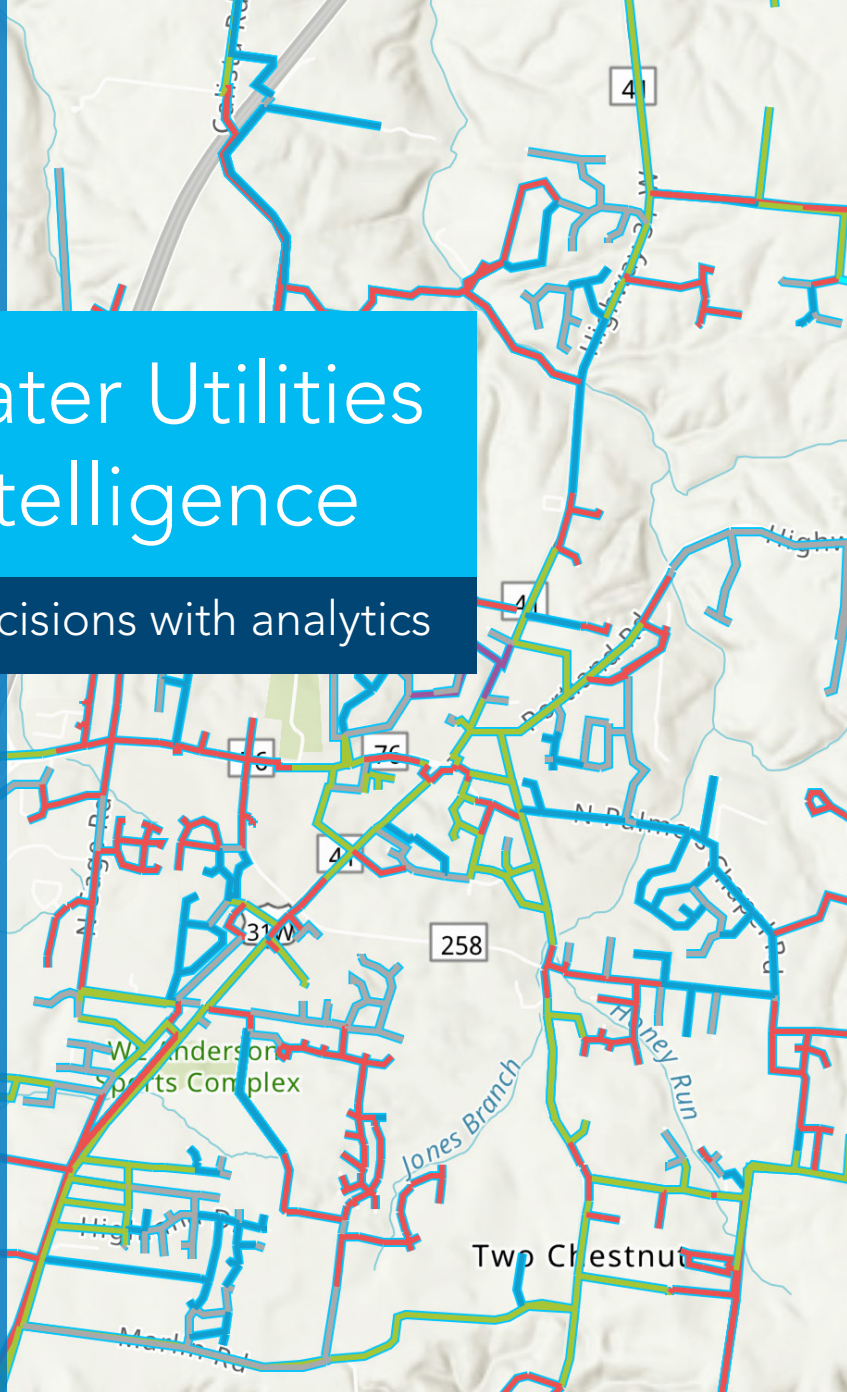
Empowering Water Utilities with Business Intelligence

How to make data-driven decisions with analytics



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GIS Analytics for Water Utilities

Digital transformation is making water utilities leaner and smarter. Sensor networks and the Internet of Things provide real-time information that helps utilities manage water loss, identify water quality issues, and more. Intelligent analytics uses data to predict water supply and consumer demand so that water managers can scientifically plan sustainable communities.

Because water data is tied to location, many utilities already use ArcGIS® to map the location of pipes, valves, pumps, meters, and other assets. Unfortunately, these agencies often don't take advantage of ArcGIS analytic capabilities.

ArcGIS® drives water service analysis.

You need to understand problems before attempting to solve them. Water engineers, treatment plant and system operators, and water authority administrators can easily use ArcGIS spatial analysis tools.

ArcGIS not only maps assets, but it also broadens operational awareness by integrating customer, climate, and other datasets with your agency's own data. Explore a variety of geospatial data and transform it into actionable intelligence. Use maps, charts, and tables that characterize your infrastructure, measure asset performance, depict maintenance activities, and visualize the risk of asset failure.

