Water quality impacts from tidal flooding in the lower Chesapeake Bay.

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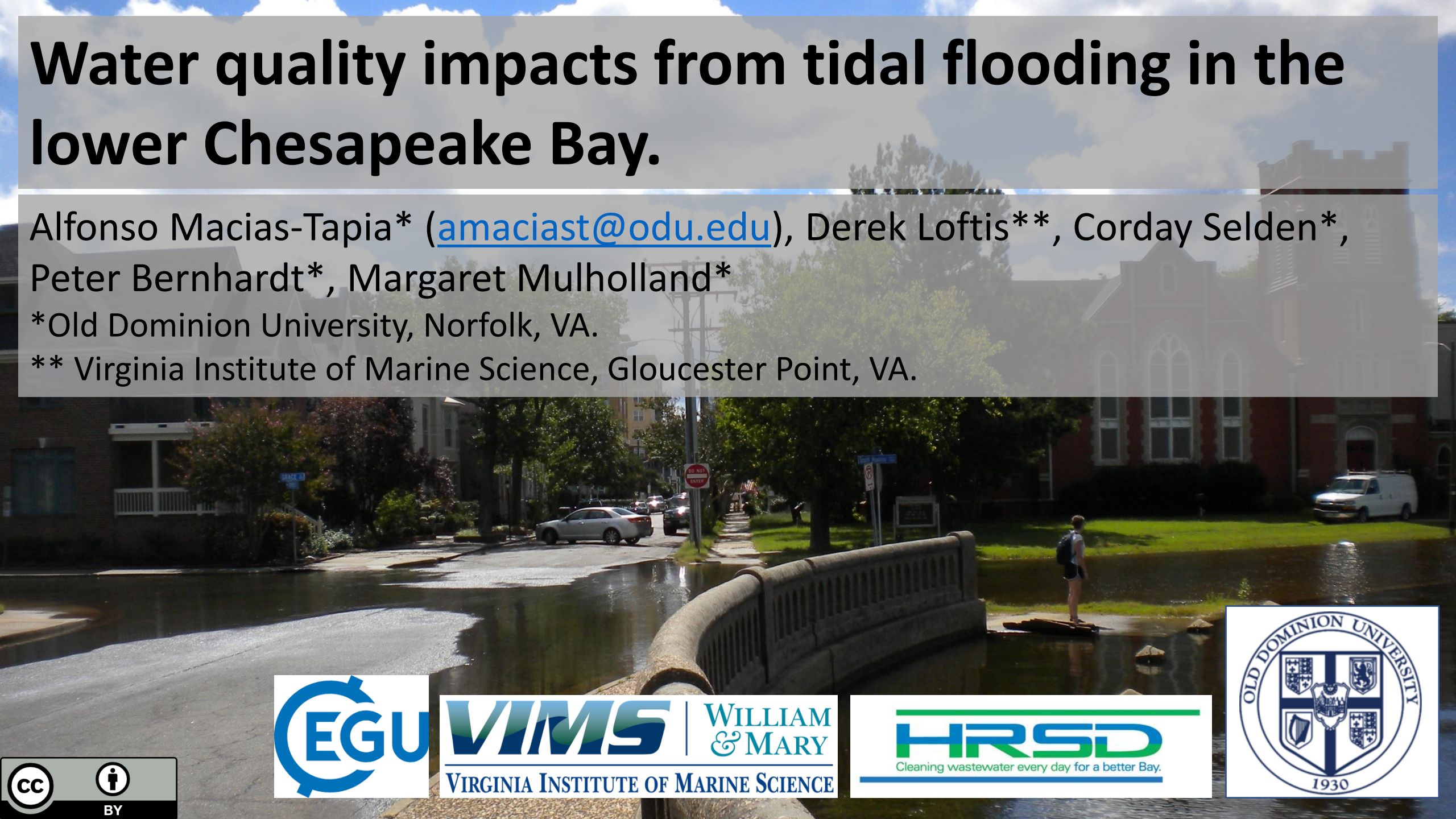

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Ghent neighborhood affected by
Tidal flooding in Norfolk, Virginia, USA

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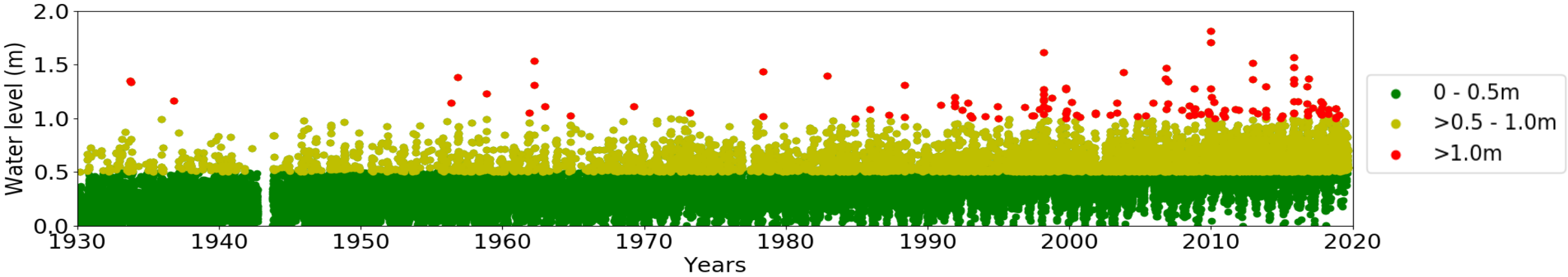
Introduction – increasing Sea level rise and tidal flooding

Daily maximum water level, during spring tide, measured between 1930 and 2019 in Virginia, USA.



