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A BLUEPRINT FOR MODERN CONSTRUCTION

Location Intelligence Guides Leading Firms to Safe, Efficient, and Sustainable Projects

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Executive Summary

Construction Leaders Find a Crucial Ally in Location Intelligence

Construction firms have a fresh way of grappling with old constraints—those that are environmental, but also those related to time, scope, and cost. They're using a mix of cutting-edge location technologies, synced with inexpensive sensors and connectivity, plus aerial, satellite, and drone imagery.

Take what PCL Construction has done while building a new hospital in Canada. The construction firm determined where to best position pumps and routed more than 500 cement trucks into and out of a site to pour a foundation in a single 12-hour period.

The firm achieved this feat guided by location intelligence from geographic information system (GIS) technology. The same tools are driving performance and sustainability for construction projects around the globe. **Listen to the podcast**. ▶

Executive Summary (continued)

Data-driven spatial analytics and visualizations make GIS technology an invaluable tool. Across hundreds of companies and thousands of projects, the use of GIS leads to streamlined operations, increased efficiency, reduced costs, and successful outcomes. GIS technology offers comprehensive business value to construction projects, including the following:

- **Superior data management**
- **Improved decision support**
- **Enhanced project coordination**
- **Integration with BIM files, imagery, and sensor feeds**
- **Real-time site management tools**
- **Location-based insights**

In practice, this means construction teams can see a virtual representation of where materials and supplies are coming from to better schedule project delivery or visually share progress with stakeholders in real time on a smart map, dashboard, or digital twin.

It also means that critical information, gathered in-house and from authoritative sources, can be layered on a single project site map. Stakeholders can overlay their own relevant data—such as utility lines, zoning regulations, land-use patterns, and environmentally sensitive areas—to aid planning and design.

With smart maps, real-time dashboards, and digital twin visualizations, modern construction is becoming safer, faster, and more sustainable.

Because GIS technology integrates with BIM, sensor feeds, and imagery, it serves as a secure, accessible, and easy-to-update information hub. Dynamic maps put all stakeholders on the same interactive page, showing real-time progress in sharp detail.

Location insights from GIS maps also bring potential risks into focus, showing the project's relationship to environmental hazards and the site's proximity to fault lines or flooding areas. Planners can use GIS-powered modeling tools to iterate on mitigation measures before making the best decision to ensure workforce safety and project longevity.

In this blueprint for modern construction, we explore how GIS is helping firms advance safety, efficiency, and sustainability and highlight industry leaders that are taking advantage of the technology. ■

Real-World Benefits of Location Intelligence

GIS technology has become an invaluable resource for large construction projects, optimizing the following:

Safety: When there is a shared and transparent awareness of a project site and the specific areas where workers are located or need to be, it enables more efficient and careful construction practices that were previously not possible. Syncing with feeds from sensors and drones, GIS maps and dashboards display hard-to-reach data inputs and imagery without putting crews at risk.

Efficiency: The convergence of BIM and GIS for project planning streamlines data flows, captures work processes and construction operations, and provides a greater site-wide perspective. GIS technology helps in visualizing project data and communicating complex information for better collaboration, more transparency, and smooth stakeholder buy-in.

Sustainability: The gold standard for tracking and analyzing environmental data, GIS maps show a project's relationship to protected areas, wildlife habitats, water bodies, and more to ensure compliance and minimize impacts. GIS technology also powers circular construction practices, tracking waste generation and disposal locations and identifying options for recycling and reusing materials. ■

Safety
Delivering Next-Level Situational Awareness

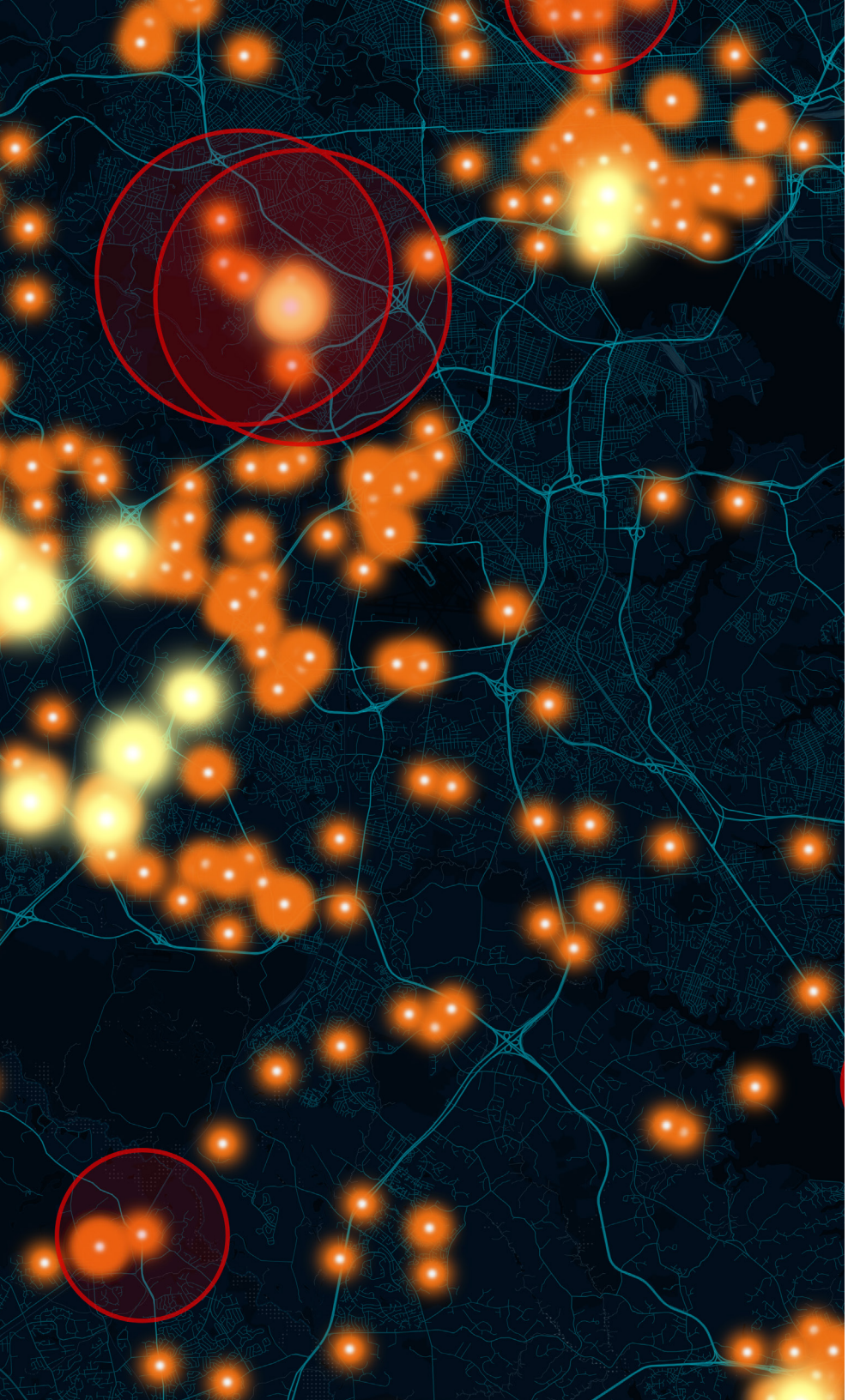
Situational awareness fosters safety, but knowing the location and condition of everything and everyone at any time had its limits—until recently.

