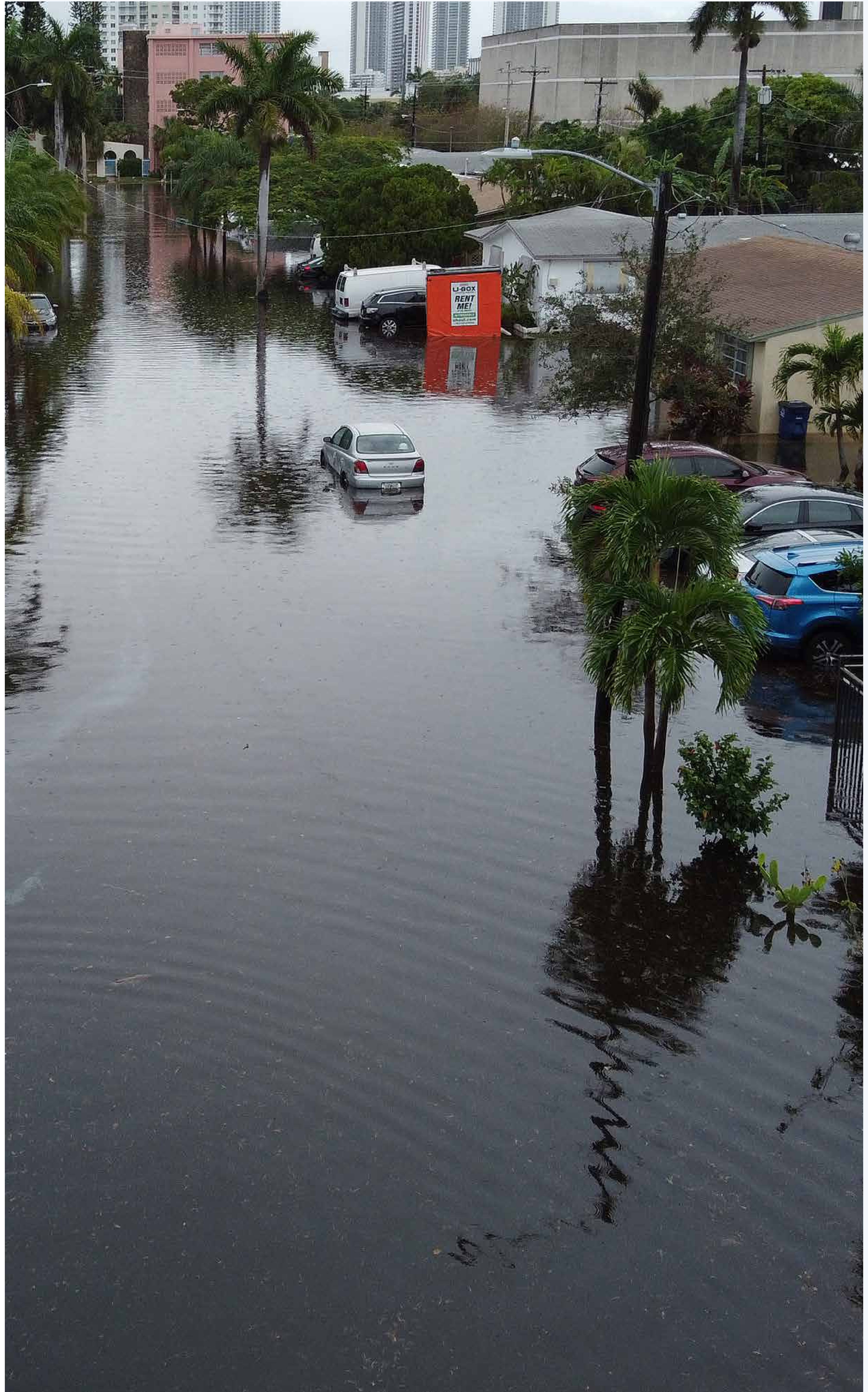
FIRST STREET FOUNDATION

Defining America’s Flood Risk

Property-level comprehensive flood risk estimates

First Street Foundation is a nonprofit formed to communicate risks from climate change to individual Americans – starting with flood risk.



We recognize an urgent need for consistent, property-level, publicly-available flood risk information for the entire United States.

By democratizing this peer-reviewed flood risk data, First Street empowers Americans to protect their most valuable asset – their homes.

First Street built an expert team to develop the first comprehensive, publicly available flood risk assessment for each of 142M properties in the contiguous US.

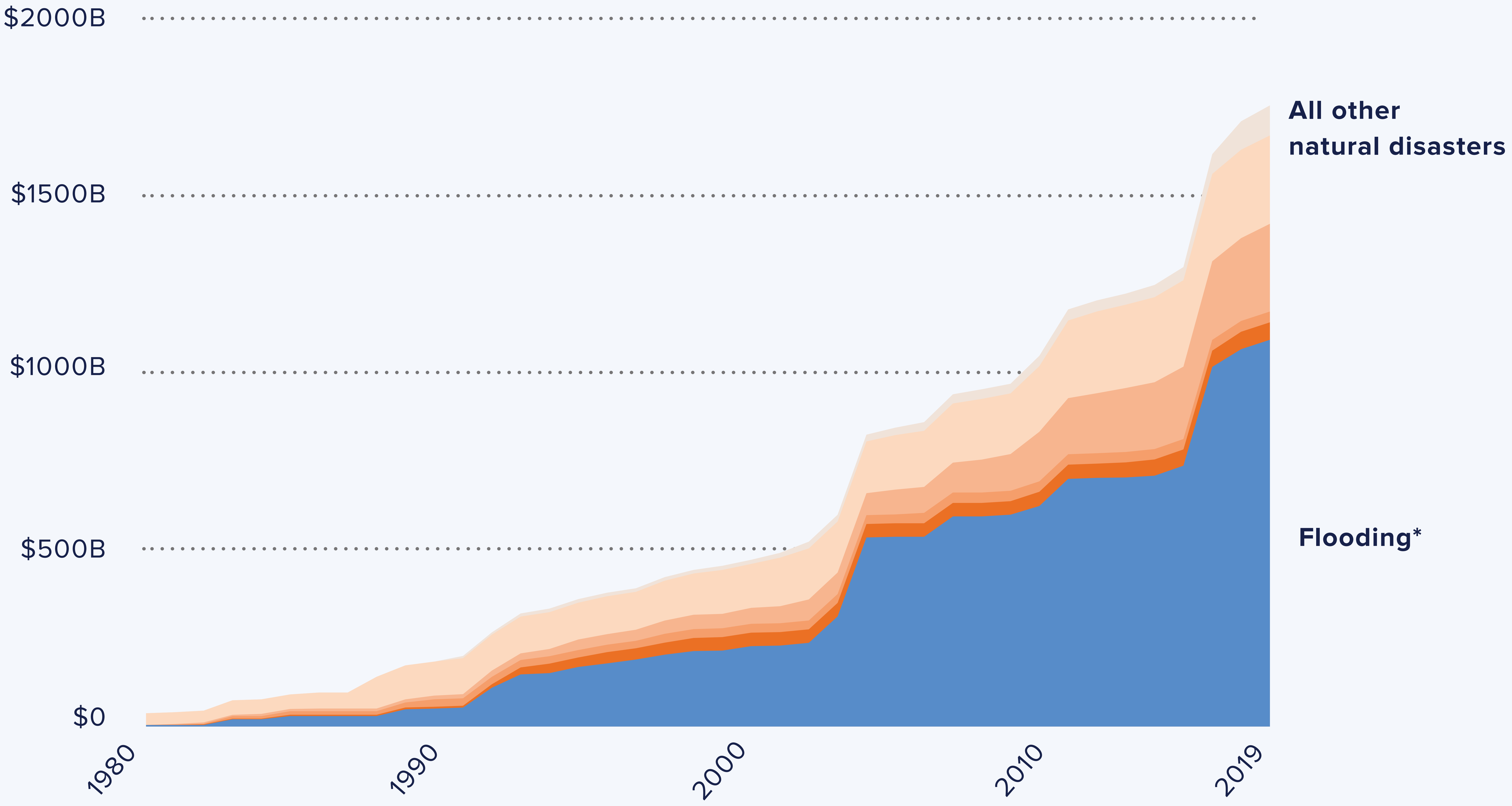
Why flood?

Flooding is the most costly natural disaster in the USA

Flooding* has cost over $1 trillion in inflation adjusted dollars since 1980 and represents over 63% of the cost associated with all billion dollar or more natural disasters.

Source:
NOAA

Over $1 trillion in flooding damages



*Combination of Flooding, and Tropical Cyclones.

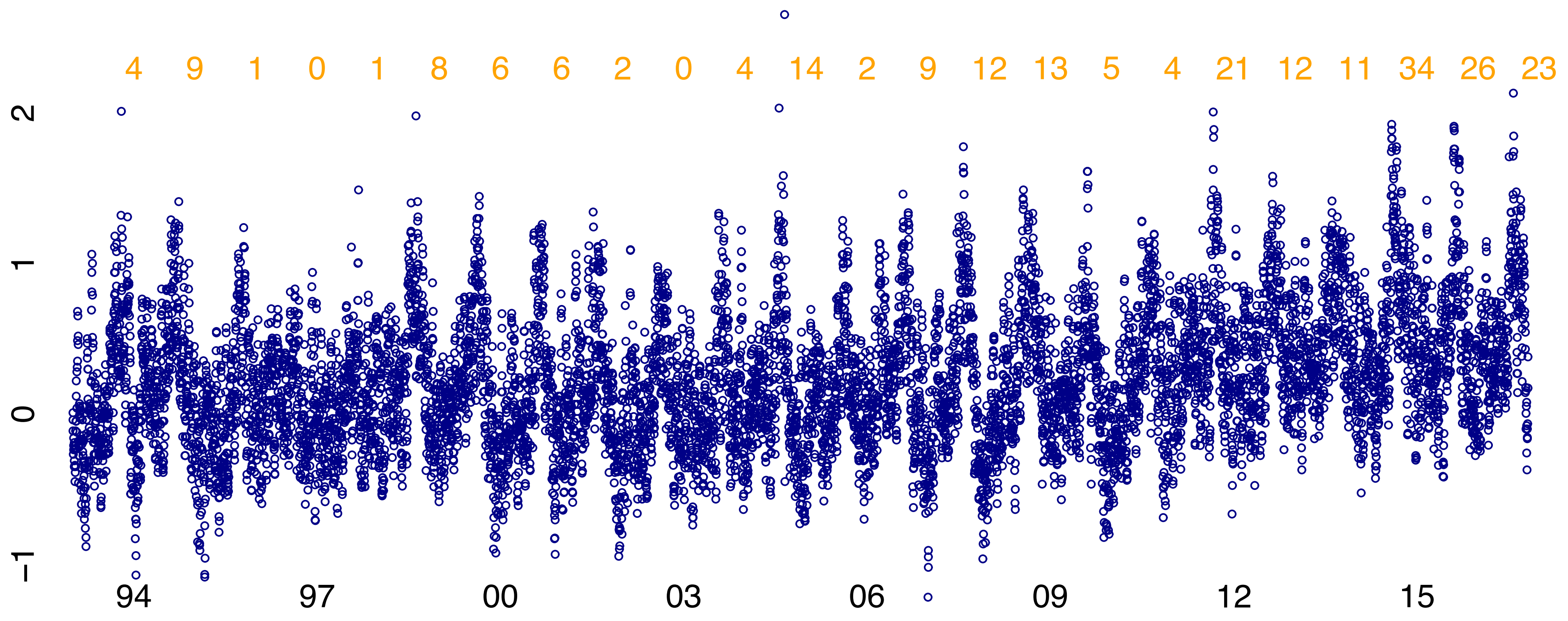
Tidal Flooding

To help build awareness around the growing flood risk from a changing climate, First Street built a peer reviewed methodology to calculate tidal flood risk at a property parcel level. The team also adjusted the model to project future risk from sea level rise. Roughly 2.5 million Americans in roughly 1 million homes are currently at risk of tidal flooding.

