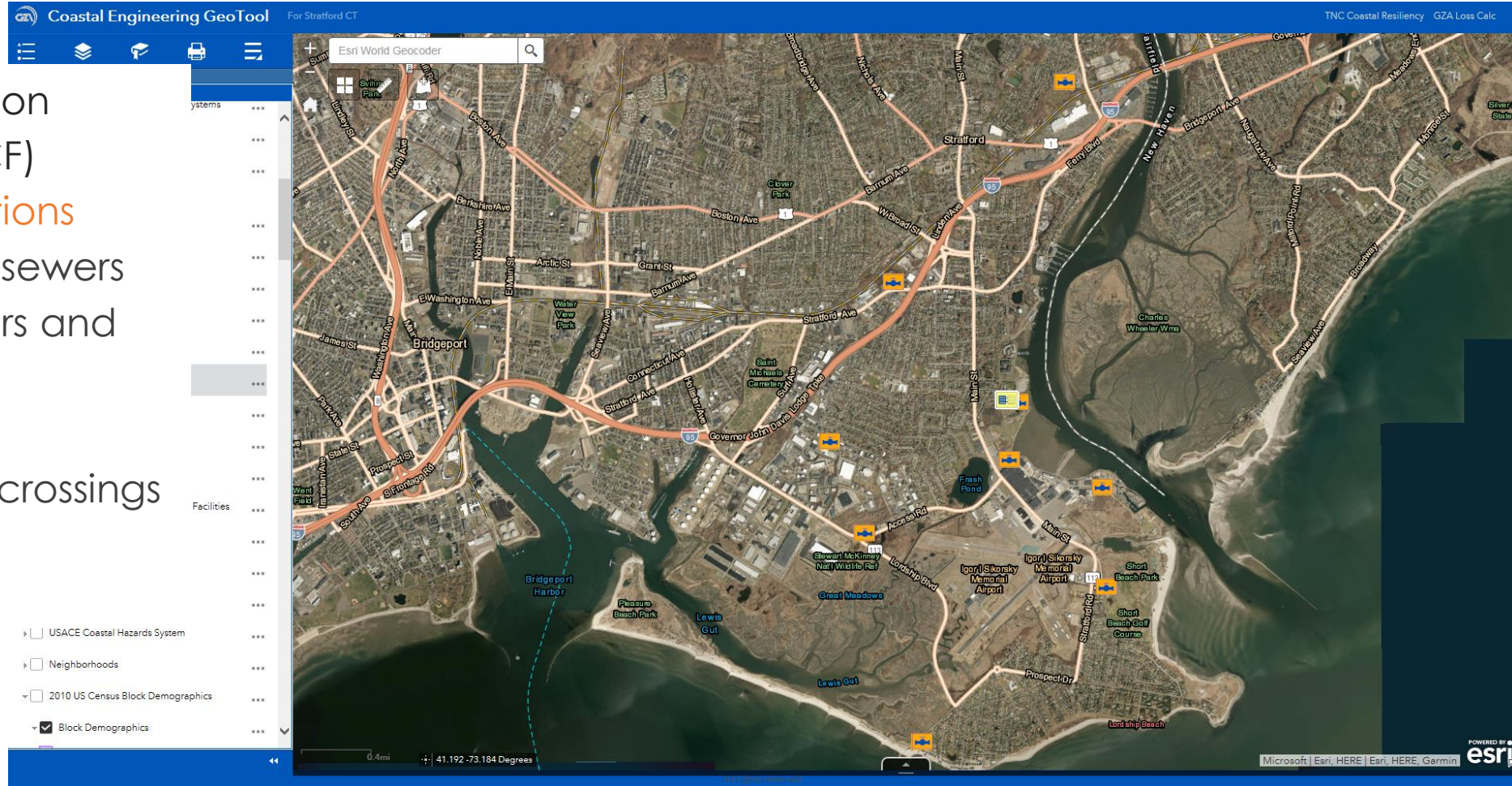
# Waste Water Treatment System

- Stratford Water Pollution Control Facility (WWCF)
- 12 Sanitary Pump Stations
- 170 miles of collector sewers
- 20 miles of trunk sewers and interceptors
- 4,500 manholes
- 20 brook and stream crossings
- 5 miles of force main



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# Waste Water Treatment System




- Stratford Water Pollution Control Facility (WWCF)
  - Capacity:
    - 11.5 mgd average
    - 19.5 mgd maximum
  - 24/7 operations
  - Discharge: Housatonic River
  - \$62M upgrade – mun. bond



# Stratford Water Pollution Control Facility

- Anoxic Tanks
- Aeration Tanks
- Blower Building and Return Pumping Station
- Secondary Settling Tanks/Clarifiers and Associated Distribution Box
- Pumping Station and Wet Well
- UV Disinfection Channel
- Control Building
- Primary Tanks
- Soda Ash Feed System
- Biofilter and Sludge Holding Tanks
- Sludge Thickening Tank and Building
- Diversion Chambers A, B and C
- Two Electrical Substations
- Emergency Generator and Load Bank
- Vehicle Storage Building
- Sludge Dewatering and Incinerator Building and Maintenance Building
- Raw Sewage Pumping Station and Inlet Works Building (Headworks)
- Bypass Valve Chamber
- Methanol Activities



