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Implementing ArcGIS for Water Utilities

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Introduction

The purpose of this paper is to provide a starting point for water utilities that are interested in updating their current implementation of geographic information system (GIS) technology or starting fresh with a new GIS project. Today, water utilities need a geospatial platform that is pervasively available across their organization to support business needs. This platform must provide easy access to maps and information on any device for everyone in the utility as well as others they collaborate and communicate with, such as contractors and customers. Water utilities need a commercial off-the-shelf (COTS) technology that can be configured to meet their foundational mapping needs, be extendable for enterprise-wide workflows, support multiple implementation patterns, and have a robust ecosystem of partner solutions and implementers.

Esri® ArcGIS® software is the geography-based platform that enables water utilities to create, organize, and share geographic information and tools with anyone in the organization on a variety of devices in the office or the field. ArcGIS apps run practically anywhere—on a local network or hosted in the cloud—and are accessible from desktops, the web, smartphones, and tablets. Through cloud computing, this platform complements and extends on-premises ArcGIS resources with **rich content** (basemaps, imagery, demographics, landscapes, etc.) and **services** (geocoding, routing, geoprocessing, analysis, etc.). The ArcGIS platform includes online mapping and geographic analysis with an enterprise portal and geospatial content management, allowing organizations to easily and securely manage content, share maps, and collaborate.

ArcGIS is the geospatial platform that can provide these capabilities to water utilities in support of mission-critical business needs. It supports the business models of all water, wastewater, and storm water utilities, which include the following:

- Sustainable management of water and sewer infrastructure
- Cost recovery such as water loss control, rate stabilization, and development fees
- Emergency preparedness and response
- Planning and financing of capital improvements
- Communication/Transparency with customers
- Environmental stewardship such as water supply, watershed protection, and conservation

Patterns of GIS

A common set of GIS usage patterns exist across industries: government, utilities, commercial business, energy, public safety, health care, nonprofit, and so forth. These patterns describe essential usages that occur independent of business models or environments. The patterns are typically mapped against the ArcGIS platform's capabilities, providing a framework for understanding how Esri's platform aligns with specific organizational needs. Organizations that comprehensively implement all six of these GIS business patterns typically reap the greatest business benefits from their GIS investments.

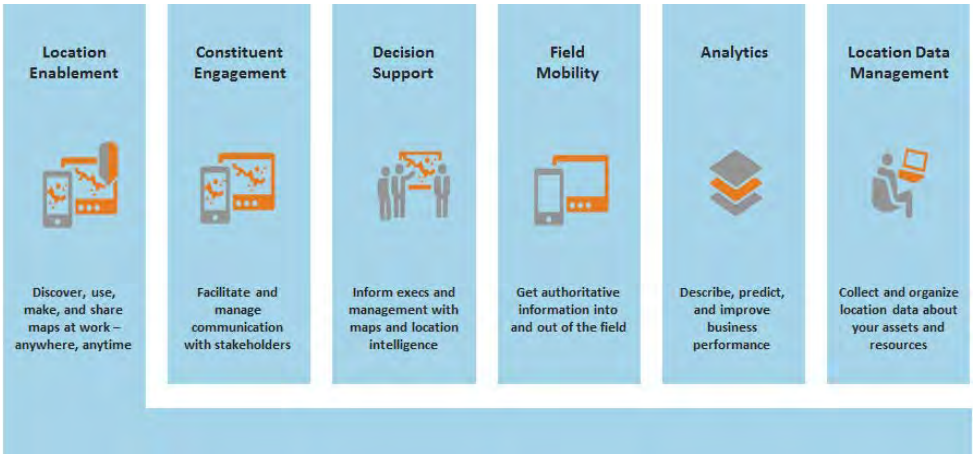

Figure 1: Solution Patterns of GIS for Water Utilities

Location Data Management

GIS solutions for data management include the collection, organization, and exchange of geographic data. Optimal data management involves the persistence of spatial data in the geodatabase—an object relational information model and data management framework for the ArcGIS platform. For water utilities, this is the authoritative repository for asset data on pipes, valves, hydrants, meters, and other network features, as well as operational data on pressure zones, work routes, main breaks, and inspection locations. Location data management leverages both ArcGIS for Desktop and data persisting in the geodatabase and requires workflows to keep data current and maintain data integrity. These workflows include procedures to

- Add, modify, and delete system assets according to data validation rules.
- Conduct quality control checks.
- Manage multiuser editing.

