

# A Path to Higher Ground: Building Flood Resiliency

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2018 Rail Conference

# Key Takeaways

- Impetus for a vulnerability analysis
- Determining vulnerable locations
- Lessons learned & next steps: implementation & planning updates

# Maryland Department of Transportation

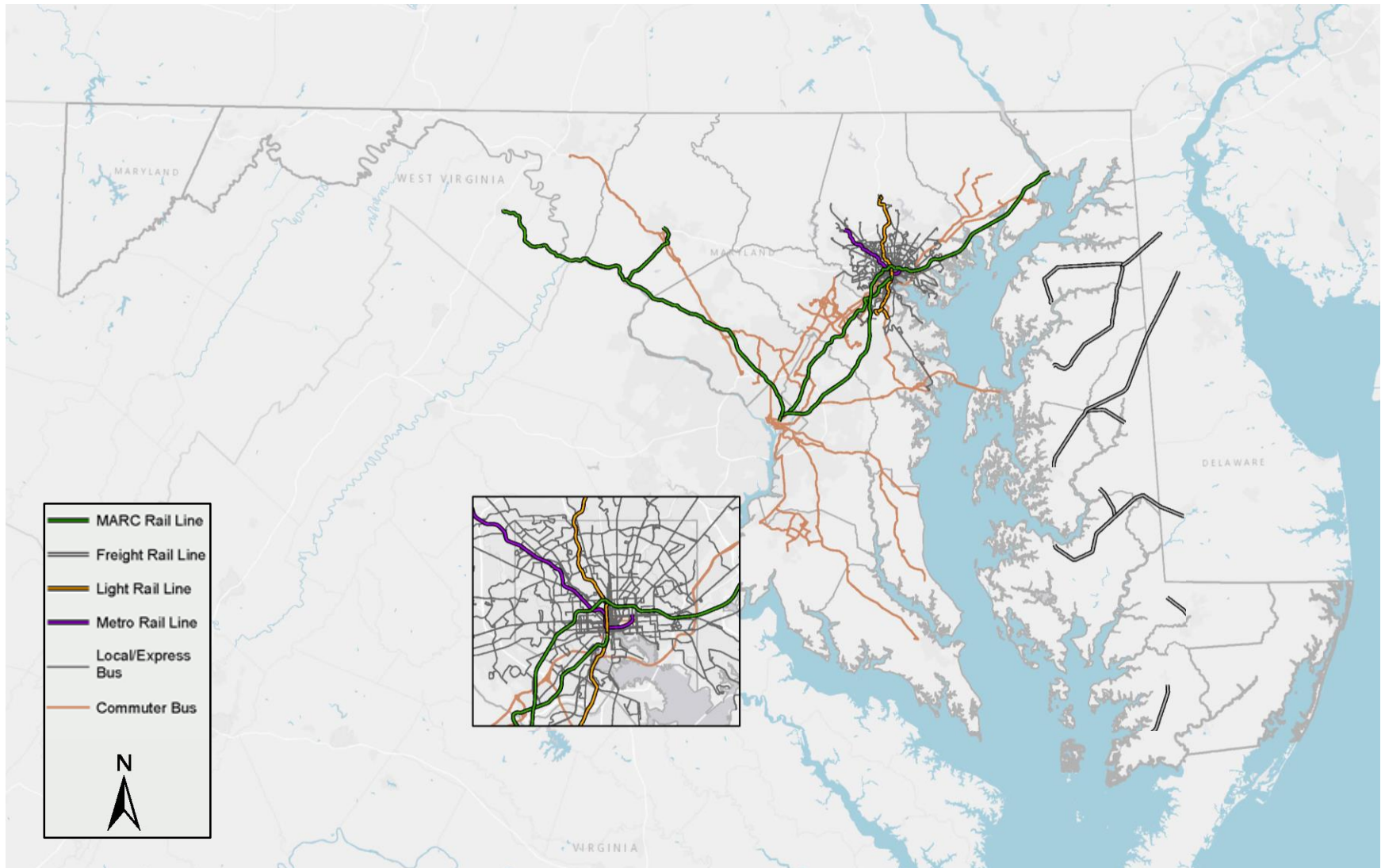


# Maryland Transit Administration



<b>Ridership Share</b>	<b>68.7%</b>	<b>11.1%</b>	<b>6.7%</b>	<b>8.1%</b>	<b>3.6%</b>	<b>1.8%</b>
<b># of Fixed Routes</b>	<b>66</b>	<b>1</b>	<b>1 (2 spurs)</b>	<b>3 (1 spur)</b>	<b>36</b>	<b>-</b>
<b>Track Route Miles</b>	<b>-</b>	<b>34</b>	<b>58</b>	<b>471</b>	<b>-</b>	<b>-</b>
<b># of Stations</b>	<b>-</b>	<b>14</b>	<b>33</b>	<b>42</b>	<b>52</b>	<b>-</b>

# MDOT MTA Service Area

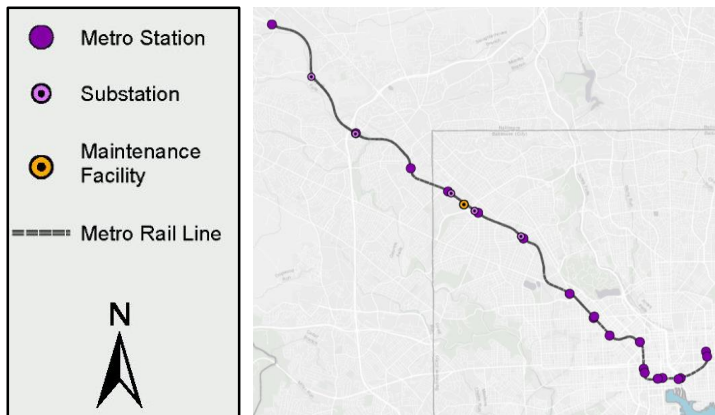


# Impetus No. 1: Hurricane Isabel

## September 18-20, 2003

Ambrose, K. Remembering Hurricane Isabel, 10 years later. [WashingtonPost.com](http://WashingtonPost.com). Web. 9 May 2018.