- The mid-Atlantic North American coast has a rate of relative SLR about 30% higher than the global average (and accelerating);
- Tidal flooding will continue to increase along the east coast of the US in the foreseeable future;
- Most studies regarding examining impacts of tidal flooding have focused on direct and indirect threats to urban infrastructure and economy.

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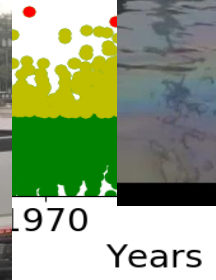
Mayflower neighborhood, in Norfolk,
affected by tidal flooding during hurricane Dorian (2019)

Gas station, in Norfolk,
affected by tidal flooding during hurricane Matthew (2016)

Larchmont neighborhood, in Norfolk,
affected by tidal flooding



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While estimates of stormwater inputs into coastal systems have been made, material (e.g., sediment, nutrients and contaminating bacteria) transported into local and regional waterways as floodwaters recede during tidal flooding events have not been quantified.

https://www.youtube.com/watch?v=PkvjnqDlTcQ&feature=youtu.be
Norfolk Flooding Following Hurricane Matthew, 2016.

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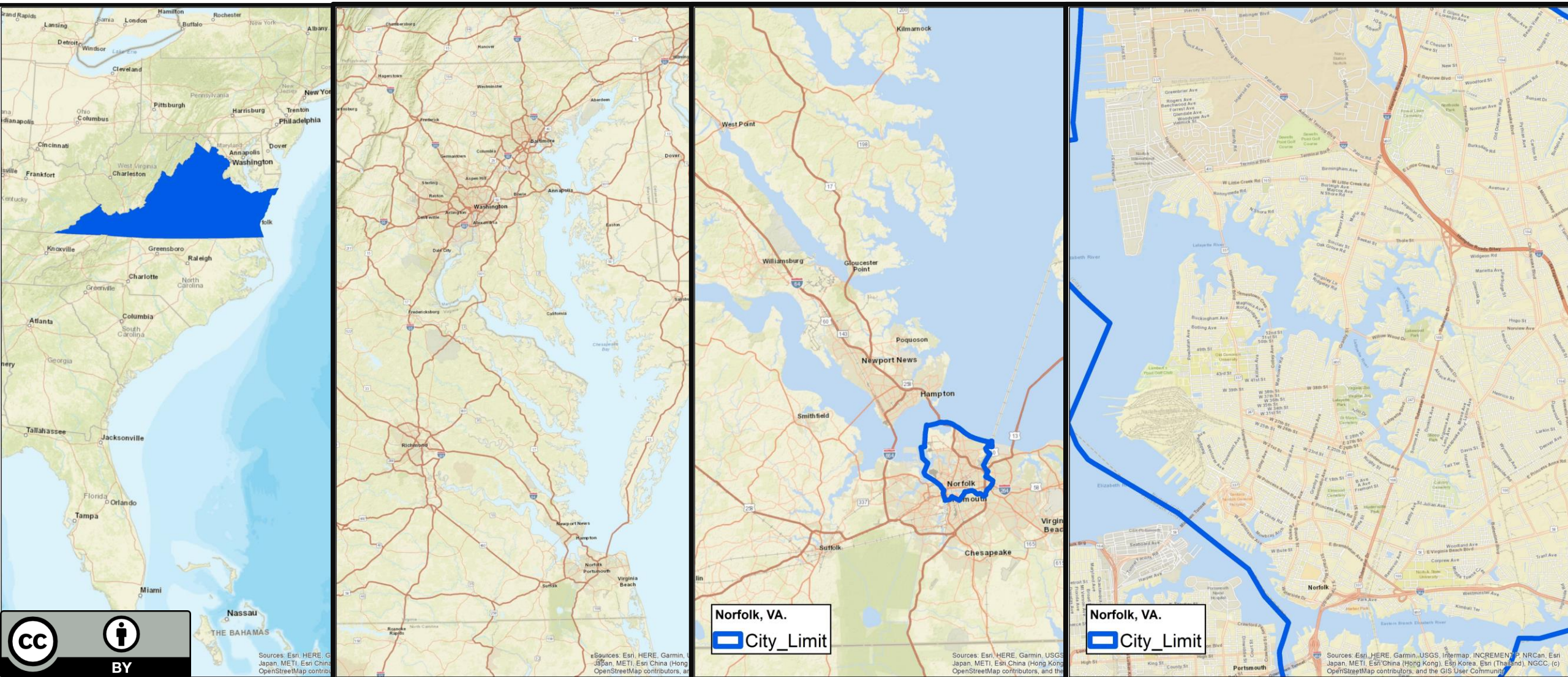
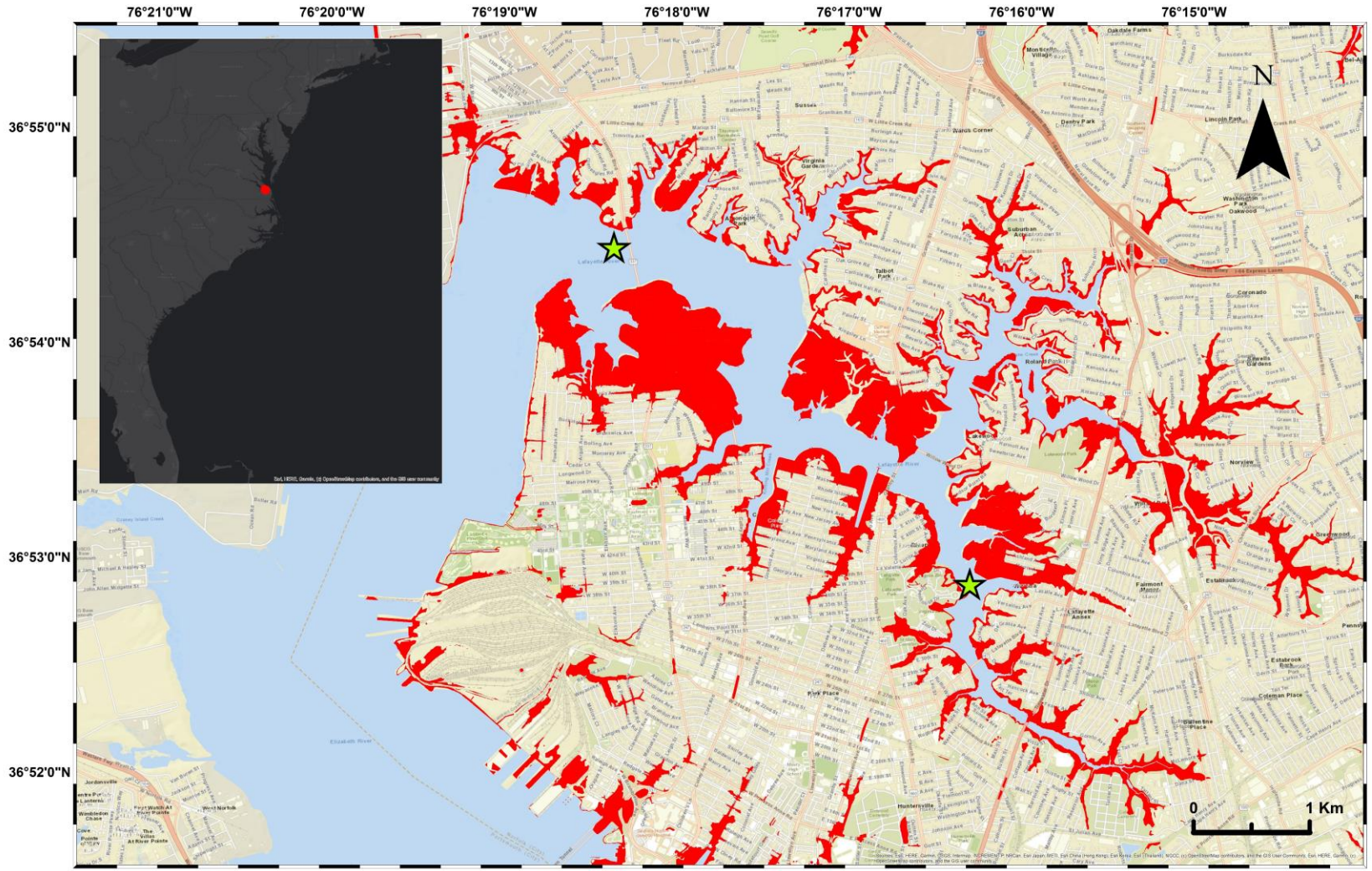
Study Site - Lafayette River, a sub-tributary of the lower Chesapeake Bay.



