AMERICAN FLOOD COALITION

FloodCoalition.org

AFC-Atkins Flood Adaptation Assessment Pilot

Overview:

American Flood Coalition (AFC) has partnered with **Atkins** engineering firm to model flood vulnerabilities and adaptation strategies in the **Town of Surfside** using the Atkins City Simulator. The **City Simulator** tool is an agent-based modeling tool built in ArcGIS. It combines federal, state, and local datasets in order to simulate municipal resilience - and the efficacy of various adaptation strategies - between 2019 and 2050. Atkins has begun to analyze the Town's flooding vulnerability and model various adaptation measures. This document serves to interpret and summarize some of Atkins' initial results.

What this pilot offers Surfside:

- **Arms leaders and decisionmakers with data on vulnerability and adaptation options** by pinpointing at-risk infrastructure and quantifying potential losses
- **Strengthens the case for local action on flooding** by analyzing the costs and benefits of different adaptation strategies. This provides an evidence base for any policy changes (e.g., an ordinance that raises BFE) and investments (e.g., raising a frequently flooded portion of road) that the municipality is considering to address flooding.
- **Builds the case for federal grant applications.** Surfside can use the results of this model to strengthen federal grant applications. In a previous project, this tool enabled a county to identify its most vulnerable road segments, which they incorporated into an application for FEMA funding that they were then awarded.
- **Supports municipalities with communications around flooding.** Municipal staff and leaders with a clear understanding of their flooding and sea level rise challenges, the solutions available, and the relative costs communicate more effectively with their residents, as well as representatives at the county, state, and federal level.

What we are going to learn:

- **Assets at risk** in Surfside such as buildings with vulnerable occupants, certain segments of roads and bridges, and exposed critical facilities
- **Impact of flooding** now and in the future (2019-2050) measured by the number of commutes disrupted, dollars in lost productivity, dollars in flood damage, and other metrics
- **Costs and benefits of Surfside-selected adaptation strategies** (see below) against a baseline, or "no action" scenario:

- ✔ Redesign select lots as stormwater retention parks
- ✔ Narrow select roads and install swales
- ✔ Mandate 1 cistern per residential parking space
- ✔ Underground or harden distribution lines
- ✔ Elevate Surfside by 4 feet over 20 years

How we model resilience:

- **Initialize virtual Surfside** using City Simulator, an extension to spatial analysis software ArcGIS
- **Import data** on population, land use, buildings, streets, flood zones, and forecasts for extreme weather and sea level rise. This model uses data at the parcel level, as opposed to a bathtub model.
- **Populate virtual Surfside** with people who match characteristics from most recent Census. Give them places of work and residence (and commutes), salaries, genders, and levels of education.
- **Press "go"** to play out nested loop of model that runs 2019-2050: every day based on imported datasets, virtual Surfside's agents go to work and may experience flooding depending on where they travel. Every year, the sea level rises, the population grows, and the town develops based on imported datasets.
- **Quantify and pinpoint damage** caused by flooding, integrating inundation, property value, and other fields
- **Compare a baseline scenario where no action is taken to adaptation scenarios** featuring any combination of custom adaptation measures from improving culverts to mandating buyouts

What the data sources are:

- **US Census** provides population data
- **Miami-Dade County** provides data on roads, parcels, building attributes, land use, canals, the watershed, and flood zones
- **USGS** provides elevation data as well as the extreme weather forecast
- **Microsoft** provides building footprint data as part of their open source, US-wide building database
- **NOAA** provides hourly high tide forecasts, sea level rise projections (intermediate-high, used by SE Florida Climate Compact), and historic rainfall (used to forecast future rainfall)
- **Dozens of Global Climate Model** high-GHG monthly rainfall projections are blended together and with Surfside's historic rainfall to produce a local daily rainfall forecast
- **Surfside** provides data on the stormwater and wastewater systems, zoning plan, buildings values broken out from land values, etc.

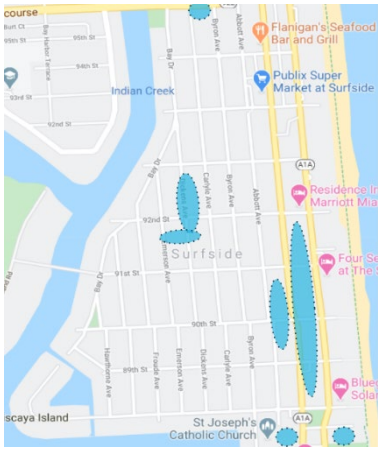


Figure: Flooding hotspots were estimated in meetings with Town staff and based on a 10-year event

What the initial baseline ("no action") model results show:

Flooding hot spots	Intense flooding could cause **$400K–$2M in damage** to homes on Abbott and Byron avenues per storm.
Average annual losses across Surfside	City Simulator estimates average **annual losses of $34K** across Surfside.
Yard flooding	Initial results estimate that tidal flooding above ground level could occur as often as **100 days per year by 2030** on the Bayside.
Disrupted trips	City Simulator estimates a maximum of **26,000 trips disrupted** per year.
Productivity loss	City Simulator estimates **$190K in average annual wages that cannot be earned** due to disasters.

What the initial modeling of adaptation scenarios shows:

Maximizing vacant lots	City Simulator "excavates" the 96th Street Park and 3 other lots to create stormwater parks. The Park shows promise to have a wide stormwater influence area and to **reduce flooding by 0.5 feet during a 500-year event**. Further modeling will reveal its impact during smaller events.
Need for stormwater conveyance	Initial modeling shows that stormwater sewers and injection/gravity wells would vastly improve the efficacy of the lots designated as stormwater parks.

AMERICAN FLOOD COALITION

ATKINS

Flood Adaptation Assessment
Virtual update - Overview slides

May 6, 2021

All images and results contained within are estimates.

Flood Adaptation Assessment
Introductions

Town of Surfside

Irina Mocanu
Primary Contact

Randy Stokes
Technical Contact

Atkins

Jack Hampson
Primary Contact

Stephen Bourne
Modeling Lead

American Flood Coalition

Caroline Resor
Advisor *(Former)*

Summer Modelfino
Advisor

Flood Adaptation Assessment
Agenda

1	**Overview**	• Overview	~ 10 min
2	**City Simulator: draft base model refresher**	• City Simulator initial “no action” results refresher	~ 15 min
3	**City Simulator: adaptation measure review**	• City Simulator initial adaptation results review	~ 30 min
4	**Next steps**	• Next steps - technical & project management	~ 5 min

AMERICAN FLOOD COALITION

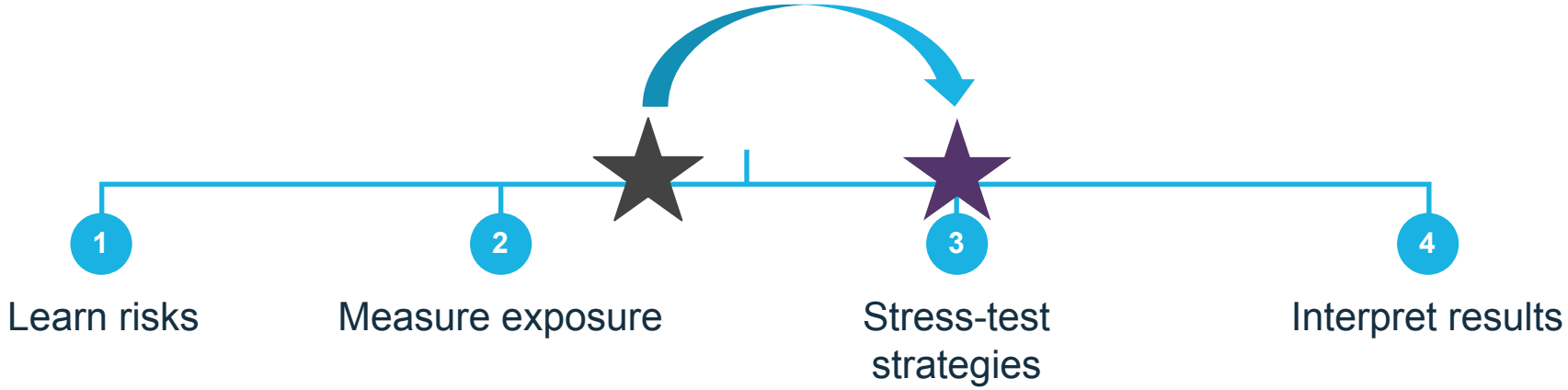
1

Flood Adaptation Assessment overview

Overview
Key milestones

Vision

Harness **City Simulator** to arrive at a clear-eyed **Flood Adaptation Assessment**



What to expect

Ongoing communication

+ Checkpoint calls when needed
+ Availability over email

Upcoming project milestones

+ Summary 2-pager
+ Adaptation scenarios

Legend:
★ current status

Overview
Using City Simulator, we are comparing adaptation to no action

ATKINS

city simulator

- **Learn flood risks and vulnerabilities:** Using the City Simulator, Atkins built a virtual model of Surfside to assess its vulnerability to flooding.
- **Measure exposure to various types of flooding over time:** We will use the tool to view exposure to various flooding scenarios into the future.
- **Stress-test multiple flood mitigation strategies:** The tool allows us to test out different flood mitigation measures with multiple adaptation scenarios.
- **Arrive at a clear-eyed Flood Adaptation Assessment:** The tool will help Surfside understand costs and benefits of possible adaptation plans.

The City of Sunny Isles Beach is also receiving in-kind engineering services through the partnership with Atkins Engineering.

Overview
We will compare a suite of adaptation options

Redesign 96th Street park and other lots for stormwater retention

+ Optimize open spaces for stormwater retention, maximizing benefit and minimizing area converted
+ Prioritize 96th Str park, 200 96th St, 90th and Harding NW corner, and 88th btw Harding and Collins

Narrow roads and install swales

+ Prioritize Bay Dr., 93rd St., and 91st St.
+ Designate nearby storage
+ Also prioritize most frequently-flooded roads

Update code: cistern mandate

+ Require 1,400 gallon cisterns for every parking space
+ Mandate for new or substantially improved homes in 2021 and existing homes in 2031

