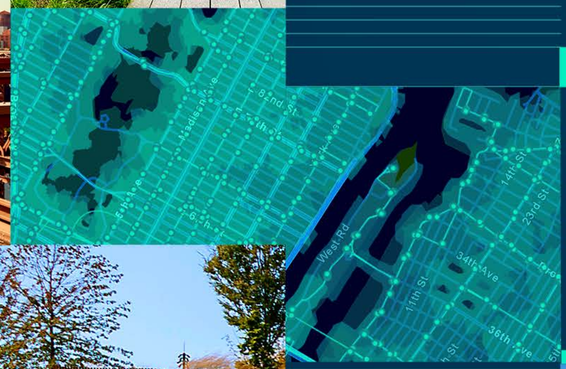
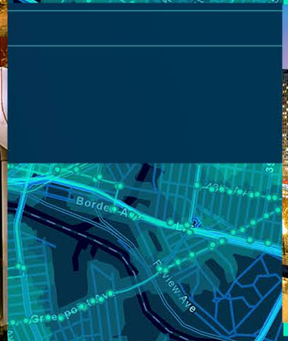
ACCELERATING ACTION FOR RESILIENT, EFFICIENT URBAN INFRASTRUCTURE

How a Geographic Approach Strengthens Operational Intelligence and Coordinates Climate Action







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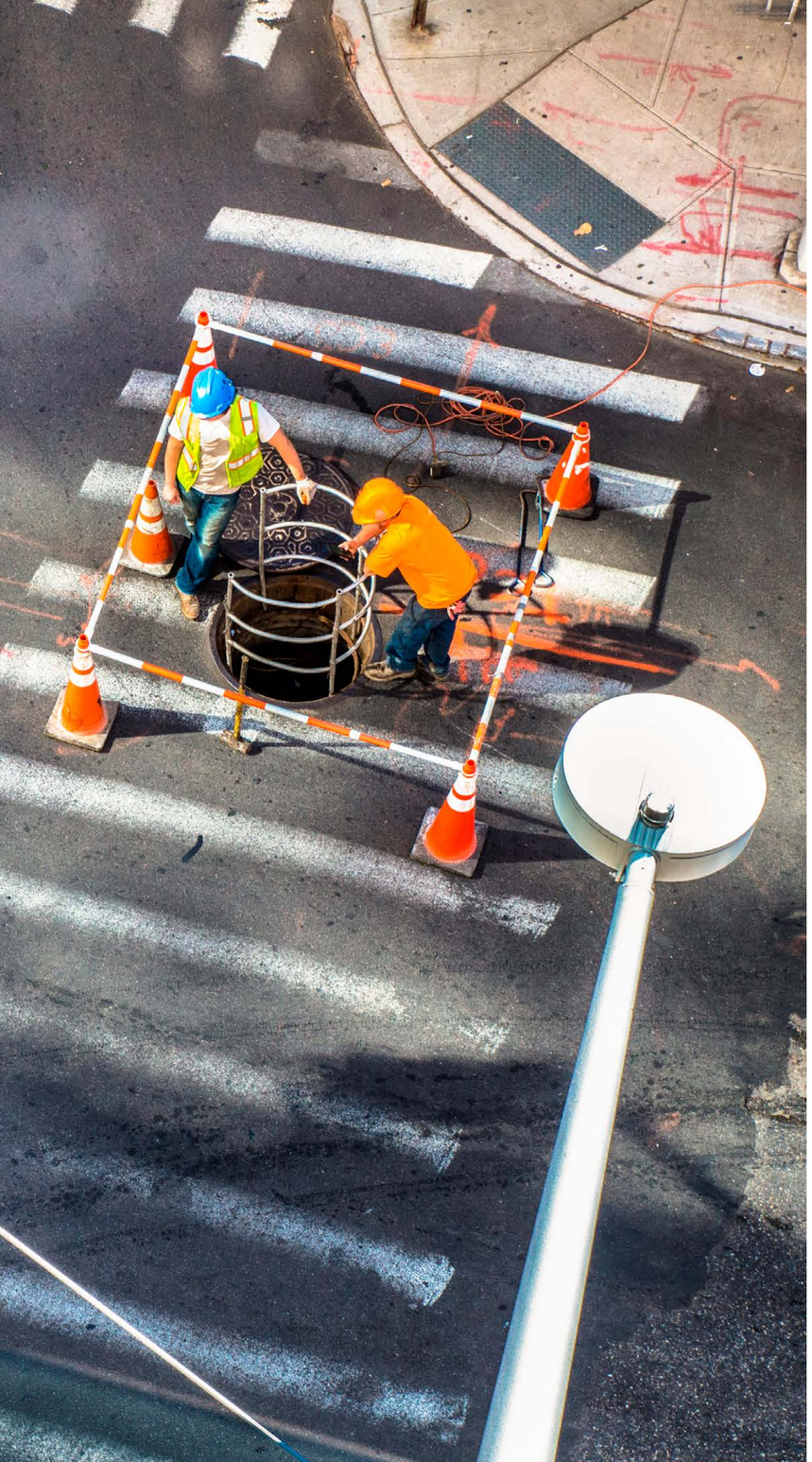
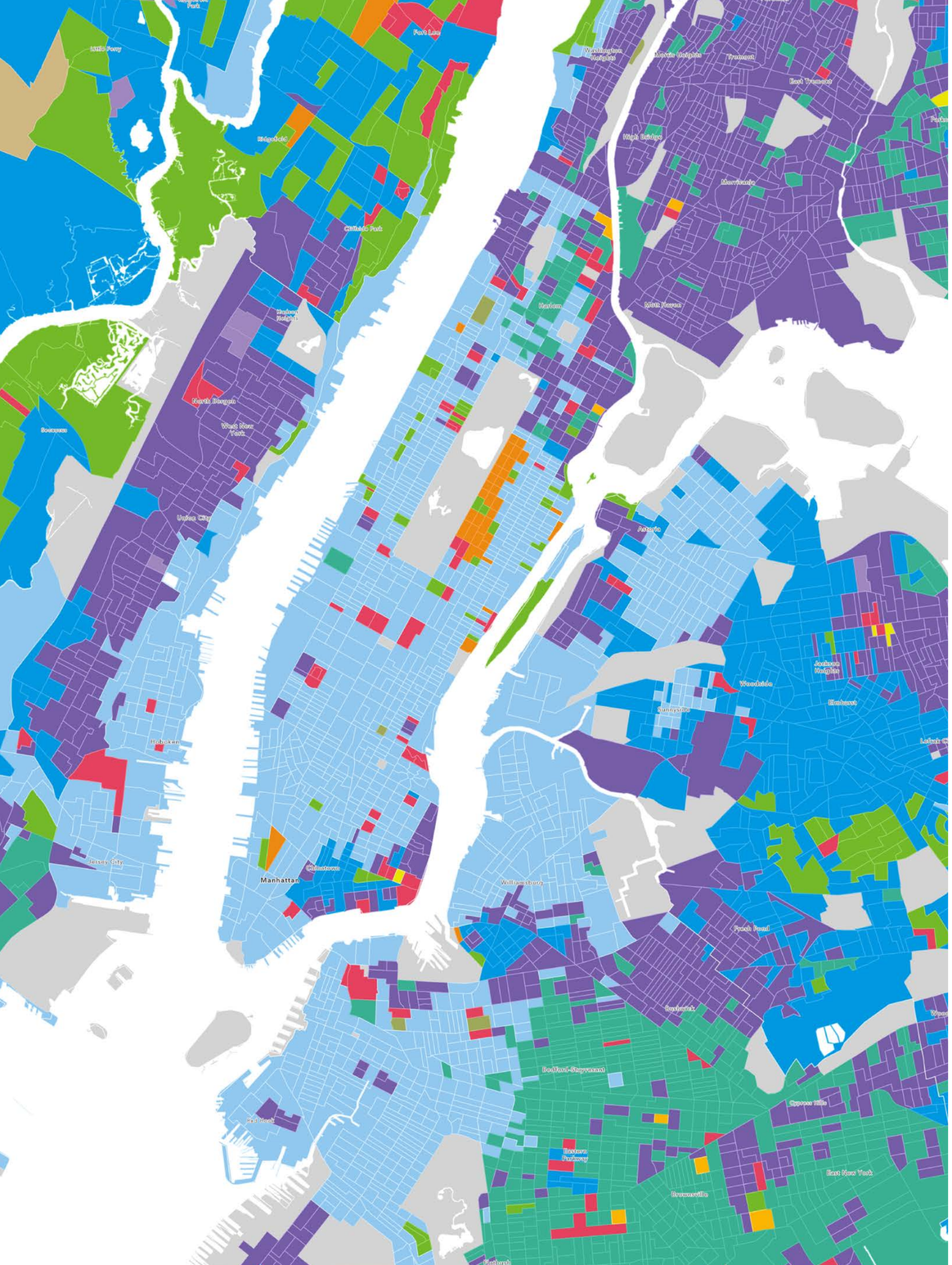


WHAT'S INSIDE



EXECUTIVE SUMMARY:
Achieving Resilient Infrastructure

In the face of escalating pressures on urban infrastructure from climate impacts and operational demands, geospatial technology gives leaders greater precision in their decision-making by mapping the need and providing necessary context to prioritize actions that lead to high-impact outcomes.

