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Account for Climate Changes in Future Flow Predictions of Collection System and Watershed Modeling

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Agenda

- **Background**

- **Impacts on Modeling**

  - Base Wastewater Flow (BWF).
  - Groundwater Infiltration (GWI)
  - Rainfall-driven Inflow and Infiltration (RDII)
  - Wet Weather/Stormwater Runoff
  - Sea Level Rise
  - Outfall and Overflow Boundary Level

- **Conclusions**

1. Background

Background

- Global warming is the long-term rise in the average temperature.

- Demonstrated by direct measurements and various effects of the warming
  - Intergovernmental Panel on Climate Change, IPCC.

- 97% of climate scientists agree that human activities are likely the cause of the climate-warming trends over the past century.

Climate Change

- Temperature
  - 1.62 degrees Fahrenheit (0.9 degrees Celsius) since the late 19th century.
  - Mostly occurred in the past 35 years
  - Five warmest years took place since 2010 (IPCC).

- Sea Level Rise (SLR)
  - Eight inches in the last century.
  - The rate doubled in the last two decades, and is slightly accelerating every year (IPCC).

- Rainfall
  - Some regions experienced increasing frequency and intensity of rainfall events (IPCC).

Climate Change - Continued

- Lakes
  - Example: Water levels in the Great Lakes have fallen since reaching record highs in the 1980s. While most models project continued, long-term declines in lake levels, shorter-term variations will remain large, and periods of high lake levels are happening. (Climate Change in the Great Lakes Region).

- Rivers
  - Example: The Ohio River may have higher water levels and flooding in springtime due to heavier rains and snow melts. Summer droughts are likely to be more severe with higher evaporation and lower summer rainfall which are likely to periodically reduce river flows (USEPA).

Personal Experience

- Jeddah, Saudi Arabia
- January 26, 2011
- Total rainfall 112 mm in 4.7 hours
- Nearly a 50-year storm

2. Impacts on Modeling

Base Wastewater Flow (BWF)

- Drought
  - More stringent conservation measures
  - Lower BWF

- The future BWF
  - Historic observed water consumption data
  - Dry and wet seasons

- Targeted water consumption goal

- Future population movements due to climate change may also increase or reduce BWF

Groundwater Infiltration (GWI)

- GWI is a function of the groundwater table impacted by precipitation, SLR and lake/river levels.

- Build a mathematical relationship

  Observed DWF/GWI seasonal variations =

  Function (Observed groundwater table seasonal variations)

- Apply the relationship to the future precipitation, SLR and lake/river level changes to predict the future GWI