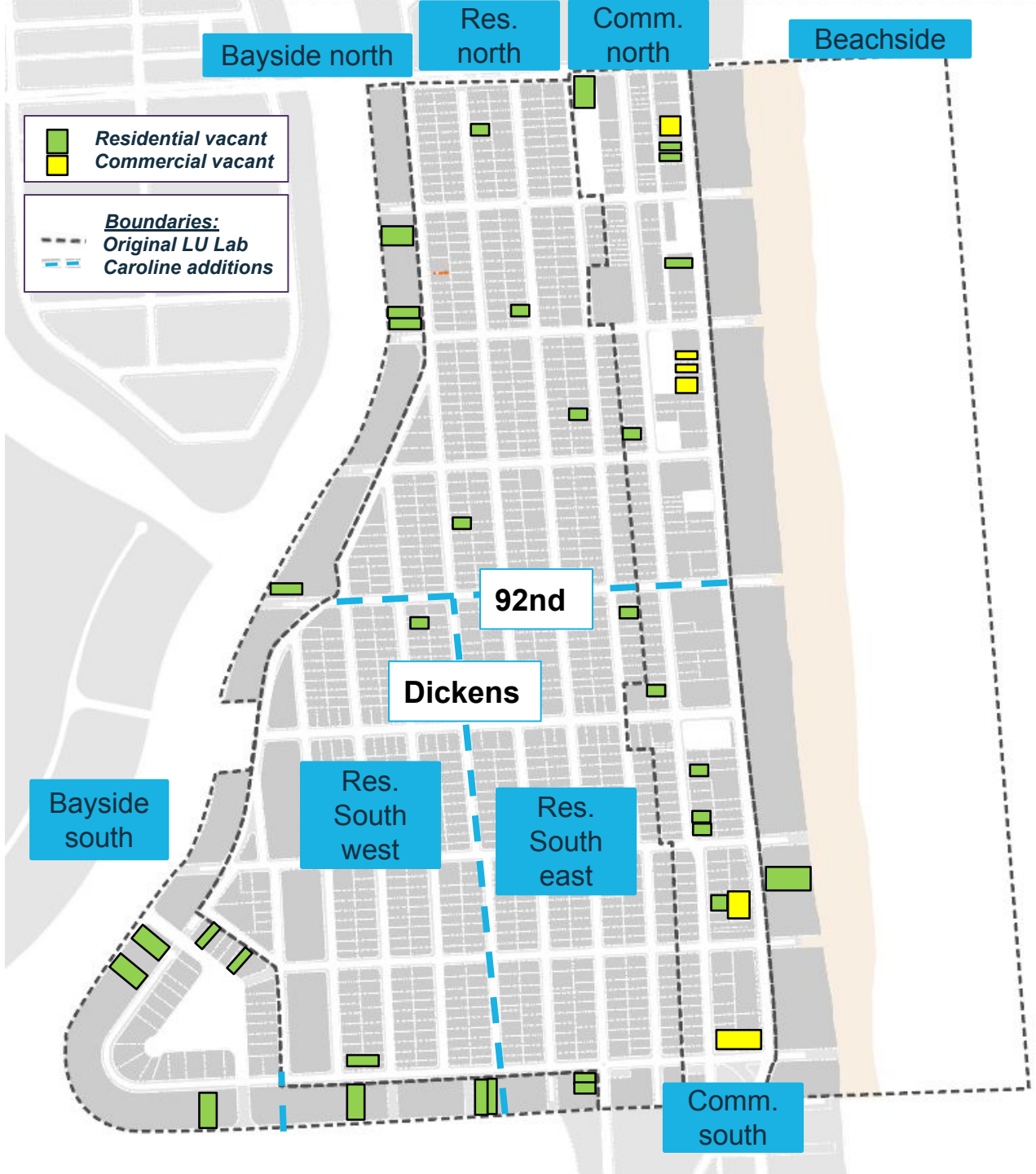
Underground distribution lines

+ Assess costs and benefits of undergrounding and/or hardening distribution lines

Overview
Including “elevate”

- Elevate everything **four feet** over **20 years**, district by district (see 8 districts to right)

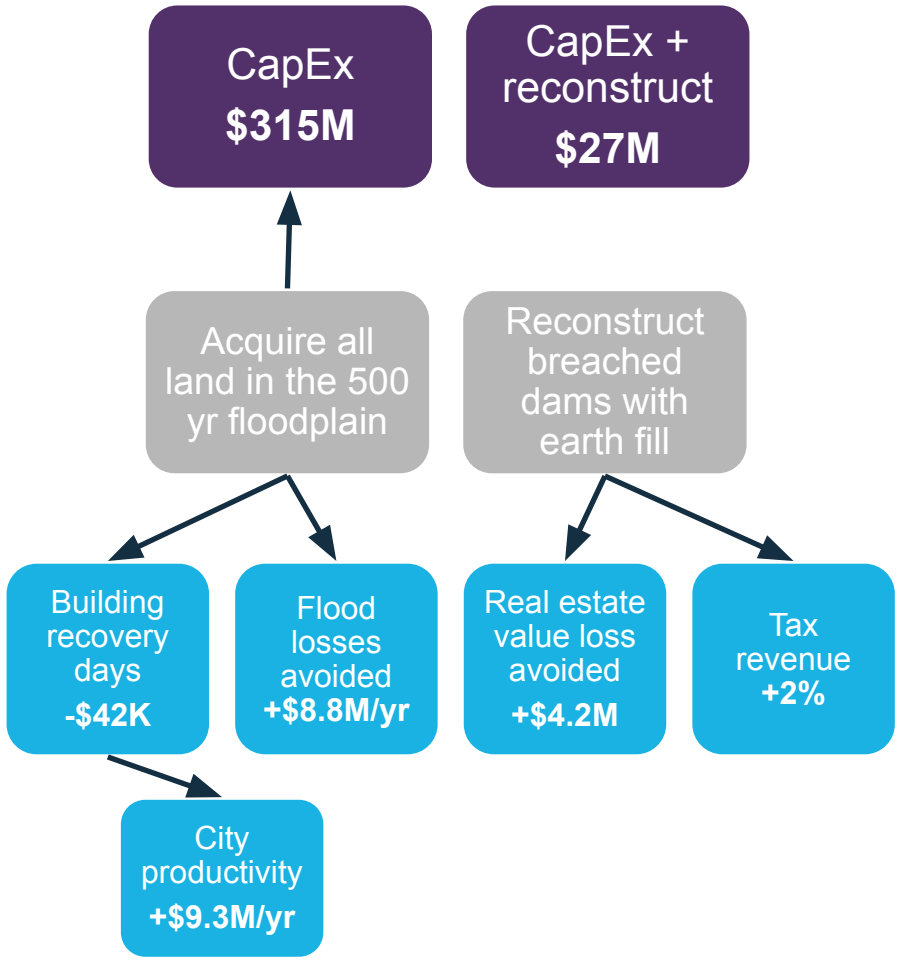
- This includes elevating **buildings, roads**, and **stormwater infrastructure**



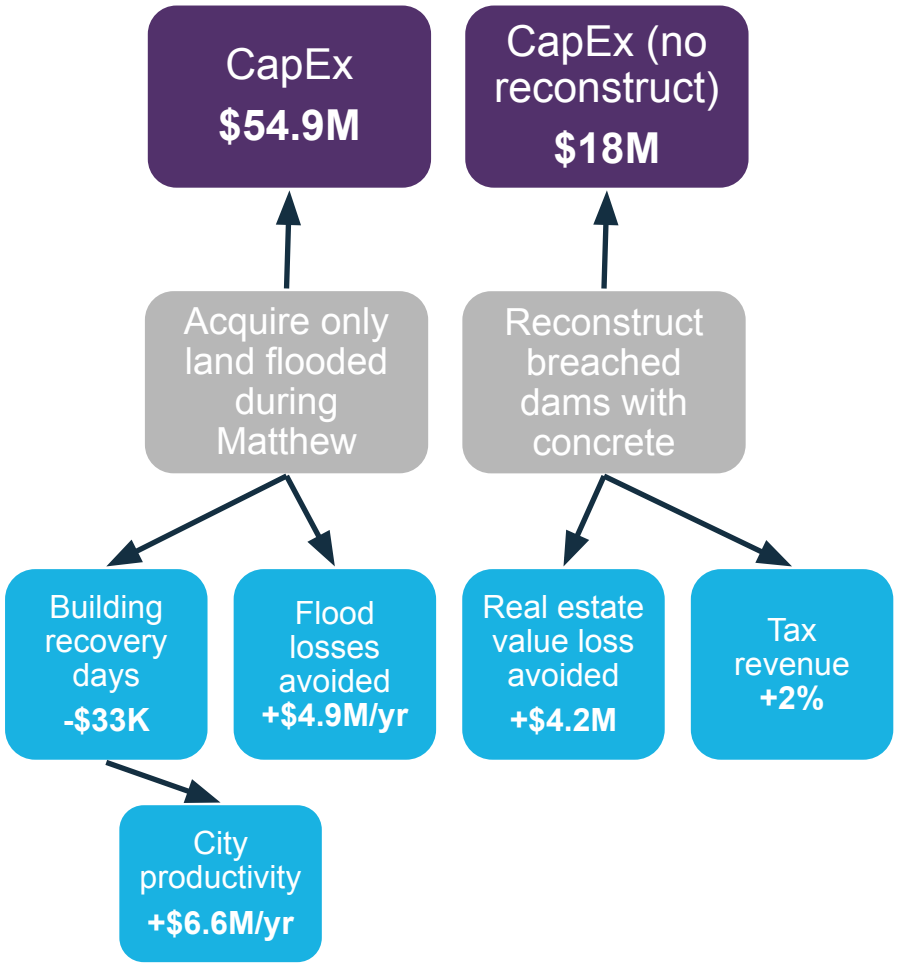
Overview

Example: comparing adaptation actions for Fayetteville, NC

Scenario 1: high cost/low risk



Scenario 2: budget conscious



Scenario 2 gets 70% of the result at 16% of the cost

AMERICAN FLOOD COALITION

2

Base model review

Base model refers to a modeled scenario that features no action on adaptation to flooding; this is a baseline scenario of risks and costs.