 	
<small>THIS PLAN IS A PRELIMINARY DESIGN AND IS SUBJECT TO CHANGE WITHOUT NOTICE. THE USER SHALL BE RESPONSIBLE FOR VERIFYING THE ACCURACY OF THE INFORMATION SHOWN ON THIS PLAN. THE USER SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY PERMITS AND APPROVALS FROM THE APPROPRIATE AGENCIES. THE USER SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY INFORMATION FROM THE APPROPRIATE AGENCIES. THE USER SHALL BE RESPONSIBLE FOR OBTAINING ALL NECESSARY INFORMATION FROM THE APPROPRIATE AGENCIES.</small>	
<b>COASTAL RESILIENCY PLAN</b> <b>STRATFORD, CONNECTICUT</b> <b>EXISTING CONDITIONS PLAN</b> <b>WASTEWATER TREATMENT PLANT</b>	
<small>PREPARED BY:</small>  <b>GZA GeoEnvironmental, Inc.</b> <small>Engineers and Scientists</small> <small>www.gza.com</small>	<small>PREPARED FOR:</small> TOWN OF STRATFORD
<small>PROJECT NO.:</small> 08 <small>DESIGNED BY:</small> RWR <small>DATE:</small> NOVEMBER 2014	<small>REVIEWED BY:</small> DCS <small>EXAMINED BY:</small> BW <small>PROJECT NO.:</small> 01.0172256.00 <small>REVISION NO.:</small> --
<small>CHECKED BY:</small> BS <small>SCALE #:</small> 8 1/2" = 1'-0" <small>FIGURE:</small> 1	<small>SHEET NO.:</small> 1 OF 4



# Stratford Water Pollution Control Facility

# Stormwater Management System

**Coastal Engineering GeoTool** For Stratford CT

TNC Coastal Resiliency GZA Loss Calc

Esri World Geocoder

**Layer List**

- Emergency Communications Systems
- Sanitary Pump Stations
- Stormwater Pump Stations
- Tide Gates
- Catch Basins
- Sewer Manholes
- Storm Manholes
- Storm Water System
- Drain Lines
- Transportation Systems
- High Potential Loss Facilities
- Hazardous Materials Facilities

— Storm Sewer;  
— Box Culvert  
— Culvert  
--- Concrete Stream Channel  
— Natural Channel  
--- Perforated Drain