Now, construction firms can look to imagery captured by drones, aircraft, satellites, or on-site cameras. Inexpensive sensors feed real-time updates about movements and locations. These devices can also travel safely to hard-to-reach places, saving the risk and time of sending a worker to capture information in person. A GIS-powered smart map or digital twin pulls it all together for interactive, in-the-moment awareness.

- One construction firm **used drones and GIS to measure material stockpiles**, cutting 800 "working at risk" days by avoiding on-the-ground inspections, resulting in a savings of £30,000 a year.
  → Read the story.

- Following a rainstorm, a drone was deployed to inspect the roof of a major Southern California airport. Detailed GIS maps of the airport **enabled the quick identification of assets that might be at risk**.
  → Watch the video.

- Managers on an active bridge project **use sensors to alert them when vibration exceeds threshold values** and a GIS map to show the precise location of the excessive vibration.
  → Read the story. ▶

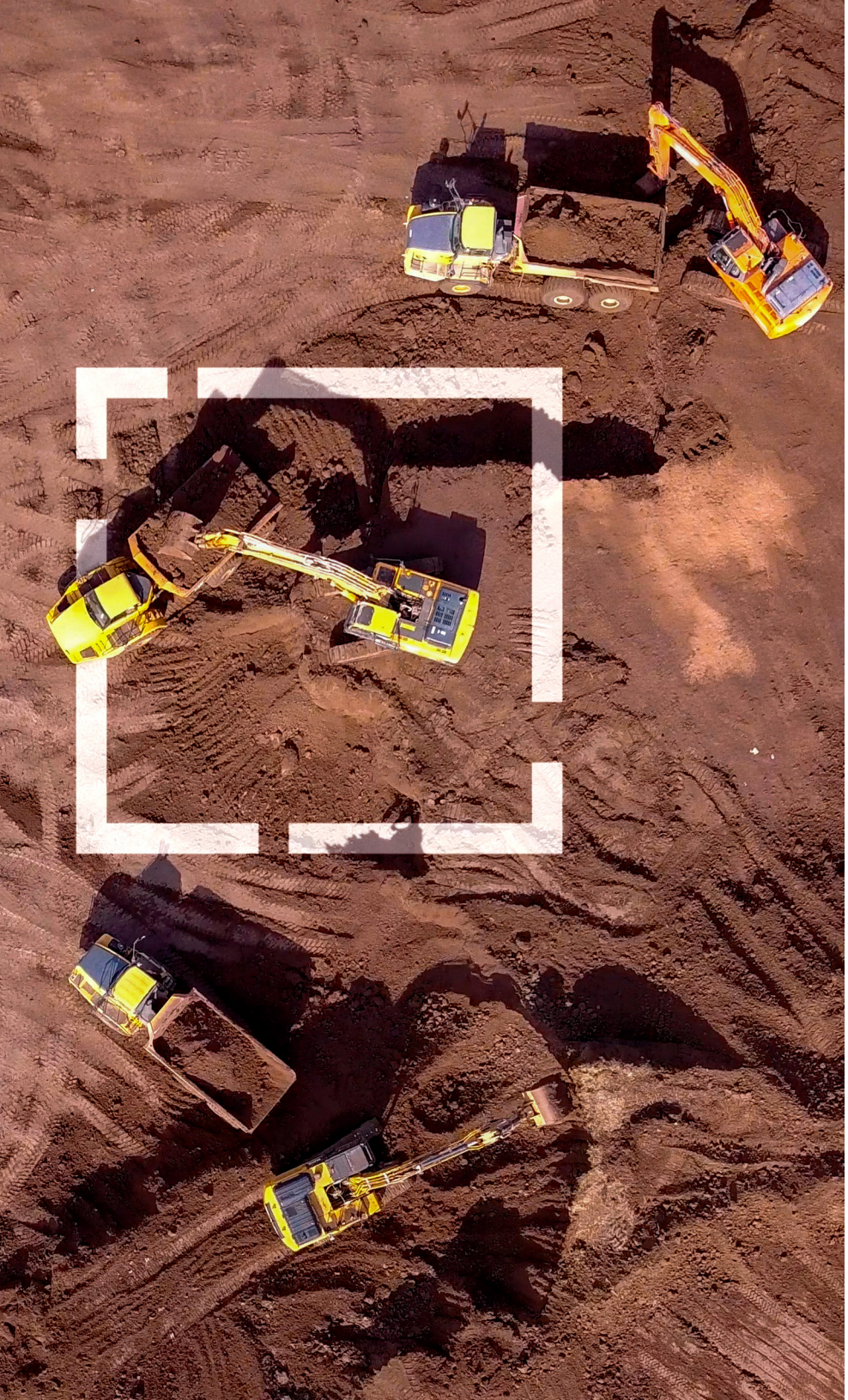


Safety (continued)

It sounds simple, but knowing the exact locations of critical equipment—such as fire extinguishers or first aid supplies—and where to go during an emergency can prevent injuries and save lives. When a construction firm is equipped with GIS technology, team members can use mobile apps such as ArcGIS® Survey123 or ArcGIS QuickCapture to report incidents and warnings at their precise locations.

On-site workers for Pacific Gas and Electric are doing just that, using GIS apps to alert their colleagues about aggressive dogs that might stand between them and an electricity meter, for example. The location-based tools then aggregate safety issues and present them visually on a real-time dashboard so management can maintain awareness and take corrective action if necessary. → **Watch the video**.

Modern GIS technology provides this interactive big picture view—of a site and its people and assets. But it can also zoom in, peering underground and behind walls to reveal hidden threats. This multilevel situational awareness helps protect workers from digging or demolishing where it may be dangerous. → **Read the story**. ▸



Safety (continued)