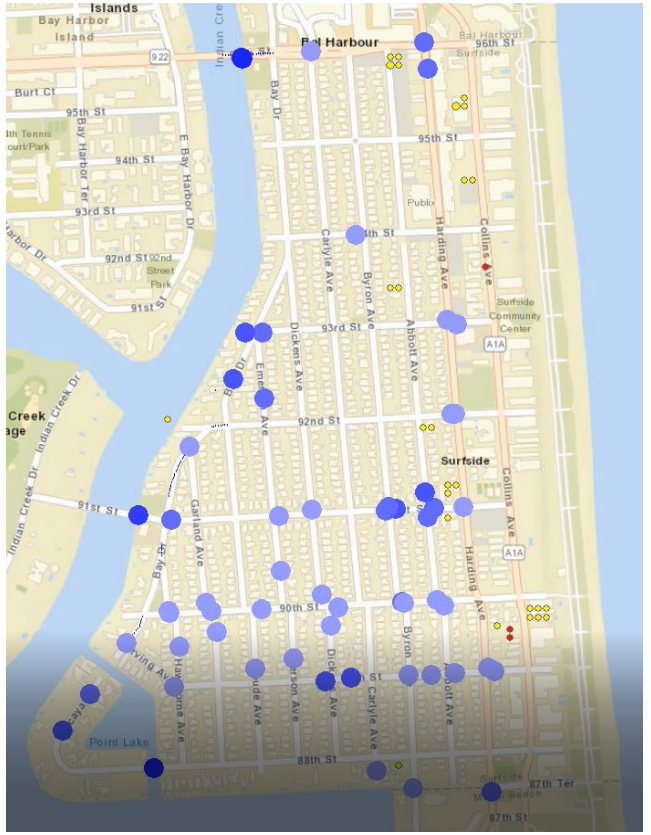
Base model review

The base model simulates a future without action

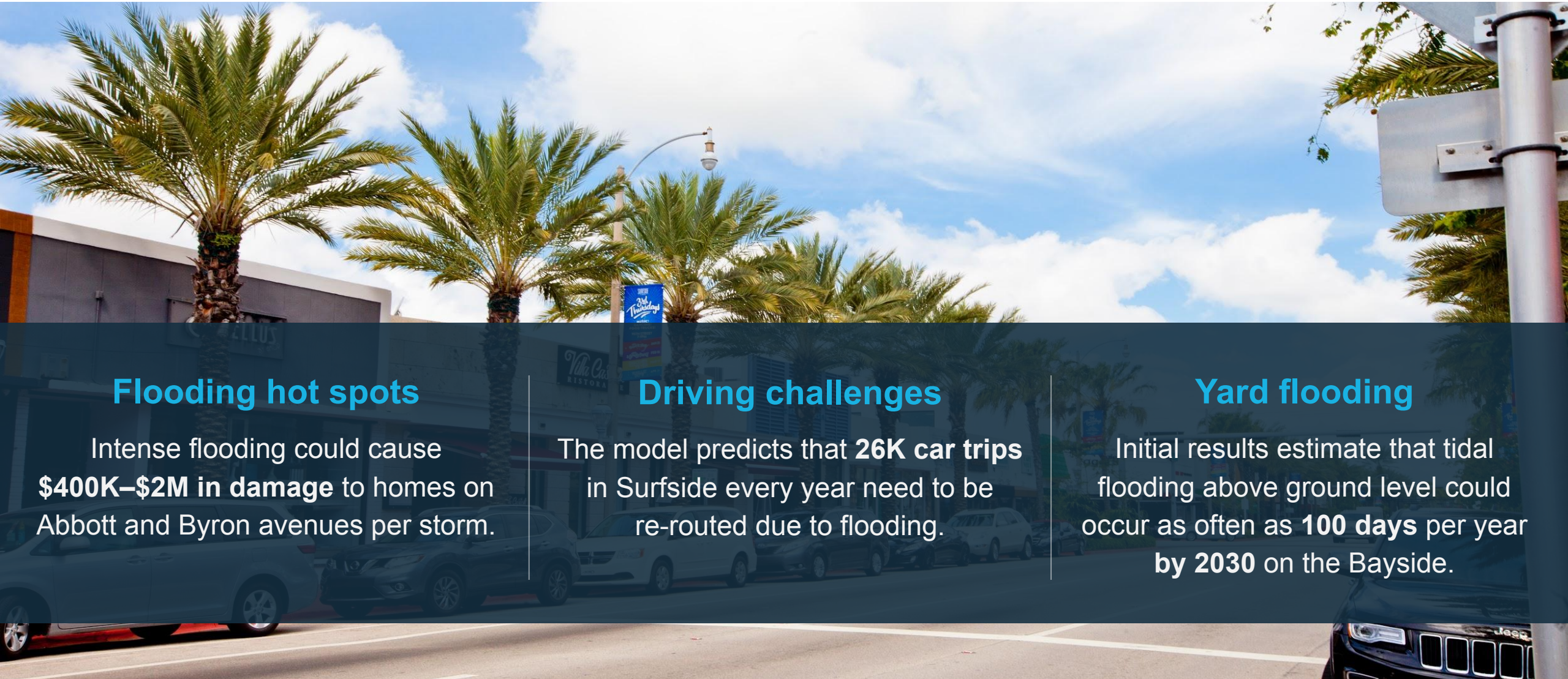
Overview of base model results

Metric	Units	Baseline
Flood damage	Average annual loss	**$34K per year**
Trips disrupted	Max. avg. annual number trips not completed as planned	**26K trips per year**
Productivity lost	Average annual salary that could not be earned due to disasters	**$190K per year**

50-year storm snapshot



Base model review
...and shows that ambitious action is essential



Flooding hot spots

Intense flooding could cause **$400K–$2M in damage** to homes on Abbott and Byron avenues per storm.

Driving challenges

The model predicts that **26K car trips** in Surfside every year need to be re-routed due to flooding.

Yard flooding

Initial results estimate that tidal flooding above ground level could occur as often as **100 days** per year **by 2030** on the Bayside.

Conceptual estimates only

Base model review
Impacts to home values

- Atkins conducted an analysis estimating tidal flooding impacts to home values at the “district” level in Surfside
- Overall, the **commercial district is projected to retain value through 2050**, but the **northern and Bayside residential neighborhoods are projected to lose value rapidly**.
- **Bayside North** is projected to lose 4-7% per year until properties become worthless on the market in 2042. **Bayside South** is projected to lose 3-5% per year until 2040, when some properties will be worthless on the market.
- **Northern residential** district is projected to start losing value in 2030, declining at a rate of 1% per year until 2042 and then 3% per year until 2050.
- **Southern residential** districts not projected to start losing value until after 2050.
- **Commercial and Beachside districts** to preserve and grow in value.

AMERICAN FLOOD COALITION

3

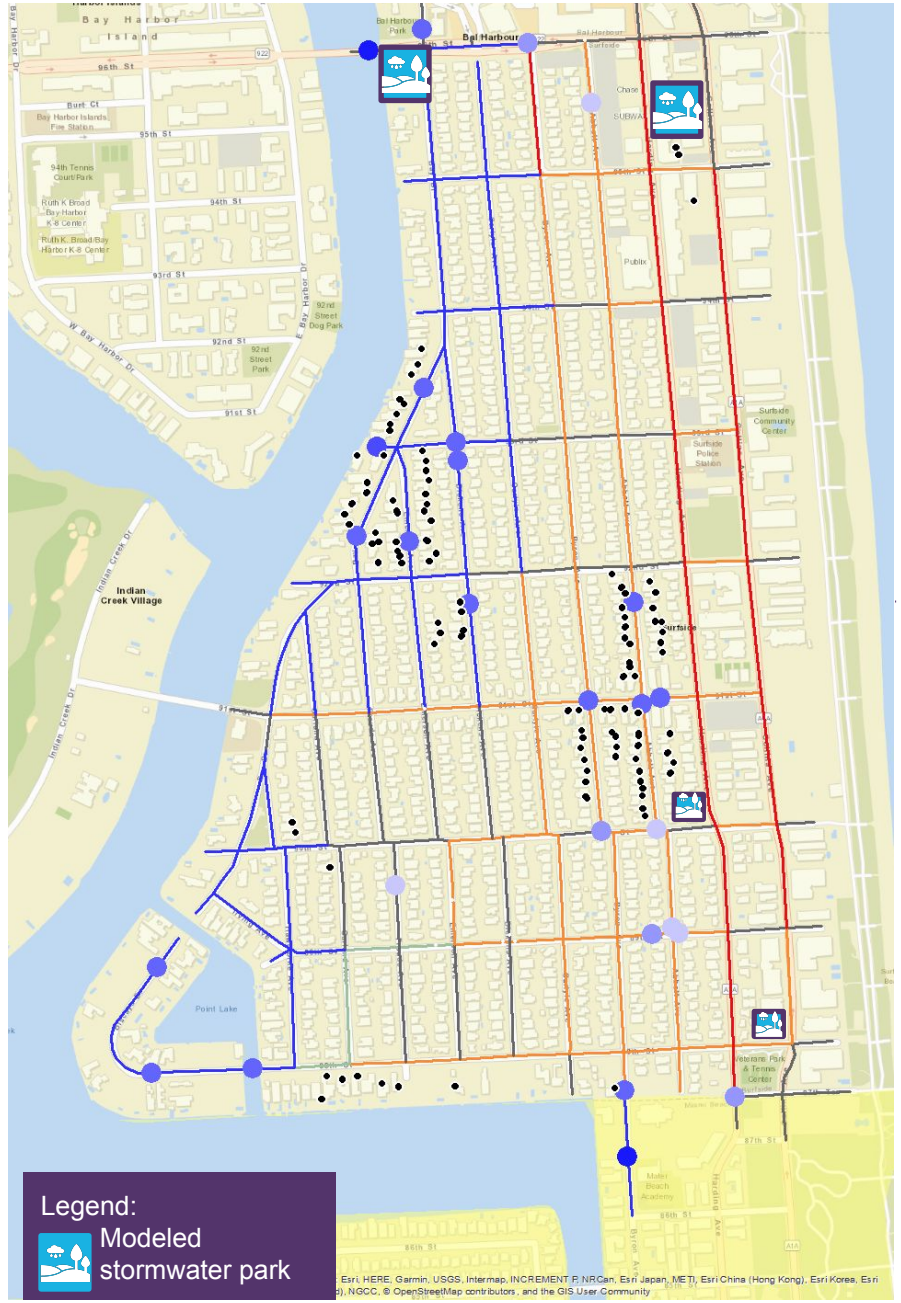
Adaptation measure review

An adaptation measure refers to an action that differentiates an alternative scenario from the base model.

Adaptation measure review
Redesign lots for stormwater control

- **Premise:** There are a few lots that can be repurposed as stormwater parks. Prioritize:
  - 96th Street Park
  - 200 96th Street
  - 90th Street and Harding Avenue (NW corner)
  - 88th Street between Harding and Collins Avenues

- **Instructions:** Optimize these lots for stormwater control.



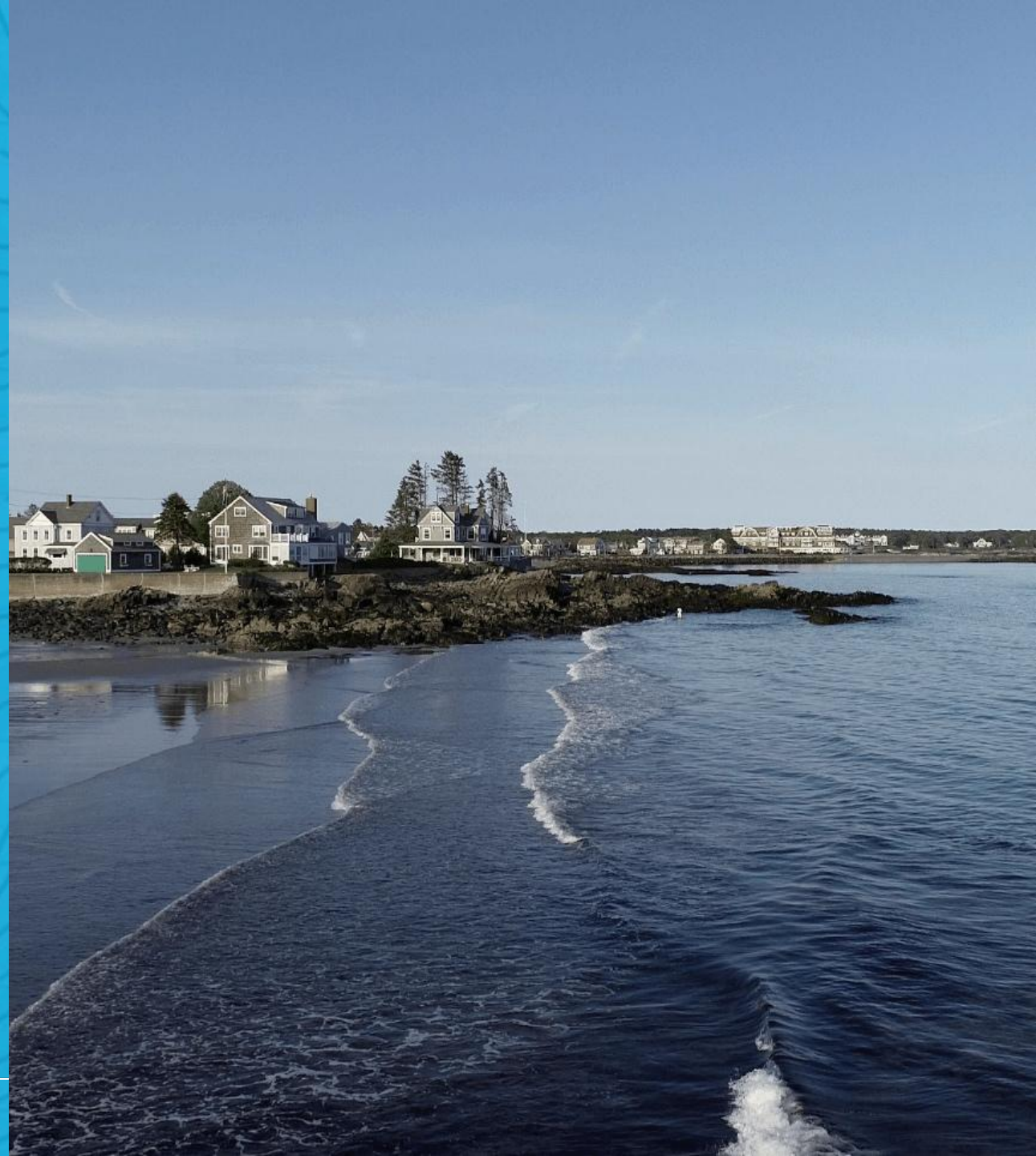
Adaptation measure review
Upcoming: comparison with the base model