Sound data management practices provide the foundation for the sustainable management of water, wastewater, and storm water infrastructure.

Analytics

Analytics transforms raw data into actionable information and is extremely powerful when applied to describe, predict, and improve business performance. The ArcGIS geoprocessing framework offers a complete set of spatial analytical functions and tools including feature overlays, selections, and modeling. Technically, there are many ways to use a geoprocessing function, but a modern approach leverages web (geoprocessing) services. For example, the water main isolation tracing function is commonly used to help field crews identify which system valves to close to isolate a segment of the system in both emergency and maintenance scenarios. This network tracing leverages complex analysis through geoprocessing models, yet can be consumed by a lightweight mobile application when published as a geoprocessing service. The ArcGIS platform allows actionable intelligence to be shared, integrated, and visualized.

Field Mobility

Mobile GIS enables field personnel at water utilities to view, capture, store, update, manipulate, and analyze their networks, facilities, and operational data (work orders, customer complaints, and inspections). Field personnel require a simple solution for data visualization, exchange, collection, and updates. This GIS solution pattern is enabled by the availability of information that has been stored and optimized for the mobile environment. The requirements for this pattern are to improve the visibility of the operational aspects of an organization, enhance workforce scheduling, facilitate an environment where data currency is no longer an issue, and empower field personnel with relevant information needed for their out-of-office tasks.

Decision Support

Decision support is concerned with visualizing data and information on a map or dashboard to better understand organizational activities, projects, and operations. An up-to-date and accurate picture of organizational activities and projects is a critical component to decision support. Applications that support decision-making are sometimes referred to as common operating pictures (COP), operational dashboards, or executive dashboards, and they provide windows into relevant information. This information becomes obvious through proper planning and analysis techniques, is collected in part from the field on mobile devices, and is created and stored in the geodatabase. From a technology perspective, this pattern involves the combination of data and analytical layers organized in a map and published over the network/web for application consumption. This pattern is often the point of entry in the use of ArcGIS technology for new adopters (e.g., executive and non-GIS domain levels) as well as the final pattern implemented by long-standing GIS domain owners.

Constituent Engagement

Information harvested from constituents (citizens, potential/existing customers, stakeholders, etc.) can have a dramatic impact on operational activities, products offered, and services delivered. Constituent-generated (crowdsourced) data can be turned into valuable information through planning and analysis techniques and then be integrated into organizational workflows in support of smoother and more responsive operations. This solutions pattern promotes an ongoing connection between constituents and organizations that will help in promoting both internal and external transparency and accountability.

Location Enablement

Location enablement is a pattern that extends the reach of your location platform, providing everyone in your organization with the ability to discover, use, make, and share maps. This pattern provides a gateway to the other five patterns by connecting people, content, and capabilities. Location enabling an organization is realized by implementing a portal that users can log in to with their identity and permissions to ensure that the right person is provided with role-specific access to the right applications and content.

This pattern also includes the ability to infuse geospatial capabilities into external systems and services accessed by conventional business users.

Using the Patterns to Understand Business Behaviors

These patterns are interwoven. Most enterprise-wide workflows are supported by a range of complementary capabilities that can be categorized by two or more usage patterns. For example, an organization responding to a water main break may need capabilities described by all six patterns through the various stages of the event, as illustrated below:

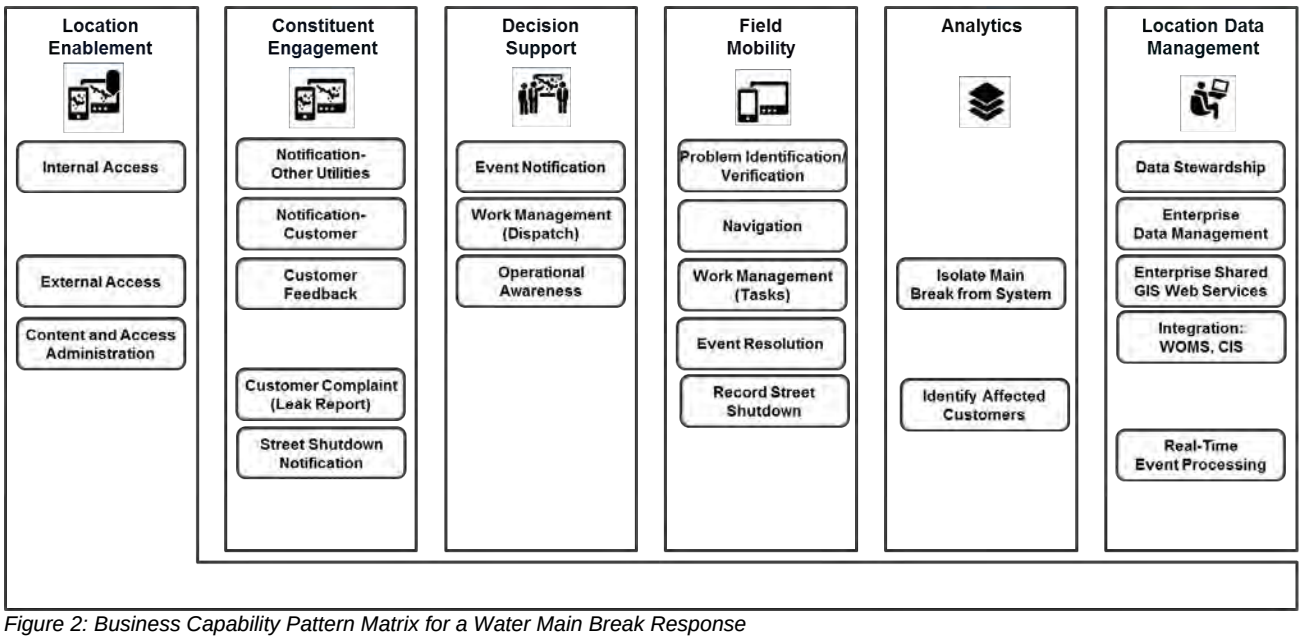

Figure 2: Business Capability Pattern Matrix for a Water Main Break Response

Platform Alignment

To overcome common water utility challenges, utilities need a location platform that provides geospatial capabilities essential to business workflows. This location platform is ArcGIS, and the configuration of the platform for water utilities is called ArcGIS for Water Utilities. ArcGIS for Water Utilities is a suite of configurable COTS solutions that

- Supports foundational needs associated with maintaining an authoritative system of record by democratizing data stewardship to those in the field as well as in the back office.
- Provides insight into business behavior (both immediate and predictive) by analyzing location information alongside information from other enterprise systems, creating a framework for geocentric decision support.
- Engages employees, contractors, and customers by providing a useful suite of apps and encouraging participation in information sharing and reuse throughout a common location platform.

A common request from water utility leadership is to justify technology investments by aligning geospatial technology with business demand. The diagram below identifies information products and technology components of the ArcGIS platform, as well as recommended partner solutions, necessary to support the specific business capabilities shown in figure 2.