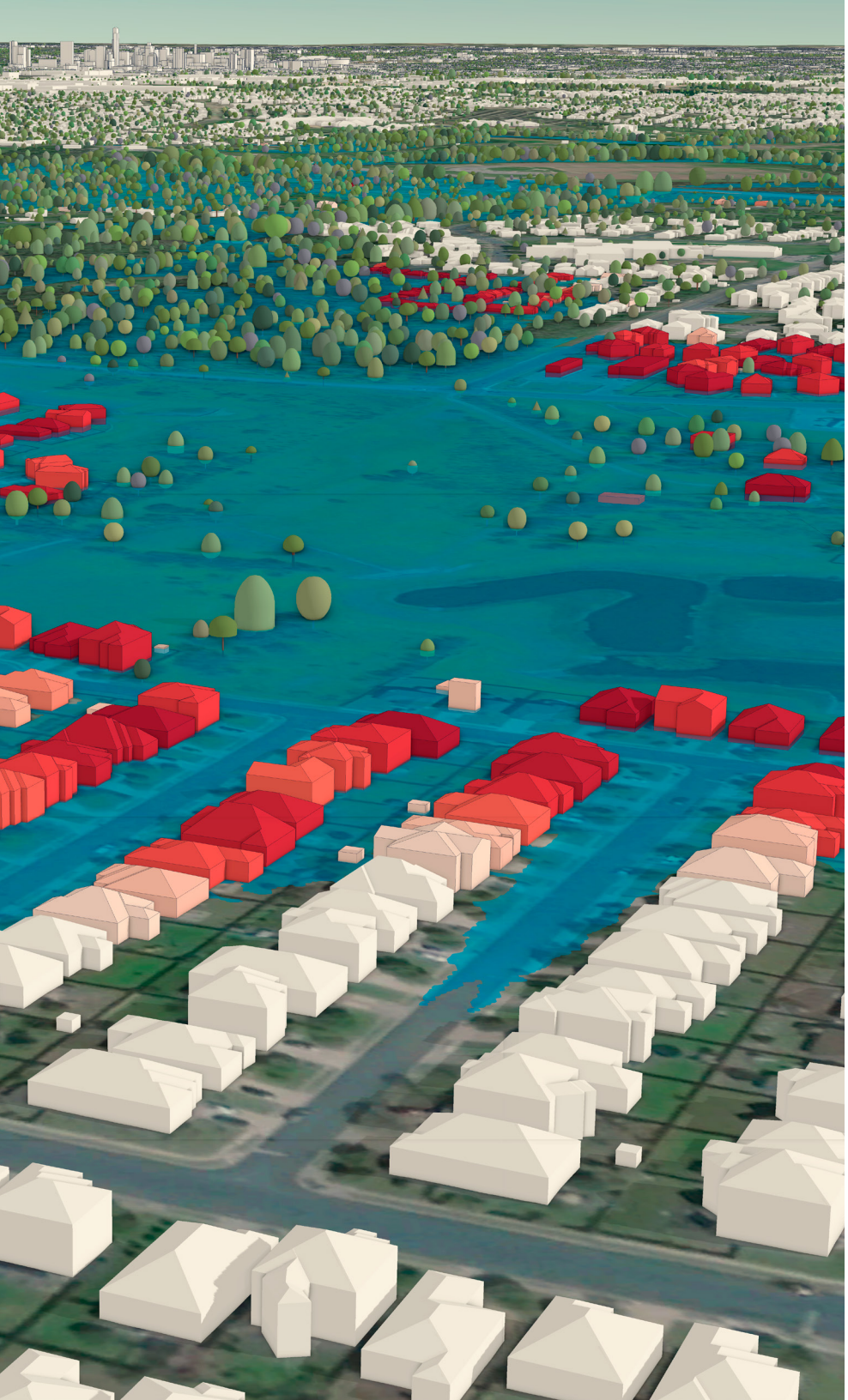
Virtual Builder Supports Construction Site Safety

A construction site simulator is empowering one major construction firm to make timing predictions for project delivery.

EIC Activities—part of the CIMIC Group, Australia's largest construction, mining, and services provider—created a GIS-based construction site simulator known as Virtual Builder. Equipment, materials, and workers are replicated in a virtual, interactive version of a jobsite. The 3D real-world simulation can show current and predicted locations and movements of equipment, materials, or people. → **Watch the video**.

Simulations and modeling with GIS technology can also show potential climate impacts based on historical data and data related to impending weather events. For the CIMIC Group and other leading firms, GIS technology affords clearer visibility into what might happen in the future based on the decisions made today. Business results include smarter solutions and better outcomes such as keeping workers safe and securing the project's future. ▶

As climate-related risks intensify, construction sites become more susceptible to hazards and need a deeper understanding of geographic risks and vulnerabilities.



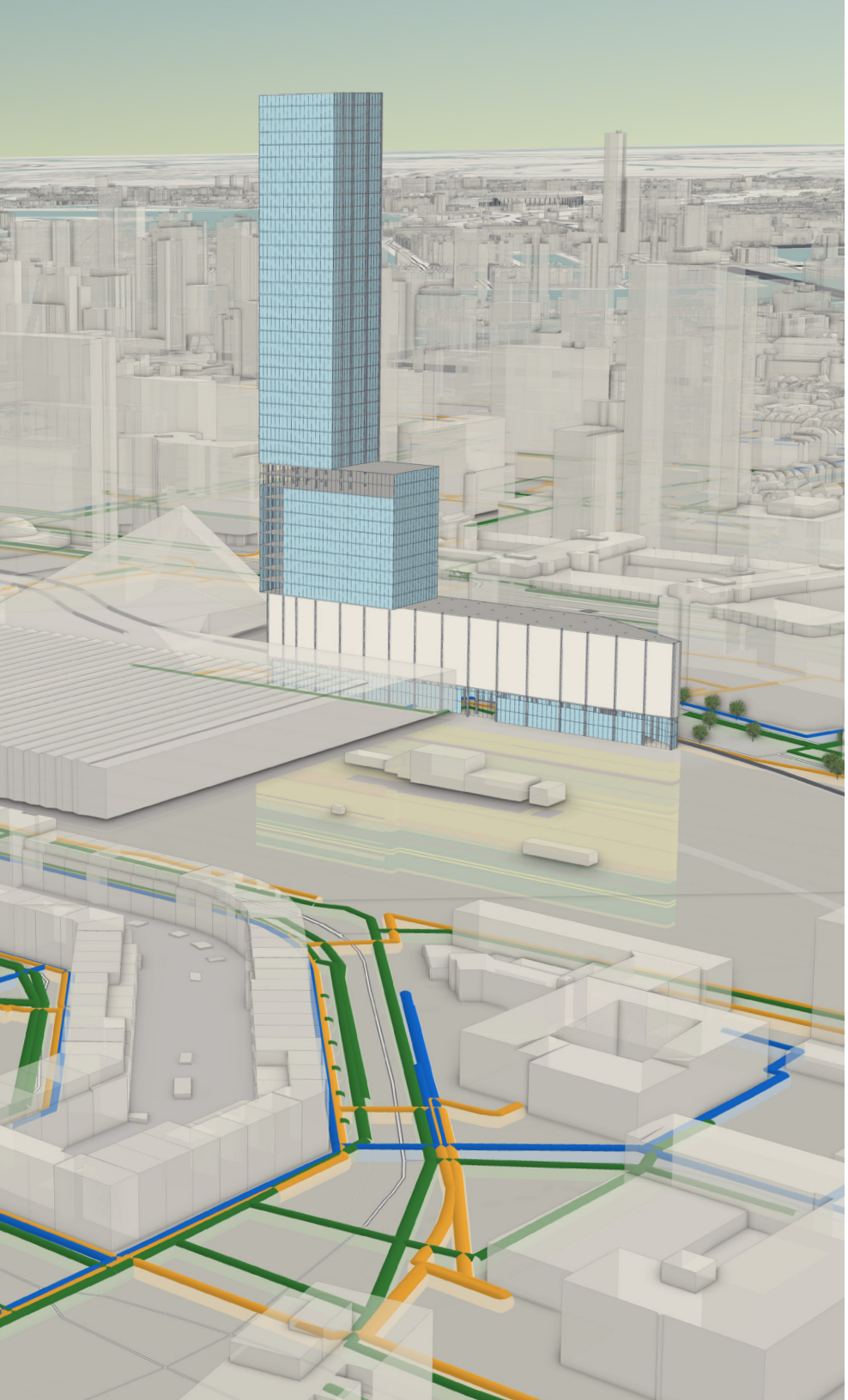
Safety (continued)