- Category 2 at landfall
- Landfall: NC Outer Banks
- Tides: 8 feet above normal
- Rain: 1-6 inches
- Winds: 55 to 65 mph





# Isabel's 8-Foot Storm Surge



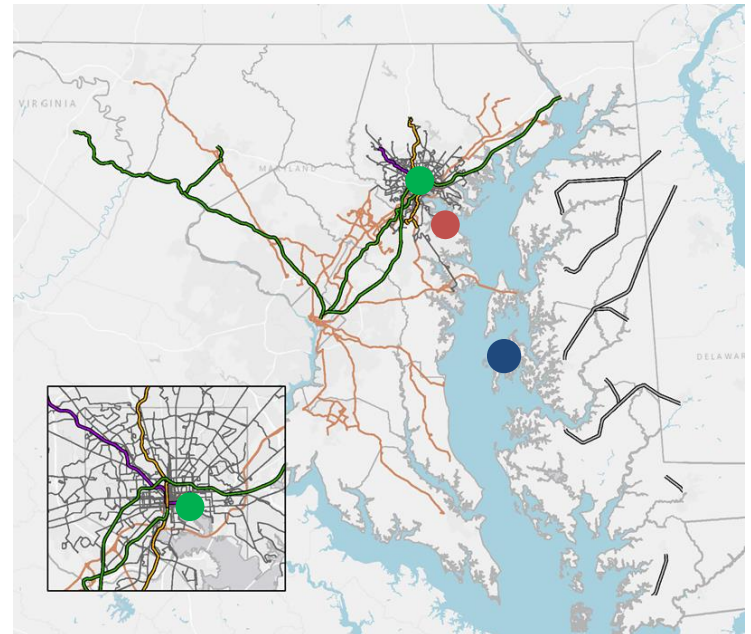
**St. Michaels, Talbot County**



**Fells Point, Baltimore City**



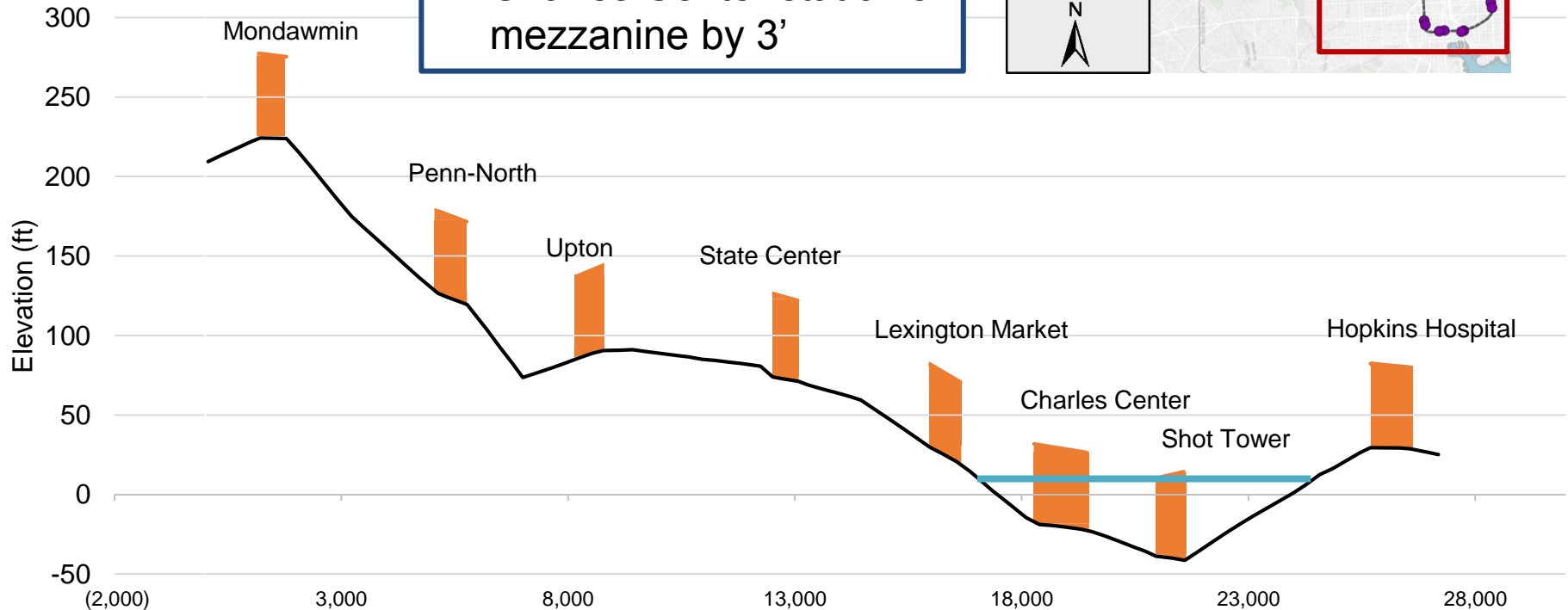
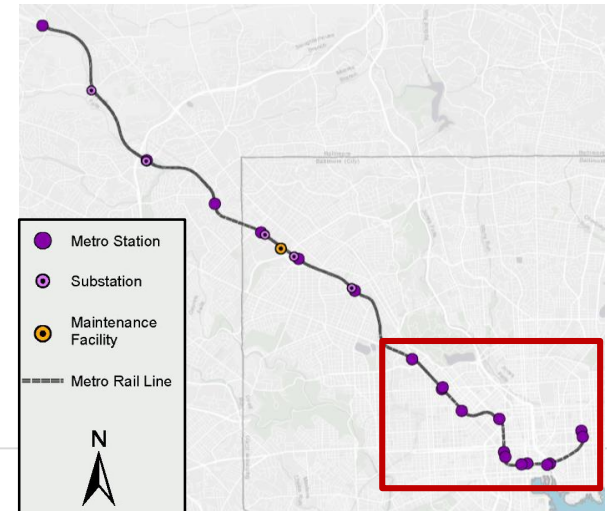
**Annapolis, Anne Arundel County**



# 2016 Metro Flooding Study

## 12' Storm Surge Will Flood:

- +7,400 feet of track
- Shot Tower station
- Charles Center station's mezzanine by 3'





# Impetus No. 2: Sea Level Rise



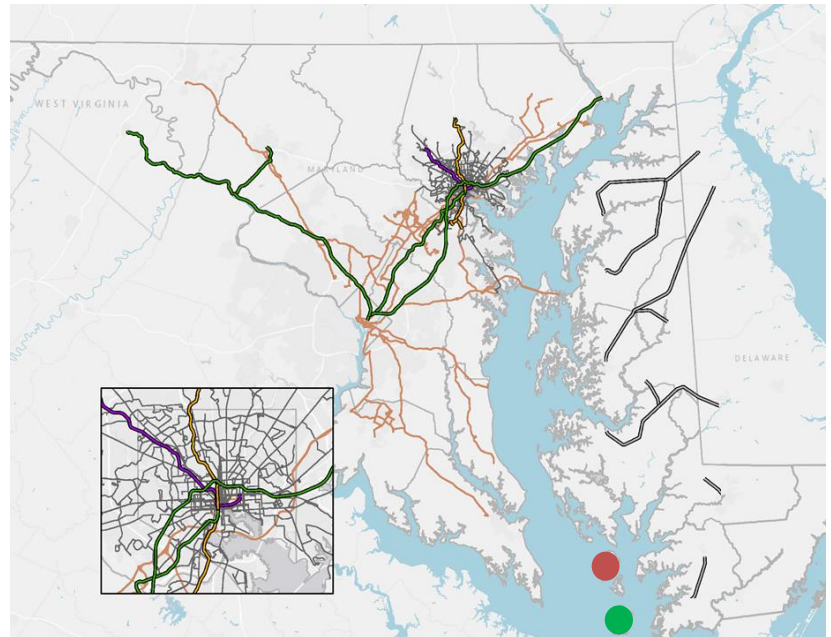
Smith Island, Somerset County



Holland Island, Dorchester County

## 2100 Projections, Maryland Commission on Climate Change

- Unrestrained emissions: 2.2-4.1 foot rise
- Rapid reductions: 1.4 to 2.8 foot rise



