URBAN FLOODING: LEGAL TOOLS TO ADDRESS A GROWING CRISIS

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While sea level rise has long received a great deal of attention, another impact of climate change is now getting greater notice—increases in extreme precipitation. As the atmosphere warms, it can hold more moisture; for every increase of one degree

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Celsius, seven percent more water vapor is carried in the air.[1] When that moisture is quickly released as intense rainstorms, stormwater systems can be overwhelmed, and cities can suffer devastating floods.[2]

The frequency and intensity of heavy precipitation events have increased since the 1950s over most of the world's land areas.[3] One 2023 study—generally consistent with several prior works— projected a 51.6% increase in extreme precipitation in the northeastern United States by the end of the 21st Century.[4] What have historically been called 100-year storms (indicating that a storm of that magnitude has a one-in-one-hundred chance of occurring in a given year) are now occurring as often as every five or ten years.[5] In one five-week period in 2022, places in several different parts of the U.S. (St. Louis, eastern Kentucky, eastern Illinois, Death Valley, California, and Dallas-Fort Worth) were all struck by what were called 1,000-year rain events—storms with a one-in-one-thousand chance of occurring in a given year.[6] On top of extreme rainfall, storm surge worsened by sea level rise can devastate coastal cities, but even inland locations that are near—or

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1. Dim Coumou & Stefan Rahmstorf, *A Decade of Weather Extremes, Nature Climate Change*, SPRINGER NATURE (Mar. 25, 2012), https://www.pik-potsdam.de/~stefan/Publications/Nature/Coumou_Rahmstorf_NCC2012.pdf; *see also Wettest Seasons in U.S. Regions,* CLIMATE CENT. (Oct. 18, 2023), https://www.climatecentral.org/climate-matters/wettest-seasons-in-us-regions-2023; Andreas F. Prein et al., *The Future Intensification of Hourly Precipitation Extremes,* 7 NATURE CLIMATE CHANGE 48 (2017); Jiabo Yin et al., *Large Increase in Global Storm Runoff Extremes Driven by Climate and Anthropogenic Changes*, 9 NATURE COMMC'NS 4389 (2018).

2. Mathew Barlow, *How Climate Change Intensifies the Water Cycle, Fueling Extreme Rainfall and Flooding – the Northeast Deluge Was Just the Latest*, THE CONVERSATION (July 11, 2023), https://theconversation.com/how-climate-change-intensifies-the-water-cycle-fueling-extreme-rainfall-and-flooding-the-northeast-deluge-was-just-the-latest-209476.

3. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2021: THE PHYSICAL SCIENCE BASIS. CONTRIBUTION OF WORKING GROUP I TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (2021), p. 8, ¶A.3.2, https://www.ipcc.ch/report/sixth-assessment-report-working-group-i/.

4. Christopher J. Picard et al., *Twenty-First Century Increases in Total and Extreme Precipitation Across the Northeastern USA,* 176 CLIMATE CHANGE 72 (2023); *see, e.g., U.S. Precipitation is Becoming More Intense,* U.S. GLOB. CHANGE RSCH. PROGRAM, https://www.globalchange.gov/indicators/heavy-precipitation#:~:text=Heavy%20precipitation%20is%20becoming%20more,of%20floods%20and%20flash%20floods.

5. FIRST ST. FOUND., THE 8TH NATIONAL RISK ASSESSMENT: THE PRECIPITATION PROBLEM 4 (June 26, 2023), https://report.firststreet.org/8th-National-Risk-Assessment-The-Precipitation-Problem.pdf.

6. Matthew Cappucci, *Five 1,000-Year Rain Events Have Struck the U.S. in Five Weeks. Why?*, WASH. POST (Aug. 23, 2022), https://www.washingtonpost.com/climate-environment/2022/08/23/flood-united-states-climate-explainer/.

not so near[7]—rivers can see similar destruction.[8] In addition to the disruption of property, many illnesses can result when stormwater causes the release of untreated sewage onto the surface of, and into, waterways.[9] Ecological impacts, such as increased fish mortality caused by the polluting runoff, also occur.[10]

There is ample literature on flooding caused by sea level rise.[11] The focus of this article, however, is on flooding in cities caused primarily by rain combined with land-use patterns and inadequate stormwater drainage. Though, of course, the two often combine.

This article proceeds as follows. Part I discusses the nature of the growing crisis in urban flooding, how precipitation is estimated, and how expected flooding is (or is not) disclosed in maps and otherwise. Part II shows the roles of the different levels of government—federal, state, and local—in addressing urban flooding. Part III goes through the various physical methods of coping with urban flooding (grey infrastructure, infiltration, storage, defense, accommodation, and retreat), and some of the associated legal implications. Part IV concerns how the physical methods discussed in Part III can be financed. Part V concludes with thoughts on setting priorities.

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7. Christopher Flavelle & Rick Rojas, *Vermont Floods Show Limits of America's Efforts to Adapt to Climate Change*, N.Y. TIMES (July 11, 2023), https://www.nytimes.com/2023/07/11/climate/climate-change-floods-preparedness.html.

8. This is distinct from the phenomenon of chronic, disruptive flooding, often called "nuisance flooding." A 2020 study found that the frequency of coastal flooding at high tide without storms was more than twice that in the year 2000, and could be double or triple that by 2030. WILLIAM SWEET ET AL., 2019 STATE OF U.S. HIGH TIDE FLOODING WITH A 2020 OUTLOOK (2020), https://tidesandcurrents.noaa.gov/publications/Techrpt_092_2019_State_of_US_High_Tide_Flooding_with_a_2020_Outlook_30June2020.pdf; *see also* Philip R. Thompson et al., *Rapid Increases in Extreme Months in Projections of United States High Tide Flooding,* 11 NATURE CLIMATE CHANGE 584 (2021) (noting that the situation could worsen in mid-2030s due to combination of sea level rise and where the earth will be in the 18.6-year nodal cycle, concerning the alignment of the earth, the moon and the sun).

9. William Addison-Atkinson et al., *Modelling Urban Sewer Flooding and Quantitative Microbial Risk Assessment: A Critical Review,* 15(4) J. FLOOD RISK MGMT. (2022), https://onlinelibrary.wiley.com/doi/full/10.1111/jfr3.12844.

10. B.F. French et al., *Urban Roadway Runoff is Lethal to Juvenile Coho, Steelhead, and Chinook Salmonids, But Not Congeneric Sockeye*, 9 ENV'T SCI. TECH. LETTERS 733 (2022); Perry Wheeler, *What's Killing the Salmon in Our Urban Streams? A Mystery Is Now Solved*, EARTHJUSTICE (Aug. 1, 2023), https://earthjustice.org/article/whats-killing-the-salmon-in-our-urban-streams-a-mystery-is-now-solved.

11. *See, e.g.*, JEFF GOODELL, THE WATER WILL COME: RISING SEAS, SINKING CITIES, AND THE REMAKING OF THE CIVILIZED WORLD (2017).

I. THE GROWING CRISIS

A. Events and Impacts

In the words of a 2018 academic report, *The Growing Threat of Urban Flooding: A National Challenge*:

> In much of the United States, urban flooding is occurring and is a growing source of significant economic loss, social disruption, and housing inequality. Extensive suburban development that creates higher flood flows into urban areas, aging and frequently undersized infrastructure in older sections of communities, an inability to maintain existing drainage systems, increases in intense rainfall events, and uncoordinated watershed management all contribute to these increases in urban flooding.[12]

Over the last century, annual precipitation has increased across most of the eastern and central United States and decreased in parts of the Southwest.[13] However, extreme rain events have increased for most sections of the country.[14] This is due mostly to warming caused by the accumulation of greenhouse gas emissions.[15] This affects inland areas as well as the coasts; flooding across the Midwest and South during 2019 affected nearly 14 million people,[16] and flooding in California's Central Valley devastated crops in 2023.[17] Every continent has recently experienced similar phenomena.[18]

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12. CTR. FOR DISASTER RESILIENCE, UNIV. OF MD., & CTR. FOR TEX. BEACHES & SHORES, TEX. A&M UNIV., THE GROWING THREAT OF URBAN FLOODING: A NATIONAL CHALLENGE 42 (2018), https://cdr.umd.edu/sites/cdr.umd.edu/files/resource_documents/COMPRESSEDurban-flooding-report-online-compressed-0319.pdf.

13. U.S. GLOB. CHANGE RSCH. PROGRAM, FIFTH NATIONAL CLIMATE ASSESSMENT 2-11 (2023), https://nca2023.globalchange.gov/.

14. *Id.* at 2-18.

15. U.S. GLOB. CHANGE RSCH. PROGRAM, FOURTH NATIONAL CLIMATE ASSESSMENT 74, 88-91 (2018), https://nca2018.globalchange.gov/downloads/NCA4_2018_FullReport.pdf; Megan C. Kirchmeier-Young & Xuebin Zhang, *Human Influence has Intensified Extreme Precipitation in North America*, 117 PNAS 13308 (2020), https://www.pnas.org/content/117/24/13308.

16. Sarah Almukhtar et al., *The Great Flood of 2019: A Complete Picture of a Slow-Motion Disaster*, N.Y. TIMES (Sept. 11, 2019), https://www.nytimes.com/interactive/2019/09/11/us/midwest-flooding.html.

17. Jonathan Vigliotti, *Severe storms have devastating impact on Central California crops*, CBS NEWS (May 11, 2023, 8:57 PM), https://www.cbsnews.com/news/california-crops-storm-impact/.

18. *See* Aijaz Hussain & Sibi Arasu, *What are Cloudbursts and is Climate Change Making Them More Frequent?*, ASSOCIATED PRESS (July 30, 2023, 11:35 AM), https://apnews.com/article/cloudbursts-india-climate-change-extreme-weather-kashmir-

The First Street Foundation found that 14.6 million properties across the United States (more than ten percent of all properties) now have at least a one-in-one-hundred risk of flooding each year.[19] Another study found that by the end of the 21st century, flooding that occurs at least twenty-six times a year could affect nearly 2.4 million residential properties (currently housing about 4.7 million people) and 107,000 commercial properties, collectively valued at over $1 trillion.[20] But this counts only the buildings that already exist; new construction continues across the country, even in areas already devastated by floods.[21] Some areas that are at high flood risk are seeing up to three times more construction than safer areas.[22]

Hurricanes have been getting more intense since the 1980s, and that trend will continue.[23] While climate change is making hurricanes stronger, it can also slow their movement and even make them almost stand still, continuously drawing water from the ocean like a massive pump and dumping torrents of rain on a single location for days on end.[24] That is what happened with Hurricane Harvey over the Houston area in 2017 and Hurricane Dorian over the Bahamas in 2019. As Kerry Emanuel has written, Hurricane Harvey produced the largest rainfall of any U.S. hurricane on record: "[B]y the standards of the average climate during 1981-2000, Harvey's rainfall in Houston was 'biblical' in the sense that it likely

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d67ef786514bbe04bad8b48c0f34ae73; Shuai Zhang, *China Sees Record Flooding in Beijing, with 20 Deaths and Mass Destruction Blamed on Typhoon Doksuri*, CBS NEWS (Aug. 2, 2023, 8:05 AM), https://www.cbsnews.com/news/china-flooding-beijing-2023-deaths-evacuations-typhoon-doksuri/; Angela Dewan, *Germany's Deadly Floods were up to 9 Times More Likely because of Climate Change, study estimates*, CNN (Aug. 24, 2021, 5:30 AM), https://www.cnn.com/2021/08/23/europe/germany-floods-belgium-climate-change-intl/index.html; Jordis S. Tradowsky et al., *Attribution of the Heavy Rainfall Events Leading to Severe Flooding in Western Europe during July 2021*, 176 CLIMATIC CHANGE 90 (June 29, 2023); *Australia flood crisis: 'Once in a century'*, BBC NEWS (Jan. 8, 2023), https://www.bbc.com/news/av/world-australia-64206297; Diane Jeantet et al., *Climate change brings extreme, early impact to South America*, ASSOCIATED PRESS (Mar. 1, 2022, 2:01 AM), https://apnews.com/article/climate-science-caribbean-forests-environment-and-nature-fdb886a31959ad3b30c57bc677a2a8be.

19. FIRST ST. FOUND., THE FIRST NATIONAL FLOOD RISK ASSESSMENT, (Jun. 28, 2020). A 2023 study by the First Street Foundation increased the 14.6 million figure to 17.7 million for properties currently at significant risk, but did not have a projection for 2050. *See supra* note 5.

20. KRISTINA DAHL ET AL., UNION OF CONCERNED SCIENTISTS, UNDERWATER: RISING SEAS, CHRONIC FLOODS, AND THE IMPLICATIONS FOR US COASTAL REAL ESTATE 4-5 (2018), https://www.ucsusa.org/sites/default/files/attach/2018/06/underwater-analysis-full-report.pdf.

21. *Id.*

22. *Id.* at 7; *Ocean at the Door: New Homes and the Rising Sea,* CLIMATE CENT. (July 30, 2019), https://www.climatecentral.org/report/ocean-at-the-door-new-homes-in-harms-way-zillow-analysis-21953.

23. FIFTH NATIONAL CLIMATE ASSESSMENT, *supra* note 13, at 2-16.

24. James P. Kossin, *A Global Slowdown of Tropical-cyclone Translation Speed,* 558 NATURE 104 (2018).

occurred around once since the Old Testament was written."[25] Similarly, a low pressure system carrying moisture from the Mediterranean stalled over central Europe in July 2021 and caused devastating flooding over parts of Germany and Belgium.[26] Another phenomenon that can cause deluges is "atmospheric rivers"—long streams of water vapor that form approximately one mile up in the atmosphere and can extend thousands of miles before touching down. These, too, are increasing.[27]

While hurricanes are often thought to do most of their damage through storm surge, some hurricanes, like Harvey did in Houston, cause most of their damage through rain, or "pluvial flooding". This type of rain-caused flooding "occurs when precipitation intensity exceeds the capacity of natural and engineered drainage systems."[28] This kind of flooding led to destruction in New York City in 2021. Hurricane Ida made landfall as a Category 4 hurricane in Lafourche Parish, east of New Orleans, on August 29, 2021, generating high winds and storm surge.[29] It traveled north across inland areas of Alabama, Tennessee, Kentucky, West Virginia, Maryland, Pennsylvania, and New Jersey, and (in what has been called its "second act") reached New York City on September 1st.[30] Just ten days earlier, New York had been hit by Hurricane Henri, which set a record for the most intense rain event in the city's history at 1.94 inches in one hour.[31] But Ida shattered Henri's record by dumping as much as 3.15 inches of rain on the city in one hour.[32] The ground was already saturated with water from Henri, causing the flooding from Ida to overwhelm the drainage system and leading to thirteen

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25. Kerry Emanuel, *Assessing the Present and Future Probability of Hurricane Harvey's Rainfall,* 114 PNAS 12681 (2017), https://doi.org/10.1073/pnas.1716222114.

26. Kai Kornhuber et al., *When Record-Breaking is the Norm: Mitigating the Impacts of Extreme Rainfall Events in a Changing Climate*, COLUM. CLIMATE SCH.: CLIMATE, EARTH & SOC'Y (Sept. 20, 2021), https://news.climate.columbia.edu/2021/09/20/when-record-breaking-is-the-norm-mitigating-the-impacts-of-extreme-rainfall-events-in-a-changing-climate/; Wolfgang Kron et al., *The July 2021 Flood Disaster in Germany*, *in* HELP GLOB. REP. ON WATER & DISASTERS 12 (2022), https://www.researchgate.net/publication/365375445_The_July_2021_flood_disaster_in_Germany; Mona Hemmati et al., *Enhanced Urban Adaptation Efforts Needed to Counter Rising Extreme Rainfall Risks*, 2 NPJ URB. SUSTAINABILITY 1, 1 (2022), https://www.nature.com/articles/s42949-022-00058-w.

27. Xingying Huang et al., *Future precipitation increase from very high resolution ensemble downscaling of extreme atmospheric river storms in California*, 6 SCI. ADVANCES 1, 1 (2020), https://doi.org/10.1126/sciadv.aba1323; Michael D. Dettinger & B. Lynn Ingram, *Megastorms Could Drown Massive Portions of California*, SCI. AM. (Jan. 1, 2013), https://www.scientificamerican.com/article/megastorms-could-down-massive-portions-of-california/.

28. Bernice R. Rosenzweig et al., *Pluvial flood risk and opportunities for resilience,* 5 WIREs WATER 1, 1 (2018), https://wires.onlinelibrary.wiley.com/doi/10.1002/wat2.1302.

29. Kornhuber et al., *supra* note 26.

30. *See id.*

31. Hemmati et al., *supra* note 26, at 1.

32. *Id.*

deaths.[33] The damage in New York was caused by rain alone; storm surge was not involved.[34]

Where inadequate stormwater controls are in place, extreme rains can lead to desperate measures. In August 2023, Beijing, an inland city, experienced its worst rains in at least 140 years.[35] Authorities diverted much of the water to the nearby (and much less politically powerful) city of Zhuozhou, where the water rose up to twenty-three feet, requiring the evacuation of 850,000 people and destroying many homes and businesses.[36] Had Beijing had adequate stormwater controls, it might have been able to handle its stormwater without diverting it and overwhelming a neighboring city.

There are four types of flooding: coastal, riverine (also called fluvial), pluvial, and compound (a combination of two or more of the first three).[37] All are on the rise.[38] Compared to the other types, pluvial flooding has received little attention from the government. It is rarely reflected in official flood maps.[39] Unlike coastal flooding, these pluvial floods tend to arrive with little warning, target relatively small areas, and involve a major pounding that might only last a few minutes but can cause sudden and unexpected

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33. Kornhuber et al., *supra* note 26.

34. N.Y.C. DEP'T OF ENV'T PROT., INCREASING STORMWATER RESILIENCE IN THE FACE OF CLIMATE CHANGE: OUR LONG TERM VISION 2, https://www.nyc.gov/assets/dep/downloads/pdf/climate-resiliency/increasing-stormwater-resilience-in-the-face-of-climate-change.pdf; *Hurricane Ida: A Storm of Two Acts*, JBA RISK MGMT., https://www.jbarisk.com/products-services/event-response/hurricane-ida-a-storm-of-two-acts/ (last visited Mar. 15, 2024).

35. Andy Wong & Huizhong Wu, *Beijing records heaviest rainfall in at least 140 years, causing severe flooding and 21 deaths*, ASSOCIATED PRESS (Aug. 2, 2023, 11:27 PM), https://apnews.com/article/china-beijing-rainfall-floods-1a8f968799bd539d11f3421010b8f2a9.

36. Keith Bradsher, *Anger Builds in China as Areas Are Deliberately Flooded to Save Beijing*, N.Y. TIMES (Mar. 5, 2023); Yuanyue Dang, *"The Capital's Moat": Thousands Forced from Homes in China's Hebei Province to ease Flooding in Beijing*, S. CHINA MORNING POST (Aug. 3, 2023, 6:46 PM), https://www.scmp.com/news/china/politics/article/3229896/capitals-moat-thousands-forced-homes-hebei-ease-flooding-beijing; Lily Kuo et al., *Rural Areas Sacrificed for Xi Jinping's New City, Satellite Imagery Shows*, WASH. POST (Aug. 31, 2023), https://www.washingtonpost.com/world/2023/08/31/china-floods-beijing-rain/.