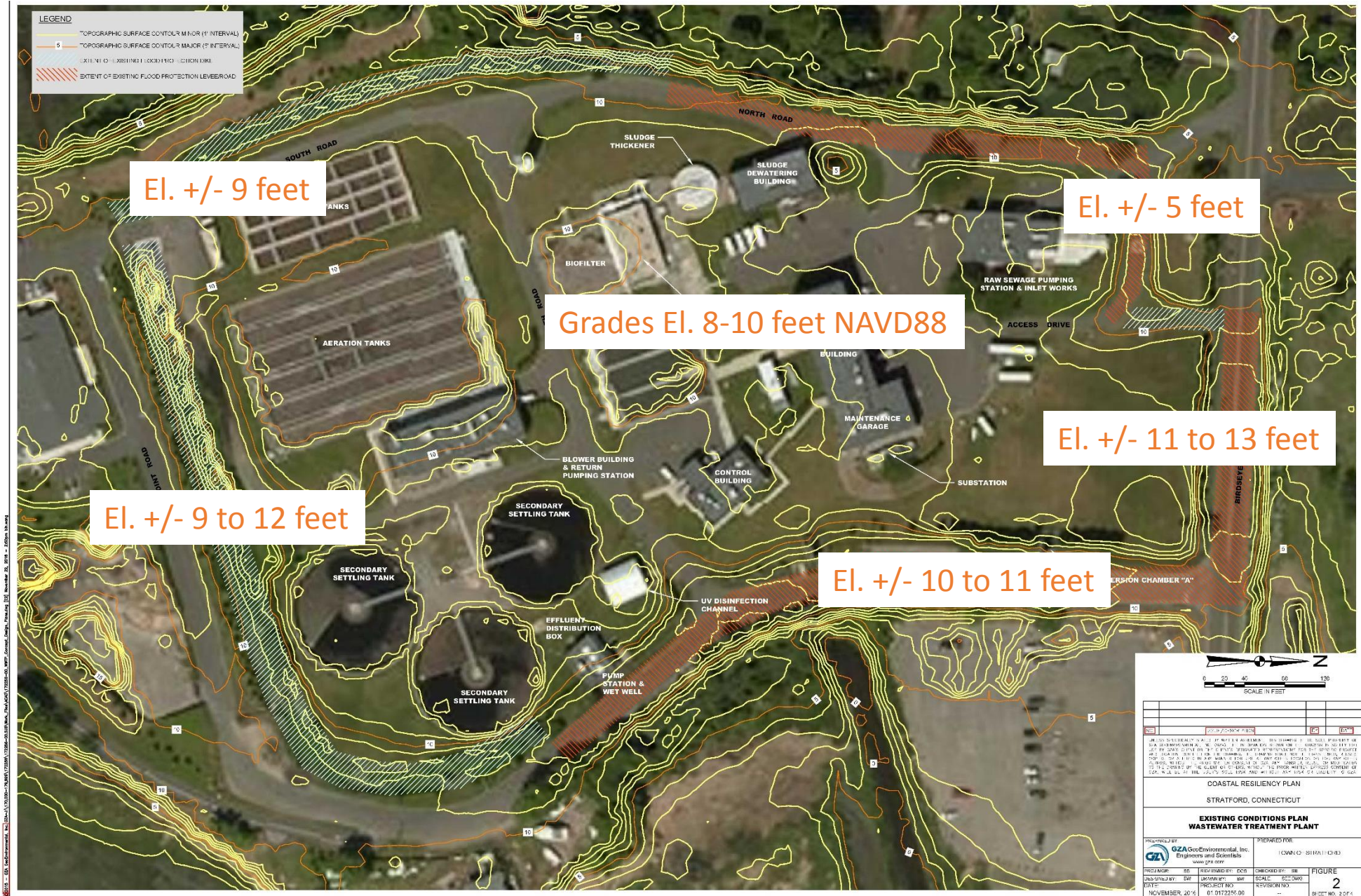
41.178, -73.131 Degrees

CRCOG/State of CT, Microsoft **esri** POWERED BY

# Coastal Flood Risk

## Wastewater Treatment Plant Flood Protection Levee and Berm System

- Levee and berm crest elevations: +/- 10 to 13 feet
- 90% perimeter coverage
- Gaps at plant entrances
- Constructed circa 1970s