# Impetus No. 3: Track Wash Outs



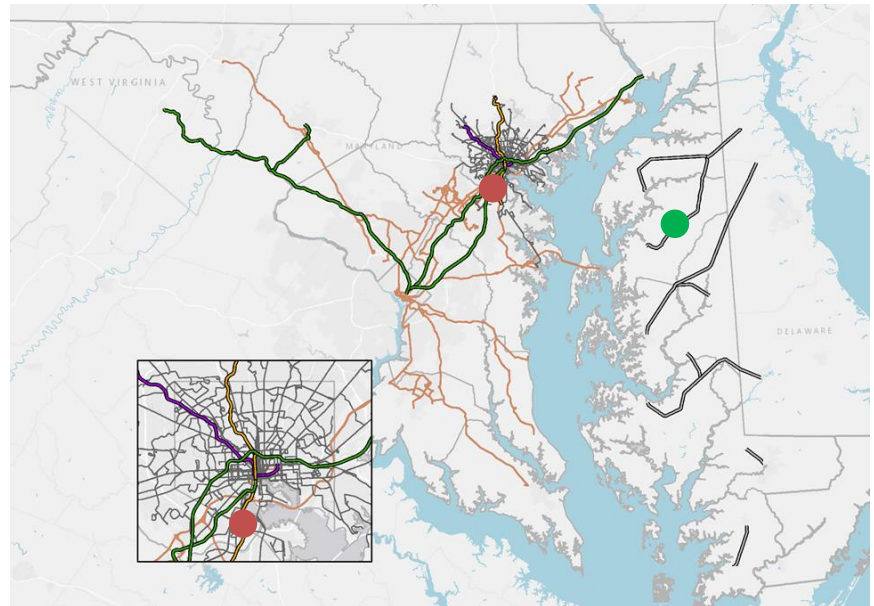
**Light Rail, Baltimore Highlands**



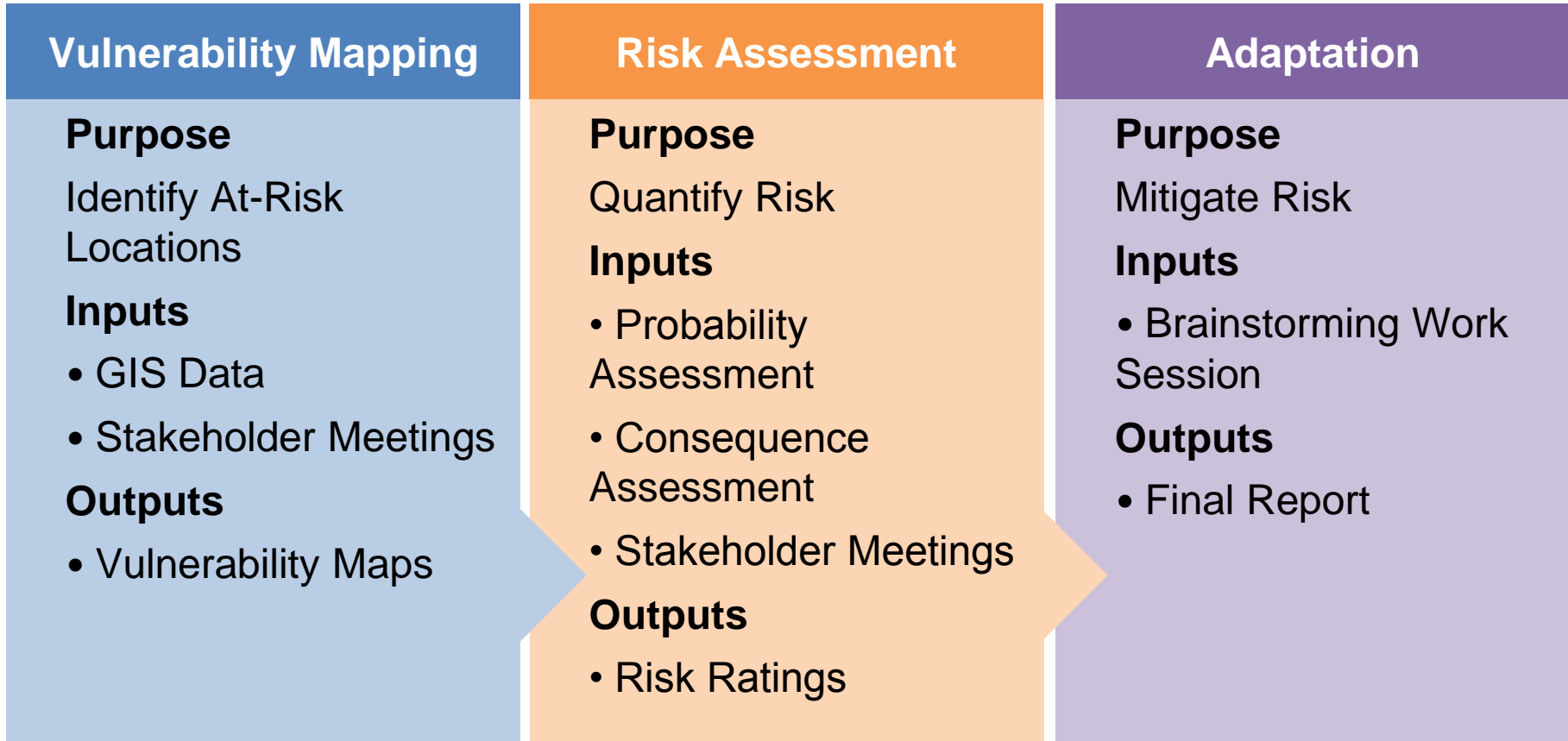
**Freight, Townsend-Centreville  
Line**

## More Severe Rain Storms & A More Built Environment

- July 2016 and May 2018 Ellicott City flooding
- Infrastructure damage exacerbated by impervious surfaces






# 2016 Climate Assessment: Vulnerability Analysis





# Vulnerability Mapping

	<h2 data-bbox="875 239 1213 287">Sea Level Rise</h2> <p data-bbox="531 315 1064 362"><b>Scenarios:</b> 2, 4, &amp; 6 feet</p> <p data-bbox="531 391 1360 486"><b>Data:</b> National Oceanic &amp; Atmospheric Administration</p>
	<h2 data-bbox="900 588 1188 635">Storm Surge</h2> <p data-bbox="531 664 1070 711"><b>Scenarios:</b> Category 1-4</p> <p data-bbox="531 739 1541 835"><b>Data:</b> USACE via NWS' Sea, Lake, &amp; Overland Surge Hurricane (SLOSH)</p>
	<h2 data-bbox="817 936 1271 983">Rainstorm Flooding</h2> <p data-bbox="531 1016 1116 1063"><b>Scenarios:</b> 100 &amp; 500 year</p> <p data-bbox="531 1092 1425 1188"><b>Data:</b> FEMA National Flood Hazard Layer Floodplain Data</p>

# Risk Assessment

**Risk**

**=**

**Severity**

Categorized Impacts to:

- Finances
- Operations
- Reputation

**×**

**Probability**

Uses yes/no scoring on sensitivity and adaptive capacity measures:

- Alternative routes
- Completed adaption projects
- Natural barriers

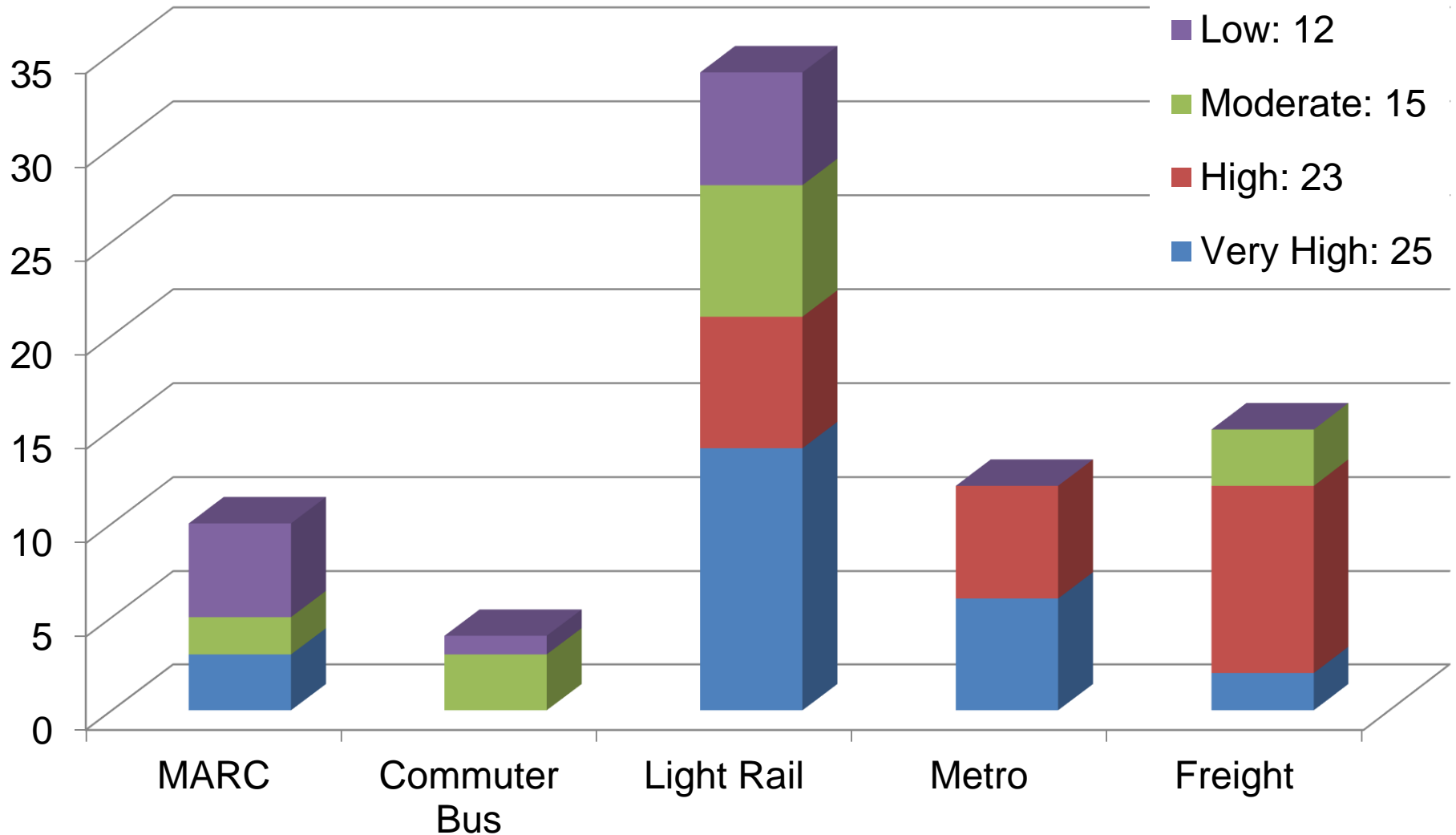




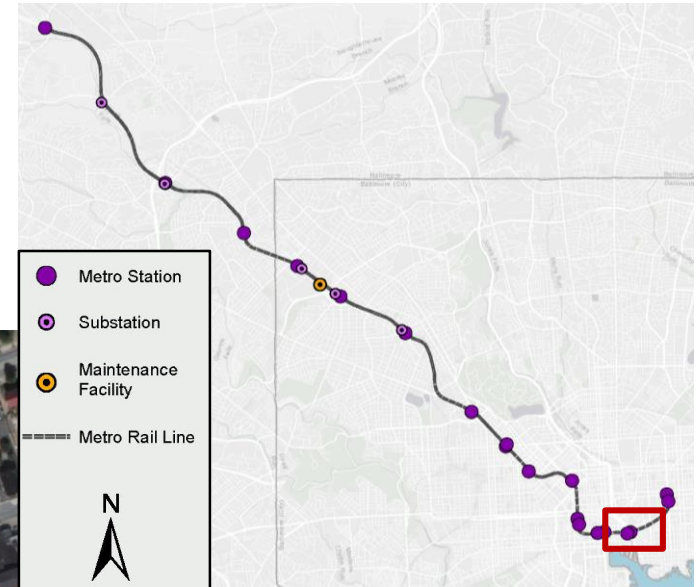
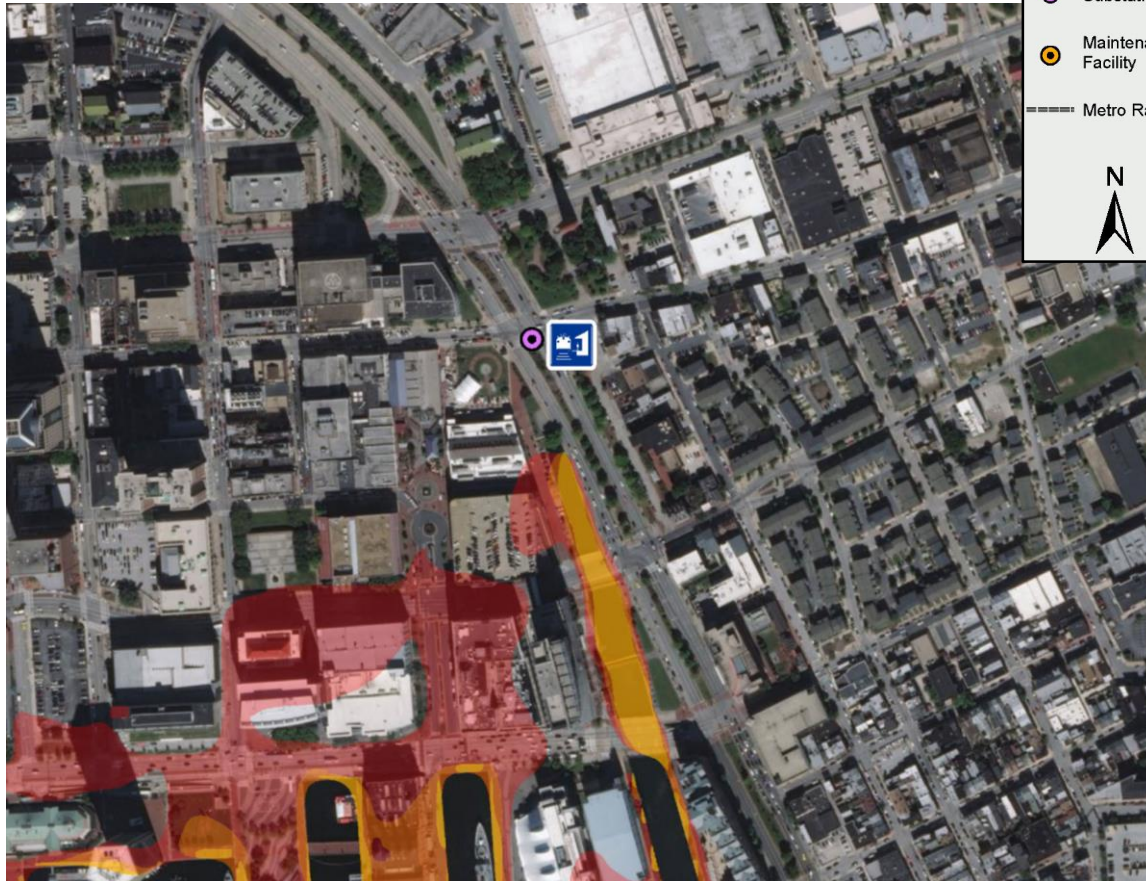
# Risk Rating