Most of its watershed is prone to flooding during high tides because elevations are less than 5m above mean sea level.



Land inundation produced by ~1m mean lower low water (MLLW) flooding event in surrounding areas of the Lafayette river, Norfolk, Virginia. Stars represent in-river samples. Inset shows the north-east coast of the continental U.S. where the city of Norfolk Virginia (red area) is located. Source, City of Norfolk, Open data portal.

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Methods – Tidal flooding water characterization and nutrient inputs

a) Citizen-engaging project;

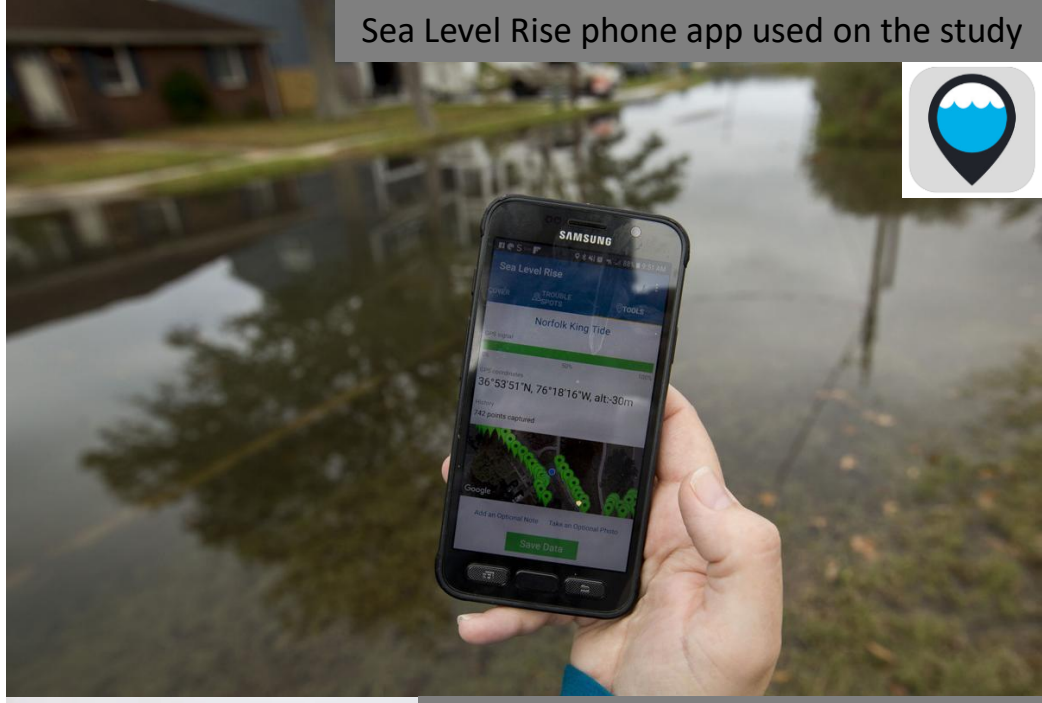
- Once a year
- Perigean spring tide
- (+spatial, -temporal)
- 2017 – 2019