The Need and the Capabilities

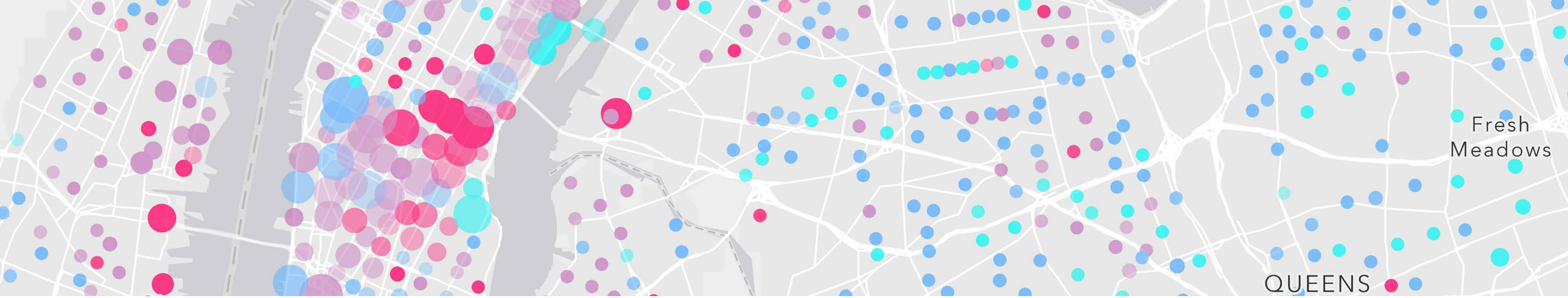
The Big Idea

A geographic approach combines data collection, analysis, and sharing to achieve operational intelligence. Around the world, complex organizations are applying geographic information system (GIS) technology, apps, drones, artificial intelligence (AI), machine learning, and the internet of things (IoT) to populate a real-time view of assets and people on a shared map. With these tools, organizations gain an edge on complicated challenges because they can see trouble coming and manage decisively around it. For cities, the same tools help deliver services more equitably and more efficiently, with the added benefit of map-based awareness and transparency for all residents and constituents. Moreover, in an age of climate change, these tools help cities mitigate risk in the present while preparing for an unstable future.

Here's the *Why*

As climate impacts intensify, the world's urban areas are under extreme pressure to manage their ongoing operations more effectively and to take action against location-specific climate risks. Cities generate the bulk of greenhouse gas emissions, a major factor in climate change, and many of the world's largest cities are among the most vulnerable to sea level rise.

For the first time in history, most of the world's population is urban and increasingly vulnerable, as the world's largest cities are coastal, owing to the ongoing advantage of shipping. Around 40 percent of the global population lives within 100 miles of a coastline, and the United Nations estimates 1 in every 10 people reside in areas less than 10 meters above sea level. ▶



New York City, as an example, checks all these boxes. Its 520 miles of coastline are more than Miami, Los Angeles, San Francisco, and Boston combined.

Although cities are often the drivers and recipients of the worst aspects of climate change, they are also where the most powerful and creative solutions to the crisis will emerge. The urgency of the threat in New York City illustrates this unique dynamic.

As it is with so much else, New York can be a beacon for the world, a laboratory for the boldest ideas, and the arena to fight the 21st century's most urgent crisis. And as it is with many different kinds of battles, geography plays a decisive role; devising a winning strategy requires a geographic approach. New York City's climate action plan, coupled with near real-time awareness, acts as a blueprint and provides situational awareness to remain resilient through near- and long-term challenges.

Managing a city requires weighing a complex set of variables and adjusting a set of systems that exist independently but function synchronously. Increasingly, the climate crisis places pressures on these everyday operational systems and thickens the complexity of the factors they manage by orders of magnitude.

A geographic approach helps a city see through this complexity to understand the ripple effects, such as with catastrophic weather events. When Hurricanes Sandy and Ida caused extensive flooding, GIS showed where to act immediately and the ways to add more resilience from these very different storms. The shore hardening after Sandy to mitigate storm surge was of no help from Ida's massive amount of rainfall in a short time. Now that New York has hardened for both scenarios, the hope is that future storms of either type will have less impact.

New York is a study in contrasts. It is the biggest city in the nation, with some of the nation's largest urban parks, but it has the smallest green space per resident. It is the proud home to people from all over the world, where the bottom half of earners have seen their wages rise steadily compared to the top half, but with inequalities in city amenities that persist.

Decision-makers and operations officials require a real-time tool that enables them to see the current condition of the city and use that information to allocate resources, people, and assets. They need to see the city not just as it is now, at the moment, but also how it is likely to shift in an hour, a day, or a week—or, in the case of climate impacts, in the months ahead.

Building on New York's unmatched success with geospatial technology—in particular, GIS software—city leaders can seize the latest evolution of these tools to set policies and make plans, from digital twins that model thousands of scenarios to AI tools that locate weak points and project them onto maps. GIS technology and its high-tech maps provide a window into all dimensions of city operations, uncover important social trends, track the success of policy, and guide actions to mitigate impacts from unplanned disruptions and natural phenomena.

Insight is not enough. It must be paired with action. In the context of a city, a geographic approach drives both insight and impactful action—both for every day resilience and for planning. ▶

Here's the *How*

A geographic approach empowered by modern GIS technology uses big data to help users understand movement and trends in the city, from traffic patterns to extreme weather events to the tracking of outbreaks and public health. GIS provides a visual means to understand the full context of the city and the way the context affects—and is affected by—the movement of people and assets. GIS is an enterprise technology as well as a suite of solutions—to address specific workflows and to see what's happening across space and time. Managers across diverse agencies and departments use GIS to make crucial resource management decisions, acting proactively rather than reactively.

Using GIS technology can accomplish these interwoven objectives, with a portfolio of tightly integrated tools that can achieve several goals simultaneously:

- **Collect, Analyze, Share**—Use purpose-built, location-based apps to collect data and optimize the efficiency of field activities. Then use GIS in the office to store, map, and analyze data points to see challenges in their totality. The data, map products, and analytical results can all be shared internally, across departments, and with partners and be pushed to and from the field.

- **Spatially Enable Operations**—GIS is rooted in operations, offering many inputs for real-time knowledge of what's going on. Operational awareness delivered by GIS lets managers see what is happening, track mobile employees, reduce mileage and fuel costs, save time and wear and tear on vehicles, and push routes and directions directly to the field to simplify communications and speed services, with tight integration between drones, apps, dashboards, and stories.

> "It's the data inputs and outputs, and the coordination that takes place on the back end that paint the picture and help us with our decision process."
>
> – Thomas Sivak, Deputy Director,
> Chicago Office of Emergency Management and Communications

- **Achieve Real-Time Intelligence**—Cities are increasingly constructing digital twins, which combine a 3D model with IoT sensor data to see activity and the workings of the urban environment in real time. Situational awareness is key to understanding a city as complex as New York. GIS ingests massive volumes of real-time data feeds and performs fast queries and analysis to help decision-makers understand movement and change. This real-time awareness allows users to see such things as bottlenecks as they change, where to respond to a crisis, and where there are service gaps.

- **Integrate Important Business Systems**—GIS provides a common meeting ground for other enterprise systems through a powerful factor—location. Through this primary attribute, contained in an estimated 80 percent of all records, relationships and patterns are established, and data from multiple systems can be seen, queried, and acted on. Esri has strong partnerships with providers of foundational enterprise technologies such as Microsoft, SAP, and Salesforce, adding the power of location intelligence.

- **Really See the Situation, with Great Clarity**—Because GIS contains tools to understand people, places, objects, and processes, it provides unique context. The transparency it produces helps create significantly higher levels of operational intelligence for the community. It's about being empowered through our devices, giving everyone faster and better answers, and getting to clarity and consensus quickly.

- **Bring Stakeholders Together for Shared Solutions**—By continuously collecting and storing data, and providing the means to visualize it on maps, GIS allows decision-makers to note historical patterns and devise intervening solutions. Using machine learning and other AI tools, planners can forecast outcomes. Managers also use GIS to organize people to collect and analyze data around initiatives. GIS workflows underpin good decision-making by helping users analyze the data at hand, target the workforce to take action, and monitor progress.

GIS help manage the level of complexity while bringing visibility to problems and awareness of progress toward the operational and resiliency goals that define an innovative, action-oriented city for the 21st century. ■

TRANSPORTATION

KEEPING PEOPLE AND COMMERCE MOVING

With billions of dollars flowing to states and local governments across the US to repair and rebuild roads, bridges, and transit as part of the Biden Administration's historic infrastructure bill, deciding how to prioritize work will present its own unique challenge. A geographic approach enables cities and states to build and renovate with a clear picture of progress on the largest infrastructure revitalization effort in the country's history.

This national renewal of infrastructure is long overdue. For too long, the frayed elements of the systems that keep cities intact have stood in the way of safety gains and economic progress.

Now that aging and obsolete infrastructure is receiving the attention it deserves, cities are confronted with a dual challenge. They must determine the best projects to begin with and distribute the funding they receive equitably—and they must do so with maximum transparency.

In the face of climate change, some of the most meaningful equitable infrastructural upgrades include those made to mass transit and public transportation systems. Unlike in years past, improvement cannot mean merely repaving worn streets, highways, and bridges. It is time to address inequities and move beyond dependence on fossil fuels. ▶

Transportation (continued)

This is something that New York, the least car-dependent city in the US, already grasps. With the city's congestion pricing for parts of Manhattan, city leaders have shown a willingness to consider bold steps to keep the city pedestrian and cyclist friendly. And New York's subway system is both historic and forward thinking, with GIS guiding transit agencies through use of a map and sensors that keep track of ridership in real time while also collecting data that can be used for maintenance and expansion plans.

As electric vehicles gain currency, New York will build a charging infrastructure, using GIS to determine the best places to provide chargers for the most New Yorkers and visitors.

GIS has also helped the city decide where to place new bike lanes and which streets to close to car traffic to maximize safety and mobility. Prioritizing active transportation has proven popular during the pandemic and has set in motion a healthier populace and city. ■

CASE STUDY

Regional Transportation Authority of Northeastern Illinois

Mapping Chicago's Transit Recovery

Situation: After months of pandemic lockdown that precipitated a dramatic drop in ridership, the Regional Transportation Authority of Northeastern Illinois (RTA) needed to examine routes and schedules to accommodate returning riders. For RTA, that meant strategizing with its three service boards—Chicago Transit Authority (CTA), Metra, and Pace Suburban Bus to communicate with each other and with riders to get the second-largest public transit system in the country rolling again.

Challenge: Sharing data across entities about the current state of usage was needed to make plans that fit Chicago's transit-dependent residents. The approach was to not just plan a return to full schedules but to make a plan that fit the needs of those who would be entirely without mobility options if area trains and buses no longer served their communities. ▶

> "We've never had to respond to a disruption of this scale and duration so quickly. We needed to find a way to compile data from a variety of sources and report on it in an online format on a weekly basis."
>
> – Brad Thompson, Manager of Data Services and Analytics at RTA

Northeastern Illinois (continued)

Solution: In response to COVID-19, the team at RTA had launched the COVID-19 Transit Dashboard as a way to easily share daily and monthly data with public officials at the local and state levels. This detailed report of ridership provided an important input on who was being served and who was still utilizing the city's transit services. Next, the team used GIS to identify the locations of people and businesses still in need of transportation, analyzing social vulnerability and the essential workers who rely on transit to reach their vital jobs.