# Coastal Flood Risk

# Coastal Site Setting



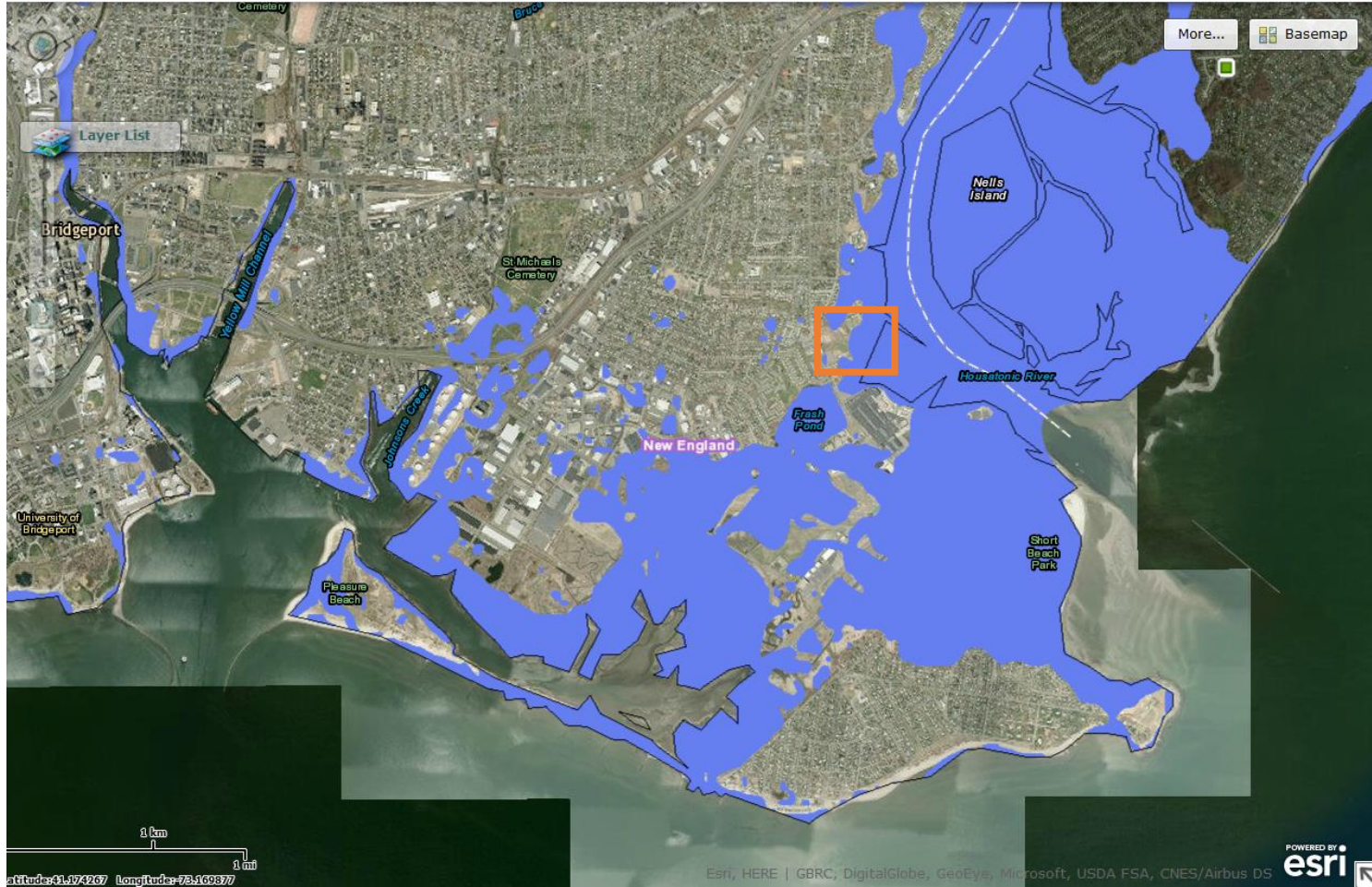
257 ft

© 2016 Google



# Coastal Flood Risk

## Hurricane Sandy





Time Step 2



Hurricane



Time Step 3



Hurricane Sandy





# Time Step 4



Time Step 5



Hurricane Sandy

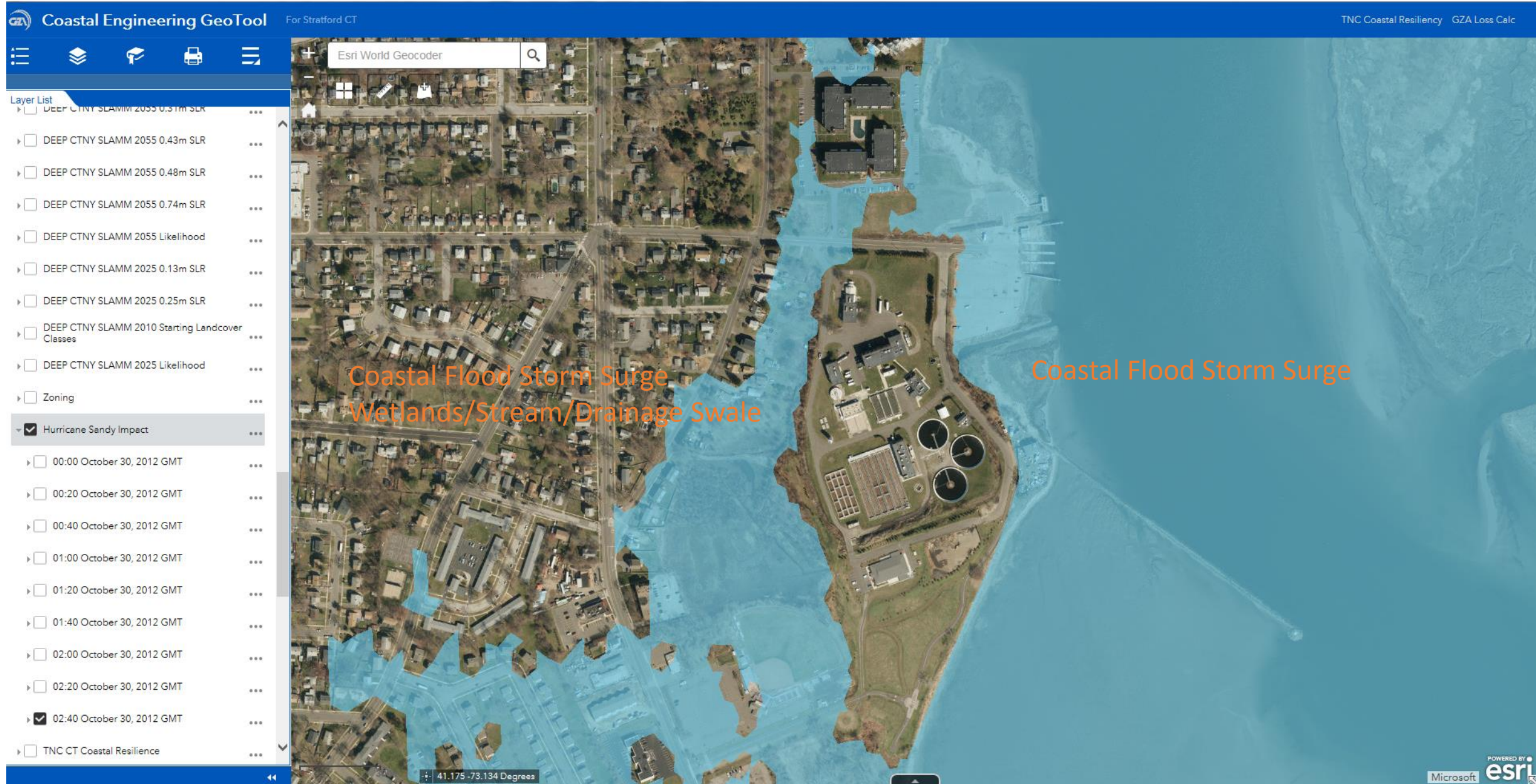
Time Step 6



Hurricane Sandy

# Coastal Flood Risk

Hurricane Sandy



# Coastal Flood Risk

Applicable Coastal Flood-Frequency Data (Stillwater Elevations, NAVD88, ft)