	CONSEQUENCE				
PROBABILITY	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Moderate	Moderate	High
Unlikely	Low	Low	Moderate	High	High
Possible	Low	Moderate	High	High	Very High
Likely	Moderate	Moderate	High	Very High	Very High
Almost Certain	Moderate	High	Very High	Very High	Very High

# Risk Ranking



# Metro's Shot Tower Station

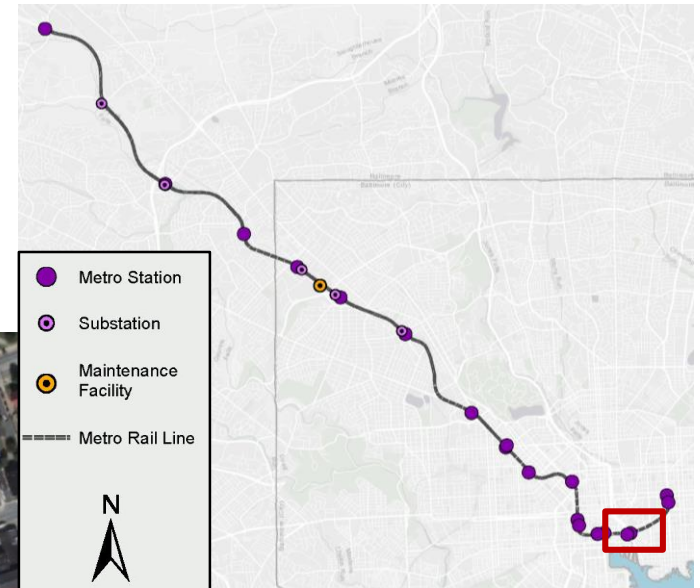
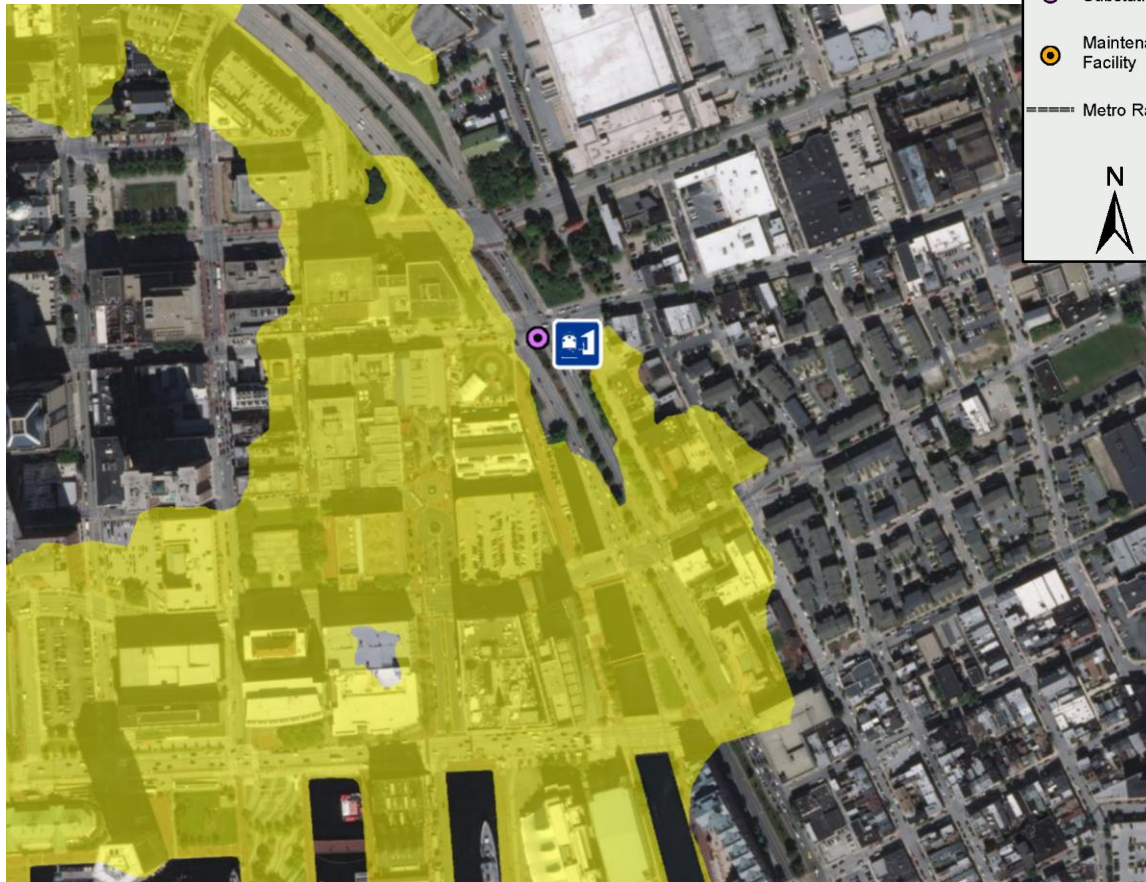