Lehigh County Authority uses Insights for ArcGIS to identify patterns and trends by looking deeper into data collected during fire hydrant flushing. Staff reviewed flow data from hydrants to identify areas where recorded flows were below the desirable PSI. Low-flow areas were then evaluated in conjunction with water mains, revealing that some low flows were within new construction areas. By performing this comparison, staff were able to identify areas that should be prioritized for leak investigation. This resulted in saved labor by mobilizing teams and equipment in focused areas of concern.

ArcGIS also helps water utilities better understand their clients.

Because most utilities make customer service their top priority, they need to know who their customers are. Understand your customers better by enriching customer data. Explore data you already have to learn how customers use water, pay their bills, or participate in rebate programs. Study data over time to understand customer behavior patterns such as water consumption trends.

East Valley Water District uses Insights for ArcGIS to analyze consumption data to more efficiently target and educate customers about water conservation. By bringing together meter location and consumption data, East Valley compared the ratio of actual water consumption to allocated consumption for each customer. Looking at outdoor versus indoor use, it identified customers that were using 50 times more water outdoors than expected. The utility then targeted these excessive users in its water conservation education efforts.

Analyze usage patterns for a customer or a neighborhood over time. Maps and charts that compare an individual household's consumption with that of the neighborhood's have proved to be effective in changing water use behavior. During droughts, cities use water availability maps to justify water restrictions and persuade the public to practice water conservation.

Ask the right question.

Using a geographic approach to problem solving involves framing the question from a location-based perspective. What is the problem you are trying to analyze or solve, and where is it located? This begins the query process that leads to spatial analysis.

Consider a problem common to all water managers: infrastructure failure. By using spatial analytics instead of guesswork, you can understand the cause. This leads you to make decisions based on real data.

Water main breaks are a classic indication of distress. Of course, you know that after decades of service, water infrastructure deteriorates. ArcGIS uses indicators to show you which mains are most at risk and predict where and when they will most likely break. To understand the durability of the pipe network, you can find correlations between the frequency of water main breaks and variables such as age, environmental conditions, faulty materials, and poor construction.

Knowing what pipe materials are best suited to certain environmental conditions or knowing how to mitigate potential issues helps you create an efficient pipe replacement strategy. What's more, you can use geographic information system (GIS) measurement and design tools to determine how much pipe is needed by type and its associated cost. Include these scientifically calculated estimates in your funding proposal.

Understand *where*.

Question: Where are my main breaks located?

Problem solving begins with data and maps. ArcGIS helps you easily visualize data as a map to recognize data patterns, groupings, and anomalies that lead to deeper questions about what is happening. Spatial analysis tools allow you to dive deeper into your data to answer these questions. Esri's Insights for ArcGIS is an analytics workbench that uses the power of geography to explore and analyze your data. For instance, it allows you to cluster incident data and calculate frequency density to reveal patterns. Figure 1 is a simple heat map that identifies areas where breaks are most frequent. This map may lead you to ask, What is it about these hot spot areas that causes more main breaks?

Use data analytics tools to filter data by a feature so that you can hone in on the specific aspects of your questions. Filter utility data to show water pressure, or PSI, levels by neighborhoods, service areas, or district metering areas. Add the main break data layer to the map to show the distribution of main breaks by water pressure zones. The outcome reveals that more breaks are occurring in zones with higher pressure levels (figure 2).

These charts and maps are connected. If you change a range in one type of chart, you instantly see that change reflected in the other charts and the data displayed in the map.

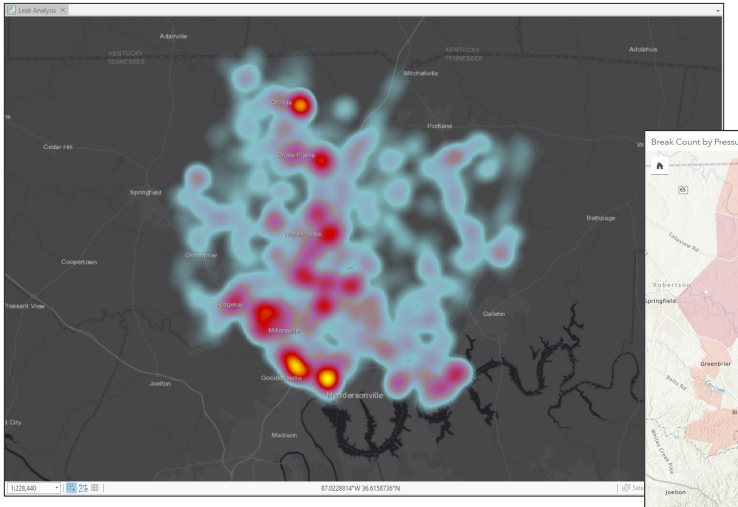


Figure 1. This heat map in ArcGIS Pro shows the frequency of work orders by area.