Recurrence Interval	1-yr	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr	1,000-yr
2015:										
NOAA Mean	5.2	6.2	6.8	7.4	7.8	8.4	9.1	-	-	-
NOAA UB	-	-	-	7.9	8.7	10.0	11.4	-	-	-
NOAA LB	-	-	-	6.9	7.1	7.2	7.9	-	-	-
FEMA	-	-	-	7.7	-	9.2	9.8	-	11.1	-
USACE Mean	5.8	6.7	8	8.8	9.6	10.7	11.7	13	15	16.4
USACE UB	8.8	9.7	10.9	11.8	12.7	14.1	15.5	16.9	18.8	20.3
USCAE LB	2.7	3.7	5.1	5.9	6.5	7.3	7.9	9.1	11.1	12.5
2040:										
USACE Mean (Low SLR)	6	6.9	8.2	9	9.8	10.9	11.9	13.2	15.2	16.6
USACE Mean (Int SLR)	6.2	7.1	8.4	9.16	10.0	11.1	12.1	13.4	15.4	16.8
USACE Mean (High SLR)	6.7	7.6	8.9	9.66	10.5	11.6	12.6	13.9	15.9	17.3
2065:										
USACE Mean (Low SLR)	6.2	7.1	8.4	9.2	10.0	11.1	12.1	13.4	15.4	16.8
USACE Mean (Int SLR)	6.6	7.5	8.8	9.63	10.4	11.5	12.5	13.8	15.8	17.2
USACE Mean (High SLR)	8.0	8.98	10.2	10.98	11.8	12.9	13.9	15.2	17.2	18.6
2115:										
USACE Mean (Low)	6.6	7.5	8.8	9.6	10.4	11.5	12.5	13.8	15.8	17.2
USACE Mean (Int SLR)	7.9	8.8	10.1	10.9	11.7	12.8	13.8	15.1	17.1	18.5
USACE Mean (High SLR)	12.0	12.9	14.2	15.0	15.8	16.9	17.9	18.2	21.2	22.6

# Coastal Flood Risk

USACE NACCS 100-year return period flood



# Coastal Flood Risk

USACE NACCS 500-year return period flood

The screenshot displays the Coastal Engineering GeoTool interface for Stratford, CT. The main map area shows an aerial view with a semi-transparent blue overlay representing flood simulation data. A small 3D house icon is positioned on the map. The left sidebar contains a Layer List with the following items:

- CT Statewide Contours
- Stratford LIDAR Contours
- Stratford Contours (2013, LiDAR)
- Assessor Parcels
- Plan of Conservation
- GZA Flood Simulation BFE Water Depth
- GZA Flood Simulation Stillwater Elevation
  - GZA 2015\_100yrFlood\_NoSLR
  - GZA 2015\_500yrFlood\_NoSLR
  - GZA 2015\_MeanHighWaterTide\_NoSLR
  - GZA 2040\_100yrFlood\_HighSLR
  - GZA 2040\_100yrFlood\_IntSLR
  - GZA 2040\_100yrFlood\_LowSLR
  - GZA 2040\_500yrFlood\_HighSLR
  - GZA 2040\_500yrFlood\_IntSLR
  - GZA 2040\_500yrFlood\_LowSLR
  - GZA 2040\_MeanHighWaterTide\_HighSLR
  - GZA 2040\_MeanHighWaterTide\_IntSLR
  - GZA 2040\_MeanHighWaterTide\_LowSLR
  - GZA 2065\_100yrFlood\_HighSLR

The top right of the map area features a search bar labeled 'Esri World Geocoder'. A popup window titled '(1 of 4)' is open, showing the following information:

GZA 2015_500yrFlood_NoSLR: ADCIRC grid	
Name	ADCIRC grid
Max Water Level (ft)	14.17
Zoom to	...

The bottom of the interface shows a coordinate display: 41.178 -73.125 Degrees. The bottom right corner includes the text 'POWERED BY esri' and 'CRCOG/State of CT, Microsoft'.