## Sea Level Rise





# Metro's Shot Tower Station

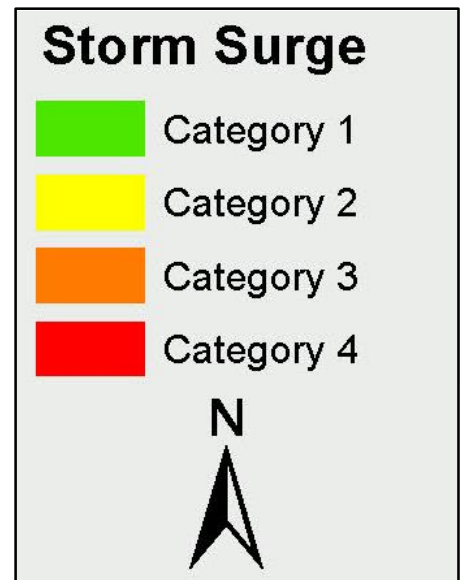
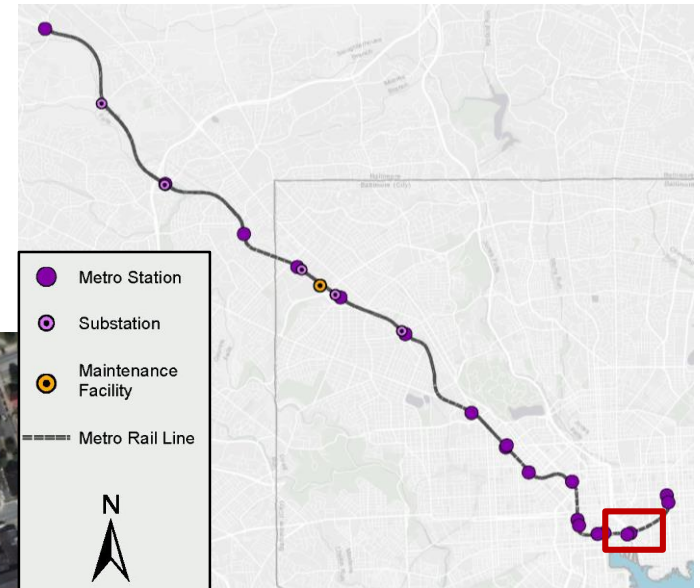
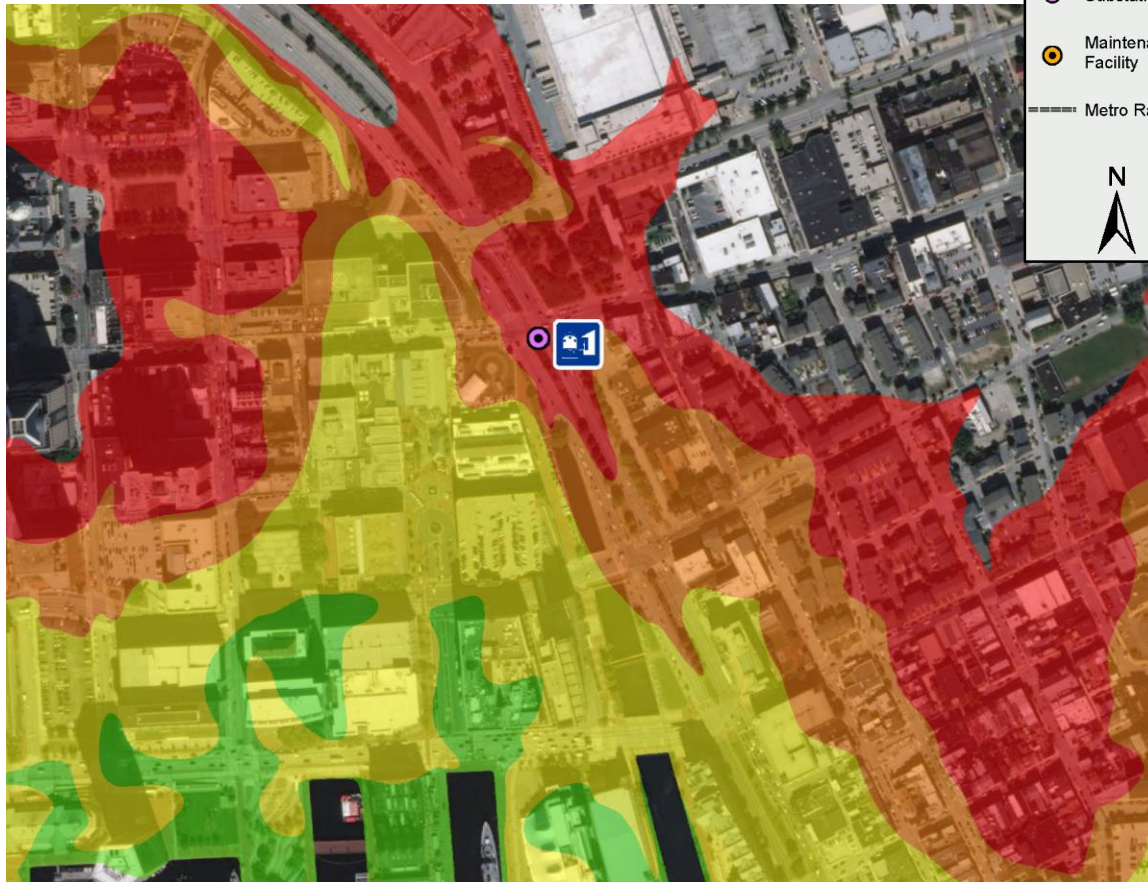


## Flooding

- 100-Year Floodplain
- 500-Year Floodplain

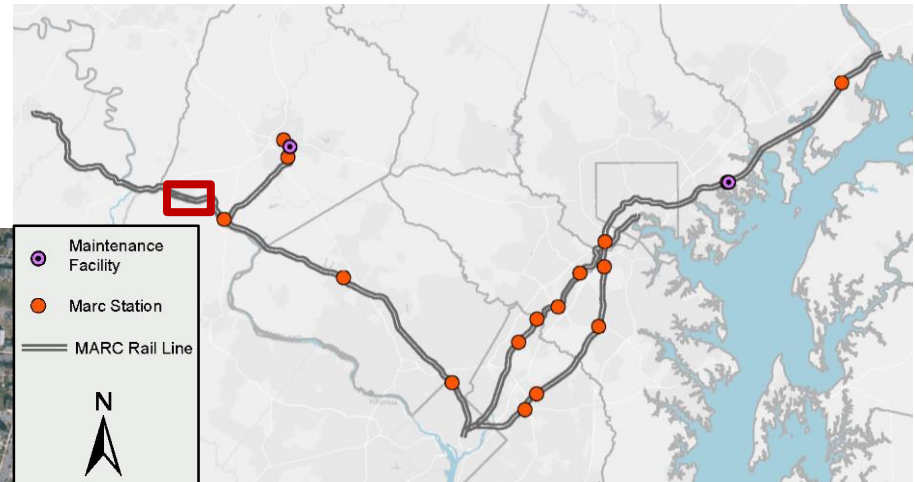
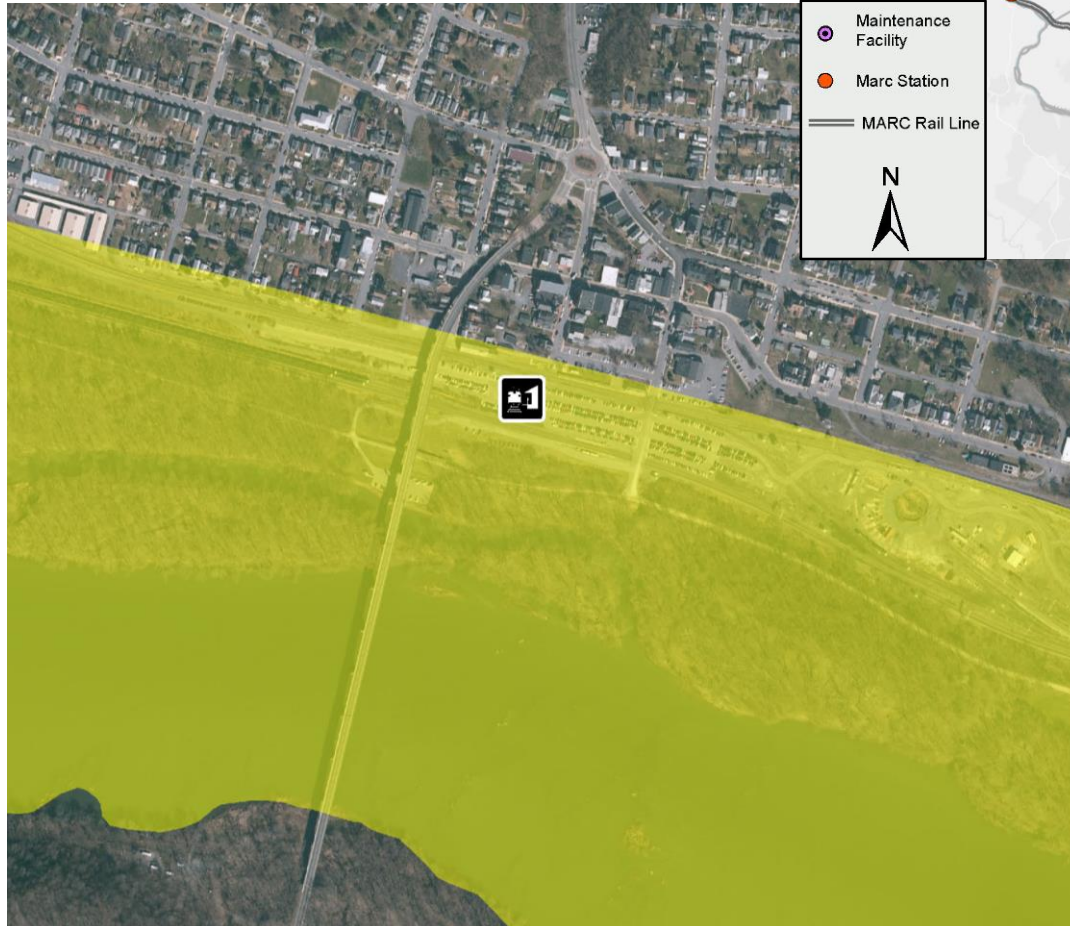