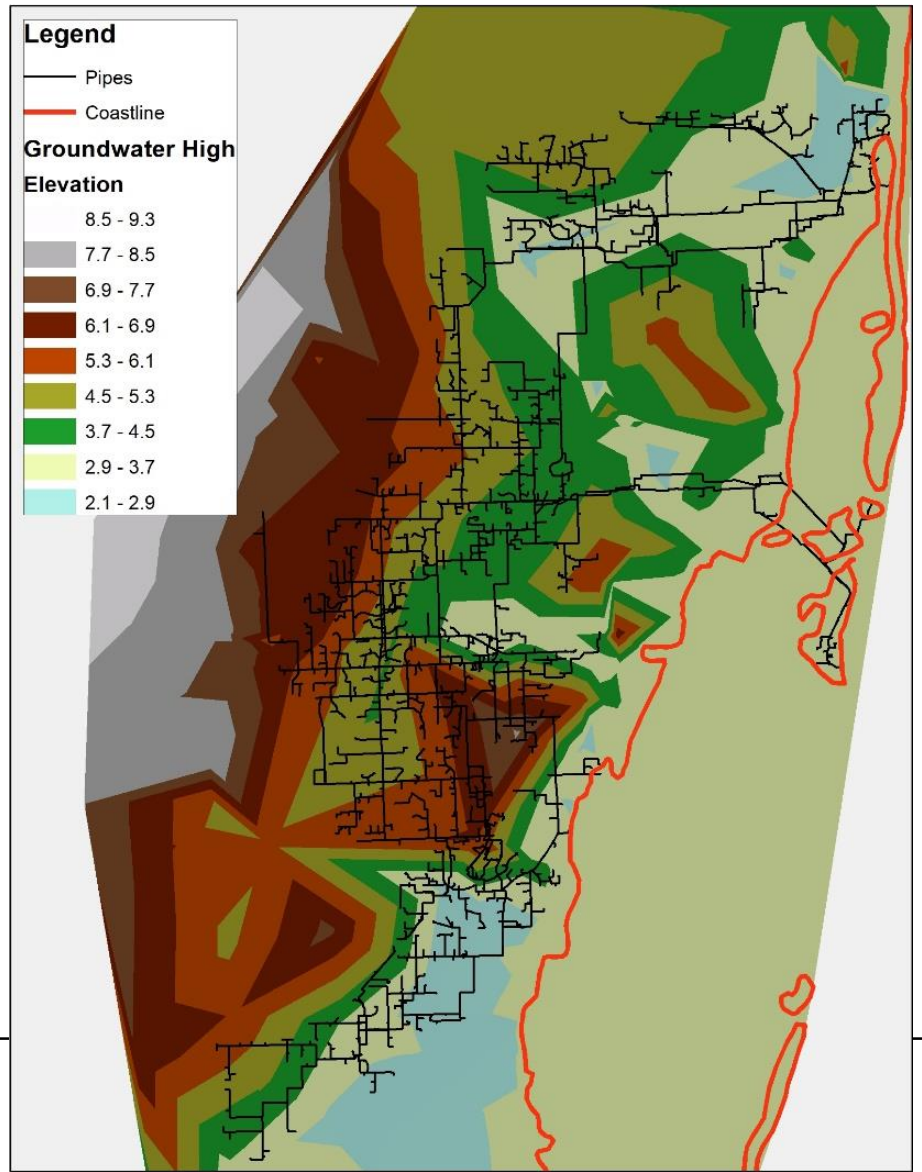
  Future DWF/GWI =

  Function (Future groundwater table)=

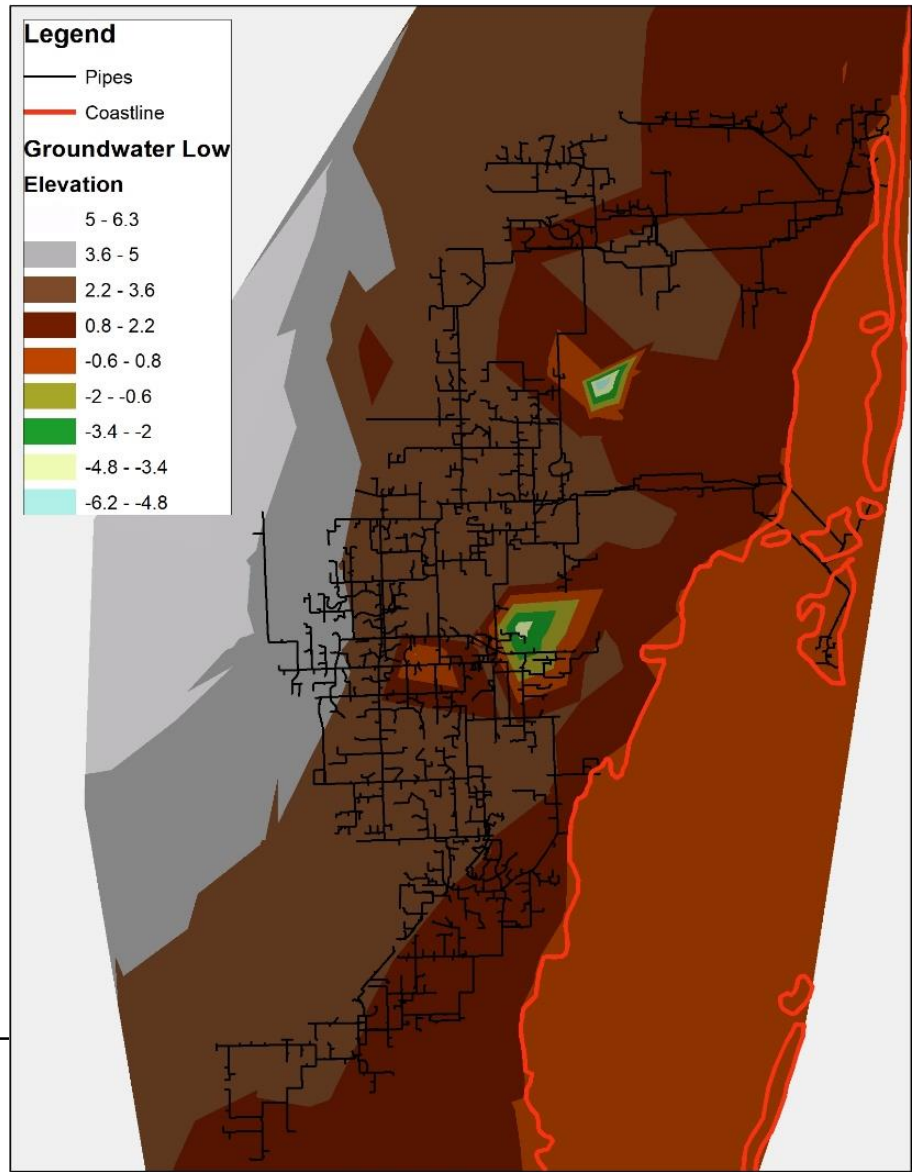
  Function (Future SLR or Lake/River Level Change)