Smart Maps Protect Assets and Keep Employees Safe

GIS technology supplies the type of knowledge that's already helping organizations like AT&T not just see its future but change it. The telecom provider worked with climate scientists and engineers at the US Department of Energy's Argonne National Laboratory to map flood and extreme wind risks to its network in the southeastern US up to 30 years in the future.

What would have been some 500 billion pages of data was turned into smart maps instead, showing AT&T's numerous assets layered with potential risks. The utility was able to see where it needed to harden its network to protect critical facilities and how to make smarter decisions about where to build new ones.
→ **Read the story**.

Similar geospatial analysis can help construction leaders position their projects within their environments and fortify them against adverse events. ■



Point Solutions for Competitive Advantage

Countless hours and millions of dollars are lost every year due to delays caused by late design changes, disorganization, and poor communication. The integration of GIS with other high-powered digital tools streamlines project time requirements.

Drones—Provides aerial imagery for monitoring construction, measuring earthwork volumes, and observing hard-to-reach or dangerous areas of a project site

Drones have all but eliminated the cost of a top-down view of construction sites. With ease of capture and speedy processing, a drone can fly over a construction site and provide regular updates on the progress of a project, as well as zoom into potential issues. Within GIS, drone data can be quickly synced, visualized, and analyzed in the context of its precise location.

GIS and BIM Integration—Gives stakeholders a seamless picture of construction and a common platform for collaboration and communication

Any structure can be viewed in a real-world context for deeper analysis throughout the project life cycle. Together, GIS and BIM support scenario planning such as flood analysis for site selection, shadow analysis for solar potential, line-of-sight analysis for urban development, material flow for circular design, and modeling staff requirements for on-site safety.

Digital Twin—Simulates the on-site experience with the ability to rewind and fast-forward progress or observe a project from any angle to see how it functions within the natural world

Virtual 3D models of cities, augmented by local information, provide a means of proposing, understanding, and analyzing development and other changes to the urban landscape. Construction firms can create their own digital twins, tapping into authoritative and proprietary data, to gain an exact replica of a project or asset—which is valuable for design, planning, building, and operations. ■

Efficiency
Saving Time and Cutting Costs

GIS technology simplifies the complexity that comes with large construction projects—helping to track hundreds if not thousands of materials, coordinate with dozens if not hundreds of contractors, and monitor thousands if not tens of thousands of activities. Additionally, GIS makes it easier to manage critical data, standardize it, and make it accessible to all.

As GIS integrates with BIM and other critical systems, it provides an environment of shared awareness. Designers and project managers gain a seamless picture of a construction site, including its surrounding land and features, and a common platform for collaborating with stakeholders.

Project models that can capture work processes and operational sequences provide an even greater site-wide perspective. This includes regular reality capture of the site, the surroundings, and environmental changes. It's made possible by the convergence of BIM and GIS, facilitated by the cloud and mobile apps. ▶

Efficiency (continued)

Technologies Team Up for Efficiency in Airport Project

Approaching an international airport terminal project, infrastructure solutions firm HNTB didn't waste any time translating data. It employed ArcGIS GeoBIM℠, a software as a service solution that integrates project information from Autodesk BIM 360, and other Autodesk Construction Cloud products. → **Read the case study**.

Integrated BIM and GIS workflows also include scheduling. By incorporating location, planners can see conflicts that may otherwise have gone unnoticed, as well as opportunities for streamlining work. Without time-enabled GIS data, a planner would not be able to test for clash detection or easily visualize what is complete or what is behind schedule without making manual updates in the datasets.

By integrating scheduling data with spatial data, cross-discipline teams can better identify and mitigate risks before construction begins, drive operational efficiencies, and improve collaboration during the construction phase.

By adding drone imagery, managers can approximate the experience of being on-site. If questions arise related to a particular section or work completed on a certain day, drone imagery managed within GIS shows any date, location, or angle needed.

With real-time tracking of progress and resources made possible by GIS, construction managers can monitor project status, identify bottlenecks, and ensure efficient use of resources. This allows for quick corrective actions, reducing delays and cost overruns.

GIS technology also helps to optimize resource allocation such as labor, materials, and equipment. Managers can use GIS to analyze data and identify the most cost-effective distribution of resources across the project site.

Construction firms can also map the locations of potential suppliers, material sources, and manufacturing facilities. By visualizing this data on a map, project managers can pinpoint the most strategically located suppliers and optimize transportation routes, reducing costs and delivery times. ▶

Efficiency (continued)

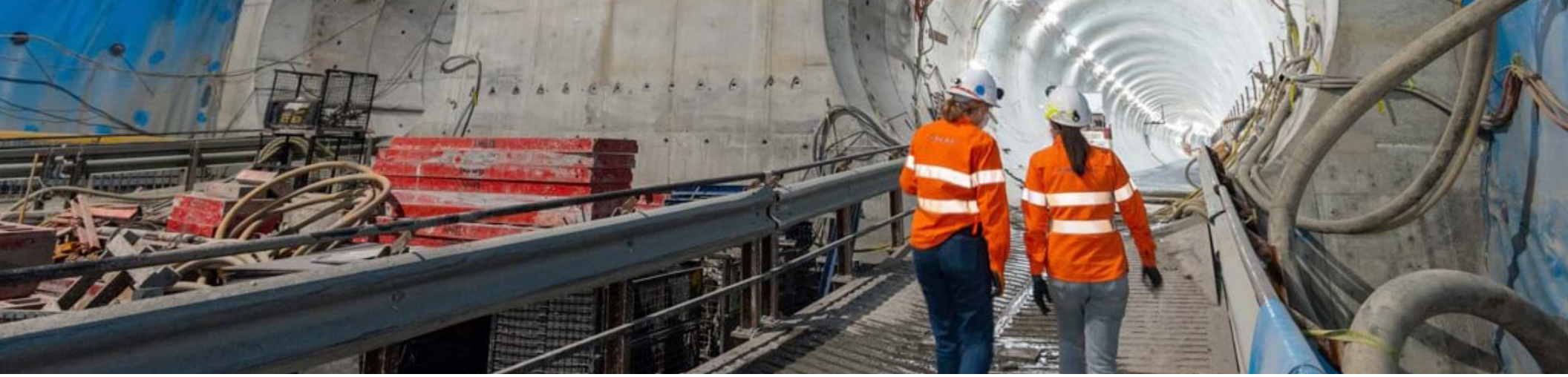
Hassle-Free, Off-Site Coordination to Lay a Hospital Foundation

To pour the foundation of the two-million-square-foot St. Paul's Hospital in Vancouver, British Columbia, Canada, PCL Construction would need to move more than 500 cement trucks into and out of the construction site for 12 hours.