# Metro's Shot Tower Station





# MARC's Brunswick Maintenance Facility & Station

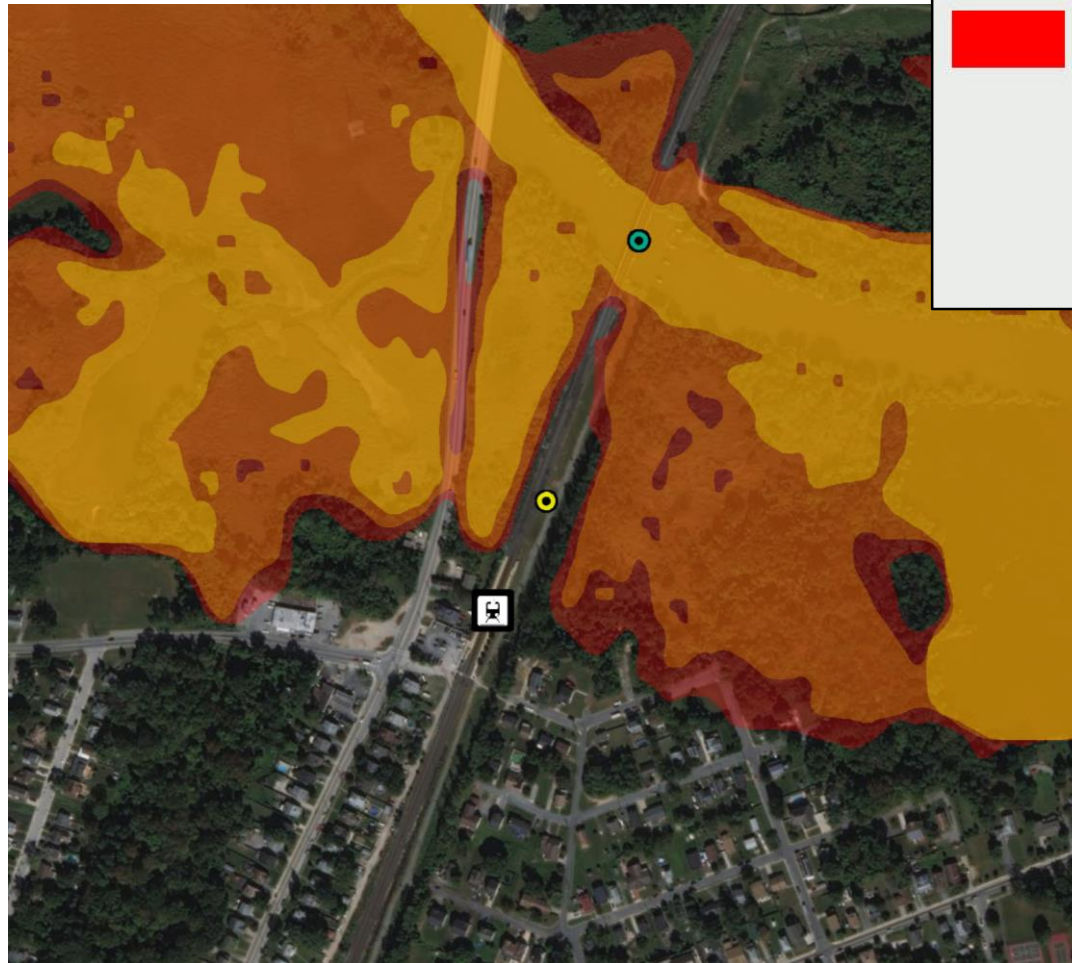


## Flooding

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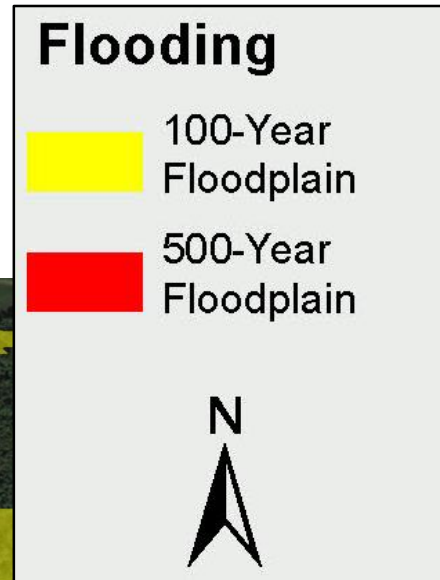
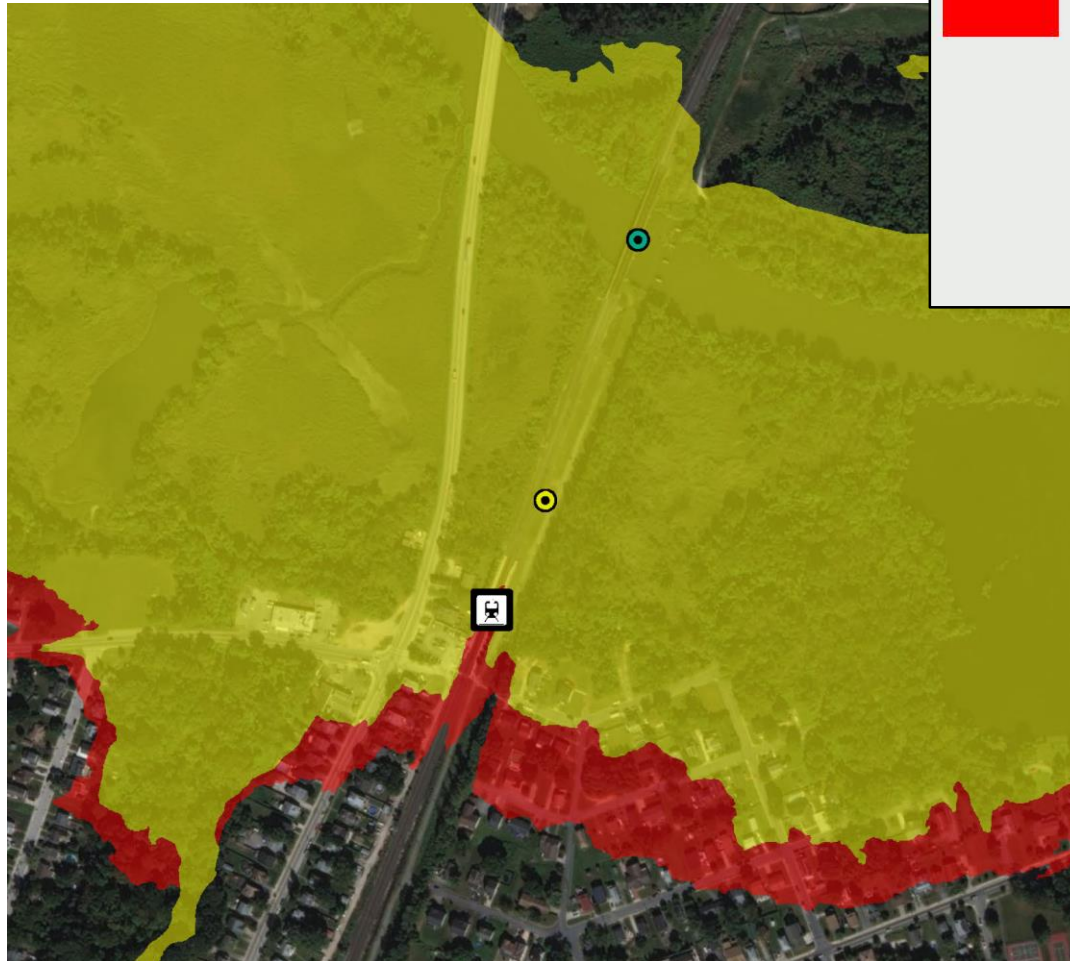


# Light Rail's Nursery Road Station & Bridge

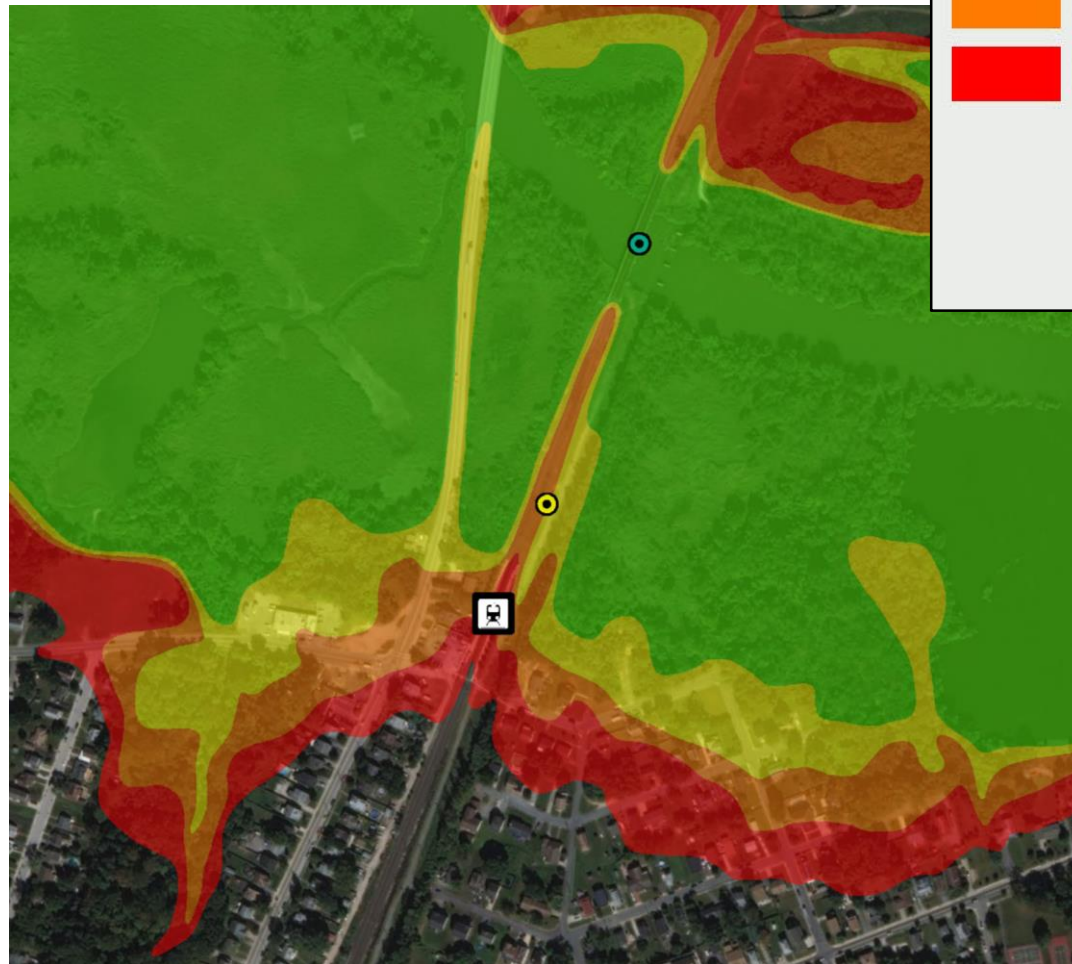




# Light Rail's Nursery Road Station & Bridge



# Light Rail's Nursery Road Station & Bridge



# Lessons Learned: Implementation

## Project Specific

- Benefit-cost ratios that reflect climate risk
- Risk-based communication
- Evolving technologies and products

## Programmatic

- Risk data to drive project prioritization
- Planning/design/construction criteria
- Maintenance plans
- Continuity of operations
- Staff training & qualifications



# Lessons Learned: Vulnerability Analysis

- Explore **mapping** resources that integrate sea level rise into storm surge and floodplain data
- Incorporating **bus routes & operations**
- Consider **critical assets** at high risk locations
- Align exposure **probability** with asset useful life
- Align **severity** definitions with those used by Asset and Safety Management Systems

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