b) Sentinel sites

- Flooding events different
- Extreme tidal flooding events
- (-spatial, +temporal)
- Since January of 2019

Analysis
- Particulate N and C
- Dissolved components
  > i.e. NH4
- Others
  >i.e. *Enterococcus*

Sea Level Rise phone app used on the study



Volunteers training for the 2017 event

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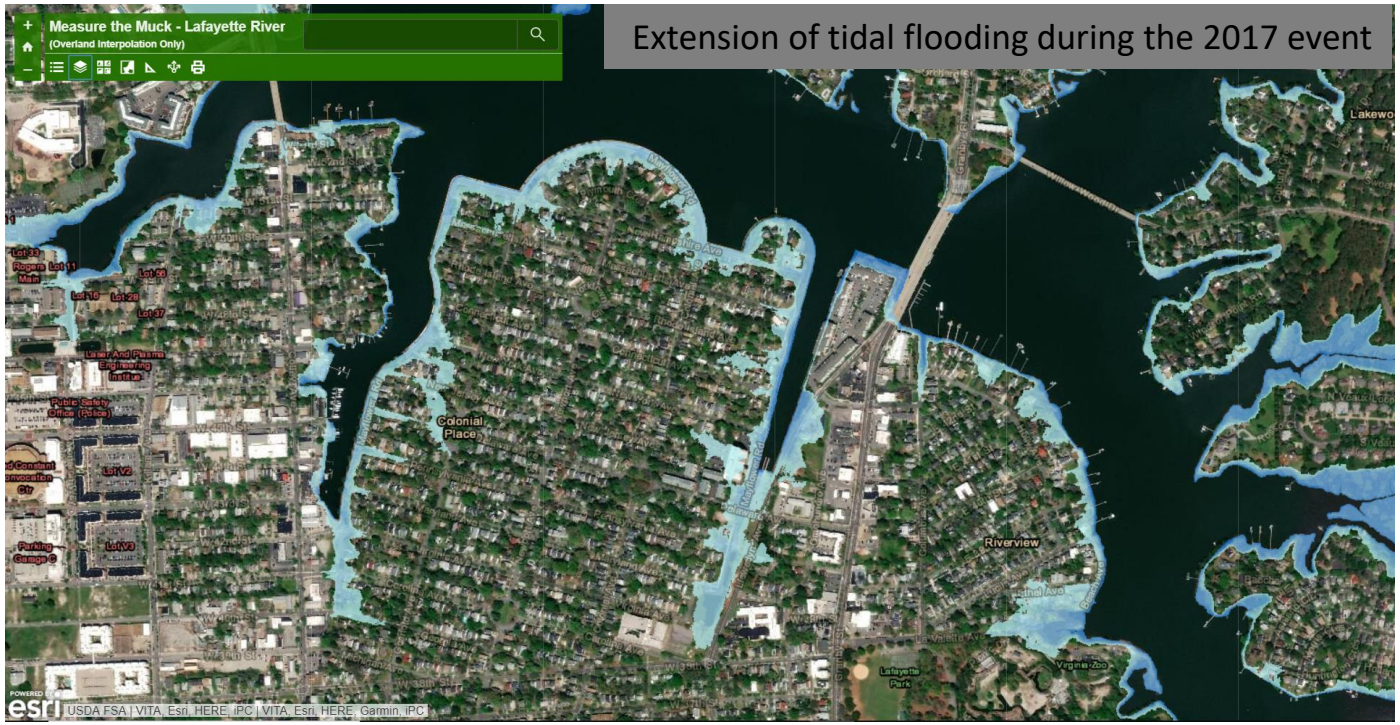
Results – Citizen project