# Coastal Flood Risk

100-year return period flood Significant Wave Height(ft)





# Coastal Flood Risk

FEMA Base Flood Elevations (100-year return period flood w/ wave effects)



# Coastal Flood Risk

## Effects of Sea Level Rise on Coastal Flood-Frequency Data (Stillwater Elevations, NAVD88, ft)

Recurrence Interval	1-yr	2-yr	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr	1,000-yr
2015:										
NOAA Mean	5.2	6.2	6.8	7.4	7.8	8.4	9.1	-	-	-
NOAA UB	-	-	-	7.9	8.7	10.0	11.4	-	-	-
NOAA LB	-	-	-	6.9	7.1	7.2	7.9	-	-	-
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2115:										
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USACE Mean (High SLR)	12.0	12.9	14.2	15.0	15.8	16.9	17.9	18.2	21.2	22.6

# Coastal Flood Vulnerability

## Primary:

- flood elevations exceeding the berm crest elevation (stillwater flood inundation, wave run-up and overtopping)
- floodwaters entering into the site via the low-lying facility entrances and egresses
- salt spray

## Secondary:

- potential for temporary increase in groundwater elevation during coastal flood events (potentially above the ground surface or flooding below-grade structures)
- backflow through surcharged storm drains
- localized intense precipitation onto the site footprint
- wind

## Flood Impact:

- flood inundation
- hydrostatic loads
- hydrodynamic loads
- debris impact loads

# Coastal Flood Risk

## Preliminary Average Annualized Loss (AAL):

- **only facility damage costs** (did not consider consequential costs associated with disruption or loss of service and/or environmental costs associated with an uncontrolled discharge of untreated effluent to the Housatonic River and surrounding wetlands)
- **project plant cost basis** (i.e., vulnerable property value including buildings and equipment) of **\$50 million**
- depth-damage curve applicable to a small treatment plant (10 to 50 MGD)
- existing exposure grade of Elevation 8 feet NAVD88
- **40-year evaluation period life** (2016 through 2056)
- **current sea levels** (i.e., sea level rise is not considered)
- only stillwater flood inundation is considered
- considered both effective **FEMA FIRM** and mean **USACE NACCS** flood-frequency

Current estimated average annual loss (AAL) ranges from about **\$145,000 (FEMA) to \$840,000 (NACCS)** per year. Over the 40 year evaluation life, the expected total life cycle loss (**40 years**) is about **\$6M to \$33.5M**.

Flood Protection

# Flood Protection Approach

1. Localized, system and component flood protection (around individual buildings, equipment, etc.) using:
  - a. Permanent flood protection measures (e.g., flood walls; building flood proofing, raising equipment)
  - b. Deployable measures (temporary flood walls, flood gates, etc.)
  - c. Combination of the above
  
2. Perimeter flood protection (around the site) using:
  - a. Permanent measures (levees, flood walls)
  - b. Deployable measures (temporary barriers)
  - c. Combination of the above

# Flood Protection Alternatives

## 1. Permanent measures:

### a. Increase dike and levee crest elevations:

- i. Increase crest elevation of full dike/levee width
- ii. Increase crest elevation for a partial width