Result: RTA's COVID-19 dashboard provided the means to share ridership data to stakeholders, city leaders, and the public. And the easy access to the information increased RTA's ability to communicate and adapt to the rapidly changing conditions. As a result, all stakeholders felt included in the planning process and more confident that their needs were foremost as the transit agency adapted to returning demand. ■

PARKS

PROVIDING HEALTH BENEFITS TO PEOPLE AND THE ENVIRONMENT

Leaders in many major US cities are approaching climate risk and social equity issues by rethinking public parks, recognizing that they are vital and essential components of healthy and flourishing communities.

When every restaurant and public place was shuttered during the darkest days of the COVID-19 pandemic, people flocked to parks to get fresh air and a respite from the crisis. Now, there's a growing awareness that parks promote health, improve well-being, and build social cohesion.

Parks also provide green infrastructure that mitigates climate change impacts, including tree canopy that increases shade and reduces heat islands, parkland that doubles as stormwater retention basins to reduce flooding, and shoreline parks that protect coasts from sea level rise.

Low-income communities suffer disproportionately from the impacts of climate change, often for deeply rooted historical reasons. Geographic context is needed to distribute nature's benefits more evenly. Maps layered with data about people and natural amenities can reveal inequities in access to green space, supporting new park initiatives in underserved communities.

Parks can also be better integrated into citywide infrastructure systems, providing services such as transportation, flood and heat protection, and support for educational and economic activities.

Increasingly, researchers are putting a dollar value on the ecosystem services of nature, such as cleaning water, filtering air, managing stormwater, and attracting visitors. Parks also provide tangible benefits to residents for recreation, relaxation, fitness, and cooling. Parks have even been shown to reduce health-care costs because people who regularly use them improve their wellness. ■

CASE STUDY

Trust for Public Land

Tackling Equity in New York City's Access to Nature

Situation: Trust for Public Land (TPL) has worked with New York City for decades to expand access to nature and enhance the quality of parks to provide better habitat for people and wildlife. During the pandemic, marginalized communities in New York City suffered far more than affluent ones. The city has an extensive park system that residents visit 527 million times per year, with 99 percent of residents living within a 10-minute walk, but there are pockets in communities of color that have a third less park space per person compared to white communities.

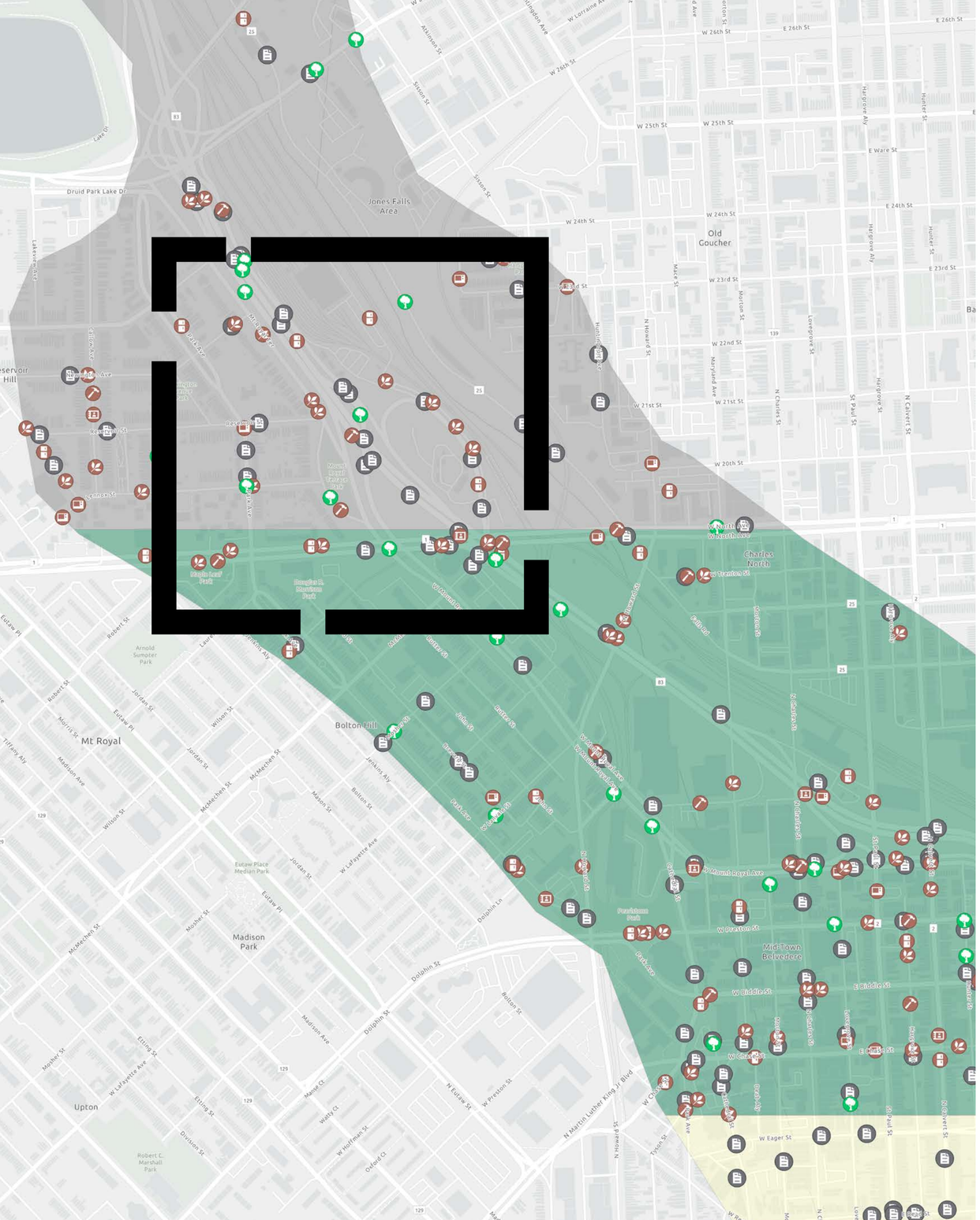
Challenge: Many New Yorkers are suffering the economic impacts of the pandemic, while others discovered they could live and work outside the city while maintaining the higher income city residents commanded. Now is the moment to reinvest in quality of life for all residents, reward those who stuck it out, and entice workers and tourists to return. Parks are a big part of New York City's appeal, but open land is scarce and expensive. ▶

Trust for Public Land (continued)

> **“We want to direct city investments to low-income neighborhoods that have less tree canopy, less parks, and are more vulnerable to extreme heat.”**
>
> – Carter Strickland, VP Mid-Atlantic Region and New York State Director

Solution: TPL staff used GIS to identify which communities are underserved by parks and determine who can reach a park within a 10-minute walk. This effort has led to the creation of a New York Park Equity Plan that calls for 70 new parks in the Bronx, Queens, South Brooklyn, and Staten Island to ensure that all New Yorkers are within a 10-minute walk to a park. Playgrounds at schools have offered places ripe for redevelopment–and are plentiful in the largest school system in the country. TPL set out to revamp more than 200 asphalt-covered playgrounds at public schools, adding trees and green spaces for parks that were hiding in plain sight.

Result: By strategically targeting the creation of parks, New York City has reduced the stress of underserved residents and improved neighborhoods while making the city more resilient to the climate crisis. Newly planted trees, gardens, turf, jungle gyms, gazebos and picnic tables, among other amenities, give students and residents a place to recreate and rejuvenate while fostering connections to nature. Now schools provide an oasis of green in asphalt-heavy neighborhoods, expanding park access to the 1.1 million low-income students who had little access to close-to-home parks. ■



SANITATION

ACHIEVING LEAPS FORWARD IN SERVICE DELIVERY

Providing the necessary services a city's residents have come to expect, day in and day out, is a complex affair for any city. New York tackles this complexity with a geographic approach that increases efficiency and promotes transparency while also laying the groundwork for continued improvement.

New York City generates 12,000 tons of waste every day—or two pounds for every New Yorker. Determining best practices for processing this overwhelming amount of material requires maximal geographic information about how and where it is generated. GIS analyzes these questions, along with investigating how collection routes can be optimized for maximum efficiency, to cut down on time, fuel costs, and emissions. Sanitation and public works departments also use real-time GIS to pinpoint where individual trucks in the fleet are at any moment, using this information to optimize coverage and efficiency.

This real-time awareness and analytical capability apply to all manner of waste processing efforts. If the city wants to expand its composting program, maps and dashboards determine the optimal placement for collection facilities. GIS is also used to analyze participation across the city to better pinpoint where to expand in the future. ▶

Sanitation (continued)

Maps can help city officials analyze the effects of changes—to fine-tune regulatory shifts or answer questions about the effective rollout of new services. Could adjusting the opposite-side parking rules make street cleaning more effective? Is there a better way to manage landfills?

The flexibility of GIS technology is such that it can generate maps while also serving as the repository for the data that drives decisions. And the more data that is gathered, the more useful patterns emerge.