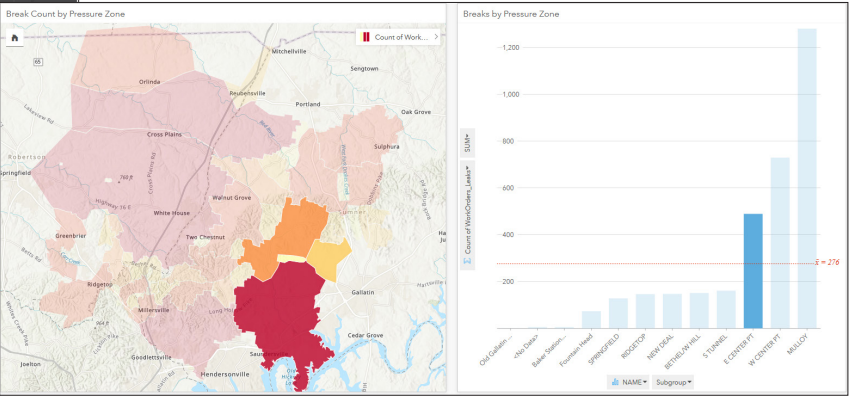


Figure 2. Breaks by pressure zone are shown in Insights for ArcGIS.

Measure size, shape, and distribution.

Question: How many breaks do I have on each water main segment?

Connect to either spatial or nonspatial datasets and use them to perform a simple distribution analysis. Using just the water main break locations, create a list of the water mains with the highest frequency of breaks. Insights for ArcGIS shows nonspatial information in various ways. The charts in figure 3 show which water mains are in the worst condition and how they compare to other water mains in the system.

What type of pipe is susceptible to breaks in this area? With ArcGIS, you can quickly normalize your pipe data and then determine which pipe materials and pipe sizes have been most susceptible to breaks (figure 4).

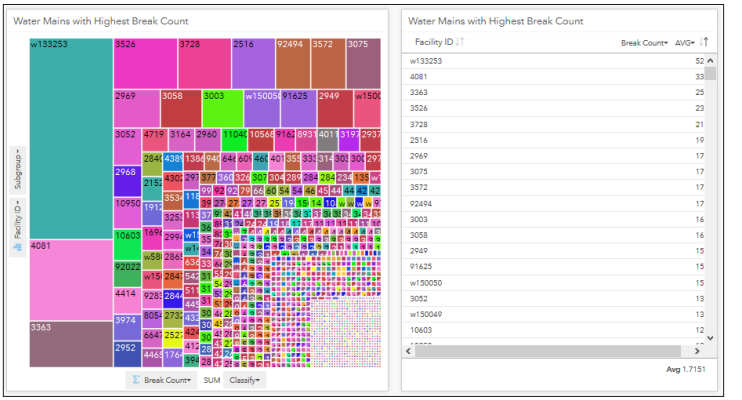


Figure 3. These graphs in Insights for ArcGIS list the pipes with the highest number of breaks.

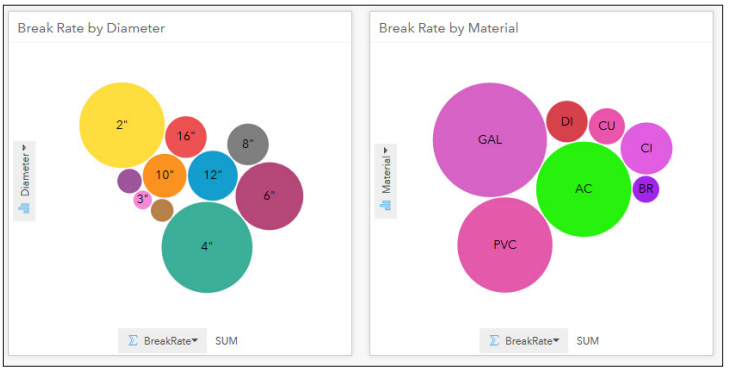
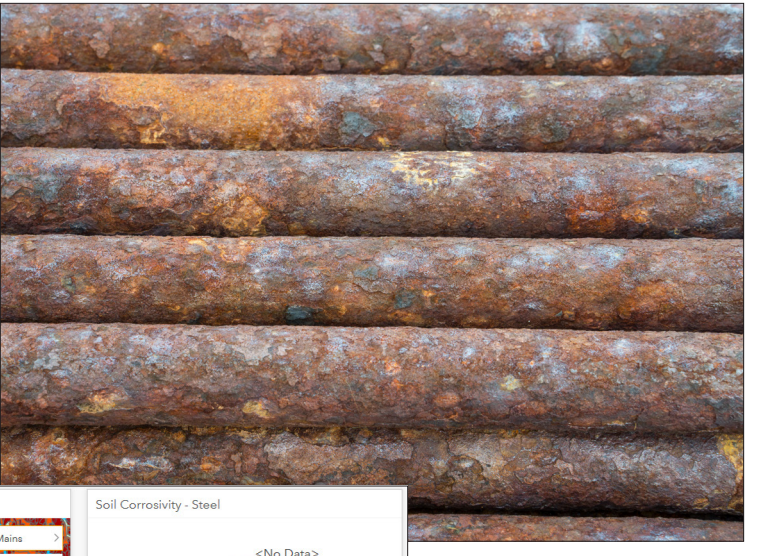


Figure 4. Normalized data is modeled in Insights for ArcGIS to show the break rate by diameter and material.