This required careful coordination of equipment, people, and tasks from varying contractors and vendors. PCL, committed to providing solutions and delivering excellence for its clients, would leave nothing to chance. Using drone imagery of the site paired with 3D modeling, the company virtually tested the ideal positions of trucks and pumps throughout the day. With a perfect plan in hand, PCL gave exact coordinates to an on-site surveying crew, enabling the crew to label the physical locations for equipment placement.

When the day arrived to pour the cement, "everything fit like a jigsaw puzzle with precision and accuracy. There was no hassle, no frustration, and no on-site coordination," said Bilal Yasir, PCL's integrated construction technology specialist.

→ Watch the video. ▶



Efficiency (continued)

Digital Twin Guides Australian Railway Project

Before a team in Australia began tunneling several stories under a teeming metropolis to construct the continent's first subterranean railway, it sought advice from colleagues on the other side of the world who had already spent several years building new tunnels and stations under Central London.

The Australian team, the Cross River Rail Delivery Authority, knew it would be a delicate task, fraught with infrastructural peril. What the team wanted to know was what, if anything, its British counterparts would have done differently if they could start over.

"They basically said, 'We would have built a bigger, better 3D digital model sooner,'" said Russell Vine, Cross River's chief innovation officer.

The group's eventual detailed and up-to-date 3D model, a project-wide digital twin, would turn out to be an ingenious application of GIS technology.

Unlike inert BIM models that are visualized as if floating in space with little environmental context, the GIS model gave a comprehensive view. The digital twin showed how each structure fit into the infrastructure above ground such as paths, roads, and light poles. It also showed what's underground—the pipes and lines that connect utility services. And it displayed the natural world—the landscaping, groundwater, and even wildlife and biodiversity considerations.

Before setting out to build the perfect GIS-driven digital twin, though, the Australian team created a common data environment with set standards for all 3D architectural models. By combining all data inputs into a single project model, the team could take the exciting step of making the model immersive.

Now, all 17 kilometers of railway infrastructure can be explored, like a first-person video game, on a screen or with a virtual reality headset. Far from a gimmick, it has become an integral way for nontechnical stakeholders to view the project as it proceeds. → **Read the story**.

Firms seeking an edge are taking this model-first approach with their complex projects, designing digital twins to visualize real-world outcomes and ease collaboration. As the use of digital twins becomes more commonplace and the amount of data collected from sensors and mobile devices continues to grow, GIS technology plays a vital role. It's the glue for connecting and integrating the datasets. ■

Sustainability
Adopting Greener Practices

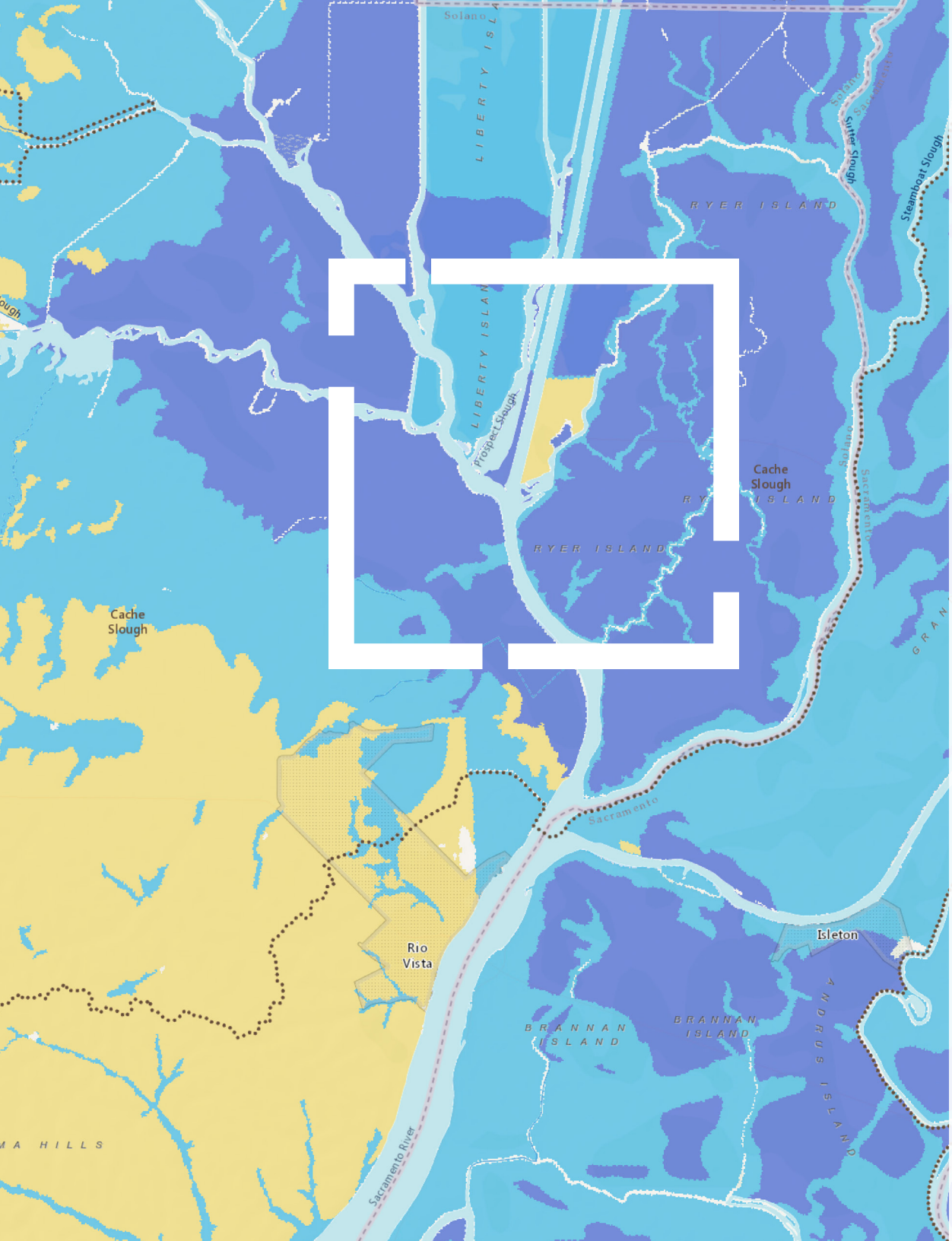
Conversations about sustainable construction often focus on completed projects—like energy-efficient high-rises, transit-accessible residential spaces, and retail centers that complement the natural landscape. But for the companies bringing these structures to life, sustainability is a process as much as it is an outcome.