37. NAT'L CLIMATE TASK FORCE, FEDERAL FLOOD RISK MANAGEMENT STANDARD CLIMATE-INFORMED SCIENCE APPROACH (CISA) STATE OF THE SCIENCE REPORT, at x (2023), https://www.whitehouse.gov/wp-content/uploads/2023/03/Federal-Flood-Risk-Management-Standard-Climate-Informed-Science-Approach-CISA-State-of-the-Science-Report.pdf (hereinafter STATE OF THE SCIENCE REPORT)

38. Zbigniew W. Kundzewicz & Iwona Pinskwar, *Are Pluvial and Fluvial Flooding on the Rise?*, 14 WATER 1, 2 (2022).

39. STATE OF THE SCIENCE REPORT, *supra* note 37, at 58-59; GOV'T ACCT. OFF., FEMA FLOOD MAPS: BETTER PLANNING AND ANALYSIS NEEDED TO ADDRESS CURRENT AND FUTURE FLOOD HAZARDS 15-16 (2021) https://www.gao.gov/assets/gao-22-104079.pdf; Samuel Oakford et al., *America underwater: Extreme floods expose the flaws in FEMA's risk maps*, WASH. POST (Dec. 6, 2022, 11:50 AM) https://www.washingtonpost.com/climate-environment/interactive/2022/fema-flood-risk-maps-failures/.

flooding to streets and buildings.[40] The most intense rainstorms, called *cloudbursts,* pose special challenges to cities whose stormwater systems cannot handle all that water, as discussed below.[41] The damages especially hit disadvantaged communities located in low-lying areas, as those tend to have older infrastructure and fewer resources for recovery.[42]

B. Precipitation Estimates

The pipes, drainage ditches, pumps, and other elements of a stormwater system all have a finite capacity. The engineers designing the systems decide what size pipes to use and how large to make all of the other elements. This requires the engineers to estimate how much rain will fall. To help them do that, in 1961, the National Oceanic and Atmospheric Administration ("NOAA") issued Technical Paper 40 (TP-40), Rainfall Frequency Atlas of the United States, which estimated the intensity, duration and frequency of rain for each part of the country.[43] This was based on the records of weather stations through 1958.[44] In 2004, NOAA began updating TP-40 and other interim reports with a new set of publications

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40. N.Y.C. MAYOR'S OFF. OF RESILIENCY, NEW YORK CITY STORMWATER RESILIENCY PLAN 11 (2021), https://www.nyc.gov/assets/orr/pdf/publications/stormwater-resiliency-plan.pdf.

41. See *infra* note 318 and accompanying text (discussing the implementation of the City of Copenhagen's Cloudburst Management Plan).

42. Thomas Frank, *Flooding Disproportionately Harms Black Neighborhoods*, E&E NEWS (June 2, 2020), https://www.eenews.net/articles/flooding-disproportionately-harms-black-neighborhoods/; *see* Laura Gersony, *In Chicago, Flooding Overwhelmingly Strikes Communities of Color*, CIRCLE OF BLUE (June 29, 2021), https://www.circleofblue.org/2021/world/in-chicago-flooding-overwhelmingly-strikes-communities-of-color/; Aydali Campa, *Record-Breaking Rains in Chicago Underscore the Urgency of Flood Resiliency Projects, City Officials Say*, INSIDE CLIMATE NEWS (July 28, 2023), https://insideclimatenews.org/news/28072023/record-rain-chicago-flood-resiliency/; Raymond Zhong, *Many Thousands Facing Risk If Floods in L.A. Are Extreme*, N.Y. TIMES, Nov. 1, 2022, at A11; Juliana Maantay & Andrew Maroko, *Mapping Urban Risk: Flood Hazards, Race, & Environmental Justice in New York*, 29 APPLIED GEOGRAPHY 111 (2009); KATY LACKEY, U.S. WATER ALL., WATER RISING: EQUITABLE APPROACHES TO URBAN FLOODING (2020), https://www.smartcitiescouncil.com/sites/default/files/main/public_resources/water_rising_paper_0.pdf; Kari Lydersen, *Inundation and Injustice: Flooding Presents a Formidable Threat to the Great Lakes Region*, BORDERLESS (Aug. 3, 2023), https://borderlessmag.org/2023/08/03/inundation-and-injustice-flooding-presents-a-formidable-threat-to-the-great-lakes-region/.

43. *See* U.S. DEP'T OF COM., TECHNICAL PAPER 40, RAINFALL FREQUENCY ATLAS OF THE UNITED STATES (1961).

44. ENGINEERING FIELD HANDBOOK CHAPTER 2: ESTIMATING RUNOFF AND PEAK DISCHARGES PENNSYLVANIA NOTICE 34 SUPPLEMENT, NAT. RES. CONSERVATION SERV. 1 (2011), https://www.nrcs.usda.gov/sites/default/files/2022-12/EFH%20page%202-15.A-N%20%28Shown%20as%202-14.A-N%29.pdf.

called Atlas 14.[45] The new estimates were issued one or a few states at a time over a period of twenty years.[46]

For sixty years, engineers have been using TP-40 and, where available, Atlas 14, to help them design stormwater systems. However, like the Federal Environmental Management Agency ("FEMA") flood maps discussed below, these rain estimates are entirely backward-looking. They are based on the historical record of rainfall for particular places, and some of that record (even in Atlas 14) is quite old for many places. But as a result of climate change, the amount of rainfall in most parts of the country has been increasing.[47] Atlas 14 is already out of date and will become more so with each passing year. This is now well understood in the engineering community, and some cities and states now undertake their own more refined analysis. However, until at least 2021, there was considerably more wringing-of-hands than action to devise forward-looking projections at a level of detail that can be used in designing stormwater systems.[48] Most existing drainage systems were designed before Atlas 14, and many even before TP-40.[49] Sewer infrastructure has a design life of approximately fifty years and a useful life of approximately 100 years,[50] and therefore many sewer components that were designated even before TP-40 will be in use for decades more to come. Moreover, these studies focused on *average* precipitation over a 24-hour period, and generally did not report on shorter-duration cloudbursts that could cause rapid flooding.[51]

Some states have adopted their own rainfall standards. For example, the Illinois State Water Survey published one set of standards in 1989 and updated it in 2020.[52] The new survey found

45. Jungho Kim et al., *Assessment of the Standard Precipitation Frequency Estimates in the United States*, 44 J. HYDROLOGY: REG'L STUD. 101276, *4 (2022).

46. *Id.*

47. Daniel B. Wright et al., *U.S. Hydrologic Design Standards Insufficient Due to Large Increases in Frequency of Rainfall Extremes*, 46 GEOPHYSICAL RSCH. LETTERS 8144 (2019).

48. *Id.*; Daniel B. Wright et al., *Resilience to Extreme Rainfall Starts With Science*, AM. METEOROLOGICAL SOC'Y (2021); Erfan Ghasemi Tousi et al., *Climate Changes Impact on Stormwater Infrastructure Design in Tucson Arizona*, 72 SUSTAINABLE CITIES & SOC'Y 103014 (2021); *e.g.*, Lauren M. Cook et al., *The Effect of Modeling Choices on Updating Intensity-Duration-Frequency Curves and Stormwater Infrastructure Designs for Climate Change*, 159 CLIMATIC CHANGE 289 (2020).

49. Thomas Frank, *Climate Change Overtakes Archaic NOAA Rain Records*, E&E NEWS, (Jan. 7, 2022).

50. N.Y.C. MAYOR'S OFFICE OF RESILIENCY, *supra* note 40, at 14.

51. FIRST ST. FOUND., *supra* note 5.

52. *See* HUFF, F. A. & J. R. ANGEL, RAINFALL DISTRIBUTIONS AND HYDROCLIMATIC CHARACTERISTICS OF HEAVY RAINSTORMS IN ILLINOIS (BULLETIN 70), ILLINOIS STATE WATER SURVEY (1989), https://www.isws.illinois.edu/statecli/rf/download.htm; JAMES R. ANGEL & MOMCILO MARKUS, PRAIRIE RSCH. INST: ILL. STATE WATER SURV., ISWS BULLETIN 75:

a substantial increase in storm frequency and intensity in the intervening years, and the new figures are now being used in the design of drainage systems and other facilities in the state.[53]

The Infrastructure Investment and Jobs Act (IIJA), also known as the Bipartisan Infrastructure Law, signed by President Biden in November 2021, provided money to NOAA to prepare a new version of the rainfall frequency reports, to be called Atlas 15, with volumes to be published in 2026 and 2027.[54] In December 2022, President Biden signed into law, as part of a short-term spending bill, the Providing Research and Estimates of Changes in Precipitation (PRECIP) Act, which requires NOAA to update its precipitation estimates and the methods it uses to prepare them. The law also requires NOAA to "update probable maximum precipitation estimates for the United States, such that each update considers non-stationarity . . . ."[55] That same month, Biden signed the Flood Level Observation, Operations and Decision Support (FLOODS) Act, calling on NOAA to establish a national integrated flood information system and to research "the role of extreme weather events and climate variability in floods . . . ."[56]

Many assumptions go into the calculations about flooding from storms and sometimes disputes arise. In 2017, Wisconsin officials lured the Taiwanese electronics company Foxconn (which makes iPhones and many other devices) to build a massive manufacturing facility, mostly on farmland.[57] But officials across the border in Lake County, Illinois, were concerned that covering the land with buildings would increase flooding from Wisconsin rivers that had recently damaged more than 3,000 structures in Illinois.[58] Wisconsin designed its drainage system to handle what it calculated to be the expected rains, but Illinois used different rain data and concluded the drainage system was much too small.[59] With a dispute brewing between these two states, legislation was introduced in

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PRECIPITATION FREQUENCY STUDY FOR ILLINOIS ii, 2 (2020), https://www.ideals.illinois.edu/items/114209

53. *See* Angel & Markus, supra note 52; Tiffany Jolley, *The Impact of Bulletin 75*, PRAIRIE RSCH. INST: ILL. STATE WATER SURV. (July 8, 2020, 11:00AM), https://blogs.illinois.edu/view/7447/2024148035.

54. NAT'L OCEANIC & ATMOSPHERIC ADMIN., OFF. OF WATER PREDICTION, *NOAA Atlas 15: Update to the National Precipitation Frequency Standard*, https://www.weather.gov/media/owp/hdsc_documents/NOAA_Atlas_15_Flyer.pdf (last visited Feb. 17, 2024).

55. Further Continuing Appropriations and Extensions Act (2023), Pub. L. 117-229, § 602(a)(1).

56. Flood Level Observation, Operations, and Decision Support Act, Pub. L. 117-316, § 3(b)(6)(B).

57. Jim Morrison, *As rainstorms grow more severe and frequent, communities fail to prepare for risks*, WASH. POST (April 9, 2021), https://www.washingtonpost.com/climate-environment/2021/04/09/climate-change-rainfall/.

58. *Id.*

59. *Id.*

Congress to fund NOAA to prepare a more comprehensive national rainfall database, and to update it frequently.[60] This particular dispute faded when Foxconn's plan fizzled for other reasons,[61] but the need for this database remains. With the passage of the IIJA in 2021 and the PRECIP Act in 2022, perhaps it will come to be.

C. Maps and Disclosures

The most important way that many people, including some real estate professionals, assess flood risk is by seeing whether a property is on FEMA's 100-year flood maps. These maps are a misleading and partial guide for several reasons. While most coastal areas are mapped, roughly half of all the flood disaster declarations since 1990 were in landlocked states.[62] Flood risk maps only exist for about one-third of the nation and many of the maps that do exist are several decades old, or were updated based on obsolete methods.[63] One study found that almost 41 million people in the United States live in places with a one-in-one-hundred annual chance of flooding, but only 13 million live in areas on the FEMA 100-year maps.[64]

Without accurate flood maps, many people are unwittingly exposed to floods. For example, Hurricane Harvey damaged more than 204,000 homes and apartment buildings in Harris County, Texas (which includes Houston); almost three-quarters of them were outside the FEMA 100-year flood maps and about 80% of them had no flood insurance.[65] In 2018, Hurricane Michael demolished

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60. *Id.*

61. *See* Scott Cohn, *After Wisconsin's Foxconn debacle, states and companies rethink giant subsidies*, CNBC (June 29, 2021), https://www.cnbc.com/2021/06/29/after-wisconsins-foxconn-debacle-states-rethink-giant-subsidies.html.

62. *Preparing for the Storm: Reauthorization of the National Flood Insurance Program: Hearing Before the H. Comm. on Fin. Servs.*, 116th Cong. 68-73 (2019) [hereinafter *Preparing for the Storm: Hearing*] (testimony of Mabel Guzman, Broker, Nat'l Assoc. of Realtors).

63. Michael Keller et al., *Outdated and Unreliable: FEMA's Faculty Flood Maps Put Homeowners at Risk*, BLOOMBERG (Oct. 6, 2017), https://www.bloomberg.com/graphics/2017-fema-faulty-flood-maps/; *Preparing for the Storm: Hearing, supra* note 62, at 81-97 (testimony of Maria Cox Lamm, Chair, Ass'n of State Floodplain Managers); *see also FEMA Needs to Improve Management of Its Flood Mapping Programs,* DEP'T OF HOMELAND SEC., OFF. OF INSPECTOR GEN. (Sept. 27, 2017), https://www.oig.dhs.gov/sites/default/files/assets/2017/OIG-17-110-Sep17.pdf.

64. Oliver E.J. Wing et al., *Estimates of Present and Future Flood Risk in the Conterminous United States*, 13 ENV'T RSCH. LETTERS 1, 1, 3 (2018). Using different methodologies, another study concluded that a total of 14.6 million properties have a 1% annual risk of flooding, but 5.9 million of these are not on the FEMA 100-year flood maps. FIRST ST. FOUND., THE FIRST NATIONAL FLOOD RISK ASSESSMENT *supra* note 19.

65. David Hunn et al., *In Harvey's deluge, most damaged homes were outside the flood plain, new data show*, HOUS. CHRON. (March 30, 2018), https://www.houstonchronicle.com/news/article/In-Harvey-s-deluge-most-damaged-homes-were-12794820.php; Bernard

70% of the homes on the coast in Mexico Beach, Florida, in an area where FEMA had characterized the flood risks as minimal.[66] More than twenty square miles of the area of New York City that was inundated by Hurricane Sandy were outside the mapped flood zone.[67] A study of flood insurance coverage in Illinois found that over 90% of insurance claims for urban flooding damage from 2007 to 2014 were outside the mapped floodplain.[68]

Some cities and states are acting on their own to protect residents from flooding. New York City is cooperating with FEMA to prepare its own flood maps—but only after having successfully beaten back an earlier effort by FEMA to expand the maps' coverage.[69] The states of New York and Connecticut have adopted laws requiring the state environmental agencies to adopt their own official sea level rise projections, but these are not specific geographically and do not translate readily into flood maps.[70] North Carolina has developed maps that divide the state into a grid of 140 million parcels of roughly a quarter-acre each. The maps display the flood risk for each parcel, giving real estate buyers, sellers, and financers a fine-grained sense of the vulnerability of individual properties.[71]

Many people buy houses without knowing they are in a flood zone or have been previously damaged by floods. Thirty-one states

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Condon & Ken Sweet, *About 80% of Hurricane Harvey Victims do Not Have Flood Insurance, Face Big Bills*, USA TODAY (Aug. 29, 2017), https://www.usatoday.com/story/money/2017/08/29/hurricane-harvey-houston-flood-insurance-damages-claims/611910001/.

66. James Bruggers, *FEMA Flood Maps Ignore Climate Change, and Homeowners Are Paying the Price*, INSIDE CLIMATE NEWS (Nov. 1, 2018), https://insideclimatenews.org/news/01112018/fema-flood-map-climate-change-hurricane-mexico-beach-florida-sea-level-rise/.

67. KIM KNOWLTON & MIRIAM ROTKIN-ELLMAN, NAT'L RES. DEFENSE COUNCIL, PREPARING FOR CLIMATE CHANGE: LESSONS FOR COASTAL CITIES FROM HURRICANE SANDY 6 (2014).

68. BRAD A. WINTERS, ILL. DEP'T OF NAT. RES., REPORT FOR THE URBAN FLOODING AWARENESS ACT 8 (2015), https://dnr.illinois.gov/content/dam/soi/en/web/dnr/water resources/documents/final-ufaa-report.pdf.

69. Liz Koslov, *How Maps Make Time: Temporal Conflicts of Life in the Flood Zone*, 23 CITY 658 (2019); 100 RESILIENT CITIES, STRENGTHENING THE NATIONAL FLOOD INSURANCE PROGRAM 9 (2017).

70. Michael B. Gerrard & Edward McTiernan, *New York's New Sea Level Rise Projections Will Affect Land Use, Infrastructure*, N.Y. L.J. (Mar. 9, 2017), http://columbia climatelaw.com/files/2017/03/070031715-Arnold.pdf; 2018 Conn. Pub. Acts No. 18-82; E.A. Cruden, *Acknowledging Sea Level Rise, Connecticut Legislature Passes Sweeping Climate Change Bill*, THINK PROGRESS (May 9, 2018, 4:04 PM); *see also* James Bruggers, *Not Trusting FEMA's Flood Maps, More Storm-Ravaged Cities Set Tougher Rules*, INSIDECLIMATE NEWS (Mar. 19, 2019), https://insideclimatenews.org/news/19032019/fema-flood-maps-risk-zones-cities-climate-change-mexico-beach-houston-outer-banks/.

71. Thomas Frank, *Precise Flood Maps Lure Insurers into Risky Market*, CLIMATEWIRE (Dec. 19, 2019), https://www.eenews.net/climatewire/stories/1061847687?t=https%3A%2F%2Fwww.eenews.net%2Fstories%2F1061847687; NORTH CAROLINA FLOOD RISK INFORMATION SYSTEM, https://fris.nc.gov/fris/Home.aspx?ST=NC (last visited Mar. 16, 2024).

have some sort of law requiring disclosure of flood risks to buyers,[72] but the quality of flood-risk information that must be disclosed varies widely. Often, the disclosures can be waived if the seller pays a modest fee.[73] Without legal compulsion or liability risk, real estate brokers have little incentive to make sure buyers are fully aware of flood risks, because doing so could kill a sale and most brokers are paid only at the time of sale. Seven states require disclosure of flood risk not only to prospective buyers but also prospective tenants.[74] At least one county (Miami-Dade, Florida) requires notice to buyers if the property is in the county's special flood hazard area.[75] In 2021, Hawaii went even further by enacting a law requiring sellers of residential properties to inform prospective buyers if the land is in an area that has been officially identified as vulnerable to sea level rise.[76]

In 2015, President Obama issued an executive order, inspired by the experience with 2012's Hurricane Sandy, which provided:

> agencies which guarantee, approve, regulate, or insure any financial transaction which is related to an area located in an area subject to the base flood shall, prior to completing action on such transaction, inform any private parties

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72. *How States Stack Up on Flood Disclosure*, NAT. RES. DEF. COUNCIL (Aug. 31, 2023), https://www.nrdc.org/resources/how-states-stack-flood-disclosure; *see* Michael B. Gerrard & Edward McTiernan, *New York, New Jersey Adopt Laws Requiring Flood Disclosure to Homebuyers, Tenants*, N.Y. L.J. (Nov. 9, 2023), https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=5200&context=faculty_scholarship.