- Miami-Dade
- Based on USGS historic groundwater well data
- Develop high/low groundwater DEM for wet/dry seasons

High Groundwater (Wet)

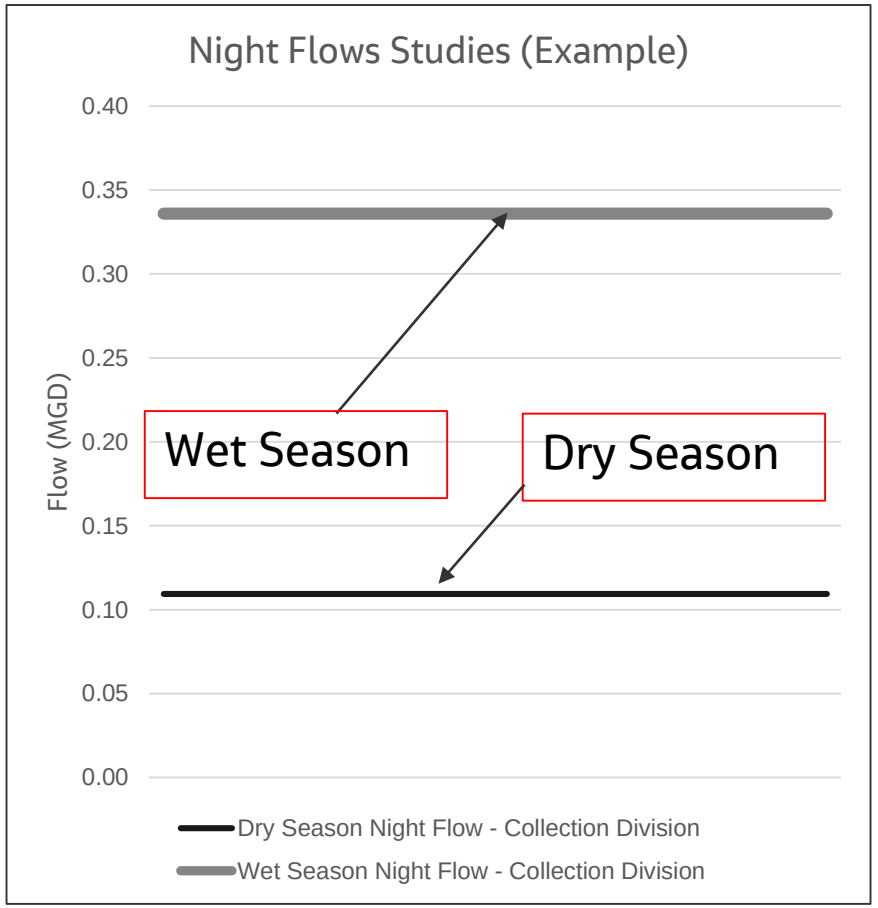


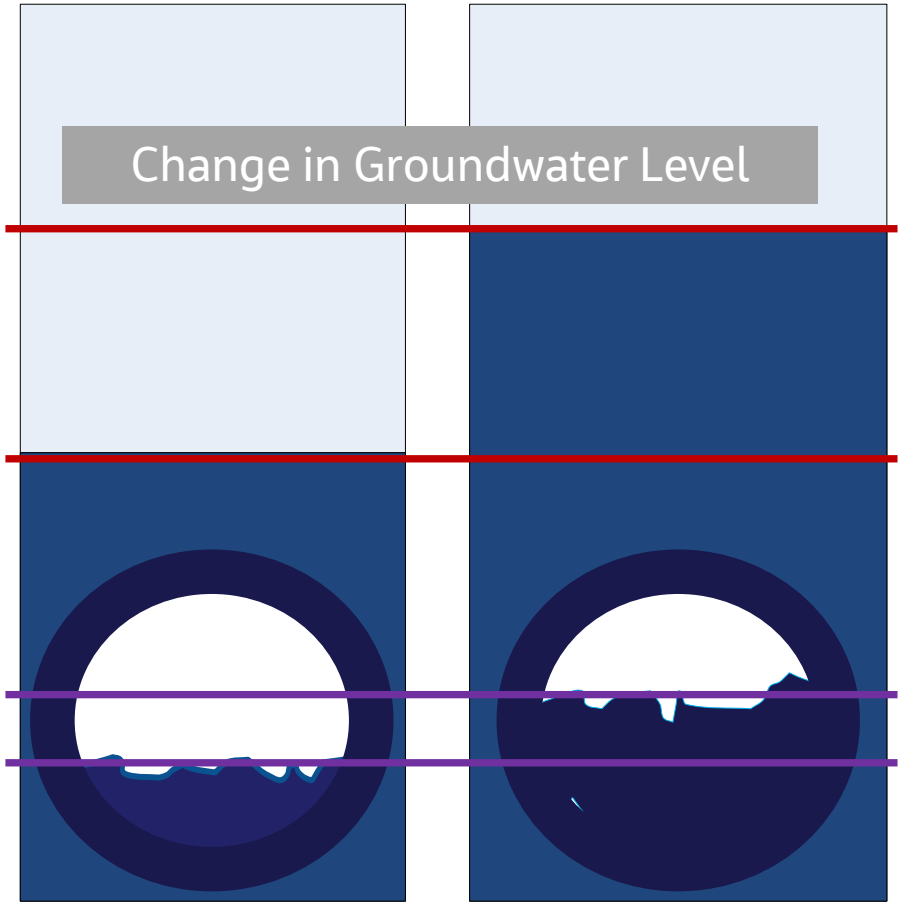
Low Groundwater (Dry)