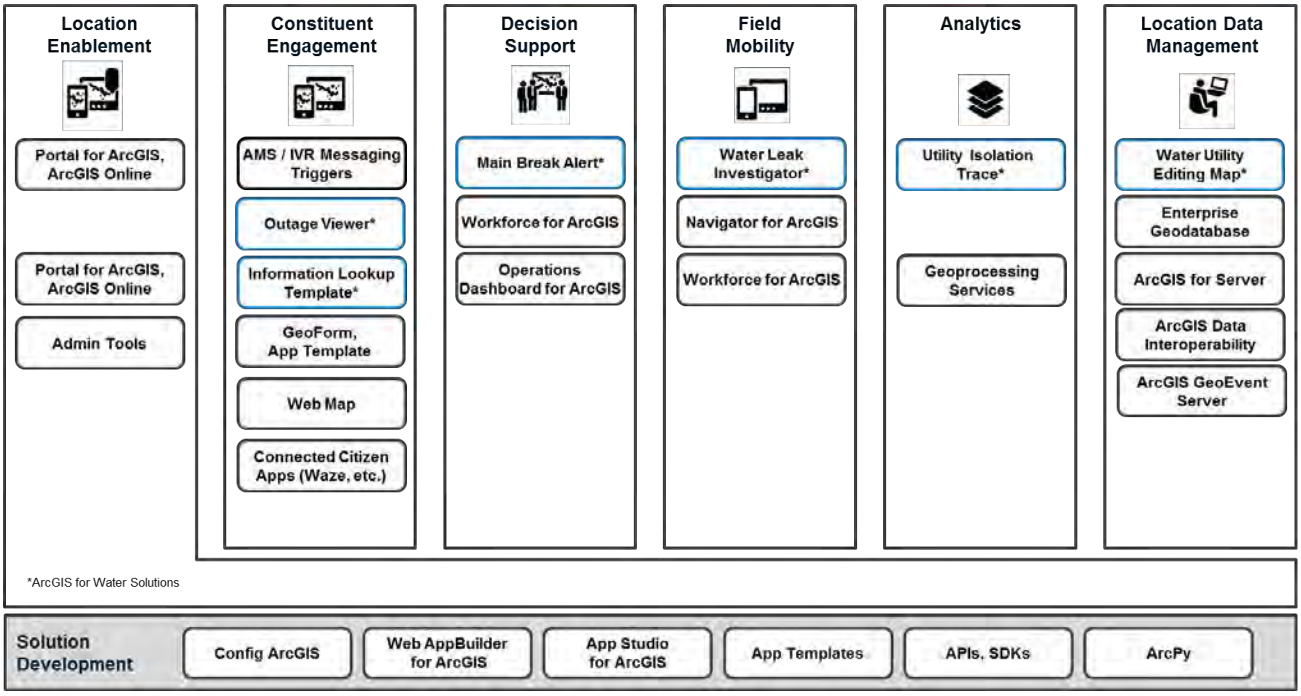

Figure 3: Aligning ArcGIS Platform Components to Enable Business Capabilities Requisite to Water Main Break Scenarios Depicted in Figure 2)

After deliberating over the technology required to realize even a limited set of business capabilities, the value of deploying ArcGIS for Water Utilities becomes apparent. Applications directly enable targeted business outcomes and yet are supported by a common platform.

ArcGIS Platform Reference Architecture

ArcGIS for Water Utilities is a set of configurable solutions for water, wastewater, and storm water utilities. These solutions provide focused applications supporting common water utility business needs and workflows, yet function within the scope of the ArcGIS platform. A common technology reference architecture is used to describe the technical components of a platform implementation at a summary level. This reference architecture is accompanied by a set of best practices for architecting the ArcGIS platform; these can be found in the Esri published document: *Architecting the ArcGIS Platform: Best Practices*.

The conceptual reference architecture of the ArcGIS platform and ArcGIS for Water Utilities (figure 4) consists of

- Role-based **applications** that connect people and their business workflows with the platform. Applications are typically used in workflows that follow one or more of the six *essential patterns of a location strategy* (location enablement, constituent engagement, decision support, field mobility, analytics, and, data management). ArcGIS for Water Utilities provides a templated portfolio of industry-standard ArcGIS applications that can be configured and deployed in an agile manner.

- A **portal** that organizes users and connects them with the appropriate content and capabilities based on their role and privileges as defined in the platform. The portal uses a person's identity to deliver the right content to the right person at the right time. From a product perspective, the portal is either Portal for ArcGIS (on-premises solution) or ArcGIS℠ Online (cloud-based solution). ArcGIS for Water Utilities content stored in the portal includes web maps and web layers that are reused in apps.

- **Infrastructure** that includes the hardware, software, services, and data repositories that are the core of the ArcGIS platform. Infrastructure can be hosted in the cloud or deployed on-premises. ArcGIS for Water Utilities map templates define a catalog of information services that can be hosted using ArcGIS for Server. Data repositories are structured by ArcGIS for Water Utilities data models. Numerous best practices—including load balancing, high availability, workload separation, and publication strategies—are associated with the platform infrastructure.

- **External systems and services** including systems that either provide services to ArcGIS or consume ArcGIS services to geospatially enable their capabilities. The ability to easily geoenable other enterprise business systems is a key capability of ArcGIS. ArcGIS for Water Utilities apps leverage information from external systems such as workforce and asset

management systems, as well as external data sources such as SCADA services and CCTV databases.