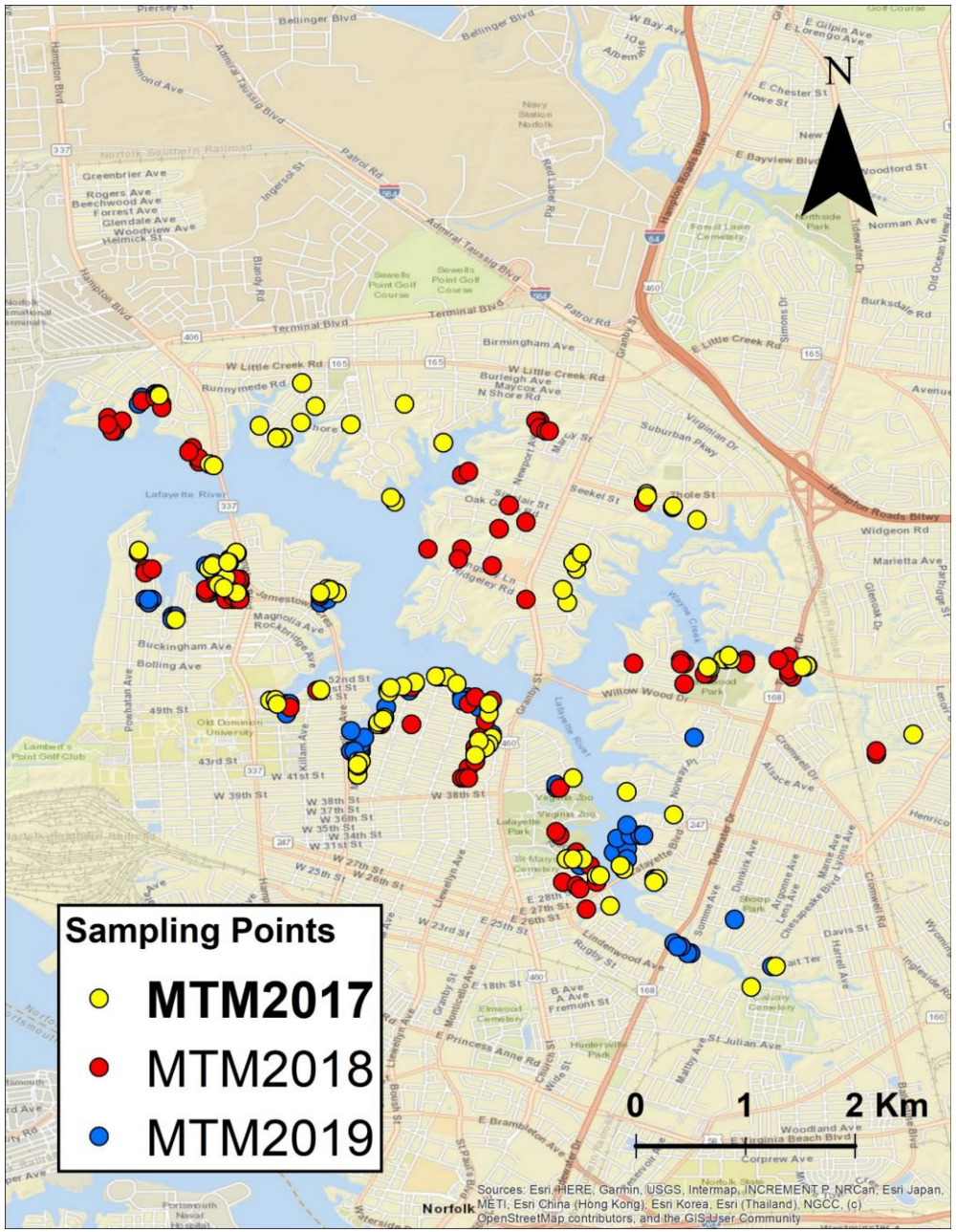


Extension of tidal flooding during the 2017 event

flood water volume x dif. median [NO3] = [N] in flooding water

4x10^10 L 6.74 – 4.48 μM NO3 **≈ 1,265 Kg of N**

2.26 μM NO3



Flood water samples collected during the citizen project events.

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- How much is too much?
  > compared with,
    + EPA, 2010
    + Total Maximum Daily Load
    + Limit for nutrient inputs to preserve natural state of the Bay

Table 9-1. Chesapeake Bay TMDL total nitrogen (TN) annual allocations[a] (pounds per year) by Chesapeake Bay segment[b] to attain Chesapeake Bay WQS

Segment ID	Jurisdiction	CB 303(d) Segment	TN WLA (lbs/yr)	TN Land Based LA (lbs/yr)	TN AtDep[c] LA (lbs/yr)	TN TMDL (lbs/yr)	TN 2009 Existing (lbs/yr)
LAFMH	VA	Lafayette River	70,367	1,941	7,274	79,582	71,296

Our calculation, **more** than the TN Land Based-TMDL permitted for this specific system in a year.

- Only NO3;
- **It is the calculation for a single event!**

880 kg

≈ 1,200 Kg of N

a. MOS is implicit for nitrogen (see Section 6.2.4)
b. Each of the 92 segments is displayed as white rows while contributing portions of some of the 92 segments are displayed as gray rows.
c. AtDep means atmospheric deposition only for direct deposition to tidal waters.
Note: Any differences between this table and Table 8-5 are due to rounding.