Dry and Wet Season GWI

- Evaluate the GWI difference between wet and dry season
- Night flow study
- Compare with groundwater table difference between wet and dry season
- Develop mathematic relationship at each loading node





Future GWI

- Use Regional Groundwater Model from USGS/SFWMD
- Predict future groundwater
- Predict future GWI increase

- Future SLR on Groundwater Table

SLR	SLR on GWE	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
1.00 ft	0.50 ft	0.45 ft	0.35 ft	0.25 ft	0.15 ft	0.05 ft
Fraction		0.90	0.70	0.50	0.30	0.10

Wet Weather Flow

- RDII for sanitary system
- Direct stormwater runoff for combined system or stormwater system
- Impacted by precipitation patterns, frequency, intensities, volumes, etc.

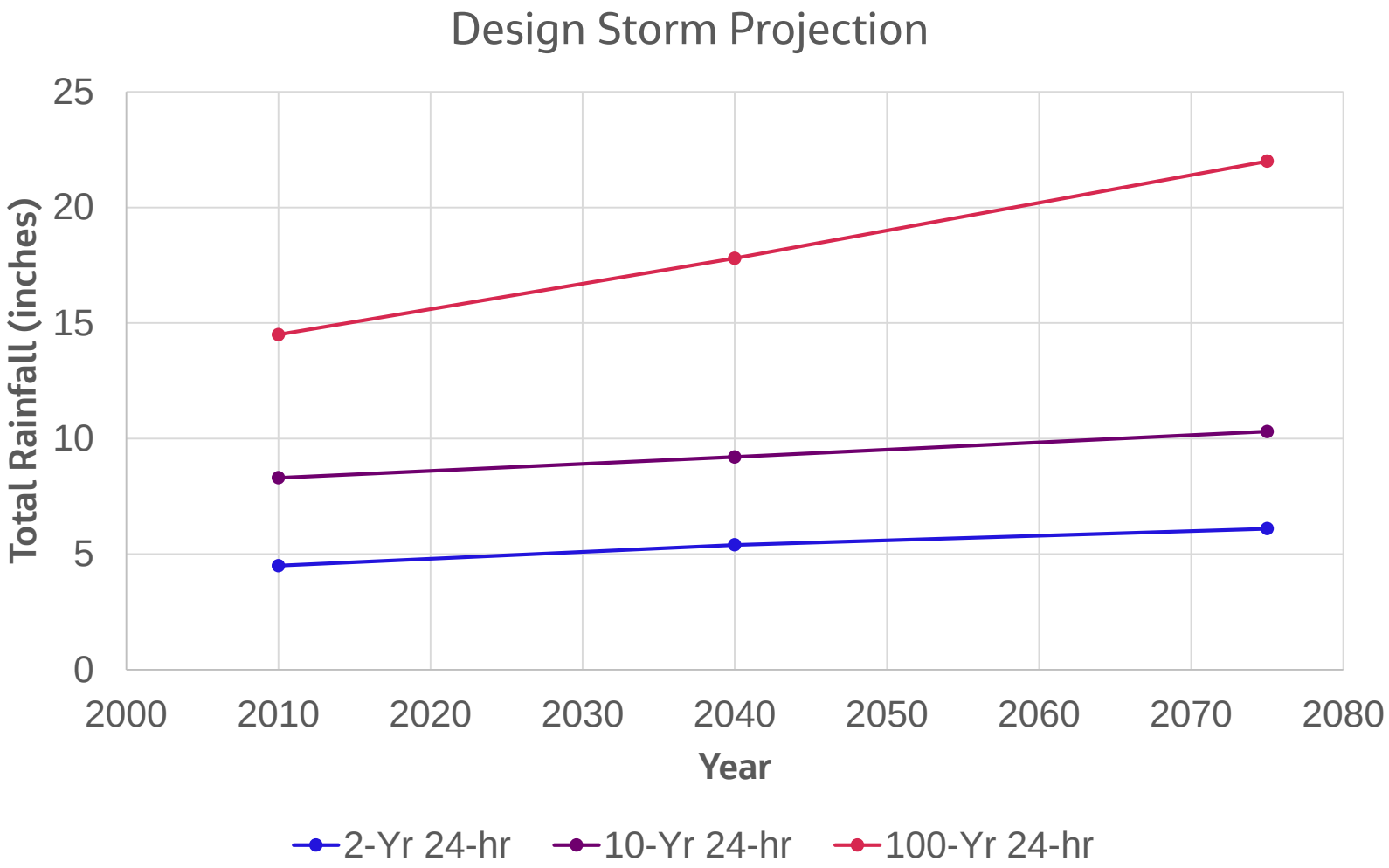
- Design Storm

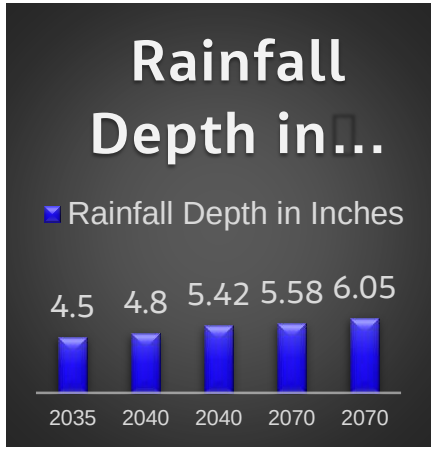
  Future Design Storm = Existing Design Storm X Scaling Factor

- Typical Year
  - Existing dry, wet season and total annual
  - Future dry, wet season and total annual
  - Interpolation

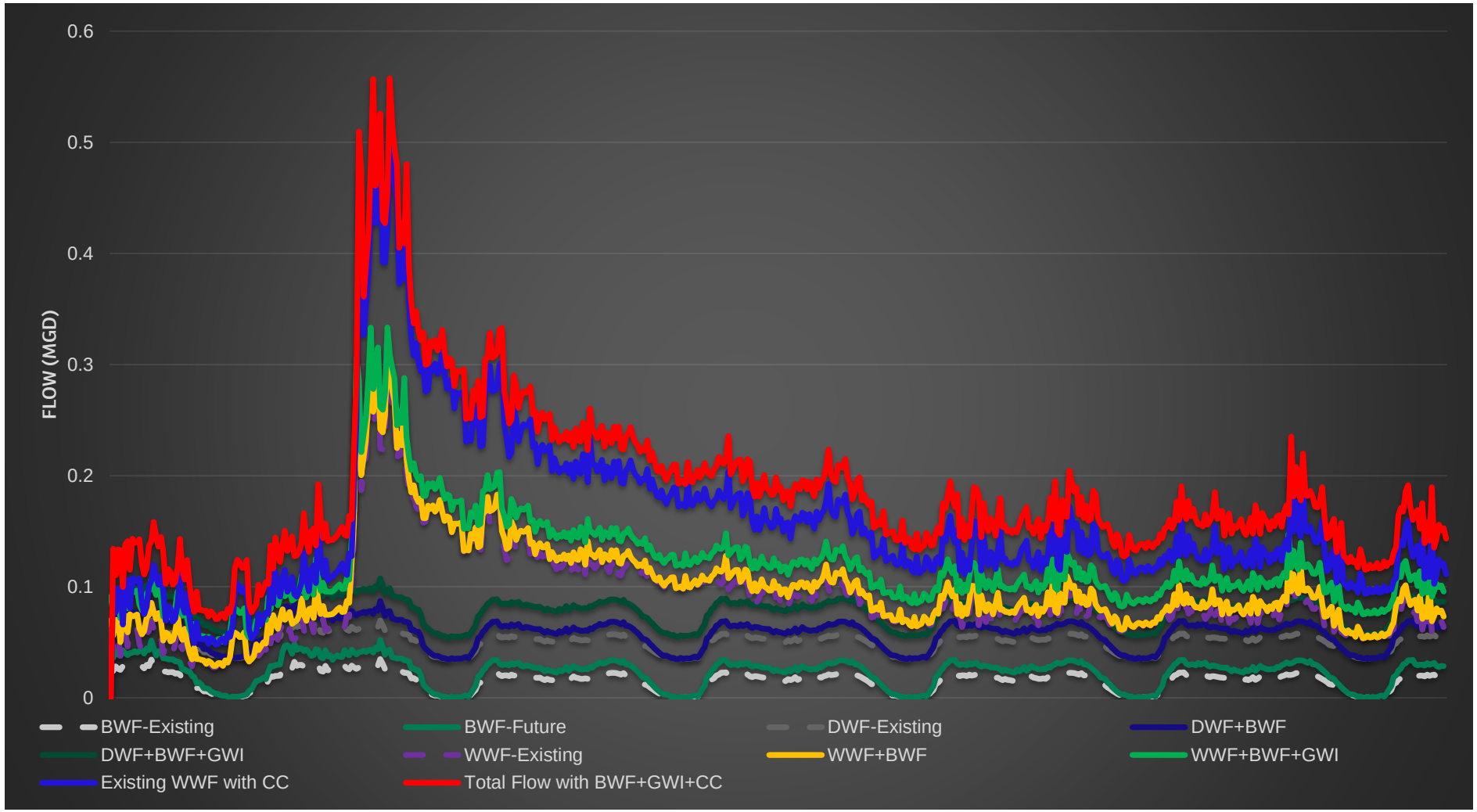
    Future Typical Year = Function (Existing Typical Year)