GIS and companion technologies provide a system for ensuring sustainable practices at every step of the project life cycle. Armed with location-centered operational intelligence, companies can

- **Identify opportunities to use greener materials.**
- **Find new ways to reuse and recycle waste.**
- **Iterate for designs in harmony with nature.**

Many construction firms are already wisely recovering, reusing, and recycling materials from demolition as they build anew. By using location intelligence to make these operations more precise, they are saving time, cutting costs, and wasting less.

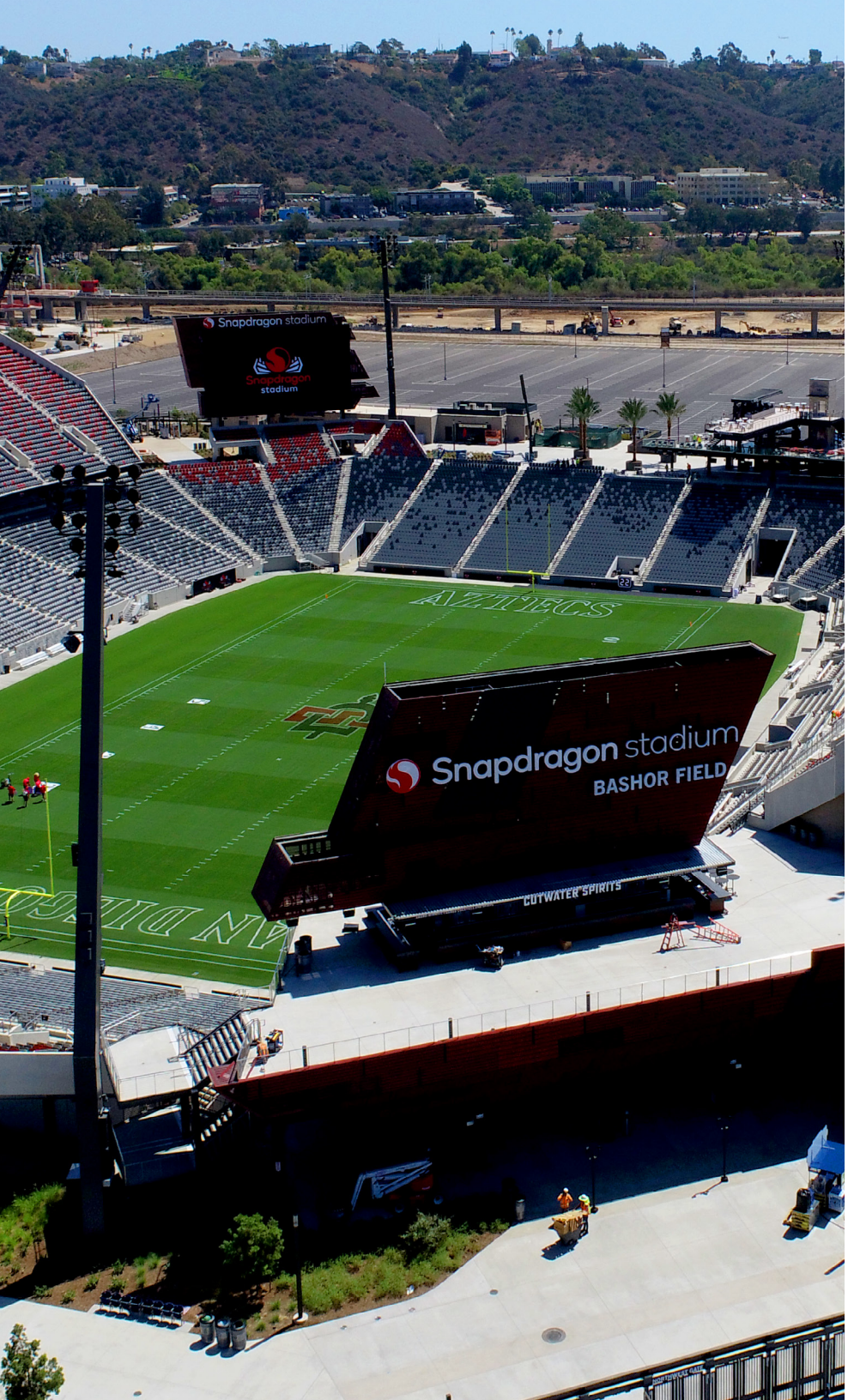
From a smartphone or tablet, an on-site worker can record details, like debris type and volume, and add photographs to determine whether the waste is in reusable or recyclable condition. Data-driven maps also help those who must move and sort the debris identify where the waste is located and where specific materials should be stored on-site. ▶



Sustainability (continued)

GIS maps and analysis can also pinpoint where the waste should go next for minimal environmental impact—like the closest processing facilities or nearby jobsites that could repurpose excess materials. Across a project life cycle, the practice of tracking and sorting waste empowers managers to spot supplies that were overpurchased—important for both reusing leftover materials and reducing future order sizes.

By including all relevant information on a GIS dashboard, decision-makers can see up-to-date sustainability metrics on a jobsite, find patterns in how waste is generated and disposed of across the company, and create reports. ▶



Sustainability (continued)