Tide Gauges

By analyzing millions of tide gauge readings, we can understand tidal flooding patterns and the likelihood of inundation from tidal flooding.

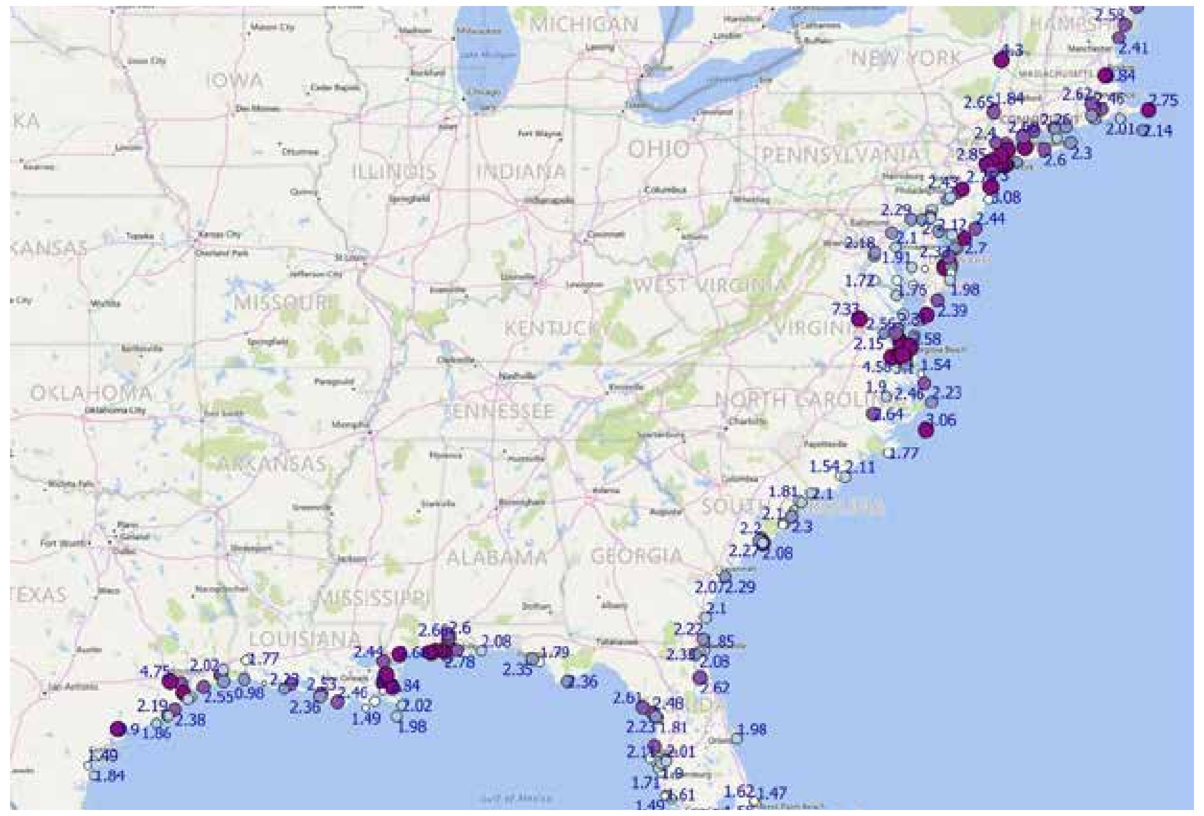
Miami Tide Station (Virginia Key) Since 1994



Methodology

Leveraging our custom methodology we can apply this prediction pattern it to all coastal areas, giving us the ability to create tidal flooding predictions that are carefully calibrated to every coastal home.

Tidal stations across the east coast and gulf



Home Values

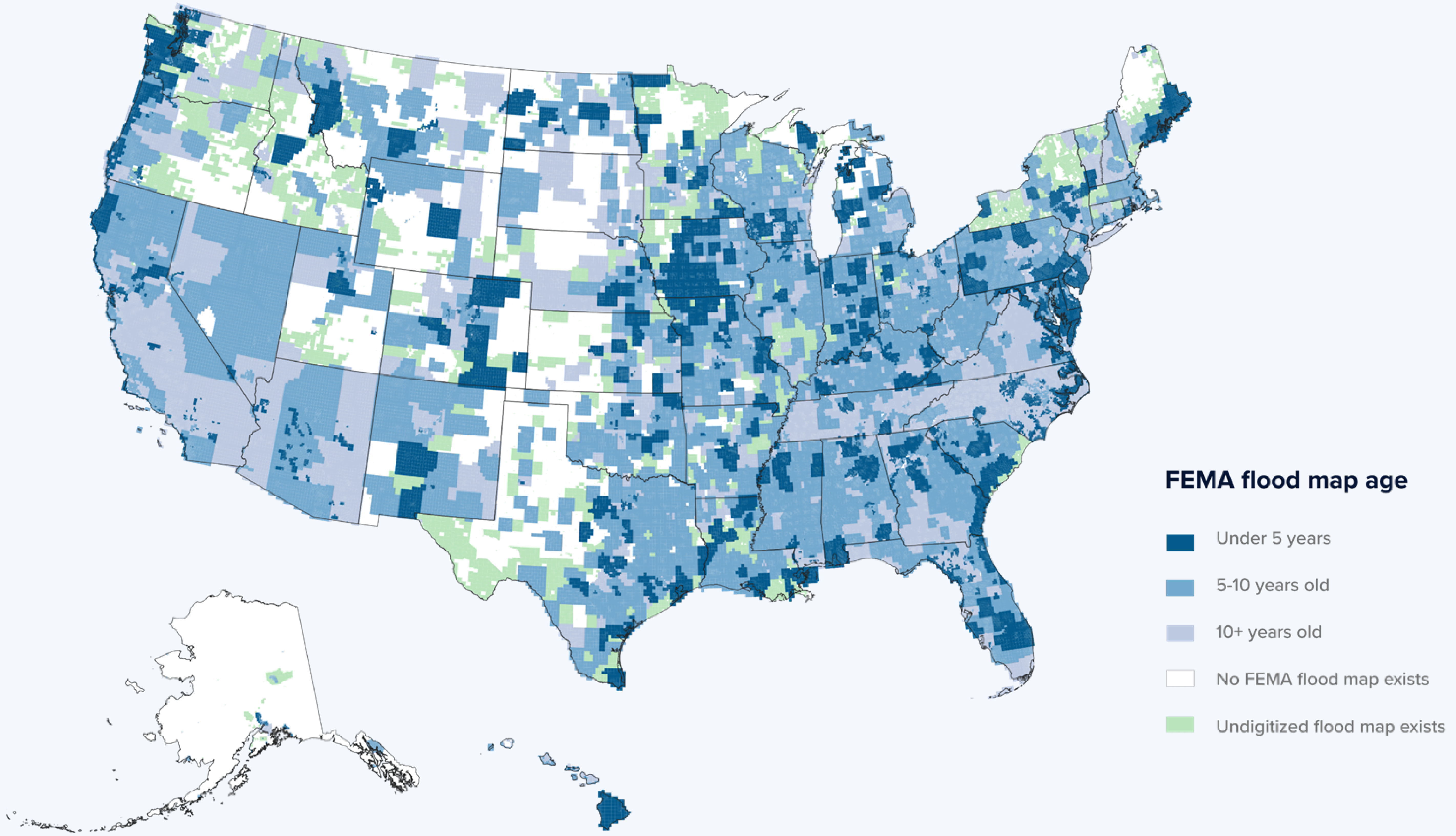
Combined with high resolution elevation data, detailed parcel attributes and real estate transaction records, we can not only predict tidal flooding patterns for each property but the impact to past and future home values.

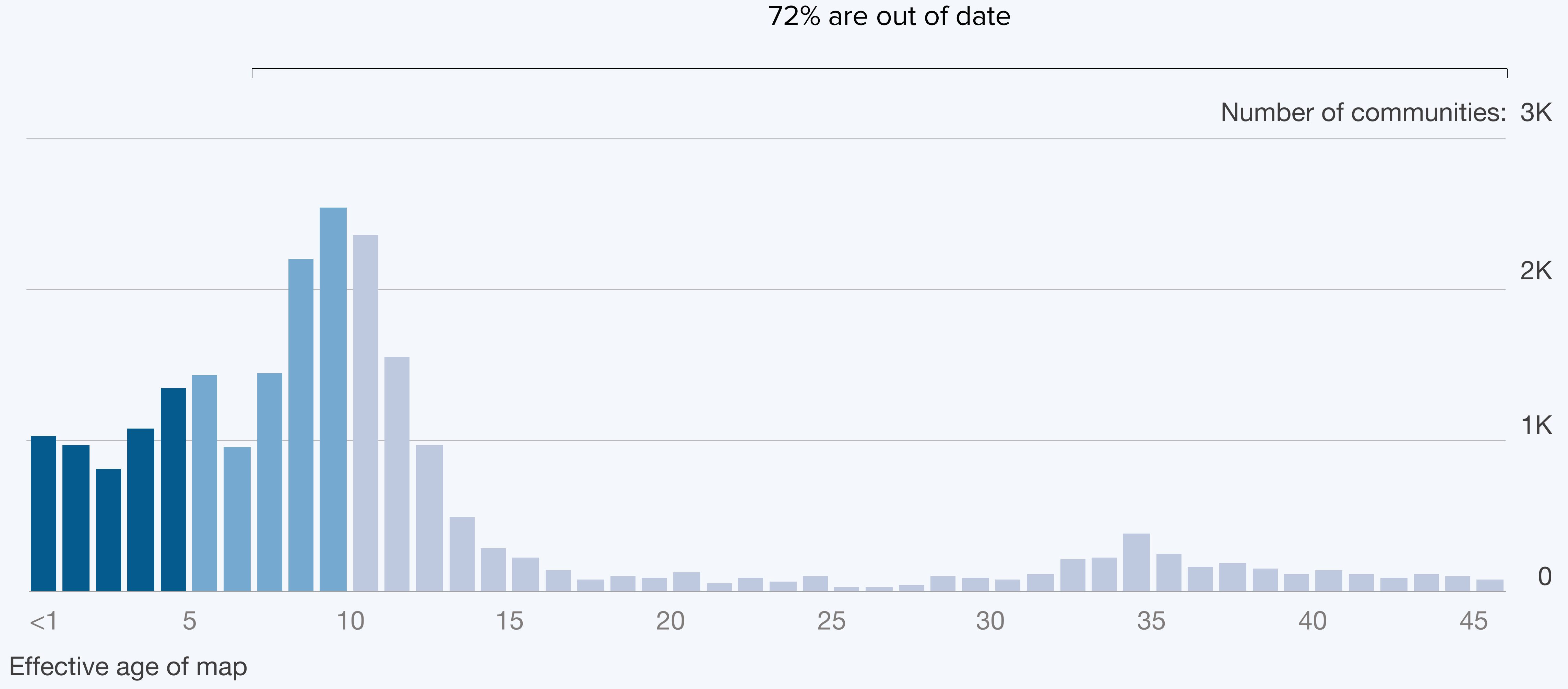
Sources:
First Street Foundation

FEMA flood maps are a work in progress

FEMA flood maps are the gold standard for understanding America’s flood risk exposure.