As with so much else in city operations, service delivery has a direct bearing on the climate crisis. As more recycling and waste management services are brought under the same GIS umbrella, New York will develop a more circular economy. The geographic approach creates a fundamentally cleaner and more efficient city. ■

CASE STUDY

City of Los Angeles

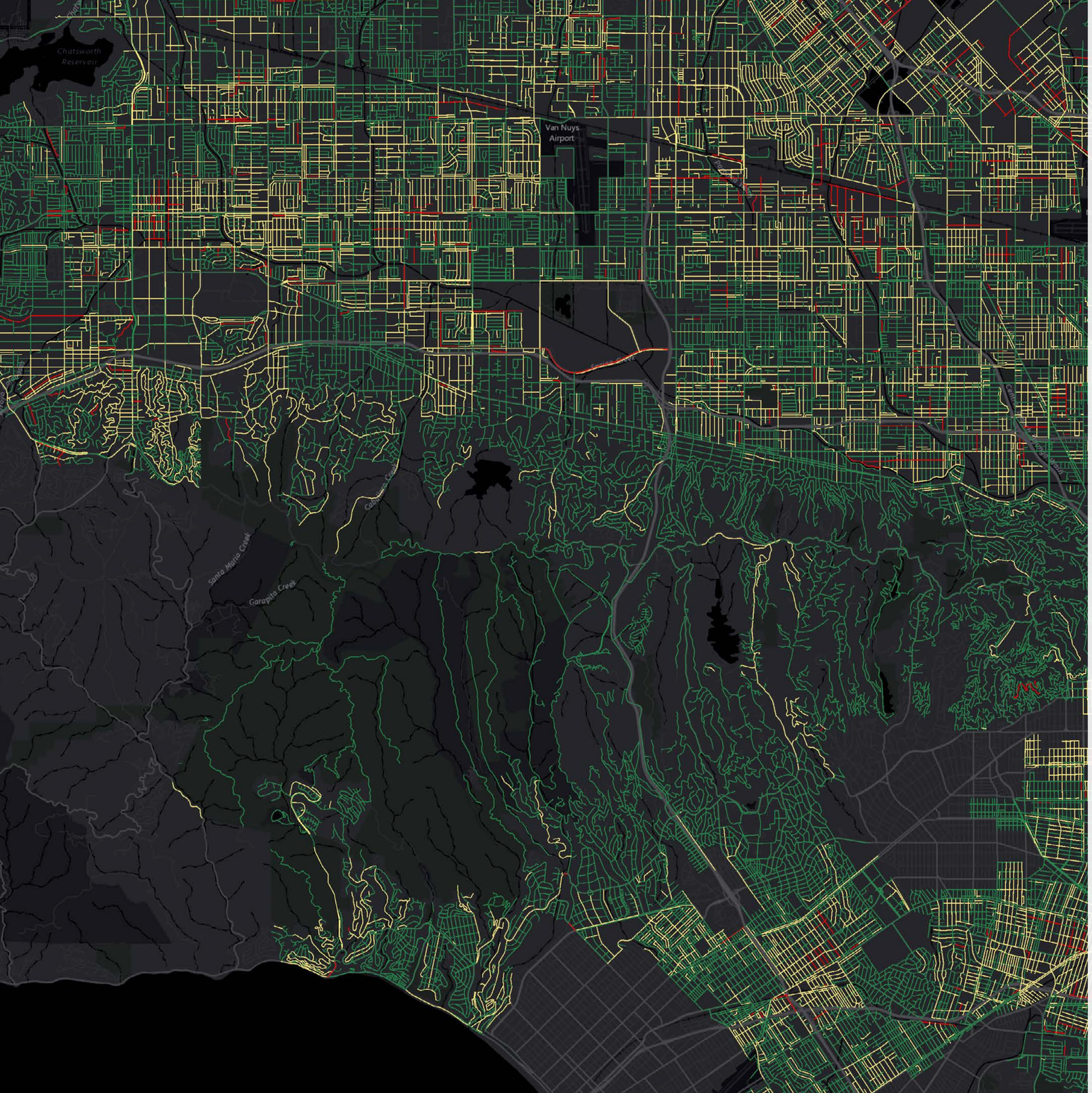
Cleaning Up Dirty Streets through Comprehensive Open Data Mapping

Situation: Los Angeles needed a data-driven solution to the problem of street cleanliness, a responsibility under the purview of the public works department. The city had seen a steady decline in cleanliness because street cleaning funds had been significantly cut back during the recession.

Challenge: Los Angeles has the country's largest street network, with 42,000 blocks and thousands of miles of roads. Given the city's size, it's difficult to know the conditions on any given block and to prioritize which blocks most require street cleaning.

Solution: Los Angeles mayor Eric Garcetti launched Clean Streets LA (CSLA), a public-private partnership, with the goal of eliminating dirty streets. One of its major projects is CleanStat, a system of judging each block's cleanliness. Using GIS tools and video capture, crews driving through the city assign cleanliness scores to blocks, adding this information to a map. They can filter the map results by scores to get a sense of areas where cleaning is most urgently required. This information can then be used to plan the most efficient routes for street cleaners. GIS helps CleanStat understand the city and develop a comprehensive method of looking at trends. It's one of many solutions on the city's GeoHub, which combines open access to data and many more tools similar to CleanStat that the city uses to look at its challenges. ▶

Los Angeles (continued)



Result: In the first year after launching CleanStat, the city reduced unclean streets by 82 percent. GIS lends authority to these figures by detailing exactly where work has been performed. The data-driven nature of the map also promotes equity by prioritizing cleaning where it is most needed ensuring that no neighborhood takes precedence over any other. This allows communities to hold the city accountable for providing services that everyone requires. By quantifying service delivery, the city has now shifted to prioritize high foot traffic areas, with a pledge to act swiftly to drive out pervasive illegal dumping under freeway off-ramps and make data-driven decisions on where to deploy trash bins in areas with persistent litter. ■

PORTS AND AIRPORTS

PLANNING WITH A MODEL OF WHAT EXISTS AND HOW IT OPERATES

Digital twins are virtual representations of the processes, relationships, and behaviors of real-world systems. Virtual 3D models of cities, augmented by local information, provide a means of proposing, understanding, and analyzing development projects and other changes to the urban landscape.

Digital twins reflect the ongoing movement and evolution of real-world assets using feeds from sensors and Internet of Things (IoT) devices. They can provide a complete dynamic rendering of complex entities, showing how systems function, both singly and together.

The earliest digital twins grew out of the industrial world. They were ways to keep tabs on the functioning of factories, down to the level of individual machine parts. The goal was not so much to provide real-time monitoring as it was to provide detailed record keeping.

Using digital twins as part of facilities management is a natural outgrowth of these early industrial digital twins. But the capabilities of the technology have expanded so that entire cities can now be modeled—including functions in near real time—using sensors and IoT feeds that provide raw data that can then be contextualized via maps, dashboards, and portals. The same digital twin can provide an ongoing chronicle of what it mirrors while keeping a record of past developments and providing the means to test future scenarios in a realistic environment. ▶

Ports and Airports (continued)

GIS isn't the only tool for constructing digital twins. However, in the context of a city and its functions, GIS offers clear advantages. Digital twins must process data from disparate sources. Often, the only common attribute the data shares is that it corresponds to events, processes, and relationship with a location component. Where things happen—and how these things affect others that are in the same location—is of paramount importance, and GIS makes these connections.

Just as important is understanding how things in one location affect those in another. In a densely populated city, chain reactions are common. Understanding them—and getting out in front of these cascading effects—is crucial. This is as true for the traffic on a tarmac or in front of the airport as it is for the traffic patterns that spread out across the city. ■

CASE STUDY

San Francisco International Airport

Utilizing a Dynamic Twin to Transform Operations

Situation: San Francisco International Airport (SFO) has been a global leader in the adoption of GIS technology. As part of the Federal Aviation Administration's (FAA) ongoing modernization effort, Next Generation Air Transportation system (NextGen), the nation's airports are required to adopt GIS to gather and share data. SFO has been at the forefront of this modernization. Although the FAA's primary interest in GIS is to manage horizontal infrastructure—runways, taxiways, pavement—SFO saw the results and adopted a vision to expand GIS use to encompass the majority of airport operations.

Challenge: This desire to expand the use of GIS at SFO reflected an understanding that airports are enormously complex environments. Like cities, they function by means of many systems operating separately while remaining connected to others. The different types of traffic—cars dropping off and picking up passengers, pedestrian foot traffic through the concourses and gates, and, of course, the aircraft that take on and disembark passengers—all affect the others. Furthermore, they are all linked to the continued maintenance of the airport's systems—everything from HVAC to elevators to rail links to terminals—that must be operating to move people and goods efficiently. What SFO wanted was a way to bring these all together into one GIS environment. ▶

"It's about delivering advanced knowledge to the user and the passenger, so they feel more in control of the experience going through the airport."

– Josephine Pofsky, Director of Infrastructure Information Management, San Francisco International Airport

San Francisco (continued)

Solution: To achieve this kind of integration, SFO used GIS to build a dynamic digital twin that incorporates other technologies such as building information models (BIM) of construction plans and work order management systems that capture maintenance details. SFO's dynamic digital twin reflects the dimensions of both the interior and exterior of airport facilities as well as the activities of most of the airport's assets, providing a constantly updated rendering of spaces and the systems that contribute to their functions. The twin portrays the airport with a great deal of detail, down to the manufacturer and model number of critical components that need regular maintenance, such as lighting and pumps that keep liquids flowing.

Result: SFO's dynamic twin provides a continuous digital alignment of the virtual and real-world environments—a window of entry into the airport's infrastructure—allowing managers to monitor how components and systems are functioning.

For the retail component of the airport, the space management team uses the tool to find the best location for a kiosk or a specific retailer. This helps in ways that span both day-to-day operations and longer-range planning. Facility personnel use it to plan their days, for example, by seeing which parts need replacing and the best points of entry. The model is tied in to the airport's emergency management system so that responders to 911 calls can orient themselves, allowing them to see which doors are automated and which are restricted, requiring special keys and badges. And the model is available to visitors to help them navigate through the sprawling facility.

The integration has been integral to pull off the airport's ambitious and transformative $7 billion renovation, modernizing it through the addition of a new hotel, revamping two terminals, adding parking, and creating tighter transit connections across the region. ■

HOUSING

ASSESSING NEEDS AND IMPROVING LIVABILITY

Around the world, cities are struggling with housing shortages and lack of affordability. Planners address these issues by analyzing the complex factors at play and designing new patterns of development that accommodate more residents while addressing climate impacts. New green growth concepts include an emphasis on walkability and natural solutions, such as planting more trees, to make cities more livable.

Planners use GIS to analyze both people and place to find ways to make housing more equitable, affordable, and sustainable.

When people can't afford to live in the community where they work, it can result in cascading impacts to individuals and the region, such as sprawl and higher emissions from transportation. By using GIS to inventory housing and employment opportunities, planners gain an understanding of how transit is a critical consideration, particularly in low-income communities. Cities use GIS to create site scoring for proposed new developments based on proximity to transit assets and other amenities.