Example Future Design Storm Projection

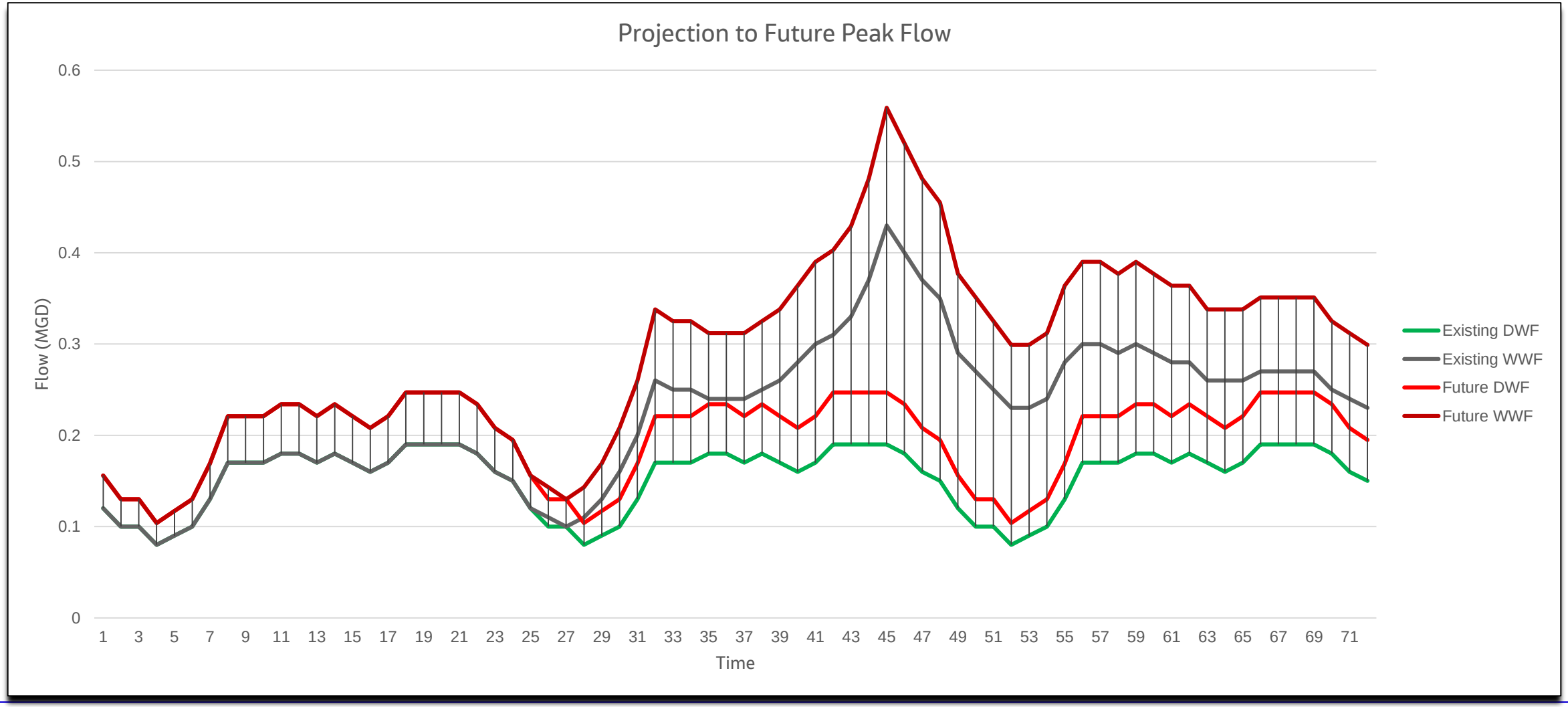




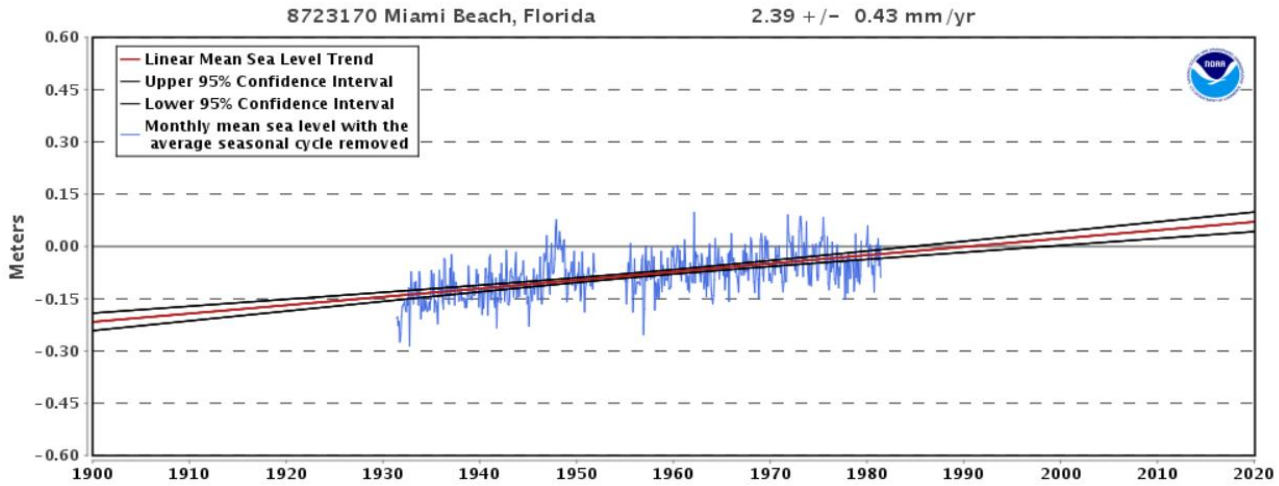
Flow Components and Climate Change Impacts

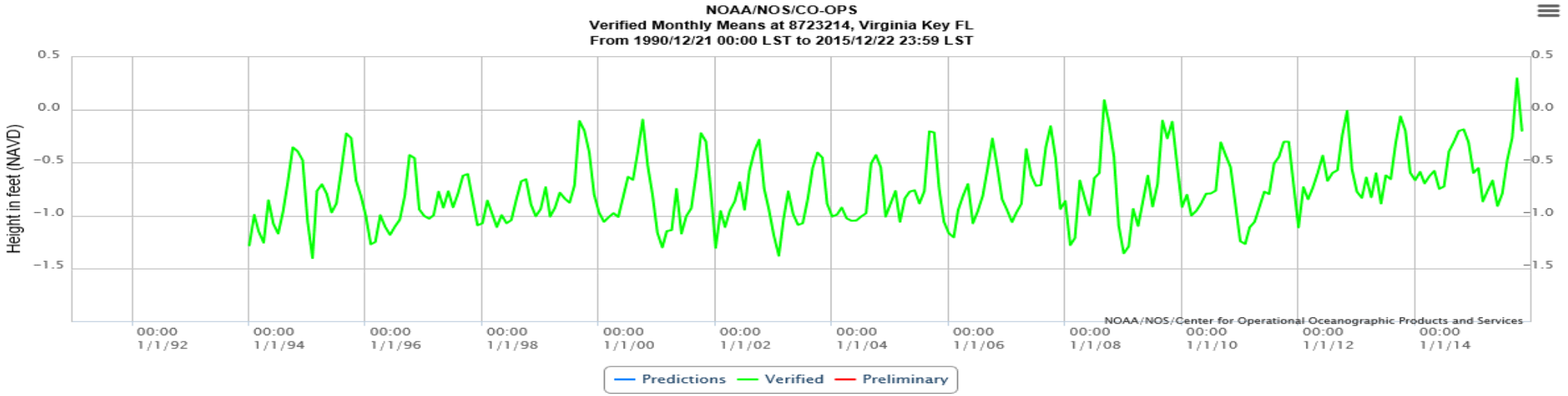


Future Flow Projection – Simplified Version



Sea Level Rise





Outfall and Boundary Level

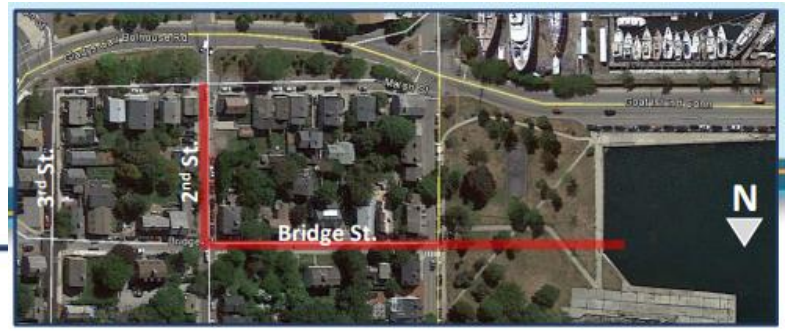
- Sea, River, Lake, etc
- Existing low, high and average levels
- Future low, high and average levels
- Interpolation