	Metric	Units	Baseline	Retention areas	Comparison
	**Flood damage**	Average annual loss	**$34K per year**	***To be determined***	*To be determined*
	**Trips disrupted**	Max. avg. annual number trips not completed as planned	**26K trips per year**	***To be determined***	*To be determined*
	**Productivity lost**	Average annual salary that could not be earned due to disasters	**$190K per year**	***To be determined***	*To be determined*

AMERICAN FLOOD COALITION

4

Next steps



Next steps
Atkins will build adaptation measures

- **Adaptation measures.** Steve and Jack will make any necessary changes to the stormwater parks adaptation measure, and will begin to build out the other ones.
- **Summary comparison.** The team will send over a 2-pager that summarizes the results achieved thus far.
- **Project management.** Jack will continue to be your primary point of contact and Steve the technical lead.

AMERICAN FLOOD COALITION

NOAA recurrence interval reference table

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.572 (0.465-0.701)	0.656 (0.534-0.806)	0.797 (0.646-0.981)	0.915 (0.737-1.13)	1.08 (0.841-1.38)	1.21 (0.919-1.57)	1.34 (0.984-1.78)	1.47 (1.04-2.01)	1.65 (1.12-2.32)	1.79 (1.18-2.56)
10-min	0.837 (0.682-1.03)	0.961 (0.782-1.18)	1.17 (0.946-1.44)	1.34 (1.08-1.66)	1.58 (1.23-2.02)	1.77 (1.35-2.29)	1.96 (1.44-2.60)	2.15 (1.52-2.95)	2.42 (1.64-3.40)	2.62 (1.73-3.74)
15-min	1.02 (0.831-1.25)	1.17 (0.954-1.44)	1.42 (1.15-1.75)	1.63 (1.32-2.02)	1.93 (1.50-2.46)	2.16 (1.64-2.80)	2.39 (1.76-3.18)	2.63 (1.85-3.59)	2.95 (2.00-4.14)	3.19 (2.11-4.56)
30-min	1.56 (1.27-1.91)	1.80 (1.46-2.21)	2.20 (1.78-2.71)	2.53 (2.04-3.14)	3.00 (2.34-3.83)	3.37 (2.56-4.36)	3.73 (2.74-4.96)	4.11 (2.90-5.62)	4.61 (3.13-6.49)	5.00 (3.30-7.15)
60-min	2.10 (1.71-2.57)	2.40 (1.96-2.95)	2.94 (2.38-3.62)	3.42 (2.76-4.23)	4.13 (3.24-5.33)	4.71 (3.60-6.16)	5.33 (3.94-7.14)	5.99 (4.24-8.25)	6.92 (4.71-9.79)	7.66 (5.06-11.0)
2-hr	2.64 (2.16-3.21)	3.01 (2.46-3.67)	3.69 (3.00-4.51)	4.31 (3.49-5.30)	5.26 (4.16-6.78)	6.06 (4.67-7.90)	6.93 (5.16-9.26)	7.88 (5.62-10.8)	9.22 (6.32-13.0)	10.3 (6.86-14.7)
3-hr	2.94 (2.42-3.57)	3.35 (2.75-4.08)	4.13 (3.37-5.03)	4.86 (3.95-5.96)	6.02 (4.80-7.79)	7.03 (5.45-9.17)	8.13 (6.09-10.9)	9.36 (6.71-12.8)	11.1 (7.67-15.7)	12.6 (8.39-17.8)
6-hr	3.44 (2.84-4.15)	3.97 (3.27-4.79)	4.98 (4.09-6.03)	5.95 (4.86-7.24)	7.50 (6.03-9.67)	8.85 (6.91-11.5)	10.4 (7.80-13.8)	12.0 (8.68-16.4)	14.4 (10.0-20.2)	16.4 (11.0-23.1)
12-hr	3.92 (3.25-4.69)	4.64 (3.84-5.57)	5.98 (4.94-7.20)	7.24 (5.94-8.75)	9.18 (7.40-11.7)	10.9 (8.49-14.0)	12.7 (9.58-16.7)	14.7 (10.6-19.9)	17.5 (12.2-24.4)	19.9 (13.4-27.8)
24-hr	4.48 (3.73-5.33)	5.38 (4.48-6.42)	7.02 (5.82-8.39)	8.52 (7.03-10.2)	10.8 (8.72-13.7)	12.7 (10.0-16.2)	14.8 (11.2-19.4)	17.1 (12.4-22.9)	20.3 (14.2-28.0)	22.9 (15.6-31.8)
2-day	5.27 (4.41-6.23)	6.26 (5.24-7.41)	8.05 (6.71-9.56)	9.70 (8.04-11.6)	12.2 (9.90-15.3)	14.3 (11.3-18.1)	16.6 (12.7-21.5)	19.1 (14.0-25.4)	22.6 (15.9-30.9)	25.4 (17.4-35.1)
3-day	5.91 (4.96-6.96)	6.94 (5.82-8.18)	8.80 (7.36-10.4)	10.5 (8.73-12.5)	13.1 (10.6-16.3)	15.2 (12.1-19.2)	17.6 (13.5-22.7)	20.1 (14.8-26.7)	23.7 (16.8-32.3)	26.6 (18.3-36.5)

Surfside

Flood Adaptation Assessment Workshop

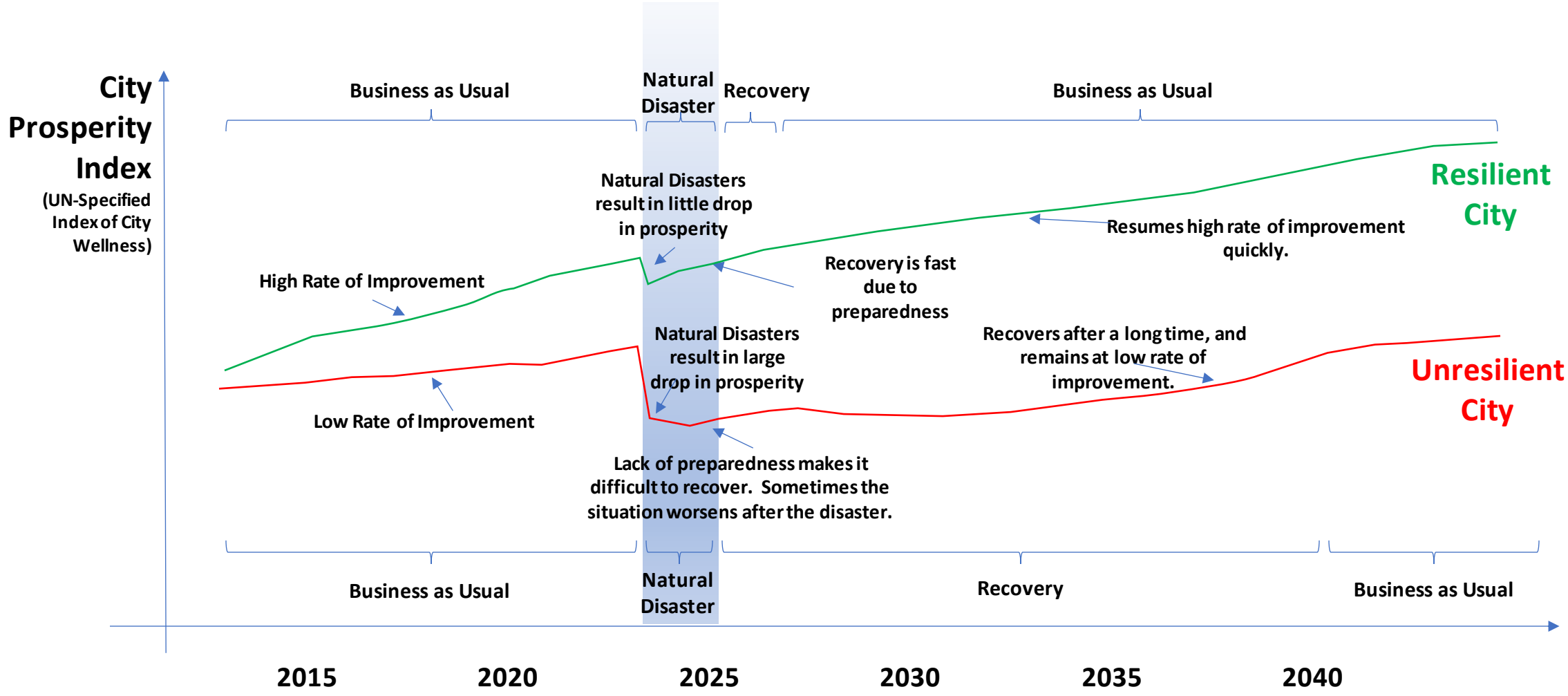
5/6/2021

Contact: Stephen Bourne, PE
Stephen.bourne@atkinsglobal.com

ATKINS

The Resilient City

Natural disasters are simulated at the size and frequency resulting from climate change.



ATKINS

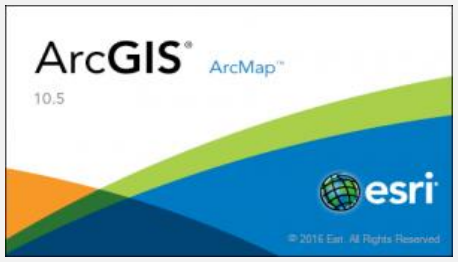
Requirements for Forecasting Resilience

- Capture **interacting systems** (Economy, People, Infrastructure, Natural)
- Include **business-as-usual as well as disasters**
- Include disasters that are **representative of climate change** effects
- Allow for addition of **proposed strategies** and measures their effect
- Include a long enough time line to measure **return on investment**
- Ensure process can happen in a **planning context and budget**

ATKINS

What is City Simulator?

A map-based decision support tool that helps communities understand their vulnerabilities to future disasters and find the most effective mitigation and adaptation actions.



Esri ArcMap Extension

Microsoft Visual Studio 2017, C#, Vb.net

ATKINS

How does City Simulator Work?