73. Kevin Wozniak et al., *Florida's Coastal Hazards Disclosure Law: Property Owner Perceptions of the Physical and Regulatory Environment*, FLA. SEA GRANT (2012), https://repository.library.noaa.gov/view/noaa/35330. In 2023 the New York and New Jersey legislatures increased the required flood disclosures. Gerrard & McTiernan, supra note 72.

74. Dan Mathis, *Risky Renting: Renters Should Have the Right to Know their Flood Risk*, NEXT100 (May 26, 2022), https://thenext100.org/risky-renting-renters-should-have-the-right-to-know-their-flood-risk/; Thomas Frank, *Texas Enacts Nation's Strongest Flood Disclosure Law*, CLIMATEWIRE (Jan. 6, 2022), https://www.eenews.net/articles/texas-enacts-nations-strongest-flood-disclosure-law/; Niki L. Pace, *Unaware, Unprepared, and Unexpectedly Flooded: Improving Louisiana's Capacity to Respond to Flood Hazards*, 6 LA. STATE U. J. ENERGY L. & RES. 121 (2017); *Governor Murphy Signs Bill Requiring Provision of Critical Flood Risk Information for Homeowners and Renters*, STATE OF N.J., OFF. OF GOVERNOR PHIL MURPHY, (July 3, 2023), https://www.nj.gov/governor/news/news/562023/20230703d.shtml; Samantha Maldonado, *Landlords Will Soon Have to Inform Tenants About Flood Risks*, THE CITY (May 30, 2023, 5:00 AM), https://www.thecity.nyc/2023/05/30/renting-nyc-flood-risks-landlords-tenants/.

75. Thomas Ruppert, *Reasonable Investment-Backed Expectations: Should Notice Of Rising Seas Lead To Falling Expectations For Coastal Property Purchasers?*, 26 J. LAND USE & ENV'T L. 239, 265 (2011).

76. S. 474, 31st Leg. (Haw. 2021); *see also* Sophie Cocke, *Some Hawaii Homeowners Damage Beaches to Protect Their Homes. A New Law Could Help Change That*, HONOLULU STAR-ADVERTISER (July 2, 2021), https://www.propublica.org/article/some-hawaii-home owners-damage-beaches-to-protect-their-homes-a-new-law-could-help-change-that.

> participating in the transaction of the hazards of locating structures in the area subject to the base flood.[77]

In 2017, two weeks before Hurricane Harvey, President Trump rescinded this order.[78] President Biden reinstated it in 2021.[79]

A federal law requiring disclosures to buyers of flood risks and prior flood damage would make a great deal of sense.[80] Homes that already have a history of flooding have been found to incur, on average, tens of thousands of dollars in damages over a 30-year period, depending on location.[81] In 2023, New York adopted a law requiring disclosure of prior flooding history in home sales .[82] One bill to reauthorize the National Flood Insurance Program would make such insurance available only in places where the state or city has adopted a requirement that flood hazards be disclosed to prospective property buyers.[83]

For starters, Congress should modify the provision of the Privacy Act of 1974 that bars FEMA from revealing a property's flood insurance claim history to anyone but the homeowner, and that prevents local governments from disclosing the addresses of properties that have suffered repetitive flood losses.[84] Additionally, federal agencies should revisit practices they adopted after 9/11 restricting the public availability of maps showing which areas

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77. Exec. Order No. 13,690, 80 Fed. Reg. 6425 (Jan. 30, 2015); *see also* Kathryn Firsching, *The New Federal Flood Risk Management Standard: Will It Lead to Improved Resiliency in America's Floodplains?*, 31 NAT. RES. & ENV'T 26 (2017).

78. Kriston Capps, *Trump Rolled Back the Government's Best Flood Protection Standard*, BLOOMBERG CITYLAB (Aug. 28, 2017), https://www.bloomberg.com/news/articles/2017-08-28/trump-removed-flood-protection-standard-weeks-before-harvey.

79. Exec. Order No. 14030, 80 Fed. Reg. 6425 (May 20, 2021).

80. Laura Lightbody, *Home Sellers Should Disclose Flood History and Risk to Buyers*, PEW TRUSTS (Jan. 17, 2017), https://www.pewtrusts.org/en/research-and-analysis/articles/2017/01/17/home-sellers-should-disclose-flood-history-and-risk-to-buyers.

81. David D. Evans & Larry Baeder, *Estimating Undisclosed Flood Risk in Real Estate Transactions: Financial Implications for Single-Family Home Buyers in New Jersey, New York, and North Carolina,* MILLIMAN (Aug. 1, 2022), https://www.milliman.com/-/media/milliman/pdfs/2022-articles/7-29-22_nrdc-estimating-undisclosed-flood-risk.ashx.

82. 2023 N.Y. LAWS 484, amending N.Y. REAL PROP. LAW §462(2) (McKinney 2023).

83. A Bill to Reauthorize the National Flood Insurance Program, S. 2143, 118th Cong. §416 (2023), https://www.menendez.senate.gov/imo/media/doc/nfip_reauthorization_act_of_2023.pdf. There has long been a federal law requiring disclosure of lead paint,[83] and some states require disclosure to sellers of other "specified conditions such as asbestos, lead paint, termites, septic systems", and toxic contamination. Lead-Based Paint Poisoning Prevention in Certain Residential Structures, 24 C.F.R. pt. 35; 40 C.F.R. pt. 745; Dennis Binder, *The Duty to Disclose Geologic Hazards in Real Estate Transactions*, 1 CHAPMAN L. REV.13 (1998).

84. 5 U.S.C. § 552a(b); Abigail Darlington, *Little-Known Federal Law Keeps Buyers from Finding Out if a Home Routinely Floods*, POST & COURIER (Aug. 9, 2018), https://www.postandcourier.com/news/little-known-federal-law-keeps-buyers-from-finding-out-if-a-home-routinely-floods/article_9e348564-9b13-11e8-934c-6ffa499e136b.html; *One Question Every Homebuyer Should Ask But Never Does*, BETTER FLOOD INSURANCE (June 18, 2021), https://betterflood.com/blog/one-question-every-homebuyer-should-ask-but-never-does/.

could be inundated if a dam or levee broke.[85] Agencies have successfully argued in court that this kind of information is exempt from disclosure under the Freedom of Information Act because it would help terrorists find the best targets,[86] but this policy also means people are unaware of the flood risk they face.

Governments are not the only sources of this information. Several private companies in the U.S. are now combining their own fine-grained flood mapping with geographic information system coordinates and real estate transaction data to offer information to the public about the flood and wildfire risk of specific addresses.[87] Some services require payment, while some are free. New York City has developed its own website that provides address-specific flood information.[88]

It is not yet standard practice in real estate transactions to look beyond FEMA flood maps in examining flood risk. In contrast, sophisticated buyers of commercial or industrial property will typically use one of the commercial services that identifies the known locations of soil or groundwater contamination on or near the site, as acquisition of contaminated property could lead to a legal obligation to clean it up, or to liability to third parties.[89] But no such obligation or liability is usually associated with acquisition or sale of property that is prone to flooding. In the U.K., unlike the U.S., land surveyors not only check the metes and bounds of a property, but also the environmental conditions and suitability of that property, including flood risk.[90]

FEMA flood maps tend not to show flooding caused by overwhelmed stormwater systems. A 2019 report from the National Academies of Science, prepared at the request of FEMA, found that a "new generation of flood maps and visualizations that integrate

85. *Preparing for the Storm: Hearing, supra* note 62, at 81-97 (testimony of Maria Cox Lamm, Ass'n of State Floodplain Managers).

86. Living Rivers v. U.S. Bureau of Reclamation, 272 F. Supp. 2d 1313, 1321 (D. Utah 2003); Pub. Emps. for Env't. Resp. v. U.S. Section, Int'l Boundary & Water Comm'n, 740 F.3d 195, 202 (D.C. Cir. 2014).

87. *See* Jesse M. Keenan, *A Climate Intelligence Arms Race in Financial Markets*, 365 SCI. 1240 (2019); Madison Condon, *Climate Services: The Business of Physical Risk*, 55 ARIZ. STATE L.J. 147 (2023).

88. N.Y.C. FLOOD HAZARD MAPPER, https://www.nyc.gov/site/planning/data-maps/flood-hazard-mapper.page.

89. *See generally* Joseph Philip Forte, *Environmental Due Diligence: A Guide to Liability Risk Management in Commercial Real Estate Transactions*, 5 FORDHAM L. REV 349 (2011).

90. *Choosing a Flood Surveyor – Flood Protection Solutions*, FLOOD PROT. SOLS. (Jan. 30, 2019), https://www.floodprotectionsolutions.co.uk/free-flood-surveys/; RESIDENTIAL PROP. SURVEYORS ASSOC., https://www.rpsa.org.uk/.

predictions and local observations of flood extent and impact is needed to communicate urban flood risk."[91] It also declared,

> The current costs and impacts of urban flooding merit national attention. Further, flood problems are likely to get worse with continued urban development and population growth in urban areas, as well as with climate change, which is increasing sea-level rise and the frequency of heavy precipitation events. Multiagency and cross-jurisdictional efforts are needed to analyze urban flood hazard, advance understanding of social impacts, and communicate urban flood hazard and flood risk.[92]

In 2021, New York City released a set of maps showing the locations most vulnerable to rain-driven flooding under two different greenhouse gas emissions scenarios, and announced that it was working on integrating those maps with coastal maps.[93] Cambridge, Massachusetts, has posted a set of maps with similar information.[94] Reasonably accurate maps of expected flooding (as opposed to rainfall) would benefit greatly from detailed information about the city's stormwater systems, such as the size and location of pipes and outfalls; this information is seldom available.

II. GOVERNANCE

The United States has nothing approaching a comprehensive law on urban flooding. The closest thing we have is the Clean Water Act's stormwater rules, but those are chiefly about water quality, not quantity. Each level of government plays a role, but the sum of all these roles is immensely less than what is needed to address the problem. This is partly due to the challenges posed by climate change. There are increasing calls for "adaptive governance"—ongoing adjustments to the way we manage resources to reflect new developments and learning—but that is beyond the scope of this article.[95]

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91. COMM. ON URBAN FLOODING IN THE U.S., NAT'L ACADS. OF SCIS., ENG'G, MED., FRAMING THE CHALLENGE OF URBAN FLOODING IN THE UNITED STATES 6 (2019).

92. *Id.* at 7.

93. N.Y.C. MAYOR'S OFFICE OF RESILIENCY, *supra* note 40.

94. *Understanding Flood Risks & Protecting Your Property*, CITY OF CAMBRIDGE, https://www.cambridgema.gov/Services/FloodMap.

95. *See* Jonathan Rosenbloom, *Fifty Shades of Gray Infrastructure: Land Use and the Failure to Create Resilient Cities*, 93 WASH. L. REV. 317, 371 (2018); Carl Folke et al., *Adaptive Governance of Social-Ecological Systems*, 30 ANN. REV. ENV'T & RES. 441 (2005).

A. Federal Government

The National Flood Insurance Act of 1968,[96] the Flood Disaster Protection Act of 1973,[97] and later amendments made FEMA the federal agency that is most concerned with flooding. It spends billions of dollars assisting communities in recovering from floods and other disasters. It also administers the National Flood Insurance Program (NFIP), which provides subsidized flood insurance to owners of property located in Special Flood Hazard Areas if their communities adopt certain land use policies, including building and zoning codes that reduce flood risks, among other requirements.[98] The office of the Federal Insurance Administrator (a FEMA official) has established various land use and building standards that communities are supposed to adopt in order to be eligible for federal flood insurance.[99] Communities are rarely audited for compliance with this requirement, and a 2020 study found that, in the prior decade, FEMA had paid more than $1 billion in flood claims for damage to homes in communities that were in violation of the standards—an amount far larger than what a good auditing program would have cost.[100] If a city is somehow found to be in violation, it seldom receives serious penalties; reflecting its limited enforcement powers, FEMA instead has a "cooperative enforcement" model, which sounds like a contradiction in terms.[101]

Most of these standards have not been updated since the 1970s but, in 2021, FEMA launched a rulemaking process to update them in response to a petition from NRDC and the Association of State Floodplain Managers.[102]

For places that go above and beyond the minimum requirements, FEMA provides steep insurance discounts through

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96. National Flood Insurance Act of 1968, Pub. L. 90-448, 83 Stat. 572 (1968).

97. Flood Disaster Protection Act of 1973, Pub. L. 93-234, 87 Stat. 975 (1973).

98. 44 C.F.R. §§ 59.22, 60 (2009). It should be noted that not all NFIP and private flood insurance policies cover all sewer back-ups; separate riders may need to be purchased. WINTERS, *supra* note 68, at 57-59.

99. 44 C.F.R. pt. 60 (2009); *see also* FED. EMERGENCY MGMT. AGENCY, FLOODPROOFING NON-RESIDENTIAL BUILDINGS (July 2013), https://www.fema.gov/sites/default/files/2020-07/fema_p-936_floodproofing_non-residential_buiildings_110618pdf.pdf.

100. Christopher Flavelle & John Schwartz, *Cities Are Flouting Flood Rules. The Cost: $1 Billion.*, N.Y. TIMES (Apr. 9, 2020), https://www.nytimes.com/2020/04/09/climate/fema-flood-insurance.html.

101. Dena Adler et al., *Changing the National Flood Insurance Program for a Changing Climate*, 49 ENV'T L. REP. 10320, 10331-32 (2019); Mark Collette, *Flood Games: Manipulation of Flood Insurance Leads to Repeat Disasters*, HOUS. CHRON. (July 9, 2018), https://www.houstonchronicle.com/business/article/Flood-Games-How-victims-local-officials-and-an-13031069.php.

102. Joel Scata, *FEMA Moves to Reform Flood Insurance Program*, NAT'L RES. DEF. COUNCIL (Oct. 14, 2021), https://www.nrdc.org/bio/joel-scata/fema-moves-reform-flood-insurance-program.

its Community Rating System. Very few municipalities have joined the program; of more than 22,000 communities participating in the NFIP, only five percent get credits under the Community Rating System.[103] The Community Rating System's involvement in stormwater is focused on erosion and runoff controls at new developments and on maintenance of drainage systems.[104]

Owners of properties in Special Flood Hazard Areas with federally backed mortgages are supposed to buy flood insurance policies, but there is widespread noncompliance.[105]

The EPA also plays an important role in flood response management, though its role is driven more by pollution than flooding. After Congress enacted what is now called the Clean Water Act in 1972 (over President Nixon's veto), the newly formed EPA focused on "point sources" of water pollution, such as pipes, and exempted "nonpoint sources" such as stormwater from the need for permits. But stormwater is a significant source of pollution; it picks up oil and other contamination as it washes over streets, construction sites, and other surfaces on its way to the river. In 1977, the D.C. Circuit ruled this exemption to be unlawful.[106] The EPA still moved slowly in regulating stormwater and, in 1987, Congress amended the Clean Water Act and put the EPA on a strict timetable to implement stormwater regulations.[107] The EPA started by requiring larger cities, and then smaller cities and towns as well as industrial and construction sites, to come up with plans to control stormwater.[108] In 1994, the EPA issued its Combined Sewer Overflow Policy to specify how cities are supposed to make sure untreated sewage is not released during storms[109] and, in 2000, Congress further amended the Clean Water Act to require compliance with this policy.[110] Not all cities complied, and the EPA began taking limited enforcement action. The principal concern, as discussed below, was that stormwater combined with sewage can

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103. Adler et al., *supra* note 101, at 10325.

104. FED. EMERGENCY MGMT. AGENCY, NATIONAL FLOOD INSURANCE PROGRAM COMMUNITY RATING SYSTEM COORDINATOR'S MANUAL, OMB NO. 1660-0022, §§450 (stormwater management), 540 (drainage system maintenance) (2017).

105. Thomas Frank, *Thousands of FHA-Backed Mortgages Lack Flood Insurance*, CLIMATEWIRE, (Apr. 1, 2022), https://www.eenews.net/articles/thousands-of-fha-backed-mortgages-lack-flood-insurance/; U.S. GOV'T ACCOUNTABILITY OFF., NATIONAL FLOOD INSURANCE PROGRAM: CONGRESS SHOULD CONSIDER UPDATING THE MANDATORY PURCHASE REQUIREMENT (2021).

106. Nat. Res. Def. Council v. Costle, 568 F.2d 1369, 1379 (D.C. Cir. 1977).

107. 33 U.S.C. § 1342(p)(3).

108. Caswell F. Holloway et al., *Solving the CSO Conundrum: Green Infrastructure and the Unfulfilled Promise of Federal-Municipal Cooperation*, 38 HARV. ENV'T L. REV. 335 (2014).

109. Combined Sewer Overflow (CSO) Control Policy, 59 Fed. Reg. 18688 (Apr. 19, 1994).

110. 33 U.S.C. § 1342(q).

exceed the capacity of wastewater treatment plants, causing untreated sewage to flow into rivers, lakes, and oceans. The EPA also worries about the pollution that stormwater picks up along the way. Its focus is on the quality of the water, not the quantity—on pollution, not flooding.

The U.S. Army Corps of Engineers has major responsibility for civil works such as dams and levees, and it issues permits for construction in navigable waterways under the Rivers and Harbors Act of 1899[111] and for dredging and filling in "waters of the United States" under the Clean Water Act.[112] It will generally only get involved in urban water damage problems under its flood control authorities if the flood discharge is greater than 800 cubic feet per second for a flood that has a ten percent chance of happening in a given year.[113]

In January 2015, President Obama issued Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, which declared, "It is the policy of the United States to improve the resilience of communities and Federal assets against the impacts of flooding. These impacts are anticipated to increase over time due to the effects of climate change and other threats."[114] Substantively, it strengthened the process of protecting federal buildings and other federal assets from flooding. President Trump rescinded this order in August 2017,[115] and President Biden reinstated it in May 2021.[116]

The IIJA provides approximately $34.7 billion toward enhanced flood mitigation, resilience, and disaster preparedness programs.[117] The Inflation Reduction Act, signed by President Biden in August 2022, is not specifically aimed at flooding but includes several billion

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111. 33 U.S.C. § 403.

112. 33 U.S.C. § 1344.

113. 33 C.F.R. § 238.7(a); U.S. ARMY CORPS OF ENG'RS, FLOOD DAMAGE REDUCTION MEASURES IN URBAN AREAS, https://www.nap.usace.army.mil/Portals/39/docs/Civil/Takoony/Flood%20Damage%20Reduction%20Measures.pdf (last visited Feb. 16, 2024).

114. Exec. Order No. 13690, 80 Fed. Reg. 6425 (Jan. 30, 2015).

115. Exec. Order No. 13807, 82 Fed. Reg. 40463 (Aug. 15, 2017).

116. Exec. Order No. 14030, 86 Fed. Reg. 27967 (May 20, 2021). The evolution of Presidential executive orders on climate change is traced in Robin Kundis Craig, *Climate Adaptation Law and Policy in the United States*, 9 FRONTIERS IN MARINE SCI. 1059734 (2022).