### b. Construct a combined levee/flood wall (without raising the crest elevations of the dike/levees), using:

#### Sheetpile wall:

Steel

Vinyl

Concrete L-wall

## 1. Temporary measures, utilizing temporary, deployed perimeter flood protection:

### a. Inflatable bladder systems

### b. Filled bag systems

### c. Deployable flood barriers (e.g., Tiger Dams, Stop Log systems, etc.)

# Elevation of Flood Protection Considerations

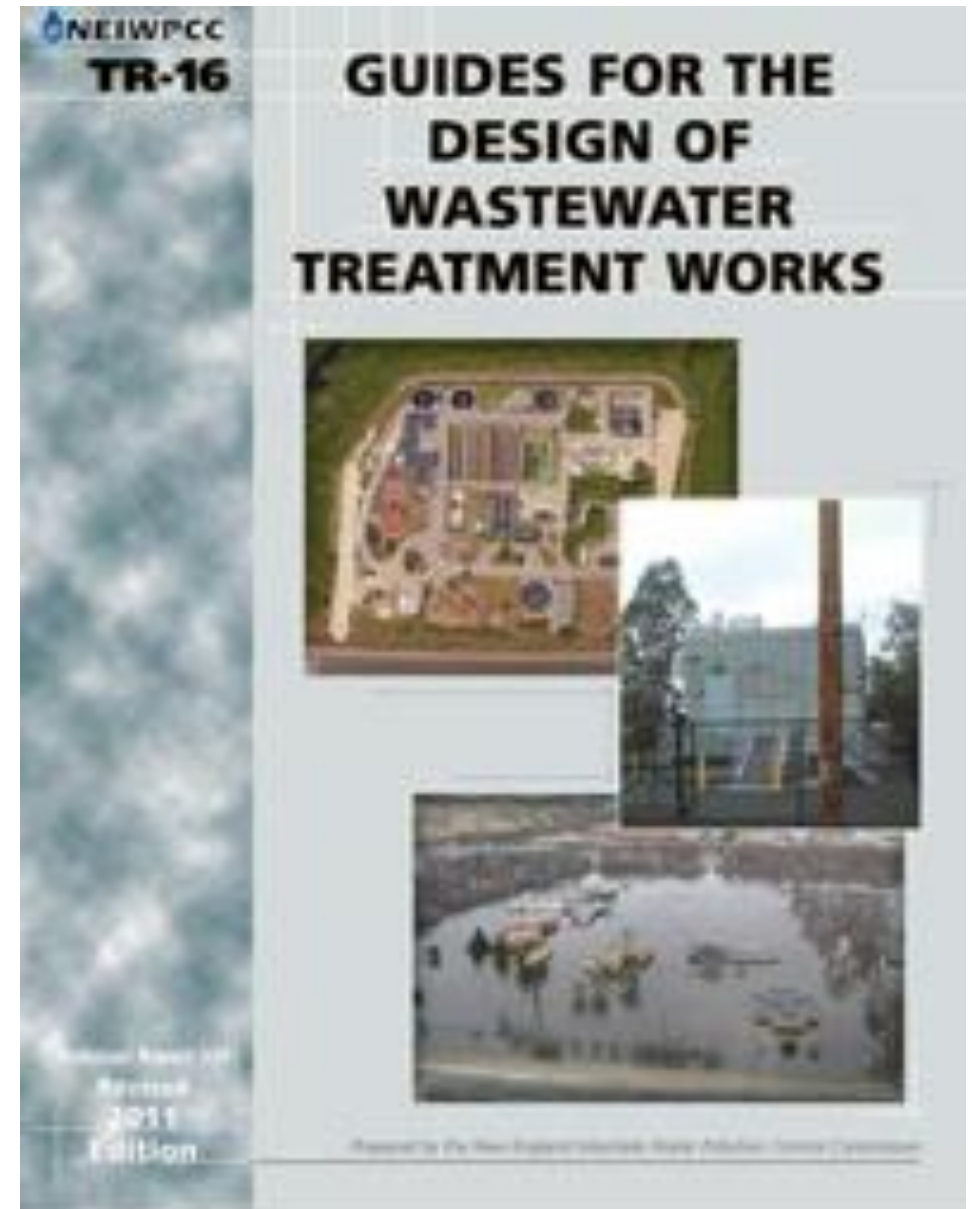
## Regulatory/Technical Guidance

### ASCE24:

- Flood Design Class 3 (critical lifeline facility)
- Coastal AE Zone
- BFE +2 feet (currently, Elevations 15 to 16 feet)

### TR-16:

1. uninterrupted operation during 100-year flood
2. above or protected against the structural, process, and electrical equipment damage that might occur in a 100-year flood elevation
3. critical equipment protected against damage up to a water surface elevation that is 3 feet above the 100-year flood elevation
4. non-critical equipment protected against damage up to a water surface elevation that is 2 feet above the 100-year flood elevation
5. backup power supply for critical equipment - emergency power generation or an alternative power source





# Elevation of Flood Protection Considerations

## Benefit/Cost Analysis

### Reduced Losses:

Elevation 10 feet NAVD88: The estimated average annual loss (AAL) is about \$132,000 to \$437,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **\$5.2M to \$17.5M**.

Elevation 11 feet NAVD88: The estimated average annual loss (AAL) is about \$83,000 to \$302,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **\$3.3M to \$12.1M**.

Elevation 12 feet NAVD88: The estimated average annual loss (AAL) is about \$50,000 to \$180,555. Over the 40 year evaluation life, the expected total life loss (40 years) is about **\$2M to \$7.2M**.

Elevation 13 feet NAVD88: The estimated average annual loss (AAL) is about \$14,000 to \$145,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **\$0.5M to \$5.7M**.

Elevation 14 feet NAVD88: The estimated average annual loss (AAL) is about <\$10,000 to \$130,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **<\$0.5M to \$5M**.

Elevation 15 feet NAVD88: The estimated average annual loss (AAL) is about 0 to \$105,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **0 to \$4.2M**.

Elevation 16 feet NAVD88: The estimated average annual loss (AAL) is about 0 to \$50,000. Over the 40 year evaluation life, the expected total life loss (40 years) is about **0 to \$2M**.