Determine how places are related.

Question: What are the environmental conditions surrounding my water main break?

To answer this question, combine multiple layers of information in the same map so that you can visualize and analyze their relationships. For example, highly corrosive soils can damage different types of pipe. A map shows the distribution of concrete and steel pipe across different soil types (figure 5).



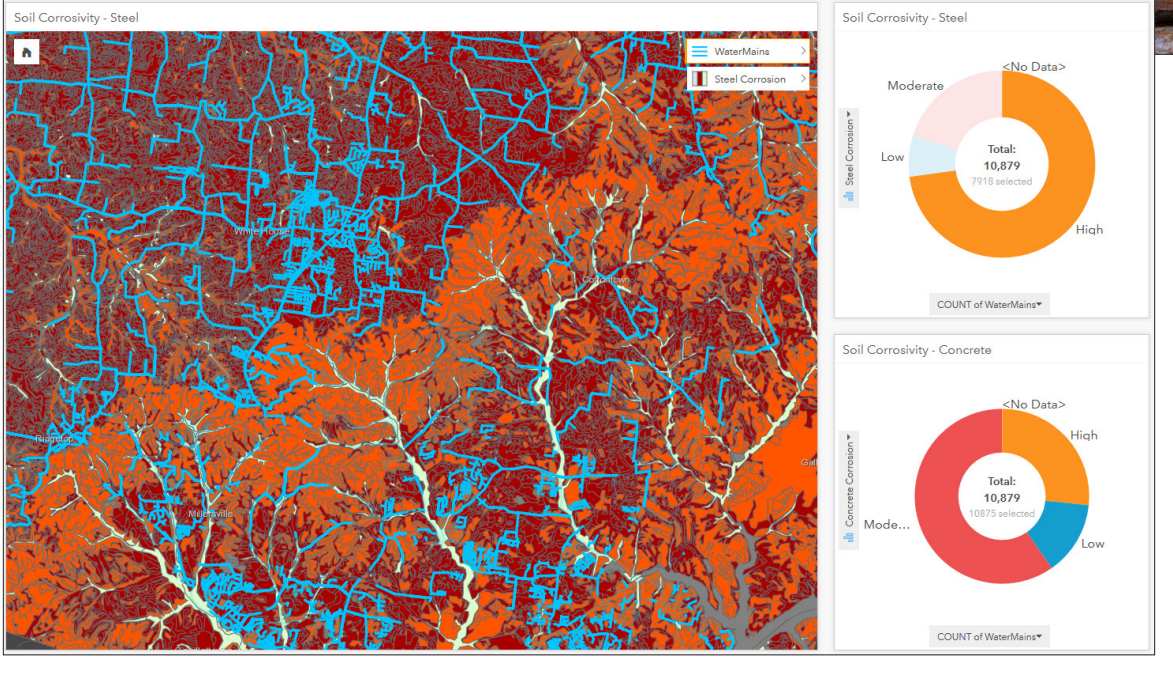


Figure 5. This image shows a steel corrosivity overlay in Insights for ArcGIS.

Find the best locations and paths.

Question: How do I locate and isolate the main break and determine its impact?

You need to know which valves will isolate a problem? The Network Analysis tool finds changes to the network isolation trace. This trace capability also identifies which customers and hydrants will be out of service (figure 6). The analysis allows you to quickly respond to breaks, dispatch crews, and notify customers.