In denser urban areas where land isn't available for new housing, redevelopment and revitalization of existing housing stock is often the priority. In Philadelphia, revitalization was spurred by suspending property tax for 10 years if a homeowner undertook major renovations or new construction. GIS was used to analyze this policy and relate the outcomes, showing that revitalization reversed a steady decline in population. ▶

Housing (continued)

> "It becomes very realistic, and you can really understand how the new development will look in the current context as we explore different scenarios."
>
> – Svante Guterstam, Strategic Community Planner, City of Uppsala

In Europe, new levels of sustainability are being devised, such as in the city of Uppsala, Sweden, which is set to grow by 33,000 people by 2050. The city has taken a pledge to be fossil-fuel-free by 2030, and a sophisticated GIS-driven digital twin has helped design new patterns to meet that ambitious goal. The digital twin allows planners to test scenarios, looking at such things as shadows, water and stormwater processes, whole streetscapes, and the mix of transportation that will be needed. With this modeling and testing framework, the plan has been proven and residents are shown how things will work better, helping them share in the excitement and live through the disruption of the transformation. ■

CASE STUDY

New York City Housing Authority

Analyzing Extreme Heat and Assessing Building Maintenance

Situation: The New York City Housing Authority (NYCHA) provides housing to nearly 400,000 low- and moderate-income New Yorkers in 335 developments spread around the city. Years of disinvestment has led to a deterioration of these facilities. NYCHA is pursuing innovative ways to raise funds to tackle the backlog of maintenance and repair issues, and rather than just renovate NYCHA is setting out to transform public housing with the climate crisis in mind. The effort sets out to create more resilient buildings and to renovate in a way that reduces greenhouse gas emissions while improving the quality of life for residents. After Hurricane Sandy in 2012, the Federal Emergency Management Agency awarded $3 billion to NYCHA, the largest grant in the agency's history, to repair and protect public housing from future similar storms. The governor recently signed legislation establishing the New York City Public Housing Preservation Trust, which will renovate an initial 25,000 apartments.

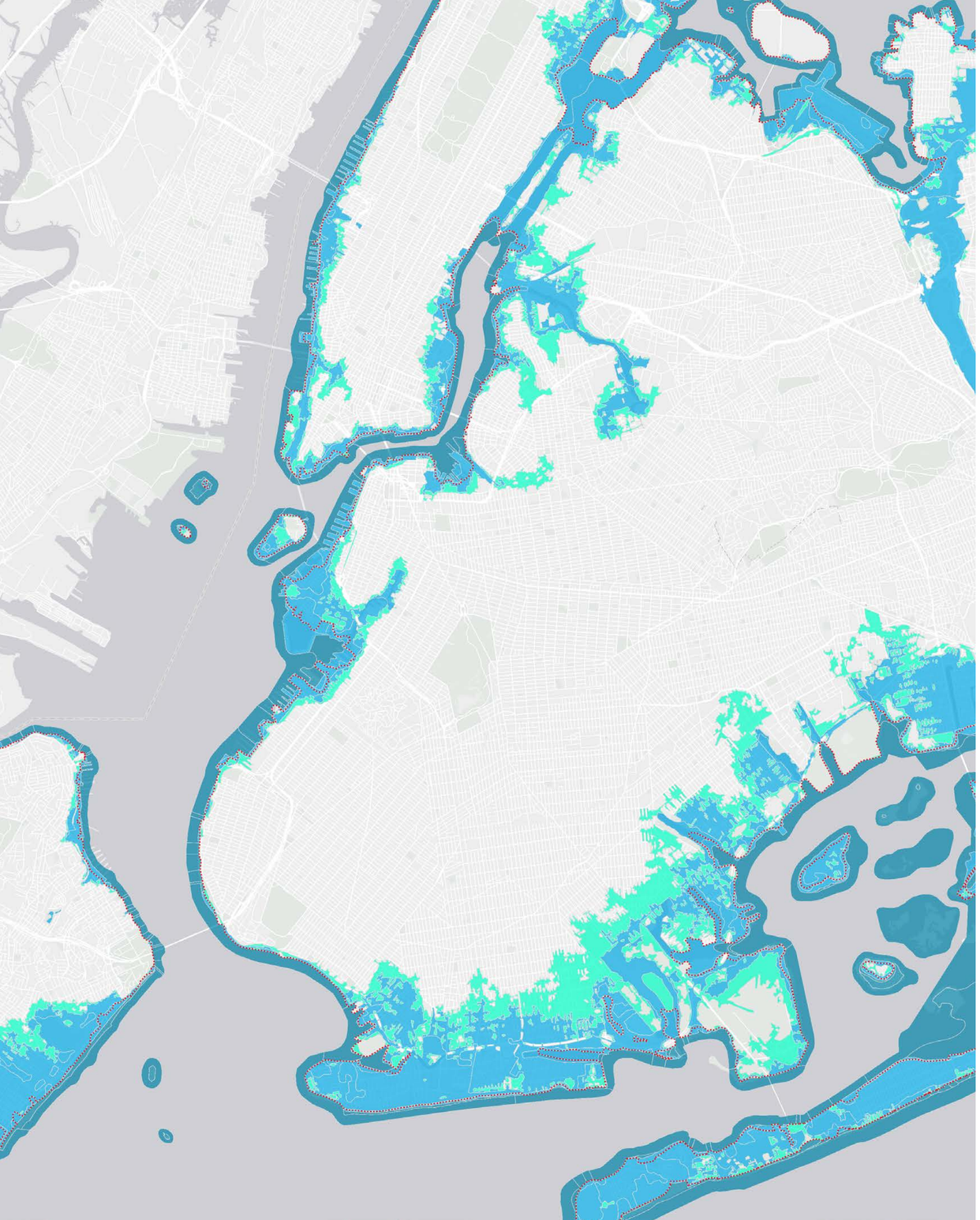
Challenge: NYCHA needed a way to prioritize projects to tackle the massive capital needs of its aging buildings and infrastructure. NYCHA also needed a way to analyze and prioritize what projects to do first, and a way to track the investments in a transparent way for residents and all New Yorkers to see how tax dollars are transforming public housing. ▶

> "For too long we have underinvested in NYCHA, leaving aging infrastructure and utilities unrepaired, but…we are ensuring that NYCHA residents will now have access to safe, high-quality, affordable homes they deserve."
>
> – Eric Adams, New York City Mayor

New York City (continued)

Solution: NYCHA took a geographic approach to decrease greenhouse gas emissions in buildings by analyzing which could be converted to geothermal, hydronic conversion, and heat pumps and putting them on a map. It also took a look at communities that have long faced environmental justice issues, and prioritized those places. It went even further by analyzing the heating and cooling loads of the conversions to make sure the grid had capacity. The resulting map is rich with details to put decarbonization plans in action. A similar effort to analyze outdoor temperature with GIS has helped prioritize outdoor cooling measures, such as tree planting and painting roofs white to combat urban heat islands that occur disproportionately in neighborhoods with public housing. The ability to see and track projects on a map has scaled up to all of NYCHA's buildings with the Capital Projects Tracker, which allows anyone to see project status and funding source, and to filter projects by borough, council district, or development.

Result: The project analysis and tracking capability provide NYCHA with runway to take off with the historic investments that will greatly improve the quality of life for public housing residents, while also revitalizing neighborhoods. The commitment to revamp the largest public housing in the country with green and sustainable solutions will go a long way toward meeting the city's climate commitments. The combination of analysis and tracking will help NYCHA make an impact with every dollar it allocates. ■



WATER

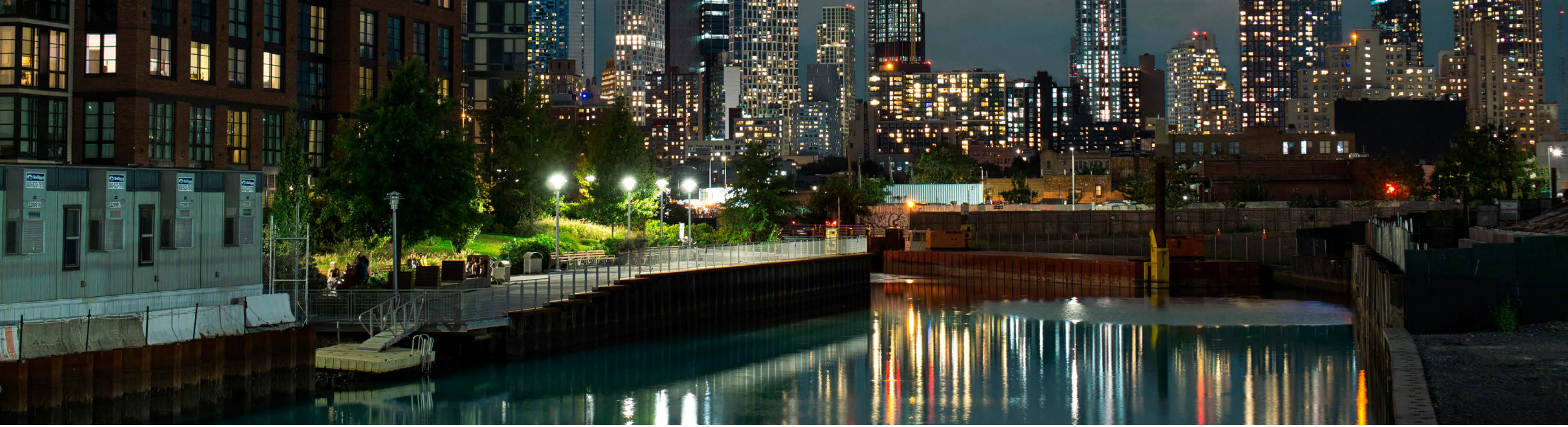
SUSTAINING INFRASTRUCTURE WHILE DEALING WITH SEA LEVEL RISE

With its hundreds of miles of coastline, New York sits where rising sea levels are an immediate existential threat. Mitigating this threat requires a multifaceted approach involving green and built infrastructure.

Creative plans are underway in New York to deal with the storm surge that will continue to get worse as storms intensify. In September 2022, we are scheduled to see the launch of a resiliency project in Battery Park that will dramatically alter the neighborhood to withstand rising waters.

