ArcNews

Syracuse Uses ArcGIS Velocity to Take Its GIS to the Next Level

Real-Time Snowplow Monitoring Proves Successful, Opening Doors for Additional Implementations
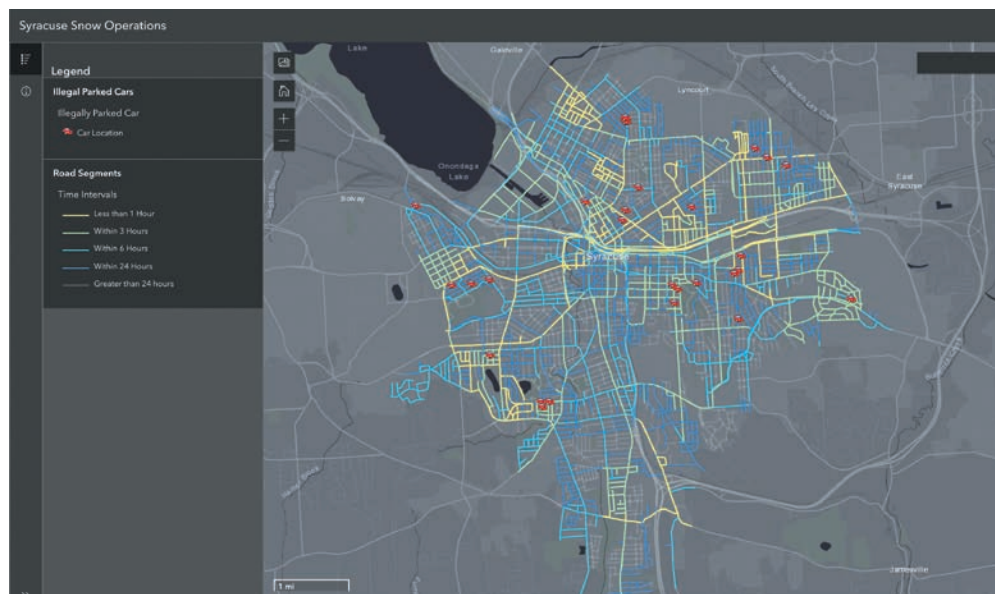
↑ During snowstorms, a new public-facing map lets Syracuse residents see which roads have been plowed recently.

Syracuse, New York, typically receives about 124 inches of snow per year, according to the National Weather Service. This means that from late fall to early spring, frequent snowstorms make it difficult for residents of the midsize city to drive to work or school, go to the grocery store, and get to their health-care appointments, among other needs.

"During heavy snowstorms, we have people call in to ask when the city is going to plow their street," said Conor Muldoon, deputy chief innovation and data officer for the City of Syracuse's Office of Accountability, Performance, and Innovation (API). "We need to be able to tell them that we plowed their street three hours ago instead of not at all, which is sometimes what it might look like."

With help from a team at Esri, Syracuse implemented the new Winter Weather Operations and Winter Weather Outreach solutions, along with

Mobile GIS Apps Help Citizen Scientists Guide Oil Spill Cleanup

By Julia Chunn-Heer, Coastal Consulting, and Ruarri Serpa, Surfrider Foundation

As waves receded from shore on a stretch of Southern California beach on October 2, 2021, they left black outlines at their extents. Soon, sticky tar balls, too toxic to touch without proper protective gear, dotted miles of sand.

A major oil spill off the coast of Huntington Beach had spewed almost 25,000 gallons of crude oil into the Pacific Ocean, killing marine life and birds; threatening wetland ecosystems; and fouling a scenic and popular coastline that contributes $2.6 billion to the local Orange County economy alone, according to the National Ocean Economics Program.

Regulatory agencies, nongovernmental organizations, and residents sprang into action to abate the disaster. The California Department of Fish and Wildlife (CDFW) and the US Coast Guard—part of the Unified Command team that directed the cleanup—received thousands of phone calls from people who wanted to help.

"But there's a problem," said Chad Nelsen, chief executive officer of Surfrider Foundation, a nonprofit
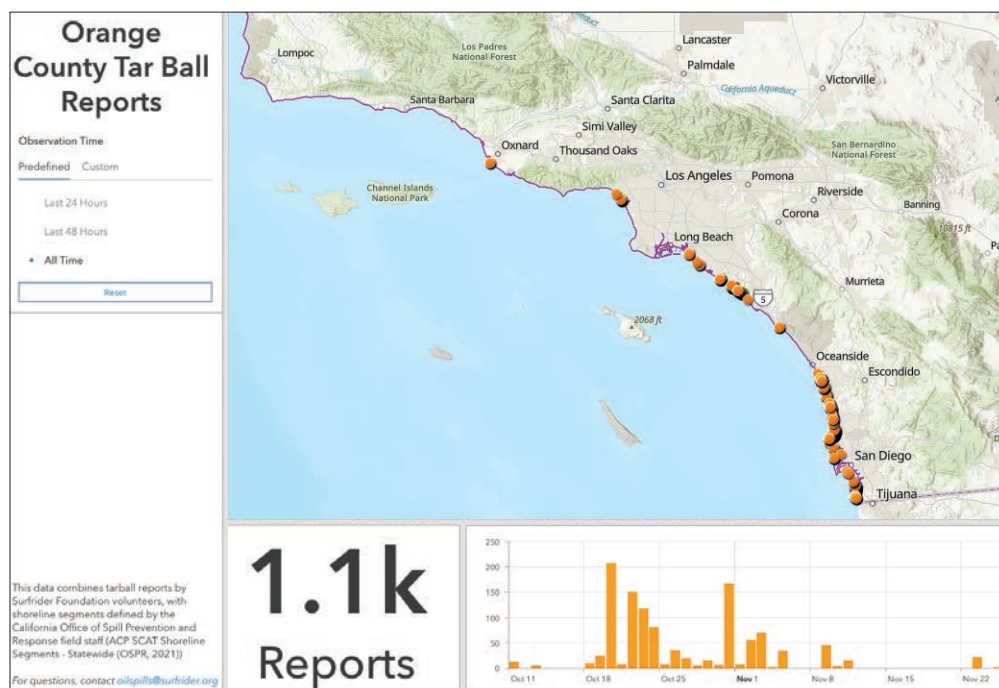
↑ Leaders at Unified Command used a dashboard to see where tar balls had accumulated and plan their daily cleanup operations. (Image courtesy of Ruarri Serpa.)

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In many communities, residents consume lead-contaminated drinking water, which can cause severe health effects. New funding through the Infrastructure Investment and Jobs Act is available to assist with replacing lead pipes. Given this new influx of capital, the City of Oconomowoc, Wisconsin, began to take action, and implementing the latest Esri technology got the city moving in the right direction.

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INDOOR MAPPING AND WAYFINDING JUST GOT BETTER

ArcGIS Indoors and ArcGIS IPS are Esri's flagship indoor mapping and positioning products that enable organizations to gain geospatial context of their interior spaces. Indoor GIS can help manage indoor assets like broken pipes and desks; evaluate space usage trends by displaying foot traffic patterns, social distancing metrics, and cleaning statistics; and provide routing to get people to where they need to go or even evacuate building occupants safely during an emergency.

New this year, ArcGIS Indoors is available in three different options: ArcGIS Indoors Pro, ArcGIS Indoors Maps, and ArcGIS Indoors Spaces. This makes it easier for organizations to extend their existing ArcGIS systems to address their indoor needs. ArcGIS Indoors Pro and ArcGIS Indoors Maps enable users to transform computer-aided design (CAD) and building information modeling (BIM) floor plans into floor-aware maps that can be used for indoor mapping and wayfinding. ArcGIS Indoors Spaces allows people to produce maps and apps that can be used for space management and work space reservations. Additionally, both ArcGIS Indoors Maps and ArcGIS Indoors Spaces can be enhanced with ArcGIS IPS, which provides real-time indoor positioning and tracking.

Read on to get a more detailed look at how these products work.

Three Options and a New Experience for Indoor Mapping

ArcGIS Indoors Pro extends the capabilities of ArcGIS Pro to build floor-aware indoor maps, supporting the creation of an indoor digital twin. Indoors Pro transforms CAD and BIM floor plan data into an indoor system of record—a single, accessible place that can be used to support asset mapping, safety, security, and event planning. Indoor maps built in Indoors Pro can be further used in wayfinding and space management workflows that are supported by two other products in the ArcGIS Indoors product suite, ArcGIS Indoors Maps and ArcGIS Indoors Spaces.

ArcGIS Indoors Maps delivers location-based experiences, such as wayfinding and incident reporting, to everyone in an organization. Building occupants and visitors can use the Indoor Viewer, kiosk mode, and the Indoors mobile app to easily locate and navigate around an organization's buildings. When there is a problem in a building, such as broken equipment or damaged property, Indoors Maps can help staff members from IT and facilities locate the issue quickly. If ArcGIS IPS is added to Indoors Maps, users can see their real-time location represented by a blue dot while wayfinding.

ArcGIS Indoors Spaces equips organizations with space management capabilities and allows employees to make work space reservations—a necessity in this new era of hybrid workplaces. The Indoor Space Planner app that can be added to Indoors Maps enables users to define, allocate, and assign space within buildings, which can help coordinate staff moves, honor social distancing requirements, support a safe return to work, and maximize space usage. It offers a simple and straightforward way to foster a productive and collaborative workplace while giving employees the flexibility to work in the spaces that best suit their needs.

ArcGIS IPS is an indoor positioning system that adds a live location experience to maps created with ArcGIS Indoors and custom-built apps based on ArcGIS Runtime SDKs. With ArcGIS IPS enabled, users can see their real-time location inside a building represented by a blue dot. This increases location awareness by showing users where places, people, and points of interest are relative to their position. ArcGIS IPS also provides options for location sharing and tracking (when users opt in), location data capture, and analytics. This can help building occupants and managers alike make better-informed decisions not only about where to go but also about space management and resource allocation issues.

Get Started with Better Indoor Mapping

Now more than ever, business leaders need the geographic context that only GIS can provide to understand patterns and relationships—indoors. ArcGIS Indoors and ArcGIS IPS give organizations the tools they need to use GIS inside their buildings and enable supervisors, employees, contractors, and visitors to better navigate and manage the indoor spaces they're in.

To get started with an indoor GIS deployment, visit the ArcGIS Indoors product page at go.esri.com/indoors and the ArcGIS IPS product page at go.esri.com/ips to reach out to an Esri representative.
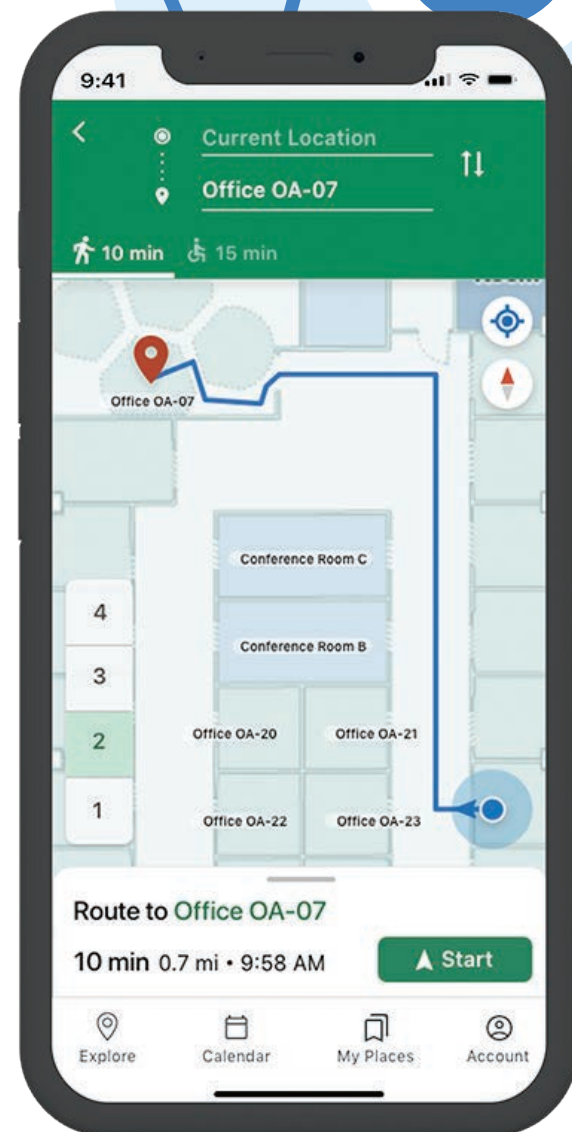
↑ While wayfinding, the blue dot makes it easier for users to see their real-time location on a map.

Try Using ArcGIS Arcade to Enhance Workflows in ArcGIS Online

ArcGIS Arcade has grown and matured throughout the ArcGIS system over the past few years. This expression language, created by Esri, allows users to write equations that take data, evaluate it, and return results that the map then treats like any other attribute. In its simplest form, users can think of Arcade as an in-map calculator that resembles the Microsoft Excel experience of creating a formula. While ArcGIS Online supports multiple scripting languages, Arcade is unique. It is geospatial, lightweight, secure, dynamic, and portable across ArcGIS. This means that Arcade can quickly become a key part of efficient workflows in ArcGIS Online.

A Unique, Dynamic Scripting Language

With Arcade, users can create expressions that include spatial operations—functions that generate spatial data from specified input data—like buffers. Arcade understands geometry, features, layers, and maps. Expressions execute quickly, and Arcade works equally well on mobile devices and desktop computers.

Unlike other scripting languages, Arcade doesn't require big libraries for the expressions to work. It is also a self-contained scripting language, meaning users can only execute it within specific contexts of the ArcGIS system. This guards it from being injected with malicious code.

One of the key benefits of Arcade is that it is portable in two ways. First, users can write an expression once and use it across the ArcGIS system, including in ArcGIS Pro, the ArcGIS Runtime SDKs, ArcGIS API for JavaScript, ArcGIS Online, and many apps. Existing expressions are accessible in the Arcade editor and autopopulate into the expression window when selected. Second, expressions are honored in downstream applications because expressions are stored within the map. For example, an expression written to customize a pop-up in a web map will also appear when the map is added to, say, ArcGIS StoryMaps.

Arcade expressions are dynamic, which is ideal for a world filled with live feeds and web layers that continually get updated. The scripting language adapts to changing data, so users don't need to perform additional configurations and calculations. Whenever a viewer loads a map, Arcade calculates the values from the expression on the fly, delivering results that reflect the latest features and attributes.

The Coral Reefs at Risk of Bleaching dashboard in ArcGIS Living Atlas of the World is a great example of how dynamic Arcade expressions work. The dashboard includes a live feed layer with daily updated data from the National Oceanic and Atmospheric Administration (NOAA) that shows coral reefs around the world experiencing heat stress. Arcade expressions define the layer's visualization and pop-ups so the color of the points on the map and the text within the pop-ups correspond to concern levels (e.g., no alert, watch, warning, alert level 1, and alert level 2) that are defined by the latest conditions.

↓ The Coral Reefs at Risk of Bleaching dashboard makes use of dynamic expressions to show daily updates of coral reefs experiencing heat stress.

→ By writing a few lines of code, users can quickly convert height from meters to feet.

Several Ways to Simplify Complicated Workflows

Users who are familiar with traditional, more manual workflows may be surprised by how powerful and smooth Arcade is. It releases users from some of the constrictions that make it difficult to work with numerous data sources and increases the options available for presenting data on maps, in pop-ups, and more.

Take a look at several ways Arcade can simplify complicated workflows in ArcGIS Online.

Freedom from Constraints

To understand the freedom Arcade provides, consider the following scenario. A map author wants to use a layer from a trusted source, but she needs one field formatted differently, plus one additional field. Historically, she would have had to contact the layer's owner and ask him to update the layer—and hope that he agreed to do so. Arcade overcomes this challenge by giving users the ability to customize and calculate new data values themselves without editing the database. Because nothing is being written to the database, users don't need owner capabilities.

More Options for Visualization

With Arcade, users can transform data to make distinctive and informative symbols and layers. Based on a calculated field, users can resize, rotate, and set transparency for the symbols in their maps to better fit a map's scale or represent a particular field. Symbols can also be rotated to indicate direction or status.

To create and customize labels with Arcade, users can define label classes, combine fields, and alter text. Label classes employ Arcade expressions to designate values, such as lowest and highest home values. If the data that needs to be showcased in a label is spread across multiple fields, users can employ Arcade to combine them. For instance, if a label reads "red star," the color can come from one field and the shape from another. Additionally, Arcade can help users alter the text in a label—to add commas and units of measurement, for example, or replace title case with sentence case.

The Power of Data-Driven Pop-Ups

Pop-ups are little windows into additional information. With Arcade, users can deftly turn a default table of elements into an informative, data-driven pop-up. They can even incorporate data from other layers, including layers they don't own and layers that aren't in the map.

Arcade performs calculations to bring information from overlapping layers into one pop-up. These more cohesive pop-ups can display information about fields that have intersecting locations, rather than making users toggle through multiple pop-ups in a single location. This could be helpful, for example, if a user wants to display the names of elementary, middle, and high schools along with building footprint information, such as the year each building was constructed.

Dynamic, On-the-Fly Calculations

Instead of making users add fields to a database, Arcade performs dynamic data calculations on the fly, saving users time and allowing them to explore data in new ways. Arcade can convert field types, calculate new fields, get statistics for a layer, perform spatial calculations, and create categories from numbers.

With just a few lines of code written in a map, Arcade can take values that are stored in a text field and quickly transform them into numbers, making it possible to visualize this data even if it's formatted incorrectly in the table. Expressions can also be used to quickly and easily convert, say, height from meters to feet.

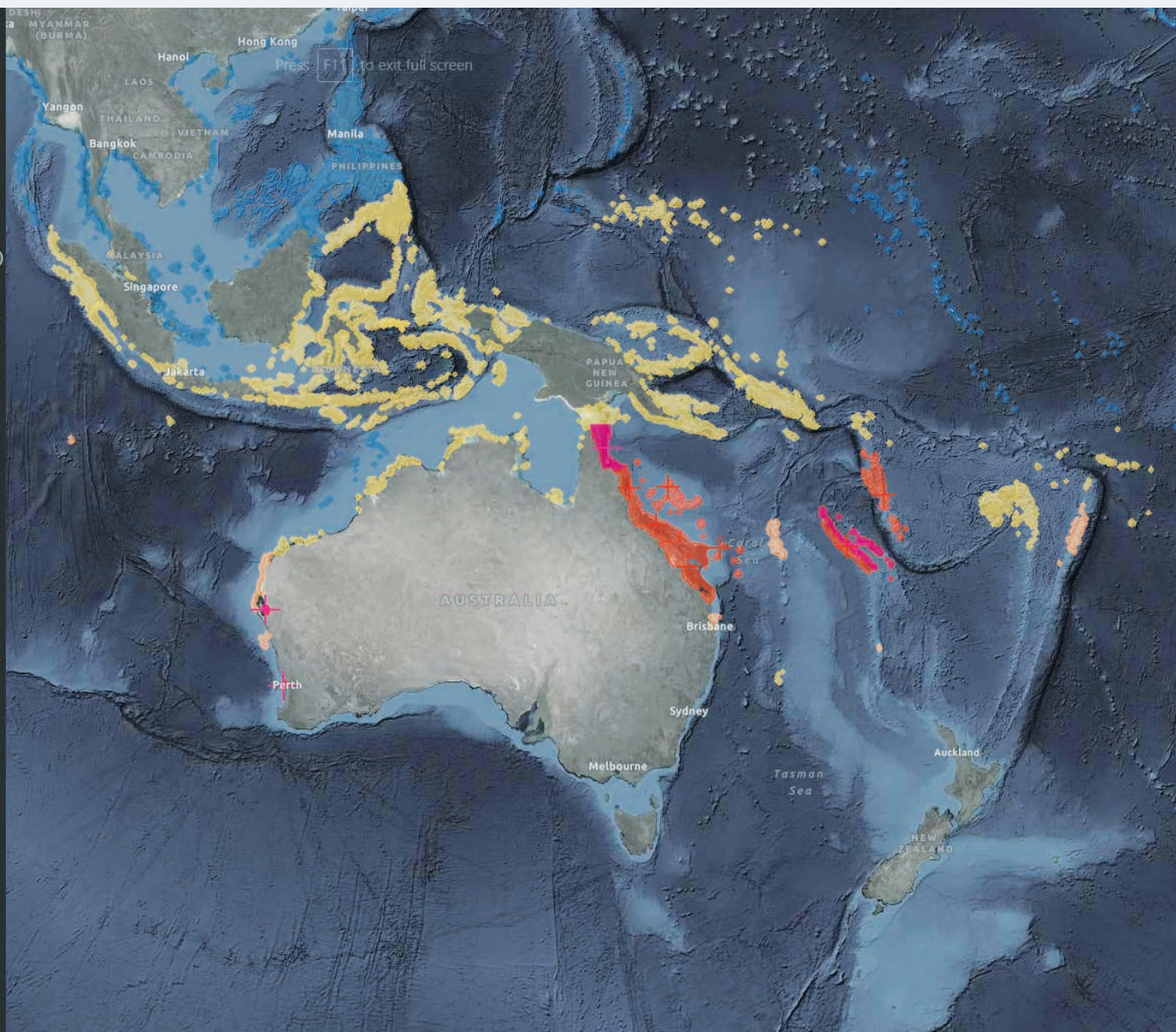Users can also write expressions to calculate percentages, ratios, absolute values, and more. This is useful, for instance, when someone has data on the number of households in a city that don't own a vehicle but wants to show this as a percentage of total households instead, which can be a more effective way of looking at the data.

Arcade also makes it easier to display statistics for a layer, such as the sum, count, average, and standard deviation. For example, users can calculate the count of each type of tree within a layer to determine the most common tree species in a neighborhood. Arcade performs geometry-based functions as well, such as calculating population density, buffers, intersects, and contains. The scripting language enables users to perform spatial joins and do geoprocessing with layers outside their maps, dynamically, in real time.

In addition, users can employ Arcade expressions to turn numeric values into categories. Imagine, for instance, that an employee at a mobility company is tasked with charging electric scooters. To quickly visualize which scooters need to be charged first, the employee could convert the battery level field from a numeric value into categories such as Charge Immediately for scooters with less than 50 percent battery, Charge When Able for scooters with batteries at 50–90 percent, and Fully Charged for scooters with batteries that are more than 90 percent charged.

With its ability to transform data nimbly and dynamically into impactful visualizations, Arcade can become a key part of anyone's efficient workflows in ArcGIS Online. To learn more about using Arcade in ArcGIS Online, visit *ArcGIS Blog* at go.esri.com/ArcGISArcade.
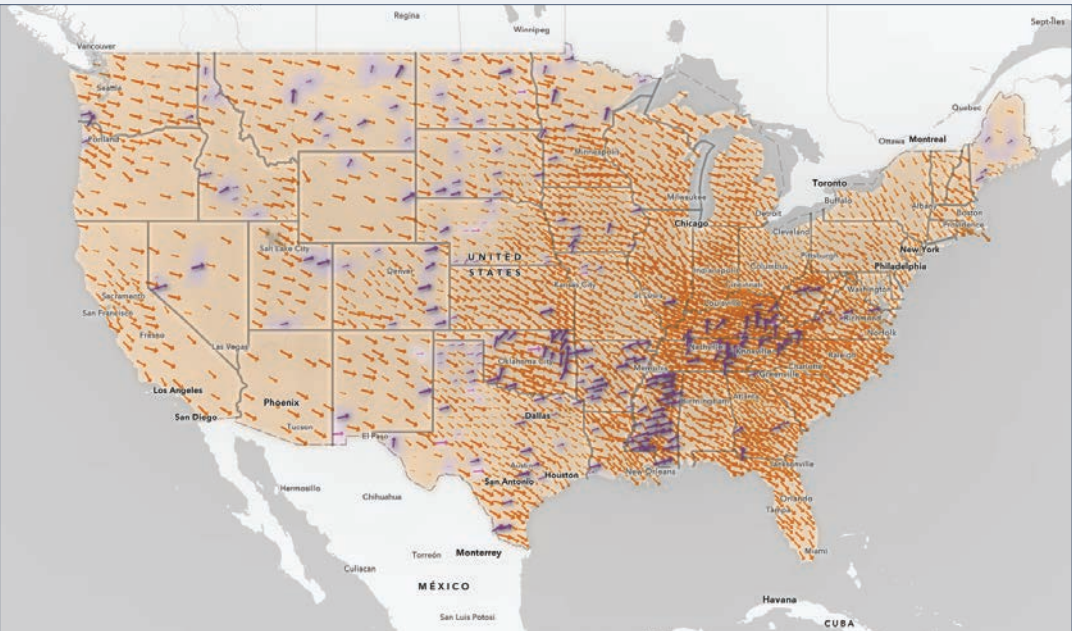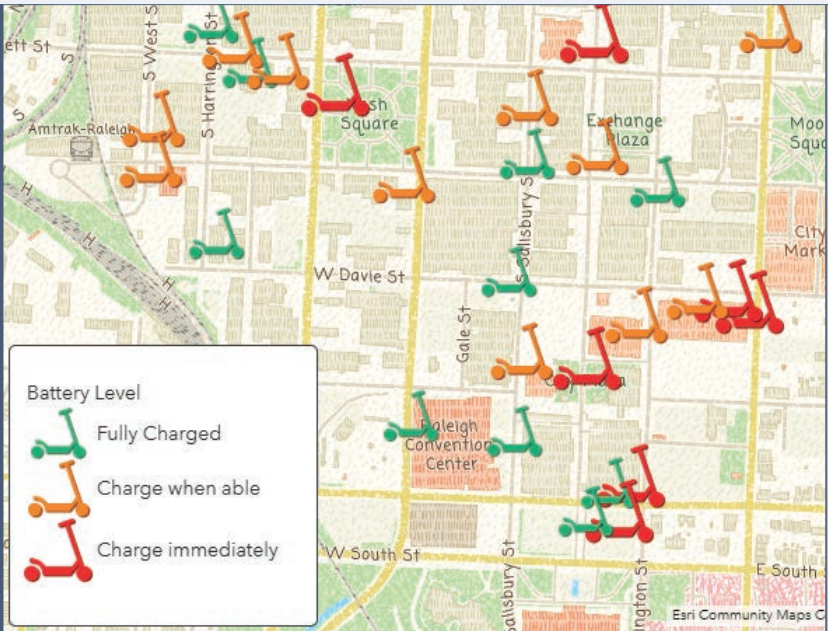
↑ With ArcGIS Arcade expressions, users can turn numeric values, like how much charge a battery has, into categories.

↑ Arcade makes it easy to resize and redirect symbols to show, for example, recent COVID-19 case trends.

Syracuse Uses ArcGIS Velocity to Take Its GIS to the Next Level

ArcGIS Velocity, to track and report—in real time—which roads have been serviced recently by snowplows during snow events. The Department of Public Works (DPW) now uses this system to manage plowing operations, and community members can see which streets have been cleared and when.

Syracuse was the first city to put these winter weather solutions into action, and although the project is still in a pilot phase, everyone from the snowplow crew leader to Mayor Ben Walsh is impressed with how they work.

"Dashboards help the crew leader tell plows where to go next, and the mayor can see the percentage of roads that have been done," said Joanna Bailey, a data analyst on the API team.

"We can communicate to residents how well we're doing and then leverage the data that's being collected to continue to improve our performance—and that's invaluable," added Muldoon.

Taking a Big Leap Forward in Technology

A few years ago, the City of Syracuse cobbled together a public-facing snowplow tracking app that was popular with residents and the administration. But the solution was fragile, and it depended on old sensor technology.

"One person wrote it in Python, and when that person left, it completely broke down. Our team…didn't have the Python experience to keep it going," said Bailey. "So we didn't really have the snow map last winter, and the administration very much wanted us to have one."

In the spring of 2021, the City of Syracuse procured new automatic vehicle location (AVL) sensors from Samsara to track a range of public works vehicles. The API team thought it would be a great opportunity to revisit the snowplow app—and perhaps take a big leap forward in terms of technology.

Muldoon and Bailey reached out to the city's Esri account manager, Gerry Aiken, and told him what they wanted to do.

"They were looking to replace a legacy system with ArcGIS GeoEvent Server and ArcGIS Enterprise, but fiscally and technically, that was going to be a huge effort for them," said Aiken. "We proposed ArcGIS Velocity—a scalable, cloud-based product that deploys in hours, not weeks—and they took to the idea right away. Now, they don't have to manage the infrastructure, so they can concentrate on configuring the solution and, ultimately, the actual data."