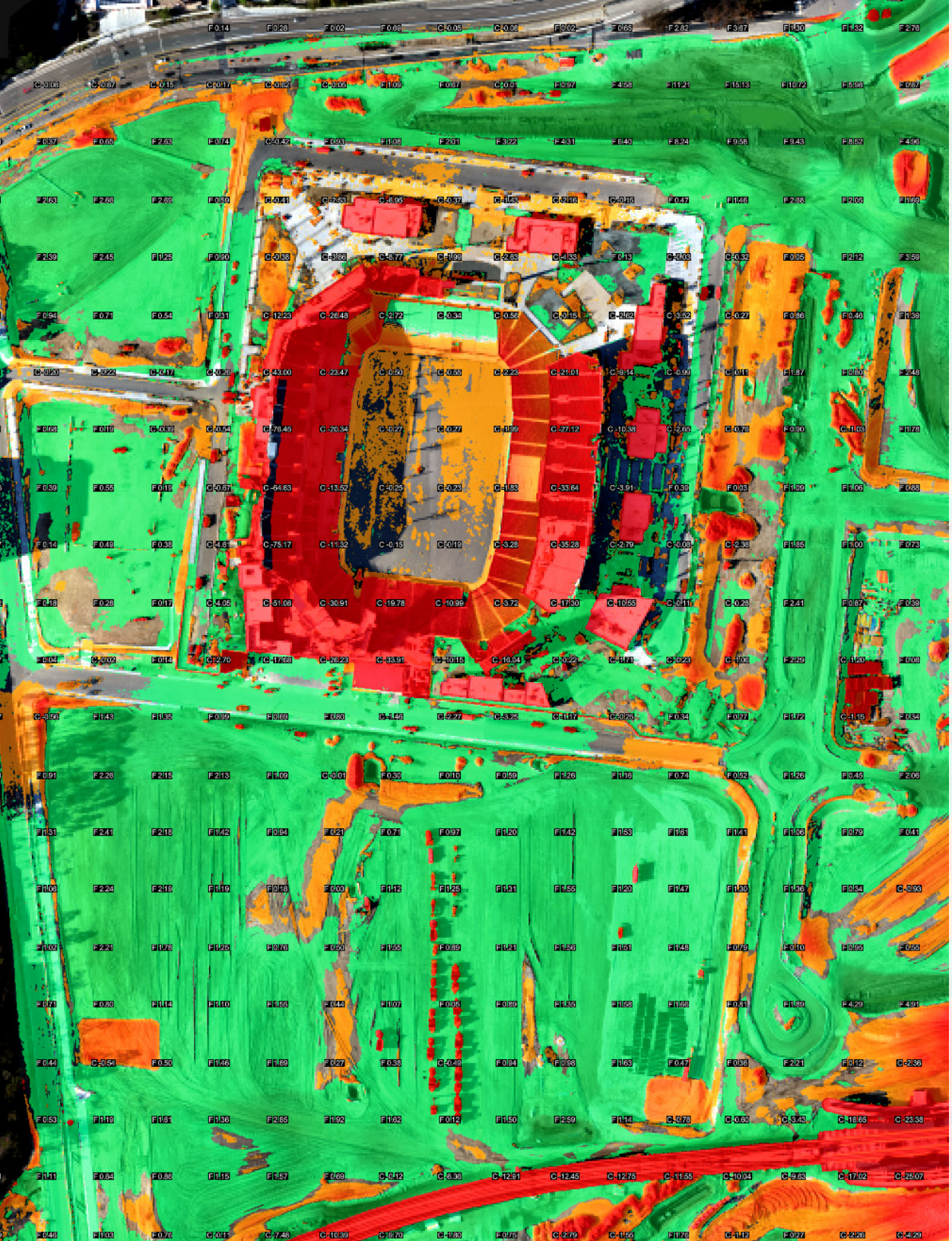
San Diego Stadium Achieves Circular Construction

For decades, San Diego's pro sports teams played inside a brutalist bowl of concrete sitting in a sea of 18,870 paved parking spaces in Southern California. When it came time to demolish the stadium and build a new one on the 166-acre site, that same concrete became the foundation for a new home for San Diego State University's football team.

As the professional football stadium was being demolished, large stockpiles of concrete were processed at an on-site batching plant for use in the construction of the new stadium, including access roads. To estimate the material size on-site at a given time, construction manager OCMI, Inc., used Site Scan for ArcGIS, cloud-based drone mapping software designed for imagery data collection, processing, and analysis.

The GIS solution allowed construction teams to run volume calculations with drone-captured imagery. When a grading subcontractor requested a change order, claiming there wasn't enough material to build the base of the stadium, the information from Site Scan proved otherwise. → **Read the story**.

It's the kind of novel reuse—part of a circular construction economy—that will become less an exception and more the rule as a greater number of global lawmakers and regulators establish best practices for the industry. ▶

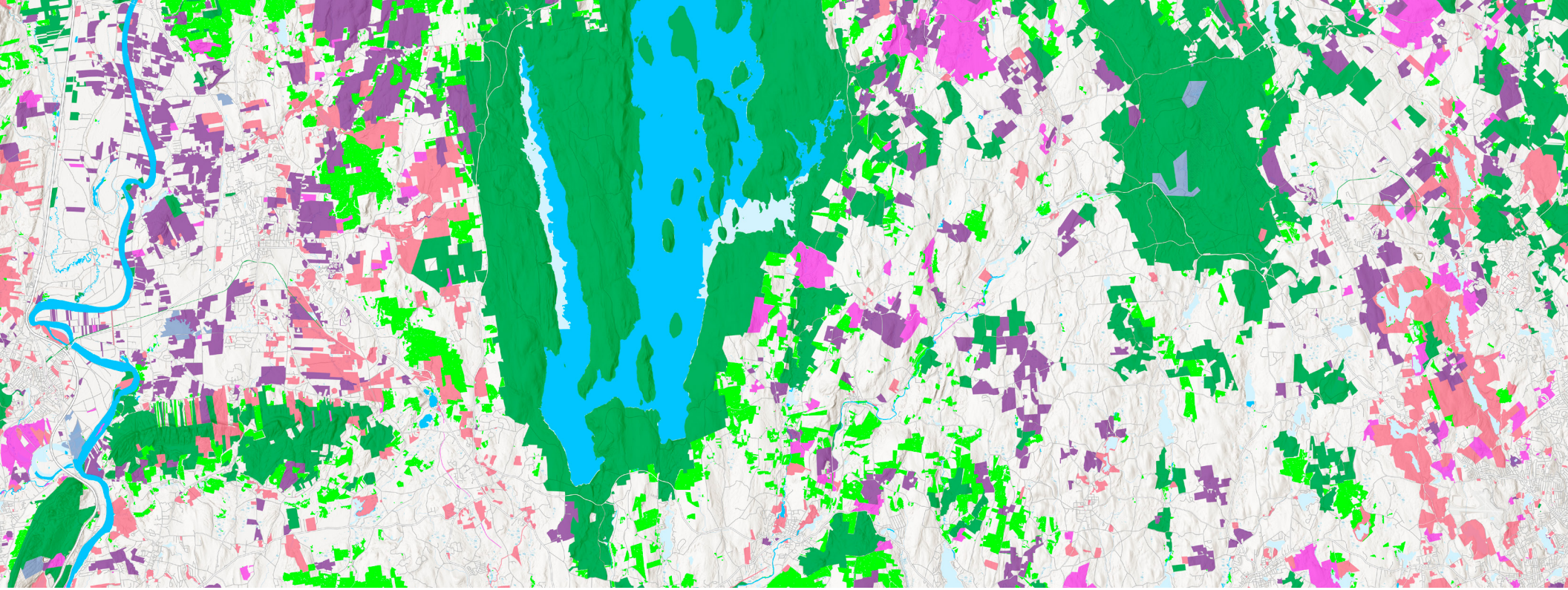


Sustainability (continued)

Sustainability in construction also involves siting projects from the start and being strategic about where features are located relative to environmental concerns. An ever-changing climate is causing firms to reconsider design choices and layouts to adapt to heat, rising sea levels, wildfires, and winds.

Using GIS technology, construction companies can evaluate multiple sites and assess suitability based on various factors, including accessibility, proximity to resources, environmental impacts, and regulatory constraints. Analyzing energy use and weather impacts can optimize building performance with net-zero outcomes in mind. GIS can also inform nature-based solutions for ecological landscape design and construction.

Together, these comprehensive insights help firms select the most suitable sites, reducing the chances of costly mistakes and improving project outcomes. ▶



Sustainability (continued)

Designing a Sustainable Global City by Studying Others at Scale

Urban design firm Foster + Partners is starting from the beginning as it designs a master plan for a new sustainable city in Kuwait. The goal is that every resident will live within 400 meters of green space and have ample shade via trees and surrounding structures.