WLA= waste load allocations

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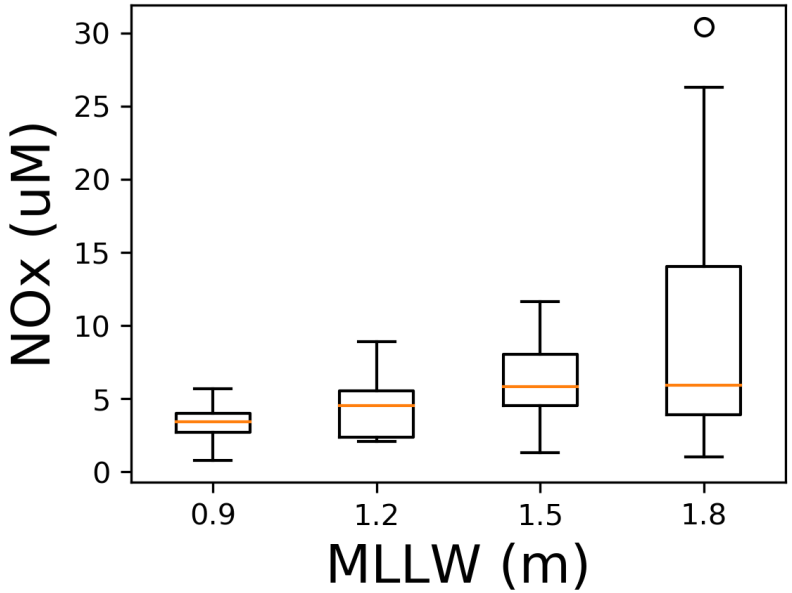
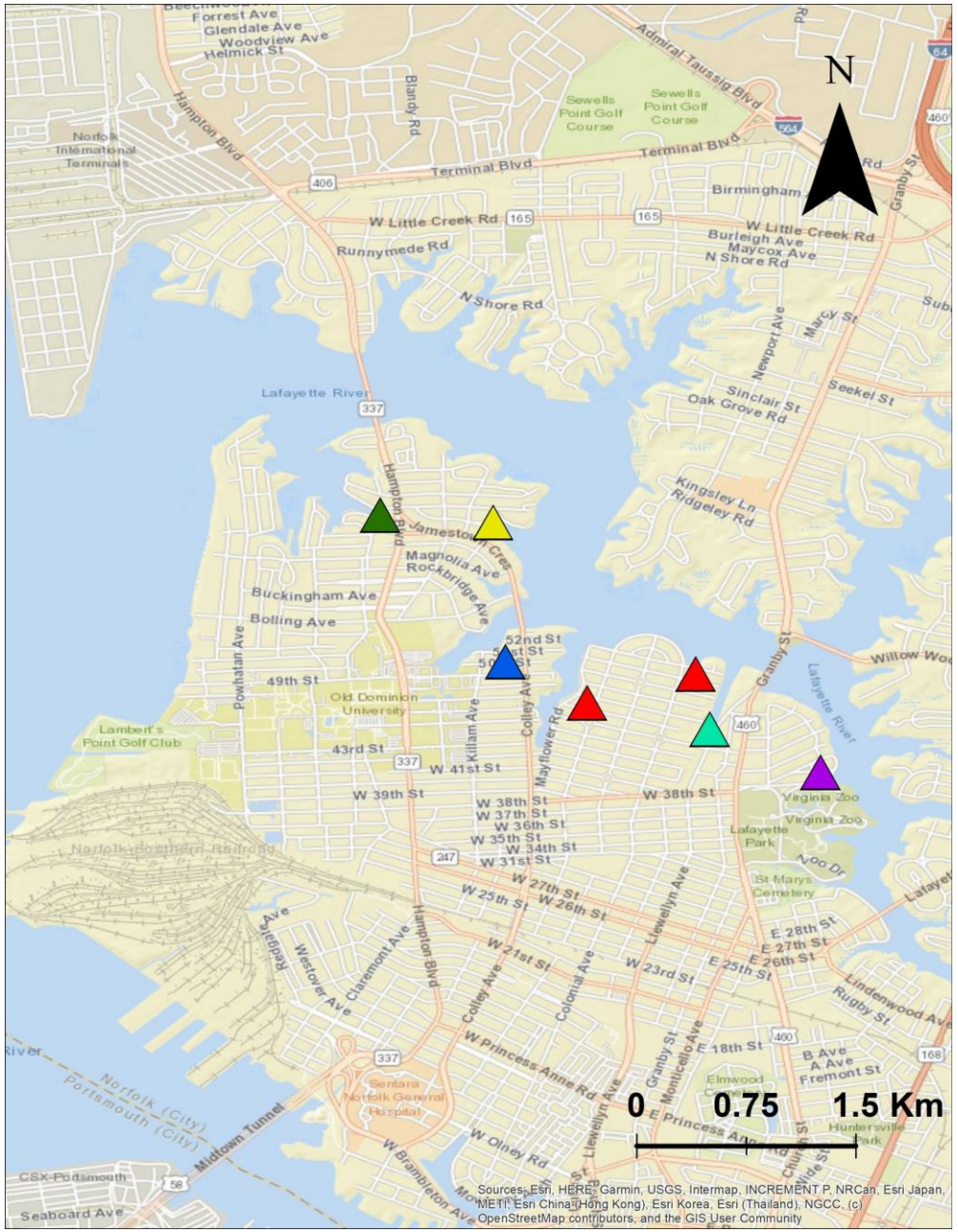
Results – Sentinel Sites



NOx concentration at all sentinel sites during different levels of tidal flooding

Relationship between nutrients in flood water and weather conditions could be affected by,

- Rain;
- Background conditions (i.e. algal bloom);
- Wind (speed and direction); etc.



Sentinel sites sampled during extreme (MLLW>1m) tidal flooding events.