As part of Esri's new Winter Weather Operations solution, Velocity takes live sensor data, feeds it into ArcGIS Online, and serves up map-based analytics that can aid with decision-making. This data can also be shared with the public via simple maps and apps that make it easy to monitor progress and see results.

"We were able to add Velocity to our existing ArcGIS technology without going through a massive overhaul of building out ArcGIS Enterprise from the ground up," said Muldoon. "Being able to take Velocity pretty much out of the box and go from having our backs against the wall to having a gold-standard, cutting-edge solution was really amazing."

Presenting the Most Accurate Picture Possible

The solution was ready to go by early December, so when Syracuse experienced its first big (and relatively late) snowstorm in early January, the API team, DPW, and the mayor were all ready to put it to use.

Within the Winter Weather Operations solution, Bailey scheduled a snow event to start when the first snowfall was expected. This essentially tells ArcGIS Online to get ready to take in and process sensor feeds from Velocity.

Once there is enough snow for the snowplows to get rolling, Velocity takes the precise GPS locations being pinged out by each vehicle's sensor and snaps those locations to Syracuse's street segment file in real time.

"What that does is, it shows the last time that part of the street was touched by a vehicle," explained Bailey.

Using a scheduled big data analytic to process the most recent vehicle location data, updates are made to the street segment layer to show which streets have been plowed in the last 10 minutes, the last half hour, the last hour, and so on.

"That feeds into an ArcGIS Experience Builder application that has multiple tabs and allows the operational team within the Department of Public Works to manage the event and direct the vehicles where to go next," explained Alexander Brown, lead solutions engineer for state and local government at Esri. "Live dashboards built with ArcGIS Dashboards can then show everything that's happening with the current winter event, along with an entire season's worth of information, in maps, charts, and metrics."

The data also feeds into a public-facing web app that was built with the Minimalist template in ArcGIS Instant Apps, available through the Winter Weather Outreach solution. This simple map, posted on the city's website, shows a live view of when all the streets in Syracuse were last plowed. Yellow indicates streets that have been plowed within the last hour; green and teal show streets that have been cleared within the last 3 or 6 hours, respectively; blue indicates streets that have been plowed within 24 hours; and gray shows streets that haven't been plowed in over a day.

"Every storm is different, and plow operations change based on conditions on the ground," said Muldoon. "Plows first have to take care of emergency routes and priority routes, so areas around hospitals, commercial thoroughfares, primary commuting routes, schools, and things like that. And then they tackle neighborhood streets. They also have to take into account the terrain throughout different neighborhoods. Just having this information available helps us justify and communicate what's getting plowed when and why."

Bailey has also incorporated a form into the solution that makes it easy for plow operators and members of the community to report double-parked cars.

"This allows residents to see that their street didn't get plowed because an illegally parked car was in the way, so the snowplow has to come back later," Bailey said. "So we're taking in information from the public and from dispatch and joining it all together to try and present the most accurate picture we can for the public."

During the first storm that the public-facing snowplow app was available, the City of Syracuse recorded 12,000 hits on the map in three days. For the next major snow event, the map received 6,000 hits in two days.

"We are getting good engagement on the map," said Bailey.

"Yeah, it's been really well received," Muldoon added.

↓ The Department of Public Works (DPW) uses dashboards to monitor and make decisions about snowplow operations.
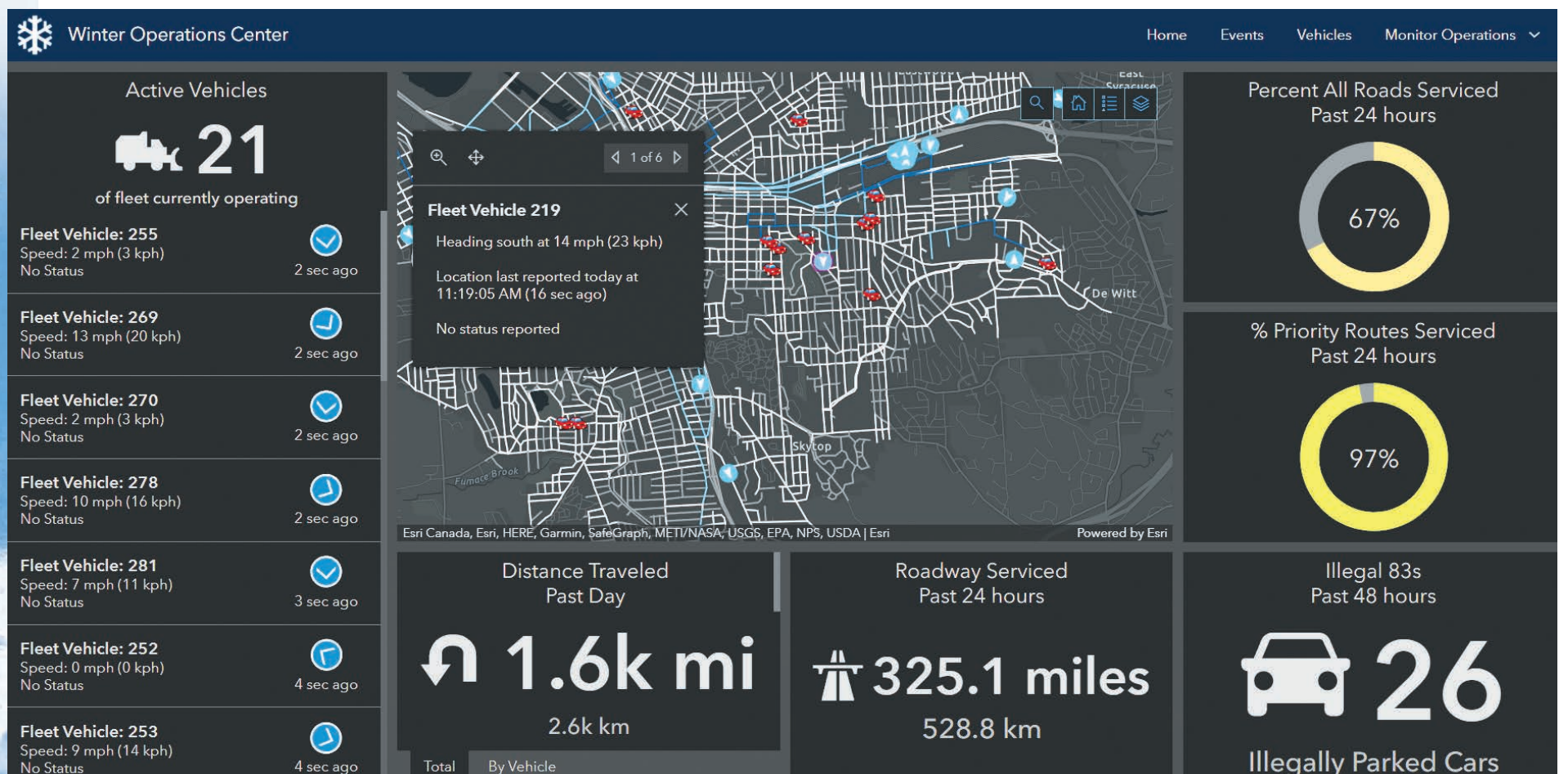
Exceeding Expectations and Trying New Things

ArcGIS Velocity and the winter weather solutions from Esri have exceeded expectations at the City of Syracuse.

"We figured out pretty quickly that this provided much more functionality than what we currently had in terms of fleet management and performance monitoring. It was also much more robust and accurate," said Muldoon. "Now, we're looking to continue to iterate off this tool and have it fit the unique needs of our community."

For one thing, Bailey is working with Esri product engineer Ryan Nosek to build a custom app that will allow leaders from DPW and the mayor's office to evaluate plow performance after storms. The two are also incorporating live sensor data from Syracuse's sidewalk plows into the solution.

"It's great to plow your roads, but you also need to make sure residents can walk around their neighborhoods and downtown," she said.

In addition, the API team is exploring how Velocity could help ingest and analyze live data from other sensor technology the City of Syracuse has in place.

"It would not be a heavy lift to take this existing platform and make a public communications portal and internal performance dashboard for other DPW activities, like trash pickup or street sweeping," said Muldoon.

Another project on the horizon is the use of Velocity for blight monitoring.

"We're working with the Greater Syracuse Land Bank to improve the way we monitor vacant properties," Muldoon explained. "We have smoke detectors and occupancy sensors in abandoned buildings, so Velocity could be used to make sure that when those sensors get tripped, the right people get notified so the police or the fire department can go check out the situation."

In essence, this is what makes the City of Syracuse such a GIS success story, according to Brown and Aiken.

"They want to push technology to make better government decisions," said Brown.

"They're forward-thinking and eager to try new things, and it's just a real pleasure to work with them," echoed Aiken.

Muldoon expressed similar views about his colleagues and the administration at the City of Syracuse.

"This is a very conducive environment for being able to use new technology and leverage data to make decisions," he said. "We are really excited to take this solution, our partnership with Esri, and the knowledge that we've gained to think through how we can use GIS more strategically as an organization."

Esri Addresses Climate Change as a Top, Company-Wide Priority

Climate change is one of the defining issues of this generation. More frequent and extreme weather events, along with gradual, longer-term changes to the environment, are impacting people's lives.

According to the World Meteorological Organization, 2021 was one of the seven warmest years on record—and the last seven years have been the warmest in history. This was punctuated with record drought in South America and unprecedented flooding in Asia and Europe. Notably, some of the most extraordinary weather events in 2021 didn't occur in typically warm areas. Canada shattered its record-high temperature by hitting 49.6 degrees Celsius (121 degrees Fahrenheit) in British Columbia at the end of June.

No place in the world is immune to the effects of climate change. Combating this crisis necessitates new ways of thinking and behaving. To understand changing climate conditions, anticipate future impacts, and drive mitigation and adaption strategies across all aspects of society, people need access to sound data, tools, apps, and workflows. This will require unparalleled collaboration—and a geographic approach.

Champions of Climate Change Are Already Taking Action

The climate-based challenges the world faces are not new, and there are already champions of climate change around the globe.

At the end of 2021, global leaders, scientists, and impassioned youth came together at the United Nations (UN) Climate Change Conference, COP26, to commit to taking collective, meaningful action in response to climate change. In early 2021, one of US president Joe Biden's first acts in office was to sign a comprehensive executive order on climate change that calls for a whole-of-government, science-driven approach to addressing the crisis. The European Green Deal, which seeks to make the European Union climate neutral by 2050, strives to engage all people in climate action.

Governors, mayors, and community leaders around the world are working on climate resilience plans that span the neighborhood level to whole regions. Local governments are evaluating new infrastructure projects for future climate risks, retrofitting buildings to improve energy efficiency, and taking a geographic approach to siting areas for wind and solar energy generation. They are also mapping out where to equitably install electric vehicle (EV) charging stations and establish interstate EV corridors.

At the same time, private companies are evaluating climate-induced vulnerabilities in their facilities and supply chains to protect their businesses and be more responsible corporate citizens. Delivery companies are analyzing driving patterns and location characteristics to evaluate how to electrify their fleets. Architecture and engineering firms are applying climate-smart principles to their project designs, and health-care providers are rethinking public health issues as climate change alters the way diseases spread. Nonprofit organizations as well are working strategically to conserve land and water, enhance nature-based climate solutions, and help governments and businesses harness new ideas and technologies.

Many of the innovators in these spheres are Esri users, and many others would like to leverage these users' experience. Esri is well positioned to assist. As a company that has always had the vision that geospatial technology could be used for a
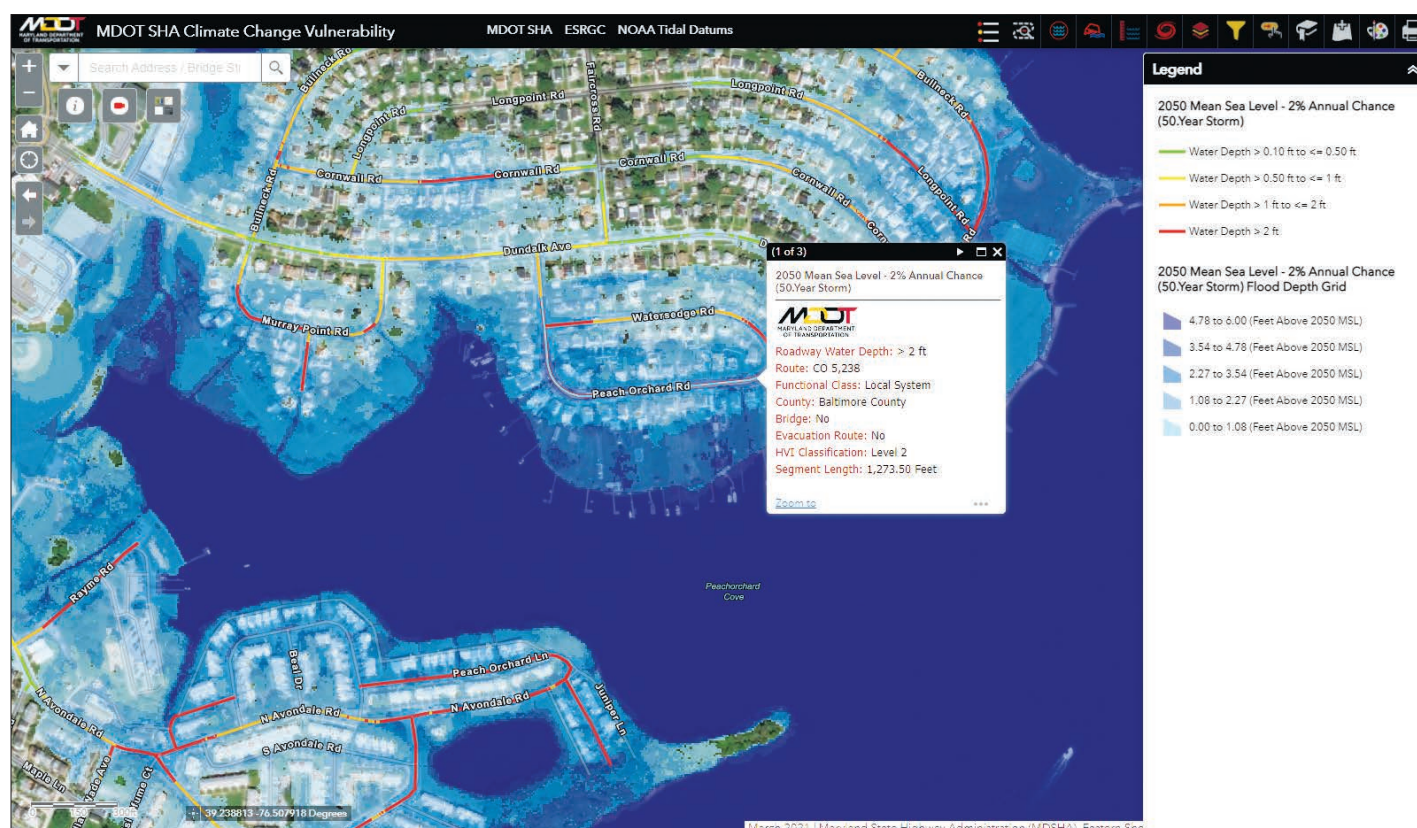
↑ Having access to various climate scenarios—like the potential extents of sea level rise during a 50-year storm, seen here for parts of Maryland—can help planners and designers prepare for future climate conditions.

Heat Intervention Index Explorer — Plan your community heat health intervention

Total Population	Temperature	Area Lacking Trees
304.2k	112 F	98.5 %

← Analyzing national heat indexes can help local government decision-makers see where to plant trees.

higher purpose—to help design a more sustainable world—Esri operates on the notion that supporting the needs of one often benefits many.

New Climate Initiatives at Esri Focus on Collaboration

For more than 30 years, Esri has been collaborating with users in the climate community, ranging from climate researchers to staff at national weather agencies. In the early 1990s, for example, Esri teamed up with the National Science Foundation in the United States to study the hole in the ozone layer and do Antarctic solar radiation modeling. Esri's work on climate-related initiatives has expanded over the years to the point that the company was awarded a top ranking in the *Forrester New Wave: Climate Risk Analytics, Q3 2020* report.

Recognizing the growing urgency to scale up its climate efforts even more, Esri formed a new climate team last year, pulling together experts from across the organization to institute a more comprehensive approach to tackling the crisis. Out of this came five focus areas that are already reshaping Esri's work.

Mitigate Changes to the Climate

Esri's climate initiative begins with climate mitigation measures that support users' efforts to reduce greenhouse gas emissions. This builds on previous work Esri has done to help find sites for alternative energy production, model transportation alternatives, and assist with sustainable land and forest management.

Carbon capture company Summit Carbon Solutions, for example, recently adopted ArcGIS technology to help with its efforts to trap and store carbon dioxide before it gets emitted into the atmosphere. In addition, the United States Department of Agriculture, in league with the European Union, is using ArcGIS to map areas that have the highest potential for carbon sequestration to determine which farm management techniques to invest in.

Understand the Impacts of Future Climate Conditions

To prepare for future climate conditions, planners and designers need access to future climate scenarios and impact modeling results. Twenty years ago, Esri collaborated with a team at the National Center for Atmospheric Research (NCAR) to incorporate netCDF (network Common Data Form) into ArcGIS and help make it an Open Geospatial Consortium, Inc. (OGC), standard.

Since then, Esri's work with NCAR has grown to the extent that data using CMIP5 and CMIP6 climate projections is published in ArcGIS Living Atlas of the World, and Learn ArcGIS lessons have been built around it.

Esri will continue to make climate projection model outputs easy to use and is committed to helping others understand how to appropriately employ this data. Layers slated to be improved and updated include projections of future temperature, precipitation, sea level rise, and inland flooding extents and frequency—all of which can be used to model future climate-related impacts. Esri will also expand related tools and workflows.

Assess Risk to People and Property

Impact maps that show things like where flooding is likely to happen in 2050 are powerful decision-making tools when overlaid with population projections, planned infrastructure, ecosystems, and other data to determine who or what will be at greatest risk. For example, being able to analyze national heat indexes can help decision-makers see where to place cooling centers, install cool roofs, and plant trees.

Esri is developing new workflows, ArcGIS Hub solutions, and Learn ArcGIS lessons to streamline risk assessments and help governments and businesses prioritize critical areas for intervention. The Esri partner community also provides climate-focused solutions and services, like the climate risk data products from Mayday.ai and tailored climate resilience planning from FernLeaf Interactive.

Geodesign with Climate Awareness

Designing and developing spaces is always an exercise in balancing competing goals. Now, assessing current and future climate risks is part of that consideration.

To help planners, resilience officers, and those who are not GIS or climate experts make well-informed decisions, Esri is developing replicable solutions and publishing data that focuses specifically on climate issues. These are being rolled out alongside training programs that show users how to properly leverage content from ArcGIS Living Atlas along with their own high-resolution and potentially more recent data.

The strength of this approach is in partnering with experts to organize relevant, high-demand climate data and make it easy to use through apps and workflows. For instance, for the recent Climate-Smart Communities challenge, put on

by The Opportunity Project, Esri put together a Hub template for extreme heat, complete with data and tools that guide users through five steps for making resilience plans. Esri is now building out this resource pattern for other threat themes, including wildfires and floods.

Communicate to Educate and Spur Action

To put all these great resources to use, people need to understand the challenges that lie ahead, plus the pathways available for making progress. That means the GIS community needs to engage with and educate the public to prompt action.

In the United Kingdom, Esri UK recently teamed up with the country's Meteorological Office to create GIS-based lessons for K–12 students that help them interpret complex scientific data about the climate. The idea is to show young people how they can build knowledge around climate change and motivate their peers to act to fight it.

One tool that kids and adults alike find useful for communicating ideas is ArcGIS StoryMaps, a story authoring app that makes it easy to build narratives around maps and data. Esri has released new Learn ArcGIS lessons that teach participants how to employ ArcGIS StoryMaps and other user-friendly software to raise awareness of climate initiatives and encourage involvement.

Esri is also currently working with Project Drawdown, a nonprofit dedicated to bringing greenhouse gas emissions into decline, to add interactive mapping experiences and apps to its two educational series, Climate Solutions 101 and Climate Solutions 201. The online courses aim to help leaders in business, philanthropy, investment houses, and communities think strategically about finding climate solutions.

Technology Is a Crucial Part of the Process

By far, Esri's biggest contribution to fighting climate change is in empowering GIS users to plan for it and take action. There are only a few thousand employees at Esri, but Esri has hundreds of thousands of users who, in turn, serve millions of people.

To ensure that GIS solutions work together to tackle the climate crisis, Esri is collaborating with users from various sectors to learn about their challenges, workflows, and new opportunities to act. This has already revealed many common business drivers and needs for data and apps, and the results of this work can be found at esriurl.com/climate.

Esri will continue to focus on its efforts to assist all users in addressing their organizations' sustainability needs. As Esri president Jack Dangermond said, "We recognize the seriousness of the climate crisis, and we know full well that technology will be a crucial part of the solution."

Other Ways Esri Is Doing Its Part

At its Redlands, California, headquarters, Esri operates more than 1.8 megawatts of rooftop photovoltaic (PV) solar power. Its newest facility on campus is a former post office that was repurposed and renovated instead of being demolished and newly constructed. It includes enough rooftop solar power to be a net-zero energy building.

To help minimize carbon emissions caused by transportation, Esri offers a variety of mass transit, vehicle, and other incentives to employees and the local community. Esri partnered with the City of Redlands and San Bernardino County to help bring passenger rail service back to Redlands this year for the first time since 1937. Esri built a station just one block away from campus to make it much easier for staff members and visitors to use mass transit to get around town and go to and from many locations in Southern California, including Los Angeles and Ontario International Airport. Additionally, there are more than 50 EV charging stations on campus, employees participate in a robust rideshare program, and two-thirds of Esri's corporate vehicles are electric.

The climate in Redlands is semiarid, so regional droughts and water usage are a top concern. Esri's high-efficiency landscape irrigation system, which makes use of weather monitoring and forecasts, consumes nonpotable water from the City of Redlands. Parking surfaces at Esri are permeable, and the company has planted more than 10,000 trees in the local community over the last two years.

↓ One of the measures Esri has taken at its headquarters to reduce its carbon footprint is installing solar panels.

About the Authors

Pat Cummens is Esri's director of government strategy and policy solutions. She provides top government leaders with GIS-based guidance on state and national government initiatives and emerging policy issues. Steve Kopp is a science community liaison and senior product engineer on the spatial analysis team at Esri.

Mobile GIS Apps Help Citizen Scientists Guide Oil Spill Cleanup

dedicated to protecting the ocean and beaches. "People want to help, but there's not much they can do because they can't actually go out there and clean up the oil on the beach. It's not safe."

To take advantage of the public's interest in volunteering and help guide cleanup efforts, CDFW set up a cumbersome process for people to report tar balls that washed up on beaches. When volunteers encountered a semisolid lump of oil, they were instructed to take a photo and send the department an email with the latitude and longitude of the tar ball sighting, plus the date and time the photo was taken. People tried to participate, but a lot of them submitted emails with incomplete information. This made it hard to pinpoint where the tar balls were and difficult to manage the incoming data.

Nelsen, who is familiar with GIS, knew there had to be a better way to engage the public in the response effort while collecting sound data. So he and his team got in touch with their contacts at Esri. Together, they used an array of ArcGIS technology—from ArcGIS Hub to ArcGIS QuickCapture—to rapidly deploy data collection and viewing apps that helped streamline operations and clean up Southern California beaches.

A Seamless Reporting System

Within a week of the oil spill, more than 10,000 people signed up to help. Surfrider encouraged them to gather data on tar balls using the geospatial apps it spun up with assistance from Esri and a volunteer from GISCorps, a GIS service program provided by the Urban and Regional Information Systems Association (URISA).

The first thing volunteers were instructed to do was go to Surfrider's Oil Spill Cleanup hub, a site created using ArcGIS Hub that orients volunteers, tracks progress, and provides information to the public. From the Volunteer tab, people were able to download an ArcGIS QuickCapture app using either a QR Code or a link or make observations through a web-based ArcGIS Survey123 form. One of the advantages of using QuickCapture was that participants could track where they had been, which showed other volunteers which beaches had recently been observed. With either app, though, these newfound citizen scientists could quickly and easily photograph tar balls on the beach, and the apps automatically recorded the GPS coordinates where the photo was taken, as well as the date and time.

"The beauty of setting this up is it made it really simple for people to provide usable information because, essentially, once you take that photo and submit it, it automatically reports the date, the time, the GPS coordinates, and all the basic information you need. So, really, all the participants have to do is just get a quality photo," said Pete Stauffer, ocean protection manager at Surfrider. "Then, we set it up so that on a daily basis, all the data that was being submitted through the app would automatically get forwarded to Unified Command. So they could take that data and know how to deploy their cleanup professionals."

To make all this work, Surfrider team members had to correlate the locations recorded by volunteers with the maps being used by Unified Command. They created a hosted feature layer that divided the shoreline into segments based on data from CDFW and then employed the ArcGIS REST API to query all the volunteer observations that had been submitted over the previous 24 hours. The results got incorporated into a feature layer that powered a dashboard, developed using ArcGIS Dashboards, that showed where tar balls had accumulated. Leaders at Unified Command used the dashboard to direct each day's operations. The dashboard was also displayed on Surfrider's Oil Spill Cleanup hub to further engage volunteers.

A Systematic Response to This Disaster—and Others

In the weeks and months that followed the oil spill, citizen scientists submitted more than 1,100 reports of tar balls on beaches stretching from Oxnard to San Diego. This allowed Unified Command to respond holistically to the disaster. In addition to having vessels skim oil out of the ocean and keep it from entering wetlands in the immediate aftermath of the spill, over the weeks that followed, trained responders in hazmat suits were able to see exactly where oil had deposited onshore and clean it up safely.

"We were able to follow the spill because of reporting through the app," said Nelsen.
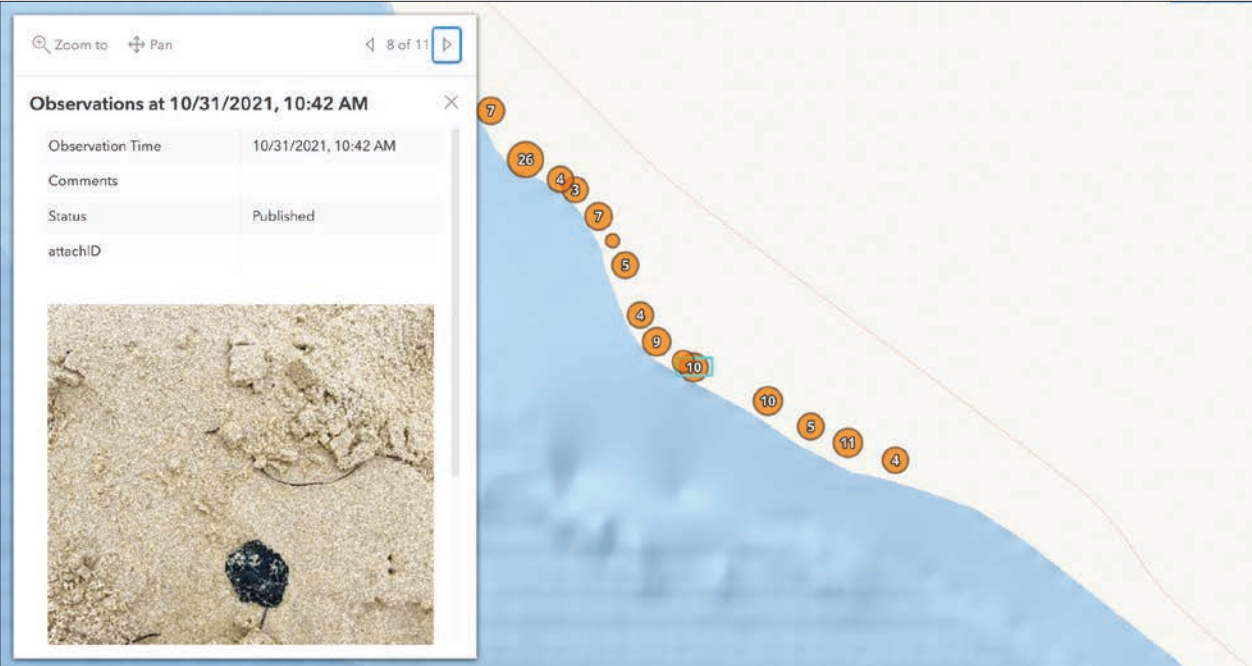
← Tar balls were found on California beaches stretching from Oxnard to San Diego.