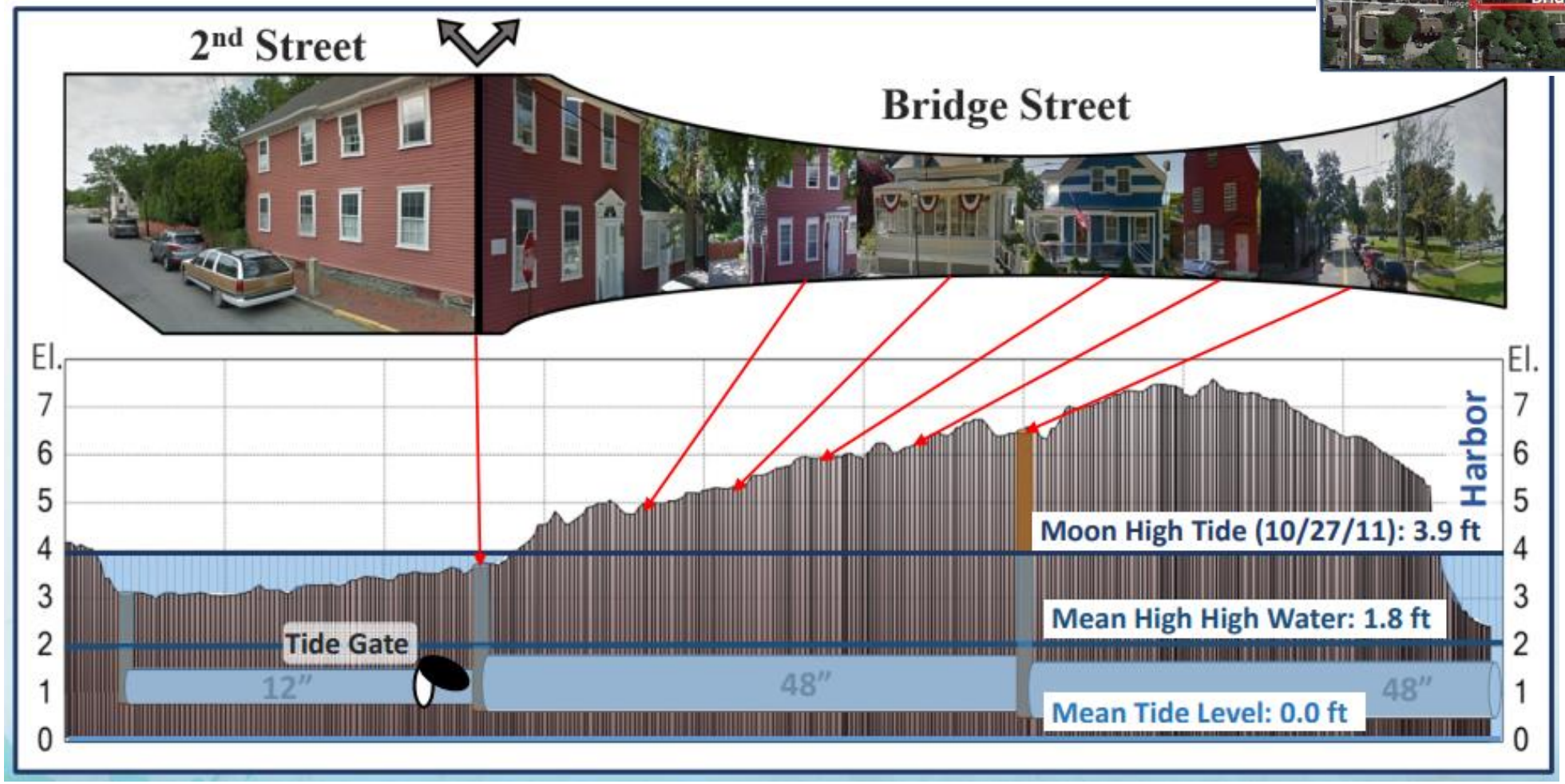
  Future Level/Tidal Time Series =

  Function (Observed Level/Tidal Time Series)
- Apply the future Level/Tidal as boundary condition
- Predict its impact to the future groundwater table and hence future GWI.

  GWI = Function (GW Table)= Function (Level Rise)

Example - City of Newport





3. Conclusions

Conclusions

- Climate changes are happening
- Future planning needs to take into account the climate change impacts
- Get the inputs from the climate change experts
- Apply the climate changes to the H&H model based on the best engineering judgements

Thank You!

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