Following the National Flood Insurance Reform Act of 1994, FEMA reviews and update all flood maps every 5 years. Currently 72% are overdue to be updated, and 11% have not been updated since the 70’s and 80’s.





Sources:
FEMA 1
FEMA 2

FEMA deals with many challenges to complete its maps

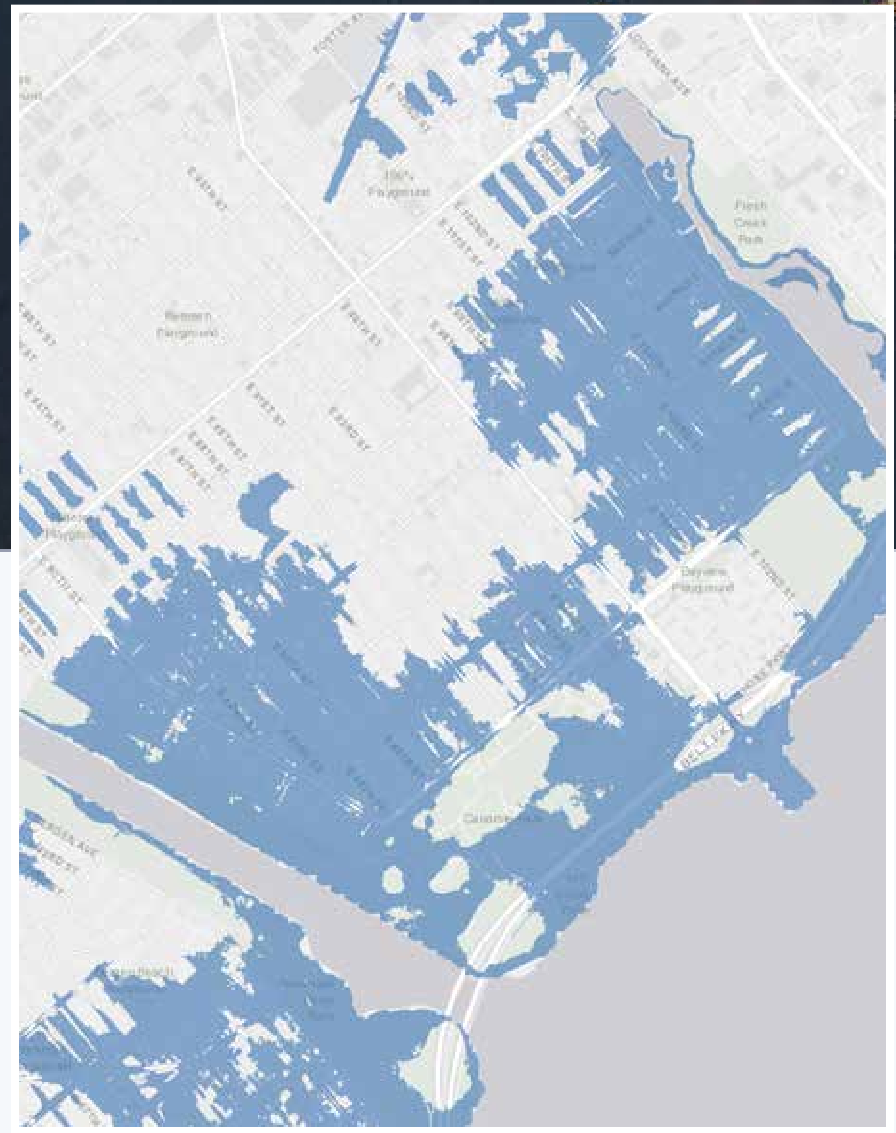
There are 8 steps involved in the issuing of updated or new FEMA flood maps. These steps involve select local leaders and business interests resulting in compromised flood maps that can take years to adopt.

Source: FEMA

2007

FEMA implements minor flood map updates to original map created in 1983.

Source: FEMA



2012

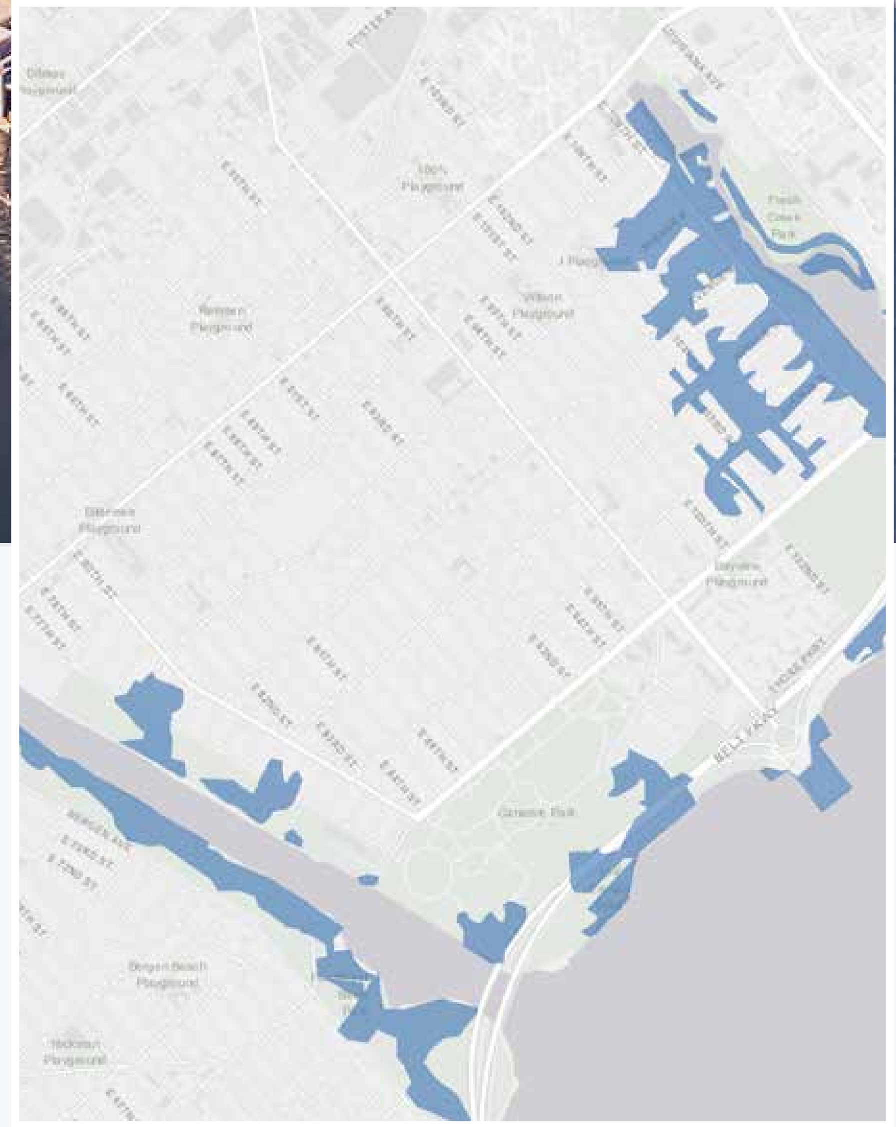
Superstorm Sandy floods Canarsie representing true flood risk.

Source: City of New York

2015

FEMA proposes new flood map. NYC rejects it and appeals.

Source: FEMA



2016

FEMA accepts NYC's appeal and proposed map.

Source: City of New York

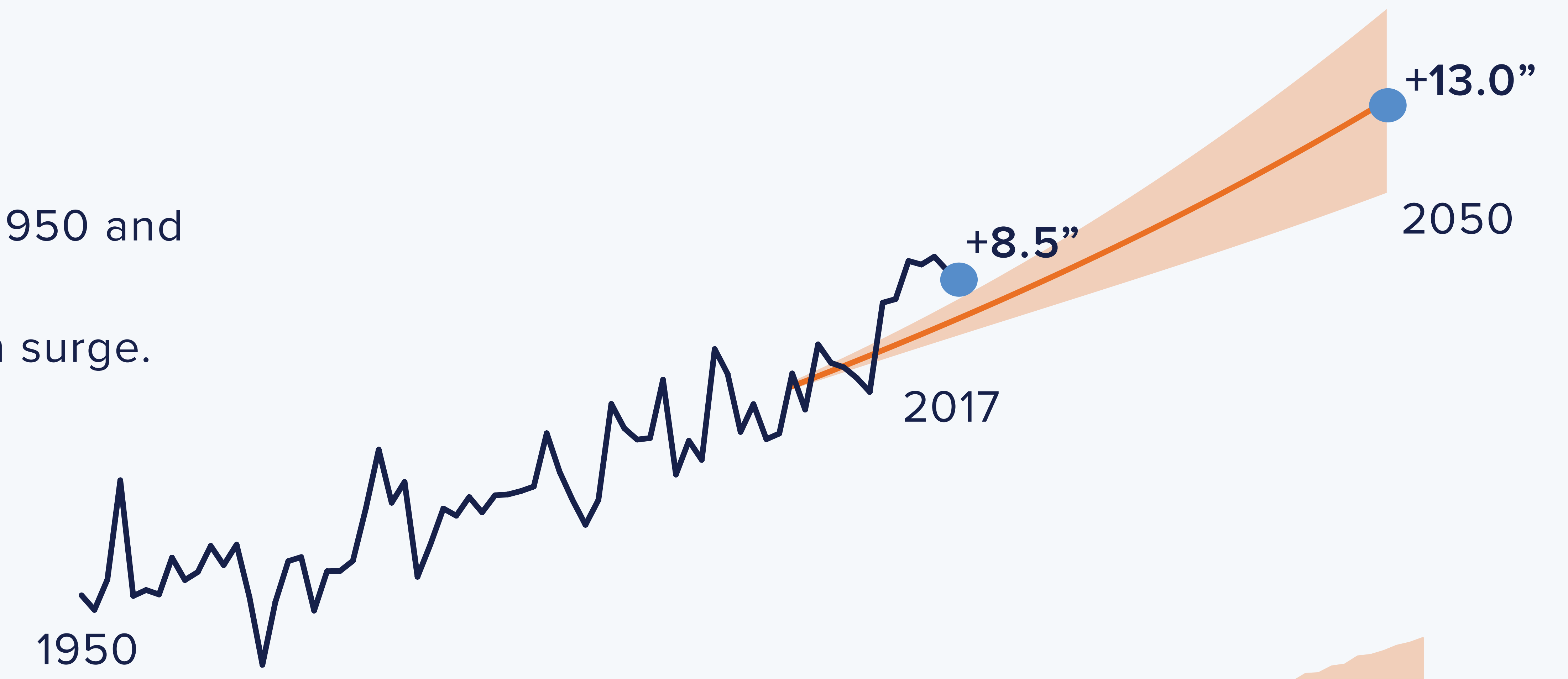
First Street estimates incorporate future environmental changes

While FEMA is now working on a “more comprehensive and graduated approach of managing flood risk across a range of probabilities, including future conditions”, flood maps are currently created by calculating the frequency and impact of historic flooding events and do not explicitly account for any future environmental changes except for erosion.