↓ The ArcGIS QuickCapture app enabled citizen scientists to track where they had been. (Photo courtesy of Mona Haddad.)

↓ Trained responders in hazmat suits know how to safely clear tar balls from a beach. (Photo courtesy of Julia Chunn-Heer.)

→ The Oil Spill Reporter app, built with QuickCapture, was simple to set up and easy for volunteers to use.

Should there be another hazmat situation that affects the Southern California coastline in the future, the infrastructure now exists for Surfrider to immediately implement GIS-based data collection, management, and mapping tools. The foundation is also advocating that other coastal jurisdictions in California and elsewhere add this suite of technology to their Area Contingency Plans, which detail how emergencies like this are handled.

In all likelihood, this is not the last oil spill that will tarnish California's coastline—or other beaches around the world. Having the tools available to empower the public to engage in citizen science and help guide safe cleanup efforts will improve response times and increase accountability in the long term.

For more information about Surfrider or this project, email Surfrider technology manager Ruarri Serpa at rserpa@surfrider.org. To learn more about Esri's Disaster Response Program, which provides immediate assistance in situations like these, visit esri.com/disaster.

About the Authors

Julia Chunn-Heer is the founder of Coastal Consulting, a contractor for Surfrider Foundation. A California native and graduate of the University of California, Los Angeles, Chunn-Heer has more than 16 years of experience working on environmental policy, and she brings a solutions-based approach to environmental challenges. Ruarri Serpa is the technology manager at Surfrider Foundation. Over the past eight years, largely as the organization's web developer, Serpa has overseen the development of apps to support Surfrider's mission and track its national impact.

↑ → Tar balls are semisolid lumps of oil that wash up on beaches both due to natural seepage and after oil spills.

ArcGIS Survey123 Helps Users Gather Data with Confidence

Every big decision made at an organization requires reliable data. Fortunately, ArcGIS Survey123—a form-first data collection app included with ArcGIS Online and ArcGIS Enterprise—makes it easy to gather data and incorporate it into maps, apps, workflows, and more.

With Survey123, users can set up a simple survey form in minutes or take a little more time to generate a sophisticated smart form that's customized to specific environments. Why forms? Because people are familiar with them. They fill them out on websites, at the doctor's office, and sometimes as part of their daily work. In terms of data collection, forms are an easy way to gather information because they require no training. Any respondent—whether an employee or a member of the public—can simply fill in the blanks with information and observations as needed.

Approximately once per quarter, Esri updates Survey123 to make it easier to use, streamline it with other ArcGIS products, and improve the user interface. Recent releases have focused on helping users design more sophisticated forms and make the data collection experience more efficient. Read on to learn about some of the more significant updates.

More Options in the Web Designer

The Survey123 web designer is a drag-and-drop interface that helps users set up a web-based form or mobile app directly in a browser. The most recent update to this includes added support for question types, such as the new address question that gives respondents another way to identify their location, and improved size options for uploading photos, documents, and signatures. The web designer now also lets users put hidden questions into their forms that make behind-the-scenes calculations, configure automatic calculations based on participant responses, and apply set formats for data entry through input masks. Additionally, if users want to set a custom map or locator for their form—to ensure that they get responses from the appropriate location—that's possible, too.

Annotation Gets Simplified and Standardized

Survey123 allows users to annotate photos, diagrams, and maps to highlight areas that need attention and convey field observations. After completely refreshing the user interface for annotation in September, the Survey123 team recently made it possible for authors of smart forms to define the number and types of annotation tools available to respondents to simplify and standardize data collection. For example, the custom drawing tools palette on a construction site inspection form may include specific tools to denote electrical equipment, water meters, pipes, and so on.

Calculations Receive a Major Performance Boost

In Survey123, users leverage calculations—powered by XLSForm expressions—to populate questions within a form. Calculations can make use of existing data that's either entered by respondents or read from a device, external sensors, photos, or other mechanisms. In the most recent release of Survey123, calculations received a major performance boost that allows users to build larger and more sophisticated surveys than ever before, which can be useful for taking a census or completing asset inspections. There is also a new option that allows survey authors to define when a calculation expression should be triggered: automatically, always, or manually.

Improved Signature Features

For workflows that require accountability, such as when an inspector needs to certify the condition of an asset or an auditor needs to ensure that a job was done properly, Survey123 accepts electronic signatures. Now, survey respondents are presented with a box that has more space to sign in, and each signature is saved as an image—set to exact dimensions—that gets attached to the survey. For approval and sign-off workflows, signatures can be viewed, and new signatures can be added to records, in the Survey123 in-box.

Additional Enhancements

In ArcGIS Survey123 Connect, users can work with media files and custom drawing tool palettes via the new Media tab. In the ArcGIS Survey123 field app, a new Overview folder lets users view and manage survey records through a primary map or list. In the ArcGIS Survey123 web app, users can leverage new, web-accessible date and time widgets. Finally, ArcGIS Survey123 report services allow users to include multiple records in a summary report map, which is helpful to show how many assets were inspected within a specified period, for example.

To learn more about ArcGIS Survey123 and how to implement it for specific needs, visit **esri.com/survey123**.

↑ To simplify data collection, smart form authors can define the annotation tools available to respondents.

→ For workflows that require a signature, respondents have more space to sign in, and each signature is saved as an image.

Location Sharing App Proves Key to Finding Missing Girl

↑ Hundreds of volunteers and multiple agencies participated in the search for the missing girl and her dog.

When a four-year-old girl and her dog went missing in a forested area of Lee County, Alabama, in March 2020, Ken Busby was called to the scene a few hours into the search. As the county's GIS coordinator, he had already printed out an aerial map of the surrounding area. But Busby knew there was a better way to help the search effort.

"Let me bring my laptop," he recalled saying to Rita Smith, the county's Emergency Management Agency (EMA) director. "Let's use live GIS to help with tracking everything and see if that can help in real time."

Busby contacted Esri's Disaster Response Program (DRP) team for assistance. He knew he needed location sharing ArcGIS software to help him and other members of the response team, led by Lee County sheriff Jay Jones, coordinate their search and rescue efforts remotely and in real time.

By the next morning, the team had access to an ArcGIS mobile app with location sharing capabilities that's now part of ArcGIS Field Maps. Busby and the rest of the response team were able to put it to work immediately.

The search was a massive undertaking, with hundreds of volunteers and multiple agencies participating in the operation, including an equestrian team from Lee County, the United States Marshals Service, emergency management agencies, sheriff's departments, and fire departments from Lee County and several neighboring counties.

After Busby briefed everyone, all members of the search parties were able to download the location sharing app to their mobile devices.

"Even people who were volunteers and not part of the coordinated search were able to be included that way," said Amanda Sides, the girl's mother, who was also on scene for the duration of the search.

"Each person that went out got a login [for the app]," said Busby. "[Members of each search party] popped up on the map in the same color. That's how we kept track of all the groupings. We were sending out five or six different teams from the different agencies that were there, going out in different directions, because we had no idea where [the missing girl] was."

At the incident command post, the team set up monitors to display maps with real-time updates on the location of each search party. Busby was in constant radio contact with the searchers to keep them on the right track.

Because of Lee County's rural setting and wooded terrain, location sharing was vital.

"Out in the woods, you could get turned around and be heading off in the wrong direction and not even realize it," said Busby. "We were able to see in real time where these guys were and keep them heading in the right direction at all times."

To address network connectivity issues in the search area, Verizon provided a mobile tower to boost the wireless cell signal in the area. This helped Busby and the rest of the team stay in touch with search parties to make sure everyone knew where they were supposed to go and which areas they had already covered.

"Having that technology, being able to know where you've been [and] focus on areas you might not have covered as thoroughly, certainly helped our sheriff's office and all the search and rescue folks," said Smith.

When searchers came across the girl's footprints on the second day, they took pictures of the evidence and emailed them to Busby, who uploaded the geotagged photos to ArcGIS Pro. From there, the response team was able to map the girl's direction of travel based on the photo locations and project where she had likely gone.

"We were able to get all that [location-based] information to these searchers. We had professionals in that group who could

↑ Location tracking enabled officials at the incident command post to see where search parties had been and home in on areas of interest, which led to a successful search and rescue operation.

utilize a lot of that data," Busby said. "They know what they're looking at and know how that's going to affect their search."

Both GIS mapping and location sharing capabilities allowed the search and rescue team to home in on a specific area of interest. This proved to be a turning point for the search effort.

"We were going all different directions and couldn't concentrate on an area," said Busby. "No matter how many people you have, if you can't concentrate on a specific area, it's a needle in a haystack. We were able to condense that haystack down to a small handful."

By narrowing the search area, the team was able to locate the girl—and her dog—unharmed, on the third day.

"If we didn't have [location sharing]—I hate to say it, but I don't know that we would have found her in as good a condition as we did, or as soon as we did," Busby said.

Although Busby wasn't previously familiar with the location sharing app, its ease of use and the quick response from Esri's DRP team enabled the search and rescue team to speedily implement this new capability into its emergency operation.

"As soon as I got [access], I was right there," said Busby. "It was ready to be put to work."

Busby immediately saw the usefulness of ArcGIS location sharing in similar scenarios.

"Search and rescue should have access to that [capability] nationwide. In this day and age, to conduct a proper search and

rescue mission in the woods, you need something like that," he said. "Everybody that's out there looking needs to have [location sharing capabilities] on them. You need to be able to see where everybody's at [and] where everybody's going. They need to be able to take pictures of what they see and evidence of what they find, and they need to be able to upload it to a central location where everybody can see and access it."

These location sharing capabilities are available in ArcGIS Field Maps, which also includes data collection and map viewing functionality. Location sharing can also be found in ArcGIS QuickCapture.

Busby doesn't routinely deal with emergency response situations, but he advocates strongly for geographic thinking when lives are on the line.

"I've seen firsthand how valuable maps and apps and GIS data are to emergencies," he said, "and how they can be used to affect the outcome."

Smith, who has participated in multiple search and rescue operations, agreed.

"There are so many things it can do that have really opened my eyes as an emergency management director," she said, speaking more broadly about GIS-based emergency response. "It's like an untapped resource that we've tapped into now."

To learn more about ArcGIS Field Maps, go to esri.com/fieldmaps. Information about ArcGIS QuickCapture can be found at esri.com/quickcapture. Esri's Disaster Response Program (DRP) provides software, data coordination, technical support, and other GIS assistance in emergency situations. More information about the DRP can be found at esri.com/disaster.

DASHBOARDS HELP MONITOR AND ABATE FOREST LOSS IN GUYANA

In Guyana, which is renowned for its lush rain forests and exotic wildlife such as jaguars, capuchin monkeys, and giant armadillos, the Guyana Forestry Commission (GFC) is developing a dashboard created with ArcGIS Dashboards that will generate reports about deforestation in the South American nation.

Esri mobile apps, such as ArcGIS Field Maps and ArcGIS Survey123, also will be used by staff at GFC field stations to collect location data and other information on mining and forestry operations, wildfires, agricultural activities, and other drivers of deforestation and forest degradation. The information gathered will provide GFC with situational awareness and a means of compliance monitoring.

"Mining operations are the main cause of deforestation in Guyana over the last decade, as shown by a monitoring system the country put into place to track such activity," said Pete Watt, team leader of the Resource Monitoring group at Indufor, an international consulting firm that provides services to the forestry sector.

Watt works as an adviser to GFC and is responsible for developing and maintaining the country's national Monitoring Reporting and Verification System (MRVS), which was created to monitor its forest areas and carbon loss.

Guyana is recognized as a low deforestation country and signed the Guyana Norway Agreement in 2009 as part of a United Nations initiative called Reducing Emissions from Deforestation and Forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks (REDD+). It is an effort to mitigate climate change. Guyana agreed to monitor, report, and verify changes in its forest cover and the related carbon loss. In return, Norway would provide performance-based payments for carbon stocks on an annual basis.

Real-Time Data Monitoring Detects Trends in Forest Loss

GFC began using ArcGIS software many years ago to create maps of its forest cover. But in a move toward conducting more real-time data collection, analysis, and information sharing, the organization recently started employing ArcGIS Dashboards in ArcGIS Online to create dashboards and launch mobile apps to help monitor and report where forest cover losses have occurred.

"The dashboard adds some analytics, so it's easier to see trends—[such as] how much forest has been lost and where," Watt said.

The current map in the dashboard shows a total of 158,274 hectares of deforestation activity and 35,621 hectares of degradation activity in Guyana, a country that's 21.4 million hectares in size. The main driver of deforestation and forest degradation is mining. Clicking on a red (deforestation) or yellow (degradation) portion of the map reveals the land-use class (e.g., degraded forest) and the driver (e.g., mining, forestry, fire).

Increases in deforestation usually occur when the price of gold spikes because of the prevalence of gold mining in Guyana, according to Watt. He added that the recent El Niño weather pattern, which has caused droughts, has led to more wildfires and deforestation in some areas.

The MRVS system is currently being expanded so it can collect data and perform analyses in near real time, according to Towana Smartt, GIS and remote sensing manager for the Forest Area Assessment United at GFC.

"These updates include reducing the lag time from when a change occurs to when it is mapped and reported," she said. "We are also taking advantage of cloud computing services and the availability of high-cadence satellite imagery."

The MRVS uses Landsat satellite imagery and imagery from the Sentinel-2 satellite of Guyana's forest cover. That imagery is processed in a cloud-based platform. GFC also is transitioning from using ArcMap to ArcGIS Pro for managing and mapping its GIS data.

All this new technology will give Guyana the ability to monitor land-cover change more frequently and with greater accuracy.

Tracking and Recording Forest Cover over the Last 30 Years

The GFC team set the baseline year for tracking deforestation in Guyana at 1990. The rate of forest loss was estimated from then until 2010 using archived satellite imagery. Since 2010, GFC has continually documented and recorded forest loss greater than one hectare. Improvements in computer processing and an increasing number of orbiting satellites have accelerated the system's speed and capabilities.

Because of frequent cloud cover in Guyana, it was necessary to develop ways to extract cloud-free imagery to allow detection of forest loss. Satellite sensors such as radar, which can penetrate cloud cover, are used to obtain clear images when necessary.

Each year, the forest cover data is summarized and run through a GIS processing model to produce the tables and figures needed to meet Guyana's REDD+ annual reporting requirements. The data stored within the GIS is used to provide information about where forest loss is occurring, produce a summary of the causes of forest loss, and help with the creation of maps and tables to support reporting and audit requirements. It is also used by government agencies in Guyana for other national projects.

GFC includes two external audits in its workflow. One of them is a map accuracy assessment.

"This analysis is conducted by a team at Durham University in England," Watt said. "The accuracy assessment is an integral part of the process because it provides an independent evaluation of the national deforestation map created annually by the GFC."

Nasheta Dewnath, program coordinator for the REDD Secretariat at GFC, said the results to date between the national map and the
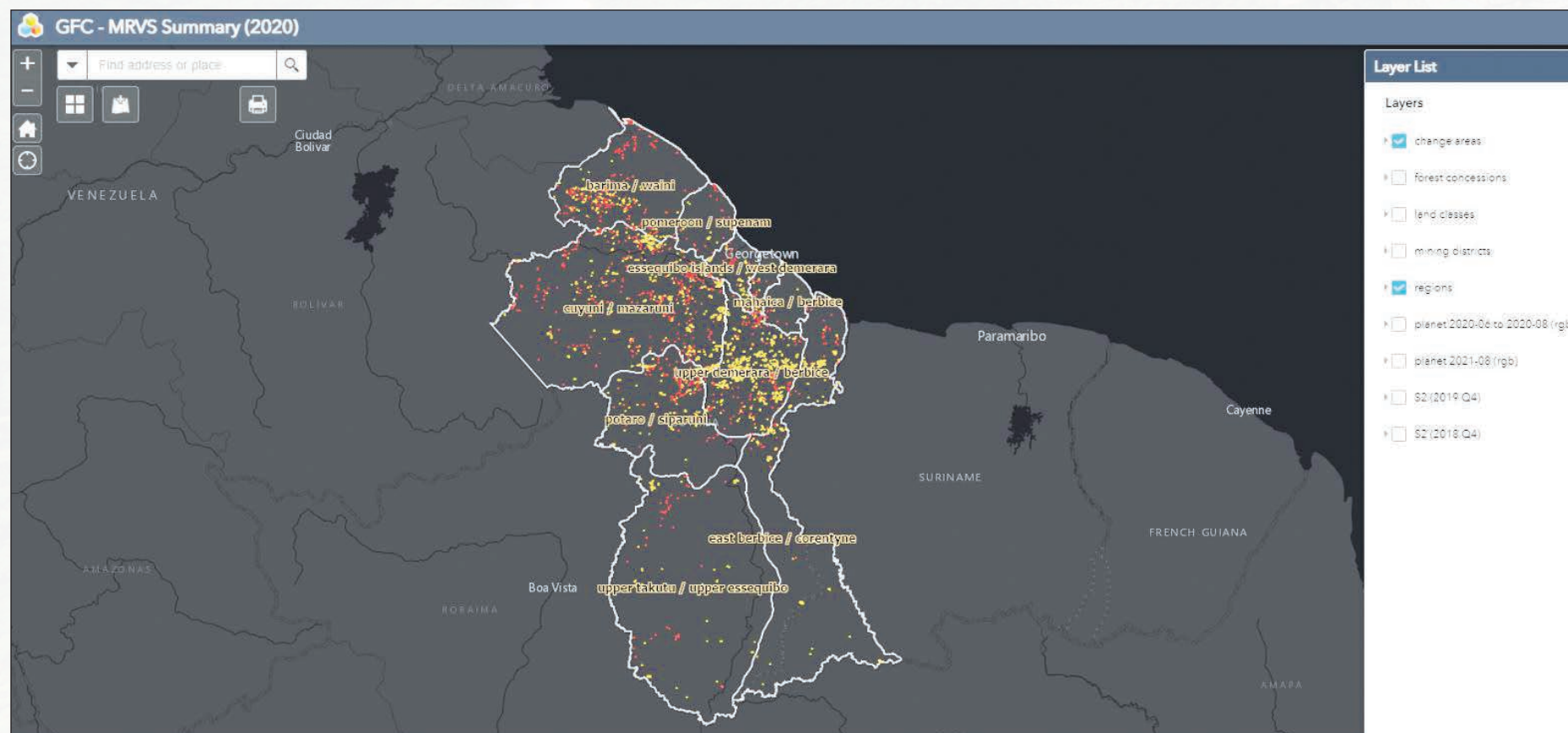
↑ While Guyana is recognized as a low deforestation country, there are pockets of deforestation and forest degradation throughout the country.

→ Rangers from the Guyana Forestry Commission (GFC) patrol forest areas. (Photo courtesy of Pete Watt.)

↓ Part of the Guyana Forestry Commission's mission is to conserve and protect the country's tropical rain forests.

accuracy assessment show close alignment. However, the feedback from this review is invaluable, as it helps identify where mapping processes may need to be improved.

In addition, once Guyana's annual report on deforestation is released—and before it is distributed—it is subject to an international review by external auditors who evaluate and verify the methods and analytical processes used. This ensures that the processes and results meet the reporting requirements specified by REDD+.

At 21 million hectares in size, Guyana's forest cover loss, on average, has been only 12,000 hectares annually, according to Watt.

"That's a good thing because the Amazon stays intact," he added.

Unexpected Benefits Reaped from the MRVS

Several applications have been developed that allow Guyana to use the data maintained by the MRVS for national projects. These include mapping and monitoring forest cover change within protected areas, capacity building, and academic research conducted at the University of Guyana.

Equally important, the data has improved the quality and frequency of the information being used to guide national policies and report on progress toward achieving sustainable development initiatives, international commitments such as the Paris Agreement, and bilateral agreements.

By implementing the dashboards, this data can be distributed to further support Guyana's land management and other government agencies. Dashboards provide actionable information in a format that can be easily understood, quickly reviewed, and conveniently shared to support and improve the management of Guyana's natural resources.

"A key strength of the MRVS program and its success has been a coordinated approach to the system's in-country development and Guyana's desire to improve the underlying monitoring processes," said Pradeepa Bholanath, senior director, climate change, at the Ministry of Natural Resources. "Today, the MRVS system provides a tool that supports the design of REDD+ activities that aim to maintain forest cover while enabling continued sustainable development and improved livelihoods for the Guyanese people."
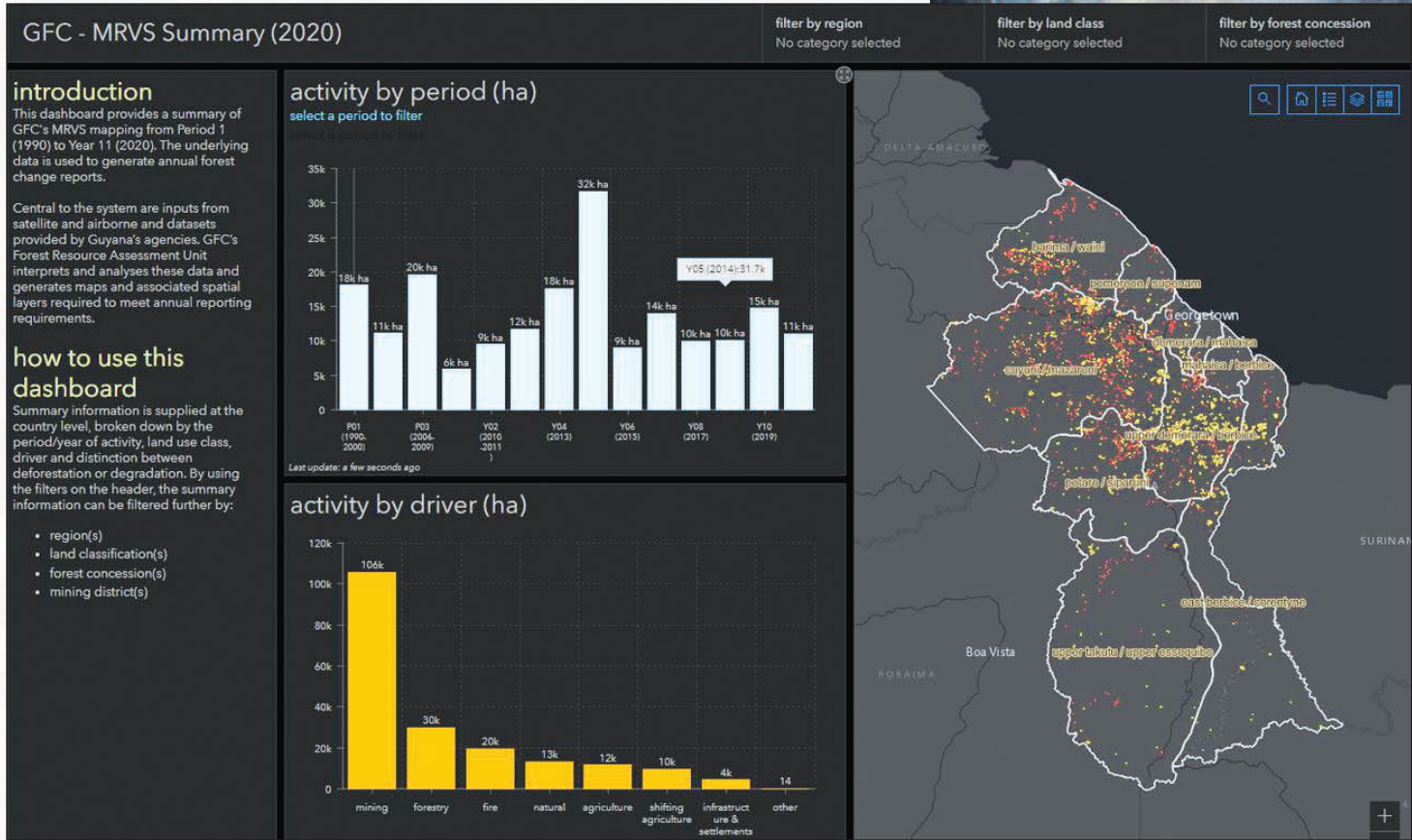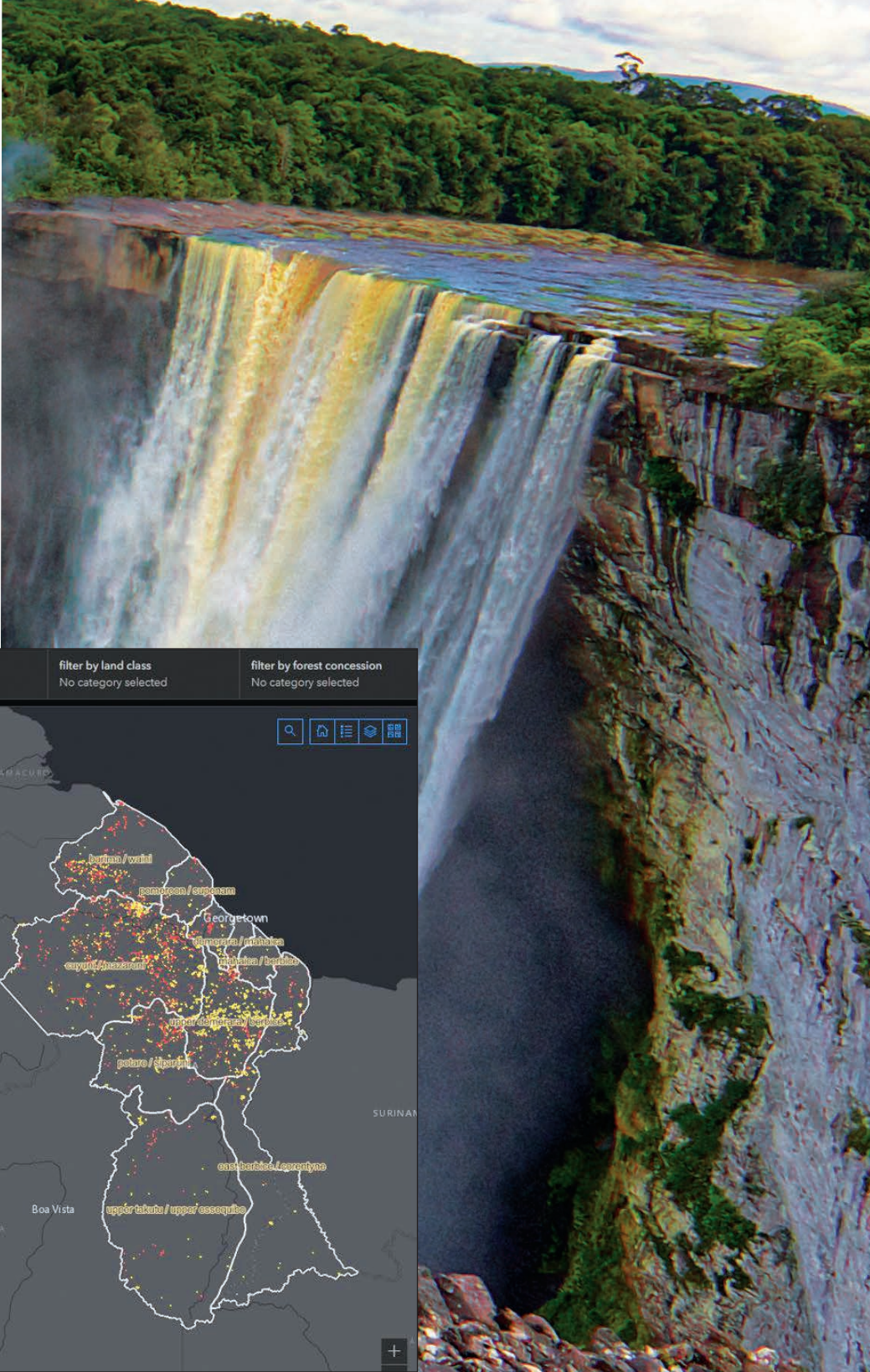
↑ The map on the right of the dashboard shows areas of deforestation and forest degradation, and the yellow graph displays some of the top drivers of deforestation, such as mining, fire, and agriculture.

World Vision Kenya Improves Access to Clean Water, Sanitation

More than two billion people lack access to safe drinking water, three billion are without basic handwashing facilities, and more than four billion people do not have safely managed sanitation, according to the United Nations (UN). In 2015, the UN ratified the 17 Sustainable Development Goals (SDGs) to be achieved by 2030. Among them is SDG 6, the water, sanitation, and hygiene (WASH) goal, which seeks to ensure the availability and sustainable management of water and sanitation.