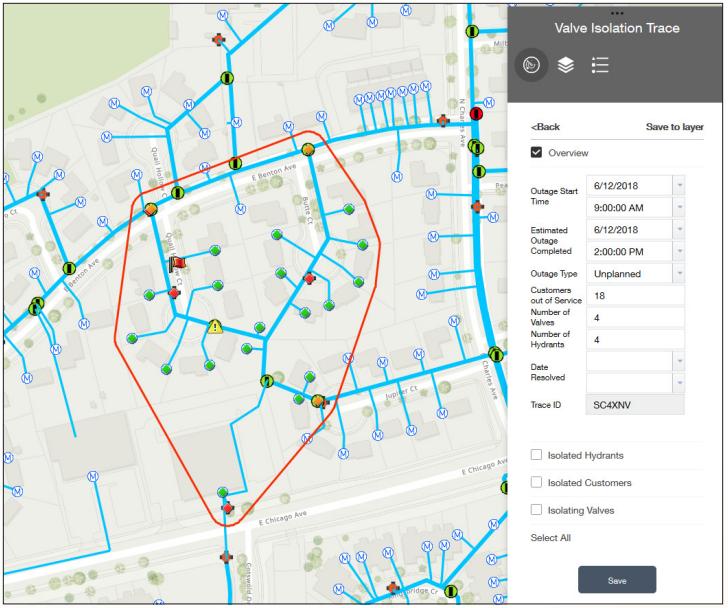


Figure 6. Network tracing, shown above, was done using ArcGIS for Water Utilities—Valve Isolation Trace.

Detect and quantify patterns.

Question: How have main breaks in my system changed over time?

Enhance the main break analysis by including temporal data to see how spatial patterns have changed in time and space. One way to do this is to aggregate temporal data into space time cubes to map frequency hot spots, show density clusters, and flag anomalies and outliers. These statistical cubes allow you to use spatiotemporal data for time series analysis, integrated spatial and temporal pattern analysis, and powerful 3D visualizations (figure 7).

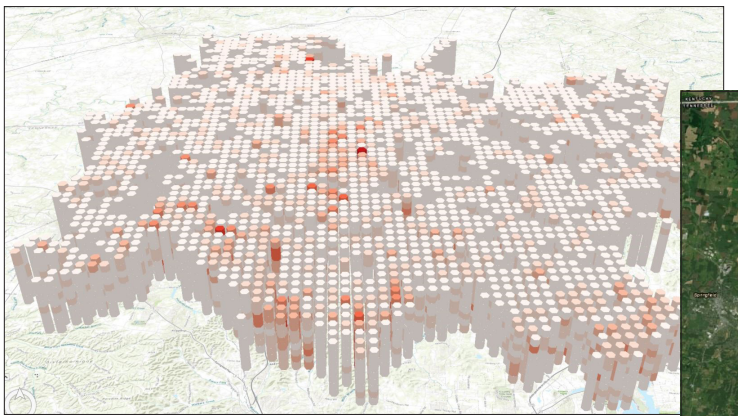


Figure 7. ArcGIS GeoAnalytics tools allow you to map space time cubes to reveal the frequency, time, and location of main break incidents.

Figure 8 shows main break information in a frequency analysis.

A hot spot map is created using statistical analysis to define areas of high occurrence versus areas of low occurrence. Since hot spot areas are statistically significant, the end visualization is less subjective than a heat map. The designation of an area as a hot spot is therefore expressed in terms of statistical confidence. The Emerging Hot Spot Analysis tool identifies trends in your data. It finds new, intensifying, diminishing, and sporadic hot and cold spots.

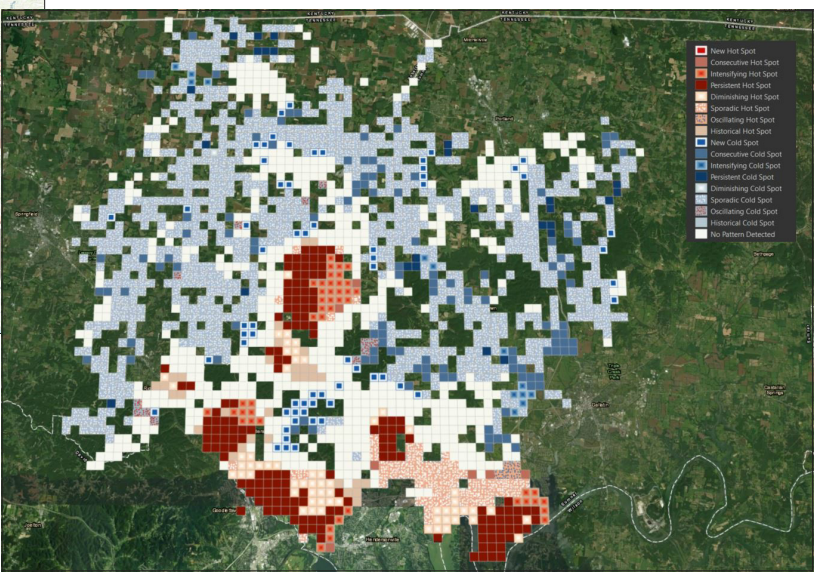


Figure 8. The above image shows the results of hot and cold spot analysis.

Make predictions.

Question: Which water mains are most likely to break next, and when?

Knowing the conditions (variables) that have led to breaks in the past helps water managers better predict where breaks are likely to occur in the future. Insights for ArcGIS creates regression models that show the relationship between explanatory variables and a response variable. For example, the regression analysis model generates a scatterplot matrix of variables to predict the likelihood (correlation) of a cast iron pipeline breaking based on its age (figure 9).