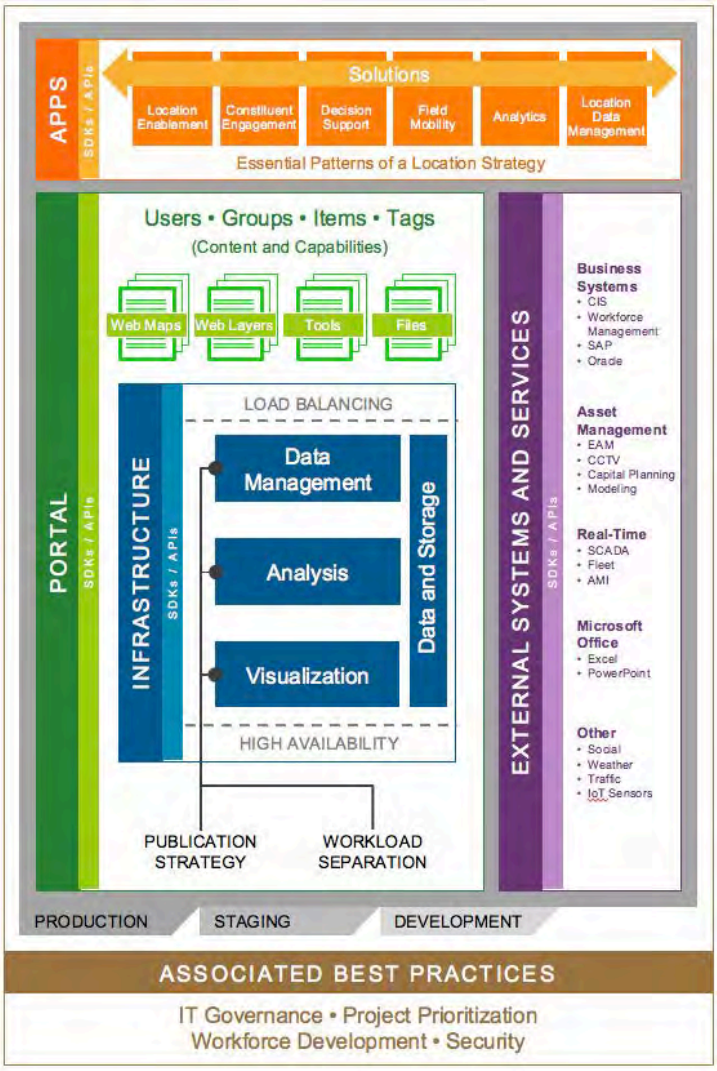

Figure 4: The ArcGIS Platform Conceptual Reference Architecture (Excerpt from Architecting the ArcGIS Platform: Best Practices)

The ArcGIS platform gives water utilities significant advantages, allowing the easy sharing of information with mobile users, users of other business systems, traditional GIS users, and also external entities the utility needs to collaborate with. The platform allows utilities to unlock additional benefits by extending the investments made previously in traditional GIS deployments while reducing risk and deployment time, resulting in a recurring return on investment. In today's world of increased regulations, tightening of budgets, and rising customer expectations, leveraging a utility-wide mapping and GIS platform is required to efficiently manage water utilities.

ArcGIS for Water Utilities

ArcGIS for Water Utilities (solutions.arcgis.com/utilities/water) is a collection of Esri products configured specifically for a water utility and is organized by workflows that integrate the six patterns of GIS to address business needs. These sets of workflows, consisting of focused maps and applications (apps), help utilities use their geographic information to improve utility operations and enhance customer service. ArcGIS for Water Utilities is a platform that includes desktop configurations, mobile and web applications, and services published from ArcGIS for Server and ArcGIS Online for creating, managing, and sharing geospatial content.

The mission of ArcGIS for Water Utilities is to increase the value of GIS for water, wastewater, and storm water organizations by making it easier to deploy ArcGIS and quickly deliver GIS content and applications throughout the organization. This gives water utilities a geospatial platform that can be leveraged by everyone in the organization, regardless of their role or location. Water utilities can extend the functionality of other enterprise systems and their data by integrating enterprise workflows within the maps and apps of ArcGIS for Water Utilities using flexible COTS integration methods.

The ArcGIS for Water Utilities maps and apps are designed to be configurable and extensible to meet the unique needs of individual water utilities. These are freely available for water utilities to deploy on their Esri licensing platform, are fully supported by Esri technical support, and are maintained by Esri. New maps and apps are continually being developed, and the source code is available for download.