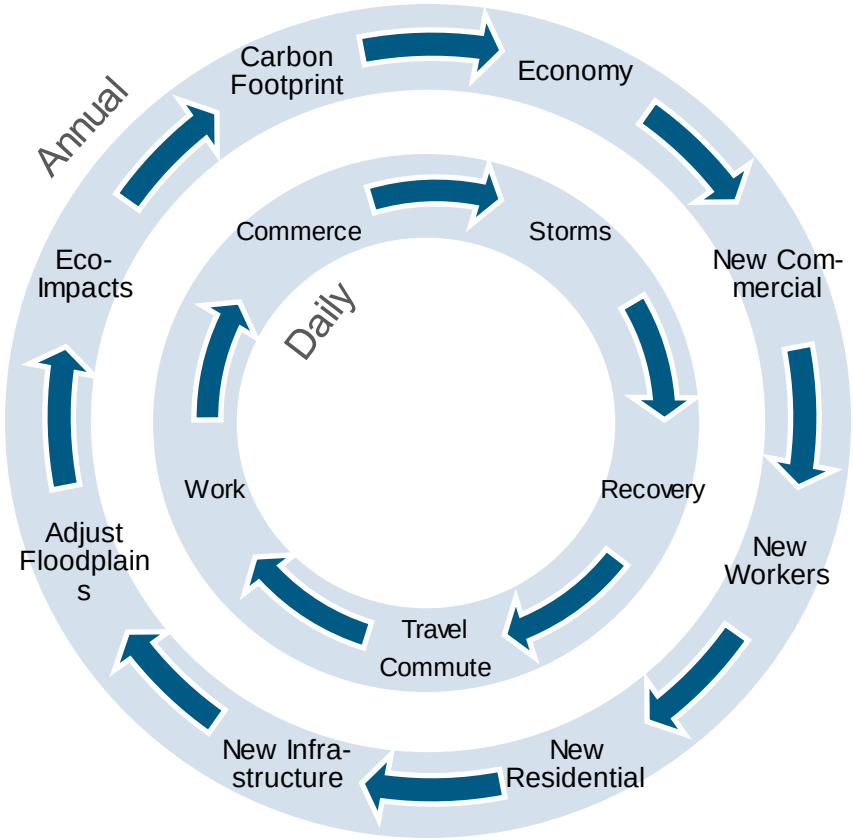
Build a digital twin using existing data & models

System Users
- Agents
- Non Residents
- Tourists

System Infrastructure
- Parcels and Buildings
- Roads and rail
- Stormwater, Wastewater, Water Supply, Telecom, Power
- Rivers, Soils

System Control
- Political Boundaries
- Zoning
- Building Code
- Policies

Simulate Scenario daily from 2020-2050



Evaluate Key Performance Metrics for Decision Making

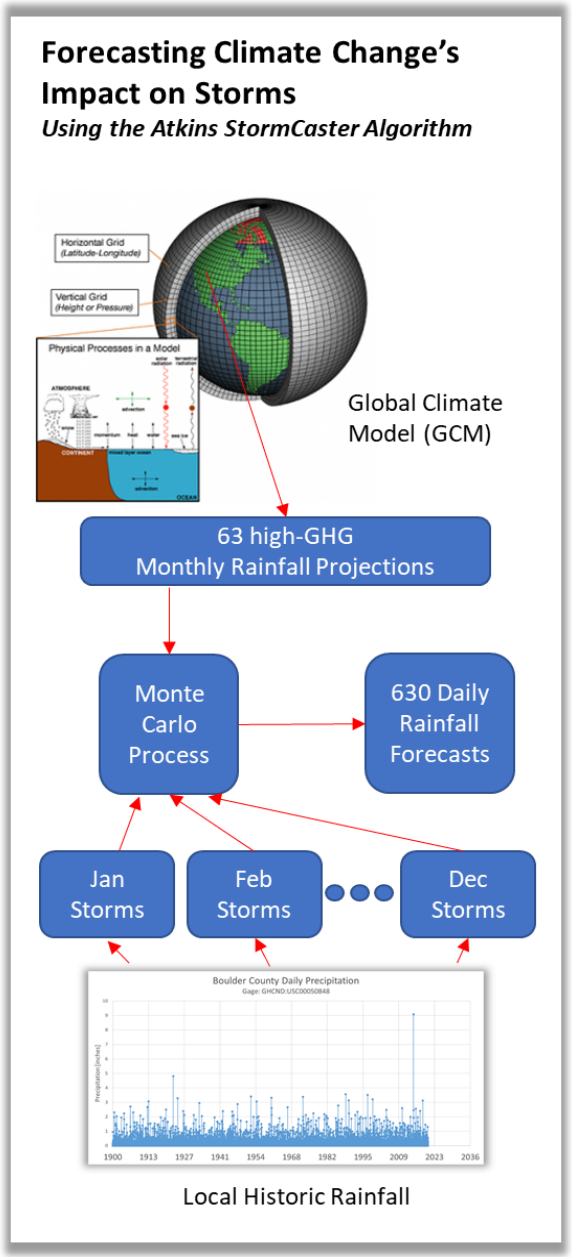
Economy
- Productivity
- Storm Damage
- Losses Avoided
- ROI
- Investment made

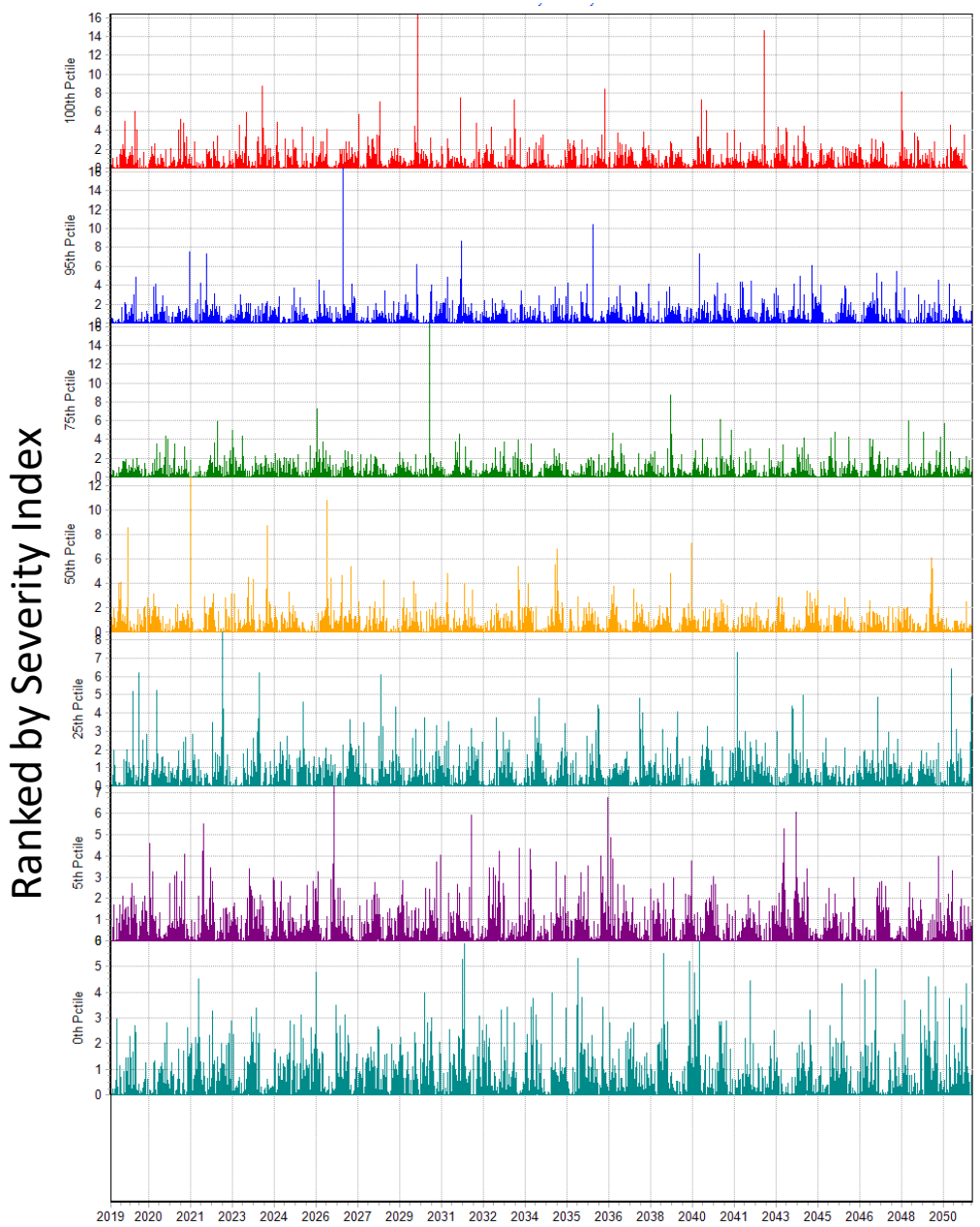
People
- Trips Disrupted/ Lost Wages
- Accessibility (shelters, critical facilities, education)
- LMI population Impacted
- Heat Exposure

Environment
- Carbon Footprint (travel, buildings)
- Pollutant Loadings
- Water Quality