GIS helps manage the enormous complexities of climate adaptation projects. The technology assists with the technical aspects well before shovels lift soil. As plans take shape, a single GIS environment serves as a way to unite the designs (including from building information modeling [BIM] software) with a digital twin that provides an engineering-grade context of the surrounding area, including a realistic 3D mesh derived from lidar.

The advantage of this geographic approach extends beyond the plans and designs themselves; the land where Battery Park is being altered includes underground tunnels and infrastructure managed by different utilities and city agencies. GIS gives all stakeholders a common frame of reference about the project and its impact on the web of infrastructure underlying the city. There are also environmental impacts to mitigate and monitor, and again GIS is relied upon by scientists and regulatory agencies to safeguard the water and species that surround the project area. ▶



Water (continued)

GIS can also help manage funding distribution, an important concern to ensure that all New Yorkers benefit from resilience protections. Models show that many low-income communities, from East Harlem to Far Rockaway, are increasingly vulnerable to storm surge. These areas include NYCHA housing, whose residents do not have the same resources and clout as other residents of the city.

Because these neighborhoods are all part of the same city, one with a long and storied history of equity and inclusivity, any project to protect New York's coastline must consider all communities. The flexibility of GIS can ensure that the projects are all visible and connected on the same map, in much the way the city's greenway projects have been linked.

On an even broader scale, these projects connect to other green infrastructure projects further inland to help minimize the effects of flooding. In Brooklyn, for example, the Gowanus Street Tree project uses plantings to maximize soil absorption, helping prevent floods and sewage overflow in the Gowanus Canal. The Parks Department uses GIS to capture a complete census of trees for the city, and the Gowanus trees are included in a tool that allows any New Yorker to examine the tree species and the value they provide for stormwater absorption.

New York has been implementing a complex mix of grey and green infrastructure to harden the coast and keep residents safe from rising climate pressures. After Hurricanes Sandy and Ida, the vulnerability of the city's aging infrastructure was exposed. Many engineered solutions are underway to build for the changing climate the city faces, including unclogging drains and widening pipes, turning parks and open spaces into stormwater sponges, and plugging the leaks that halted the subways after heavy rains.

For all measures, GIS provides the means to design projects focused on outcomes, to address the complex vital connections of underground infrastructure, to aid efficiency and track progress, and to deliver results for all New Yorkers regardless of income. ■

CASE STUDY

Miami Beach, Florida

Consolidating Public Works Projects to Minimize Disruptions to Residents

Situation: The city of Miami Beach, Florida, located on a barrier island a few miles off the coast of Miami, is one of the most vulnerable areas for sea level rise in the US. According to forecasts, South Florida is likely to see 17 to 31 inches of sea level rise by 2060. Miami Beach has a unique bowl-like topography that makes the center of the island lower than the coast, exacerbating flooding, particularly when the island experiences the higher-than-average "king tides."

Challenge: Miami Beach needed a way to identify its most pressing flooding concerns. It also needed to determine how best to consolidate public works projects to address these concerns while minimizing disruptions to residents.

Solution: Miami Beach worked with hydrologists and GIS experts at the engineering firm Jacobs. They began by mapping the island's infrastructure and the most vulnerable spots for flooding. They determined ways the city could integrate "blue" and "green" infrastructure that reduced flood risk. These measures included preserving the island's freshwater lens, which lies on top of saltwater; adding traffic chicanes that maximized stormwater retention; installing permeable pavement in parking lanes; and installing enlarged tree pits. The same tools helped the city evaluate a road-raising strategy to address areas that were perpetually underwater.

Result: The city was able to devise a comprehensive plan to deal with future sea level rise. The GIS tools gave engineers a holistic sense of the interaction between the island's natural systems and the human-made infrastructure. Geospatial analysis helped the city upgrade its stormwater pumping system, raise the streets that were most likely to flood, and harness the natural absorptive powers of green space. ■

CLIMATE ADAPTATION

DIGITAL TWINS, REPEATABLE STRATEGIES, AND ADDRESSING INJUSTICES

Leaders and planners have commonly used GIS to take on the climate crisis. The geographic approach allows them to analyze the impacts of climate change on human and natural systems and to take targeted action that's fair and swift. The mayor's new Office of Climate and Environmental Justice was established to identify and address the inequitable distribution of environmental problems. The infrastructure bill signed into law last year makes that same connection, with the Justice 40 Initiative that sets aside 40 percent of certain funds for disadvantaged communities. Knowing who is served and where the work is needed most are critical to taking smart climate action.

Using the geographic approach, leaders can proactively prepare for changing conditions by analyzing where and how a changing climate will affect residents and properties. GIS allows users to examine place and people to see what's needed for every mitigation measure and to ensure everyone is served equally. The same tools can then be used to develop strategies and track action toward goals.

By creating accurate visualizations and conducting robust modeling and analysis, decision-makers test scenarios and devise effective responses. A digital twin approach provides a scenario-testing tool to simulate future conditions against plans and fine-tune ideas based on simulated outcomes. With these tools, cities and communities are devising plans backed by the best science and engineering.

Whether the immediate challenge is extreme heat, frequent flooding, and inequitable impacts on disadvantaged people, GIS helps guide smart climate action. Better coordination is possible with apps, hubs, and dashboards that are accessible to all stakeholders in the incremental work that turns people and places from vulnerable to resilient. ■

CASE STUDY

PRAGUE INSTITUTE OF PLANNING AND DEVELOPMENT

Visualizing mitigation measures to reduce stress on people

Situation: Prague is particularly vulnerable to extreme heat. Compared to other European cities, it has more paved spaces, built-up areas, and industrial infrastructure—the kind of spaces that can create heat islands. In mid-August 2022, temperature records were again broken across the Czech Republic, with new highs at 20 of 160 meteorological stations that have been recording for more than 30 years. In some areas, the highs exceeded 95 degrees.

Challenge: Prague needed a way to see where it could enhance long-term resilience and reduce its vulnerability to climate change and extreme heat. A study that compared the heat waves of 1994 and 2015 found that mortality rates among the elderly increased. They were, as a group, very vulnerable to heat waves, and the growing population in this age group meant that things could get increasingly grim as temperatures during summer months continue to rise. ▶

Prague Institute (continued)

Solution: Prague's planners turned to GIS to analyze where the city could add more resilience. GIS allows IPR Prague to analyze the city in both street-level granularity and bird's-eye view. GIS provides a way to visualize—and therefore contextualize—extreme heat statistics. Demographics and other human population data become layers on a smart map. The layers can be set against environmental features of the city, offering a graphic representation of how the city and its populations interact.

Result: In Prague, an awareness of extreme heat at the microclimate level led to the creation of new parks in places where they would best cool the city. The next phase of Prague's climate strategy, which IPR Prague hopes to commence this year, will involve using GIS to construct intricate 3D models of the city's microclimates. Once established, these models will provide a way to analyze the likely effects of mitigation strategies before the city makes any large investment of time and money. ■