World Vision is a Christian organization that works in 106 countries with people experiencing poverty and other hardships to promote human transformation and social justice. In Kenya, the nongovernmental organization (NGO) recently conducted a study to help people gain access to clean water, sanitation, and good hygiene. It involved using ArcGIS technology to map community access to WASH assets and track progress in providing more of these critical resources to community members.

"The WASH program is fully implemented in Mogoi, Moigutwo, and Chesim—the three villages in the Bartabwa settlement of Baringo County targeted for our study," said Everlyne Atandi, GIS specialist for World Vision Kenya. "We are using ArcGIS for planning and monitoring micro-level interventions to improve access to WASH services."

To identify households within the villages that needed better access to WASH resources, World Vision Kenya took a census. The team used ArcGIS Survey123 for mobile data collection and included GPS coordinates to pinpoint specific households and related WASH facilities. Recorded asset information included water points, such as boreholes, standpipes, and protected springs; water supply systems, including water kiosks and water pipelines; latrines; handwashing stations; and waste disposal pits.

The team then analyzed the data to get a baseline status of how many households had access—and needed better access—to WASH services. World Vision Kenya periodically updates the data as well to track progress toward getting 100 percent of residents in these villages suitable WASH services.

"We used ArcGIS Pro to map the exact location of WASH assets, households, community education and health facilities, and village boundaries, which allowed us to easily see their geographic distribution in the villages," Atandi explained. "We created 500-meter buffers around water points in the villages to determine which households were outside the recommended distance from safe drinking water. It is estimated that it takes 30 minutes to walk to and from a water point that is 500 meters away. So the buffer zones were created based on the assumption that households would collect water within a radius of 500 meters from a water point."

Because people do not necessarily walk in a straight line, the team generated overlapping buffer zones to provide different water point

locations where community members could collect water based on other factors, such as convenience and proximity to other amenities.

"Our geodatabase includes a unique identifier for each household and WASH asset," said Atandi. "The data was centralized in an ArcGIS Online server on the World Vision International account. Data was visualized on [a] dashboard [to get] summary statistics on performance across the different indicators. It was also exported and visualized in ArcGIS Online [to do] advanced analyses, such as proximity analysis and overlay analysis. This helped provide a basis for future targeted interventions in those areas with inadequate water and sanitation facilities."

The team also employed ArcGIS Geostatistical Analyst and the IBM SPSS Statistics software platform to perform inferential statistical analysis and develop summary data by percentages.

Based on the study, the team at World Vision Kenya was able to determine that, for drinking water, community members use public taps 35.4 percent of the time, protected springs 27 percent of the time, individual connections to water sources 19 percent of the time, shared taps 4.6 percent of the time, and unimproved sources like unprotected wells 14 percent of the time. In total, 85.4 percent of households in the villages have drinking water available from an improved water source within a 30-minute round-trip walk. And further analysis done in each village shows that 93.8 percent of households in Mogoi, 91 percent of households in Moigutwo, and 74.4 percent of households in Chesim access water from improved sources.

As far as sanitation goes, the analysis shows that, collectively, 98.5 percent of community members in these three villages own latrines and that 97.5 percent of the latrines are functional and in use. The majority of households that have latrines—68 percent—have pit latrines with a slab for seating, while 32 percent are without a slab. For all three villages combined, 32 percent of residents have basic sanitation facilities, 63 percent have improved sanitation amenities, 4 percent have shared sanitation resources, and 1 percent engage in open defecation.

The study also indicates that 86.9 percent of households in Mogoi, Moigutwo, and Chesim have handwashing facilities. Of these handwashing stations, 75 percent have at least water, and 60 percent have both soap and water.

Overall, these study results show that the three villages are making headway in achieving the WASH SDG. World Vision Kenya plans to do more targeted interventions using GIS to get additional households access to better water, sanitation, and hygiene facilities.

The leaders of the study—Atandi and Pamela Wamalwa, a monitoring and evaluation specialist for World Vision Kenya—provided community members, government officials, and other NGOs with the results to prompt further study and action. This has enabled the program to be scaled

up to hundreds of villages, where GIS-based progress tracking is helping to implement better WASH services for many more households.

"We believe that using GIS at the village level plays a vital role in progressing toward the UN's SDG goals by targeting the practical needs of communities, especially in underserved areas," Atandi said. "In addition, this approach encourages communities to take practical action to achieve localized priorities."

Atandi and Wamalwa plan to use GIS in future work for World Vision Kenya—for example, to advance conservation and climate change mitigation projects, do remote monitoring and progress tracking of community infrastructure projects in real time, and mobilize resources.
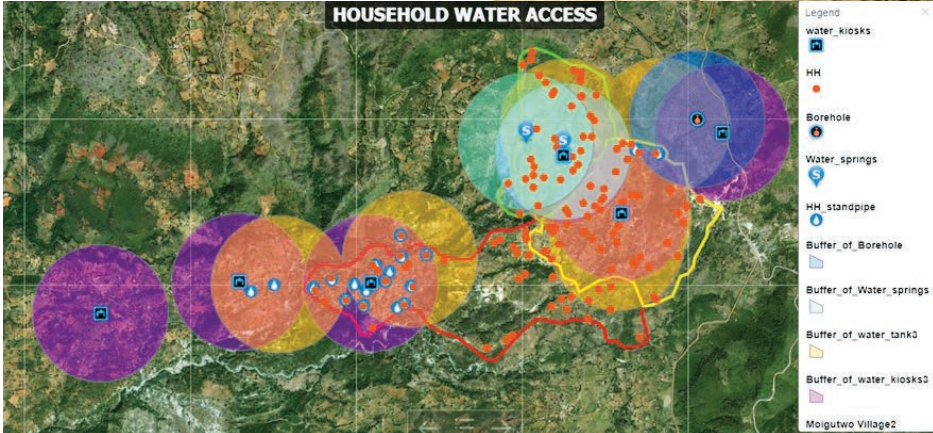
↑ Overlapping buffer zones show where nearby water points are located relative to various households.

↑ Almost 87 percent of households have handwashing facilities, and more than half of them were recorded as having soap and water.

↑ The team recorded and mapped which households have latrines and noted whether those sanitation facilities have seating slabs.

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City Uses ArcGIS Solutions to Replace Lead Water Pipes

By Ryan Eckdale-Dudley and Brian Armstrong, Symbiont Science, Engineering and Construction, Inc.;
and Scott Osborn, City of Oconomowoc, Wisconsin

Every person deserves clean drinking water. Unfortunately, this basic standard goes unmet in many communities due to lead-contaminated water. When consumed, this can cause impaired mental and physical development in children and accumulate in adults to the point that it damages the nervous system, the brain, the kidneys, and red blood cells.

These ill-health effects can be completely avoided by removing lead pipes from water service lines. Despite this well-known fact, the Natural Resources Defense Council (NRDC) estimates that between 9.7 million and 12.8 million homes in the United States are connected to water mains via lead service line (LSL) pipes. Funding to assist communities with replacing lead pipes was negligible until the Infrastructure Investment and Jobs Act, passed with bipartisan support at the end of 2021, allocated $55 billion for expanding access to clean drinking water, particularly in low-income communities.

With this new influx of capital, the City of Oconomowoc, Wisconsin, acted quickly and began taking elevated measures to replace all the lead service lines within its jurisdiction. Together with Esri partner Symbiont Science, Engineering, and Construction, Inc., the city implemented some of the latest Esri technology—including the Lead Service Line Inventory solution and ArcGIS QuickCapture—to get moving in the right direction.

Gaps and Inefficiencies in Data and Documentation

A key component of implementing a lead service line replacement program is having an inventory of service line locations and the materials the pipes are made from. This helps utilities better understand, plan for, and manage all the activities associated with the replacement. However, in many cases, utilities lack complete and accurate information about pipe materials.

As operations staff at the City of Oconomowoc's water utility got started on the replacement project, they soon identified significant gaps and inefficiencies in their existing datasets and documentation practices. For one, the city recorded information about service lines and replacement activities in spreadsheets. Additionally, supplemental datasets on sidewalks, street surface condition ratings, and water main breaks simply didn't exist.

To support the LSL replacement program, the city needed a way to quickly advance its datasets and develop new tools to monitor progress. The timing proved ideal. The city was already undergoing a multiyear GIS conversion from an external, third-party provider to an in-house ArcGIS Enterprise system.

"It became apparent that there had to be a better way," said Joe Pickart, the City of Oconomowoc's utility manager.

This realization prompted Pickart to contact Symbiont, a nationally recognized engineering, design-build, and construction firm. The GIS team there introduced the utility's operations staff to the Lead Service Line Inventory solution from Esri, which, although it wasn't available in ArcGIS Enterprise, could serve as a framework to support the LSL replacement program. The solution was built with inventory, tracking, and reporting in mind, and it is meant to be a comprehensive system that can also incorporate supplemental datasets. Symbiont offered to replicate the solution's data structure and apps in the city's ArcGIS Enterprise implementation.

But first, the City of Oconomowoc was going to need to collect data, and leaders wanted that done in just two months, since the water utility

→ Water utility staff members use a dashboard to track lead service line materials and pipe replacement statuses.
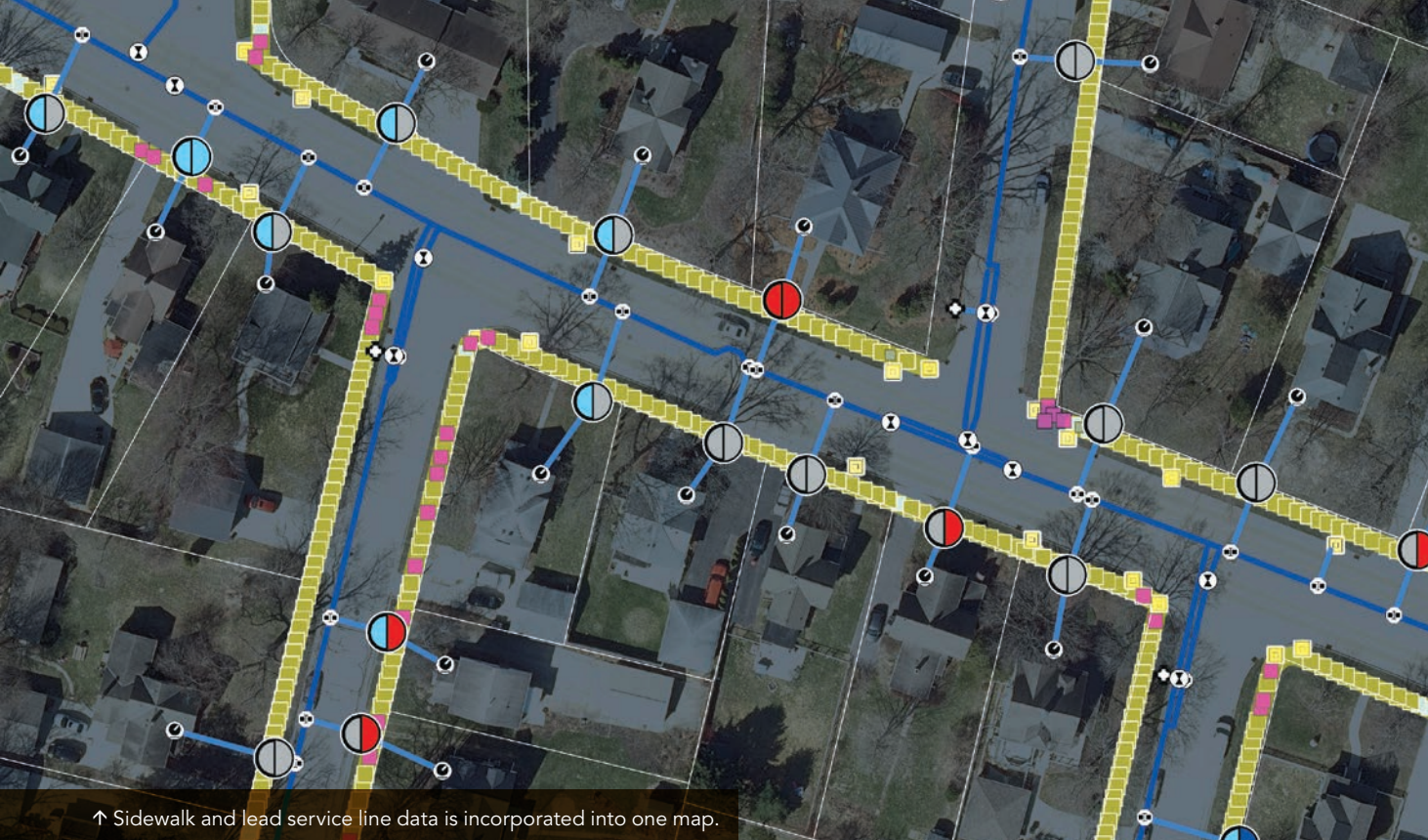
↑ Sidewalk and lead service line data is incorporated into one map.
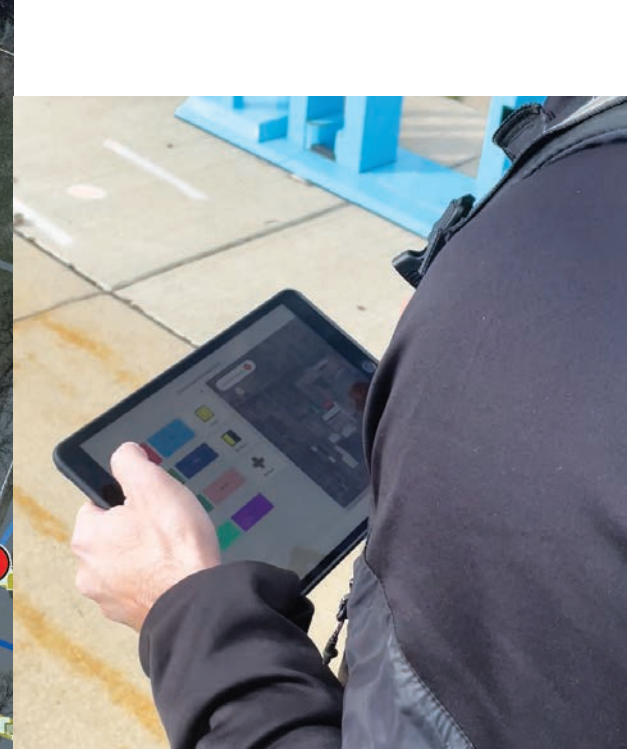
↑ The team implemented ArcGIS QuickCapture, which allows mobile crews to walk fast while capturing highly accurate data on sidewalks.

had a number of assignments to tackle in fast-approaching 2022. This was going to be tough because the team had to gather some critical data from scratch.

Quick and Accurate
Mobile Data Collection

In many cases, water service pipes cross beneath sidewalks as they extend from the water main to a house. Thus, replacing lead pipes often requires digging up sidewalks, which adds to the cost of an LSL replacement project—unless pipe and sidewalk replacements can be done in tandem.

This is what the City of Oconomowoc sought to do. Staff from the water utility got in touch with the city's engineering department to identify sidewalks that needed to be moved or replaced. However, the engineering department didn't have maps that pinpointed the locations of previous data collection activities, which made it difficult to determine the scope of the project and estimate costs.

When Symbiont got involved, the team there proposed that Oconomowoc map every single sidewalk as an individual asset instead of a line, which is what the city had been doing before. This way, the data would better support long-term sidewalk management and simplify coordination between the sidewalk and LSL replacement projects.

After doing a quick analysis, Symbiont's GIS team determined that it would have to gather data on an estimated 135 miles of sidewalk. Using a high-precision GPS unit, Symbiont planned to capture data on approximately 8 miles of sidewalk per day. Instead, after one day of mobile work, the team collected fewer than 2 miles of sidewalk data. This would have made it impossible for the team to meet the city's data collection deadline.

Having heard of ArcGIS QuickCapture, a simple geospatial app that speeds up field data collection, the team at Symbiont decided to try using it for the sidewalk project. QuickCapture allows mobile crews to walk at a faster pace while still capturing information about each

asset—in this case, sidewalks—using high-accuracy data collection software.

QuickCapture took just a few hours to configure. After also implementing the R2 backpack-mounted GPS unit from Esri partner Trimble, the team tested this new approach to mobile data collection. Immediately, crew members recognized the benefits of using QuickCapture: collection speeds improved significantly while still maintaining accuracy.

On average, the team gathered 6,000 data points per day, which amounted to more than 100,000 points by the time the project was finished. This reduced the time it took to collect sidewalk data from an estimated 59 days to just 16 days, allowing the team to meet the city's data collection deadline.

Streamlined Data Helps
Prioritize Improvement Projects

With the sidewalk datasets complete, Symbiont's GIS team focused on implementing the Lead Service Line Inventory solution for the City of Oconomowoc. The solution engages many Esri products that the city already had in place, including ArcGIS Field Maps, ArcGIS Dashboards, ArcGIS Web AppBuilder, and ArcGIS StoryMaps. This made it easier to implement a comprehensive software solution for the LSL replacement project that provides precise mapping, accurate infrastructure analysis, ongoing tracking and reporting, increased field mobility, and detailed communication and outreach with stakeholders.

And because the city streamlined data collection and management for its supplemental datasets, various teams can better prioritize their city improvement projects as they set out to achieve the goals in Oconomowoc's five-year capital improvement plan. The web mapping app built for the LSL replacement project integrated so much information—including sidewalks in disrepair, poor street conditions, historic water main breaks, and water quality complaints—that city staff can now focus on clusters of issues in problem areas instead of dealing with issues one by one.

Of course, the city has also been able to use the Lead Service Line Inventory solution to identify customers with suspected lead laterals and integrate this information with precise sidewalk, street, water main, and customer datasets. Now, the City of Oconomowoc is actively removing lead pipes from residents' service lines, paving the way for other efforts to provide safe, clean drinking water to all.

About the Authors

Ryan Eckdale-Dudley, GISP, is the GIS manager and director of business development at Symbiont. Brian Armstrong is a GIS specialist at Symbiont. Scott Osborn is the water operations superintendent at the City of Oconomowoc.

Get to Know Your River

ArcGIS Hub Site Aggregates Data on Waterways, Making It Easily Accessible to the Public

By Tonya Bonitatibus, Savannah Riverkeeper; Damon Mullis, Ogeechee Riverkeeper; and Rosco Peters and Lindsay Wallace, NewFields

Agencies, organizations, and individuals collect hundreds of thousands of water samples from waterways across the United States each year. Every sample tells a story about the health of a waterway and its ability to handle stress from a variety of sources, including development, agriculture, contamination, drought, flooding, and changing seasons. When examined comprehensively, this data can provide a more accurate and complete foundation for making decisions that affect waterways and the wildlife, people, and industries that depend on them. Those decisions can be as simple as finding a good fishing hole or as complicated as determining how to preserve an entire ecosystem.

Too often, however, this data is fragmented, compartmentalized, or even kept completely out of reach. People and organizations house various datasets in diverse formats and in different physical and digital locations. This makes it difficult to manage waterways holistically.

In the southeastern United States, the Savannah Riverkeeper and Ogeechee Riverkeeper organizations, along with the Phinizy Center for Water Sciences, are working with federal, state, and local governments and nonprofits to give the public better and easier access to data about the Savannah River and Ogeechee River basins. Using ArcGIS Hub as the basis of the solution, this cross-agency collaborative developed Know Your River (knowyourriver.com), a powerful tool that collates data from more than 40 different sources into one interactive, geospatial interface. And although this particular solution is designed for a distinct geographic region, the team envisions that it can be scaled up or down to fit the needs of other waterways around the world.
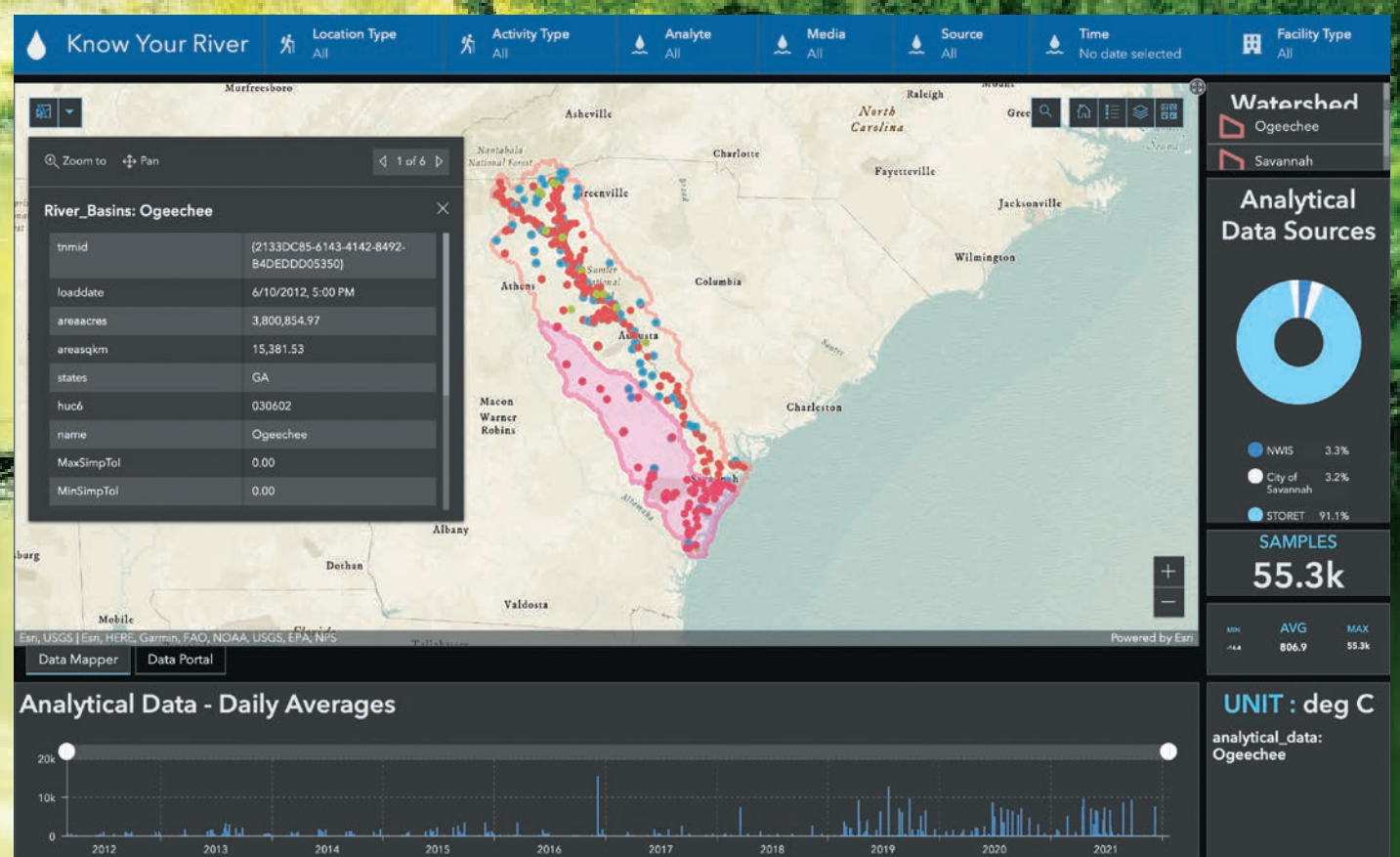
↑ Dashboards on the Know Your River hub site display a wealth of data in visually appealing ways.

Improving Public Access to Dispersed Data
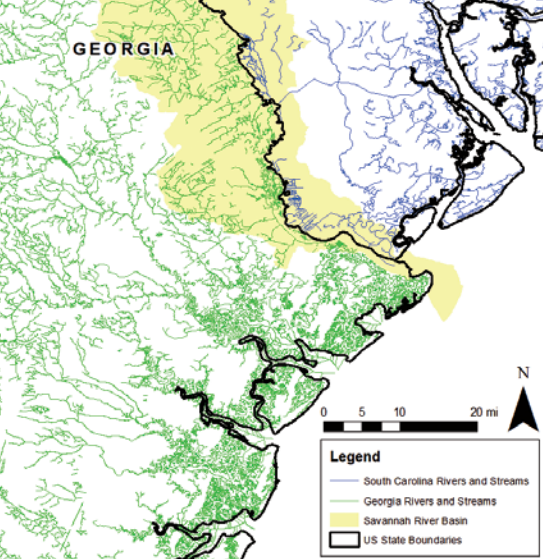
The Savannah River and Ogeechee River basins span the Georgia-South Carolina state border, so river keepers in this area understand how difficult it can be to get cohesive data about these waterways from the various organizations and people who collect it. Even when projects are taxpayer funded, it can be an uphill battle to make useful information about the rivers available to the public. Data is often dispersed among governing agencies in different cities, counties, and states. Some data isn't available in digital format at all, and a lot of it lacks spatial information. Typically, the only way people can retrieve data is by calling or emailing the data owner or, in some cases, filing a Freedom of Information Act (FOIA) request.

But data is only as good as it is accessible. That is why Savannah Riverkeeper and Ogeechee Riverkeeper have partnered with the City of Savannah and the City of Augusta and—with funding from the Georgia Environmental Protection Division (EPD)—are working to make the best science and knowledge about these waterways available to the most people. As Laura Walker, environmental administrator for the City of Savannah's Water Resources Department, put it, "We [are] advancing the work of making siloed data accessible to everyone."

The Know Your River hub site is organized around four themes: recreation, surface water, groundwater, and environmental justice. By toggling through the tabs of an ArcGIS StoryMaps story on the primary page of the hub, users can find out things like where to launch a boat along the Savannah River and adjoining lakes, which surface water bodies have recently had contaminants detected in them, information about groundwater levels at monitoring wells, and cancer risk statistics near Superfund sites. The hub also contains open datasets; a video tutorial for how to use the site; and a growing list of scientific studies on the Savannah and Ogeechee Rivers, complete with links to where they can be read.

Aggregating Data So It's Easy to Find and Use

When the team from Savannah Riverkeeper and Ogeechee Riverkeeper began this project, staff members had a giant spreadsheet that listed as many water quality data sources for the Savannah River and Ogeechee River basins as possible. To find a range of other useful data, they searched government websites, such as the South Carolina Department of Natural Resources, which posts the latitude and longitude of boat ramp locations. Team members also requested pertinent data directly from cities and nongovernmental organizations throughout the area.

Priority was placed on finding real-time data from water loggers—instruments maintained by the United States Geological Survey (USGS) that monitor water levels. The team also sought out web services that display water access locations, fishing advisories, flood zones, environmental justice statistics, and more from organizations such as the Water Quality Portal (a cooperative service sponsored by the USGS), the Environmental Protection Agency, the National Water Quality Monitoring Council, the Federal Emergency Management Agency, the South Carolina Department of Health and Environmental Control, and the EPD.

Now, the team has aggregated a range of data types and included them in online maps and apps that are easy to use and widely accessible. These data types consist of surface water features like rivers and ponds, public boat ramps, parks and campgrounds, infrastructure such as dams and power plants, fish consumption advisories, groundwater wells, real-time surface water levels, and real-time and forecasted rainfall. They also include water quality measurements that detect bacteria like E. coli, flood zones, potential sources of pollution, demographics related to environmental justice, and data collected by citizen scientists.

To bring all these data types into Know Your River in a way that makes them easy to employ and understand, the team used ArcGIS Online to create data layers that could be presented in web maps. ArcGIS StoryMaps and ArcGIS Dashboards display the data in visually appealing ways. ArcGIS Hub brings all this together in a user-friendly hub site. Additionally, the team used ArcGIS AppStudio to build an app that allows users to access data visualization and analysis tools on their mobile devices. The app can currently be downloaded via ArcGIS AppStudio Player and is expected to launch in app stores by June 2022.

Staff members from Savannah Riverkeeper and Ogeechee Riverkeeper also regularly train Georgia Adopt-A-Stream-certified citizen scientists to collect water quality and visual inspection data from dozens of sample locations throughout the river basins. ArcGIS Survey123 allows these citizen scientists to submit their data, which the team then curates and incorporates into Know Your River if it is found to be sound data.

Making Upgrades and Planning for Expansion

Now that the hub site is up and running and data is easier to access in several visual formats, the Savannah Riverkeeper and Ogeechee Riverkeeper organizations have additional bandwidth to gather their own data. Staff members are currently launching their own water loggers to collect real-time data on temperature, dissolved oxygen, water levels, pH levels, and other important parameters for the two waterways. This data will be displayed in the maps available on the hub site.

The team is also continuing to improve Know Your River. Staff members are pulling similar data into uniform tables to improve data analysis capabilities and are building a dashboard that contains data analysis tools all in one place. The team would like to be able to offer users real-time text or email alerts when data they're interested in is updated or added to the system. And the team is working on a new version of its Survey123 app-based water quality data collection app to improve its utility and combine it with Know Your River.