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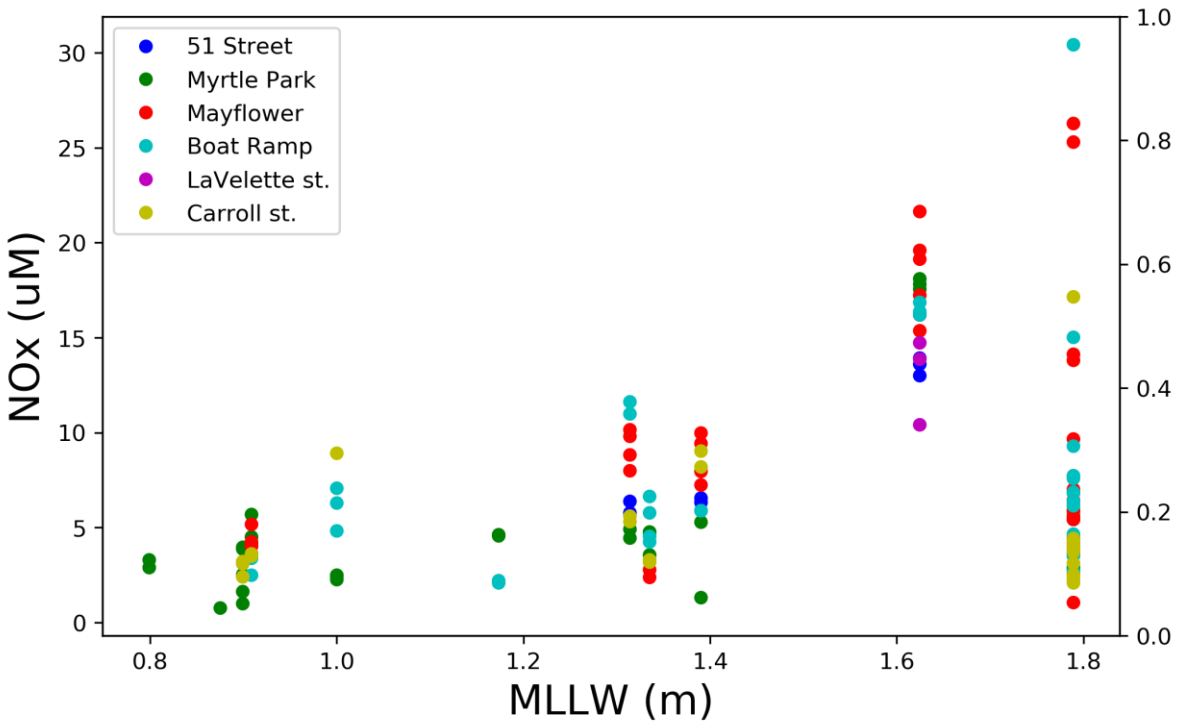
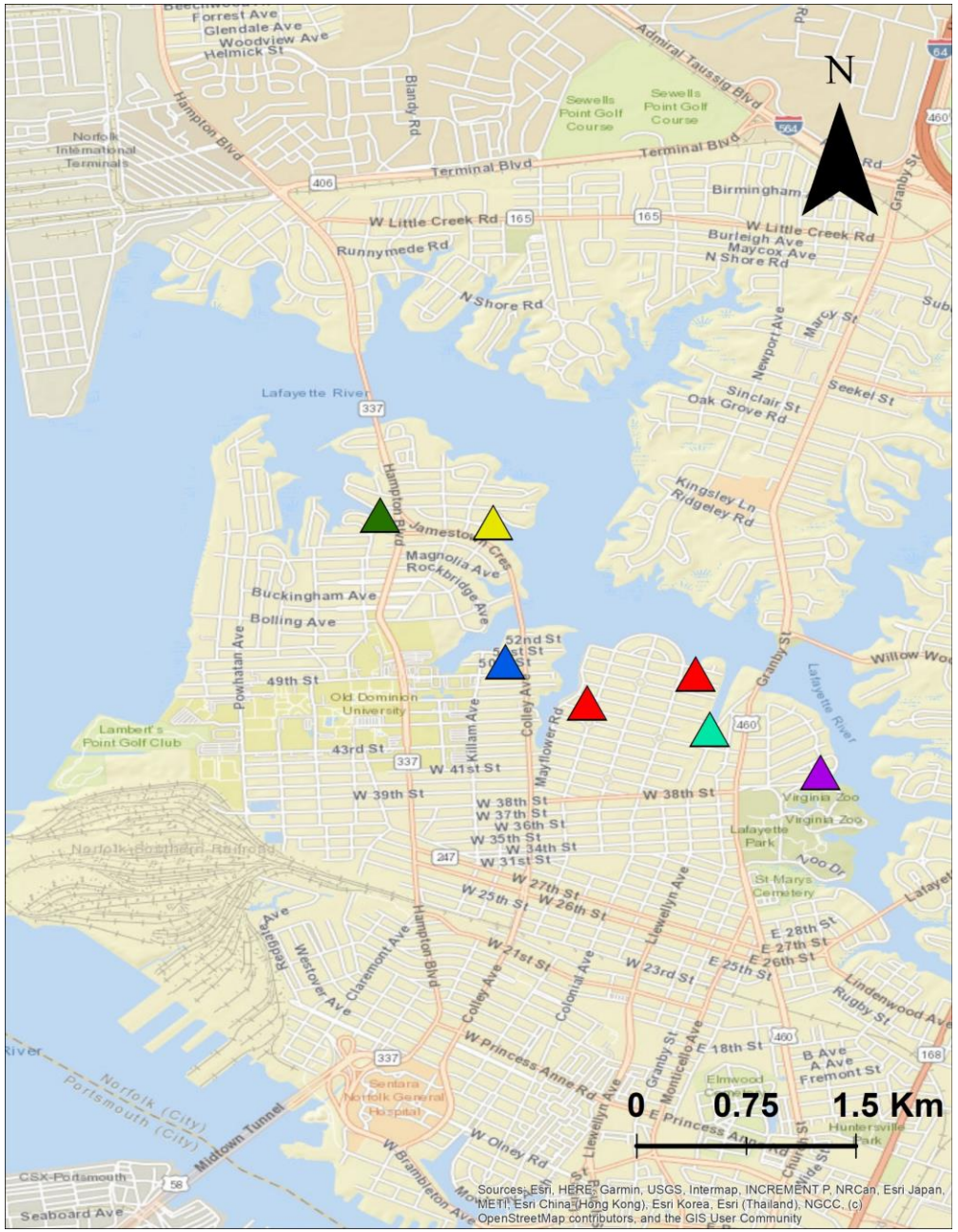