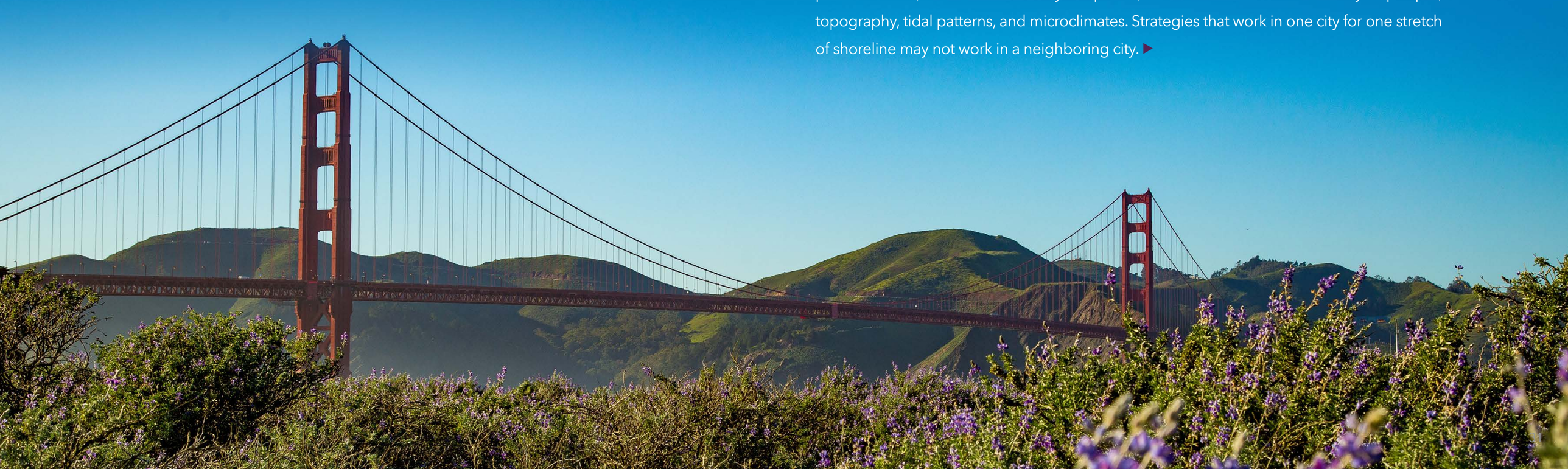
CASE STUDY

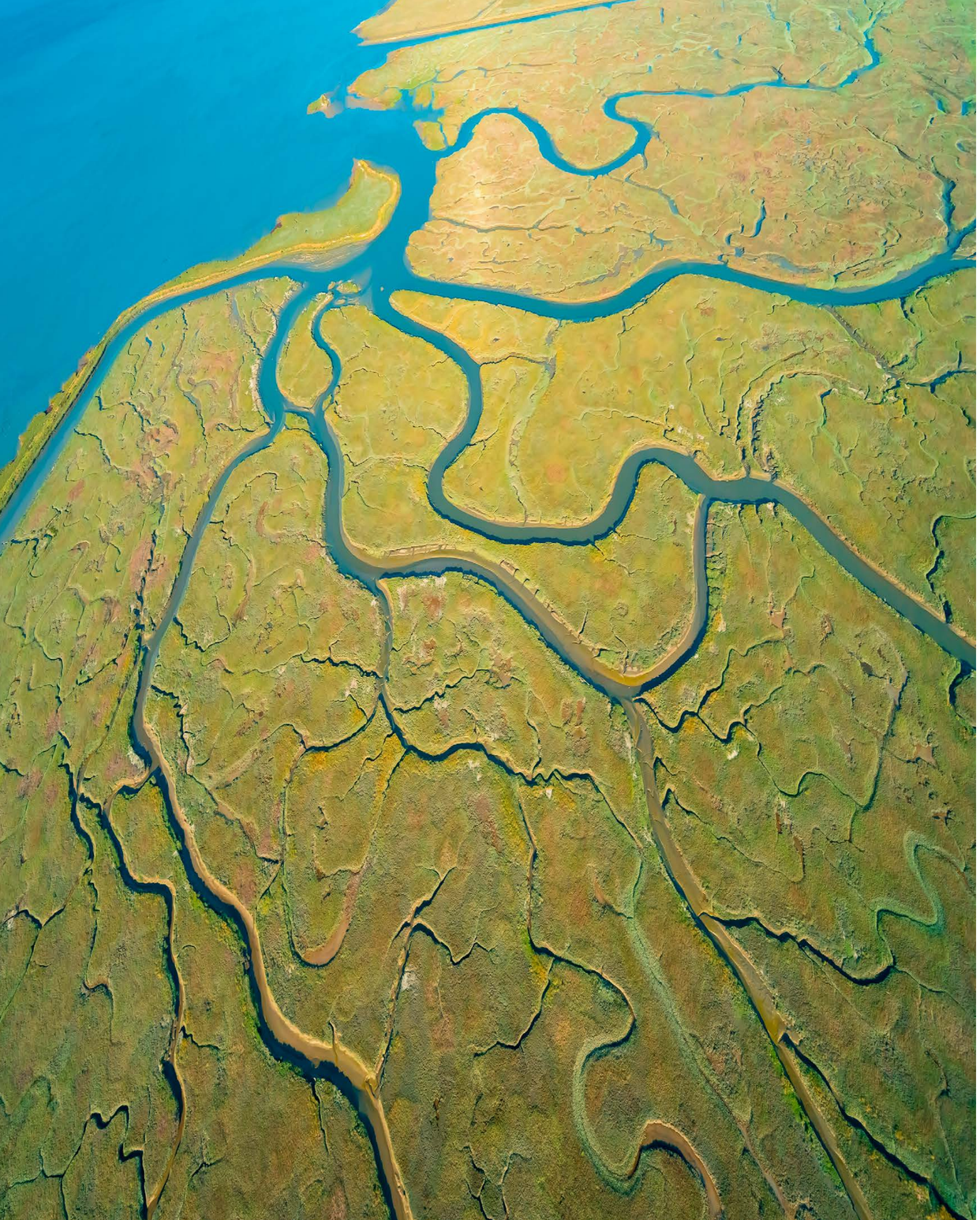
THE SAN FRANCISCO ESTUARY INSTITUTE

Adapting to Frequent Flooding, Including Eliminating Housing Mitigation

Situation: The San Francisco Bay, one of America's great estuaries, has experienced increasing impacts from sea level rise. The area has been plagued by wetland loss, with about 80 percent of marshes and mud flats eliminated from this natural buffer to storms. The more than 350 miles of trails that wind through 47 cities and 9 counties along the wetlands' borders are more frequently impassible.

Challenge: Regulations protecting the bay have historically prohibited the use of sediment to fill it in. Traditionally, riprap and concrete seawalls were used to harden the shoreline. There was no guidance, though, on how to alternatively soften the shoreline with green infrastructure when faced with the threat of sea level rise. Regulators wanted a clearer path toward understanding what mitigation proposals would be the most environmentally appropriate. Experts knew, for example, that attempting to build up marshes in deep water prone to high wave energy isn't possible. Also, because of the bay's expanse, the area is home to a diversity of people, topography, tidal patterns, and microclimates. Strategies that work in one city for one stretch of shoreline may not work in a neighboring city. ▶





San Francisco (continued)

> **"If each entity is just going to plan for its own piece of shoreline, it's not going to be effective, it won't be resilient, and it doesn't have any ecological benefit. The poorest communities get left behind, and the richest communities pay to build themselves out of sea level rise."**
>
> – Julie Beagle, Former Senior Scientist at the San Francisco Estuary Institute

Solution: *The San Francisco Bay Shoreline Adaptation Atlas*, a shared resource that took the San Francisco Estuary Institute five years to create, illustrates and matches the best types of shoreline management projects for the physical conditions in each place. This framework led to the creation of 30 operational land units, categorizing types of shore that share geophysical and land-use characteristics spanning the bay's 400 square miles. The common categorization can then be translated to other coastal work. The institute's leaders hope the resource encourages all entities that touch the shoreline—cities, counties, highways, wastewater treatment plants, and private landowners—to work together on regional approaches. The atlas was created using GIS technology that the institute has used for decades to analyze and manage information about the estuary's chemical, physical, and biological health. Now with $500 million in voter-approved bond funding for wetland restoration over 20 years, that data will drive decisions that make the most of these investments. ▶

San Francisco (continued)

Result: The East Bay Regional Park District is already utilizing the atlas to understand the bay trail system's vulnerability to flooding and determine ways to mitigate the potential damage. By taking advantage of natural processes, the atlas serves as a science-based framework for developing adaptation strategies specific to the estuary's diverse shoreline.

The San Francisco Estuary Institute is also using its EcoAtlas to manage information about all of the state's bay restoration projects. In EcoAtlas, the institute is using regularly updated aerial imagery—including imagery from drone flights—to observe sediment volumes in stream channels and tidal marshes, inventory pieces of trash trapped in the wetlands, and raise awareness of harmful algal blooms. The information is then tracked by regulators over time to monitor compliance and progress. Years of remediation have improved water quality and restored vital habitat in the bay, but there's still work to be done on equitable resilience. ■

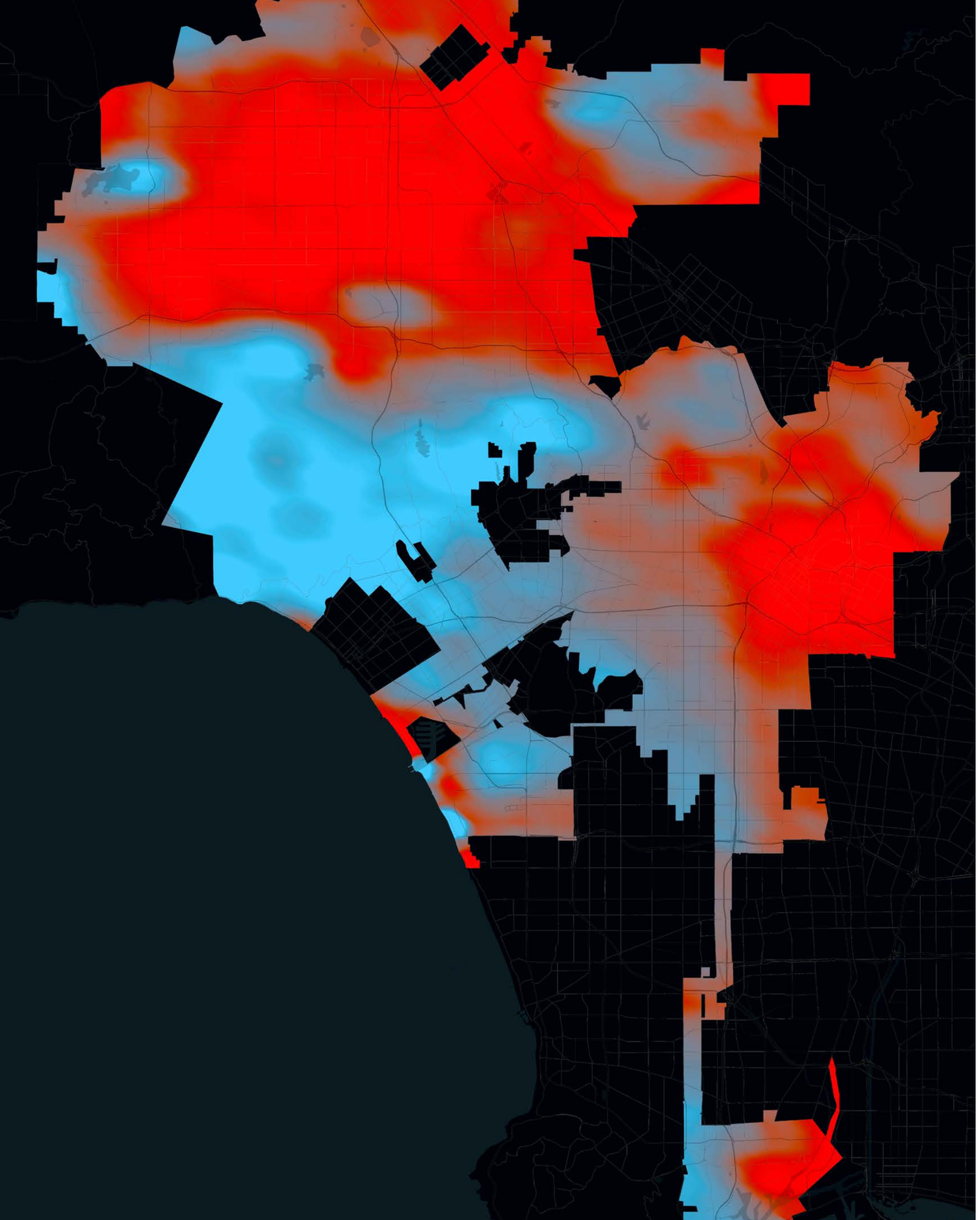
CASE STUDY

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

Using a Geographic Approach to Environmental Justice

Situation: One of the environmental justice movement's key tenets is that pollution—and its effects—are unevenly distributed. The presence of pollution, furthermore, does more than contribute to a community's ill health; it also perpetuates it, exacerbating social conditions that are not directly caused by pollution. In communities with a heavy pollution burden, an already embattled population experiences it in a way that makes it even heavier, creating an oppressive feedback loop.