At its core, the Know Your River tool is a pilot project. Leaders at Savannah Riverkeeper and Ogeechee Riverkeeper would like to increase the number of users who engage with and employ the data available on the hub and would like the project to grow beyond the Savannah River and Ogeechee River basins. Ideally, people, organizations, and government agencies around the world will eventually be able to use the tool to access more cohesive data about the waterways that are important to them. In the spirit of data democratization, Know Your River is also available to be used as a template.

As Bruce Azevedo, chair of the Savannah-Upper Ogeechee Regional Water Planning Council, noted, "Informed decisions can only be made with the best available science and knowledge."

↑ People can find important information on bacteria recently detected in surface water, groundwater levels at monitoring wells, and cancer risk statistics near Superfund sites.

About the Authors

Tonya Bonitatibus is the executive director of Savannah Riverkeeper, where she strives to protect the health and vibrancy of the Savannah River in South Carolina and Georgia. Damon Mullis, a freshwater biologist and water quality specialist, is the executive director of Ogeechee Riverkeeper. Rosco Peters is an environmental scientist with expertise in GIS at NewFields, an environmental, engineering, and construction management consulting firm. Lindsay Wallace is a senior environmental scientist at NewFields with 20 years of experience using GIS, 3D visualization, and animations for water management.

Utility Uses Mobile GIS to Prove Water Rights Violations

↑ Mobile workers at the Lower Valley Water District (LVWD) now use a GIS-based app to report water rights violations in real time.

In El Paso County, Texas, the Lower Valley Water District (LVWD) investigates unusual spikes in water use and monitors water rights, often in partnership with other water districts, such as El Paso Water. For years, those investigations involved dusting off paper maps and manually keeping track of customers and violations. If it turned out that there was a violation and a water user pushed back, there was little physical evidence to prove otherwise.

That changed when LVWD adopted a GIS-centric approach to its investigations, shifting information collection online and including photos of violations. Now the utility can clearly identify issues, such as when residents illegally dig canals, install pumps, or flood their properties to access water that isn't theirs.

"We're able to prove that residents are stealing water," said LVWD's IT director Ryan Rodriguez, who explained that mobile crews can now show residents maps and photographs of violations or disputed water rights claims on an iPad. "There is proof in the picture. A picture says a thousand words."

When Rodriguez joined LVWD in 2018 as the IT director, he noticed that the utility hadn't taken advantage of its existing location intelligence tools. Rodriguez advised LVWD to modernize its operations by fully embracing GIS technology. He saw GIS as a go-to solution and felt that the rest of the organization would come around to that thinking, too.

Becoming a geospatially driven organization would not be easy. But putting in the work would address challenges across multiple facets of the business, ultimately improving workflows and providing better service to residents. First, however, staff members would have to undergo GIS training—an essential step to agencywide GIS adoption.

GIS Training Across the Utility

To help key LVWD staff members learn the technology, Rodriguez and his team created a plan for them that leveraged support and educational resources available through the Esri Advantage Program. The team started by assessing where GIS tools could solve critical business problems in various departments.

Rodriguez met with stakeholders, mobile workforce staff members, team leaders, and other potential users to identify challenges and brainstorm GIS-based solutions. Takeaways from these conversations included the need to create apps, visualize data with dashboards, migrate data, upgrade databases, and update workflows to improve data quality.

Building from those business goals, Rodriguez worked with a team from Esri Services to develop a training program for LVWD GIS users that ranged from beginner to advanced. Rodriguez himself completed six training courses, including Using

ArcGIS for Water Utility Workflows and ArcGIS for Server: Site Configuration and Administration. He and other employees also took courses related to key GIS workflows such as data management, mobile GIS, map design and visualization, spatial analytics, and enterprise administration.
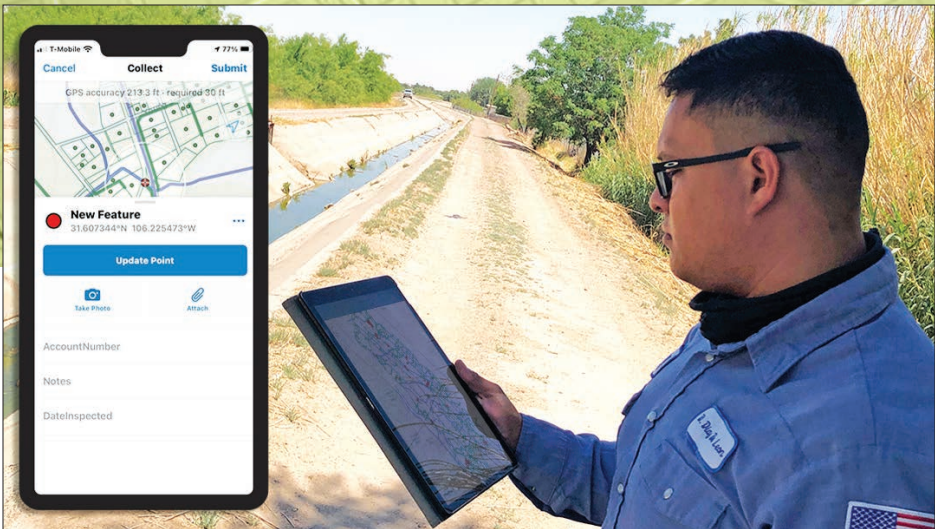
Finding Ways to Better Serve Residents

In addition to working on a new workflow for water rights investigations, Rodriguez and his team focused on developing solutions for water management and waste modernization.

Rodriguez used ArcGIS Pro to create a map that tracks and highlights water meters around the county, helping operations managers determine which water meters—out of 12,000—need to be replaced. He also worked with the solid waste department, using ArcGIS QuickCapture to plot current trash pickup routes and create optimized itineraries for future operations. GIS even proved helpful to human resources when, in the early months of the COVID-19 pandemic, Rodriguez assisted the department in developing a questionnaire with ArcGIS Survey123 to track employee exposure to COVID-19 with the aim of reducing risk.

"While it has been a challenge to get everyone to adopt using this technology daily, I would say every department in some way has benefited from using GIS," Rodriguez said.

That is what happened with the water rights department. After seeing the benefits GIS brought to other divisions, officials came

to Rodriguez and his IT team to get help with tracking violations. Rodriguez built a mobile data collection app using ArcGIS Collector that stores customer account information along with details on ditches and canals throughout El Paso County. This information integrates with ArcGIS Pro to create a data-layered map.

The app allows utility staff members to edit canals and submit photos and videos, enabling field personnel to take pictures of violations and attach them to their reports. The reports supply water rights management with vital real-time data. Additionally, the app has fillable fields so users can enter notes, account numbers, inspection dates and times, and the inspector's name.

"It Made Their Job So Much Easier"

Collaboration among the water rights staff, Rodriguez, and Esri Services yielded positive results. The app provides mobile workers with easy access to customer information, allows them to capture proof of stolen water and issue citations, and enables increased cooperation between mobile and office staff. So far, the app

has helped the team prove 92 violations and issue appropriate penalty fees.

Rodriguez and his team received positive feedback for their work on the app, which has encouraged more departments to reach out with requests for similar solutions.

"[Water rights staff members] are just loving the application because it made their job so much easier, and I know they're going to be using it more," said Rodriguez. "If anything, it probably created a little bit more work for us because they realized how quickly we can make applications."

After successfully implementing training, adopting more ArcGIS technology, and building unique apps like the one used to determine water rights violations, LVWD has a bright future with GIS. Rodriguez and his team envision more uses for the technology—for billing, tracking unreported hydrant use, maintaining meters across the district, and even expanding into solid waste management.

"I think [GIS] has made everyone more efficient," said Rodriguez. "Everyone is using it now. I feel that whenever a problem arises, people come to me to see if I can figure out a solution."

With a growing list of projects, Rodriguez hopes to continue collaborating with Esri Services as his organization works toward becoming even more geospatially driven.
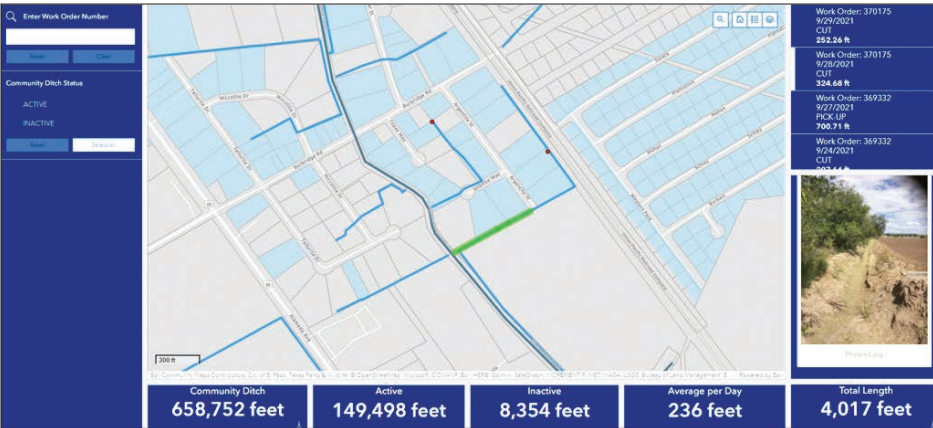
← Dashboards help LVWD staff members track work orders for projects like cleaning canals.

↓ The water rights app provides mobile and office staff members with the same capabilities, enhancing collaboration and the accuracy of citations.
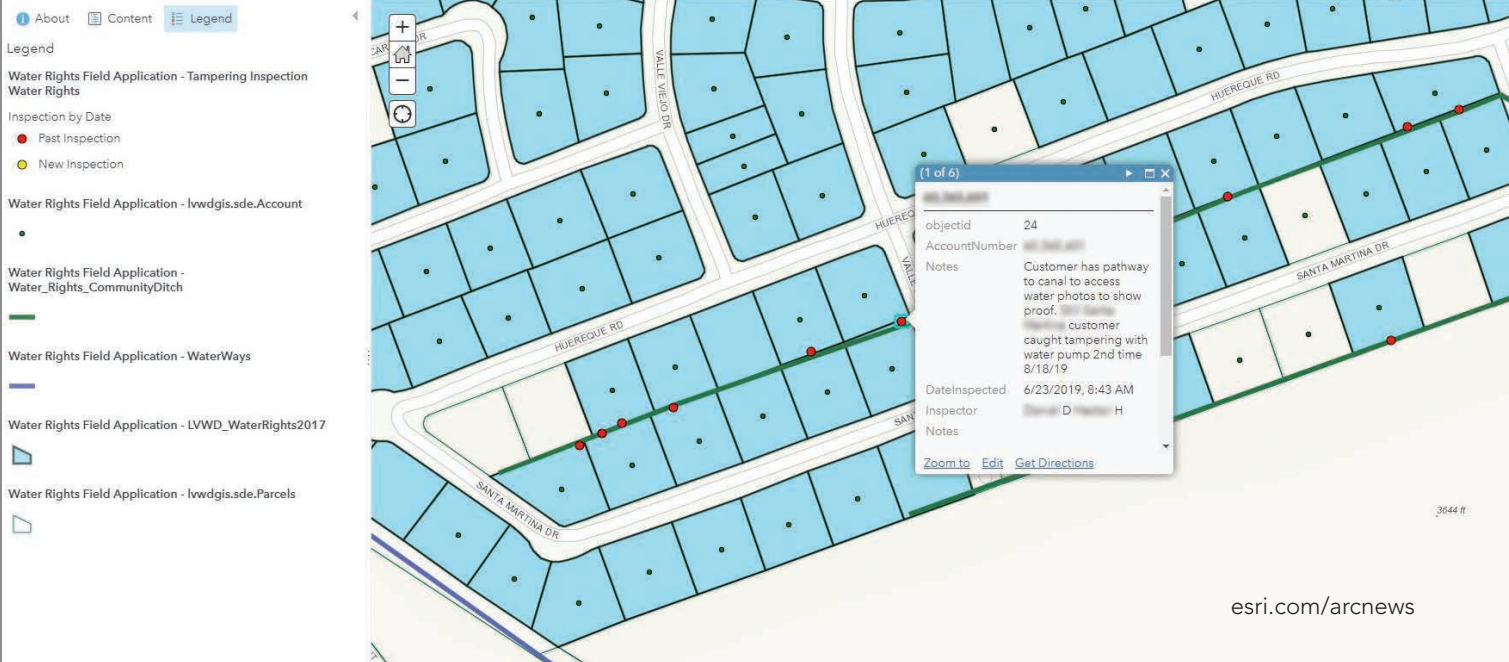
ArcGIS Pro Add-In Simplifies Creation of EPA-Compliant Metadata

By Dan Spinosa and Max Marno, Innovate!, Inc.

Metadata is critical for helping users document and locate datasets and geospatial assets. When metadata includes sufficient and consistent detail, it facilitates the search and discovery of key data. But creating metadata is a challenge for many government agencies across the United States. That's because, although government metadata must comply with various standards and requirements, establishing consistency, there aren't many tools available that make it easy to enter and edit metadata.

The United States Environmental Protection Agency (EPA) has a large inventory of geospatial assets that continually grows, such as data on the climate, air and water quality, the population, and environmental impacts. These assets require metadata to ensure that EPA staff, employees from other government agencies, and the public can easily find, effectively interpret, and appropriately use them to do work that ranges from environmental monitoring to emergency response. The metadata must also conform to the EPA's Geospatial Metadata Technical Specification and the International Organization for Standardization's ISO 19115, which has been endorsed by the Federal Geographic Data Committee (FGDC).

To help people create and edit metadata that meets the EPA's standards, the agency released the EPA Metadata Editor (EME), available at ow.ly/4Krm50HE2YY. Originally developed in 2007 as a stand-alone, open-source Windows desktop app that had basic integration with Esri products, the EME is now an add-in for ArcGIS Pro. As the EME has evolved over the years, Esri partner Innovate!, Inc., has assisted with its design and development, ensuring that as technology and standards change, the EME keeps pace.

A More Effective Way to Write and Edit Metadata

EME Pro, the most recent iteration of the EME, was released in November 2020. It offers ArcGIS Pro users an efficient way to edit and modify the metadata in their geospatial data so it complies with the EPA's standards, including both the EPA Geospatial Metadata Technical Specification and the North American Profile (NAP) of ISO 19115:2003. Given that EME Pro is an ArcGIS Pro add-in, it is easy to distribute and install.

As with all iterations of the EME, the new ArcGIS Pro add-in offers customized tools and automated workflows. Once the EME is incorporated into ArcGIS Pro, users access it from a tab labeled EME Tools that appears on the ArcGIS Pro ribbon. The tools allow users to edit metadata, update thumbnails for the data, sync contacts in a metadata document with a prepopulated list of EPA contacts, and import and export metadata according to the EPA's specifications.

The EME Database Manager that's included with EME Pro also gives users the ability to manage default values and options for some metadata elements, such as keywords, contacts, and security constraints. Access to these defaults is provided within the editor's interface via drop-down menus or a Load Defaults button, depending on the element.

Custom Features Enhance and Improve the Toolset

Through each iteration of the EME, the Innovate team has been able to merge functionality from past versions and enhance select components. Thus, EME Pro isn't just the newest version of the toolset; it also improves on the most useful features from previous builds.

With the transition to ArcGIS Pro, the team at Innovate had to make sure all the functionality that the EPA wanted was possible. Staff at Innovate also had to create several custom features that weren't available straight out of the box.

For example, the team combined two tools—the Metadata Upgrade tool and the Clean tool—to allow users to safely update metadata and clean up legacy elements that are no longer needed in current metadata formats. Results are reported to users, and backup copies of the metadata are automatically saved in a scratch folder so users can restore the unaltered metadata in the event of an error.

The Innovate team also redesigned a tool that allows users to efficiently merge a source record with one or more target records according to customized rules. This Merge tool gives users a quick start for populating metadata, which saves time—especially when various metadata records share the same values for certain elements. The team hopes to continue building out this merge functionality in future releases as well.

Developing a Streamlined User Experience

In building EME Pro, the team at Innovate relied heavily on the ArcGIS Pro Metadata Toolkit, a flexible template for customizing what appears in the ArcGIS Pro metadata editor. Team members were able to further customize the user interface using ArcGIS Pro SDK for the Microsoft .NET Framework, which also gave them access to items' underlying metadata components.

For the metadata tools provided on the ArcGIS Pro ribbon, the team used arcpy.metadata, a Python metadata module, to develop basic data management tasks and gain more granular access to items' metadata components. Python scripts also enabled EPA-specific management tasks, batch processing, and special tools for generating ISO-compliant metadata. And while most of the customized tools were written in Python, some—like the thumbnail updater—were written entirely in C#.

All the custom tabs and buttons that the Innovate team built directly into ArcGIS Pro now provide a convenient, streamlined user experience for directly editing metadata and accessing geoprocessing tools.

Wide Use of EME Improves Metadata Across Organizations

Since the EME was initially released in 2007, the EPA has recorded thousands of EME downloads from all 50 US states, hundreds of organizations, and even other countries. Organizations such as the United States Census Bureau, the Federal Emergency Management Agency, the United States Department of the Interior, the United States Department of Energy, the United States Department of Agriculture, and the United States Army Corps of Engineers use the EME, as do numerous universities, local associations, and private groups.

The EME has been customized for other federal agencies' metadata management needs as well. Use of the EME—in all its formats—has improved the quality and quantity of metadata at the EPA and other organizations. And EME Pro is now a key component of the EPA's geospatial metadata framework.

With Innovate continuing to make improvements to the EME, the toolset will only continue to simplify the process of creating compliant metadata in ArcGIS Pro.
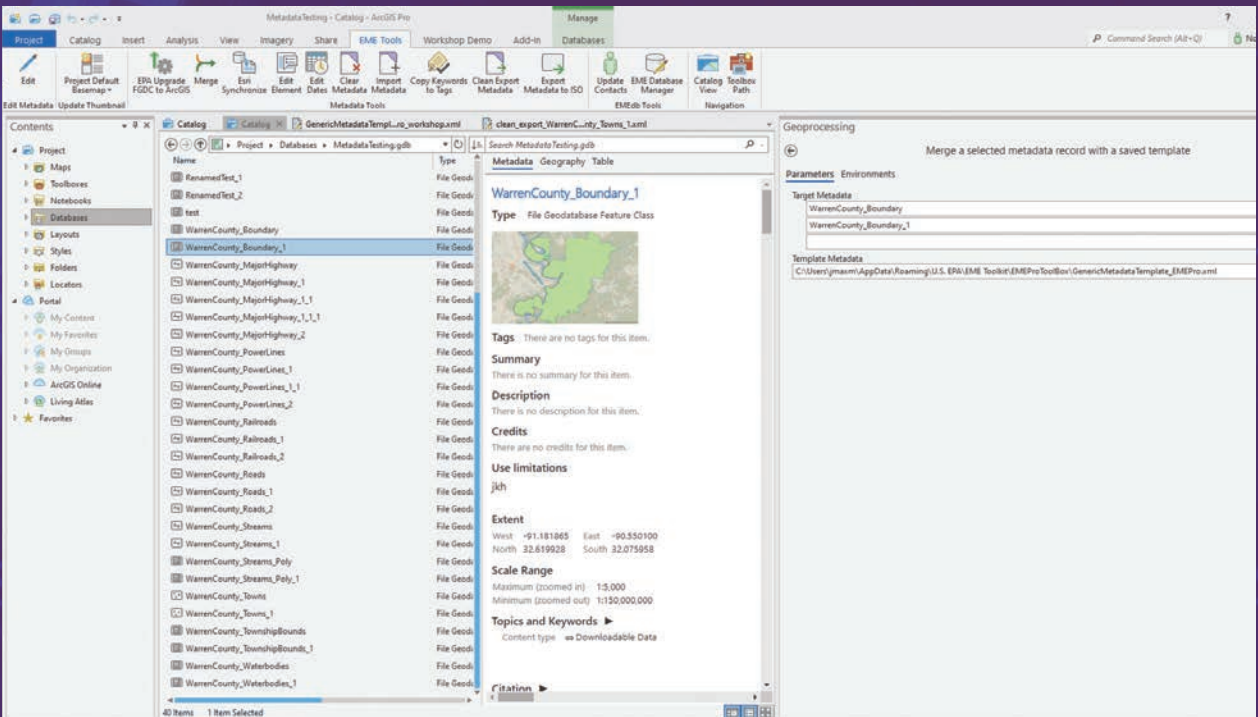

Throughout its iterations, the EME has been recognized for its metadata management capabilities and ease of use. Awards conferred include the following:

- Winner, Best Embedded GIS Application, Esri, 2007
- Winner, Mason Hewitt Award for Technical Excellence in GIS, EPA, 2008
- Winner, Agency IT Achievement Award, Government Computer News (GCN), 2008
- Second place, Best Embedded GIS Application, Esri, 2011

About the Authors

Dan Spinosa is a geospatial applications developer and manager at Innovate and was the lead developer for the EME. He has more than 15 years of geospatial experience, specializing in mapping, modeling, and data visualization. Spinosa earned a bachelor's degree in resource recreation and tourism and a master's degree in GIS from the University of Idaho. Max Marno is a GIS developer at Innovate and was the lead developer for EME Pro. He holds a bachelor's degree in economics and geography and a master's degree in GIS from the University of Denver. Marno is also a Part 107-certified small unmanned aircraft systems (sUAS) pilot.

↑ Innovate!, Inc., redesigned the EME's Merge tool to save users time when populating multiple records with consistent aspects.

Weaving the Geospatial Fabric of the World with Authoritative Data

By Greg Bunce, Utah Geospatial Resource Center

The old saying "Many hands make light work" is true now more than ever. In our increasingly connected world, we are able to collaborate with an infinite number of people. Moreover, we can contribute to products that go beyond the boundaries of our organizations. A great example of this in the public sector is how government agencies work together to build statewide and national geospatial datasets. As we've done this, we have learned that collaboration, relationships, and agreed-on data standards hold these datasets together.

Geospatial practitioners are some of the best collaborators. For one, geospatial data is inherently visual. Much like adding pieces to a puzzle, it is rewarding data to assemble. Geospatial folks also tend to speak the same language. In the early days of the industry, most people working in GIS used Esri products and created and shared data in similar formats. This is generally still true in the public sector.

What's exciting now is that technology continues to make collaboration easier. Because of this, we have entered a moment in which siloed data can become a thing of the past. The individual work that we all do can be interlaced to form a seamless, uniform geospatial fabric of the world. And those of us in the geospatial industry—especially people who work with authoritative data—are weaving that fabric.

Authoritative Data Requires Accountability

Authoritative data can be defined as data that is provided by a recognized source, such as a surveyor or governing entity (i.e., an entity that is authorized to develop or manage the data, such as a governmental jurisdiction). To ensure that people use authoritative data, it is critical that it be placed in the public domain.

Authoritative data is different from crowdsourced data. Crowdsourced data is typically generated by a large group of users who are contributing information at will and to the best of their knowledge. Crowdsourced data can be useful for projects where stewardship is of less concern—to show live traffic data on a map, for example. It is also helpful when information is needed quickly, such as during a humanitarian crisis or following a natural disaster. In the midst of these events, individuals must come together quickly and generate data without the additional oversight that is often associated with authoritative data.

The clearest use cases for authoritative, open data are in systems like 911, elections, health, and taxation. These systems support vital government services, such as public safety and emergency response; the creation, dissemination, and collection of election ballots; the monitoring of infectious disease outbreaks; and the setting of property and sales tax rates. In these cases, it is important to use authoritative data with a clearly defined steward that can be held accountable.

Data Stewards and Data Aggregators Work Together

Authoritative data is typically woven together through a process of aggregation. In this scenario, there are data stewards and data aggregators, with occasional overlap. Ideally, the data stewards work most closely with the assets. For datasets such as address points, land parcels, and road centerlines, the data stewards are often local government employees.

Data aggregators tend to play a facilitator role. When the aggregator is a government entity, it is usually positioned at the state or national level. In Utah, for example, the state's GIS office—the Utah Geospatial Resource Center (UGRC)—functions as the aggregator. The aggregator's role is to build relationships with data stewards, standardize the data, and produce a single product that is diverse enough to be used in a wide range of systems and applications.

The steward-aggregator model has well-defined roles and contains accountability at all levels. One of the many benefits of this is that when an asset, such as an address point, is created or modified, it is done so at the steward, or local, level. Through the process of aggregation, this data then flows into larger and more encompassing datasets, like spring water flowing from a high mountain stream into larger rivers; lakes; and, eventually, oceans.

This workflow reduces duplicate data and promotes a single source of truth. It also ensures that users from the local to the national levels are using the same data. This is great because the more the data is used, the better it becomes.

Advisory Groups Set Goals and Solidify Standards

Collaboration, relationships, and agreed-on standards hold the geospatial fabric together. As with fostering collaboration and nurturing relationships, maintaining standards requires clear communication among stakeholders. A big part of this is making sure that everyone understands their roles and each other's goals.

Data stewards typically create and maintain data for a specific purpose. However, when stewards, aggregators, and other stakeholders communicate, they often discover that they share goals and standards. Incorporating these into workflows—by establishing naming conventions, for example, or using the same spatial reference system—makes data aggregation faster and more efficient, especially for statewide and national datasets.

Geospatial advisory groups are a great way for various organizations to communicate their goals and solidify common standards. A few examples of these include the Federal Geographic Data Committee (FGDC); the National Geospatial Advisory Committee (NGAC); the Open Geospatial Consortium, Inc. (OGC); and state-led advisory groups such as the Utah Geographic Information Systems Advisory Committee (GISAC).

The FGDC and NGAC are federally focused committees that work in conjunction with each other. Collectively, they seek to advance a National Spatial Data Infrastructure (NSDI) and develop and implement policies, best practices, metadata, and standards relating to geospatial data.

The OGC is an international consortium that adheres to the principles of making geospatial data findable, accessible, interoperable, and reusable (FAIR). Its members work to create royalty-free, publicly available, open geospatial standards.

State-led advisory groups like GISAC typically work to develop and update standards and best practices within their states. Clearly defining these is key to making speedy data updates within statewide datasets. In Utah, UGRC is able to aggregate the state's road centerline dataset more efficiently because a set data model is already in place. UGRC (the aggregator) and the county GIS offices (the stewards) adhere to the same standards, which streamlines the process.

Geospatial advisory groups exist to ensure that the wider geospatial community moves forward together. By taking an active role in one or more of these groups, GIS practitioners can ensure that their organizations are well represented and that the products they create fit into the larger geospatial fabric that's coming together.

An Encompassing Geospatial Fabric Takes Shape

If we do this right, the geospatial fabric should stretch across the United States and around the globe. In other words, the authoritative data created at the local level should be the same data showing up in larger statewide, national, and even international datasets.

A great example of this in action is to compare an address point in the National Address Database with its corresponding point in UGRC's statewide address database. It's immediately clear that they are one and the same. This is a successful steward-aggregator model in which local data makes its way to the state GIS office and then into the national fabric. The magic happens because of collaboration, relationships, and shared data standards.

As authoritative geospatial data providers, our goal should be to weave open data together in such a way that individuals, organizations, and government entities have the tools they need to make better data-driven decisions.

About the Author

Greg Bunce is the geospatial data coordinator at the UGRC. He is actively involved in the state's 911 and election efforts and is currently focused on streamlining aggregation and promoting data sharing in the state geographic information database. Bunce believes that collaboration, relationships, and standards are key to building and maintaining quality data.

Fun-Loving GIS Evangelist Brought Street Map Data to the Forefront

↑ John Cassidy

Think of how easy it is to pull up a map on your smartphone and search for a store, get driving directions to a friend's house, or see how long it will take to get to the airport on various modes of transportation. It's so simple. But that detailed street map data—with things like speed limits, turn restrictions, and routing information—hasn't always existed. It had to come from somewhere.

In the mid-1980s, fresh out of college, John Cassidy set out on a career-consuming journey to help bring street map data out of government files and make it available and serviceable for commercial use. This endeavor that Cassidy was part of while working at Geographic Data Technology (GDT); Tele Atlas; and, later, Esri partner TomTom ended up morphing into a digital mapping revolution that still reverberates today.

"If you think about all the street data that's available on the internet and the advances that have been made in GIS alone, John had a pretty big part in that," said Dave Magee, a former colleague of Cassidy's who is now the northeast account executive for Esri partner Schneider Electric.

Cassidy also had an expansive perspective of what street map data could be used for, according to his longtime friend Earl Nordstrand, retired manager of the ArcGIS Business Analyst development team at Esri.