Sea Levels

The ocean has risen 8.5 inches nationally since 1950 and is projected to rise another 4.5 inches by 2050.
This increases tidal flooding and hurricane storm surge.

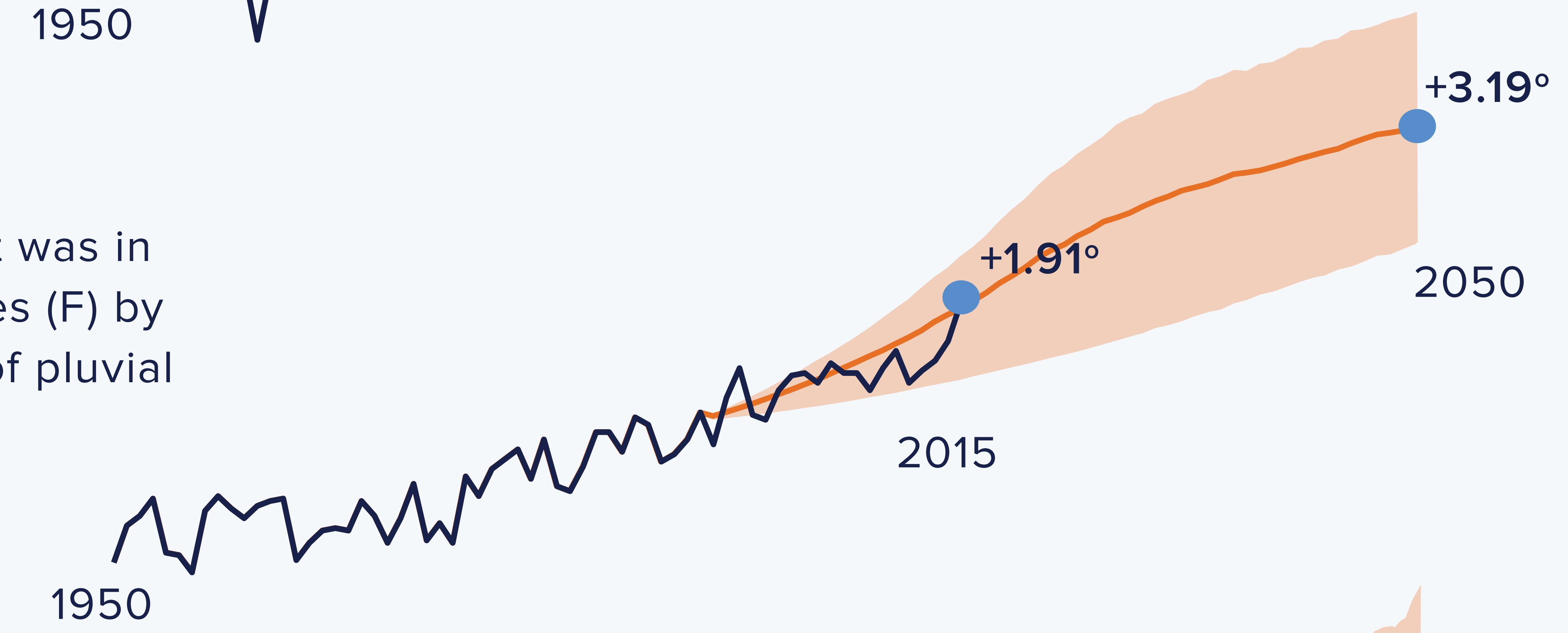
Observation Source: CSIRO
Projections Source: IPCC



Surface Air Temperatures

The atmosphere is 1.9 degrees (F) warmer than it was in 1950. It is projected to warm another 1.28 degrees (F) by 2050. This impacts the frequency and intensity of pluvial (precipitation) and fluvial (riverine) flooding.

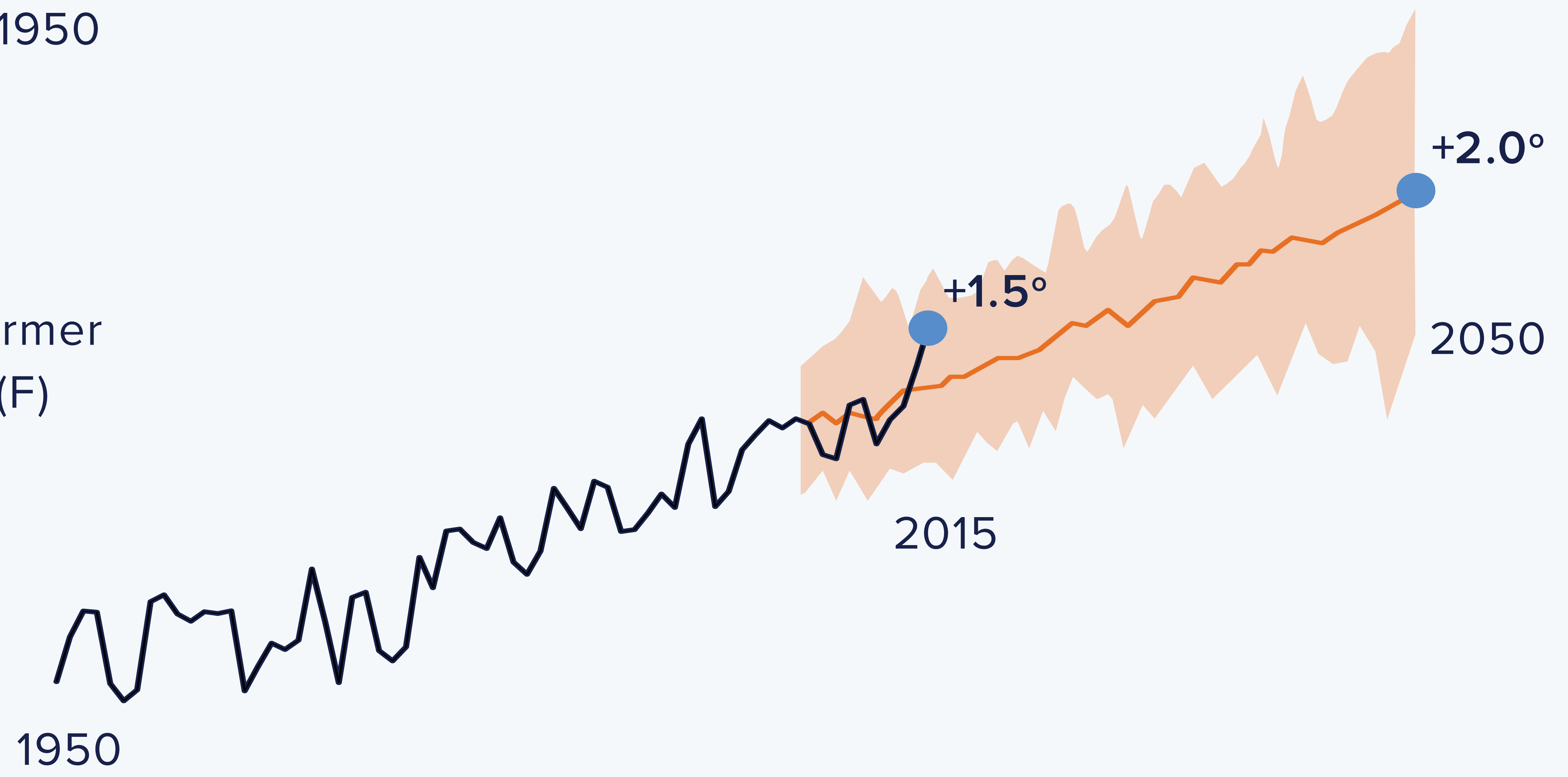
Observation Source: NOAA / EPA
Projections Source: IPCC



Sea Surface Temperatures

The sea’s surface temperature is 1.5 degrees (F) warmer than it was in 1950. It will rise another 0.5 degrees (F) by 2050. This impacts the intensity and geographic area hurricanes make landfall.

Observation Source: NOAA / EPA
Projections Source: IPCC



We will complement FEMA's technical approach to solve this problem

Until the total flood risk for every home in America is effectively calculated and communicated, property owners, buyers and renters will continue to suffer.

First Street Foundation has assembled a group of over 80 experts, scientists, economists and technologists to define flood risk and address this problem.

The 80+ scientists, economists, and technologists that are working to further America's understanding of flood risk

- Berkeley, University of California
- University of Bristol
- Columbia University
- Fathom
- First Street Foundation
- George Mason University
- IBM
- Lippincott
- Massachusetts Institute of Technology
- The University of North Carolina at Chapel Hill
- Rhodium Group
- Rutgers
- Wharton, University of Pennsylvania

See full list here

We began by modeling every major flood type

Tidal

King tides

Tidal flooding in Miami

Pluvial

Precipitation

Pluvial flooding in Houston

Fluvial

Riverine

Fluvial flooding in Cincinnati

Surge

Hurricane

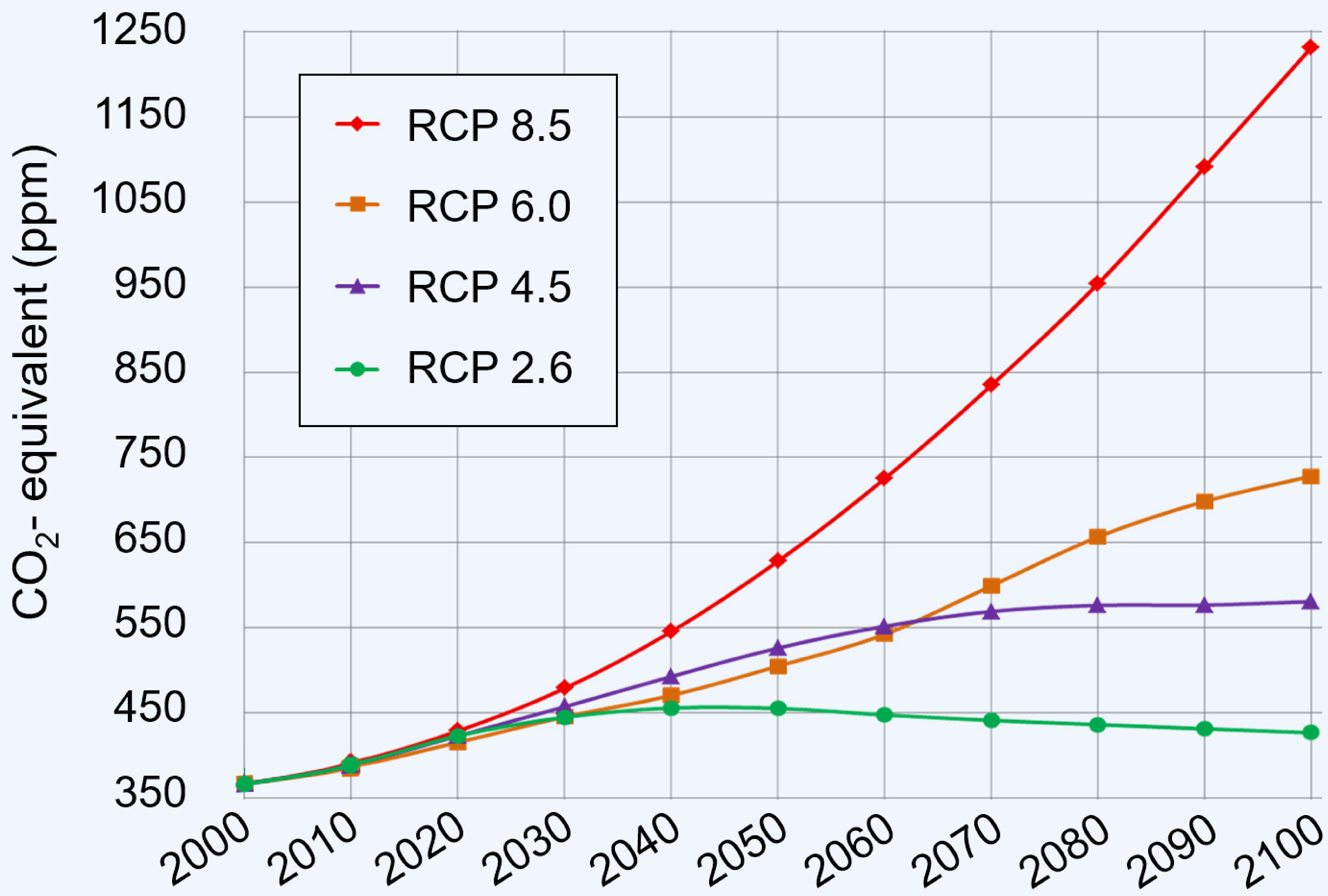
Surge flooding in Wilmington

IPCC models were analyzed for future environmental scenarios

CMIP5 climate model outputs under the RCP 4.5 scenario, were used for assessing future flood risks. A high, median, and low range were created to represent uncertainties in the projections for:

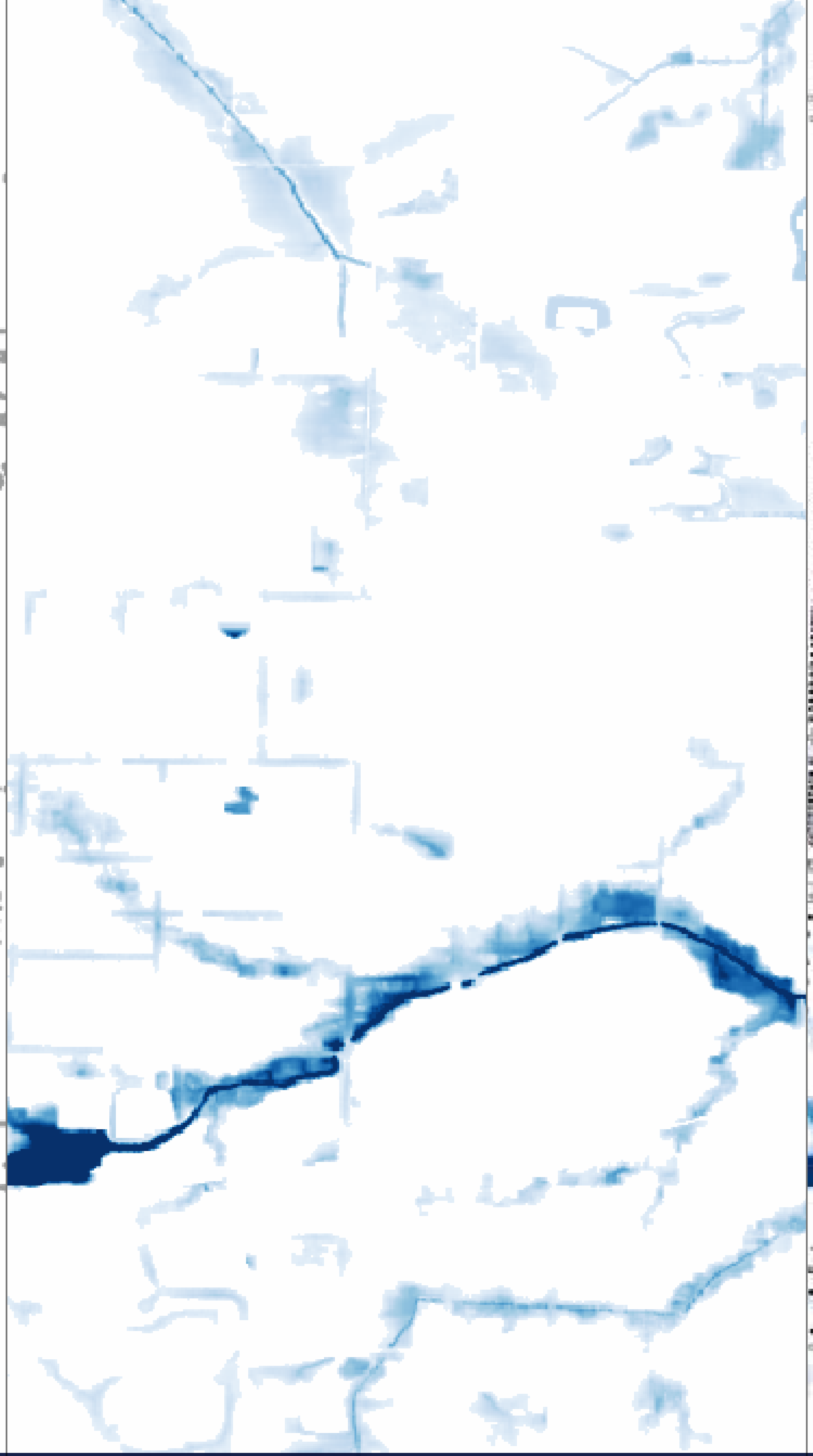
- precipitation patterns
- river discharge
- sea level rise
- hurricane intensity and landfall locations

Source:
IPCC



Parcel data

Building footprints



Hazard layer

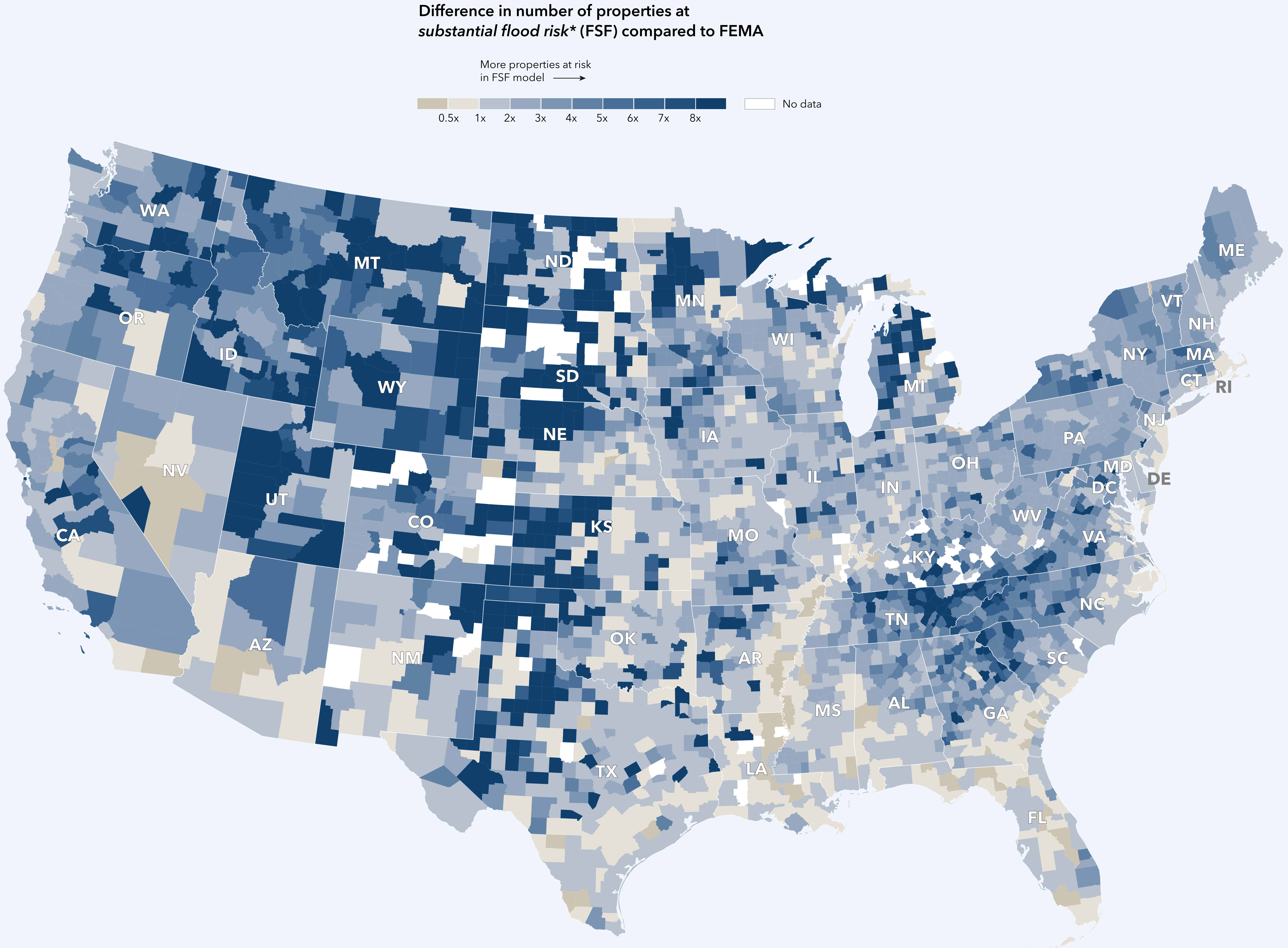
Max depth

(edge of building footprint or depth at property centroid)

Comparing the model results to FEMA maps

Comparing the FEMA Special Flood Hazard Area (1% annual risk) to The Foundation's same definition (1% annual risk for the median forecast in 2020), roughly 70% more properties are estimated to have that level of risk, representing an additional 5.9 million properties.

Source:
First Street Foundation
MassiveCert (FEMA ratings)