117. *The bipartisan infrastructure bill will create flood-resilient communities – here's how*, AM. FLOOD COAL. (Nov. 15, 2021), https://floodcoalition.org/2021/11/the-bipartisan-infrastructure-bill-will-create-flood-resilient-communities-heres-how/.

dollars for a variety of programs that could be used for climate adaptation, including to address flooding.[118]

B. States

The Clean Water Act operates under a system of "cooperative federalism" in which the states may implement the federal permit programs. Most states have delegation agreements with the EPA to implement EPA stormwater rules.[119]

Several states have taken positive actions on their own to prepare for the impacts of climate change.[120] For example, in 2014, New York enacted the Community Risk and Resiliency Act,[121] which required the state to adopt official sea level rise projections (which it did[122]) and to consider sea level rise in state government decisions (which it has sometimes done[123]). The state legislatures of Connecticut[124] and Florida[125] enacted statutes and the governor of Rhode Island signed an executive order[126] calling for systematic action to prepare for sea level rise. Some of the most comprehensive actions have been taken by California, which has adopted and periodically updates a detailed climate adaptation strategy, as required by an executive order by former governor Jerry Brown.[127]

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118. Sarah Gimont, *Legislative Analysis for Counties: The Inflation Reduction Act,* NAT'L ASSOC. OF CNTYS. (Feb. 22, 2023), https://www.naco.org/resources/legislative-analysis-counties-inflation-reduction-act; *What the Inflation Reduction Act means for flood resilience,* AM. FLOOD COAL. (Aug. 30, 2022), https://floodcoalition.org/2022/08/what-the-inflation-reduction-act-means-for-flood-resilience/#:~:text=Specifically%2C%20the%20Inflation%20Reduction%20Act,technical%20assistance%20within%20underserved%20communities.

119. *NPDES Stormwater Program*, ENV'T PROT. AGENCY, https://www.epa.gov/npdes/npdes-stormwater-program (last visited Feb. 16, 2024).

120. This is different from state laws to reduce greenhouse gas emissions; about 25 states have those. *U.S. State Greenhouse Gas Emissions Targets*, CTR. FOR CLIMATE & ENERGY SOLS., https://www.c2es.org/document/greenhouse-gas-emissions-targets/ (last visited Feb. 16, 2024).

121. A6558B, Assemb., 2013-2014 Reg. Sess. (N.Y. 2013); Michael B. Gerrard, *New Statute Requires State Agencies to Consider Climate Risk*s, N.Y. L.J. (Nov. 13, 2014).

122. Gerrard & McTiernan, *supra* note 70.

123. *See New York State Climate Law Tracker*, SABIN CTR. FOR CLIMATE CHANGE L., https://climate.law.columbia.edu/content/new-york-state-climate-law-tracker.

124. Conn. Pub. Act No. 18-82 (2018); *see also* E.A. Cruden, *Acknowledging sea level rise, Connecticut legislature passes sweeping climate change bill*, THINK PROGRESS, (May 9, 2018), https://archive.thinkprogress.org/connecticut-climate-change-sea-level-rise-6ec048453ad3/; Erin Flannery Keith, *New England Laws Meet Rising Seas with Yankee Ingenuity*, 37 NAT. RES. & ENV'T 50, 50-52 (2023).

125. S.B. 178 (2020); S.B. 1954 (2021); *see also* Zachary T. Sampson & Kirby Wilson, *DeSantis signs landmark Florida sea level rise bills into law*, TAMPA BAY TIMES (May 12, 2021), https://www.tampabay.com/news/florida-politics/2021/05/12/desantis-signs-landmark-florida-sea-level-rise-bills-into-law/.

126. R.I. Executive Order No. 17-10: *Action Plan to Stand up To Climate Change*, (Sep. 15, 2017), https://governor.ri.gov/executive-orders/executive-order-17-10.

127. CAL. NAT. RES. AGENCY, SAFEGUARDING CALIFORNIA PLAN: 2018 UPDATE – CALIFORNIA CLIMATE ADAPTATION STRATEGY, 1 (2018), https://www.srta.ca.gov/DocumentCenter/View/4762/Safeguarding-California-Plan-2018-Update.

Louisiana has also taken comprehensive action. Its Comprehensive Master Plan for a Sustainable Coast was mandated by the state legislature after Hurricanes Katrina and Rita in 2005, and has been periodically updated.[128]

But these are exceptions. While about 20 states have issued climate adaptation plans of some sort,[129] only a few state legislatures have enacted laws addressing climate change adaptation, and the vast majority of municipalities are laggards. This is especially so with respect to waterfront areas where property values are high and owners often have the political clout to block restrictions on development.[130]

States must prepare hazard mitigation plans as a condition of receiving certain federal grants to help them prepare for and recover from future disasters. In 2016, FEMA issued guidance making it clear that these plans should consider future climate conditions.[131] A 2019 survey of these plans from all 50 states and three U.S. territories found that 49 of the 53 jurisdictions explicitly recognize and discuss climate change in their plans, and most had improved the plans' consideration of climate change since a prior survey six years earlier.[132] The quality of the plans varied considerably, with Kentucky, South Carolina, Texas, and Wyoming at the bottom of the heap, and California, Colorado, Connecticut, Hawaii, Massachusetts, Minnesota, Oregon, New York, Rhode Island, Vermont, and Washington getting the top rating.[133]

C. Local Governments

Local governments have the principal responsibility for dealing with urban flooding. They build and operate the sewage and drainage systems, sometimes with federal assistance.[134] But the increased precipitation that will be caused by climate change in the coming decades will put enormous strains on systems that are

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128. LA. REV. STAT. § 49:214.5.3 (2018).

129. *See State Adaptation Progress Tracker*, GEO. CLIMATE CTR., https://www.georgetownclimate.org/adaptation/plans.html.

130. *See* Sarah J. Adams-Schoen, *Beyond Localism: Harnessing State Adaptation Lawmaking to Facilitate Local Climate Resilience*, 8 MICH. J. ENV'T. & ADMIN. L. 185 (2018).

131. *See* Dena P. Adler & Emma Gosliner, *State Hazard Mitigation Plans & Climate Change: Rating the States 2019 Update*, SABIN CTR. FOR CLIMATE CHANGE L. 4-6 (2019).

132. *Id.*

133. *Id.*

134. *See, e.g.*, *Local Government Strategies for Mitigating the Risks of Flooding*, CMTY. & ECON. DEV. IN N.C. & BEYOND (Feb. 24, 2015), https://ced.sog.unc.edu/2015/02/local-government-strategies-for-mitigating-the-risks-of-flooding/; LOCAL ELECTED AND APPOINTED OFFICIALS GUIDE: ROLE AND RESOURCES IN EMERGENCY MANAGEMENT, FED. EMERGENCY MGMT. AGENCY (2022), https://www.fema.gov/sites/default/files/documents/fema_local-elected-officials-guide_2022.pdf.

poorly equipped to deal with even today's storms. Retrofitting existing drainage systems or building new ones is extremely expensive and would strain or break many municipal budgets.

Responsibility for dealing with flooding tends to be spread across multiple local agencies. In New York, for example, the Department of Environmental Protection maintains the sewer system; the Department of Emergency Management activates emergency plans and coordinates agencies; the Department of Transportation maintains the catch basins on arterial roads; the Department of Sanitation clears catch basins on minor roadways; the Metropolitan Transportation Authority maintains the subways, and so on.[135] These agencies plan in silos with limited coordination and general oversight.[136]

Some cities and counties have elaborate plans to reduce storm flows. In places where flooding is a regional problem, some municipalities have come together to form regional stormwater management boards or at least plans to form such boards.[137] Several counties in Illinois were found to have effective stormwater plans.[138] New York City has several consent decrees with the state environmental department to bring it into compliance with Clean Water Act requirements for stormwater. In 2022, the city adopted a Unified Stormwater Rule, which applies to all development projects that involve the disturbance of 20,000 square feet or more of soil or the creation of 5,000 square feet or more of impervious surface, and to all projects requiring a new sewer connection. Subject projects must use vegetated retention projects (discussed below) to the maximum extent practical.[139] A severe but necessary limitation is that the rule only applies to new construction projects, and 70% of

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135. REBUILD BY DESIGN & ONE ARCHITECTURE, TOWARD A RAINPROOF NEW YORK CITY: TURNING THE CONCRETE JUNGLE INTO A SPONGE 20 (July 2022), https://rebuildbydesign.org/wp-content/uploads/2022/09/Toward-a-Rianproof-NYC-Compressed.pdf (hereinafter TOWARD A RAINPROOF NEW YORK CITY).

136. *Id.* at 24.

137. *E.g.*, *Passaic Valley (New Jersey) Regional Flood Control Board*, BOROUGH OF WOODLAND PARK, http://www.wpnj.us/content/167/337/default.aspx (last visited Mar. 16, 2024); *Feather River Region (California) Regional Flood Management Plan*, CAL. DEP'T OF WATER RES., https://www.yubawater.org/DocumentCenter/View/3223/Feather-River-Region-Regional-Flood-Management-Plan?bidId=; *Clark County (Nevada) Regional Flood Control District*, FED. EMERGENCY MGMT. AGENCY, https://www.fema.gov/es/node/453824 (last visited Mar. 16, 2024); *Pajaro (California) Regional Flood Management Agency,* CALIFORNIALOCAL https://californialocal.com/localnews/monterey/ca/government/show/185-pajaro-regional-flood-management-agency/overview/ (last visited Mar. 16, 2024). Texas has formed fifteen Regional Flood Planning Groups; *see Lower Red Basin*, LOWER RED-SULPHUR-CYPRESS, https://lowerredsulphurcypress.halff.com/ (last visited Mar. 16, 2024).

138. WINTERS, *supra* note 68, at 33-38.

139. 15 R.C.N.Y. § 19.1-03.4; *see* Karen Mintzer et al., *New Unified Stormwater Rule in NYC: Why Now and What Developers Need to Know*, 42 N.Y. ENV'T L. at 27 (2022); *infra* Section III(C) ("*Storage*") (describing vegetated retention projects and other storage measures).

the city—the "concrete jungle"—is already built up with impervious surface.[140]

III. Physical Coping Mechanisms

The physical means by which cities can cope with flooding can be divided into six categories:

1. Grey infrastructure: pipes and other devices to convey water to a receiving water body
2. Infiltration: having the water seep into the ground
3. Storage: holding the water for a time and releasing it gradually
4. Defense: barriers to hold back the water
5. Accommodation: arrangements that allow the water to enter without inflicting damage
6. Retreat: moving residences and other activities away from flood-prone areas

The magnitude of current and future floods is such that no one or two of these methods will be sufficient; some combination of all six will be needed. Each of these measures and its legal implications will now be discussed in turn.

A. Grey Infrastructure

Just about every city has street drains and pipes that carry rainwater to a nearby river or other body of water. In more than seven hundred (mostly older) cities, the pipes also receive sewage and send the combined flows to a sewage treatment plant.[141] When it rains, the combination of rainwater and sewage can exceed the capacity of the collection system and the plant, and untreated sewage needs to flow into the river; the plants are designed to let that happen.[142] That's why it is a particularly bad idea to swim near a sewage treatment plant outfall after it rains. Whether the stormwater pipes are separate or combined, they can only handle a certain amount of water. If it rains so hard as to exceed the capacity

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140. *Info Box "Did You Know?",* RESILIENT NYC PARTNERS, N.Y.C. DEP'T OF ENV'T PROT., https://www.nyc.gov/site/dep/whats-new/resilient-nyc-partners.page; 15 R.C.N.Y § 19.1-01.1 (stating that the rules apply to "covered development projects"); id. § 19.1-01.2 (defining "covered development project").

141. U.S. ENV'T PROT. AGENCY, GREENING CSO PLANS: PLANNING AND MODELING GREEN INFRASTRUCTURE FOR COMBINED SEWER OVERFLOW (CSO) CONTROL 5 (2014), https://www.epa.gov/sites/default/files/2015-10/documents/greening_cso_plans.pdf.

142. *Combined Sewer Overflow Basics*, U.S. ENV'T PROT. AGENCY, https://www.epa.gov/npdes/combined-sewer-overflow-basics.

of the pipes before the water reaches the river, the system backs up and water flows out of rather than into the street drains, and manholes can become geysers. Then the streets flood, and if there is enough rain, so do buildings. Most pipes—and, in older cities, just about all pipes—are, at best, of a size that would handle the rains that we experienced when they were installed (the "design storm"). In New York City, many of the sewers were built to handle 1.5 inches of rain per hour and the City wants to upgrade all sewers to about 1.75 inches per hour, which would handle what was thought of as a "five-year storm" based on rainfall data from 1903-1951.[143] But, under some new projections, a five-year storm could produce 2.15 inches per hour in the years 2040-2069.[144] As noted above, Hurricane Ida had a peak of 3.15 inches per hour. As Detroit Mayor Mike Duggan said after a storm overwhelmed his city's sewer system, "[t]he infrastructure in this country was built for the climate of the 20th century. It was not built for what we have today."[145]

In coastal areas, storm surge and tidal flooding make all of this worse; if the sea level rises higher than the height of sewer outfalls, the water has nowhere to discharge and backs up.[146]

Installing more or larger sewers is one approach to dealing with more intense rainfall, though it is very expensive, especially if buildings or other infrastructure have been erected above. It is sometimes impeded by protracted environmental permitting processes.[147]

Street drains have grates to keep out large debris. If the drains are large enough and do not have grates, people are sometimes sucked in, with tragic results.[148] The debris accumulates outside the grates and must be removed from time to time; otherwise, the drain becomes clogged. One inspection of the New York City subway

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143. N.Y.C. DEP'T OF ENV'T PROT., *supra* note 34, at 8; N.Y.C. MAYOR'S OFF. OF RESILIENCY, *supra* note 40, at 5.

144. N.Y.C. MAYOR'S OFFICE OF RESILIENCY, *supra* note 40, at 5; ARTHUR T. DEGAETANO & CHRISTOPHER M. CASTELLANO, NE. REG'L CLIMATE CTR., DOWNSCALED PROJECTIONS OF EXTREME RAINFALL IN NEW YORK STATE (2015), http://ny-idf-projections.nrcc.cornell.edu/idf_tech_document.pdf.

145. Kyle Bagenstose & Kevin Crowe, *Climate change brings a perfect storm of raw sewage and rainfall in cities that can least afford it,* USA TODAY, (Dec. 3, 2021, 11:28 AM), https://www.usatoday.com/in-depth/news/investigations/2021/11/30/sewer-systems-climate-change/6201425001/.

146. TOWARD A RAINPROOF NEW YORK CITY, *supra* note 135, at 10.

147. N.Y.C.: OFF. OF THE DEPUTY MAYOR FOR ADMIN., THE NEW NORMAL: COMBATING STORM-RELATED EXTREME WEATHER IN NEW YORK CITY 64 (2021), https://www.nyc.gov/assets/em/downloads/pdf/combatting_extreme_weather_in_nyc_report.pdf (hereinafter THE NEW NORMAL).

148. Topher Sanders, *Storm Drains Keep Swallowing People During Floods*, PROPUBLICA (Dec. 9, 2021, 6:00 AM), https://www.propublica.org/article/storm-drains-keep-swallowing-people-during-floods.

system found that at the targeted pace for cleaning drains—150,000 linear feet a year—it would require fifteen years to clean the entire system.[149] As is probably typical of cities nationwide, many of the flood control channels in Los Angeles become clogged with sediment and vegetation, impeding flows.[150]

B. Infiltration

As discussed above, the usual way to control stormwater has involved "grey infrastructure"—pipes, concrete sewers and other hard structures. This has traditionally been required or at least encouraged by state and local governments on both public and private property.[151] But another method is simply to let the water seep into the ground.

The problem of impervious surfaces has long been recognized. In 1789, Benjamin Franklin wrote that in his home city of Philadelphia:

> [C]overing a ground plot with buildings and pavements, which carry off most of the rain and prevent its soaking into the Earth and renewing and purifying the Springs…the water of wells must gradually grow worse, and in time be unfit for use as I find has happened in all old cities.[152]

Starting around 2008, the EPA increasingly included community-based green infrastructure in the combined sewer overflow plans that it negotiated with cities.[153] In 2019, Congress amended the Clean Water Act to provide that the EPA "shall promote the use of green infrastructure in, and coordinate the integration of green infrastructure into, permitting and enforcement under this Act, planning efforts, research, technical assistance, and funding guidance."[154] Congress defined "green

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149. Anne Barnard et al., *How Can New York City Prepare for the Next Ida? Here's a To-Do List.*, N.Y. TIMES (Sept. 22, 2021), https://www.nytimes.com/2021/09/20/nyregion/nyc-flooding-infrastructure.html.

150. Raymond Zhong, *Aging Infrastructure May Create Higher Flood Risk in L.A., Study Finds*, N.Y. TIMES (Oct. 31, 2022), https://www.nytimes.com/2022/10/31/climate/los-angeles-flood-risk.html?searchResultPosition=1.

151. Rosenbloom, *supra* note 95.

152. Bruce Stutz, *With a Green Makeover, Philadelphia Is Tackling Its Stormwater Problem*, YALE ENV'T 360 (March 29, 2018), https://e360.yale.edu/features/with-a-green-makeover-philadelphia-tackles-its-stormwater-problem.

153. Arthur Smith, *Climate Change Impact on Sewer Overflow Litigation: A Spark for Sustainability and Justice*, 36 NAT. RES. & ENV'T 23 (2021).

154. 33 U.S.C.A § 137(a). Pursuant to a 2011 Clean Water Act settlement with the EPA and the Pennsylvania state environmental agency, Philadelphia has embarked on a $2.4

infrastructure" as "the range of measures that use plant or soil systems, permeable pavement or other permeable surfaces or substrates, stormwater harvest and reuse, or landscaping to store, infiltrate, or evapotranspirate stormwater and reduce flows to sewer systems or to surface waters."[155]

Among the methods used are rain gardens (depressed areas in the landscape, planted with grasses or flowering perennials) that collect rain water from a roof or street and allow it to soak into the ground; bluebelts (similar in function to rain gardens, but linear, larger, and often connecting wetlands); grassy highway medians; permeable pavements; green roofs; infiltration trenches; disconnecting downspouts from sewers, so that the rainwater can run across the land and be absorbed by the soil; and bioswales, which drain runoff into vegetated areas that slow and filter stormwater, allowing it to seep into the soil. To save the cities some of the expense in building sewers and to encourage these more nature-based approaches, the EPA has entered into consent decrees with about thirty cities, allowing them to meet at least part of their stormwater compliance obligation by using green infrastructure.[156] Other cities and developers have employed green infrastructure voluntarily, or to comply with emerging federal, state or local standards.[157]

In a built-up city, installing green infrastructure can involve thousands of small projects. It is easier to promise them than to implement them. New York City adopted a Green Infrastructure Plan in 2010 to help comply with EPA consent orders with the state environmental department under the Clean Water Act, with the aim

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billion, 25-year stormwater control program that is focused on green infrastructure. PHILADELPHIA WATER DEPARTMENT, GREEN CITY CLEAN WATERS IMPLEMENTATION AND ADAPTIVE MANAGEMENT PLAN (Dec. 1, 2011); *Green City, Clean Waters: Philadelphia's 21st Century Green Stormwater Infrastructure Program*, AM. PLANNING ASSOC. (2015), https://www.planning.org/awards/2015/greencity.htm.