Each ArcGIS for Water Utilities maps and apps download includes the following:

- An information model to support the app
- A map document defining the service definition
- A shortcut to the app configuration directions in Esri's online help documentation

The information model provided for each app contains the data structure necessary to power the app. For many of the lighter-weight field apps, the data required can be very simple. For other applications, such as the Water Utility Network Editing configuration, the information model can be more extensive (see appendix B).

ArcGIS for Water Utilities includes these workflows: maintaining and viewing asset information, designing and planning for capital improvement projects, optimizing field operations, understanding the status of operations, and connecting with customers.

Maintaining and Viewing Asset Information

For maintaining and viewing asset information, ArcGIS for Water Utilities includes a couple of ArcGIS for Desktop solutions for editing water networks and ensuring the quality of the data (solutions.arcgis.com/utilities/water/utility-asset):

- **Water Utility Network Editing** tools can be used by mapping technicians to maintain comprehensive water distribution, wastewater, and storm water records. The toolbars contain a series of editing and reporting tools that accelerate data editing when working with infrastructure data. (solutions.arcgis.com/local-government/water-utilities/help/network-editing)

- **Data Reviewer for Water Utilities** is a preconfigured set of data checks for performing quality control. (solutions.arcgis.com/local-government/water-utilities/help/data-reviewer-for-water-utilities)

For publishing and sharing this data, ArcGIS for Water Utilities includes a set of network viewer configurations, allowing the office and field crews to view the network assets (solutions.arcgis.com/utilities/water/help/water-distribution-network).These configurations serve as a foundation for other apps:

- **Map Change Request** is a configuration of ArcGIS Online for use on a mobile device with the Collector for ArcGIS application. The app's map can also be accessed by office staff from a web browser. By using this interactive map, field crews can efficiently communicate with GIS staff about data inaccuracies. (solutions.arcgis.com/utilities/water/help/map-change-request)

Designing and Planning for Capital Improvement Projects

The **Water Utility Capital Improvement Planning** app supports planning and analysis and can be used by engineers to rate the condition of assets and estimate the cost of capital improvement projects. (solutions.arcgis.com/utilities/water/infrastructure-planning)

For designing and planning for capital improvement projects, ArcGIS for Water Utilities includes an ArcGIS for Desktop solution, **Plan Capital Projects** to rate the condition of infrastructure networks and estimate the cost of capital improvement projects. (solutions.arcgis.com/utilities/water/help/capital-improvement-planning)

For publishing and sharing this data, ArcGIS for Water Utilities together with ArcGIS for Local Government includes a set of configurable web applications for sharing project information internally and/or externally, for example, share pavement coordination internally or share where projects are under way or being planned with the public.

- **Develop Capital Plans** allows utility staff to define and coordinate capital projects, engage external agencies, and share capital improvement plan with key stakeholders and the general public. This includes specific apps for water, wastewater, and storm water as well as pavement moratoriums and

external agency projects. (solutions.arcgis.com/local-government/help/capital-project-planning)

- **Monitor Capital Projects** allows utility staff to track project performance and share project status with key stakeholders and citizens. Capital Project Tracking complements Capital Project Planning and leverages project information defined by utility staff. This solution includes crowdsource applications to improve collaboration between engineers, project managers, and the general public, as well as dashboards for executives to monitor the status of capital projects. (solutions.arcgis.com/local-government/help/capital-project-tracking)

Optimizing Field Operations

ArcGIS for Water Utilities includes a collection of maps and apps that enable field operations and maintenance staff to gain access to utility information and conduct inspections (solutions.arcgis.com/utilities/water/field-operations). This collection includes optimized apps for helping staff respond to main breaks, maintain fire hydrants, exercise valves, inspect manholes, and capture field notes or request map changes. The Utility Isolation Trace app allows the operator to specify a location, such as a main break, and determine which valves to close and which hydrants and customers will be out of service. The outage information can then be quickly shared with the entire organization and the public. These applications are configurations of ArcGIS Online for use on a mobile device with the Collector for ArcGIS application. They are easy to use, work on smartphones and tablets, and automatically synchronize field data with the office.