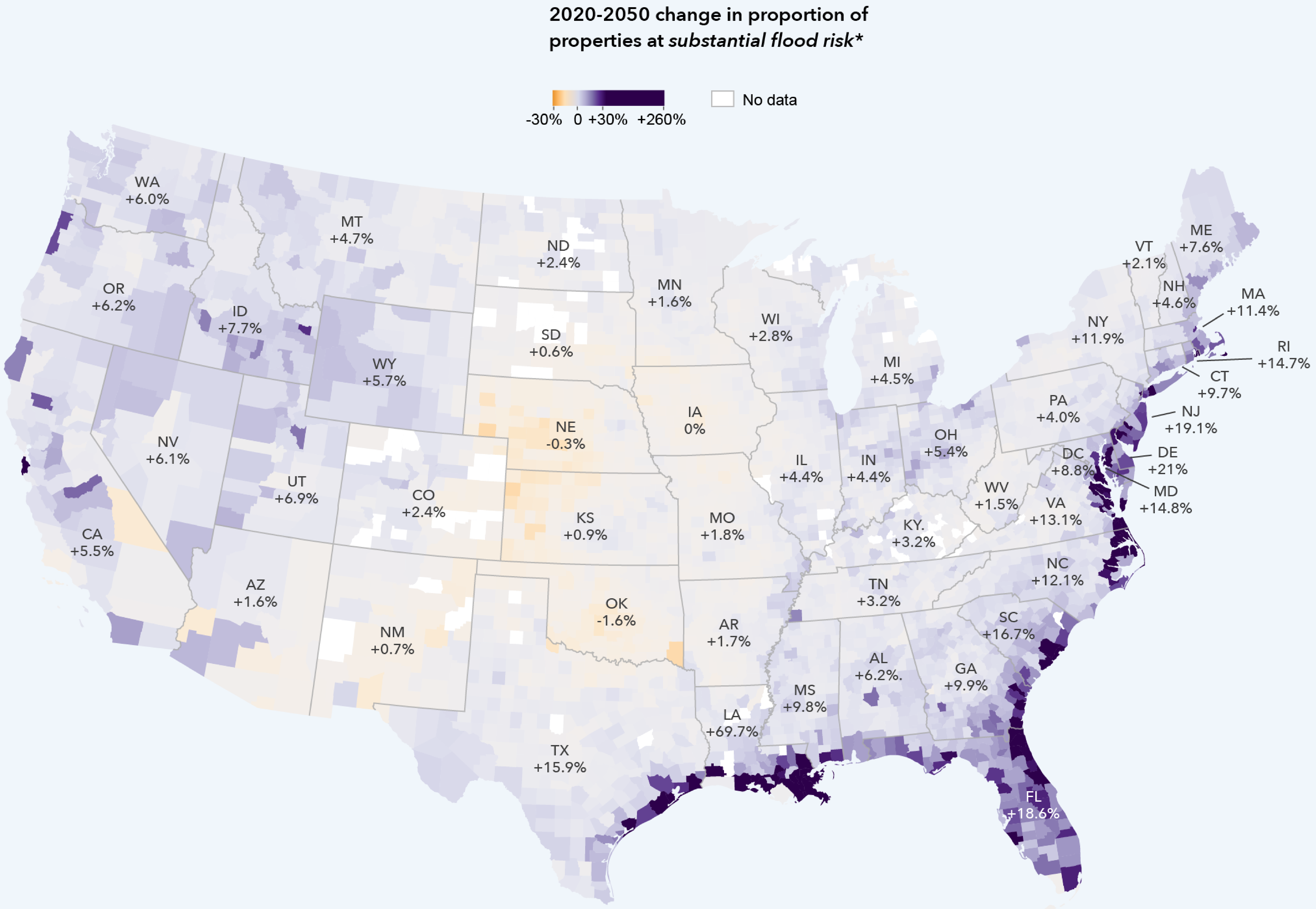


Future risk

The model estimates how flood risk will change as the environment changes.

While some portions of the country have dramatic increases in risk, others have reduction of risk.

Overall, the model shows an additional 10.9% or 1.6 million properties as having that 1% or greater annual risk by 2050.



* Substantial risk is calculated as inundation 1 cm or more to the building in the 100 return period (1% annual risk)

Open and transparent methods, and public data

The findings were freely and publicly released by The Foundation on June 29th, 2020 via a detailed technical methodology document, The First National Flood Risk Assessment report, and through Flood Factor (floodfactor.com) which presents individual properties' assessments.

Sources:
Technical Methodology
National Report
Flood Factor

Sources of input data

Precipitation Frequency
NOAA Atlas 14

River Flows
USGS Stream Gauge data

Tide and Surge Data
NOAA Tide Gauges

Elevation Data
USGS National Elevation Database supplemented with high res local datasets (e.g. lidar)

Climate forecasts
CMIP5 simulations (21 models, RCP 4.5)
Downscaled data from NASA NEX-GDDP

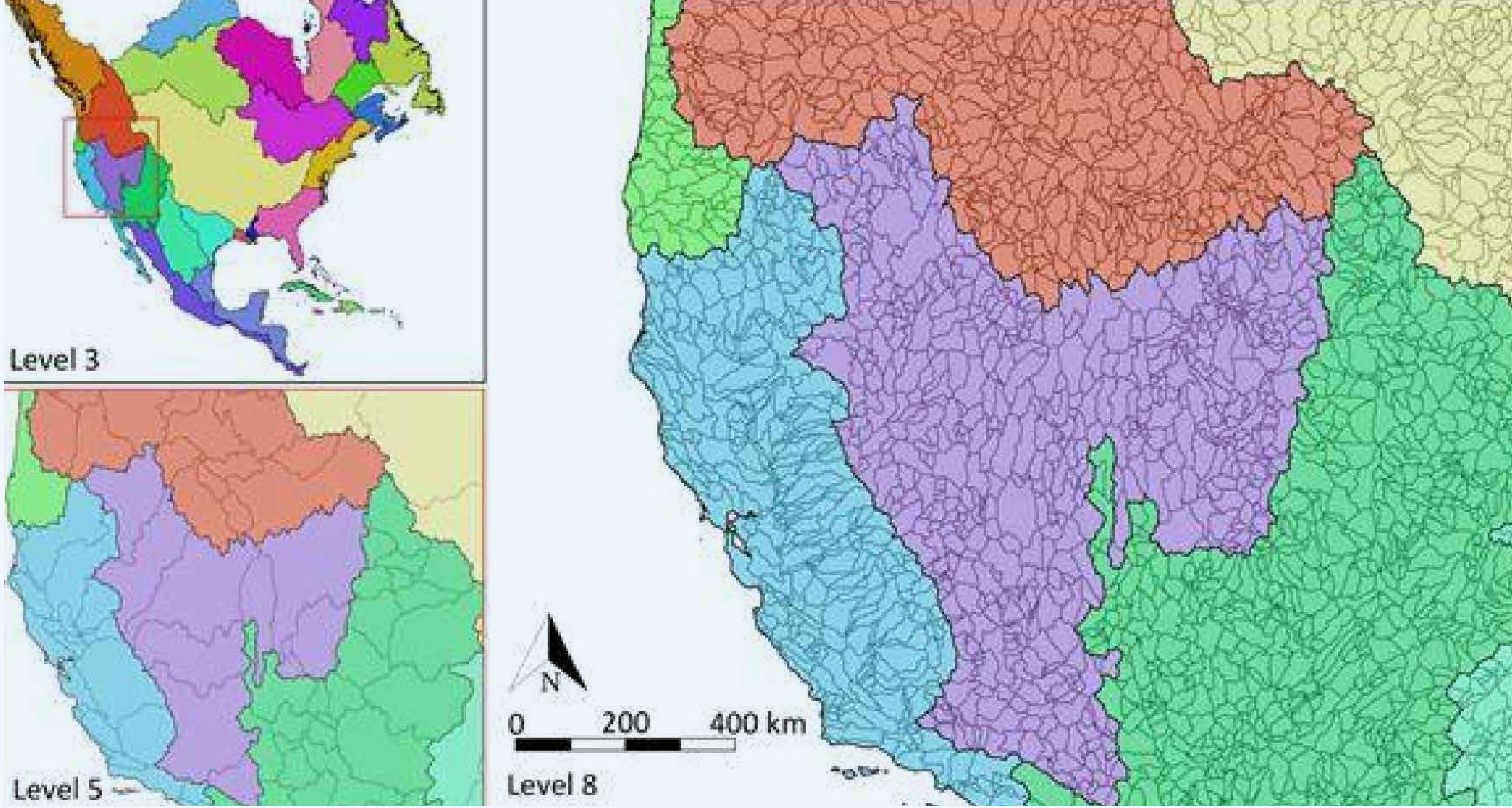
Historic
USGS High Water Mark data
NFIP flood claims
FEMA Individual Assistance claims

Hurricanes
Synthetic Hurricane Tracks from K. Emmanuel
NOAA IBTrACS Historical Hurricane tracks

Property info
Property boundaries from LightBox/DMP
Building footprints from MapBox and Microsoft
FEMA Flood Zone (estimated) from MassiveCert

Fluvial and pluvial model technical description

The Fathom-US Model uses statistical analysis to fill in a lack of observed data at 30m resolution (Wing, 2017)



Flood frequency analysis of river gauge records to characterize extreme river flows and generate boundary

Conditions for the hydraulic model does not employ a rain-fall-driven hydrological model

Uses regionalization methods to assign curve typologies from gauged catchments into ungauged catchments

Surge and tidal model

Coastal catchments can be influenced by pluvial, fluvial, and coastal processes (compound events)

Characterize all event processes to the hydraulic model and the frequency at which events occur jointly

Use long synthetic event sets

Derive depth-event (hazard) layers associated with the synthetic events

Calculate depth-return period distributions

Thousands of synthetic hurricane tracks via GeoClaw to generate surge levels

Post-processing statistical correction to account for waves

Synthetic tracks create thousands of years of simulations to determine frequency

West Coast - No hurricanes, limited to frequency analysis of historic data

Flood model outputs

Hazards downscaled to 3m resolution

Current (2020)

5 hazard layers explicitly modeled for median climate scenario

3 hazard layers for both high & low

Future (2035, 2050)

13 hazard layers explicitly modeled with low, median and high climate scenarios

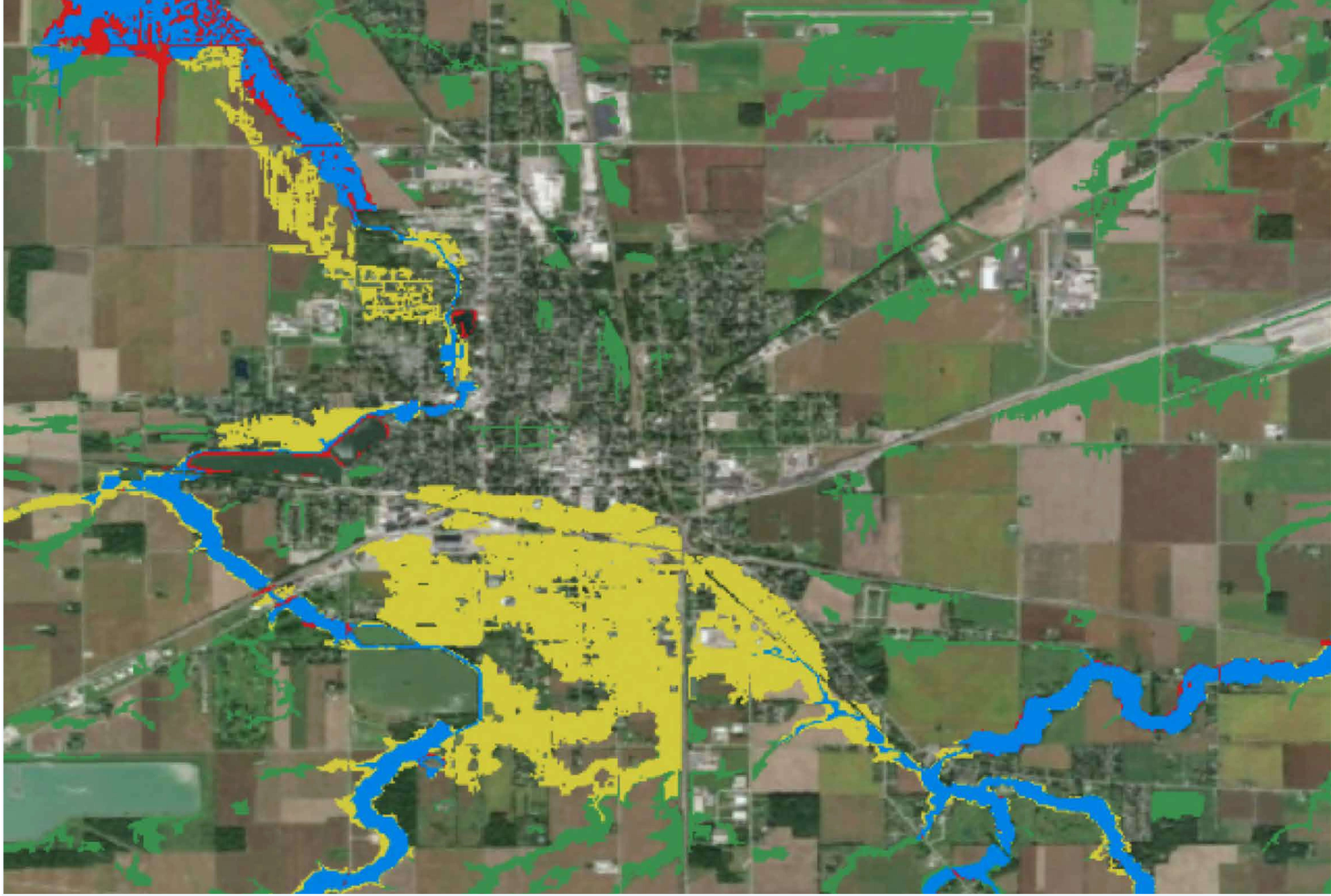
Historic

30 inland river flooding events simulated

25 coastal storms simulated including hurricanes, tropical storms, and noreasters