155. *Id.* § 1362.

156. U.S. GOV'T ACCOUNTABILITY OFF., STORMWATER MANAGEMENT: EPA PILOT PROJECT TO INCREASE USE OF GREEN INFRASTRUCTURE COULD BENEFIT FROM DOCUMENTING COLLABORATIVE AGREEMENTS (2017), https://www.gao.gov/assets/gao-17-750.pdf; *see also* ENV'T PROT. AGENCY, CONSENT DECREES THAT INCLUDE GREEN INFRASTRUCTURE PROVISIONS (undated), https://19january2017snapshot.epa.gov/sites/production/files/2015-10/documents/epa-green-infrastructure-supplement-1-061212-pj.pdf.

157. ENV'T PROT. AGENCY OFF. OF WETLANDS, OCEANS & WATERSHEDS, GREEN INFRASTRUCTURE CASE STUDIES: MUNICIPAL POLICIES FOR MANAGING STORMWATER AND GREEN INFRASTRUCTURE (2010), https://nepis.epa.gov/Exe/ZyNET.exe/P100FTEM.TXT?ZyActionD=ZyDocument&Client=EPA&Index=2006+Thru+2010&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYear=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C06thru10%5CTxt%5C00000033%5CP100FTEM.txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL.

of reducing combined sewer overflows. The City spent about $1 billion on about 11,500 green infrastructure projects (mostly on publicly-owned sites or rights-of-way) and took many other steps, but it was falling far behind in its obligation to reduce flows.[158] In May 2023 it signed a complex agreement with the state to spend another $2 billion on a set schedule through 2045 on green infrastructure projects.[159] Some forms of green infrastructure, such as rain gardens, require periodic maintenance, which is not always provided.[160] And some states have statutes that limit the ability of municipalities to adopt their own building codes, which could limit cities' ability to mandate green infrastructure.[161]

Despite the challenges, green infrastructure can have many benefits beyond storing water and improving water quality. It reduces the urban heat island effect; improves the aesthetic appearance of streets; absorbs some air pollution; provides wildlife habitat; and creates jobs in construction and maintenance.[162] Some of it provides space for recreation, or even for growing food. Green infrastructure can raise local property values, sometimes with the unfortunate effect of increasing gentrification (displacement of people who cannot afford higher rents).[163]

Some green infrastructure is placed on public streets and sidewalks, but much goes on private property. The zoning or building codes of several cities require new developments and buildings undergoing major renovation to have a certain amount of permeable surface.[164] To induce the owners of already-developed property to allow this, in addition to reduced stormwater fees there

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158. Order on Consent Decree, In the Matter of the Violations of Article 17 of the Environmental Conservation Law and Part 750, et seq., of Title 6 of the Official Compilation of Codes, Rules and Regulations of the State of New York (2023) (No. CO2-20230228-38), https://www.dec.ny.gov/docs/water_pdf/2023nycgiordermod.pdf; *see also* Laird Gallagher, *Before the Next Flood: NYC Needs More Progress Building Green Infrastructure*, CTR. FOR AN URB. FUTURE (2021), https://nycfuture.org/research/before-the-next-flood.

159. Sources cited *id.*

160. MARJORIE LANDA, CITY OF N.Y., OFF. OF THE COMPTROLLER, AUDIT REPORT ON THE DEPARTMENT OF ENVIRONMENTAL PROTECTION'S MAINTENANCE OF RAIN GARDENS 1-2 (2019).

161. Hillary Aidun, *Smart Surfaces, Smart Cities: Reducing Heat and Promoting Equity in Urban Areas*, SABIN CTR. FOR CLIMATE CHANGE L. (Sept. 2021), https://climate.law.columbia.edu/sites/default/files/content/Smart%20Surfaces%20White%20Paper%20FINAL%209.10.21.pdf.

162. Alexandra Dunn, *Siting Green Infrastructure: Legal and Policy Solutions to Alleviate Urban Poverty and Promote Healthy Communities*, 37 B.C. ENV'T AFFS. L. REV. 41 (2010); Haozhi Pan et al., *Contribution of Prioritized Urban Nature-based Solutions Allocation to Carbon Neutrality*, 13 NATURE CLIMATE CHANGE 862 (2023).

163. Rebecca H. Walker, *Engineering Gentrification: Urban Redevelopment, Sustainability policy, and Green Stormwater Infrastructure in Minneapolis*, 23 J. ENV'T POL'Y & PLAN. 646 (2021).

164. GEO. CLIMATE CTR., *Green Infrastructure Toolkit: Regulatory Tools*, https://www.georgetownclimate.org/adaptation/toolkits/green-infrastructure-toolkit/introduction.html (last visited Mar. 17. 2024).

can be tax abatements; grants; or development bonuses (allowing larger buildings than the zoning usually allows). Easements or covenants may be imposed to make sure the next owner does not pave over the green feature.[165]

Urban flooding has been such a problem in China that in 2012 President Xi Jinping introduced the concept of the "Sponge City," with nationwide standards requiring designs that absorb rainwater rather than let it flow.[166] The Chinese central government initiated the Sponge City Program in its 13th Five-Year Plan with subsidies to about seventy pilot cities to implement these practices. One of those cities was Zhengzhou, the capital of Henan Province in Central China. About $8.25 billion was invested there in green infrastructure.[167] However, in July 2021, Zhengzhou suffered devastating losses when it was hit with what was called a one-in-one-thousand year storm event.[168] Other Chinese cities have had similar experiences. China's "Sponge City" effort seems adequate for ordinary heavy rains but not for the extreme events that have been occurring more frequently.[169] Some cities in Germany have also adopted a "Sponge City" approach.[170] Similar concepts using different terminology have been employed in several other countries.[171]

One study ranked eleven cities in order of "sponginess" based on three factors: amount of blue and green space; soil type factors; and water runoff potential. The rankings (from most to least spongy): Auckland, Nairobi, Singapore, Mumbai, New York, Toronto, Montreal, Shanghai, London and Sydney.[172]

A correlation to creating green infrastructure might be called "infiltration protection"—that is, where the surface is already permeable, keep it that way. The covering of natural areas with pavement and buildings is a major contributor to flooding in all

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165. Justin Gundlach, *Putting Green Infrastructure on Private Property in New York City*, SABIN CTR. FOR CLIMATE CHANGE L. (2017).

166. ARUP, *Global Sponge Cities Snapshot* (2022), https://www.arup.com/perspectives/publications/research/section/global-sponge-cities-snapshot.

167. *Id.*

168. James Griffiths et al., *Interpretation and Application of Sponge City Guidelines in China*, 378 PHIL. TRANSACTIONS OF THE ROYAL SOC'Y A 2168 (2020); Eric Gies, *Sponge Cities Can Limit Urban Floods and Droughts*, SCI. AM. (Dec. 2018); Faith Ka Shun Chan et al., *Transformation Towards Resilient Sponge Cities in China*, 3 NATURE REVS. 99 (2022).

169. *China's 'Sponge cities' Are Not Built for Extreme Flood Events*, BLOOMBERG NEWS (Aug. 3, 2023); Alok Gupta, *Devastating Beijing flood test China's 'sponge cities,'* CLIMATE HOME NEWS (Aug. 17, 2023), https://www.climatechangenews.com/2023/08/17/beijing-floods-airport-shut-down/.

170. *Germany's Sponge Cities to Tackle Heat and Flooding*, OECD (undated), https://www.oecd.org/climate-action/ipac/practices/germany-s-sponge-cities-to-tackle-heat-and-flooding-7b6caa58/ (last visited Mar. 17, 2024).

171. Leah Hamilton, *Urbanism 101: What is a Sponge City?,* THE URBANIST (Feb. 8, 2023), https://www.theurbanist.org/2023/02/08/urbanism-101-what-is-a-sponge-city/.

172. ARUP, *supra* note 166.

urbanized areas. Many states and some cities restrict development in wetlands, floodplains, and other sensitive areas; flood control is only one of the many reasons for these controls.[173] The Army Corps of Engineers, working with the EPA, has an important regulatory program (called the Section 404 program, after the relevant section of the Clean Water Act) to restrict dredging and filling in wetlands and other waters,[174] though in 2023 the Supreme Court severely limited its coverage.[175] There is a large legal literature concerning this program, so it will not be discussed further here.[176]

C. Storage

Because it can take time for stormwater to soak into the ground or make its way through pipes, some of the water in big storms must be stored temporarily. This can be done in holding tanks, natural or artificial underground caverns, and other hard facilities, some as small as rain barrels.[177] More on the green infrastructure side, water can be stored in retention ponds and in sunken athletic fields, playgrounds, and other areas that people use on dry days but are designed to flood during heavy rains. Old golf courses provide a prime opportunity; if they are in natural depressions or are dug out, they can become excellent reservoirs for water storage.[178] Green roofs store water for a time, and in hot weather they help cool the buildings on which they sit.[179] Wetlands form natural storage and seepage areas.

The largest water storage facility in the United States (not counting lakes behind dams) is the Chicago area's Tunnel and Reservoir Plan (TARP), known as Big Tunnel.[180] It actually includes four tunnel systems totaling 110 miles of tunnels up to thirty-three

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173. MITIGATION MATTERS: POLICY SOLUTIONS TO REDUCE LOCAL FLOOD RISK, PEW CHARITABLE TRS. 4-5 (2019).

174. Clean Water Act § 404, 33 U.S.C. §1344.

175. Sackett v. EPA, 598 U.S. 21 (2023).

176. *E.g.,* Monika U. Ehrman & Robin Kundis Craig, *The Supreme Court's Wetland Saga Continues*, REGUL. REV. (July 13, 2023), https://www.theregreview.org/2023/07/13/ehrman-craig-the-supreme-courts-wetland-saga-continues/.

177. Some states have design standards for stormwater detention facilities, commonly expressed as an allowable release rate for a specified return interval event. WINTERS, *supra* note 68, at 45-47.

178. Dylan Baddour, *Reclaiming Golf Courses Could Help Houston Fight the Next Hurricane Harvey*, WASH. POST (Nov. 27, 2017); Aileen Kwun, *The Suburban Golf Course, Reconsidered for the Age of Climate Change*, FAST CO. (Feb. 27, 2018); Rick Jervis, *How this Small Houston community Survived Hurricane Harvey When Other Parts* Didn't, USA TODAY (Jan. 19, 2018).

179. LOOK UP TO MAKE ROOM FOR A GREENER NYC, THE NATURE CONSERVANCY 1 (2019), https://www.nature.org/content/dam/tnc/nature/en/documents/NYC_Green Roofs_Summary.pdf.

180. *Tunnel and Reservoir Plan*, METRO. WATER RECLAMATION DIST. OF GREATER CHI., https://mwrd.org/what-we-do/tunnel-and-reservoir-plan-tarp (last visited Apr. 29, 2024).

feet in diameter and up to 300 feet underground. They capture combined sewage and stormwater and convey them to three reservoirs in the suburbs, and then send them to what has been called the world's largest wastewater treatment plant[181] as capacity becomes available. Construction began in 1975 to help comply with the new Clean Water Act and keep untreated sewage out of Lake Michigan, which is the area's source of drinking water, and to control flooding.[182] A powerful local congressman was able to obtain substantial federal financial assistance to help build the project.[183] TARP has been very successful in improving water quality in the lake, and several other cities are imitating it, including Milwaukee, St. Louis, Washington, D.C., London and Guangzhou. However, especially with the increase in extreme precipitation, TARP is not big enough to prevent urban flooding; after the heaviest rains it still fills up faster than it can drain and the sewers back up.[184] The agency that runs the area's wastewater system has signed a consent decree with the EPA committing to many green infrastructure projects.[185]

Tokyo also has an enormous underground flood protection system rivalling the size of TARP—its central cavern has been called a "floodwater cathedral"[186]—and it, too, may be insufficient in view of climate change.[187] There appears to be growing international recognition that while large hard infrastructure projects such as

181. *Stickney WRP*, METRO. WATER RECLAMATION DIST. OF GREATER CHI., https://legacy.mwrd.org/irj/portal/anonymous/stickney#:~:text=The%20Stickney%20Water%20Reclamation%20Plant,Chicago%20and%2046%20suburban%20communities (last visited Mar. 6, 2024).

182. *Tunnel and Reservoir Plan, supra* note 180.

183. *See, e.g.*, Henry Grabar, *Tunnel Vision*, SLATE (Jan. 2, 2019, 5:50 AM), https://slate.com/business/2019/01/chicagos-deep-tunnel-is-it-the-solution-to-urban-flooding-or-a-cautionary-tale.html; *see* JOSEPH D. KEARNEY & THOMAS W. MERRILL, LAKEFRONT: PUBLIC TRUST AND PRIVATE RIGHTS IN CHICAGO 288 (2021).

184. Joe Barrett, *Chicago Is Spending $3.8 Billion to Fight Flooding. It Might Not Be Enough*, WALL ST. J. (Aug. 30, 2023, 8:00 AM), https://www.wsj.com/us-news/climate-environment/chicago-is-spending-3-8-billion-to-fight-flooding-it-might-not-be-enough-f9a30bbd.

185. *Tunnel and Reservoir Plan*, *supra* note 182; Stanley A. Changnon, *Stormwater Management for a Record Rainstorm in Chicago*, 146 J. CONTEMP. WATER RSCH. & EDUC. 103 (2010); Grabar, *supra* note 182; *Costly Deep Tunnel Flooding Project Struggles to Handle Severe Storms Amid Climate Change*, EARTH INFORMANT (July 20, 2023), https://www.earthinformant.com/post/costly-deep-tunnel-flooding-project-struggles-to-handle-severe-storms-amid-climate-change; KEARNEY & MERRILL, *supra* note 183, at 287-89.

186. Diego Arguedas Ortiz, *The Underground Cathedral Protecting Tokyo from Floods*, BBC (Nov. 29, 2018), https://www.bbc.com/future/article/20181129-the-underground-cathedral-protecting-tokyo-from-floods.

187. Elisa Jiménez Alonso, *Tokyo's Massive Flood Protection Facility Might Not be "Enough" Due to Climate Change*, PREVENTIONWEB (Mar. 29, 2018), https://www.preventionweb.net/news/tokyos-massive-flood-protection-facility-might-not-be-enough-due-climate-change; Hiroko Tabuchi, *Tokyo Is Preparing for Floods 'Beyond Anything We've Seen'*, N.Y. TIMES (Oct. 6, 2017), https://www.nytimes.com/2017/10/06/climate/tokyo-floods.html.

those in Chicago and Tokyo can make a substantial contribution to reducing urban flooding, green infrastructure is also needed.[188]

D. Defense Measures

With rising seas and increasingly intense coastal storms, much attention is being devoted to building sea walls and even more expensive tidal gates such as, most famously, the Thames Barrier in London and the MOSE barrier in Venice. However, those are designed to defend against water coming from the sea, not the sky, and are beyond the scope of this article. Levees—artificial embankments or other linear structures—are mostly built to hold back water from rivers and seas. More relevant to pluvial flooding are protections for buildings. Rather than moving the stormwater to receiving waters like rivers and lakes (through grey infrastructure) or allowing it to infiltrate into the ground (through green infrastructure), these methods try to keep stormwater out of the place to be protected.

Every year, many buildings are damaged or destroyed by floods or storms. Building codes are the principal legal mechanism to make sure they are soundly designed and built. These are creatures of state law; there are no federal building codes except for federal buildings and manufactured homes (trailers).[189] Some states have codes that apply to virtually all kinds of buildings (residential, commercial, schools, and others); others have codes only for certain kinds of buildings, or none at all.[190] Some states allow cities to adopt their own codes, which may be weaker or stronger than the state codes.[191]

As with flood maps, most building codes are backward-looking. They assume a continuation of the precipitation rates, temperatures, and other conditions in the historical record, rather than what a changing climate will bring.[192] However, the 2021 update to an American Society of Civil Engineers standard for

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188. Faith Ka Shun Chan et al., *Comparison of Sustainable Flood Risk Management by Four Countries – the United Kingdom, the Netherlands, the United States, and Japan – and the Implications for Asian Coastal Megacities*, 22 NAT. HAZARDS & EARTH SYS. SCI. 2567 (2022).

189. *How Building Codes Work in the US*, CONSTR. PHYSICS, https://www.construction-physics.com/p/how-building-codes-work-in-the-us.

190. *Id.*

191. *Id.*

192. U.S. GOV'T ACCOUNTABILITY OFF., GAO-17-3, CLIMATE CHANGE: IMPROVED FEDERAL COORDINATION COULD FACILITATE USE OF FORWARD-LOOKING CLIMATE INFORMATION IN DESIGN STANDARDS, BUILDING CODES, AND CERTIFICATIONS (2016), https://www.gao.gov/assets/d173.pdf; Diane P. Horn & Erica A. Lee, CONG. RSCH. SERV., R47612, BUILDING RESILIENCE: FEMA'S BUILDING CODES POLICIES AND CONSIDERATIONS FOR CONGRESS 6-7 (2023), https://crsreports.congress.gov/product/pdf/R/R47612.

minimum design loads for buildings and other structures increased the covered flood hazard area from the 100-year flood plain to the 500-year flood plain for certain sensitive uses.[193]

When states or cities adopt their codes, almost all of them start with standard codes developed by others, and adopt them, fully or with modifications, as their own. The dominant drafter of these codes in the United States is the International Code Council (ICC), which has developed more than a dozen codes and standards covering buildings, fire, plumbing, energy conservation, and other subjects. It reviews and updates the codes every three years.[194] The ICC is a nonprofit corporation based in Washington, D.C., with over 700 staff members and 405 chapters worldwide.[195] It has an elaborate governance process, but the National Association of Home Builders, the main trade association and lobbying arm of the home construction industry, plays a key role. Controversy has arisen as the ICC has quietly modified its processes to increase the power of the National Association of Home Builders and reduce that of local governments in setting standards, including those relevant to climate.[196]

The National Association of Home Builders and many of its chapters have often fought standards that would make construction more expensive, including by imposing greater energy efficiency and climate resilience standards. This association has also pushed back against EPA stormwater regulations.[197] The stakes are high for the

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193. AM. SOC'Y OF CIV. ENG'RS, SUPPLEMENT 2 FOR MINIMUM DESIGN LOADS AND ASSOCIATED CRITERIA FOR BUILDINGS AND OTHER STRUCTURES S2-42 (2021), https://ascelibrary.org/doi/10.1061/9780784415788.sup2.

194. *International Codes and Standards*, INT'L CODE COUNCIL, https://global.iccsafe.org/international-codes-and-standards/#:~:text=The%20core%20work%20of%20the%20International%20Code%20Council,every%20three%20years%20through%20an%20open%2C%20consensus-based%20process. (last visited Apr. 29, 2024).

195. *Who We Are*, INT'L CODE COUNCIL, https://www.iccsafe.org/about/who-we-are/ (last visited Mar. 6, 2024).