"He understood what GIS was, and he took a broad view of how this data could be used in the GIS industry," said Nordstrand. "He was very much an advocate of not creating just a street network but also integrating that street network into an overall data structure that allowed users to have the correct boundaries and correct geography for a lot of different applications."

This outlook helped Cassidy get some of the biggest companies in the world on board with using street map data—companies that, today, couldn't operate without it. And he did it by being curious and personable; listening to people's needs; understanding how to apply GIS technology to solve business problems; and, perhaps most importantly, having fun with it all.

Comfortable with Maps and Computers

Geography wasn't Cassidy's first choice for a major in college, but after realizing that he wasn't cut out for computer science or meteorology, he figured it would be an interesting subject to study.

At the University of New Hampshire, he got a bit of a false start with the major, frustrated that most of the work involved memorizing facts that, he said, anyone could look up in a book. So Cassidy transferred to the State University of New York College at Oneonta (SUNY Oneonta), where, he was told, faculty and students were doing interesting work.

"They had a pretty progressive applied geography program with lots of computer-based cartography," he recalled. "That's how I wound up staying with the major, and I'm really happy that I did."

When he finished school in 1985, a small company in his home state of New Hampshire was gearing up for a big project and went on a hiring spree. Cassidy got a job there, at GDT, as a digital map technician.

"It was a real novelty to get somebody who actually knew something about geography," said Don Cooke, founder of GDT. "To succeed in the work, you had to be comfortable with maps and computers, and you had to be able to learn and pick up on stuff. John scored very high on all those points."

Cooke, who worked at the United States Census Bureau in the 1960s, established GDT in 1980, and the company soon became the Census Bureau's primary contractor for building nationwide digital maps using its Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line Files. The files provided the first standardized coverage of street centerlines across the United States, Puerto Rico, and island territories.

Not long after Cassidy started at GDT, Cooke learned that the Census Bureau was planning to release its TIGER/Line Files to the public starting in 1989. What Cooke, Cassidy, and their colleagues realized was that, with additional development, the files could be useful beyond government projects—in the private sector.

"We knew cold what was coming out. We knew what it would be good for and where it would be very weak: in areas that didn't have street addressing," said Cooke. "We came up with a process to augment the TIGER map data using the address information that the [United States] Postal Service was just making available."

This was the beginning of GDT's Dynamap product line, a comprehensive street network that could match about 95 percent of US addresses to a geocoded map, compared to what the TIGER/Line Files could match, which was approximately 60 percent, according to Cooke. This—and the fact that GDT continually updated its database rather than waiting for the Census Bureau to release its TIGER/Line Files every 10 years—made the company's products the gold standard in street map data.

"GDT was the only player in the ball game in those days," recalled Nordstrand, who was looking for the best street map data he could find to incorporate into Esri's GIS products. "We had looked at the TIGER datasets and knew there was a lot of work to be done on them to make them more spatially accurate, so we started talking to GDT, and John was our main contact there."

"If you think of it, those were John's first years at the company, when we really developed our premier product line that served us well for the rest of the history of the company," said Cooke. "It was a great environment for someone with his temperament and skills to get thrown into because we expanded tremendously, and he stepped right up. He was a leader in all that."

Motivated to Expand What Could Be

Throughout his career, Cassidy remained a leader in advancing street map data and became a visionary for how to apply GIS to business issues.

When Tele Atlas acquired GDT in 2004, Cassidy stayed on as vice president of GIS and government markets, where he nurtured client relationships across both the public and private sectors in the United States, Canada, and Europe. And when Tele Atlas was acquired by TomTom in 2008, Cassidy stayed on for a while before heading to Esri to work as an account manager out of the Boston office for a few years. Some former colleagues at TomTom asked him to come back, though, so he did because "street mapping was always something I really loved," he said. Cassidy finished out his career leading geospatial and business development initiatives there.

"I wound up, all in all, working for 34 years and did just about everything," he said—from product management to sales. "I just always looked for ways to do good things."

According to Cooke, Cassidy put a face to the technology they were building and made people feel comfortable with it—an invaluable skill.

"John was a technological evangelist at the one-on-one level," Cooke said. "Being a friendly, fun, extroverted type of guy, I think he reached a lot of people."

One person Cassidy certainly reached was his stepdaughter, Katie Decker, the marketing community manager for the Esri Startup program. Although Cassidy and his wife, Martha—whom he met at GDT—never pressured Decker to pursue a career in GIS, she said she was almost inherently drawn to data and information.

"He [was always] motivated to help expand what could be, which I found interesting," Decker said. "He helped broker a lot of important data deals that led the technology where it needed to go to actually be useful to people."

After a long and rewarding career helping to bring street map data to the point that it is now used by governments, businesses, and people all around the world, every day, without much thought, Cassidy retired in 2019. And while, as Cooke noted, Cassidy had always been "totally unfazed by any challenges at all," the biggest challenge of his life was the last one he faced: cancer. Cassidy passed away on February 21, 2022. But the legacy he's leaving will no doubt endure.

"The world always has problems that need to be solved, and GIS is a great tool to do that," he said. "Just keep learning, keep doing, and keep solving problems."

↑ Cassidy lived in New Hampshire, where he enjoyed going for walks.

← When clients came to his home state, Cassidy (left) often hosted lobster boils.

GIS Hero

Location Intelligence Keeps Employees Safe in Saudi Arabian Desert

By Fawaz K. Patta, Hussain Alnasser, and Faisal Al Hammad, Saudi Aramco

At Saudi Arabian oil company Saudi Aramco, employees and contractors engaging in work-related vehicle travel must manage their trips using a journey management (JM) process that makes it easier to reduce travel-related risks. In the company's day-to-day operations, which occur around the clock and span the Kingdom of Saudi Arabia, vehicle transportation is one of the activities with the highest potential risk. It isn't unusual for drivers to get lost or stranded in desert areas, where most of the company's oil exploration and drilling activities are carried out. In 2019, Saudi Aramco's company vehicles racked up more than 200 million kilometers (124 million miles) in work-related travel throughout Saudi Arabia.

To minimize the increased hazards associated with traveling through remote desert areas, Saudi Aramco implemented its JM process based on the following core elements of its travel policy:

- Employees must inform their supervisors of where they are traveling to.
- Employees must reserve a vehicle that can handle the terrain and any hazards they may face.
- Employees must stay with their vehicle if they get lost or the vehicle breaks down or gets stuck in the sand.
- Supervisors must call 911 if their employees are out of contact for three or more hours.

In the past, all these processes were manual, and some were even paper based. But in alignment with ongoing digital transformation initiatives at Saudi Aramco, the GIS team developed an in-house, end-to-end, GIS-based solution called SafeTravel that is now available to employees and contractors online and on the go. ArcGIS Enterprise, ArcGIS Pro, and other ArcGIS apps and technology were key to imbuing the solution with sophisticated location intelligence.

An End-to-End Solution

SafeTravel is an easy-to-use GIS solution that consists of three main components: a mobile app, a web-based dashboard, and a back-end monitoring engine. It integrates Saudi Aramco's existing ArcGIS Enterprise deployment with corporate automatic vehicle location (AVL) devices, a corporate emergency responder tool, a text messaging and email gateway, human resources services, and an enterprise resource planning (ERP) back end.

To set up the framework for the solution, the team used a mobile data collection app that is now part of ArcGIS Field Maps to gather data about remote areas and sites where Saudi Aramco employees and contractors travel for daily operations. The team also employed the app to record locations where there is no mobile network coverage.

With that data stored in ArcGIS Enterprise, the team created a custom mobile app and dashboard using ArcGIS API for JavaScript and other developer technology. To ensure that the maps in the solution display quickly and smoothly on desktop and mobile devices, the team published a new basemap layer service for mobile apps using caching tools in ArcGIS Pro.

When employees and contractors need to take a work trip in a company vehicle, they now start the travel process by creating a new trip in the SafeTravel mobile app. Based on the type of trip they are taking, the solution triggers an approval workflow that goes to the driver's immediate supervisor and the department's JM coordinator. Once a trip is approved, employees and contractors use the mobile app to pick an appropriate vehicle from a pool of AVL-equipped company cars. They then acknowledge a pretrip checklist.

When the trip actually begins, drivers depend on ArcGIS Navigator to find their way to remote Saudi Aramco sites. They can use the app to update their arrival time and report any emergencies during the trip. If all goes as planned, drivers can simply complete and close their trip in the app when they are finished. However, if they experience an emergency, they can tap the 911 button in the SafeTravel app to make an emergency phone call or use the SOS Panic button that is available in all Saudi Aramco corporate vehicles. Either way,

↑ The SafeTravel dashboard provides supervisors and journey management (JM) coordinators with a quick view of active travel and alerts about delays.

the system sends a notification to the employee's supervisors and JM coordinators and to the nearest 911 emergency control center.

Constant, Digital Communication

In the past, since the JM process was mandatory, each department at Saudi Aramco implemented its own JM solution that ranged from paper forms and Microsoft Excel files to simple apps. JM coordinators used to spend a lot of time making phone calls to drivers and entering updates manually into their records.

By shifting the entire JM process to a digital, ArcGIS technology-based format, trip records are now accurate; up-to-date; and stored in a single, unified, electronic system. SafeTravel also provides supervisors and JM coordinators with real-time visualizations of all active journeys and sends automatic notifications when someone's trip doesn't go as planned.

In addition, the system monitors all the company vehicles being used for travel and notifies management if any vehicles are on the road without an approved journey in SafeTravel. This ensures that employees and contractors don't travel to remote areas without having done the proper preparation and gotten approval.

A major advantage of using SafeTravel is the system's ability to maintain constant communication among drivers and JM coordinators. Once drivers begin a trip, their route is immediately uploaded to the SafeTravel dashboard, which has real-time tracking. If a driver is unable to reach his or her destination within an hour of the planned arrival time, the system alerts the driver's direct manager and the JM coordinator for that department. If the delay extends to two hours, the system escalates the alert to the head of the driver's division. If the driver doesn't get in touch within three hours, the system automatically classifies the trip as an emergency and notifies the 911 center nearest to the driver's last-known location, which is based on positioning data from the driver's mobile device or satellite data from the vehicle's AVL system. Thus, emergency responders can start search and rescue operations immediately.

GIS Is a Prerequisite

Not only does Saudi Aramco's new SafeTravel system streamline and digitize all company travel, but it also has the potential to save lives. With employees and contractors driving through harsh desert conditions, to and from remote places, at all hours of the day and night, a GIS-based travel system is a prerequisite for Saudi Aramco—and the company now has that.
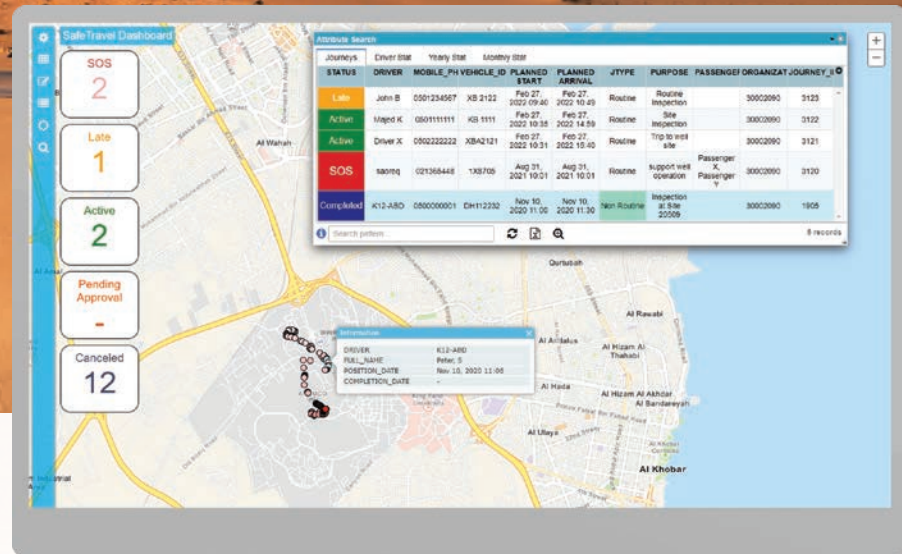
About the Authors

Fawaz K. Patta is a GIS specialist at Saudi Aramco. He has a background in enterprise GIS implementations, project management, and overseeing ArcGIS Enterprise and related systems. Hussain Alnasser is the corporate GIS group lead at Saudi Aramco. He has 20 years of experience in the industry and often leads the rollout of innovative GIS solutions within the company. Faisal Al Hammad is a full stack web developer at Saudi Aramco who specializes in Java and Web GIS technologies.

Esri Partners Level Up GIS Implementations

When organizations need help upgrading technology, managing and analyzing large amounts of data, and synchronizing systems, Esri partners can help. Their expertise in ArcGIS technology, GIS consulting, and training relieves pressure on organizations to do everything themselves and ensures that staff members have the knowledge and skills they need to continue the work going forward.

Read on to find out how four partners helped three utilities and one city take their GIS data and implementations to the next level.

## Offline, Map-Based Data Improves Digital Field Experience

At electric and gas utilities like Ameren, it is important for mobile crews to have easy access to current, accurate, GIS-based asset data so they can inspect, maintain, and repair equipment efficiently and correctly. But for too long, staff at Ameren relied on mobile mapping solutions that were only updated quarterly, resulting in outdated information—or data that could only be used online—which was impractical for workers on the go. And because Ameren's existing work management tool didn't have an integrated map, mobile crews struggled to gain spatial reference as to where their work needed to be done.

As the Missouri-based utility prepared to roll out an improved digital field experience initiative to its 4,000 mobile workers—which included multiple software updates to simplify how dispatch areas and service territories were managed—it became clear that having a reliable and field-ready mapping app was vital. To address this challenge, Ameren partnered with Epoch Solutions Group (epochsg.com) based on the strength of its EpochField tool and the company's extensive GIS consulting experience.

Ameren implemented the scalable, highly configurable EpochField mobile mapping solution, which is built on ArcGIS Runtime SDK for .NET. Using the SDK's Xamarin libraries, the app runs on Windows 10, iOS, and Android devices. Now, mobile crews at Ameren can use EpochField to work offline or online, download and view updated GIS data on demand, and draw accurate field diagrams with the map markup tool. Thanks to seamless integration between EpochField and ClickSoftware's Click Field Service Edge (CFSE), mobile workers can find and complete tasks either through legacy, text-based searching or by using the intuitive map interface in EpochField. Additionally, with user authentication enabled throughout Ameren's on-premises ArcGIS Enterprise portal, end users enjoy a convenient single sign-on experience.

Equipped with an offline, mapcentric mobile solution configured to their unique needs, mobile crews at Ameren are now completing their daily work—from routine maintenance and inspections to making repairs and dealing with service outages—using the most up-to-date information available. Despite deployment challenges caused by the COVID-19 pandemic, Ameren continues to roll out this powerful solution across its mobile workforce, transforming how gas compliance representatives, substation technicians, and electric distribution specialists deliver excellent service.
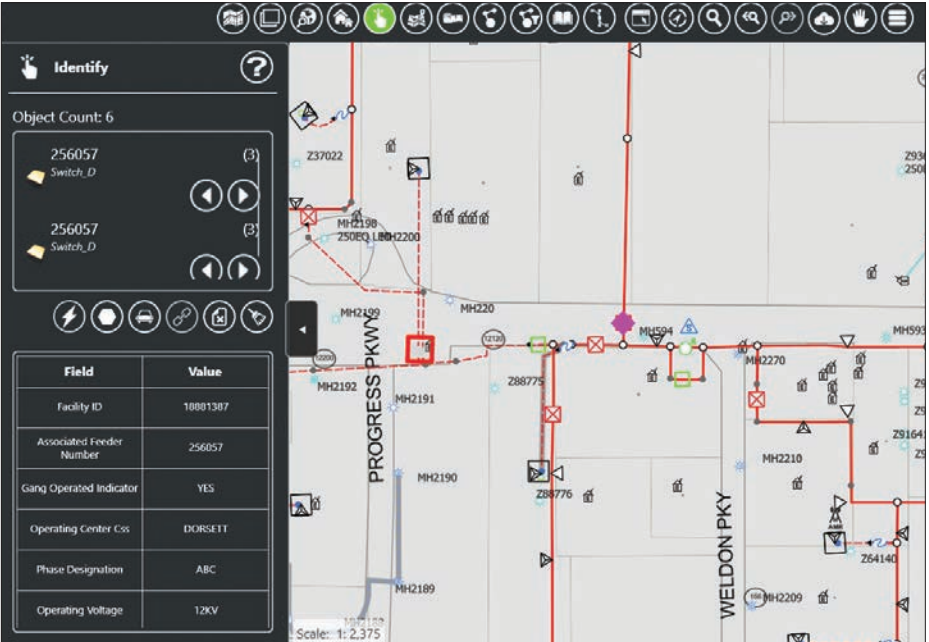
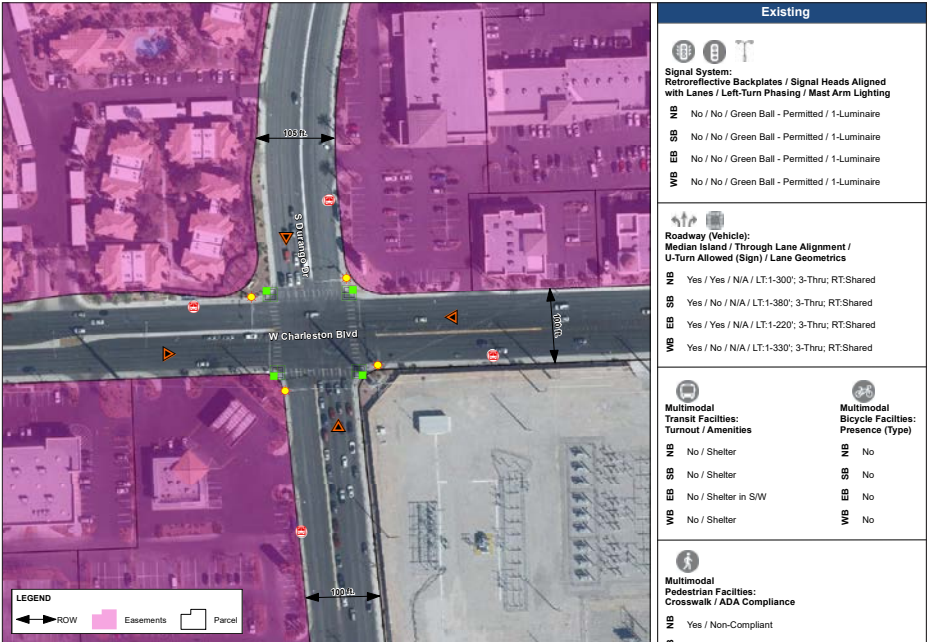## Easy-to-Visualize, Comprehensive Analysis Kick-Starts Vision Zero
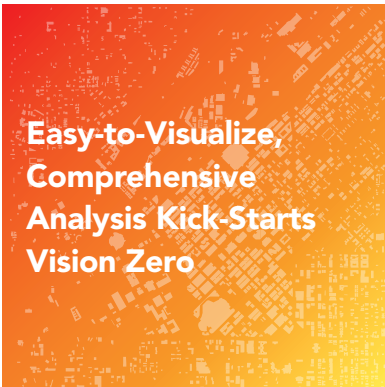
The City of Las Vegas, Nevada, recently kicked off its Vision Zero action plan, which seeks to eliminate traffic fatalities and serious injuries by 2050 while making mobility safer, healthier, and more equitable. The plan is a multidisciplinary approach that brings together local traffic planners and engineers, policy makers, safety stakeholders, and public health professionals to collaboratively address vehicular, pedestrian, and bicycle safety.

Before Las Vegas could put its Vision Zero action plan into practice, however, city staff members needed to first understand the locations and types of crashes occurring on local roadways. They sought to do this through a Citywide Intersection Crash Mitigation Program (CICMP) and approached **Wood Rodgers, Inc.** (woodrodgers.com), for help. The goal of the CICMP was to identify intersections throughout Las Vegas with the highest number of crashes and the highest crash rates, focusing on fatal vehicle-pedestrian and vehicle-bicyclist crashes.

Working with the city's Transportation Engineering division, the GIS group at Wood Rodgers managed and analyzed large amounts of traffic data, automated the presentation of results, and quickly shared the outcomes with stakeholders.

Team members used ArcPy to categorize nearly 60,000 crash-related data points by intersection and segment location. This data was presented in an easy-to-read infographic that contained charts and figures related to the crashes. Next, the team employed the cluster and heat map analysis functionality in ArcGIS Pro to determine the 10 intersections in Las Vegas with the highest number of crashes. The team then used ArcGIS Survey123 to collect existing-conditions data for these intersections.

As each step of the project was completed, the team at Wood Rodgers added the results to narratives built with ArcGIS StoryMaps and ArcGIS Online. These served as comprehensive, living documents that City of Las Vegas employees and other stakeholders could use to determine areas of focus and need. The interactive, map-based stories helped project participants and decision-makers easily visualize areas of concern so they could make informed choices on where to implement the most-needed improvements.

↑ With EpochField, mobile crews at Ameren can work offline or online, download and view updated GIS data on demand, and draw accurate diagrams with the map markup tool.

↑ Analysis results showed what kinds of improvements could be made at each intersection to mitigate crashes.

Synchronization Offers a Better Way to Manage Work Order Geometry

Marin Water is a publicly owned and managed water utility serving more than 190,000 customers in central and south Marin County, California. Like many utilities, Marin Water manages its asset inspection, maintenance, and repair work in an enterprise resource planning (ERP) system that's separate from its GIS—in this case, SAP ERP Central Component (ECC).

In 2018, Marin Water worked with **Locana** (locana. co)—known then as Critigen—to codevelop an Esri-SAP synchronization tool that used Python and a .NET add-in to keep asset data synchronized between ArcGIS and SAP for the entire water network. To build on that work and spatially enable SAP work orders and notifications, Locana updated the existing synchronization tool so that Marin Water's SAP database would automatically sync with the utility's geodatabase in ArcGIS Enterprise. That enabled the geodatabase to incorporate work orders from SAP and assign any associated assets with an initial location and geometry in GIS. The tool also monitors changes made to work order data in SAP. It synchronizes them with the geodatabase via automated processes and sends scheduled reports, which helps maintain data integrity.

Synchronizing work order data with ArcGIS has allowed Marin Water to build a user-friendly, map-based interface that empowers users to more easily manage geometry changes in work orders. For example, if a work order for a leak gets assigned to the wrong asset prior to excavation, it's now simpler for staff members to correct the geometry of that asset postexcavation. All they have to do is click a custom button within SAP that brings up a web map and then follow a quick workflow for creating, changing, or viewing the geometry of the work order.

Having the ability to view and manage SAP work orders and notifications across the utility's enterprise GIS implementation provides significant benefits to Marin Water. For annual maintenance and inspection programs, like valve turning, supervisors and managers can now view each program's progress on a map. Staff at the utility can also gain deeper insight into suspected problem areas and types of equipment by viewing historical repair history according to asset type and/or geography.

"By leveraging our previous investment with *[Locana]* to develop the Esri-SAP synchronization framework, we were able to quickly update the tool to synchronize additional work order data with GIS," said Marin Water GIS coordinator Gavin McGhie. "We built a user-friendly Esri map our employees can use to manage work order geometry."
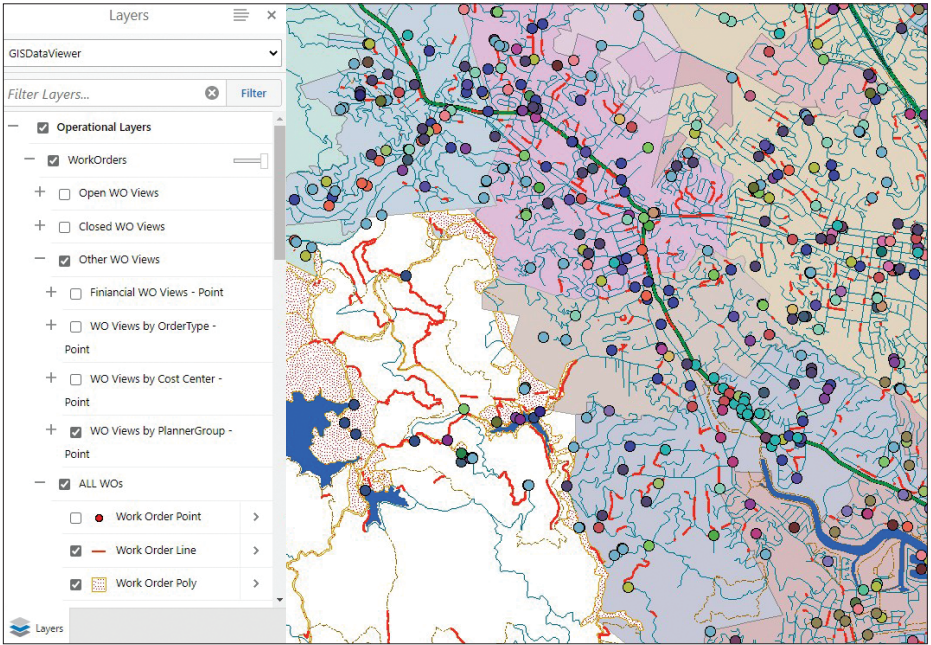
↑ Employees at Marin Water use a map-based interface to manage geometry changes in work orders.

Move to ArcGIS Utility Network Reduces Headaches and Paper Cuts
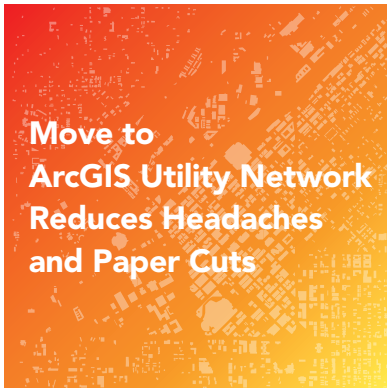
The City of Hastings, Nebraska, administers water, sewer, gas, and electricity services for approximately 25,000 residents who depend on quick response times. For years, the city has relied on a geometric network within ArcGIS Desktop to manage and maintain its water utility infrastructure. But as the city has grown and its needs have evolved, city employees realized that they required more advanced GIS capabilities.

With the geometric network, staff members used paper maps to do data collection. Communication—both internally and externally—was slow and inefficient. That said, the idea of doing a full migration to ArcGIS Utility Network was daunting, considering how dependent employees were on the geometric network for conducting day-to-day operations. When Esri announced last year that it would move fully to Utility Network by 2026, however, the initiative to get Hastings off its geometric network and working in ArcGIS Utility Network got fast-tracked.

That's where **Axim Geospatial** (aximgeo.com), which holds the Utility Network Management Specialty, came into play. A team at Axim worked with City of Hastings staff members to migrate all their crucial data to Utility Network. Because this was done during the COVID-19 pandemic, it entailed working both remotely and on-site—an adjustment for everyone. Five days on-site, plus additional remote work, gave the team at Axim enough time to learn the city's needs, address its most pressing problems, and accomplish everything that needed to be done.

Learning new software can be challenging, so to ensure that the City of Hastings had the institutional knowledge it needed to maximize its Utility Network investment, Axim provided in-depth training that included knowledge transfer, collaboration, and tools for success. This empowered city staff members to understand the workflow well enough so they could implement it themselves for additional utilities.