Quality assurance

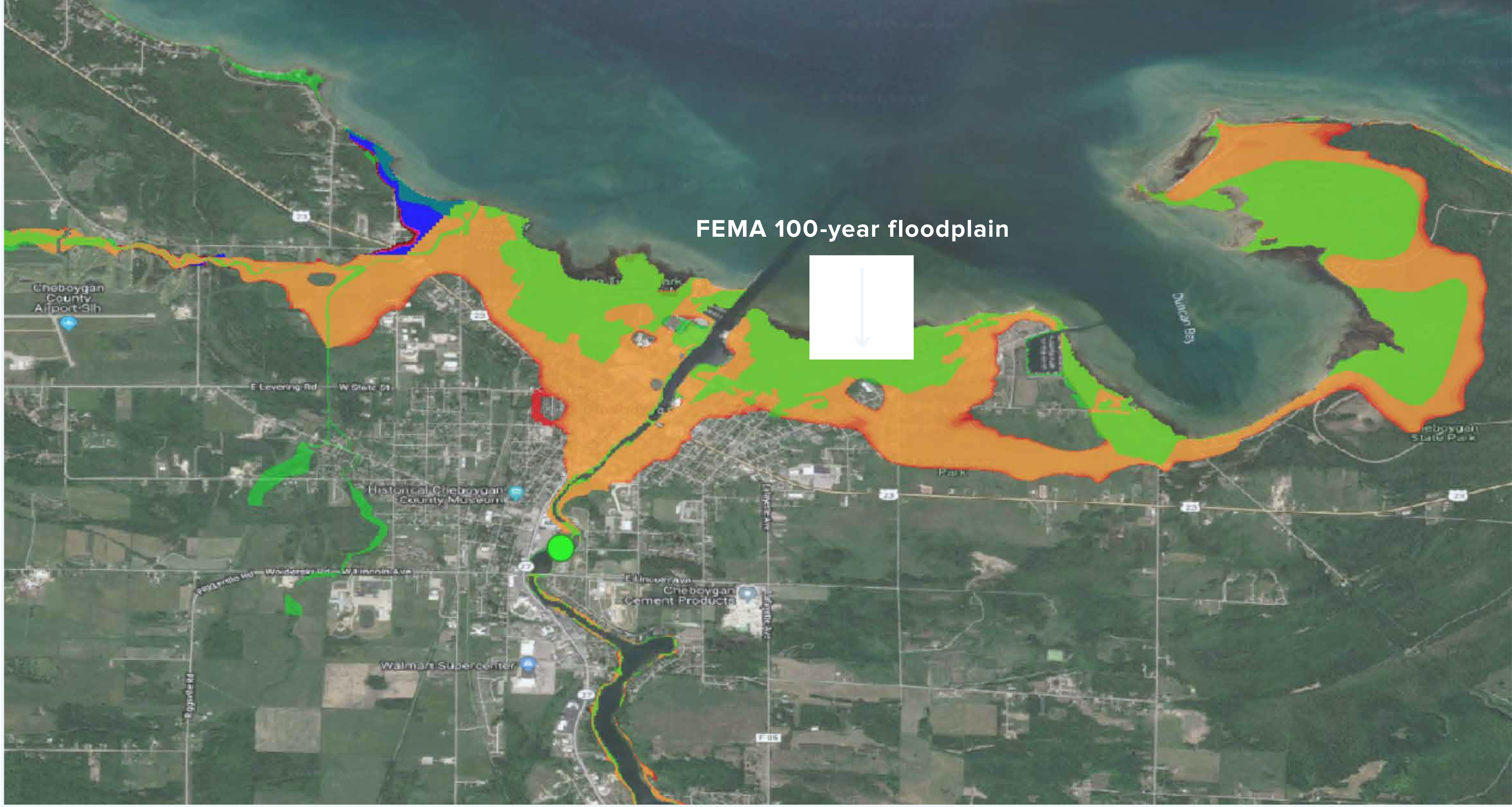
- Identification and incorporation of flood control infrastructure
- Differences against FEMA hazard layers, where available
- Analysis of areas of high population density
- Model internal consistency
- Validation against historic events using NFIP claims data and research
- Visual review



Fluvial overprediction Fluvial underprediction Both flooding

Inclusion of effects from adaptation features

Adaptation Database assembled of over 23,000 features (levees, seawalls, pumps). Postprocessing of hazard layers includes the effects of major infrastructure and adaptation features, with protection up to documented design standards (no dynamic operations).

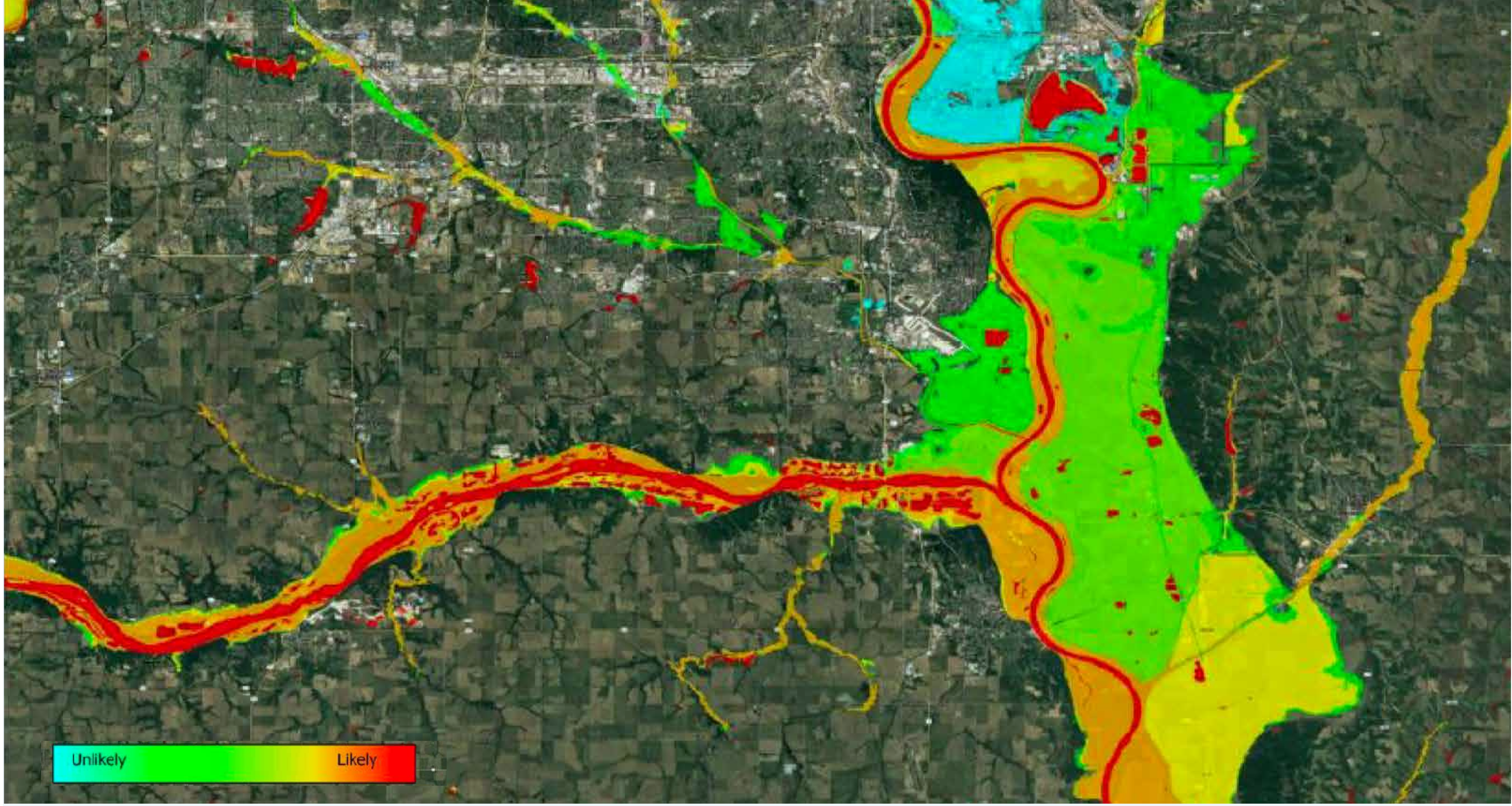


Inundation Depths for eight return periods in 5 year intervals 2020-2050

Cumulative likelihood of flooding over 15/30 years at three depths (>0”, 6”, and 12”)

Geospatial processing prepared hazard layers for display and statistical calculations