196. Alexander C. Kaufman, *After Championing Greener Building Codes, Local Governments Lose Right to Vote*, HUFFINGTON POST (Mar, 4, 2021), https://www.huffpost.com/entry/building-codes-international-code-council_n_603fd6b4c5b682971504df8e; Alexander C. Kaufman, *With Time Running Out to Cut Carbon From Buildings, Industry Just Tightened Its Grip*, HUFFINGTON POST (July 1, 2021), https://www.huffpost.com/entry/building-codes-climate-change_n_60de150fe4b0ddef8b0e2a62; Emma Foehringer Merchant, *The Fight to Change US Building Codes*, INSIDE CLIMATE NEWS (Aug. 2, 2021), https://insideclimatenews.org/news/02082021/building-codes-california-climate-change/; Justin Gillis, *What Happens if Home Builders Get Their Way?*, N.Y. TIMES, January 25, 2021, at A19; Christopher Flavelle, *Secret Deal Helped Housing Industry Stop Tougher Rules on Climate Change*, N.Y. TIMES (Oct. 26, 2019), https://www.nytimes.com/2019/10/26/climate/building-codes-secret-deal.html; Christopher Flavelle, *Inside the Lobby Against Tougher Homes*, BLOOMBERG (July 6, 2016), https://www.bloomberg.com/view/articles/2016-07-06/inside-the-lobby-against-tougher-homes.

197. Letter from Ty Asfaw, National Association of Home Builders, to EPA, Re Draft NPDES General Permits for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems in Massachusetts North Coastal Watersheds (March 31, 2010), https://www3.epa.gov/region1/npdes/stormwater/ma/masms4comments/NAHBComments.pdf.

builders. In 2019, St. Louis County, Missouri, which had been using the 2009 version of the ICC codes, adopted the 2018 version, with its stronger energy efficiency rules.[198] This so outraged the local builders' association that it contributed $250,000—a very large amount for such a race—to the primary election campaign of the county executive's opponent.[199] The Sierra Club supported the incumbent; he won.[200] Lobbying by the builders, together with anti-regulatory sentiment, is a major reason that a few states have weakened their building codes despite facing stronger storms.[201]

Imposing local building codes can make a big difference. Nashville, Tennessee, has one of the nation's most restrictive codes, requiring the ground floor of new houses to be at least four feet above the expected height of a major flood.[202] However, many nearby towns lack any building codes, and those places suffered catastrophic flooding in August 2021, leaving at least twenty people dead.[203] In Florida, the state code requires more wind-resistant features for buildings in the southern part of the state, which was thought to be more prone to hurricanes, than in the north. However, in 2018, a Category 5 storm, Hurricane Michael, hit the Florida Panhandle (in the northern part of the state) and devastated several towns where weaker standards were in place.[204] Some houses there

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198. Jacob Barker, *After St. Louis County Updated Building Codes, Home Builders Put Big Money Behind Page, Dunaway Opponents*, ST. LOUIS POST-DISPATCH (July 5, 2020), https://www.stltoday.com/news/local/metro/after-st-louis-county-updated-building-codes-home-builders-put-big-money-behind-page-dunaway/article_427049f6-d0fe-56bb-80db-ba5bc9d279d0.html.

199. *Id.*

200. *Id.*; Jeremy Kohler, *Sam Page Wins Democratic Primary for St. Louis County Executive*, ST. LOUIS POST-DISPATCH (Aug. 5, 2020), https://www.stltoday.com/news/local/government-politics/sam-page-wins-democratic-primary-for-st-louis-county-executive/article_0a3d7ecd-7465-5927-86a5-4d000bcaf5b6.html.

201. Christopher Flavelle, *As Storms Get Stronger, Building Codes Are Getting Weaker*, BLOOMBERG (Mar. 19, 2018, 4:00 AM), https://www.bloomberg.com/politics/articles/2018-03-19/storm-prone-states-ease-off-building-codes-as-climate-risk-grows; Cameron Smith & Wiliam Booher, *When it Comes to Louisiana Floods, how much does a Foot Really Matter?*, NOLA.COM (Feb. 14, 2017), https://www.nola.com/opinions/guest-column-when-it-comes-to-louisiana-floods-how-much-does-a-foot-really-matter/article_a0ea1d2a-9498-5a36-a923-cd0829067643.html; David Boraks, *North Carolina Lawmakers Override Veto of Bill that Delays Building Code Updates*, WUNC 91.5 (Aug. 17, 2023, 5:44 PM), https://www.wunc.org/2023-08-17/north-carolina-lawmakers-override-veto-of-bill-that-delays-building-code-updates; *see also* INS. INST. FOR BUS. & HOME SAFETY, RATING THE STATES 2021: HURRICANE COAST 7 (2021).

202. Christopher Flavelle, *How Government Decisions Left Tennessee Exposed to Deadly Flooding*, N.Y. TIMES (Aug. 26, 2021), https://www.nytimes.com/2021/08/26/climate/tennessee-flood-damage-impact.html.

203. *Id.*

204. Daniel Cusick, *Michael Roared through Loophole in Vaunted Building Code*, E&E NEWS (Oct. 19, 2018, 7:36 AM), https://subscriber.politicopro.com/article/eenews/2018/10/19/michael-roared-through-loophole-in-vaunted-building-code-037044; Andres Viglucci et al., *Florida's Building Code is Tough, but Michael was Tougher. Is it Time for a Rewrite?*, MIA. HERALD (Oct. 13, 2018, 7:15 AM), https://www.miamiherald.com/news/state/florida/article219862625.html.

survived amid their toppled neighbors because they were erected by Habitat for Humanity, which goes beyond code with more secure ties of the roofs to the walls, thicker lumber, windstorm plywood and metal roofs.[205]

Houses can be constructed to withstand most hurricane winds, floods and wildfires, but few are built that way where it is not legally required.[206] Where states or localities have imposed especially strong standards, they have tended to withstand legal challenges.[207] In Connecticut, a couple whose home had been destroyed by Hurricane Sandy sought to erect a new house that would be elevated, and thus better able to withstand flooding.[208] The town zoning board denied a variance based on aesthetic grounds.[209] The court reversed the denial, finding that the increased height would reduce the hazard and warranted a variance.[210]

Strong codes make buildings much safer and are highly cost effective. The National Institute of Building Sciences has calculated that the benefit-cost ratio for adopting the ICC's 2018 codes versus codes represented by 1990-era design was eleven-to-one.[211] As noted, not all are happy with the ICC process, but its latest codes are much better than those that came before. FEMA advocates for strong building codes, and it calculated in 2020 that the ICC codes save a total of $1.6 billion in losses per year nationwide, and that number could grow above $4 billion by 2040 depending on how many structures are built to these codes.[212] There are national standards for mobile homes (since they are manufactured in different places

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205. Patricia Sullivan et al., *Houses Intact After Hurricane Michael were Often Saved by Low-Cost Reinforcements*, WASH. POST (Oct. 17, 2018, 8:19 PM), https://www.washingtonpost.com/politics/panhandle-houses-intact-after-michael-were-often-saved-by-low-cost-reinforcements/2018/10/17/d3ca97c0-d152-11e8-b2d2-f397227b43f0_story.html.

206. Christopher Flavelle, *Hurricane-Proof Homes Are Real. Why Isn't Anyone Buying Them?*, BLOOMBERG (June 20, 2018, 4:00 AM), https://www.bloomberg.com/news/features/2018-06-20/hurricane-proof-homes-are-real-why-isn-t-anyone-buying-them?embedded-checkout=true; Patricia Mazzei, *Among the Ruins of Mexico Beach Stands One House, Built 'for the Big One'*, N.Y. TIMES (Oct. 14, 2018), https://www.nytimes.com/2018/10/14/us/hurricane-michael-florida-mexico-beach-house.html.

207. Lindstrom v. Cal. Coastal Comm'n, 352 Cal. Rptr. 3d 817 (Cal. Ct. App. 2019); Martin v. Cal. Coastal Comm'n, 281 Cal. Rptr. 3d 343 (Cal. Ct. App. 2021).

208. *Id.*

209. *Id.*

210. Turek v. Zoning Bd. of Appeals of Milford, 66 Conn. L. Rptr. 353 (Conn. Sup. Ct. 2018).

211. NAT'L INST. OF BLDG. SCIS., NATURAL HAZARD MITIGATION SAVES: 2019 REPORT 393 (2019); *see* Kevin M. Simmons et al., *Economic Effectiveness of Implementing a Statewide Building Code: The Case of Florida*, 94 LAND ECON. 155 (2018).

212. FED. EMERGENCY MGMT. AGENCY, BUILDING CODES SAVE: A NATIONWIDE SURVEY 7-19 (2020); *see also* Thomas Frank, *Harvey Spared Homes Built to New Codes, Flood Maps*, E&E NEWS (Apr. 5, 2019, 7:12 AM), https://subscriber.politicopro.com/article/eenews/1060143891; Ralph Vartabedian & Ben Welsh, *How Houston's Newest Homes Survived Hurricane Harvey*, L.A. TIMES (Nov. 8, 2017), https://www.latimes.com/projects/la-na-houston-harvey-home-survivors/.

than where they are used).[213] These national standards were imposed after Hurricane Andrew destroyed 90% of the mobile homes in parts of Florida in 1992.[214] The homes built to those standards have proven themselves much more resilient to storms than older units.[215]

In a 2020 poll of a sample of 999 American adults, 84% of the respondents favored requiring new building codes to minimize flood damage, and 57% supported prohibiting development in flood-prone areas.[216] Several cities have adopted forward-looking building or zoning codes that are stronger than the ICC's with respect to climate resilience. These include New York City,[217] San Francisco,[218] and Boston.[219] Most of these apply only to buildings owned or financed by the city. However, in 2020, New Jersey Governor Phil Murphy issued an executive order instructing the state environmental department to draft new regulations that would require private developers to take into account the impact of climate change, including sea level rise.[220] The state finalized the rules in June 2023 after delays caused by lobbying by business groups.[221]

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213. National Manufactured Housing Construction and Safety Standards Act of 1974, 42 U.S.C. §§ 5401-5426; 24 C.F.R. §§ 3280, 3282, 3284-86, 3288, 3800 (2024).

214. Danielle Paquette, *Florida has 828,000 Mobile Homes. Less than a Third were Built to Survive a Hurricane*, WASH. POST, (Sep. 12, 2017, 11:51 AM), https://www.washingtonpost.com/news/wonk/wp/2017/09/12/florida-has-828000-mobile-homes-only-half-are-insured/; Cornell et al., *1992 Hurricane Andrew and Housing Sensitivity in South Florida*, INTEGRATE, https://www.e-education.psu.edu/earth107/node/1421 (last visited Apr. 17, 2024).

215. Joseph B. Treaster & Henry Fountain, *Considered Vulnerable, Mobile Homes Are Battered but Largely Intact*, N.Y. TIMES (Sep. 14, 2017), https://www.nytimes.com/2017/09/14/us/mobile-homes-florida-irma.html.

216. BO MACINNIS & JON A. KROSNICK, CLIMATE INSIGHTS 2020: SURVEYING AMERICAN PUBLIC OPINION ON CLIMATE CHANGE AND THE ENVIRONMENT – REPORT: NATURAL DISASTERS 8 (2020), https://media.rff.org/documents/Climate_Insights_Overall_Trends_Final_RCFAejQ.pdf.

217. N.Y.C. Council Int. 2092-2020 (2021) (enacted); Press Release, Office of the Mayor, New York City, Recovery For All of Us: New York City Adopts new Zoning Rules to Protect Coastal Areas From Climate Change (May 12, 2021), https://www.nyc.gov/office-of-the-mayor/news/356-21/recovery-all-us-new-york-city-adopts-new-zoning-rules-protect-coastal-areas-climate; N.Y.C. MAYOR'S OFF. OF RECOVERY & RESILIENCE, CLIMATE RESILIENCY DESIGN GUIDELINES, VERSION 4.1 (2022), https://www.nyc.gov/assets/sustainability/downloads/pdf/publications/CRDG-4-1-May-2022.pdf.

218. *See* CITY & CNTY. OF SAN FRANCISCO, GUIDANCE FOR INCORPORATING SEA LEVEL RISE INTO CAPITAL PLANNING IN SAN FRANCISCO: ASSESSING VULNERABILITY AND RISK TO SUPPORT ADAPTATION (2015), https://onesanfrancisco.org/sites/default/files/inline-files/Guidance-for-Incorporating-Sea-Level-Rise-into-Capital-Planning1.pdf.

219. *See* Tom Acitelli, *New Boston Development Rules Aim to Mitigate Climate Change Effects*, CURBED BOST. (June 15, 2018, 6:38 AM), https://boston.curbed.com/boston-development/2018/6/15/17467382/boston-development-rules-climate-change.

220. Tracey Tully, *Builders Must Consider Climate Change and Rising Seas, New Jersey Says*, N.Y. TIMES (Jan. 28, 2020), https://www.proquest.com/docview/2346152559?accountid=4840&sourcetype=Newspapers.

221. Jon Hurdle, *NJ Uses Climate Projections to Set New Restrictions on Developers*, NJ SPOTLIGHT NEWS (June 7, 2023), https://www.njspotlightnews.org/2023/06/nj-

Under the Obama administration, several federal agencies took steps to advance building resilience, but fell short of imposing binding regulations on purely private activities not receiving federal funding.[222] In January 2015, President Obama issued an executive order establishing a federal flood risk management standard for federally funded projects;[223] President Trump revoked that order in August 2017;[224] and President Biden canceled the revocation in January 2021.[225] Several FEMA programs require adherence to a variety of building code standards.[226]

To advocate for action in the new administration, shortly before President Biden was inaugurated, several groups petitioned the federal government to call for more stringent building standards for homes and infrastructure along rivers and coasts.[227] That has not happened, but in 2023 the Congressional Research Service noted that Congress has several options: it could consider requiring federally funded projects to rebuild to standards resilient to "future conditions," whenever possible, and could direct FEMA to incorporate estimations of future conditions into the agency's definition of resilience so that recipients of FEMA funding may use that money to build to codes and standards reflecting anticipated conditions on a certain future date.[228] They noted that "Congress could also incentivize, rather than require, such mitigation measures by authorizing higher federal cost shares, discounts on insurance premiums, tax credits, or access to additional grants or loans".[229]

The nonprofit U.S. Green Building Council, which maintains the influential Leadership in Energy and Environmental Design (LEED) standards, has a Climate Resilience Screening Tool.[230]

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development-climate-projections-restrictions-flood-levels-new-rule/. The rule itself is available at N.J. ADMIN. CODE §7:13 (2023), https://dep.nj.gov/wp-content/uploads/rules/adoptions/adopt-20230717a.pdf.

222. *Fact Sheet: Obama Administration Announces Public and Private Sector Efforts to Increase Community Resilience through Building Codes and Standards*, THE WHITE HOUSE (May 10, 2016), https://obamawhitehouse.archives.gov/the-press-office/2016/05/10/fact-sheet-obama-administration-announces-public-and-private-sector.

223. Exec. Order No. 13,690, 80 Fed. Reg. 6425 (Jan. 30, 2015).

224. Exec. Order No. 13,807, 82 Fed. Reg. 40463 (Aug. 15, 2017).

225. Exec. Order No. 13,990, 86 Fed. Reg. 8637 (Jan. 20, 2021).

226. Horn & Lee, *supra* note 192, at 16-17.

227. Christopher Flavelle, *Early Biden Climate Test: Groups Demand Tougher Rules on Building*, N.Y. TIMES (January 6, 2021), https://www.nytimes.com/2021/01/06/climate/flood-zone-building-restrictions.html.

228. Horn & Lee, *supra* note 192, at 33-34.

229. *Id.* at 33.

230. *LEED Climate Resilience Screening Tool for LEED v4 Projects*, U.S. GREEN BLDG. COUNCIL, https://www.usgbc.org/resources/leed-climate-resilience-screening-tool-leed-v4-projects (last visited Feb. 17, 2024); U.S. GREEN BLDG COUNCIL, MEASURING RESILIENCE: A GUIDE TO MEASURING COMMUNITY RESILIENCE IN LEED V4.1 CITIES AND COMMUNITIES: EXISTING (2019), https://www.usgbc.org/sites/default/files/Measuring-Resilience-Guide.pdf.

Among the factors to be considered in resilience to flooding are back-up power supplies and location of equipment above the 500-year floodplain, or sufficient protections if below that level.[231]

Not all flood hazards in buildings are due to inadequate building codes. When Hurricane Ida hit New York in 2021, eleven people drowned in basement apartments, including a two-year-old boy and an 86-year-old woman.[232] The apartments were illegal and were not in a FEMA special flood hazard area. More rapid communication of evacuation warnings might have saved some of these lives, but the tragedy was fundamentally about a crisis in affordable housing. At least 100,000 New Yorkers live in 50,000 or more illegal basement apartments.[233] Many of them are immigrants who cannot afford anything better and, as tenants of illegal apartments, have few legal rights. These units, often without windows or other ventilation, are an important part of the city's housing stock. This raises social issues beyond the scope of this article, but it should be noted.[234]

When a building is first erected, adding certain features to make it more resilient can often be done at modest cost, and the owners or purchasers will often be willing and able to pay. Retrofitting an existing building is another matter entirely. That has been a particularly acute issue for California ever since the San Francisco earthquake of 1906, but satisfactory remedies have been a long time coming. The experience with earthquake protection illustrates some of the possibilities and challenges.

In 1977 Congress passed the National Earthquake Hazards Reduction Act, creating an interagency program to develop nationally applicable seismic design guidelines for new buildings.[235] The ICC and the National Fire Protection Association have issued their own codes.[236] San Francisco, Los Angeles and some other

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231. *Design for Enhanced Resilience*, U.S. GREEN BLDG. COUNCIL, https://www.usgbc.org/credits/enhancedresilience (last visited Feb. 17, 2024).

232. Thomas Frank, *11 People Drowned in 'Minimal' Flood Zone During Ida*, E&E NEWS (Oct. 6, 2021).

233. THE NEW NORMAL, *supra* note 147 at 47.

234. *See* Sateesh Nori, *The Ground Beneath Our Feet: Basement Apartments, Climate Change, and Housing Inequality*, 30 N.Y.U. ENV'T L.J. 325 (2022); Stephanie Lai et al., *Life and Death Underground: N.Y. Immigrants Perish in Flooded Basements*, WASH. POST (Sept. 4, 2021), https://www.washingtonpost.com/politics/hurricane-ida-new-york-floods/2021/09/04/b661e9da-0ce7-11ec-a6dd-296ba7fb2dce_story.html; Venessa Wong, *The Housing Crisis led Them to Basement Apartments. Climate Change Flooded Them Out*, BUZZFEED NEWS (Mar. 4, 2022), https://www.buzzfeednews.com/article/venessawong/basement-apartment-flooding-housing-climate-change.

235. CONG. RSCH. SERV., R43141, THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM (NEHRP): ISSUES IN BRIEF (2018), https://crsreports.congress.gov/product/pdf/R/R43141/15.