Understanding operational relationships allows your utility to be proactive. Insights for ArcGIS locates areas with similar conditions, such as aging cast iron pipes, so that you can mitigate problems.

Correlation analysis is a quick way to assess potential cause and effect relationships; however, predicting main breaks often requires a deeper level of analysis. Today, leading utilities use machine learning to better assess the probability of failure. Connect your historical data machine learning libraries to identify pipes for which there is a high probability of failure. Visualize those predictions with maps to optimize your asset management plans (figure 10).

Pipeline deterioration is but one of many challenges water agencies face. Because GIS is agile, you can use spatial analysis to rate the threat level of storms, drought, pollution, and population growth. Understand the water infrastructure life cycle or predict water demand over time and by location. Insert your own criteria into ArcGIS to prioritize construction projects. The opportunities for water utilities to analyze spatial problems are endless. Just ask the questions—ArcGIS provides the answers.

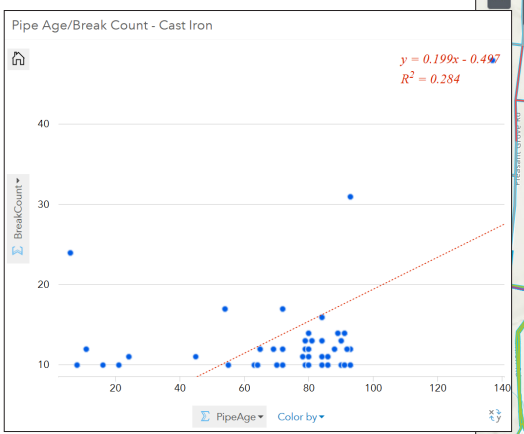


Figure 9. Correlation analysis in Insights for ArcGIS shows how likely a cast iron pipeline's age will affect its integrity.

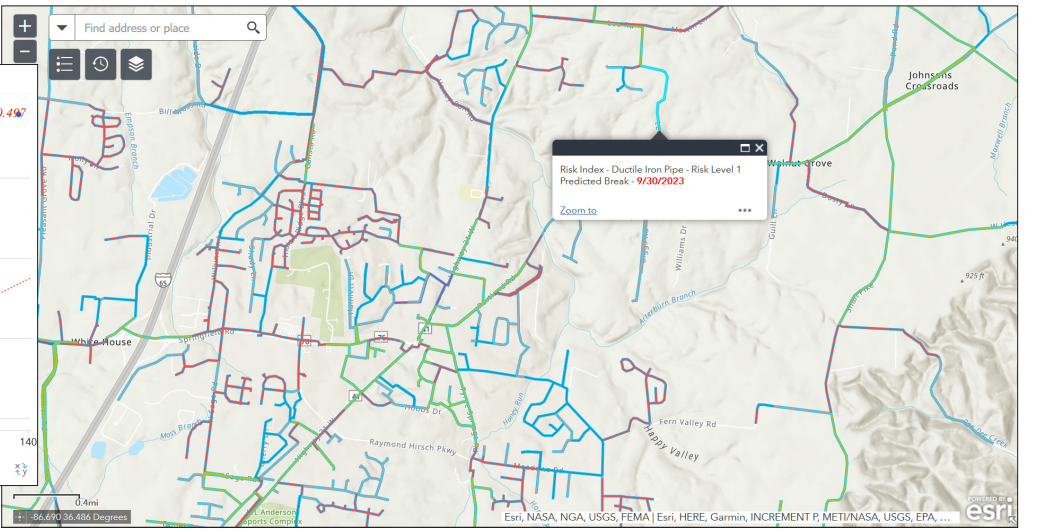
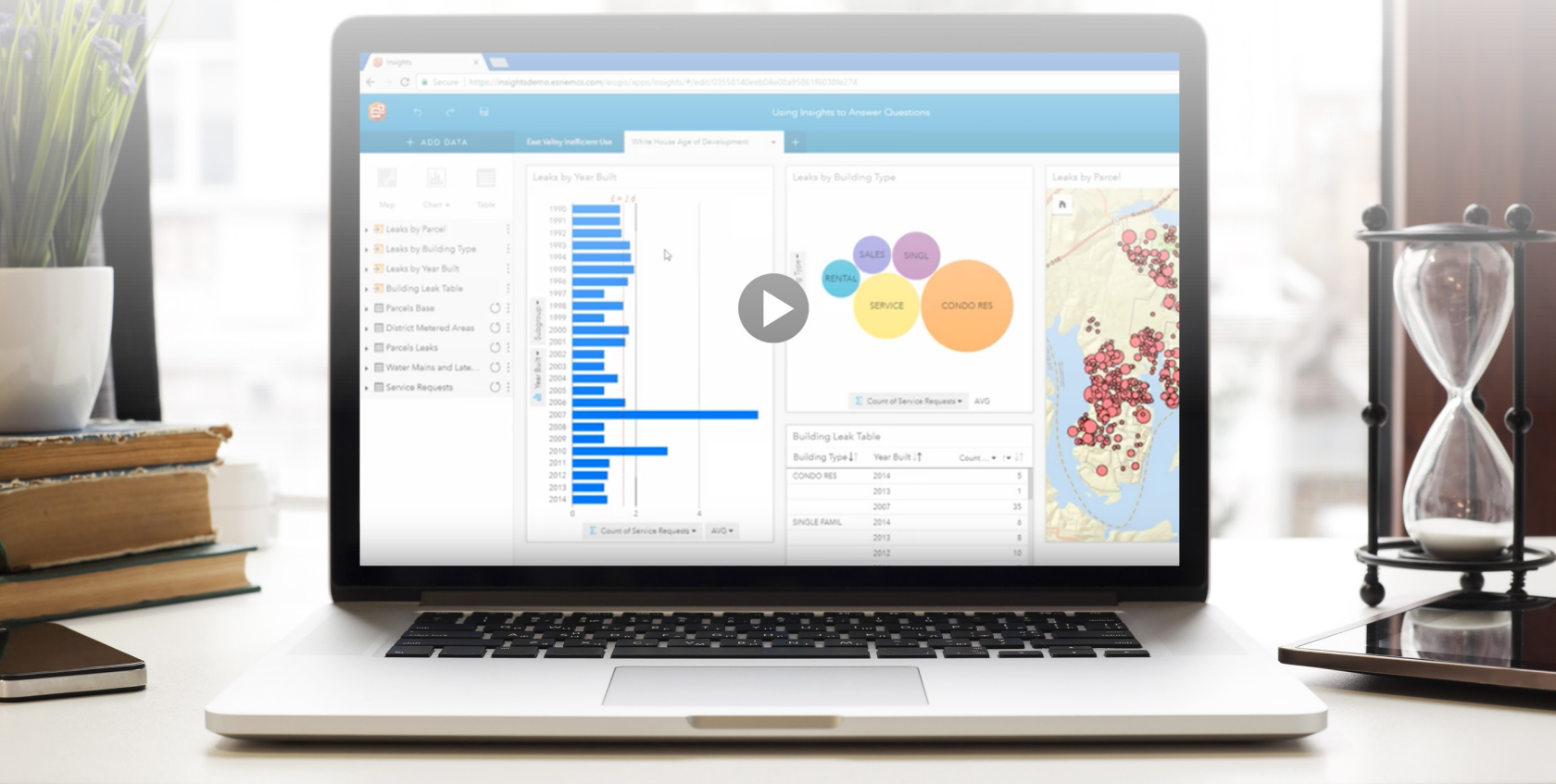