The City of Hastings has now fully migrated its water utility data to ArcGIS Utility Network. Having switched from paper maps to digital solutions for collecting data has greatly improved efficiency and accuracy—and has simultaneously reduced headaches and paper cuts. Now that data in the field is collected in real time, communication within and from the city has become more responsive, which has increased job satisfaction among city employees and had a positive impact on the community.
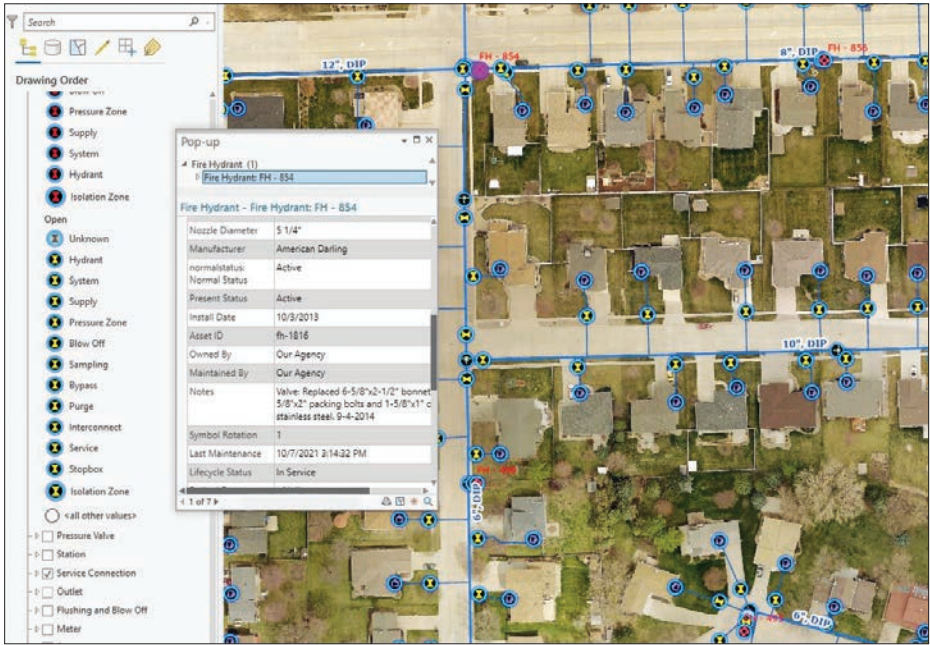
↑ The City of Hastings, Nebraska, has migrated its water utility data to ArcGIS Utility Network and now conducts real-time, digital data collection.

Voice Technology and Location Data Transform Community Engagement in Canada

Canada's Durham, Ontario, region is home to several of the fastest-growing technology organizations in the nation. This atmosphere of technological innovation is reflected in the government's commitment to improving the lives of residents by making information more widely available. Known as Durham Region, the government organization has a new smart city strategy that focuses on creating an omnichannel approach to communication.

Early in 2021, Durham Region partnered with two organizations—the Spark Centre, which provides resources to entrepreneurs, and the Ontario Centre of Innovation, which fosters collaboration between academia and industry—to challenge small- and medium-sized enterprises to help make regional services more accessible to the public. In response, Esri startup partner and voice technology company Qwhery, Inc. (qwhery.com), developed myDurham 311, a tool that integrates with ArcGIS technology and is designed to help users access regional information through smart home devices.

Connecting Homebound Residents with Crucial Information

Content and services on municipal websites can be difficult to find, and residents who use a city's call center to get specific information often get frustrated by long wait times. Compounding the problem, many cities faced budget cuts due to the COVID-19 pandemic—a time when local government organizations needed to engage with residents often yet had to move more of their services online.

Municipalities such as Durham are finding it increasingly difficult to meet their target service levels year after year and are actively seeking innovative communication channels to use to connect with residents. Smart home devices and virtual assistants offer an intuitive way to link people with the local information and services they need.

Durham's challenge posed the question, How can Durham Region leverage smart home technologies and 5G to empower residents to interact with regional services? Qwhery's existing integration with ArcGIS Solutions and ArcGIS APIs, paired with its own platform's ability to consume spatial data from local municipalities' open data portals, made the company an ideal candidate to respond to the call.

Qwhery provided a solution that connects many municipal business systems on one platform that reaches approximately 800,000 users in and around Durham.

A Startup Company Built from Open Data

Qwhery has been an Esri startup partner since 2020. Cofounder and CEO Matt Pietryszyn has been an advocate of municipal government transparency and community engagement for almost 20 years.

In 2019, Qwhery was founded as a voice-first solution provider that helps cities connect their open data to voice-enabled devices like Amazon Alexa and Google Assistant. This allows residents to ask their smart speakers the same questions they would use a call center for, but without the wait times.

Qwhery already had a history of creating innovative solutions for local governments before Durham Region put out its call for development. Relying on its existing use of ArcGIS REST APIs and ArcGIS Solutions, Qwhery built a service in 2020 called Where to Vote in Collin County, Texas, for Amazon Alexa and Google Assistant. Leveraging the location of each user's device, the solution queried Collin County's existing feature services to help more than 200 voters find their nearest polling place while also providing directions for how to get there and current wait times. This got people to their voting locations safely and efficiently, helped them avoid large crowds, and contributed to a record-breaking turnout for the 2020 United States presidential election.

Other custom-branded solutions from Qwhery include Marketplace Milton, a voice-enabled business directory for Milton, Ontario, Canada, and Ask Sugar Land, which connects the City of Sugar Land, Texas's mature and well-established enterprise GIS to voice technology. The solution provides immediate responses to community members' questions through apps and devices that Sugar Land residents were already using, which increased adoption rates and improved citizen engagement. These implementations gave Durham Region reason to trust Qwhery's ability to deliver.

A Voice-Enabled Solution That Residents Can Use Anywhere, Anytime

With myDurham 311, residents of Durham can easily find out information about elected officials and regional facilities, when waste pickup happens in their neighborhoods, where the nearest bus stop is, and even when to expect the next Durham Region Transit bus. To enable the voice service, all users have to do is say, "Alexa, open myDurham 311," or "Hey, Google, talk to myDurham 311," to their respective devices. The service then guides users

through how to interact in a conversational way with Durham Region information.

"Durham Region is a forward-thinking organization, focused on innovation and modernization," said Elaine Baxter-Trahair, chief administrative officer for Durham Region. "This service is the first step in our transformation toward a customer-centric approach."

myDurham 311 showcases how Durham Region is focused on improving the customer experience through an omnichannel approach. It is a coordinated system that helps ensure that regional services are accessible in a variety of ways, including in person; via the web, emails, and phone calls; and on social media. As the product matures, further capabilities will be introduced to myDurham 311—especially as Durham Region integrates more systems into the voice solution. This will make it easier for residents to quickly access the information that's most relevant to them based on their location and where certain services are available.

This ability for residents to interact quickly with government services will eventually produce cost savings for Durham Region's call center. Currently, municipalities the size of Durham spend approximately C$6 (US$4.70) per call and answer between 300,000 and 500,000 phone calls from residents per year. Providing more information to residents through a voice-enabled, location-based platform will also allow call center staff more time to address more complicated questions. This should increase customer satisfaction in the short and long terms.

Having a voice service on two of the largest smart home device platforms that integrates with its own location-based data is making Durham Region one of the first municipalities to provide residents with key local information wherever they are, whenever they need it. As Baxter-Trahair pointed out, "True customer engagement begins by offering access to services at a time that works for the individual rather than the corporation."

Municipalities currently using ArcGIS software, including ArcGIS Online, can easily connect their data and services to the Qwhery Cloud and begin engaging with residents and customers through new and modern communication channels. For more information about Qwhery's voice-enabled solutions, contact Pietryszyn at matt@qwhery.com.


"Alexa, what's being built nearby?"

"There is a road construction project on Main Street South, 1.5 miles away."

↑ Qwhery's online platform lets government organizations connect their location-based service information to Amazon Alexa and Google Assistant.

→ Approximately 800,000 users in and around Durham use myDurham 311.

← With myDurham 311, residents can get their questions answered quickly without having to visit a website or make a phone call.

"Alexa, ask myDurham 311 about garbage day."
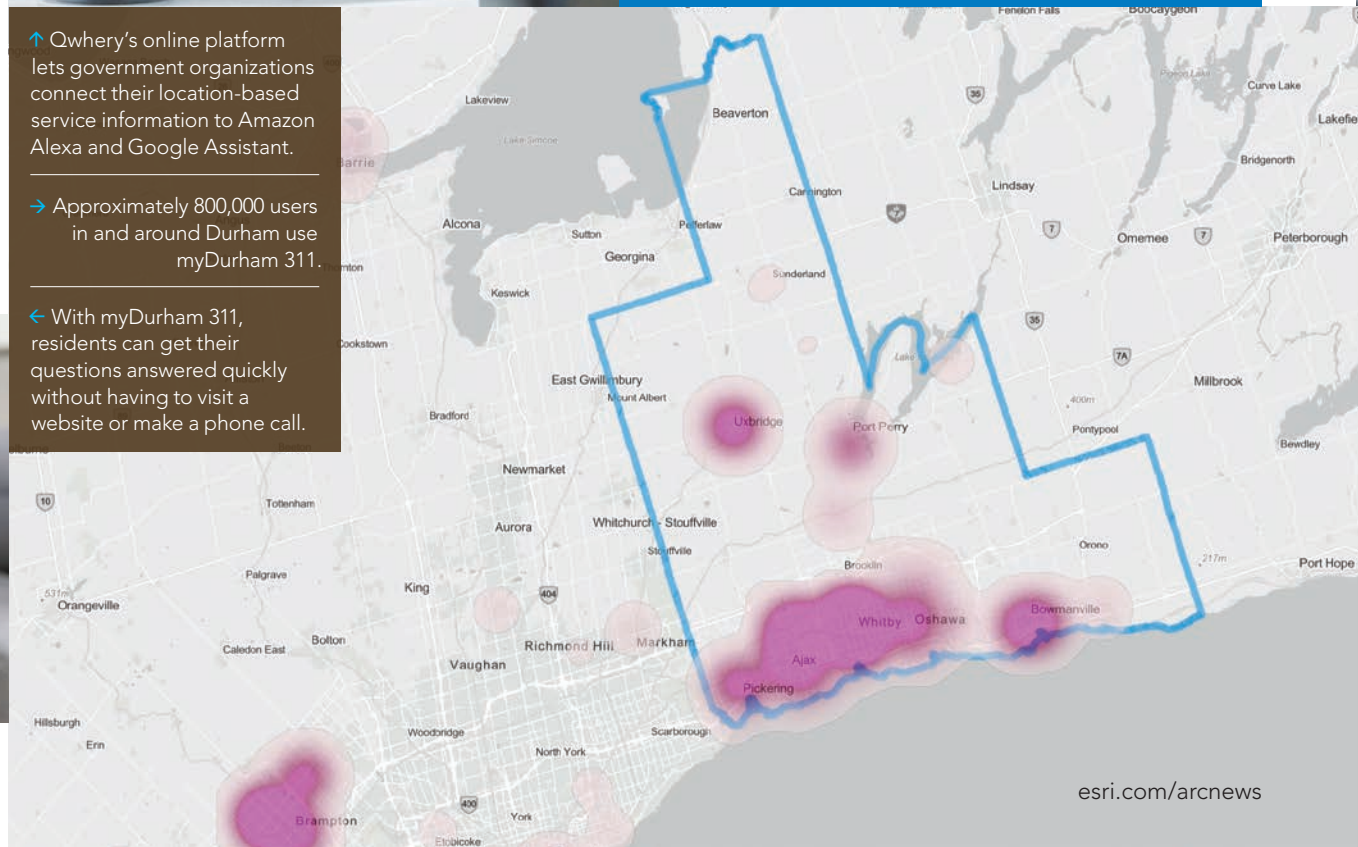
To Build a Smart Community, Lean into GIS

By Robert Kirkman and Teresa Townsend, Planning Communities

In recent years, the idea of smart communities has evolved from a niche focus into a wide-ranging practice with variable concepts. The terms *smart communities* and *smart cities* have been used to describe a range of programs and projects, so there is no exact formula for how to create a smart city.

Theoretically, living in a smart community would be appealing to everyone, given that it entails leveraging the best available data to make the smartest decisions that benefit the most people. But without concrete planning guidelines, many efforts to build smart communities have remained amorphous, revolving around vague talk of things like cloud computing and the Internet of Things (IoT).

Technology often comes to mind when people think about smart communities and smart cities, and that's not surprising. Many high-profile projects have revolved around implementing new technology to build the cities of tomorrow. That idea, however, can make it intimidating for smaller communities to implement smart city initiatives—not least because it would be difficult for many of them to pay for big technology upgrades on their already thinly stretched budgets.

But smart communities are not always the most technologically advanced. A smart community, at its core, offers better ways to plan to meet people's needs. Increasingly, this means leveraging already existing technologies in better ways, or better connecting people to the data they need. Ultimately, smart communities focus on the end result of their initiatives rather than on the initiatives themselves. And they remain committed to answering the question, How do we want to live?

Building More Human-Centered Communities

A silver lining of the COVID-19 pandemic has been a return to focusing on how people want to live their lives. Over the last two years, communities have done more than just consider what improvements could be made to people's quality of life; they have acted to achieve this goal in ways that didn't seem possible before.

Small projects undertaken around the world have demonstrated how communities can be more human centered while reinventing how business is done. For example, to help financially battered restaurants weather the pandemic while indoor dining was restricted, many cities extended outdoor dining areas across sidewalks and even out into parking lots and streets. As fewer cars traveled along roads, greenhouse gas emissions were demonstrably reduced. Soon, projects aimed at repurposing streets and altering public rights-of-way began supporting pedestrian and bike-friendly spaces and incorporating transportation demand management strategies. And this was happening in communities big and small, in all sorts of locations.

Permanent and widespread adoption of practices like these could result in long-term improvements to air and noise pollution, more accessible and resilient public spaces, and generally healthier communities. Those are concrete quality of life improvements. And this is one example of how the discussion about smart communities is moving away from the next great thing in technology and toward reorganizing existing spaces and applying enduring technologies to enhance how people live.

GIS Is Key Technology for Smart Cities

Much of the next wave of work that will be done to improve cities is the work that GIS professionals are already involved in and have been doing quietly for decades. We have long been conducting analyses to improve transportation and walkability, protect the environment, inventory assets, determine demographics, strengthen emergency management, and mitigate hazards. By continuing to partner closely with planners, GIS professionals can help bridge the gap between smart technologies and the futures our communities deserve.

Before local governments and organizations implement smart community programs as stand-alone initiatives, GIS professionals need to help position GIS as the key technology that can deliver critical services and bring together various disciplines and departments. Similar to how planning professionals shaped the smart communities movement, GIS professionals can be instrumental in developing the tools and apps that will make cities smarter.

When smart communities make better use of the substantial investments they have already made in GIS instead of merely purchasing new technologies, they are engaging in smart budgeting and fiscal responsibility. Scaling up rather than out creates opportunities for cities to expand their initial technology expenditures and put more stock into the staff and training they already have. What's more, it allows cities to start collecting new data immediately so they can begin integrating it into useful solutions.

At some point, of course, smart communities do need new technology. Adding sensors, apps, and more to a technology stack inevitably produces more data. In turn, new solutions are required to work with that data. It's a cycle. But planning and GIS professionals have the expertise to decipher patterns in the data; make models for evaluating future scenarios; build the maps, dashboards, and hubs that can be used to educate and communicate with people; and more. Therefore, it is essential to start thinking of GIS professionals not so much as the mapmakers but rather as essential partners and solution builders.

It's Time to Take a Seat at the Table

The American Planning Association recently released a report entitled *Smart Cities: Integrating Technology, Community, and Nature*, which defines smart cities as places that "equitably *[integrate]* technology, community, and nature to enhance...livability, sustainability, and resilience, while fostering innovation, collaboration, and participatory co-creation." This is what GIS does: it enables planners, GIS practitioners, and people from other disciplines to work together to create, integrate, and exchange data with the aim of building better communities.

As communities strive to become more equitable, resilient, sustainable, and smart, GIS technology and geospatial data are vital to achieving those goals. It is time, then, to make GIS professionals partners in these endeavors. So let's find space at the table, pull up a chair, and get more involved in developing solutions for smart communities.

About the Authors

Robert Kirkman, AICP, is the chief technology officer at Planning Communities. After starting out in environmental science, Kirkman has developed a broad career in remote sensing and enterprise GIS. Teresa Townsend, AICP, is a founding partner and chief executive officer of Planning Communities. A seasoned urban and environmental professional planner, she believes that data is key to understanding social and environmental complexities.

University's Interdisciplinary Geospatial Science Center Fosters Innovation

Growing global challenges, including climate change, need creative solutions. Institutions of higher education are increasingly playing a vital role in empowering future generations with the knowledge, skills, tools, and interdisciplinary collaboration necessary to produce innovative outcomes.

Clemson University is doing so by integrating geospatial technologies within diverse academic disciplines. The Clemson Center for Geospatial Technologies (CCGT), established in 2016, fosters a community of interdisciplinary geospatial science practitioners through the support of research, teaching, and outreach activities. CCGT assists students, faculty, and researchers to leverage GIS technology within their disciplines and bridge global connections among academic, industrial, government, and nongovernmental organizations worldwide.

Centrally located in Clemson's Cooper Library, CCGT hosts upward of 3,000 people a year and teaches 11 workshops per semester that provide participants with a basic understanding of GIS. In addition, CCGT serves as a resource when geospatial services are needed, including offering drone imagery, mapping, and analytics services university-wide. Departments such as Agriculture, Automobile Engineering, Athletics, and Campus Operations have participated.

"This model has been a game changer in terms of collaboration to eliminate data redundancy and lower costs," said Patricia Carbajales-Dale, executive director of CCGT.

In seven years, CCGT staff have leveraged workshops, word-of-mouth messaging, departmental collaborations, campus events, and more to make the center what it is today: a valuable academic and operational resource. Currently, the center employs six staff members and offers internship roles. It also facilitates workshops led by student collaborators and members of the IT department.

"We have a great relationship with our students and faculty, and for me, that is where our support starts," said Carbajales-Dale. "*[CCGT]* is a service, and our job is to support people at Clemson."

IT Staff and Librarians Partner to Start Geospatial Technology Center

The journey to creating CCGT began in 2014 as a collaboration between the IT department and librarians to ensure that GIS more widely benefited the campus. At the time, the university had an enterprise license agreement and seven labs dedicated to geospatial equipment. Departments such as Environmental Engineering, Forestry, and Geology were primarily benefiting from GIS.

"Clemson University had a lot of investments in GIS, remote sensing, *[and]* exclusive labs, but no one to directly support it. The technology was falling into the hands of faculty, who were very overwhelmed," said Carbajales-Dale. "The chief information officer at the time had this vision to add a human component to the investment to make the most of the technology for the community."

That human component was Carbajales-Dale, hired in 2014 as a facilitator to ensure the technologies' impact grew campus-wide. To expand this vision, Carbajales-Dale first offered basic GIS workshops on campus for students and faculty. The courses had high attendance rates and offered opportunities for Carbajales-Dale to learn from others where GIS support could enhance campus learning.

"Some departments didn't have faculty but wanted a semester-long course taught. Some

↑ For the Intelligent River project, the Clemson Center for Geospatial Technologies (CCGT) is using ArcGIS technology to help 40 scientists visualize and monitor real-time data collected from sensors along the Savannah River.

↑ CCGT staff members teach 11 workshops per semester that provide attendees with a basic understanding of GIS.

→ High-resolution aerial imagery taken by drones helps facilities staff see where maintenance is needed.

faculty needed support to stay up-to-date on the technology, while students needed help with a thesis or for undergraduate research," Carbajales-Dale said. "Our solution needed to offer flexible support, *[and]* we needed to show some sort of sustainability. So we created the center."

Getting Buy-In Took Time and a Tailored Approach

CCGT received funding for three years with the intent to become self-sufficient through cost sharing of equipment, licenses, drone insurance, and more. CCGT staff began building a sustainable foundation by nurturing buy-in with various faculty members, students, and other departments to find collaborative opportunities that met the needs of the university.

"Buy-in doesn't happen overnight," said Carbajales-Dale. "It took a few years. But we started with faculty, and we showed them by doing the things they needed that we were there to support them. They're our biggest champions."

Carbajales-Dale noted that CCGT staff members overcame buy-in challenges by tailoring their approach to understand the users' end needs. Often this meant meeting with department chairs, lecturers, or students one-on-one to understand what technology they could benefit from in their disciplines—or even developing example syllabi.

By 2017, the center's popularity had grown, and staff members introduced a cost-sharing model through strategic partnerships with other departments. This new model moved the center toward self-sustainability while empowering staff to maintain specialized equipment and develop new support programs for unmanned aerial vehicles (UAV) and lidar technology. By having the center and departments share costs, geospatial and imagery requests are fulfilled within the university instead of being outsourced.

Most recently, the center and several other university departments contributed to the costs of a drone imagery project spanning the entire campus. Over 12 days, more than 7,000 high-resolution aerial photos were captured. The detailed aerial view of the campus allows departments such as facilities to see where maintenance is needed. Moreover, CCGT staff used Clemson's Palmetto Cluster supercomputer to process the images and generate GIS products such as orthomosaics and digital surface models.
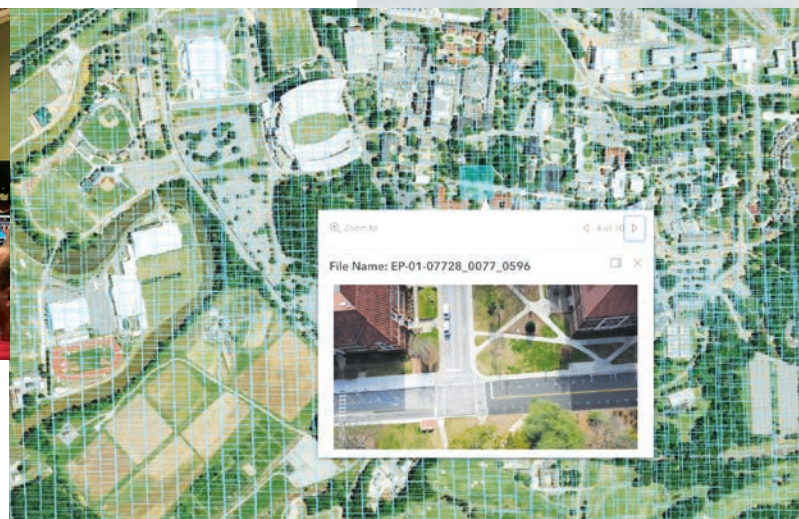
"This partnership between two very centralized units—the libraries and IT—I believe, has given the center the best of both worlds," added Carbajales-Dale.

In addition to the work CCGT provides across campus, Clemson University is a land grant institution, meaning staff provide public services and research across the state. For example, Clemson University was awarded $3 million by the National Science Foundation (NSF) Major

> ## " We are beyond proud for making GIS approachable and less intimidating to all disciplines across our campus. "
>
> **Elham Masoomkhah**, Former GIS Manager, Clemson University

Research Instrumentation (MRI) Program to support the Intelligent River project. The project entails designing, developing, and deploying a basin-wide network of computerized sensors to monitor water quality along the 312-mile Savannah River. CCGT staff will be using ArcGIS to help the 40 scientists on the project visualize and monitor real-time data collected from the sensors.

Enhancing GIS Curriculum via Coteaching and Centralized Resources

Today, CCGT provides a range of services to faculty, students, administration, and campus operations. Services include GIS fundamentals; course development; weekly workshops; outreach activities; field data collection; and access to drones, 3D printers, lidar, and UAVs.

From the classroom perspective, CCGT supports six to eight classes per semester by providing workshops, lectures, or training related to the subject matter in a coteaching setup with the faculty member. Disciplines such as architecture, forestry, geology, and natural resources regularly incorporate CCGT as a resource. As part of ongoing efforts to make GIS more accessible to students in disciplines outside technology and science, CCGT staff members have offered curriculum support, consultations, and training sessions for social sciences and humanities programs. These efforts have led departments such as Anthropology, Sociology, History, and Public Health to bring GIS into the classroom.

"We are beyond proud for making GIS approachable and less intimidating to all disciplines across our campus," said Elham Masoomkhah, former GIS manager at Clemson University. "Through CCGT support efforts, we have developed our GIS community from the ground up. We are humbled by an enormously increased demand for our services and are doing our best to answer the needs of our GIS community."

One example of CCGT's outreach to other disciplines is a course cotaught by Carbajales-Dale and Natallia Sianko, assistant professor in the Department of Sociology, Anthropology, and Criminal Justice at Clemson University. The class—Globalization & Social Change: Intro to GIS for Public Health, Visualization for the Social Sciences—is an interdisciplinary approach to teaching students theory and

technology. The purpose of GIS in this course is to show students how to use ArcGIS StoryMaps as a tool to develop their final project. During the technical session, students set up their accounts and create a practice map.

"Social science students typically have a solid theoretical understanding of how the world works or should work, and 'hard science' majors often have a very focused view of how a specific process works. It can be difficult to pair up these two perspectives," said Sianko. "The collaboration is a perfect example of connecting the course content with technology to address challenges."

Sianko and Carbajales-Dale have collaborated multiple times on research and course content development for graduate students. In one instance, the pair worked together on a session that was part of a five-week-module class. Carbajales-Dale taught a session that introduced social science graduate students to the graphic exploration and presentation of quantitative and qualitative data.

"Patricia's class was a perfect illustration of how to apply an interdisciplinary approach using a real example from our life today, here and now," Sianko said.

Carbajales-Dale hopes to continue offering GIS in non-science, technology, engineering, and mathematics (STEM) courses with a future goal to extend services to the school of business.

CCGT received recognition from Esri as an official development center in 2019 and has made a lasting impact on Clemson University. To meet expanding GIS needs, the center established a GeoAmbassador program, which empowers students, postdoctoral researchers, and faculty members who have experience with GIS or other spatial skills to create workshops to teach their peers. The center also sponsors a student-led group called the Clemson Mappers, which promotes spatial thinking and GIS on campus. Despite the pandemic, in 2020, CCGT had over 1,388 students attend its workshop series, including 55 faculty members, and hit a new attendance record for the first workshop of the series.

As the world grapples with complex challenges, from COVID-19 to climate change and population growth, higher education institutions will continue to find creative ways to empower students to be future leaders and problem solvers. Many will follow the lead of Clemson University, imparting knowledge, skills, and the use of technology tools like GIS. This trend toward interdisciplinary collaboration bodes well for a future in which experts across industries and nations can work together on important issues.

↑ CCGT is centrally located on campus at Cooper Library.

By Kelly León
Sweetwater Union High School District

Geography Education Needs an Urgent Transformation

Every year, students in my high school geography class formulate geographic questions about a community issue of their choice. Through research and the use of ArcGIS technology, such as ArcGIS Online, ArcGIS StoryMaps, and ArcGIS Survey123, they visualize data, communicate their analysis and insight, and recommend ways to take action.

The curriculum and tools make it possible for students to pose and address questions that align with their interests and experiences, such as, How does an area's income affect available skateboarding opportunities, or How do families' income levels shape students' education and impact their schools' spending decisions? Other students choose to use their knowledge of GIS and ArcGIS technology to explore issues of environmental or social justice by looking at Black Lives Matter protests, access to libraries, or polluted waterways. They use geography to better understand their lives and issues that mean something to them.

But less than a decade ago, this work was almost made impossible when officials at the Sweetwater Union High School District (SUHSD), where I work, considered ending the ninth-grade geography requirement. Given that SUHSD—located between San Diego and the California-Mexico border—is the largest secondary school district in California, this would have hindered a significant number of students from learning a subject that is not only crucial for making sense of the world but that also introduces skills and ways of thinking that are in high demand professionally. Teachers advocated to preserve the requirement, though, and worked with the California Geographic Alliance to reenvision its purpose and design. Today, almost all ninth graders in the district take the enhanced geography course, or Advanced Placement (AP) Human Geography.

Unfortunately, this local success story is not a common one. Despite a rise in select students taking AP Human Geography, geography education in the United States is in peril. While it is common in many countries for students to take multiple years of geography in school, in the United States, it is rare for students to get more than one year of stand-alone geography. In fact, fewer than half of states require geography at all. Geography's status as a school subject is particularly depressing when compared to that of other well-funded, newer subjects like computer science, which benefits from having a central position in the push for more science, technology, engineering, and mathematics (STEM) education.

Better funding doesn't always result in better outcomes, however. Computational disciplines like computer science still struggle to attract young women and Black, Indigenous, and People of Color (BIPOC) students. Interestingly, to improve student engagement in different subject matters, including computer science, GIS is increasingly being used as a teaching tool. This highlights the potential for improving learning outcomes if teachers align GIS-inspired curriculum with the interests and concerns of students and their communities. On the other hand, the growing use of GIS as a teaching tool also means it risks being uncoupled from learning about geography and geographic thinking.

Today's students live at the intersection of social, economic, and environmental systems that are intricately interconnected and often conflicting. A rising sea of big data reflects current challenges but also offers a vital opportunity to take control of the future. Schools need to respond by equipping students with the literacies they need to understand and navigate the complexities of today. For example, there is a growing number of jobs that require skills in both geography and computer science, yet school structures—like which classes are required for graduation and high teacher-to-student ratios—make it a challenge to teach lessons that join the two. Cross-disciplinary lessons, however, may be crucial to teaching students complex ways of thinking early on in their educational journeys.

This potential is the focus of a three-year project funded by the National Science Foundation called Encoding Geography. The project seeks to develop curriculum that can lead students on a pathway toward majors and careers where geography and computer science converge.