236. *See Earthquake Safety and Recovery*, INT'L CODE COUNCIL, https://www.iccsafe.org/advocacy/safety-toolkits/earthquake-safety-and-resources/ (last visited Apr. 29, 2024); Shawn Mahoney, *Introduction to Seismic Protection for Sprinkler*

California cities have passed laws requiring the retrofitting of vulnerable buildings, but allowing generous amounts of time to comply (in some cases up to 25 years).[237] The courts have upheld the mandate to retrofit buildings, finding that the "fact that a building was constructed in accordance with all existing statutes does not immunize it from subsequent abatement as a public nuisance."[238] Building codes are the minimum requirements, but they are not necessarily enough.

In San Francisco, buildings that have missed their retrofit deadlines must be posted with large signs that say (in red lettering in English, Spanish and Chinese) "EARTHQUAKE WARNING!," with the legend: "This Building is in Violation of the Requirements of the San Francisco Building Code Regarding Earthquake Safety."[239] In Los Angeles, landlords and tenants equally share the costs, but the maximum rent increase is capped at $38 per month.[240] Landlords who fail to carry out the required retrofits have been held liable if a tenant is injured or killed in an earthquake.[241]

The state established the California Earthquake Authority to provide affordable earthquake insurance. Buildings that have been retrofitted get a premium discount.[242] The state also has an Earthquake Bolt + Brace program to provide homeowners up to $3,000 toward a residential seismic retrofit.[243]

One can imagine a system of standard codes, warning signs, subsidies, and insurance for building retrofits for flooding, similar to those for earthquakes.

Some relatively small retrofits can enhance the ability of buildings and infrastructure to defend against flooding. These

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Systems, NAT'L FIRE PROT. ASSOC. (Mar. 19, 2021), https://www.iccsafe.org/advocacy/safety-toolkits/earthquake-safety-and-resources/.

237. *See, e.g., Los Angeles*, SEISMIC ORDINANCES: WISS, JANNEY, ELSTNER ASSOC., https://www.seismicordinances.com/non-ductile-concrete-structures/los-angeles (last visited Apr. 29, 2024); *San Francisco*, SEISMIC ORDINANCES: WISS, JANNEY, ELSTNER ASSOC., https://www.seismicordinances.com/wood-frame-soft-story-structures/san-francisco (last visited Apr. 29, 2024).

238. City of Bakersfield v. Miller, 64 Cal.2d 93, 101 (1966).

239. Rong-Gong Lin II et al*., As San Francisco Rents Soar, Tenants still Willing to Pay for Earthquake Safety",* L.A. TIMES (Oct. 6, 2015), https://www.latimes.com/local/lanow/la-me-ln-quake-san-francisco-20151006-htmlstory.html.

240. Rosanna Xi, *L.A. Landlords and Tenants will Share Earthquake Retrofit Costs Under Deal Approved by City Council*, L.A. TIMES (Jan. 13, 2006), https://www.latimes.com/local/lanow/la-me-ln-retrofit-20160113-story.html#:~:text=After%20many%20housing%20studies%20and,increase%20of%20%2438%20per%20month.

241. Myrick v. Mastagni, 185 Cal. App. 4th 1082 (2010).

242. Press Release, Cal. Earthquake Auth., Earthquake Brace + Bolt Grants Now Available To More Eligible California Homeowners (Jan. 10, 2024), https://www.earthquakeauthority.com/press-room/press-releases/2024/earthquake-brace-bolt-grants-now-available-to-more-eligible-california-homeowners.

243. *What is EBB?,* EARTHQUAKE BRACE + BOLT, https://www.earthquakebracebolt.com/What-is-EBB (last visited Feb. 17, 2024).

include such items as closing off entrances through which water can enter, installing permanent or removeable flood shields, and adding household backwater valves to prevent sewer backups.[244] Several companies sell removable flood barriers that can be placed in front of doors or loading docks, or around entire buildings; a search on Google or Amazon for "removable flood barrier" yields advertisements for a wide variety of these devices. As one very low-tech measure, New York City offers sandbags to residents in advance of major storms.[245]

E. Accommodation

Accommodation measures allow the water to enter in a way that does little or no damage. Typical measures include elevating buildings on stilts or otherwise; putting electrical equipment, furnaces, air conditioning units, and the like at higher levels in buildings; and devoting the ground level to vehicles that can be moved away in the event of an oncoming storm.[246]

These measures are typically used to guard against coastal flooding. Sea level rise can be predicted, and storm surge can at least be foreseen, and so some new beach houses, for example, are designed to accommodate water intrusions at their lower level. Property owners rarely anticipate riverine or pluvial flooding, and building designs rarely reflect such accommodations.

FEMA rules now require that if a home has been substantially damaged (whether by a flood or otherwise), any reconstruction must include elevating the home so that its lowest floor (which includes basements but does not count parking or open storage) is at or above the base flood elevation, generally meaning the expected level of a flood that has at least a one percent chance of occurring a year, as

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244. FED. EMERGENCY MGMT. AGENCY, REDUCING FLOOD RISK TO RESIDENTIAL BUILDINGS THAT CANNOT BE ELEVATED (2015), https://www.fema.gov/sites/default/files/2020-07/fema_P1037_reducing_flood_risk_residential_buildings_cannot_be_elevated_2015.pdf; N.Y.C. DEP'T OF CITY PLAN., COASTAL CLIMATE RESILIENCY: RETROFITTING BUILDINGS FOR FLOOD RISK (2014), https://www.nyc.gov/assets/planning/download/pdf/plans-studies/retrofitting-buildings/retrofitting_complete.pdf.

245. THE NEW NORMAL, *supra* note 147 at 6-7, 17.

246. *See, e.g.,* JOSEPH W. LSTIBUREK, BLDG. SCI. CORP., DESIGNING FOR FLOODS (2022), https://buildingscience.com/sites/default/files/document/bsi-128_designing_for_floods_0.pdf; Ben Gibran, *Why We Should Build Cities on Stilts*, MEDIUM (June 29, 2020), https://medium.com/environmental-intelligence/why-we-should-build-cities-on-stilts-cd5bc7b1e6e6; Isabella O'Malley, *Climate change is transforming architecture: Think houses on stilts, with a rounded shape like a ship that can survive a hurricane*, FORTUNE (Nov. 6, 2023), https://fortune.com/2023/11/06/sustainable-hurricane-resistant-home-building-extreme-weather-climate-change/; COLORADO CITY REVAMPS FLOOD PLAIN MANAGEMENT AFTER SEVERE FLOOD, PEW CHARITABLE TRS. (Nov. 19, 2019), https://www.pewtrusts.org/-/media/assets/2019/11/colorado_fort_collins_brief_v5.pdf.

shown in the FEMA maps.[247] Some critical structures such as hospitals, nursing homes, data storage centers, and power generating centers must be elevated even higher if their reconstruction is to receive FEMA funds.[248] The Homeowner Flood Insurance Affordability Act of 2014 allows homeowners to use "alternative mitigation measures" if it is not possible to elevate the homes.[249] Some cities have had to amend their zoning or building codes to allow buildings to meet the FEMA standards,[250] and several states and localities have even more stringent rules.[251]

FEMA does not require buildings that have not been substantially damaged to be elevated, but if they are elevated, flood insurance can be purchased at a significant discount.[252] Between April 1, 2021, and April 1, 2023, FEMA phased in its "Risk Rating 2.0" policy that raises flood insurance rates a considerable amount in many places.[253] FEMA says the rates reflect multiple factors, including "flood frequency, multiple flood types—river overflow, storm surge, coastal erosion and heavy rainfall—and distance to a water source along with property characteristics such as elevation and the cost to rebuild,"[254] though it is not clear just how heavy rainfall is reflected. The increased rates have led hundreds of thousands of homeowners to drop their coverage[255] and have drawn

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247. *Frequently Asked Questions About Building Science: When Does a Flood-Damaged Home Need to be Elevated?*, FED. EMERGENCY MGMT. AGENCY, https://www.fema.gov/emergency-managers/risk-management/building-science/faq (Nov. 16, 2021); FED. EMERGENCY MGMT. AGENCY, FOUNDATION REQUIREMENTS AND RECOMMENDATIONS FOR ELEVATED HOMES (2013), https://www.fema.gov/sites/default/files/documents/fema_hurricane-sandy-recovery-fact-sheet.pdf.

248. FED. EMERGENCY MGMT. AGENCY, POLICY NO. 104-22-0003, PARTIAL IMPLEMENTATION OF THE FEDERAL FLOOD RISK MANAGEMENT STANDARD FOR PUBLIC ASSISTANCE (INTERIM) (2022), https://www.fema.gov/sites/default/files/documents/fema_fp-104-22-0003-partial-implemetnation-ffrms-pa-interim.pdf; Thomas Frank, *On This Flood Policy, Biden and Trump Agree*, CLIMATEWIRE (June 16, 2022), https://www.eenews.net/articles/on-this-flood-policy-biden-and-trump-administrations-agree/.

249. REDUCING FLOOD RISK TO RESIDENTIAL BUILDINGS THAT CANNOT BE ELEVATED, *supra* note 244.

250. N.Y.C. Dep't of City Plan., Proposed Flood Resilience Text Amendment (2013), https://www.nyc.gov/assets/planning/download/pdf/plans/flood-resiliency/presentation.pdf.

251. *E.g.*, New York City Building Code, Appendix G – Flood-Resistant Construction, https://www.nyc.gov/assets/buildings/apps/pdf_viewer/viewer.html?file=2022BC_AppendixG_FloodResistantWBwm.pdf&section=conscode_2022.

252. *See* REDUCING FLOOD RISK TO RESIDENTIAL BUILDINGS THAT CANNOT BE ELEVATED, *supra* note 244, at 2, 7-9; DISCOUNT EXPLANATION GUIDE, FED. EMERGENCY MGMT. AGENCY (2022), https://www.fema.gov/sites/default/files/documents/fema_discount-Explanation-Guide.pdf.

253. Christopher Flavelle, *The Cost of Insuring Expensive Waterfront Homes Is About to Skyrocket*, N.Y. TIMES (Sept. 24, 2021), https://www.nytimes.com/2021/09/24/climate/federal-flood-insurance-cost.html.

254. *NFIP's Pricing Approach*, NAT'L EMERGENCY MGMT. AGENCY, https://www.fema.gov/es/node/467888 (last visited Apr. 17, 2024).

255. Thomas Frank, *Hundreds of Thousands Drop Flood Insurance as Rates Rise*, CLIMATEWIRE (Aug. 17, 2022), https://www.eenews.net/articles/hundreds-of-thousands-drop-flood-insurance-as-rates-rise/.

considerable controversy. As this is written in the autumn of 2023, Congress is considering alterations to the flood insurance program that may again alter the rate structure.[256] A suit brought by ten states challenging the Risk Rating 2.0 policy is pending in federal court in Florida.[257] Balancing the desire to keep flood rates affordable, on the one hand, and generating enough premiums for the National Flood Insurance Program to remain solvent without additional Congressional subsidies, on the other hand, has been a constant and still unresolved struggle.

One common method of erecting buildings in flood-prone areas is called "fill-and-build". It involves clearing the site of vegetation, importing fill to raise the land surface, and putting the building on top, typically on a concrete slab. This method creates new impermeable surface and merely moves the floodwater elsewhere. Several cities have begun banning it[258] and FEMA's Technical Mapping Advisory Board has recommended that it be limited.[259] It is an "accommodation" method for the property owner, but to the detriment of the neighbors.

In sum, true accommodation, such as raising buildings on stilts with no sensitive uses at the ground level, is a well-accepted method of coping with floods but it is of little, if any, use with respect to pluvial flooding.

F. Retreat

"Managed retreat" is the idea of intentionally moving people and assets away from areas that are at high risk of flooding or other natural hazards, and not allowing new construction in those areas. In 2018, the National Climate Assessment stated that retreat will be "unavoidable" for some coastal areas in the United States.[260]

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256. National Flood Insurance Program Reauthorization and Reform Act of 2023, S. 2142, 118th Congress (2023); Thomas Frank, *Flood Insurance Rates will Soar in Some Areas, FEMA Says,* CLIMATEWIRE (May 10, 2023), https://www.eenews.net/articles/flood-insurance-rates-will-soar-in-some-areas-fema-says/.

257. Thomas Frank, *10 States sue FEMA to Block Higher Flood Insurance Rates*, CLIMATEWIRE (June 2, 2023), https://subscriber.politicopro.com/article/eenews/2023/06/02/10-states-plan-to-sue-fema-to-block-new-flood-insurance-rates-00099793.

258. Daniel Cusick & Thomas Frank, *Dangerous 'Fill and Build' Floodplain Policy Should Be Scrapped, Experts Say*, SCI. AM. (Nov. 1, 2023), https://www.scientificamerican.com/article/dangerous-fill-and-build-floodplain-policy-should-be-scrapped-experts-say/; Daniel Cusick, *Drowning in Dirt: How Homebuilders are Making Floods Worse*, CLIMATEWIRE (May 9, 2022), https://www.eenews.net/articles/drowning-in-dirt-how-homebuilders-are-making-floods-worse/; ANTHROPOCENE ALL., SAVE OUR COMMUNITIES: BAN "FILL AND BUILD", https://anthropocenealliance.org/wp-content/uploads/2021/01/Factsheet-BanFillandBuild.pdf (last visited Feb. 17, 2024).

259. Cusick & Frank, *supra* note 258.

260. FOURTH NATIONAL CLIMATE ASSESSMENT, *supra* note 15, at 64.

Managed retreat has received a great deal of attention in the academic and planning communities; it is the subject of numerous conferences, articles and white papers.[261] However, its actual application has been limited. Local politicians almost always resist the idea; it would reduce their electorate and their tax base, and their constituents seldom want to move.[262] Inducing people to leave their homes usually requires the government to buy them out, which is a very expensive proposition if done at scale. Between 1989 and 2019, FEMA has funded managed retreat for around 40,000 properties – less than 0.1% of the more than 49 million housing units in shoreline counties.[263]

Difficult as it is to persuade people and their elected representatives that it is wise to move when their homes are in a designated flood hazard area, it appears to be virtually impossible to do so in the absence of such a designation (or at least a history of damaging floods, rather than just one damaging flood). There seem to be few, if any, examples of managed retreat happening as a result of pluvial flooding, and thus this technique does not have much place in the toolkit of legal techniques to deal with urban flooding from pluvial, as opposed to coastal or riverine, flooding.

IV. FINANCING

Coping with urban flooding is extremely expensive. There is no overall estimate of what it would take to prepare adequately. One 2017 study proposed scenarios for New York City based primarily on green infrastructure.[264] It estimated that designs for a 100-year storm (as then defined) would require approximately $370 million in capital costs and $1.7 million/year in operational points.[265] If designed for a 10-year storm, the estimated capital costs were $110 million.[266] The study said that New York City's 10-year capital strategy designed to safeguard roughly the same area to a five-year storm using grey infrastructure is about twice the cost of the $370 million green infrastructure scenario.[267] The study estimated that the $370 million scenario would yield $603 million in benefits

261. *See, e.g.*, *Managed Retreat Conference*, COLUMB. UNIV. CLIMATE ADAPTATION INITIATIVE, https://adaptation.ei.columbia.edu/retreat/home.

262. Zoya Teirstein, *Retreat from coastlines? Politicians don't want to talk about it.*, GRIST (Apr. 8, 2021), https://grist.org/climate/retreat-from-coastlines-politicians-dont-want-to-talk-about-it/.

263. A.R. Siders, *Managed Retreat in the United States*, 1 ONE EARTH 216, 216 (2019).

264. *See* RAMBOLL A/S, N.Y.C. DEP'T OF ENV'T PROT., CLOUDBURST RESILIENCY PLANNING STUDY: EXECUTIVE SUMMARY (2017), https://www.nyc.gov/assets/dep/downloads/pdf/climate-resiliency/nyc-cloudburst-study.pdf.

265. *Id.* at 19.

266. *Id.*

267. *Id.*

(including avoided physical damages, output loss, injuries, mental stress and anxiety, and environmental costs).[268]

A different study for New York City found that all fourteen of its wastewater treatment plants and 58 of its 96 pumping stations are at risk, and that a 100-year flood with thirty inches of sea level rise (quite possible by the end of this century) could cause more than $2 billion in damage.[269] The study recommended protective measures totaling $315 million.[270] Yet another study for New York City included far higher costs for long-term reduction in combined sewer overflows.[271]

Whatever the city and the plan, the costs of coping with urban flooding are high. A number of methods are being used to pay these costs.

A. Water Charges

Cities typically charge property owners for their water use. In some places it is a flat fee; in other places, the charge is based on usage. The revenues go to both operating and capital costs. Many cities are struggling because they find that the water charges are too low to pay for repairs or replacement of aging infrastructure, even without respect to increased flooding due to climate change.[272]

B. State Appropriations

Many states have provided direct appropriations for grey and green infrastructure to control flooding.[273]

C. Bond Issues

Rather than paying when the costs of flood control are incurred, many states issue bonds to pay for the capital costs over time. For example, in 2022 the voters of New York State approved the $4.2 billion Clean Water, Clean Air and Green Jobs Environmental

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268. *Id.* at 20.

269. N.Y.C. DEP'T OF ENV'T PROT., NYC STORMWATER RESILIENCY PLAN: CLIMATE RISK ASSESSMENT AND ADAPTATION STUDY 2 (2013), https://www.nyc.gov/assets/dep/downloads/pdf/climate-resiliency/climate-plan-single-page.pdf.

270. *Id.*

271. NEW YORK CITY STORMWATER RESILIENCY PLAN, *supra* note 40, at 5-6.

272. STANTEC, N.Y.C. DEP'T OF ENV'T PROT.: BEPA-SRSA COMPARATIVE RATE STRUCTURE ANALYSIS FINAL REPORT 38 (2021), https://www.nyc.gov/assets/dep/downloads/pdf/whats-new/programs-initiatives/bepa-srsa-comparative-rate-structure-analysis.pdf.

273. LAURA LIGHTBODY, MATT FUCHS, & SARAH EDWARDS, PEW CHARITABLE TRS., MITIGATION MATTERS: POLICY SOLUTIONS TO REDUCE LOCAL FLOOD RISK 2 (2019), https://www.pewtrusts.org/-/media/assets/2019/11/flood_overview_brief_final.pdf.

Bond Act; about $250 million of this is dedicated to local stormwater projects, especially in areas prone to flooding.[274]

D. Federal Assistance

FEMA has several programs that can help communities reduce or prepare for floods. The Flood Mitigation Assistance Grant Program provides funding to states, local communities, federally recognized tribes and territories for projects to reduce or eliminate the risk of repetitive flood damage to buildings.[275] It depends on annual appropriations from Congress and is only available to communities that participate in the National Flood Insurance Program.[276] A larger program, Building Resilient Infrastructure and Communities (BRIC) was established as part of the Disaster Recovery Reform Act of 2018[277] and provides that up to six percent of federal disaster assistance may go to preparing for future disasters.[278] FEMA has indicated that nature-based solutions may be eligible for funding under either of these programs, but both operate on a competitive basis and such solutions and other stormwater-related projects will not necessarily receive funding each year.[279]

As noted previously, the IIJA provides approximately $34.7 billion toward enhanced flood mitigation, resilience, and disaster preparedness programs.[280]

The Federal Water Pollution Control Act Amendments of 1972 (part of what is now the Clean Water Act) created a program to pay for 75% (reduced to 55% in 1981) of the costs of building wastewater

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274. Brendan J. Lyons, *New York voters overwhelmingly pass Environmental Bond Act*, ALBANY TIMES UNION (Nov 9, 2022), https://www.timesunion.com/state/article/New-York-Environmental-Bond-Act-17567482.php.