ATKINS

Rainfall/Storms – Projecting a range of futures



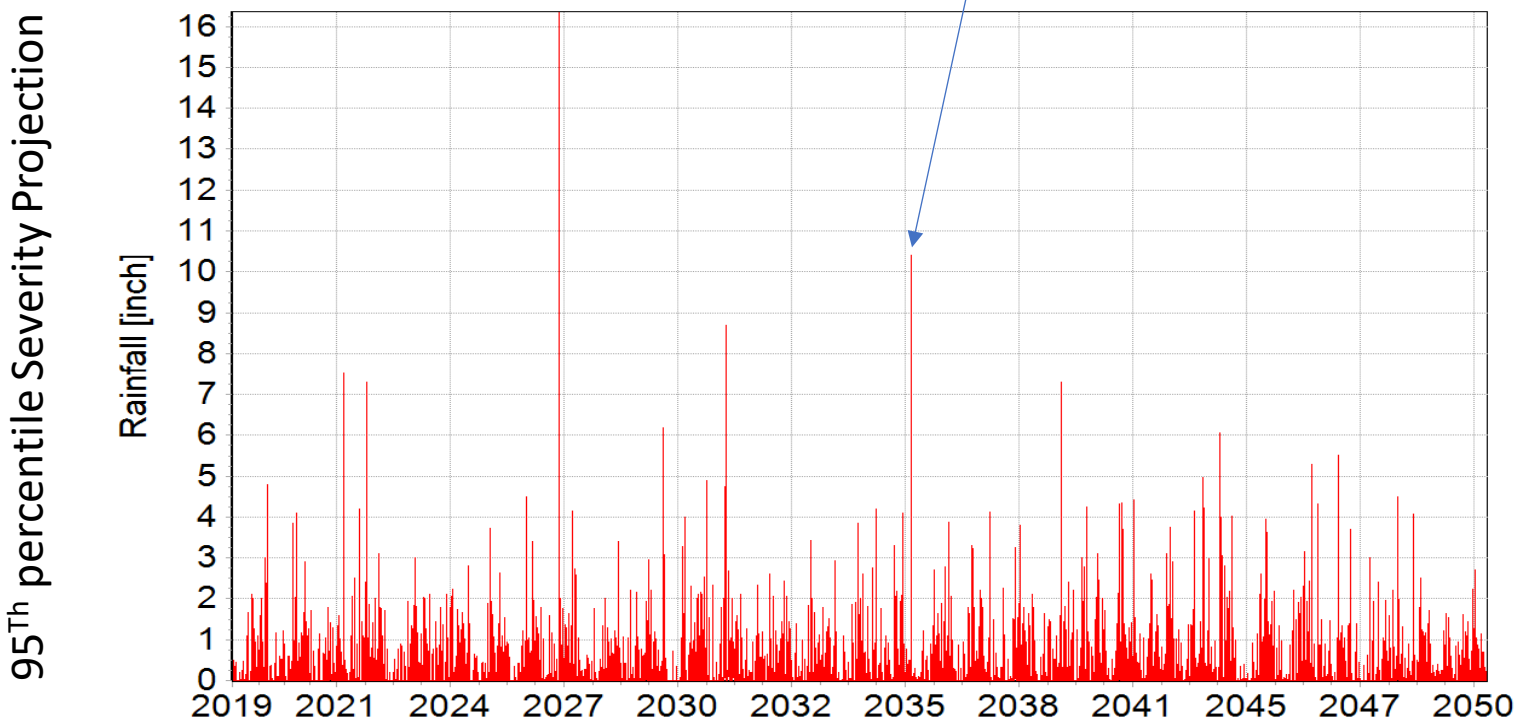


ATKINS

Rainfall/Storms - Simulating Flood Response to Varying Storm Types

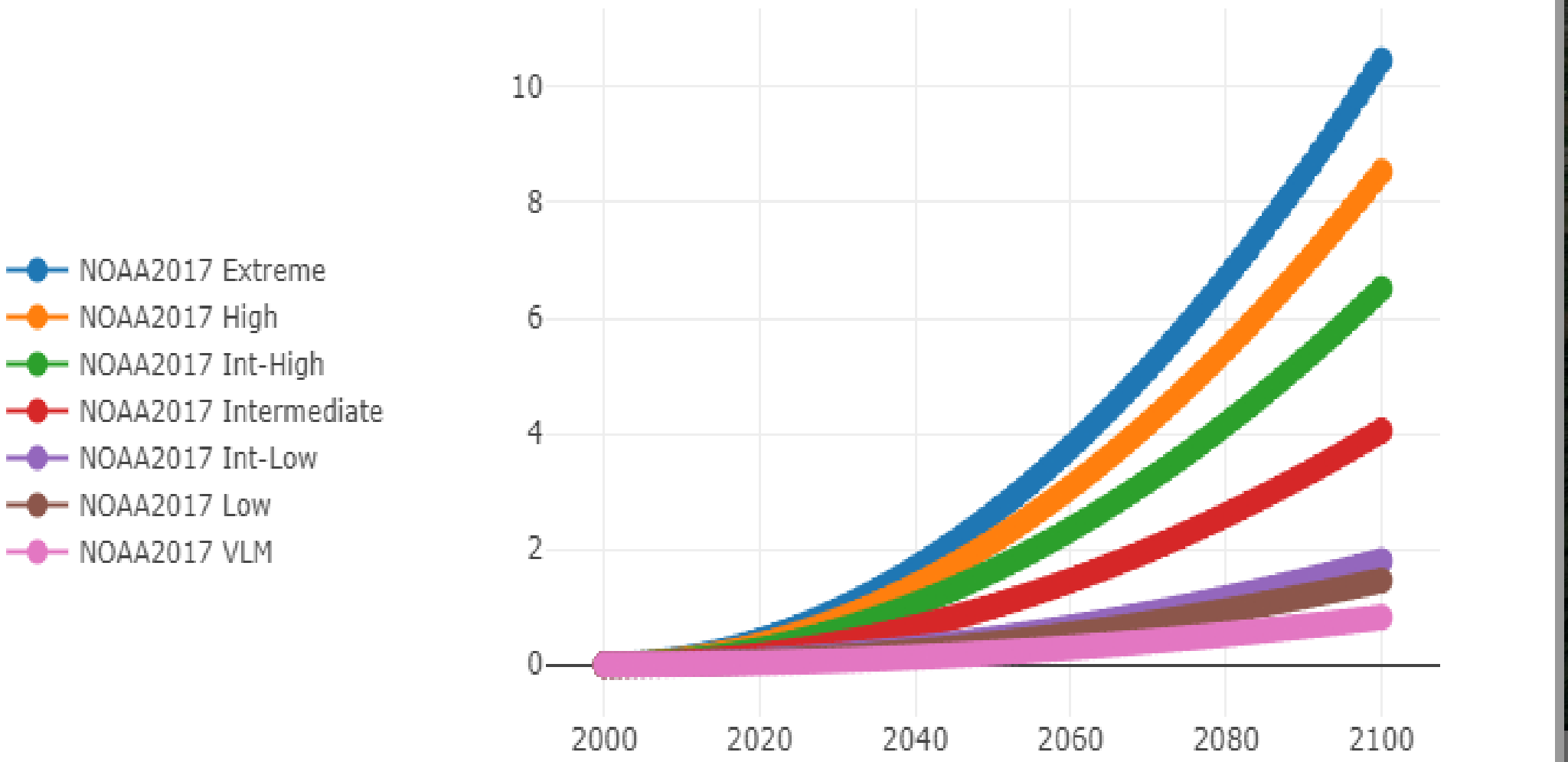
Tropical Storm – use existing FEMA FIS as flood response, based on storm surge models

Convective Thunderstorm
– use Pluvial Flood Model (Telemac2D, HecRAS2D)