NOx concentration at individual sentinel sites during different levels of tidal flooding

- Effects of land use. Norfolk is predominantly urban.
- Analysis on similar areas of the Chesapeake Bay and other regions impacted by tidal flooding.



Sentinel sites sampled during extreme (MLLW>1m) tidal flooding events.

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Conclusions

- Affected areas accumulate various types of compounds that can potentially be carried during flooding into the water body.
- The results from this study suggest that nutrients transported to the water system due to flooding events should be taken into account.
- Community-engaging projects can play an important roll in measuring nonpoint nutrient sources.

Colonial Place, in Norfolk, affected by tidal flooding

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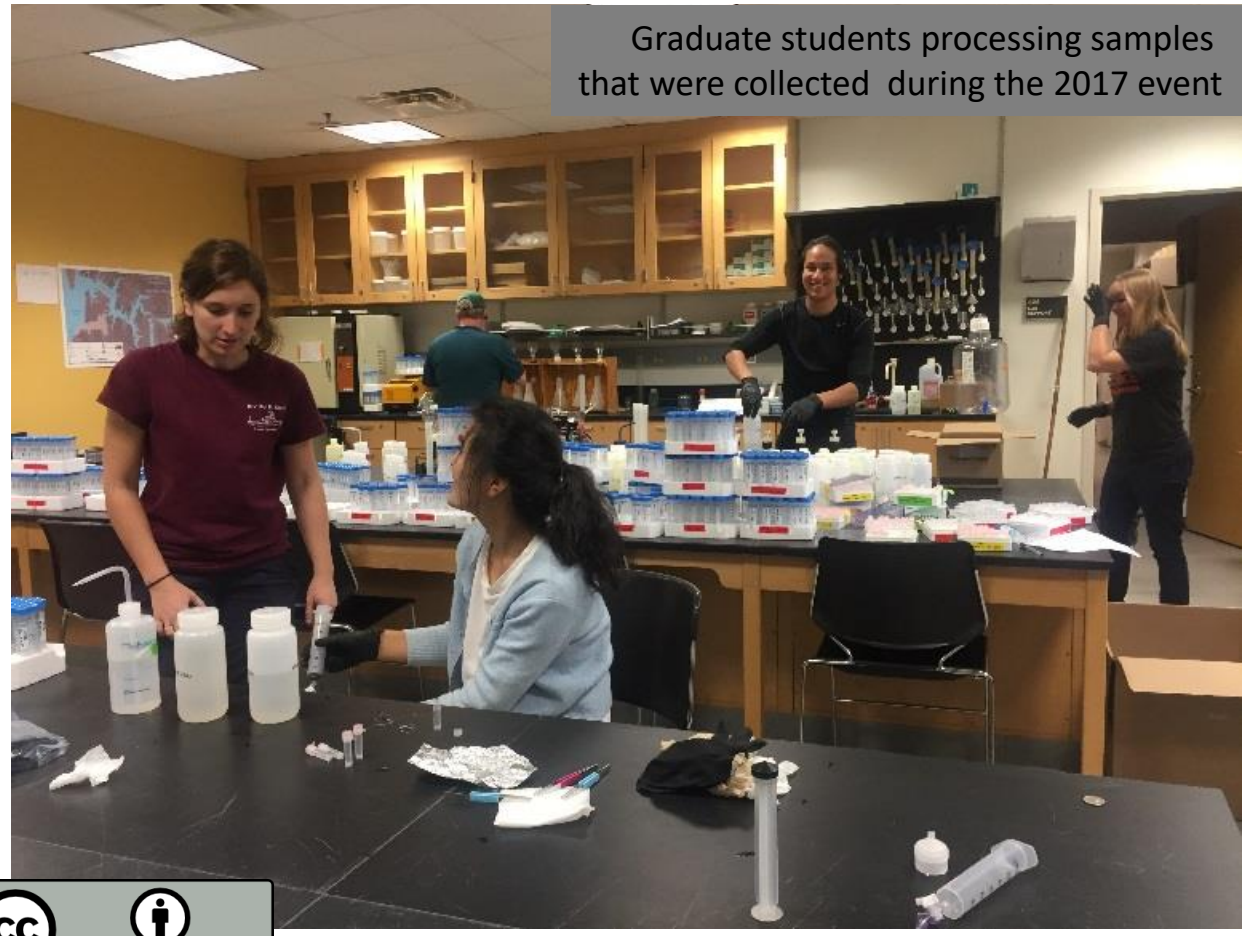
Thanks

Volunteers getting ready to collect samples for the 2018 event


Graduate students processing samples that were collected during the 2017 event

Cleaning wastewater every day for a better Bay.

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