275. *Flood Mitigation Assistance Grant Program*, FED. EMERGENCY MGMT. AGENCY, https://www.fema.gov/grants/mitigation/floods (last visited Feb. 18, 2024).

276. FED. EMERGENCY MGMT. AGENCY, HAZARD MITIGATION ASSISTANCE PROGRAM AND POLICY GUIDE 33 (2023), https://www.fema.gov/sites/default/files/documents/fema_hma-program-policy-guide_032023.pdf.

277. Disaster Recovery Reform Act of 2018, Pub. L. No. 115-254, 132 Stat. 3438-3469 (2018); Carlos Martin et al., *Federal disaster management is a confusing patchwork. Reforming FEMA and improving interagency coordination can fix it*, BROOKINGS INST. (Aug. 3, 2023), https://www.brookings.edu/articles/federal-disaster-management-is-a-confusing-patchwork-reforming-fema-and-improving-interagency-coordination-can-fix-it/.

278. FED. EMERGENCY MGMT. AGENCY, HAZARD MITIGATION ASSISTANCE PROGRAM AND POLICY GUIDE 32, *supra* note 276.

279. FED. EMERGENCY MGMT. AGENCY, BUILDING COMMUNITY RESILIENCE WITH NATURE-BASED SOLUTIONS 26 (2021), https://www.fema.gov/sites/default/files/documents/fema_riskmap-nature-based-solutions-guide_2021.pdf.

280. *The Bipartisan Infrastructure Bill Will Create Flood-Resilient Communities – Here's How,* AM. FLOOD COAL. (Nov. 15, 2021), https://floodcoalition.org/2021/11/the-bipartisan-infrastructure-bill-will-create-flood-resilient-communities-heres-how/.

treatment plants and sewers.[281] Congress ultimately appropriated nearly $41 billion for this program, making it the largest nonmilitary public works program since the Interstate Highway System.[282] The Reagan Administration targeted this program for budget cuts, and in 1987 Congress acted to phase out the grant program and replace it with a revolving loan program.[283] As a result, federal assistance for wastewater treatment systems became considerably less generous.[284] Several other agencies run smaller programs that include wastewater facilities among the eligible grants.[285]

E. Special State Funds

Several states have established special funds to undertake flood mitigation projects. Iowa established a flood mitigation fund, using a local sales tax, to pay for flood protection measures.[286] Indiana[287] and Maryland[288] both have state-funded revolving fund programs for political subdivisions undertaking flood control projects. The Texas Flood Infrastructure Fund, established in 2019 through an amendment to the state constitution, provides financial support to communities for drainage, flood mitigation, and flood control projects.[289]

F. Stormwater Fees

At least two-thousand U.S. cities in the forty-eight contiguous states and Washington, D.C., have "stormwater utilities" that charge stormwater fees to property owners, mostly to pay for grey

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281. *See* JONATHAN L. RAMSEUR, CONG. RSCH. SERV., R46471, FEDERALLY SUPPORTED PROJECTS AND PROGRAMS FOR WASTEWATER, DRINKING WATER, AND WATER SUPPLY INFRASTRUCTURE 1 (2022), https://crsreports.congress.gov/product/pdf/R/R46471.

282. *Id.*

283. *Id.*

284. JONATHAN L. RAMSEUR & MARY TIEMANN, CONG. RSCH. SERV., 96-647, WATER INFRASTRUCTURE FINANCING: HISTORY OF EPA APPROPRIATIONS 1 (2019), https://www.everycrsreport.com/files/20190410_96-647_981dcf4b10a712aad371e7b8bce38a4430f1608d.pdf.

285. *See* RAMSEUR, *supra* note 281, at 1.

286. *Iowa Flood Mitigation Board*, IOWA DEP'T OF HOMELAND SEC. & EMERGENCY MGMT., https://homelandsecurity.iowa.gov/flood-mitigation-board/ (last visited Feb. 13, 2024).

287. *Flood Control,* IND. FIN. AUTH., https://www.in.gov/ifa/srf/flood-control/ (last visited Feb. 13, 2024).

288. *Resilient Maryland Revolving Loan Fund,* MD. DEP'T OF EMERGENCY MGMT., https://mdem.maryland.gov/Pages/rlf-fund.aspx (last visited Feb. 13, 2024).

289. *Flood Infrastructure Fund (FIF),* TEX. WATER DEV. BD., https://www.twdb.texas.gov/financial/programs/FIF/index.asp (last visited Feb. 13, 2024); *see also Texas Flood Insurance Fund*, ADAPTATION CLEARINGHOUSE, (2019), https://www.adaptationclearinghouse.org/resources/texas-flood-infrastructure-fund-a.html.

and green infrastructure.[290] The fees are typically based on the amount of impermeable surface, and the fees go down if more surface is permeable (think grass or gravel rather than cement or asphalt, or porous paving blocks rather than marble).[291] Depending on how they are structured, these fees provide a stable source of revenue for the needed work and also give property owners an incentive to properly manage their stormwater.[292]

Washington, D.C., has established a Stormwater Retention Credit market; if developers cannot capture enough of the rain that falls on their properties to meet the standards, they can buy credits from owners of properties that have more permeable surface than they need to absorb their own stormwater.[293] StormStore in Cook County, Illinois, a partnership of The Nature Conservancy and the Metropolitan Planning Council, is similar.[294] Landowners in certain Chicago suburbs who are able to manage stormwater by installing rain gardens, bioswales, or other natural features can sell stormwater credits to developers in the same watershed who cannot manage enough stormwater on their own property to meet requirements.[295]

G. Incentives

Vermont's Emergency Relief and Assistance Fund provides state funding to match federal public assistance after federally-declared disasters, and it contributes extra money to communities that have taken specific steps to reduce flood damage.[296] Arkansas gives income tax credits to taxpayers who develop, restore, or conserve

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290. Warren Campbell & Jerry Bradshaw, *Western Kentucky University Stormwater Utility Survey 2021*, W. KY. UNIV. SEAS FAC. PUBL'NS (2021) (noting that all 48 contiguous states have at least one stormwater utility); *The Property Owner Guide to Stormwater Utility Fees*, RAINPLAN, https://myrainplan.com/what-are-stormwater-utility-fees/#:~:text=Stormwater%20fees%20are%20a%20new,charges%20on%20your%20utility%20bill (asserting that more than 2,000 U.S. cities have a stormwater utility).

291. Warren Campbell & Emily G. Davis, *Western Kentucky University Stormwater Utility Survey 2023,* W. KY. UNIV.:SEAS FAC. PUBL'NS 19 (2023).

292. Nathaniel R. Mattison, *The Legal Case for Stormwater Fees in New York City*, 86 ALB. L. REV. 4 687, 694 (2023).

293. *Stormwater Credit Trading: Lessons from Washington, D.C.*, METRO. PLAN. COUNCIL: NEWS BLOG (Jan. 23, 2019), https://www.metroplanning.org/news/8671/.

294. *See* STORMSTORE, https://www.stormstore.org/ (last visited Feb. 13, 2024).

295. *Building a StormStore for Cook County*, THE NATURE CONSERVANCY (May 5, 2020), https://www.nature.org/en-us/about-us/where-we-work/united-states/illinois/stories-in-illinois/stormwater-trading/.

296. *Emergency Relief and Assistance Fund,* STATE OF VT. FLOOD READY, https://floodready.vermont.gov/find_funding/emergency_relief_assistance (last visited Feb. 13, 2024).

wetland and riparian zones.[297] The village of South Holland, Illinois provides rebates to residents to undertake flood control projects on their property.[298]

As noted above, the National Flood Insurance Program was intended to provide local governments with incentives to adopt land use and building rules that could reduce flooding, but it has worked poorly.

H. Landlords

Building owners may, of course, pay for flood protections for their buildings. Unless required by building codes or other legal mandates, few are likely to spend much of their own money on such work, and it would be difficult for them to pass the costs along to any but the wealthiest tenants. Imposing requirements on new construction is rather straightforward; mandating retrofits of existing buildings is far more difficult.

The financing of building retrofits received stark attention in a situation unrelated to flooding—the July 2021 collapse of a condominium building in Surfside, Florida, that killed ninety-eight people.[299] Engineers had been warning for years that the building needed structural repairs, but it took several years (and much internal fighting) for the condominium board to approve a $15 million special assessment, and the work was not completed in time.[300] The members of these boards receive great pressure from fellow owners not to spend everyone's money on repairs.[301] Among the proposals that have emerged from this disaster are leaving the final decisions on repairs to engineers, not board members; requiring ample reserves to be set aside in segregated accounts to ensure there will be money to pay for repairs needed for safety, without the need for a huge one-time special assessment; more frequent and intense government inspections; requiring buildings along coastlines to have waterproofing; and creating government-backed funds to assist with financing the repairs.[302] The "business judgment rule" (insulating corporate boards from liability for

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297. *Wetland & Riparian Zones Tax Credit Program,* ARK. DEP'T OF AGRIC., https://www.agriculture.arkansas.gov/natural-resources/divisions/water-management/wetlands-riparian-zone-tax-credit-program/ (last visited Feb. 15, 2024).

298. *Flood Assistance,* VILL. OF S. HOLLAND, https://www.southholland.org/departments/public_works/flood_resources/flood_assistance/ (last visited Feb. 15, 2024).

299. *See* David B. Haber, *I Know All About Condo Living. Let's Fix It*, N.Y. TIMES, July 31, 2021, at A19; Michael LaForgia et al., *Lax Enforcement Let South Florida Towers Skirt Inspections for Years*, N.Y. TIMES (July 4, 2021), https://www.nytimes.com/2021/07/04/us/south-florida-condo-maintenance-violations.html.

300. *See* Haber, *supra* note 299, at A19.

301. *Id.*

302. *Id.*; LaForgia et al., *supra* note 299.

decisions that seemed rational when made, even if wrong) provides protection to condominium board members,[303] but the massive litigation that has followed the Surfside collapse may test the limits of this insulation.[304] It is not yet clear whether climate change played a role in that collapse,[305] but many buildings along coastlines will face increasing perils from rising seas, and condo boards (as well as other building owners, tenants, and financiers) will face very tough decisions.

Programs have been proposed (but not adopted) to provide low-interest loans to landlords so that they can retrofit their buildings to provide greater flood protection, to be repaid by surcharges on property tax bills, similar to the PACE (Property Assisted Clean Energy) program for energy efficiency retrofits.[306] Another proposal has been to reduce property taxes for low-income homeowners for capital upgrades to address flooding-related issues.[307]

I. Litigation

About two dozen cases are currently pending in the U.S. brought mostly by states and cities against fossil fuel companies seeking money damages to help the plaintiffs pay for adaptation measures.[308] The cases were held up for several years by disputes over whether they belong in state court (where the plaintiffs prefer) or in federal court (where the defendants prefer).[309] All the Court of Appeals decisions said the cases should be in state court, and in 2022 the Supreme Court refused to take up any of these cases, so they have remained in state court so far.[310] As this is written, there is considerable motion practice about the fate of these cases, and it

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303. Deborah Koplovitz & Andrew Freedland, *Cooperatives and Condominiums: Board Repair Obligations, Revisited*, 266 N.Y. L.J. 3 (Sept. 2, 2021).

304. *See, e.g.*, Curt Anderson, *$997 million settlement reached in Surfside condo collapse lawsuit, lawyers say*, USA TODAY (May 11, 2022), https://www.usatoday.com/story/news/nation/2022/05/11/surfside-condo-collapse-class-action-lawsuit-families-victims/9738407002/.

305. *See* Randall W. Parkinson, *Speculation on the Role of Sea-level Rise in the Tragic Collapse of the Surfside Condominium (Miami Beach, Florida U.S.A.) was a Bellwether Moment for Coastal Zone Management Practitioners*, 215 OCEAN & COASTAL MGMT. (2021).

306. THE NEW NORMAL, *supra* note 147, at 62-63.

307. *Id.* at 61.

308. *See* MICHAEL BERGER & MARIA ANTONIA TIGRE, U.N. ENV'T PROGRAMME & SABIN CTR. FOR CLIMATE CHANGE L., GLOBAL CLIMATE LITIGATION REPORT: 2023 STATUS REVIEW 53 (2023), https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=1203&context=sabin_climate_change (discussing pending litigation).

309. *See id.*

310. *Id.*

is highly uncertain whether they will ultimately become a source of funding for adaptation.[311]

Several efforts to use the courts to force municipalities to undertake stormwater and other flood improvements have failed.[312]

J. Nonprofits

Some nonprofits are playing a role. For example, a public benefit company called MyStrongHome strengthens roofs so that they can better endure extreme weather.[313] This work lowers insurance premiums, and the company reduces the homeowners' up-front cost of the new roof by capturing some of the premium savings.[314] Several foundations have assisted with the financing.[315]

In sum, numerous sources of money are available to help with flood protection measures, but it is not clear whether they add up to enough to fully address the problem.

V. SETTING PRIORITIES

As we have seen, most of the facilities dealing with urban flooding—whether grey or green—are owned or controlled by cities. City governments must make many decisions concerning building or modifying these facilities, including what, when and where.

Important technical steps in making these decisions include estimating future rainfall levels, especially in view of climate change; determining the impacts of nearby rivers, lakes, and oceans on flooding; and estimating how much of the rainwater will be absorbed into the ground and how much will make its way into the pipes, based on such factors as the topography and the permeability

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311. *Id.*; *see also* City & Cnty. of Honolulu v. Sunoco LP, 537 P.3d 1173 (Haw. 2023) (denying defendants' motions to dismiss in one of these cases, allowing it to go to trial). At the time of publication, there is a pending petition for certiorari in the *Sunoco* case. *See* Petition for Writ of Certiorari, Sunoco LP, No. 23-947 (Mar. 1, 2024).

312. *See* Harris Cnty. Flood Control Dist. v. Kerr, 499 S.W.3d 793 (Tex. 2016); *see also* Jennifer Klein, SABIN CTR. FOR CLIMATE CHANGE L., *Potential Liability of Governments for Failure to Prepare for Climate Change* (2015), https://scholarship.law.columbia.edu/cgi/viewcontent.cgi?article=1124&context=sabin_climate_change; *see also* ALICE C. HILL & LEONARDO MARTINEZ-DIAZ, BUILDING A RESILIENT TOMORROW: HOW TO PREPARE FOR THE COMING CLIMATE DISRUPTION 40-46 (2020); Michael B. Gerrard, *Governmental and Private Liability for Flooding*, 246 N.Y. L.J. (Nov. 10, 2011), https://climate.law.columbia.edu/sites/default/files/content/docs/Michael%20Gerrard/Gerrard-2011-11-GovernmentPrivate-Liability-for-Flooding.pdf.

313. *Calvert Foundation Announces $8 Million Investment in MyStrongHome*, PR NEWSWIRE (May 30, 2017, 12:00 PM), https://www.prnewswire.com/news-releases/calvert-foundation-announces-8-million-investment-in-mystronghome-300465403.html.

314. *Id.*

315. *Id.*

of the ground surface (such as how much of it is covered with buildings or pavement). But estimates of future rainfall are the foundation of their calculations.[316] These estimates are also used to design roads, train tracks, concentrated animal feeding operations, and many other facilities. These are all decisions to be made by technical experts like engineers and hydrologists. These experts must also advise on how much the work would cost, how long it would take, and how much disruption it will cause. For much green infrastructure, the availability of land is an especially important factor.

Beyond these essentially technical matters, political judgments must be made. To the extent that dedicated grant funds are not available or sufficient, how much of the city's budget should go to controlling flooding, in view of all the competing demands on the budget? Should taxes or sewer fees be raised? Should the expense be borne now or passed on to future officials/taxpayers/generations through borrowing? Should some parts of the city receive more or faster protections than others?

One especially fraught issue is tolerance for risk. How much flooding is too much? One bit of legal guidance is found in the FEMA regulations that define a "critical action" as "an action for which even a slight chance of flooding is too great." These include the construction of facilities that "produce, use or store highly volatile, flammable, explosive, toxic or water-reactive materials," "hospitals and nursing homes, and housing for the elderly, which are likely to contain occupants who may not be sufficiently mobile to avoid the loss of life or injury during flood and storm events," emergency operations centers, and electricity generating plants. For these, even a floodplain with a one-in-five-hundred chance of flooding in a given year may be too dangerous.[317] For less sensitive uses, more frequent flooding is considered tolerable.

Beyond that, little legal guidance is available. Copenhagen's Cloudburst Management Plan, which has received a good deal of positive attention in the climate adaptation community, attempts to quantify the goals: "In the future: sewer discharge will be allowed to reach ground level once every ten years, and average water levels will be allowed to exceed ground level by ten centimeters once every 100 years, excepting areas specifically designated for flood control

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316. GERALD E. GALLOWAY ET AL., THE GROWING THREAT OF URBAN FLOODING: A NATIONAL CHALLENGE 33 (2018), https://cdr.umd.edu/sites/cdr.umd.edu/files/resource_documents/COMPRESSEDurban-flooding-report-online-compressed-0319.pdf.

317. 44 C.F.R. § 9.4.

storage."[318] Recognizing that not everything can be done at once, the plan also listed "essential elements to be considered when ranking the initiative," as follows: "[h]igh risk areas;" "[a]reas where measures are easy to implement;" "[a]reas with ongoing urban development projects" (i.e., if the flood-related work can be done in conjunction with other ongoing construction); and "[a]reas where synergistic effects can be gained."[319]

To these items, one should also add, for example, addressing existing disproportionate exposure of disadvantaged communities to flood risks; reducing adverse health effects of exposure to untreated sewage; and positive and negative effects of green infrastructure on biodiversity.

While Copenhagen's goals are laudable, it is not at all clear whether they will be met, there or elsewhere, especially in the long term in view of climate trends. That makes conscious choices all the more important. At the same time that cities are coping with pluvial flooding (and perhaps coastal and riverine flooding, depending on their location), they will also have to deal with the other pressures worsened by climate change such as heat waves and wildfires, on top of the pressing need to transition their energy systems away from fossil fuels.

One factor that is important in all these measures is the availability of money. While Congress has sometimes been generous to localities that have suffered natural disasters, it cannot be counted on to keep paying for disaster preparation and response everywhere, in a future where the entire country is facing climate-related perils of various sorts, and where the accumulated federal debt is already high. State and local governments will shoulder most of the burden, and they will have to take a hard look at the amount and distribution of taxes they impose. When they do, they should also consider what happens if they do not gather and spend this money, since we know that it is far cheaper to prepare for disasters than to recover from them, if recovery is even possible.

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318. CITY OF COPENHAGEN, THE CITY OF COPENHAGEN CLOUDBURST MANAGEMENT PLAN 2012 12 (2012), https://en.klimatilpasning.dk/media/665626/cph_-_cloudburst_management_plan.pdf.

319. *Id*. at 14.