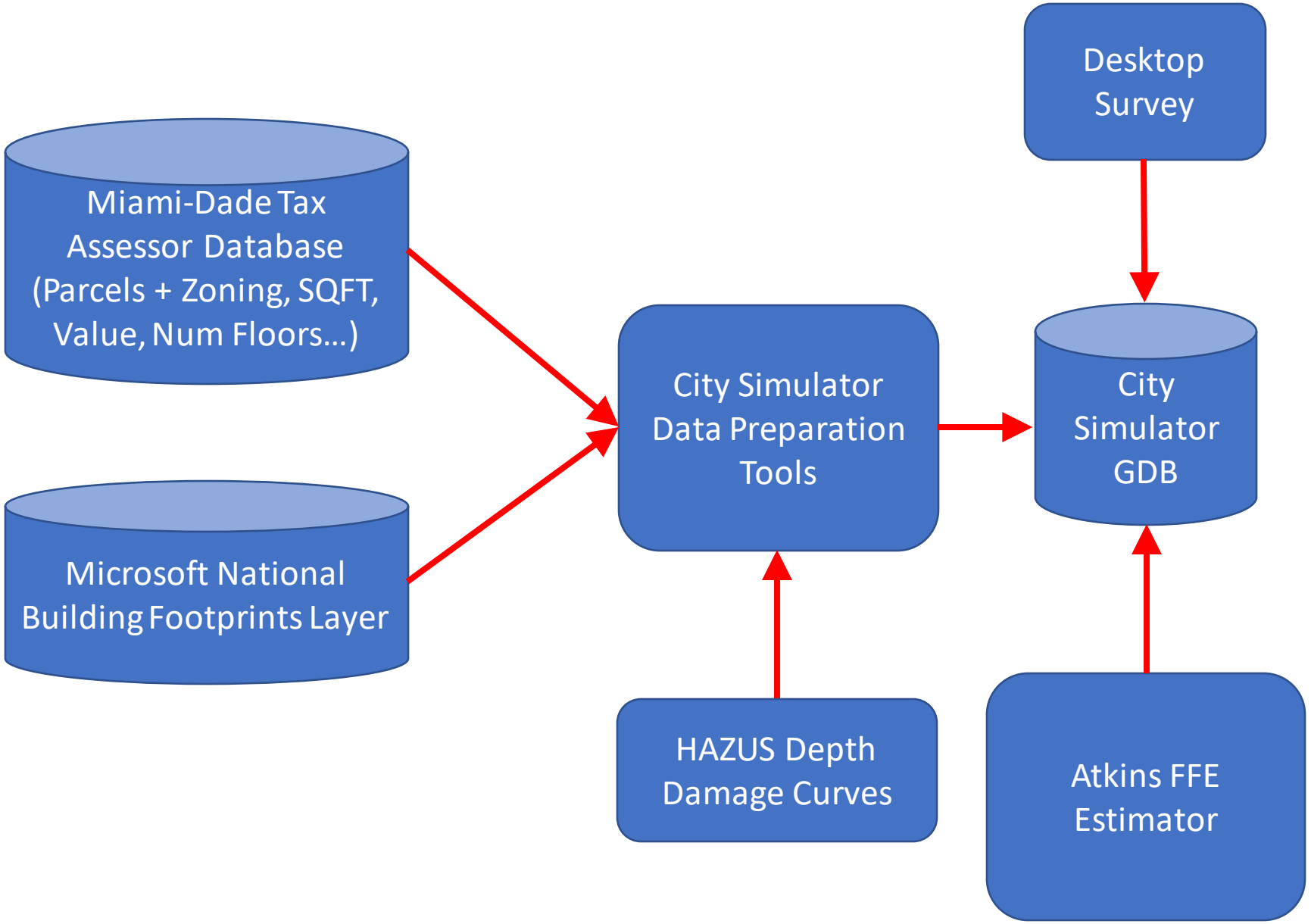


ATKINS

Projecting Sea Level Rise



Building Stock Development

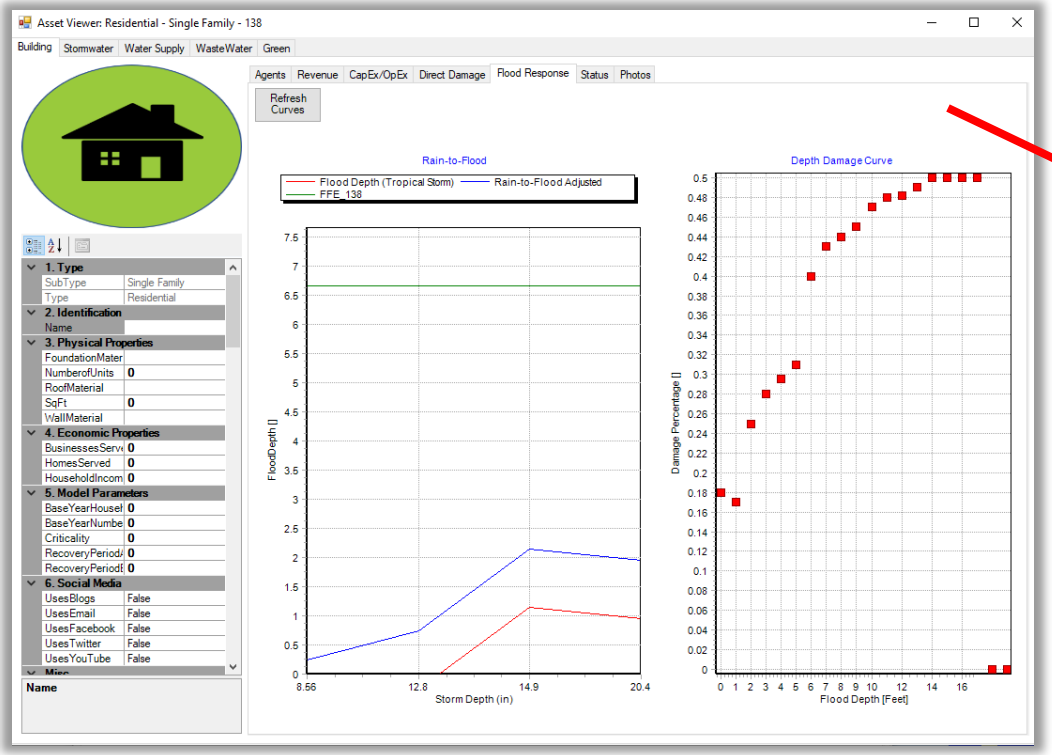


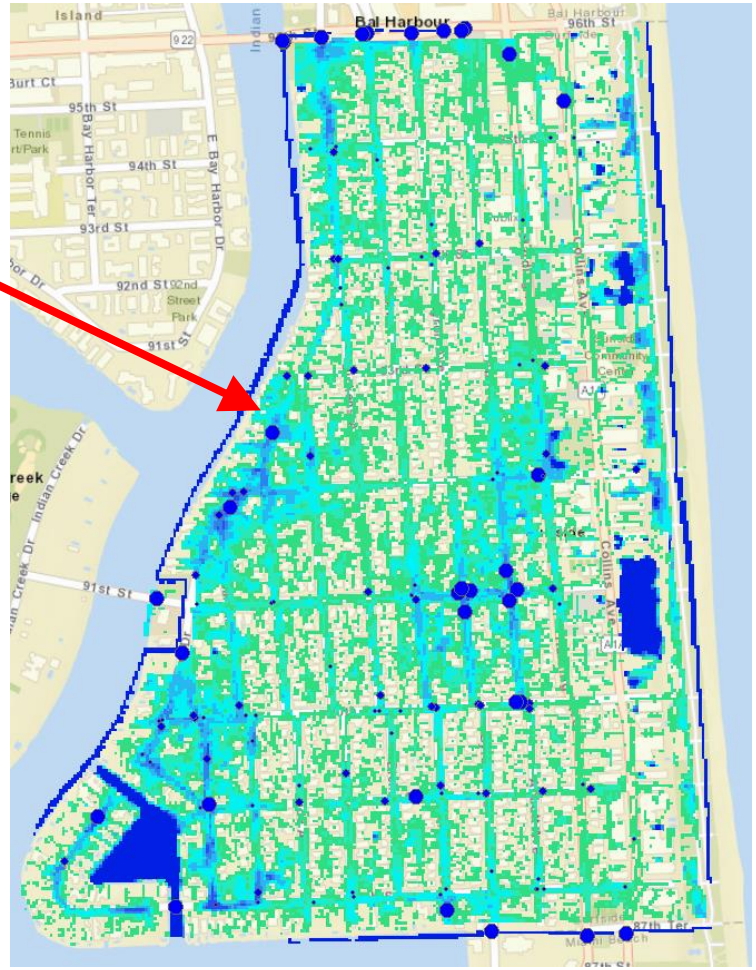
ATKINS

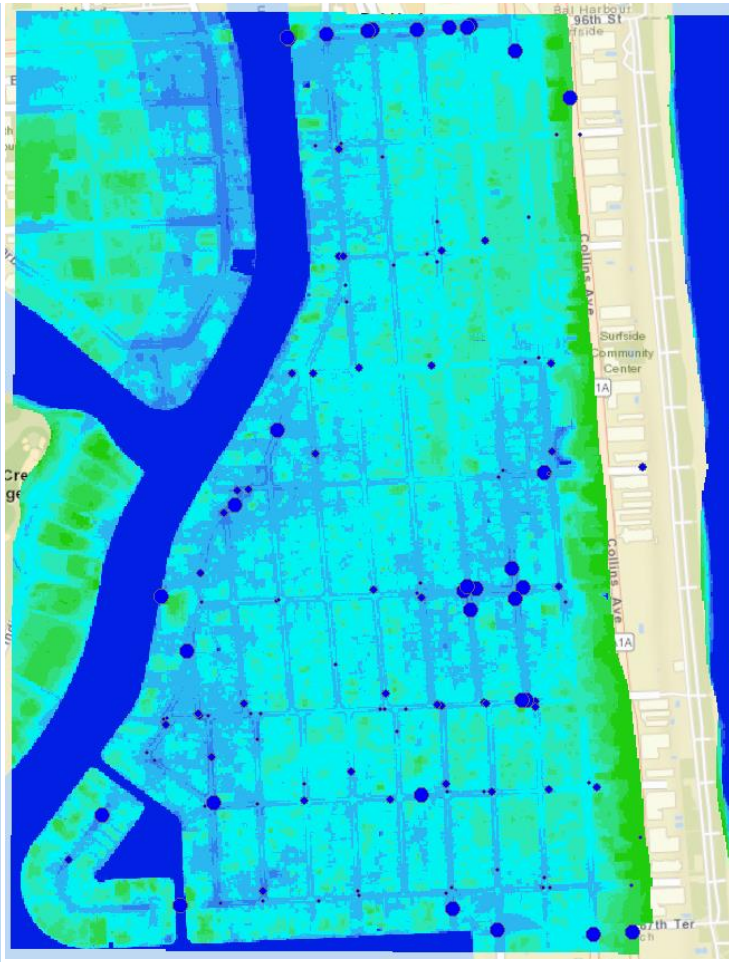
Building Stock Flood Response

Pluvial Flood Model
HECRAS2D 500yr Flood

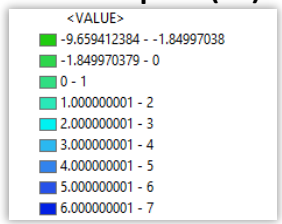
FEMA FIS Model
500yr Storm Surge





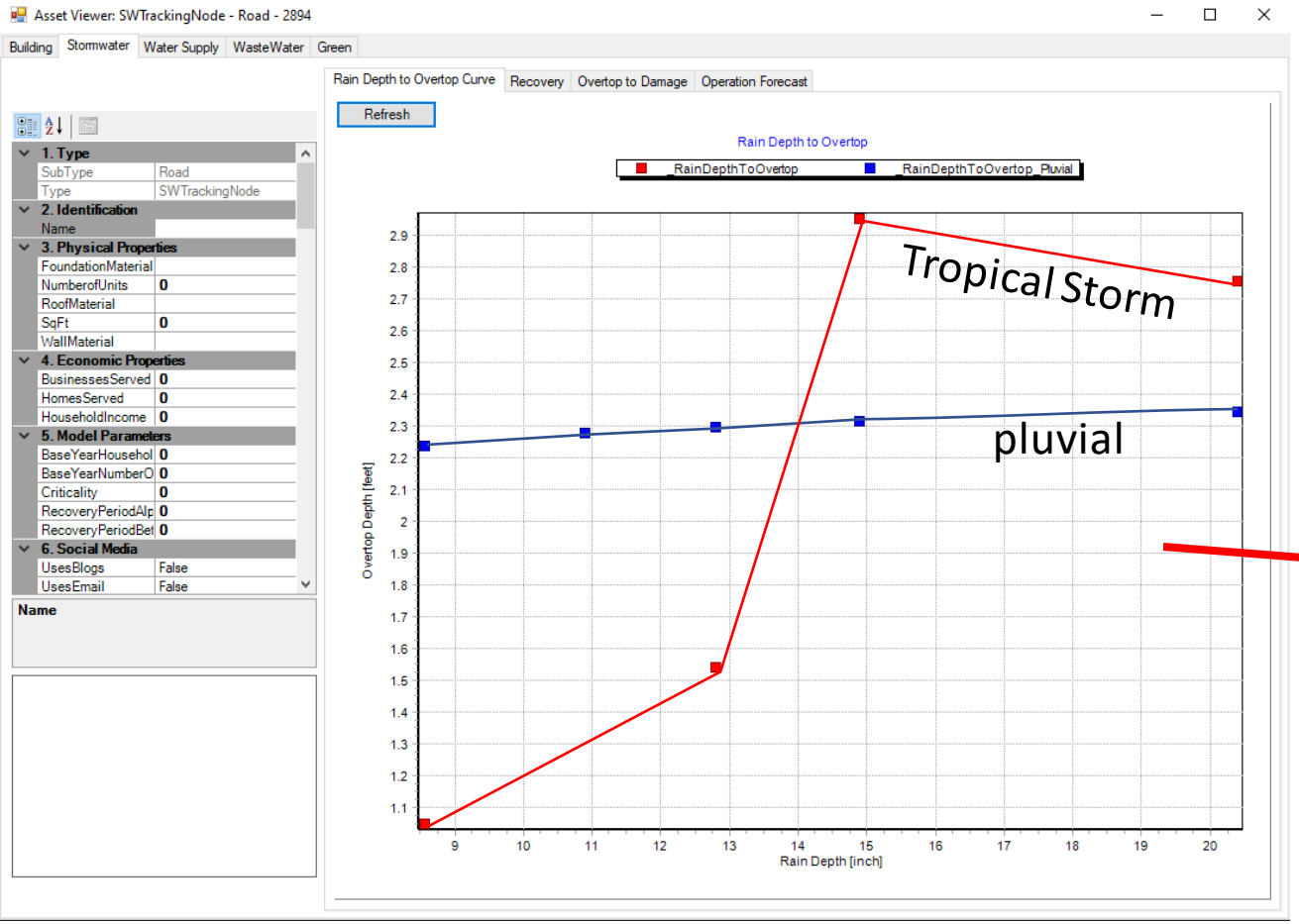


Flood Depth(ft)