Model validation using historic flooding events



Validation data inputs

USGS High Water Mark data

FEMA open data NFIP flood claims

FEMA Individual Assistance claims

Coastal

ADCIRC-SWAN models using historic wind data and FEMA spatial mesh

Inland

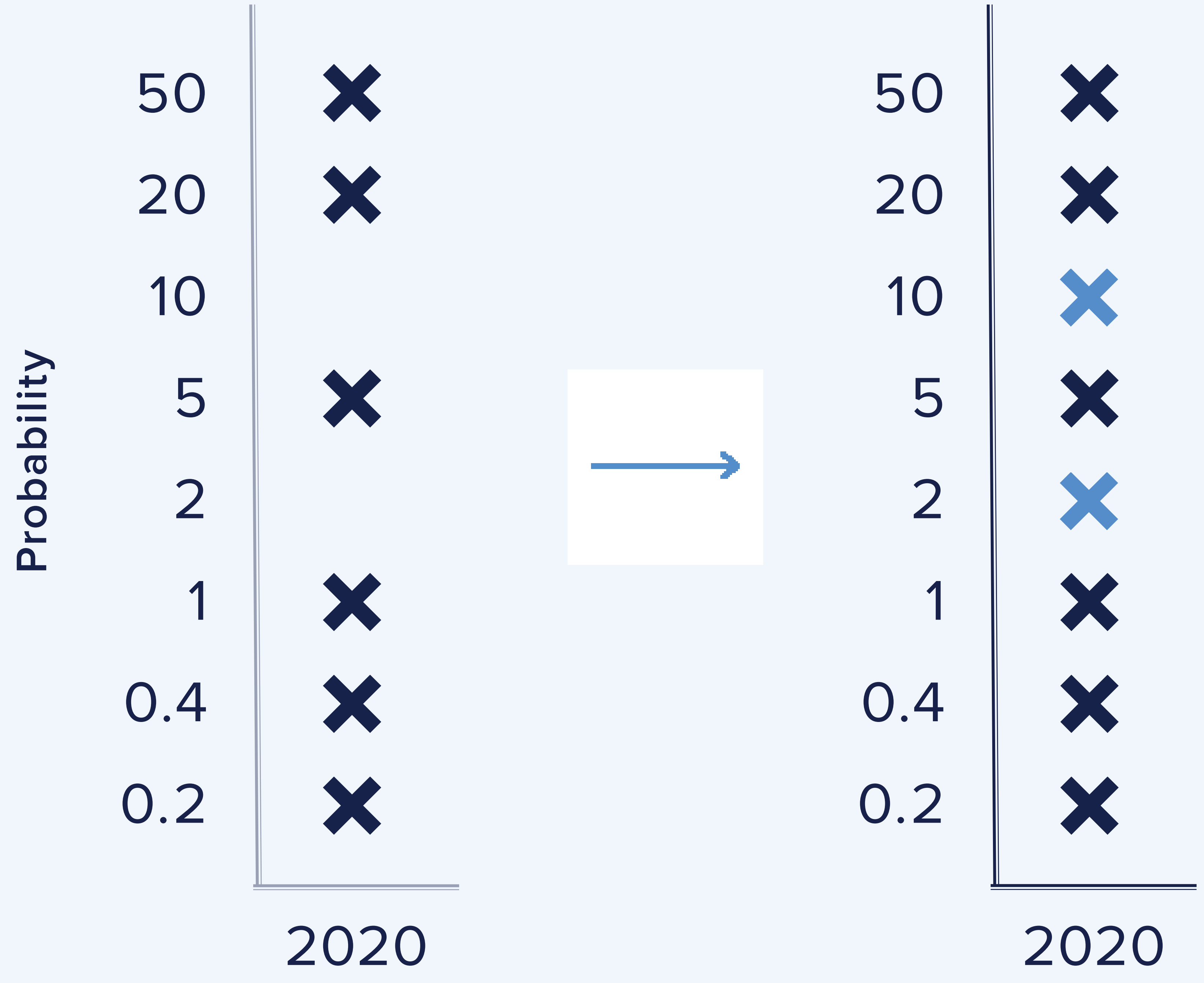
Multiple realizations of historic stream gauge data

Interpolation within return periods

To save computation expense and time, non-linear regressions were used to interpolate the depth of flooding in return periods within the years 2020 and 2050.

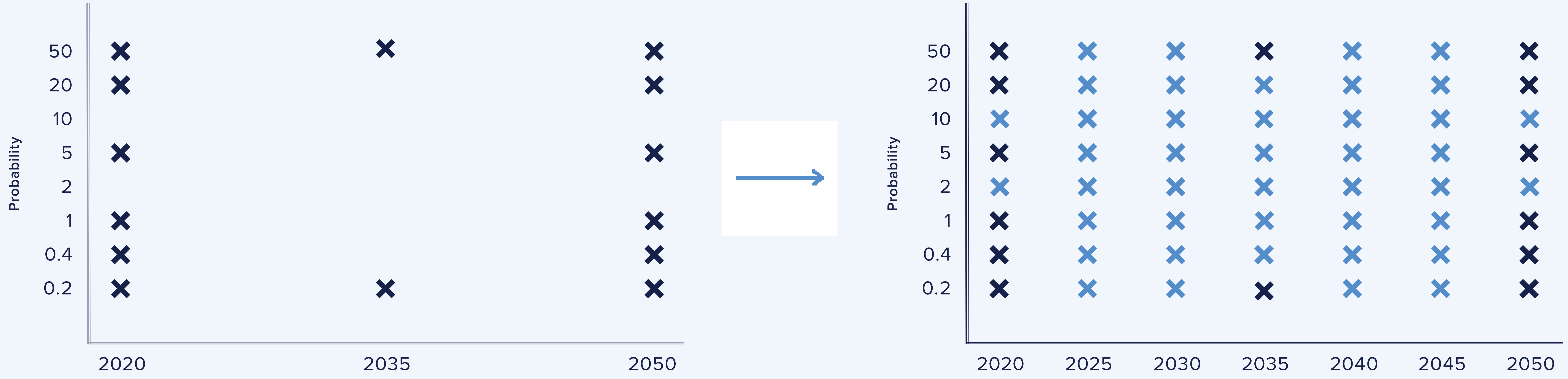
Inundation depths have a log-linear relationship with event return period

$$D_{i,j} = a_{i,j} + b_{i,j} \times [log_{10}(RP)]^{c_{i,j}}$$



Interpolation across years

Linearly interpolation was used to fill in the depths at any missing return period and year combination between 2020 and 2050, again saving computation expenses and time.



Inundation depths for eight return periods in 5 year intervals 2020-2050

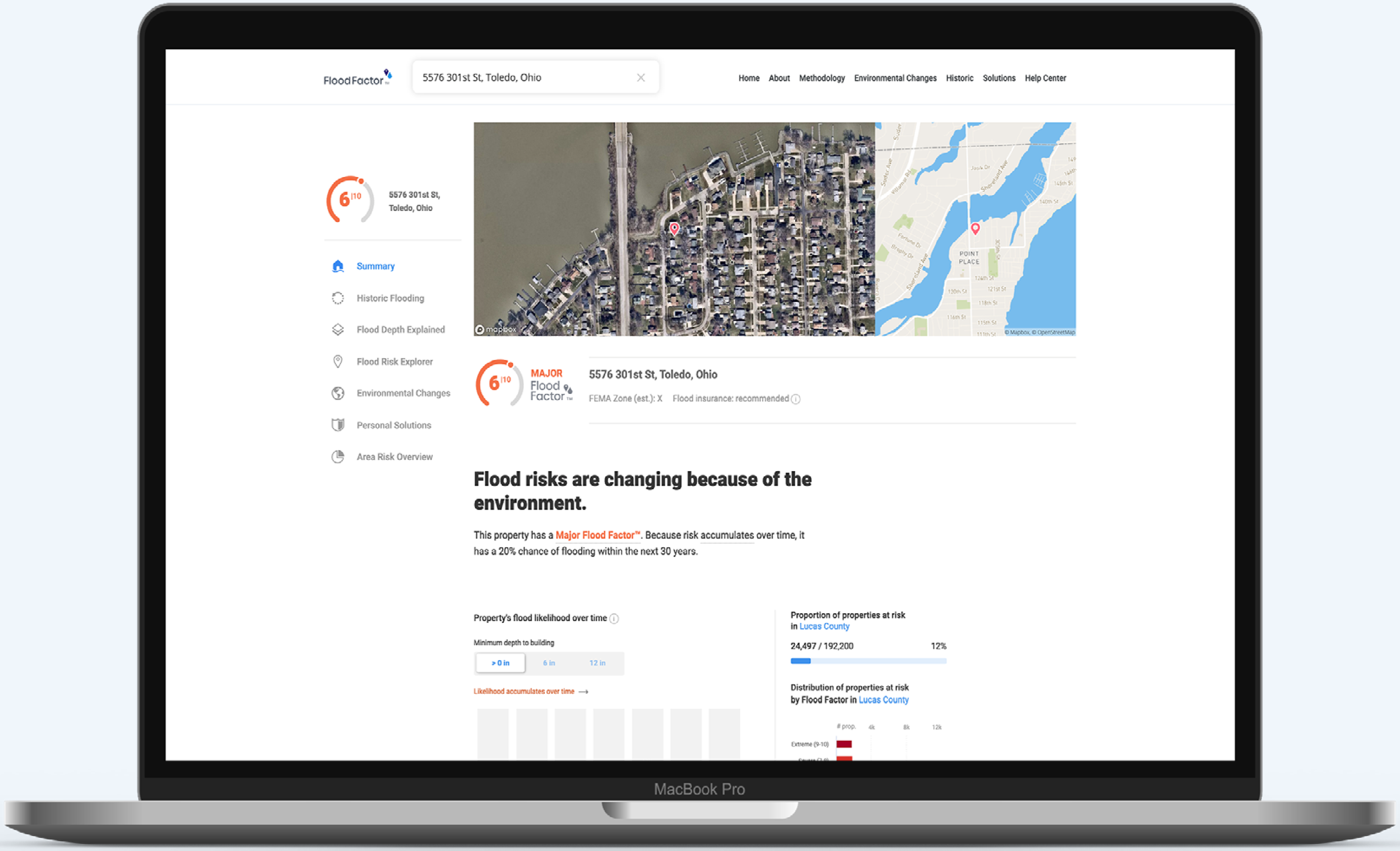
Flood
Factor

The Flood Factor provides a single number from 1 (minimal) to 10 (extreme) that represents both the potential severity and the 30-year cumulative probability of flooding.

Flood Factor Matrix

Flood Factor

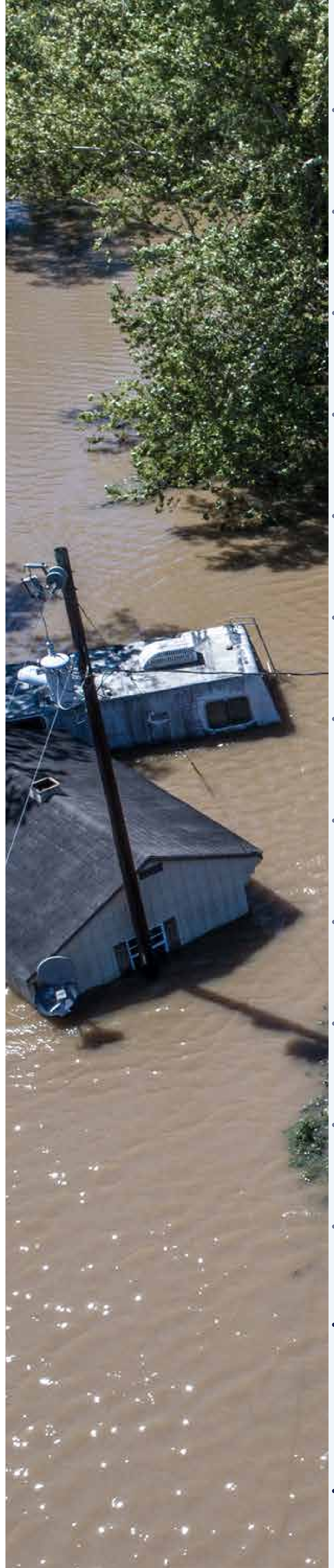
Our online visualization tool empowers anyone to understand risk at the property, ZIP, city, county, or state level for free.



For the 142 million property parcels, our API serves the data for bulk consumption

Bulk data access is sold to generate revenue and self fund the nonprofits continued work

API documentation:
API High Level Overview
API Technical Documentation



- Address
- FEMA Zone
- Property Parcel
- Property elevation
- Inundation statistics for 8 return periods in 5-year intervals from 2020 up to 2050
- Number of nearby properties flooded under each return period and interval
- Property flood risk relative stats by neighborhood, ZIP, city, county, congressional district and state
- Historic flooding with date, max depth to building, storm name
- Number of nearby NFIP claims and total value by census tract, ZIP, county and state
- Cumulative flood risk stats by 3 select depths for 2035 though 2050 in 5 year increments
- Adaptation protecting the property, defense standard, and geometry
- Risk direction and environmental cause(s)
- Hazard layers as Cloud Optimized GeoTIFFs for the return periods of 500, 100, 20, 5, and 2 years for the years of 2020, 2035, 2050
- Property's Flood Factor

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Thank You