Encoding Geography is a research-practice partnership among SUHSD; San Diego State University; San Diego Mesa College; and the University of California, Riverside; with organizational support from the California Geographic Alliance, the American Association of Geographers (AAG), and the National Center for Research in Geography Education. Educators will engage students with geocomputational lessons that illustrate how both spatial and computational thinking can be useful for understanding issues that are important to them and their communities. This partnership also invites professionals to showcase how geocomputational thinking is used in an array of careers.
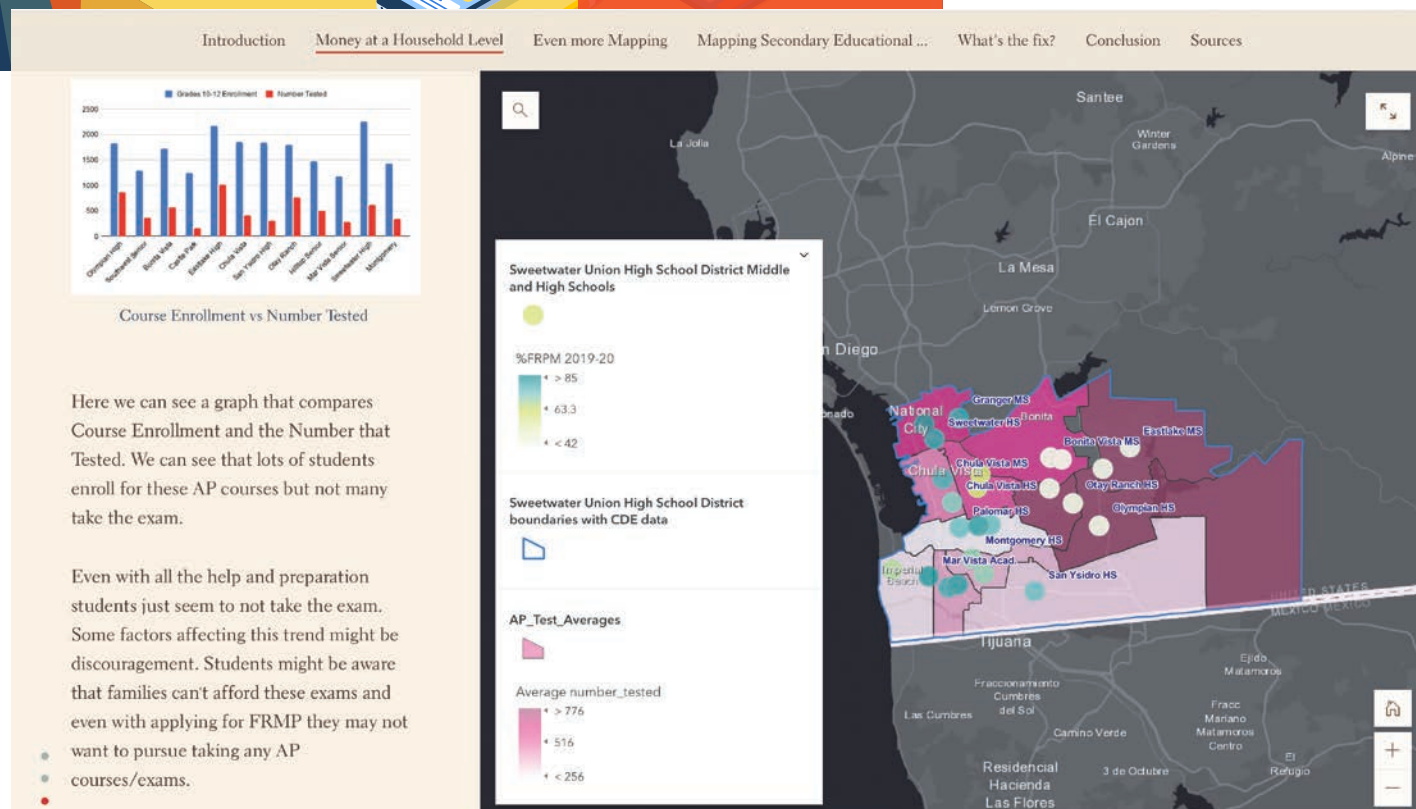
Encoding Geography addresses an important first step in creating structures for collaboration across disciplines. Without reinstating geography in schools where it has disappeared, without transforming the geography that's currently taught, without inclusively meeting the needs and aspirations of diverse student populations, and without partnerships like the ones described here, preparing students for geospatial majors and careers will be severely limited. Furthermore, it will be difficult to develop a more geographically informed populace in the United States, which is currently a critical need.

The student projects made possible by SUHSD's reimagined geography course don't simply prepare students for potential employment as GIS specialists; they also provide a rationale for all students to learn geographic ways of thinking and studying the world. This strengthens the case for geography and GIS in schools and might go a long way toward introducing the prospect of geospatial careers to a more diverse group of young people.

> If your job entails spatial thinking, computational thinking, or both, and you would be willing to be interviewed for Encoding Geography—or would like to get involved in some other way—contact SUHSD's coprincipal investigator for the project, Kelly León, at **kleon@sdsu.edu**.

Here we can see a graph that compares Course Enrollment and the Number that Tested. We can see that lots of students enroll for these AP courses but not many take the exam.

Even with all the help and preparation students just seem to not take the exam. Some factors affecting this trend might be discouragement. Students might be aware that families can't afford these exams and even with applying for FRMP they may not
- want to pursue taking any AP
- courses/exams.

↑ Students at Sweetwater Union High School District (SUHSD) use GIS to study questions that align with their interests, such as how families' income levels shape students' education.

About the Author

Kelly León is a ninth-grade geography teacher for SUHSD, a part-time instructor in the School of Teacher Education at San Diego State University, and a doctoral candidate in the Education for Social Justice program at the University of San Diego.

From the Meridian is a regular column from the AAG, a nonprofit scientific and educational society whose members, from nearly 100 countries, share interests in the theory, methods, and practice of geography. Find out about the AAG's programs and membership at aag.org.

Cartographers Advance Science at 30th ICC

The International Cartographic Association (ICA) was fortunate to have held the 30th International Cartographic Conference (ICC) in Florence, Italy, in mid-December, just before the omicron variant of COVID-19 spread rapidly around the world. The highly successful hybrid event saw 630 registrants from 53 countries—half of whom enjoyed the in-person company of colleagues at several Renaissance-era locations, all anchored to the main conference venue at the University of Florence's School of Humanities. Virtual participants were able to actively engage with and present in all the sessions, too.

Immediately preceding the ICC, 15 ICA commissions hosted workshops on various topics for anyone interested in getting involved. These workshops offered a glimpse into the diversity of the ICA's work. Themes included cartography and geospatial education in the classroom and the cloud, geospatial approaches for combating COVID-19, map generalization and multiple representation, historical cartography, and map design for atlases. These events were hybrid as well, allowing remote presentations and participation, and provoked excitement about the interesting, fun, and important work of the ICA before the ICC began.

During the opening ceremony for the ICC, Dr. Peter Gluckman, president of the International Science Council, reminded cartographers how important it is to integrate the physical, biological, environmental, social, and economic data sciences. This is something that cartography does very well, given its ability to illustrate the complex world we live in. But Gluckman offered a note of caution, pointing out that science has never been contested in some of the ways it's being challenged now and reminding everyone that governments do better when science is used effectively. Thus, science

needs to be more actionable, which is something cartographers can—and should—help with.

The ICA recognized two outstanding cartographers for their contributions to the field during the opening ceremony at the Palazzo Vecchio. Professor Ulrich Freitag from Germany and Dr. Alan MacEachren from the United States both received the ICA's highest award, the Carl Mannerfelt Gold Medal. Freitag, in his early work, advanced cartography as a communication medium and later proved that cartography developed as a valid scientific discipline. MacEachren is a pioneer of real-time exploratory analysis and visualizing geographic datasets, which now influences interactive, online, and mobile media. The ICA hasn't presented this prestigious award since 2013.

After the opening ceremony, a rich scientific program ensued. The ICC held 563 presentations with 80 sessions interspersed among 2 keynote speeches and 4 special sessions on topics that ranged from cartography in the age of digital transformation to the importance of national mapping and geospatial agencies in contributing to global and national priorities. Participants were able to attend sessions on storytelling in interactive atlases, spatial thinking in teaching cartography to schoolchildren, mapping autistic wayfinding, using cartographic and archival material to approach local history, machine learning methods for automatic mapping, developing cartographic terminology in African languages, cartography and the Sustainable Development Goals, and many more topics.

Abstracts and papers from the ICC are available in different publications. The number of high-quality papers received prompted the ICA to publish two special editions of the *International Journal of Cartography*: Volume 7, Issue 3, and Volume 8, Issue 1. The remaining papers and abstracts are available at icaci.org/icc2021.

To celebrate the achievements of organizations and individuals that have made recent contributions to the field of cartography, the ICC convenes the International Cartographic Exhibition (ICE). This is an opportunity for member nations and affiliate members of the ICA to exhibit their best cartographic work. This year's ICE was hosted by the Italian Geographic Military Institute. A panel of expert judges evaluated the entries, and three levels of winners were determined. Additionally, members of the public can vote for their choice of best product, which encompasses a separate award in each category.

The array of cartographic visualizations presented at the ICE included 271 maps and charts, 33 atlases, 58 digital cartographic products and services, and a special category of 22 cartographic educational products. Twenty-six additional entries were displayed that represented other types of cartographic products, from woodcut maps to games with maps. And the hybrid nature of the event enabled participants to take part in the ICE remotely. A comprehensive, 391-page catalog that describes each submission alongside an accompanying graphic can be found at icaci.org/icc2021. Example graphics of the winners' entries are also available on the *President's Blog* on the ICA website.

A highlight of each ICC is the Barbara Petchenik Children's World Map Drawing Competition. The theme for this year was A Map of My Future World. Children from 38 countries entered 178 drawings into the competition, and all the artistic renderings were displayed in Florence. The ICC then conferred 12 awards—plus 1 for creativity and 1 public award—to participants in four age categories. The children who participated give us a lens through which to better understand their concerns and opportunities. Examples of the entries, which I encourage everyone to look at, are available at icaci.org/icc2021.

During the closing ceremony, the ICA awarded three people the ICA Honorary Fellowship. Professors Georg Gartner, Lysandros Tsoulos, and Vladimir Tikunov were recognized for their longstanding contributions to the ICA. Diplomas for outstanding service to the ICA were awarded to three ICC members of the local organizing committee: Paola Zamperlin, Margherita Azzari, and Gilberto Fumarola. Manuela Schmidt also received a diploma for her contributions to managing the ICA website.

The ICA recognizes the importance of investing in the future of cartography and geoscience as scientific disciplines. In addition to opportunities like the ICC and various publication streams, the organization offers scholarships to young scientists to invest in the future. In a separate ceremony, 27 individuals were awarded ICA scholarships to the 30th ICC. It was rewarding to experience the recipients' excitement, gratitude, and refreshing views and ideas.
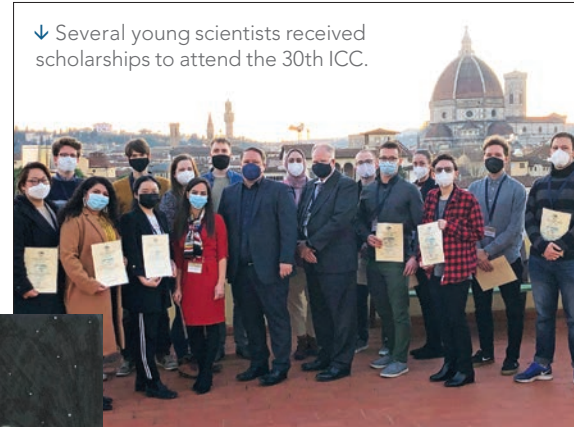
The ICC brings together so many colleagues who, in addition to attending informative presentations, enjoy gathering with friends and acquaintances at coffee breaks and meals. The event also allows the ICA to engage with sister societies; advance collaborations with organizations such as the United Nations (UN), the International Hydrographic Organization, and the International Map Industry Association; and strengthen its commitment to members like the country of Switzerland, national mapping organizations, and companies including Esri.

And the splendor of Florence—the seat of the Renaissance—was an ideal setting for an international cartography conference. While the scientific program advanced interest in and understanding of cartography and GIScience, the city's streets, buildings, and art drew attendees into the area's fabulous history and culture. One of the many architectural highlights was the gala dinner held at the Palazzo Borghese.

The last act of the ICC was the closing ceremony. This is where individuals and exhibitors received their awards, and the winners of the orienteering competition were recognized. The host of the 31st ICC then gave an enticing presentation inviting everyone to Cape Town, South Africa, for the next conference in August 2023. At the end of the event, the Florence hosts handed the ICA flag over to a representative for South Africa. And as we bid Florence farewell, we know we have a lot to look forward to at the next ICC in Cape Town.

More details about the ICC, along with photographs from the various events, are available at icaci.org/icc2021.

↓ Several young scientists received scholarships to attend the 30th ICC.

↑ One of the highlights of the International Cartographic Conference (ICC) is always the Barbara Petchenik Children's World Map Drawing Competition, which gives adults a lens through which to better understand children's concerns and opportunities.

About the Author

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Esri Press

Local Voices, Local Choices:
The Tacare Approach to Community-Led Conservation
By The Jane Goodall Institute, Introduction by Jane Goodall

Just as Jane Goodall's work with chimpanzees has been transformative, so have her efforts to empower communities living on the edge of human settlement to protect their natural resources—or risk losing them forever. *Local Voices, Local Choices: The Tacare Approach to Community-Led Conservation* details the Jane Goodall Institute's holistic method for conservation, which puts local communities in charge of preserving the natural world around them. Working with science and technology and with support from conservationists, local residents grow to understand the impact they have on the environment and are empowered to find ways to balance their communities' needs with the surrounding ecosystems. Written for conservationists, fans of Goodall, and anyone interested in environmental issues, *Local Voices, Local Choices* is a vibrant expression of Goodall's vision and her hope that the Tacare approach will be understood and adopted wherever there is a need for genuine, community-driven conservation. June 2022, 280 pp. Ebook ISBN: 9781589486478 and hardback ISBN: 9781589486461.
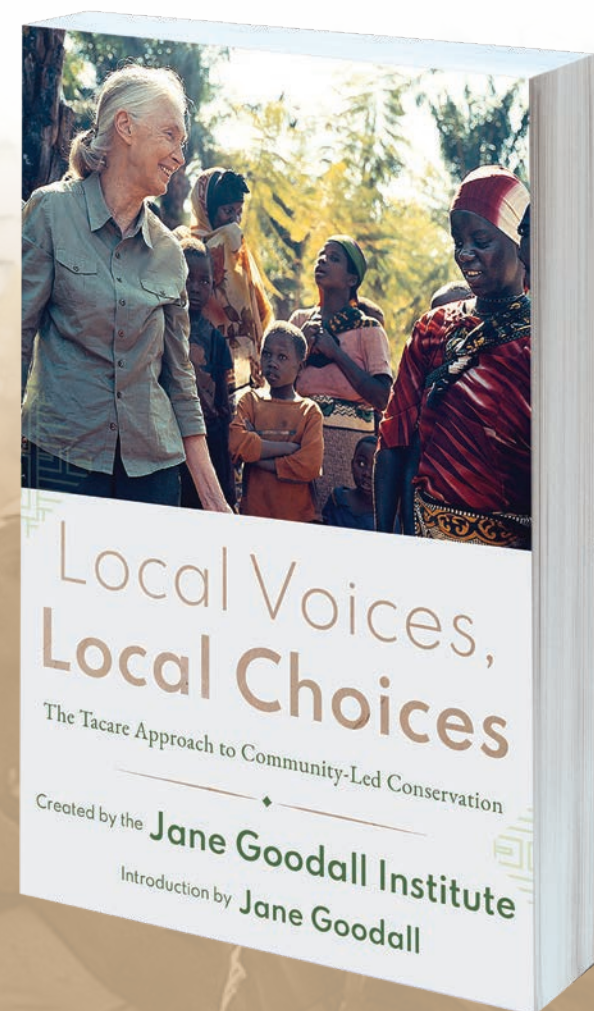
Thematic Mapping:
101 Inspiring Ways to Visualise Empirical Data
By Kenneth Field

Maps are rarely right or wrong; they are simply different versions of the truth. The meaning people find in a map can reinforce or challenge their understanding, and people are much more likely to trust a map if it presents a version of the truth that they already believe in. Using 101 maps, graphs, charts, and plots of the 2016 presidential election in the United States, *Thematic Mapping: 101 Inspiring Ways to Visualise Empirical Data* explores the rich diversity of thematic mapping and the visual representation of data. Each map illustrates a different approach to the same data, and all lead to different maps and different ways of seeing different shades of truth. August 2021/March 2022, 296 pp. Ebook ISBN: 9781589485587 and paperback ISBN: 9781589485570.
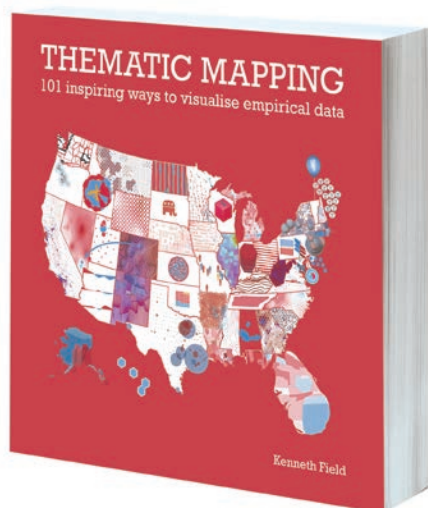
Mapping the Nation:
Navigating Complex Challenges
By Esri

In this current time of crisis, governments that embrace GIS reap great value from it. *Mapping the Nation: Navigating Complex Challenges* is an annual compilation of inspiring stories about how government organizations use GIS. This year's book focuses on the many ways geospatial technology helps solve issues related to a range of challenges, from population growth to public safety. It showcases, for example, how cities across the United States have used GIS to examine and understand who they serve—and who they leave out—as they adjust their budgets to address inequities. The book also highlights how states and other localities have used the technology to address and forecast economic hardship and plan for contingencies and recovery. March 2022, 188 pp. Paperback ISBN: 9781589487154.
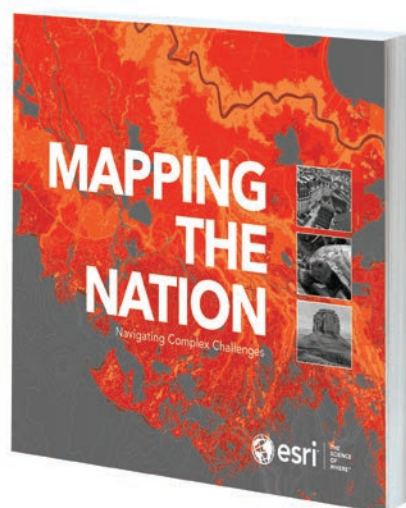
Measuring Up: The Business Case for GIS, Volume 3
Edited by Cory Fleming, Christopher Thomas, and Shannon Valdizon

After community-altering events, such as an economic downturn or a pandemic, how do government organizations maintain the quality of their day-to-day operations while solving big problems? Many turn to GIS. *Measuring Up: The Business Case for GIS*, Volume 3, presents real-world stories of how organizations utilize GIS to save time and money, increase accuracy, improve productivity, and manage resources. Readers can use this collection as a model for how to work through considerable challenges and employ GIS not just as a tool but as an integral part of the solution. February/May 2022, 200 pp. Ebook ISBN: 9781589486256 and paperback ISBN: 9781589486249.
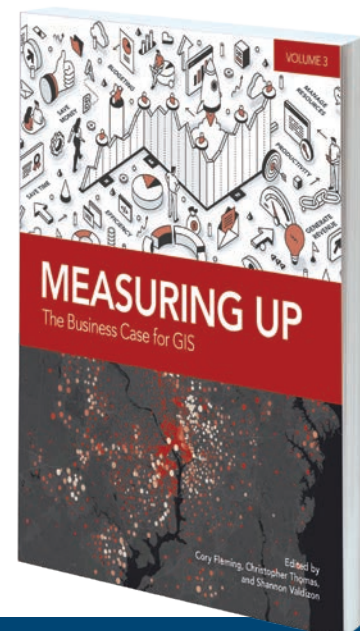
Mapping Community Health: GIS for Health and Human Services

Edited by Christopher Thomas, Shannon Valdizon, and Matt Artz

For many public health service agencies, the ability to build healthier communities, increase access to health care, and improve people's health outcomes relies, in large part, on using GIS. *Mapping Community Health: GIS for Health and Human Services* showcases health organizations that are employing location technology to address issues such as the opioid epidemic, homelessness, food insecurity, and health and racial inequities. The book suggests strategies to help readers get started with using GIS for health and human services. December 2021/March 2022, 120 pp. Ebook ISBN: 9781589487000 and paperback ISBN: 9781589486997.
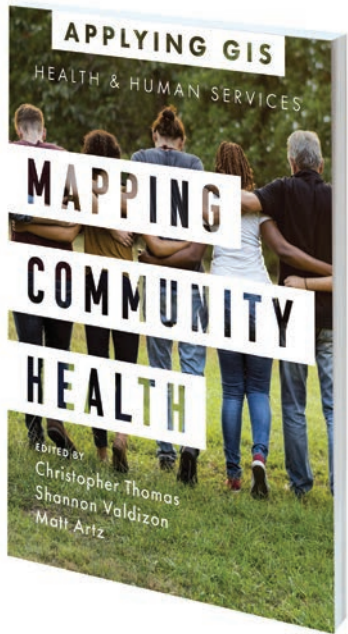
Learning from COVID-19: GIS for Pandemics

Edited by Este Geraghty and Matt Artz

With the health community now examining the worldwide response to the COVID-19 pandemic, it's time to think about how to raise the bar for responding to the next public health emergency. Now is the time to revisit health preparedness strategies and plans; now is the time to review what worked to see how that can be done again; now is the time to put lessons learned into practice. *Learning from COVID-19: GIS for Pandemics* gives real examples of how spatial thinking became invaluable for both local and full-scale outbreaks of COVID-19. Answering the question of "where" was paramount, and when civic leaders and public health agencies used GIS to do real-time disease surveillance, it transformed overwhelming amounts of data into valuable location intelligence. May 2022, 175 pp. Ebook ISBN: 9781589487123 and paperback ISBN: 9781589487116.
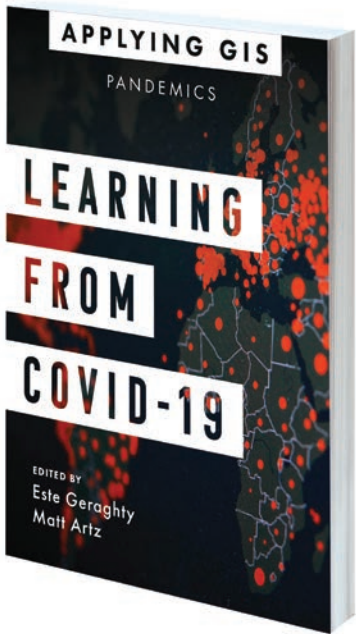
Valuing Place and Purpose: GIS for Land Administration

Edited by Brent Jones and Keith Mann

Location intelligence is changing the way people protect and maintain land. The stories in *Valuing Place and Purpose: GIS for Land Administration* show how various communities, government agencies, nonprofits, and other organizations are implementing GIS in four key areas: to visualize parcels and property; manage land use; strengthen climate and conservation efforts; and address land rights, equity, and social justice. The book includes a special section to help readers use web apps, online maps, dashboards, and other GIS solutions to better represent the value of land and property and more efficiently manage, edit, and share land parcel data. March/May 2022, 120 pp. Ebook ISBN: 9781589487079 and paperback ISBN: 9781589487062.

New **Training** and **Certification** Offerings

Training

Take an Instructor-Led Course

Are you looking for captivating ways to display data and maps? Do you need a better system for sharing GIS resources? If so, check out the following instructor-led courses to discover tips and tricks that you can apply to your work right away:

- **Creating Stories with ArcGIS:** Get ready to become a visual storyteller in this two-day class designed for anyone who wants to share information in an interactive and highly engaging manner. Stories made with ArcGIS StoryMaps are a popular way to engage with project stakeholders, inspire audiences, and present portfolios of work. Course participants learn best practices for creating and sharing great stories using ArcGIS StoryMaps.
- **Sharing Content to ArcGIS Enterprise:** Bring your organization's enterprise GIS portal to life by sharing web maps, apps, and other authoritative geospatial resources there. This course teaches attendees essential workflows for efficiently sharing resources that support collaboration within and across business lines and, ultimately, make it easier for portal users to infuse their projects with location-based insight.

Esri's instructor-led courses are developed in-house by subject matter experts who have a deep understanding of ArcGIS best practices and recommended workflows. All instructors have Esri technical certifications and CompTIA CTT+ certification. Courses are currently offered online, in real time (in multiple time zones), and as private training events.

Improve Your Tech Savviness by Taking an Esri MOOC

Massive open online courses (MOOCs) are free and convenient and offer a great way to build in-demand skills and stay up-to-date with Esri technology. Participants get access to ArcGIS software, and each course includes video lectures by Esri experts, hands-on software exercises, and interactive forums to engage with learners from around the world. For a closer look at some upcoming courses, take a look at the following:

- **Going Places with Spatial Analysis, April 13–May 25:** Learn the fundamental concepts of spatial analysis and see how it supports better decision-making at businesses, private organizations, and government agencies. Attendees get to have fun using ArcGIS Online to turn data into information as they explore real-world scenarios in which performing spatial analysis makes a difference. Registration is open through April 27.
- **Imagery in Action, April 27–June 8:** In this MOOC, learners explore the cutting-edge ArcGIS capabilities used to visualize, process, analyze, and share imagery and remotely sensed data. Top imagery experts demonstrate how to derive 2D and 3D imagery products from satellite and drone-captured imagery, lidar data, and more. Course exercises guide participants through essential imagery workflows using the latest ArcGIS desktop and cloud-based apps, as well as a pretrained deep learning model. Registration closes on May 11.

Everyone who completes a MOOC receives a certificate of completion. View all the MOOCs Esri has available at esri.com/mooc.

Certification

The Esri Technical Certification Program is growing to support the needs of the global GIS community. If you work with ArcGIS Pro, ArcGIS Enterprise, ArcGIS Online, or developer technologies related to ArcGIS, there are new exams available (or coming soon) to help you validate your knowledge and skills.

The process to achieving certification begins with selecting an exam to take based on your current experience. Review all the information provided on the exam's web page—especially the candidate qualifications and skills measured—to determine which exam offers the best match.

Once you've chosen an exam, purchase an exam voucher and then make an appointment with Esri's testing partner, Pearson VUE. Esri certification exams can be taken at Pearson VUE testing centers or remotely using Pearson's OnVUE option.

Planning adequate preparation is vital to passing a certification exam. Allow yourself plenty of time to study, and pay extra attention to exam topics that you're less familiar with.

With these tips in mind, take a look at the following recently released certification exams to see if one is right for you:

- **ArcGIS Pro Professional:** Ideal for people with significant experience in GIS, this exam measures proficiency in a range of advanced ArcGIS Pro capabilities related to mapping, analysis, data management, and sharing geospatial content. Exam takers should have spent four or more years successfully completing or leading complex GIS projects.
- **GIS Fundamentals Foundation:** This certification is an excellent option for students and others who have entry-level GIS knowledge and experience using ArcGIS Online and ArcGIS Pro to make maps, visualize data, perform spatial analysis, and share tasks. A minimum of three to six months of GIS coursework or workplace experience is recommended.
- **ArcGIS Developer Foundation:** GIS professionals and non-GIS developers who have up to two years of experience interacting with the ArcGIS system and its application programming interfaces (APIs) to deliver geospatial solutions will find this exam to be a good fit. It measures familiarity with user roles, authentication, and service types, and individuals should be able to create apps and publish and manage data.

If certification is something you're interested in pursuing, explore the latest Esri technical certification exams at esri.com/training/certification. Get some inspiration for your GIS journey by viewing certification success stories at go.esri.com/certification-success, and join the Esri Technical Certification groups on LinkedIn and Esri Community.

Go to **esri.com/training** for more information. Find courses at **esri.com/training/catalog/search**. Keep up with Esri training news by subscribing to the newsletter (**go.esri.com/training-news**), visiting the *Esri Training* blog (**go.esri.com/trainingblog**), connecting with the Esri Training community on Esri Community (**go.esri.com/training-community**), and following **@EsriTraining** on Twitter.

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