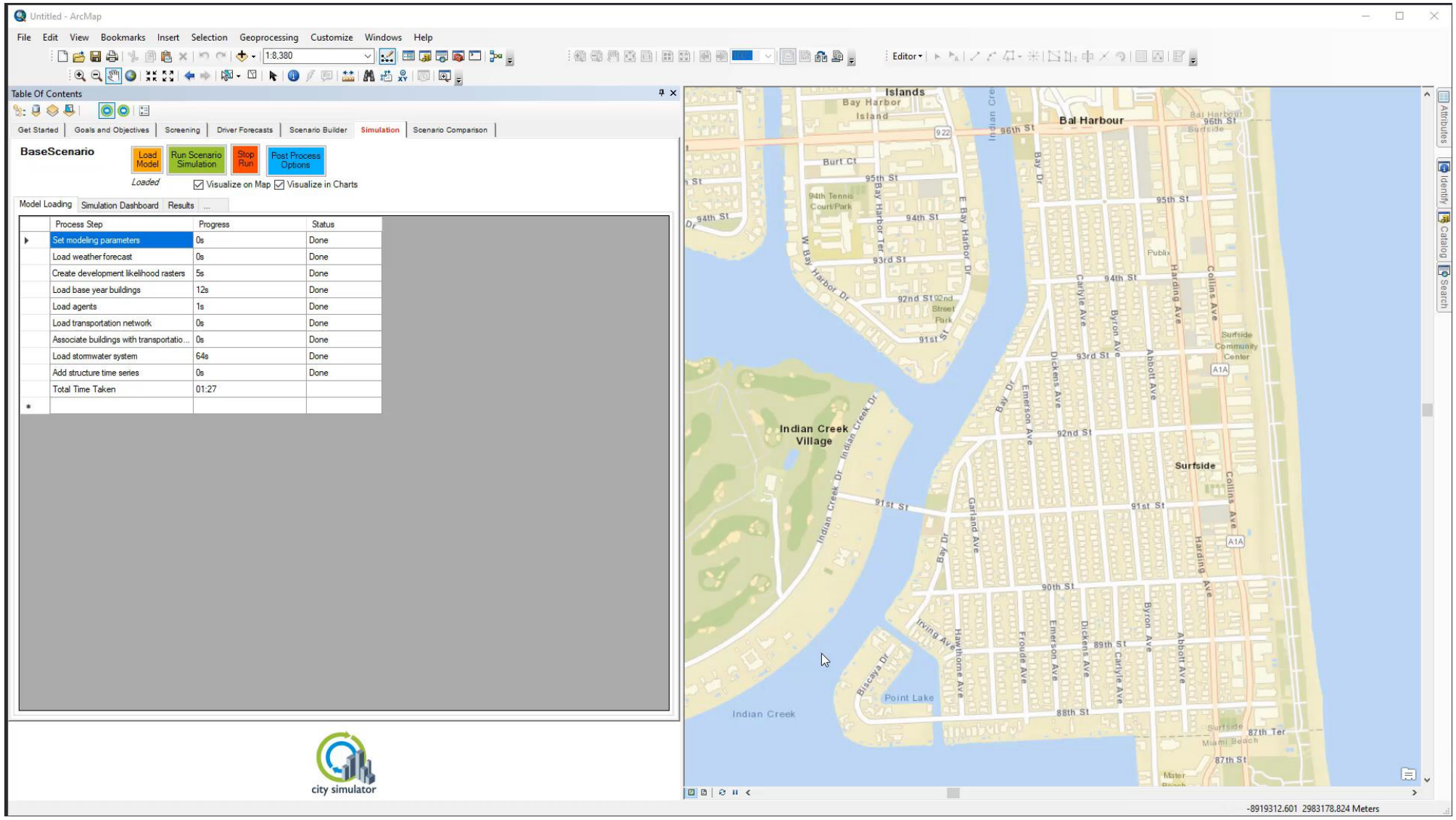


ATKINS

Road System Flooding



Baserun Results



ATKINS

Baserun Results

Average Annual Key Metrics

Metric	Value
Storm Damage	$33.5K/yr
Productivity Loss from Flood	$190K/yr
Trips Disrupted	25.6 K/yr
- By Work Flood	3.1%
- By Home Flood	4.2%
- By Road Flood	92.3%

2019 Convective Thunderstorm

2021 Tropical Storm

Building Damage

Trips Disrupted

ATKINS

Baserun Results – Key Findings

Community Statistics

- Population: 5,820
- Households: 2,328 - w/ children 65%
- Jobs: 2,430
- Future Job Growth: 38% (vs 33% for US)
- Average new commercial buildings per year: 1 from 2010-2017

Risks from Weather and Climate

- Storm Types: frontal, convective thunderstorms, and tropical storms inducing storm surge.
- Pluvial Model (HECRAS2D) for convective thunderstorms and frontal
- Sea level rise NOAA high projection used (approx. 2ft of rise from 2020 – 2050)
- FEMA FIS (storm surge) for tropical storms
- Monte Carlo analysis was used to generate 1,000 potential future rainfall driver forecasts based on global climate model projections and local rainfall.
- In general, GCM projections show increasing extreme events over 30-year time frame.
- Design forecast: 95Th percentile severity forecast in terms of severity was used as the representative driver rainfall forecast.
- Key Storms: Large tropical storms in 2021. Large convective thunderstorms (pluvial flooding) in 2019, 2024, 2026, 2039, and 2049.

Base Run Stormwater Vulnerabilities

- Significant flooding across the city with an annual average loss of $33K per year structural damage.
- Structural damage (flooding above FFE) caused primarily by the storm surge resulting from the 2021 tropical storm; pluvial flooding resulted in some damage as well.
- Stormwater related flooding occurred in low elevation spots across the city with key spots at:
    - Abbott Ave & 91st
    - Byron Ave & 91st
    - Bay Dr. and 92nd.

ATKINS

Baserun Results – Key Findings

Base Run Disruption

- Disrupted trips (home to work or work to home) occurred across the city (see map)
- Maximum average annual disrupted trips were:
  - Carlyle and 89th, 35,266 trips per year
  - Byron Ave and 91st, 31,797 trips per year
  - Abbot Ave and 91st, 31,453 trips per year
  - Bay Dr and 92nd, 31,453 trips per year.
- Disrupted trips largely caused by road flooding (93%), while home and road flooding were the cause 4% and 3% of the time respectively.
- Disrupted trips resulted in an average annual loss in city productivity (salaries not earned because people couldn't get to work) of $190K per year.
- Tidal flooding (Sunny-day flooding) steadily impacts homes and the road system over the course of the simulation.

ATKINS

Stormwater Parks Adaptation Scenario

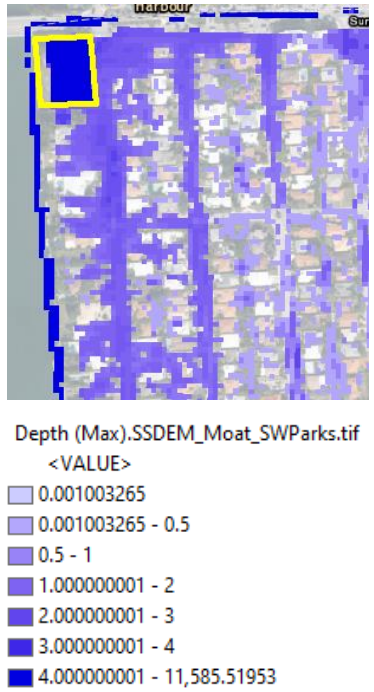
"burn" in proposed stormwater parks in HECRAS 2D

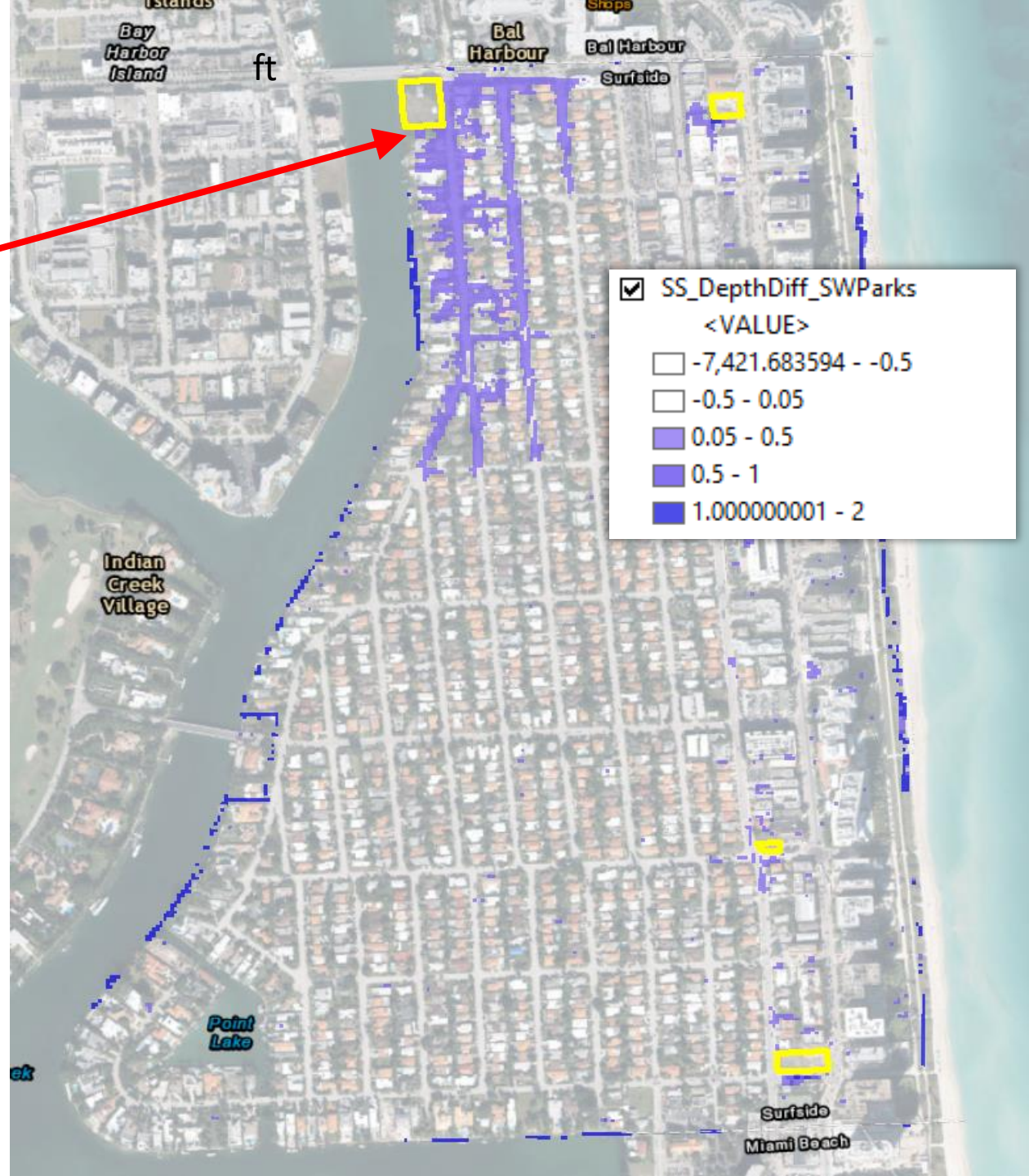
Difference b/w 500yr flood shows 96th street park has widest influence.

ATKINS

Stormwater Parks Adaptation Scenario

- Difference b/w 500yr flood shows 96th street park has widest influence.
- Flood depth of reduction is 0.4-0.5’ maximum close to the SW park.
- Flood depths still appox 4’ at deepest point.
- Other SW Parks achieve more localized flood reduction.
- Would require new SW sewers and gravity or pump flow to enlarge area of influence





Mitigation and Adaptation Options

Increased Monitoring, Study, and Prediction	Planning and Policy	General Infrastructure Improvement	Physical Counter-measures to Climate Change
Collect Key Building Stock attributes (FFE, Materials)	Zoning Adjustment/ Economic Dev Zones	Enlarge Stormwater System Capacity	Elevating Structures
Detailed local precipitation and temperature recording	Resilience Bonds	Harden Transportation Infrastructure	Buy-out programs
Improved Precipitation Projection	Adjust storm-related design regulations	Green Infrastructure	Elevate Sea Walls
Refine understanding of market value	Increased inspections with focus on climate change resilience	Enlarge Stormwater System Capacity	2nd Flood Conversion
Develop dashboards to track changing climate and compare to forecasts	Improve/introduce climate change related training	Ensure emergency routes not disrupted by future events	Elevating Landscapes
Collect key transportation system attributes (AADTs)	Awareness Campaigns	Improve Telecom system to encourage work-from-home	Managed Retreat

ATKINS