Figure 10. Machine learning tools produced this main break risk analysis map.

See what others are doing with Insights for ArcGIS.

White House Utility District (WHUD) is a water and sewer provider in Tennessee that uses ArcGIS throughout the organization. The utility was experiencing significant water loss throughout the district. Using Insights for ArcGIS to perform leak analysis, the district's analysts joined meter data and meter location and created a leak information map that showed leak types and located high occurrences of continuous leaks. Watch the Video

Furthermore, the analysts noticed a high level of leaks in the district's southeast service area. An Insights histogram charted leak information over the past 15 years to reveal a spike in leaks in 2007. Insights also mapped leak data and location for just 2007 to reveal that new condos had reported a high level of leaks. The analysts looked at the type of pipe that was used in these developments and saw that it was copper. Upon investigation, crews found these pipes to be defective and changed them.

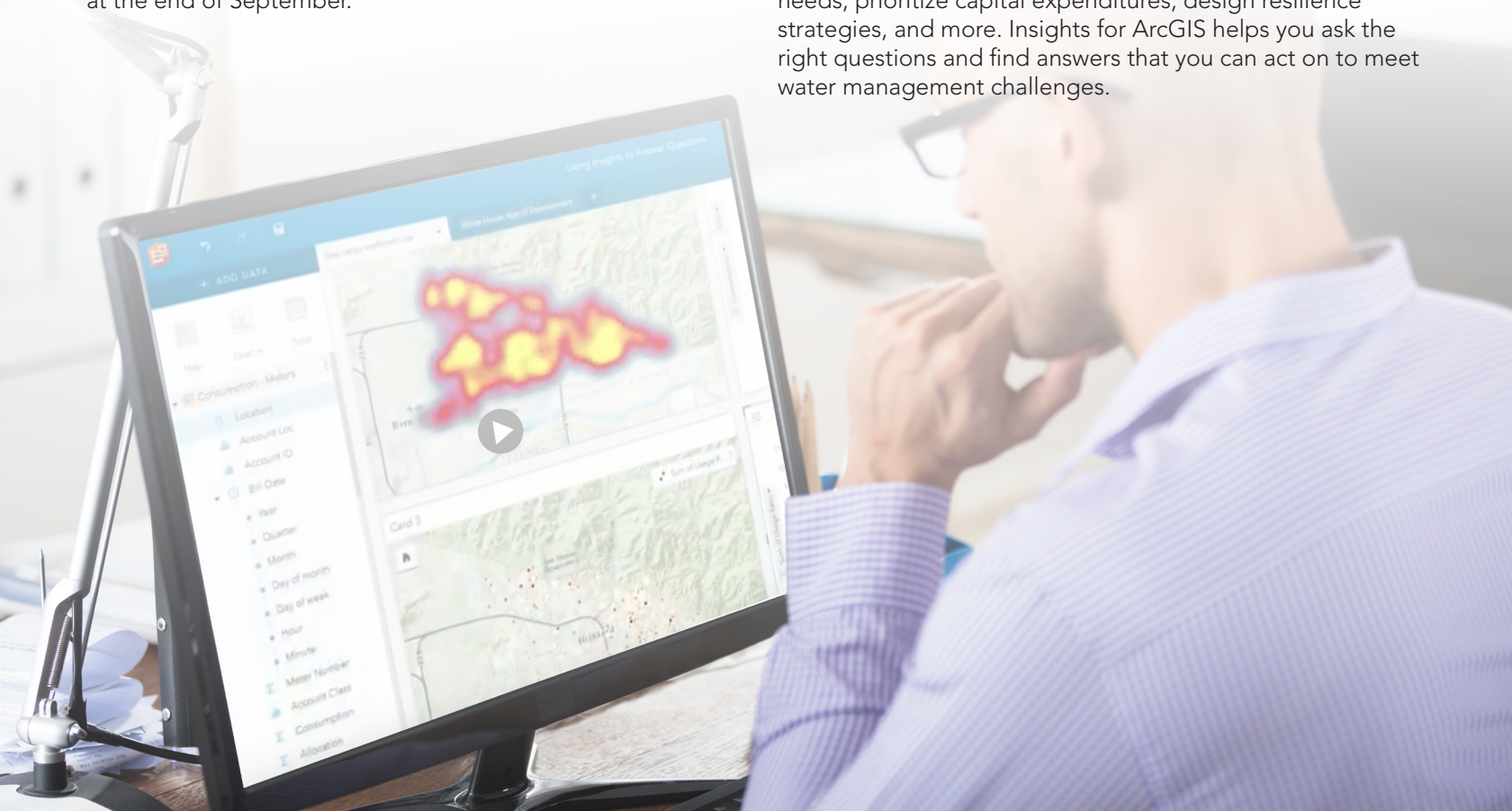


East Valley Water District (EVWD) in Southern California is in a drought-prone area. To reduce water consumption, an analyst wanted to locate the customers who had the most inefficient water usage so that the district could help them conserve. Watch the Video

Using Insights for ArcGIS, EVWD calculated, by customer, the ratio of allocated water consumption and created a heat map that showed pockets of inefficiency throughout the service area. Using consumption and billing data, Insights determined temporal water use patterns and presented the outcome on a time chart. It showed a spike in consumption at the end of September.

Moreover, the app created a ratio of outdoor water use to indoor water use and then filtered for customers using 20 times more water outside than inside—a total of 400 customers. Then the analyst found the worst offenders by filtering for customers that used 100 times more water than expected. Layering this data onto an imagery map, the analyst zoomed to one of these 30 locations and saw that the house had a large pool and very green landscape. He could now give this information and location to customer outreach staff.

Use geospatial analytics to predict the community's water needs, prioritize capital expenditures, design resilience strategies, and more. Insights for ArcGIS helps you ask the right questions and find answers that you can act on to meet water management challenges.



Get started.

All you need to get started exploring data with Insights for ArcGIS is an ArcGIS Online account and an Insights for ArcGIS license. You can access data, perform analysis, and share results.

Simply log in to ArcGIS Online, select Insights from the app launcher, and select New Workbook. You'll be prompted to add data to page 1 of the new workbook. From here, you can bring in services from ArcGIS Living Atlas of the World (demographics, soils, boundaries, etc.) along with content from your organization and other ArcGIS organizations. You can also leverage data from Excel and CSV files. This is a powerful way to bring information from other systems (CMMS, billing, water quality, etc.) into your analysis. Insights works with both spatial (containing address or latitude-longitude) and nonspatial data. If nonspatial data can be joined to GIS data using unique IDs, the relationship can be created right on the Insights page!

Once you've added data, you can drag it onto the page to begin your analysis. Data can be visualized as a map, chart, or table. Adjust the card size to meet your needs, easily edit symbology, and define classifications. You can continue to iterate on each card and take your analysis as far as you like. Every step taken on an Insights page can be seen in the analysis view, so your process can be shared (or repeated with new/updated data) along with your results!

Get Started with Powerful Analytics

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