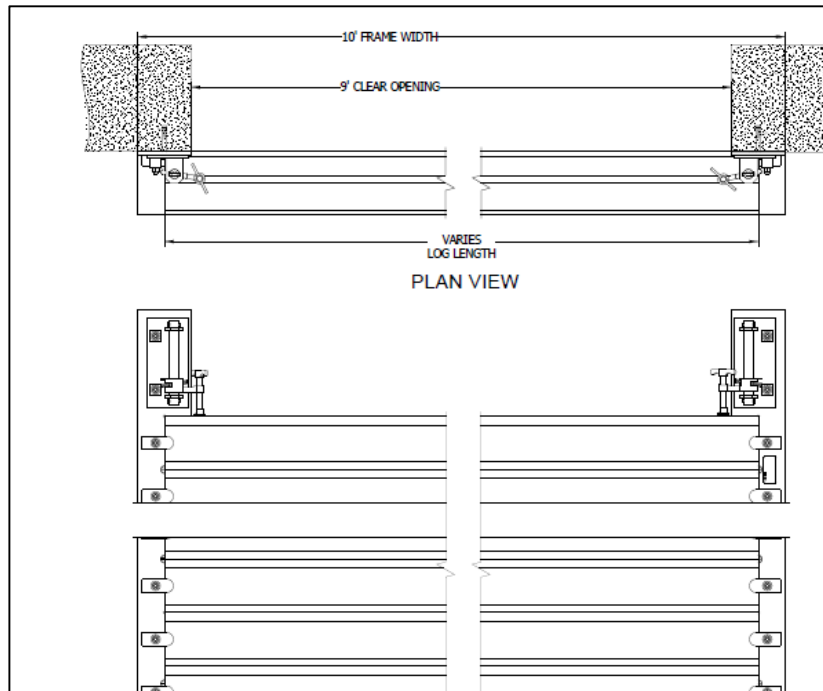
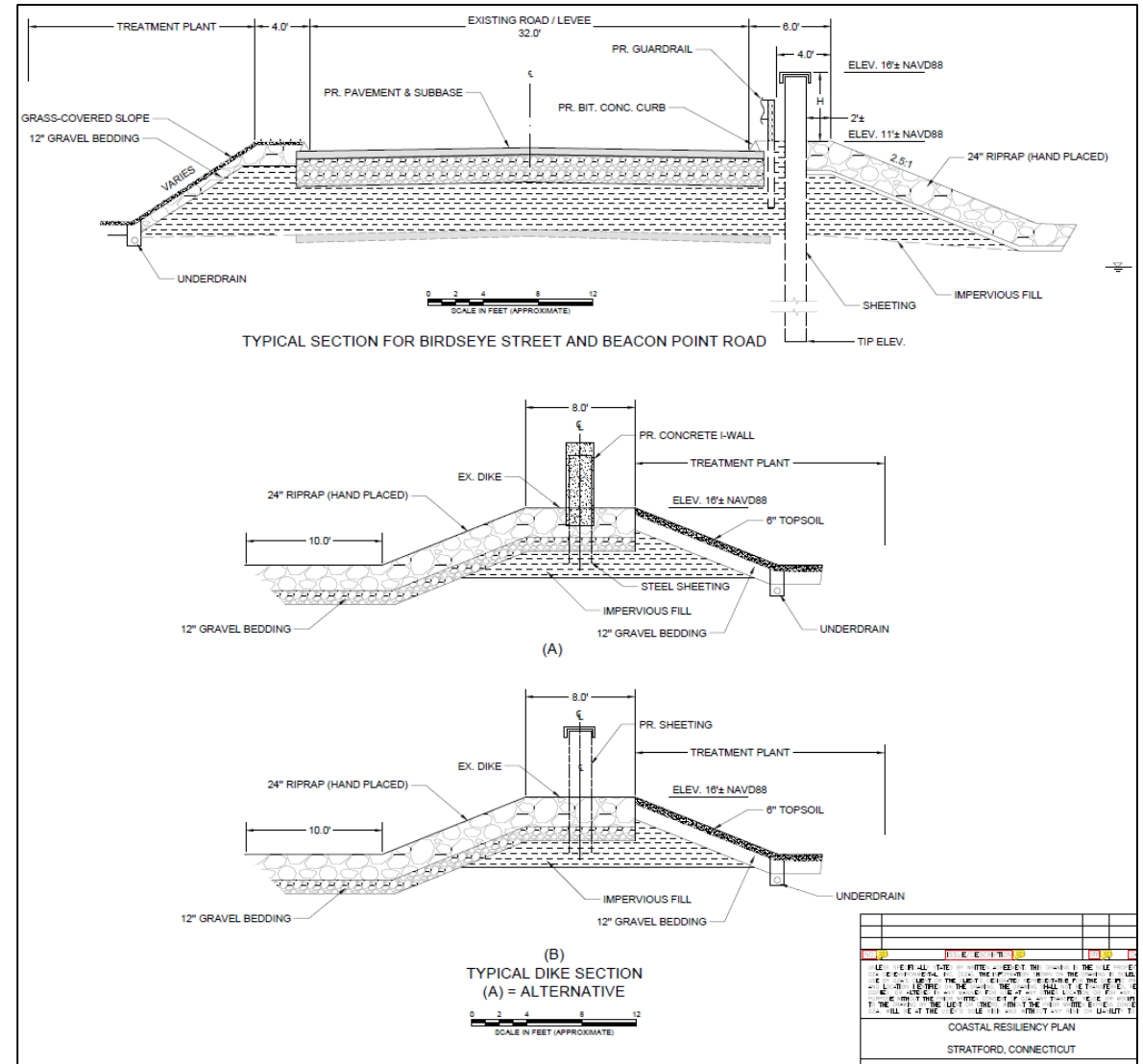
Elevation 17 feet NAVD88: The estimated average annual loss (AAL) is essentially **zero**.

**Estimated Cost: \$5M to \$7M**

# Permanent Flood Protection Alternative

Phase II

Phase I



Phase III  
Adaptation measures to respond to climate change

NO.	DATE	DESCRIPTION	BY	CHKD

COASTAL RESILIENCY PLAN  
STRATFORD, CONNECTICUT