Foster + Partners has been using GIS technology, including developing immersive virtual scenes in ArcGIS CityEngine®, to better design and visualize its plan. The proposed city of short distances will eventually house 280,000 people, feature open spaces, and include a multilayered public transit system.

One important step has been studying the geography of other major global cities and understanding how built places are shaped by their natural environment. Or as Bruno Moser, head of urban design for Foster + Partners said, "In order to design the world we want to see, we need to understand the world that is today."

Foster + Partners created a library of city maps to compare them at the same scale. The firm has run algorithms on street networks to see the locations of businesses and how they cluster around transportation arteries.

"We need to understand the patterns and relationships, the forces that shape our cities, so that we can make informed decisions when we design new projects," Moser said. → **Watch the video**

Exposed to a continually changing climate, the need for more sustainable and resilient structures grows more urgent. Location intelligence from GIS delivers the reliable data, streamlined workflows, enhanced safety, and collaboration that construction firms need to meet that demand. ■

Conclusion

Modern GIS Technology Meets the Needs of Modern Construction

GIS technology brings together the science of geography with the modern capabilities of data management, analysis, visualization, integration, and collaboration.

It shows the location, certainly, but also the terrain, the traffic, the weather, the natural features, and the built environment. It shows the interconnections among them all—on a map or a screen—including relationships, patterns, and risks.

For the construction industry, this translates to increased situational awareness, improved site selection, and enhanced communication and coordination, as well as easier adaptation to environmental regulations and optimization of resources.

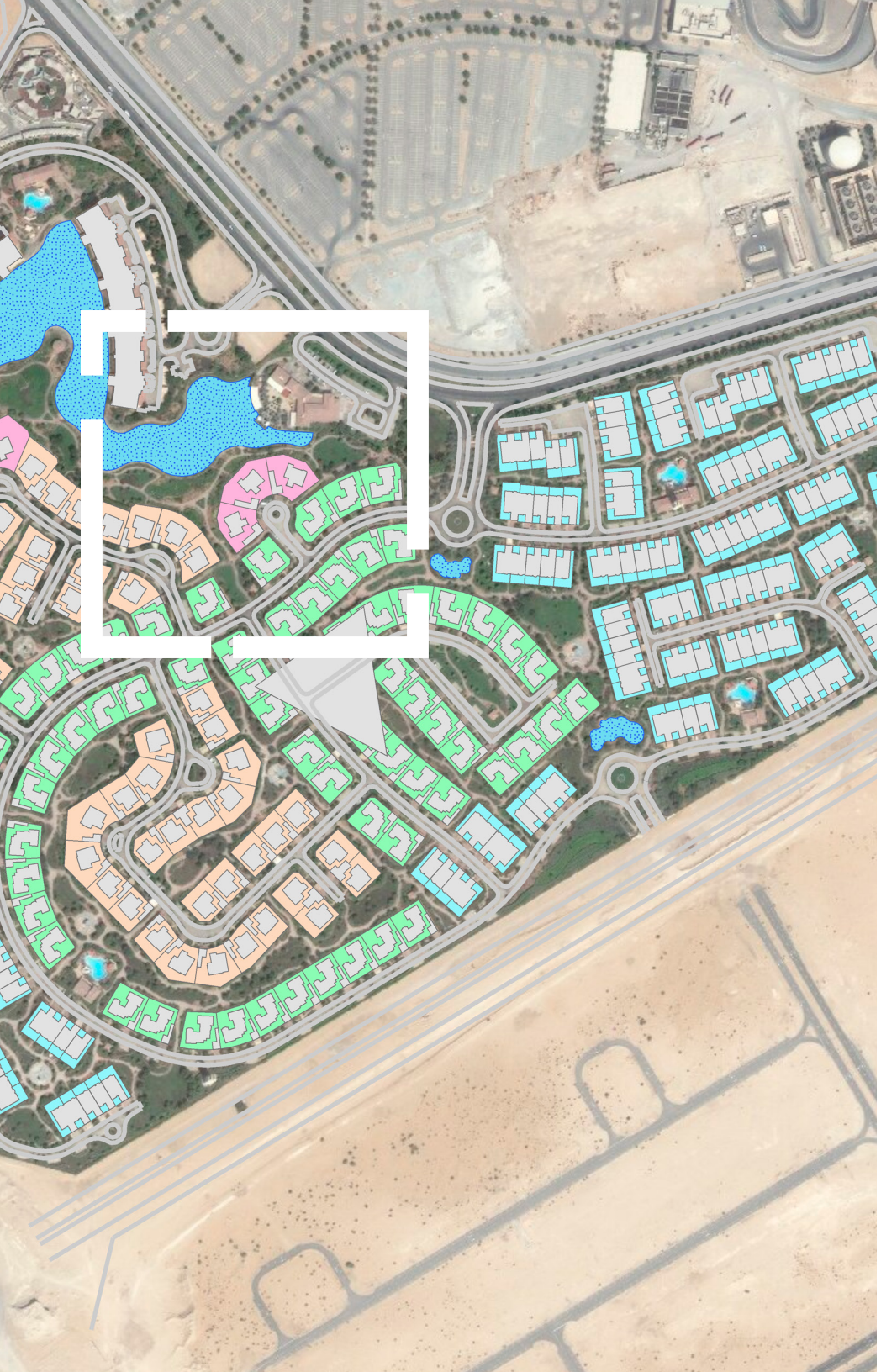
Through digital twins, dashboards, and smart maps, GIS technology provides a way to organize and understand a problem so decision-makers can see solutions and decide where and how to act. It shows what happened before, what's happening now, and what's likely to happen in the future.

With location intelligence from GIS, construction leaders can see where and when they should make interventions to ensure a project's safety, efficiency, and long-term sustainability. They can see beyond what is to what can be.

That dynamic is made possible by the enterprise technology—modern GIS—that can answer critical questions about a place or a problem, discover insights, and reveal creative solutions.

For the Cross River Rail Delivery Authority, the solution was an elaborate 3D digital twin to build Australia's first underground train system. For PCL Construction, it was planning the complicated choreography involved in pouring a foundation for a new hospital. For OCMI, it was finding a more sustainable way of using a stadium's worth of demolished concrete to build a new one.

Despite the projects being vastly different, GIS technology was the key to each creative solution and to delivering safety, efficiency, and sustainability. ■



Learn More

Esri, the global market leader in geographic information system (GIS) software, location intelligence, and mapping, helps customers unlock the full potential of data to improve operational and business results. Founded in 1969 in Redlands, California, USA, Esri software is deployed in hundreds of thousands of organizations globally, including Fortune 500 companies, government agencies, nonprofit institutions, and universities. Esri has regional offices, international distributors, and partners providing local support in over 100 countries on six continents. With its pioneering commitment to geospatial technology and analytics, Esri engineers the most innovative solutions that leverage a geographic approach to solving some of the world's most complex problems by placing them in the crucial context of location. **Visit us at esri.com**.

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