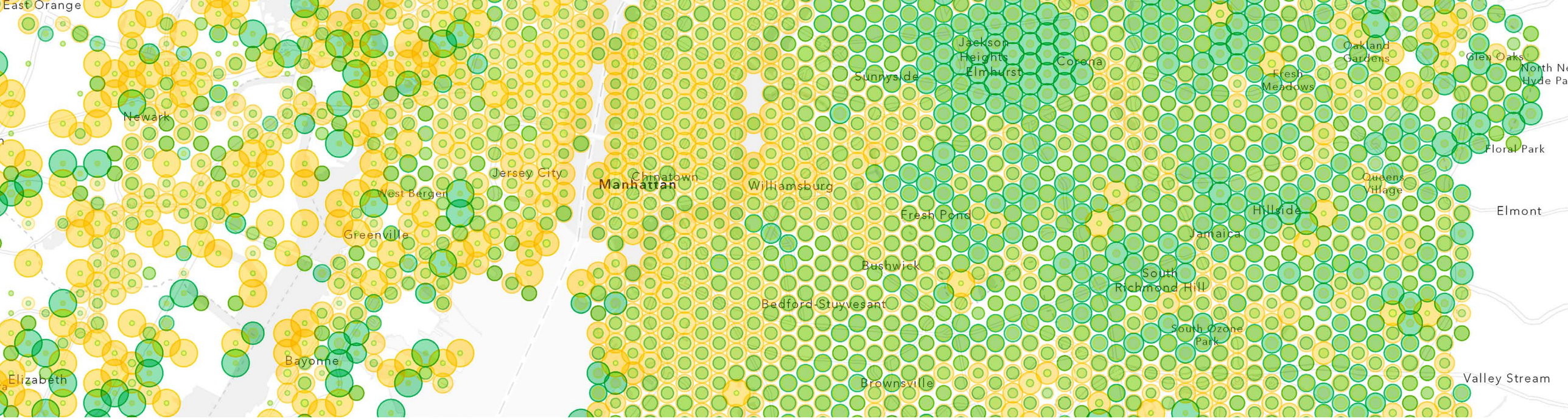
Challenge: The California Environmental Protection Agency (CalEPA) needed a way to show this burden and guide mitigation measures. It needed a way to gauge where the issues of pollution were causing the most dangerous situations, and it needed to know the profile of people in the place in order to guide funds to disadvantaged communities. ▶



California (continued)

Solution: Using GIS technology, CalEnviroScreen ranks and color-codes California's more than 8,000 census tracts to reflect vulnerability to pollution. The formula behind CalEnviroScreen considers the presence of various types of pollution, the prevalence of health problems that can be worsened by pollution, and population data. The map emphasizes specific categories of inequities by color code based on the percentage of people in different demographic groups.

Result: CalEnviroScreen has gained wide praise, including from the White House. It has guided projects to tackle environmental justice issues across the state, including impacts from industrial zones and the overapplication of pesticides in farming communities. It reveals with a score the environmental condition and the people who are most vulnerable. As the state's main vehicle for investing funds, CalEnvironScreen has allowed CalEPA to launch a series of initiatives that have targeted vulnerable areas. Because the tool focuses investment on infrastructure and capacity building, it promises community benefits that extend well beyond each community that is remediated. ■



Tools from Esri

Three ArcGIS® products add important real-time perspectives that enhance an organization's situational awareness:

ArcGIS Velocity℠ is a cloud-native software as a service for ArcGIS Online that allows organizations to ingest data from IoT platforms, message brokers, and third-party APIs. It helps users process, visualize, and analyze real-time data feeds; store them as big data; and perform fast queries and analysis. This capability adds an awareness that brings clarity to essential operational decisions, allows remote monitoring of important assets, and provides key inputs to achieve predictive maintenance and process optimization.

ArcGIS Field Maps integrates the ability to capture data with easily configured forms; combine position and locations on a map to find assets and route to the work; capture the tracks of field staff, monitor where they are, and analyze where they have been; and improve transparency between the field and office by seeing tasks alongside the location of the workforce.

ArcGIS Hub℠ community engagement software provides an easy way to organize people, data, and tools to tackle challenges. Cities, states, and even the White House have applied this framework of tools to take on operational challenges. The suite of products provides a means to share open data, create unlimited outreach efforts, and organize action around initiatives.

Each of these tools speeds an organization's ability to gather data at high volumes to provide context. ■

CONCLUSION

Geospatial technology continues to evolve, with streaming location data providing a current view of reality that greatly speeds understanding, as well as the ability to look at historical patterns and see trends. GIS enables a common view and a way to share data and input from anyone. A growing suite of spatial analytics tools allow organizations and agencies to dive deeply into every incident to answer the *where*, the *why*, and the *now-what* questions quickly.

By applying a geographic approach in operations, the data gets better; the root causes and places to invest in become readily apparent; and the analysis, communication, and collaboration necessary for success grow clearer.

A geographic approach and the technology that empowers it help us tackle and understand complex, emerging challenges such as the climate crisis.

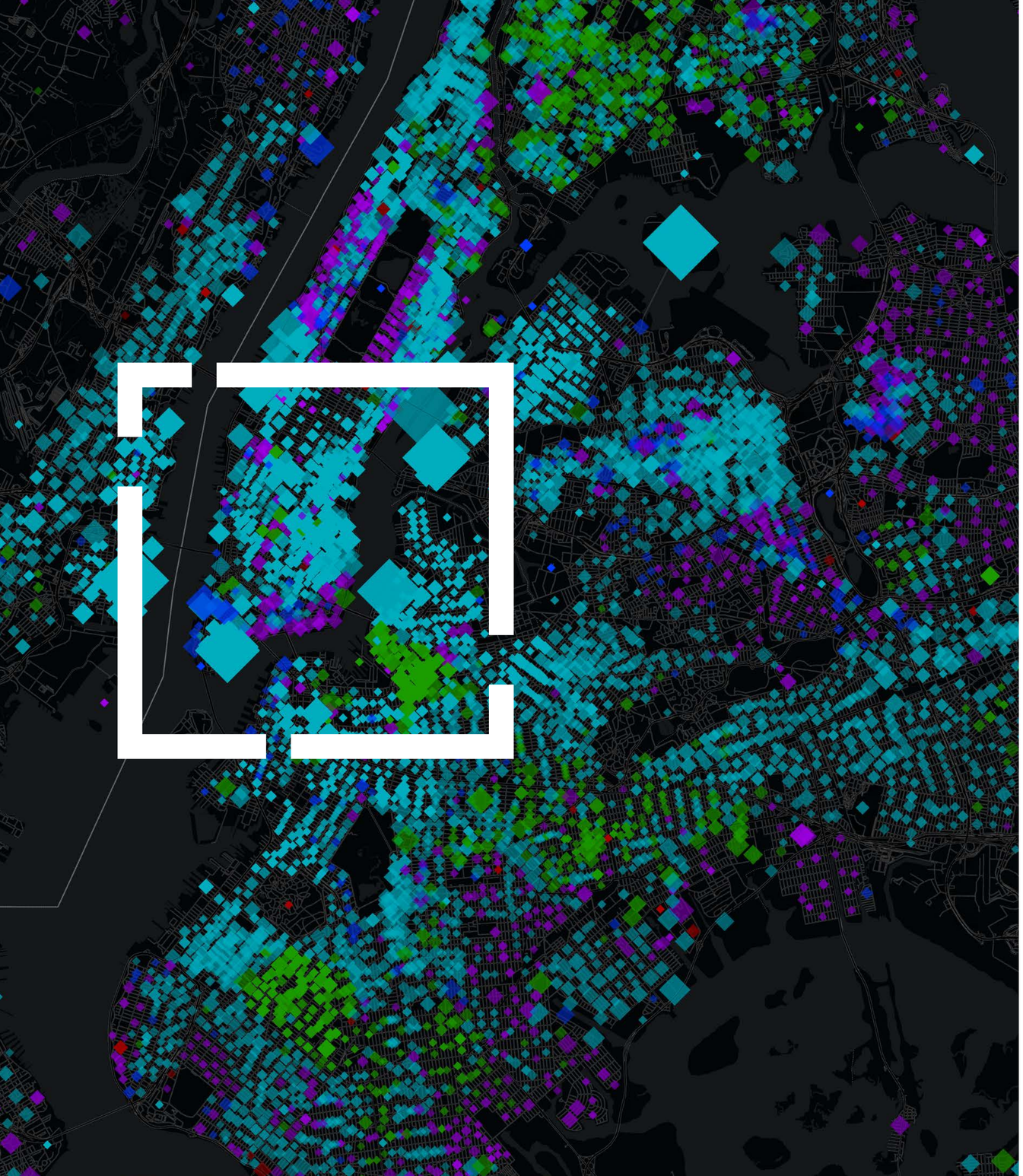
The recent scientific assessment released by the United Nations' Intergovernmental Panel on Climate Change paints an alarming picture of widespread damages to human and ecological health. The urgency of the situation means we must move past obsolete approaches in order to reduce compounding impacts.

The report relates intertwined issues that have highlighted food and water security, extreme weather disasters, species loss and extinctions, and declines in human physical and mental health.

These related factors require interdisciplinary experts to work together to accelerate solutions, but they can't do that easily with the systems that are in place. Speeding collective action—across state agencies, with all levels of government, and with the public—requires whole new levels of data sharing. Collaboration on solutions requires technology that fosters data transparency and tools for collective analysis, planning, and actions.

A new combination of technologies—cloud computing, mobile applications, Internet of Things sensors, and artificial intelligence—can speed understanding and foster swift and meaningful climate action across any city.

New York City has billions of federal dollars to make its infrastructure, transit, housing, and coast more resilient. Now is the time to modernize the city's geospatial infrastructure to optimize the projects and opportunities and mitigate the risks, making the most of historic funding to build an even stronger city. ■



Learn More

Esri, the global market leader in geographic information system (GIS) software, location intelligence, and mapping, helps customers unlock the full potential of data to improve operational and business results. Founded in 1969 in Redlands, California, USA, Esri software is deployed in more than 350,000 organizations globally and in over 200,000 institutions in the Americas, Asia and the Pacific, Europe, Africa, and the Middle East, including Fortune 500 companies, government agencies, nonprofits, and universities. Esri has regional offices, international distributors, and partners providing local support in over 100 countries on six continents. With its pioneering commitment to geospatial information technology, Esri engineers the most innovative solutions for digital transformation, the Internet of Things (IoT), and advanced analytics.

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