Understanding the Status of Operations

An example of technology enabling users to understand the status of operations with ArcGIS for Water Utilities is Esri's Water Conservation solution suite, which includes apps for green infrastructure verification, leak and main break response, and issuing watering violations using ArcGIS Online and Collector for ArcGIS applications. (solutions.arcgis.com/utilities/water/water-conservation)

Operations managers can view the progress and results of these field operations by using the **Water Conservation Dashboard**. This dashboard, which is a configuration of Operations Dashboard for ArcGIS, provides operational awareness through a map view of water conservation field operations and statistical data; for example, how many rebates have been verified and awarded, how many and which types of violations have been issued, and how much water has been lost from main breaks. (solutions.arcgis.com/utilities/water/help/water-conservation-dashboard)

Understanding the status of operations is essential to intelligent decision-making. Configurations of Operations Dashboard for ArcGIS play a key role in the solutions for capital improvement planning, spatializing system data, water loss analysis, and connecting with customers. Dashboards allow operators and decision-makers to see the big picture and connect the dots. This enhances the ability to make fast, defensible decisions during time-sensitive events such as a main break. Understanding the current and historical status of operations also enhances longer-term planning and decision-making such as determining where to direct preventive maintenance.

Connecting with Customers

Proactively communicating with customers—which, in the past. has been optional—is now an increasingly critical aspect to managing the utility, as customers are demanding more information and transparency in the operations of their utility providers. To support this need, ArcGIS for Water Utilities also includes a collection of maps and apps that provide detailed information about maintenance activities and empower customers to improve the quality of services in their community (solutions.arcgis.com/utilities/water/connect-citizens):

- The **Combined Sewer Overflow Notification** map provides the public with detailed information about wastewater overflow events. (solutions.arcgis.com/utilities/water/help/cso-notification)

- The **Drinking Water Advisory** map provides the public with detailed information about drinking water alerts or advisories. (solutions.arcgis.com/utilities/water/help/drinking-water-advisory)

- The **Outage Viewer** application allows citizens to enter their location and view any water service outages. (solutions.arcgis.com/utilities/water/help/drinking-water-advisory)

These COTS methods include using web services or routine extract, transform, and load (ETL) data movements. In some cases, utilities can leverage the COTS integrations built for other systems; ArcGIS has already configurable integrations with technologies such as Microsoft Office, SharePoint, IBM Cognos, SAP, Salesforce.com, and MicroStrategy, transforming the use of these systems by geoenabling business data with intuitive mapping and analytical tools. Through these capabilities, ArcGIS for Water Utilities can transform the way organizations leverage business data to make more intelligent decisions; be more efficient; and, ultimately, increase their quality of service to their customers.

Using a configurable COTS-based solution approach saves a significant amount of cost and time on design and development that would otherwise be needed to build customized solutions. Deploying ArcGIS for Water Utilities can provide several benefits to water utilities including

- Eliminating the risk and cost of customization.
- Enabling the utility to easily add apps and capabilities
- Reducing the risk of version lock (a common occurrence with custom solutions/workflows where applications depend on a specific version of a system or related application)
- Making the deployment more sustainable for utility staff to manage.

These benefits ultimately decrease risk; reduce total cost of ownership; and increase the opportunity for a successful, cost-effective implementation. The deployment of an enterprise mapping platform with focused applications to support the utility's workflows empowers members of the organization to accomplish their tasks more efficiently, make better decisions, and communicate with each other as well as with customers and stakeholders.

Implementing ArcGIS for Water Utilities

This section provides a strategy for implementing ArcGIS for Water Utilities. The strategy outlined below is based on the agile approach to system implementation. This approach reduces both the cost and the time to deploy the system. At a high level, the framework for this implementation strategy is to understand and prioritize the business needs, deploy the mapping portal and other components of the ArcGIS platform (ArcGIS for Desktop, ArcGIS for Server, and the enterprise geodatabase), and then use an iterative approach to selecting and deploying applications to fulfill the prioritized needs.

The strategy outlined below generally applies to a water utility new to ArcGIS for Water Utilities, but the approach can easily be adapted for any implementation scenario because the solution can

- Be deployed in a mix of environments.
- Provide standard tools and data models.
- Leverage best practice integration methods.
- Be deployed using an agile approach.

The order in which the ArcGIS components are deployed and which maps and apps of the ArcGIS for Water Utilities solution are implemented and when may vary from utility to utility based on the priority of the business needs and the maturity of the existing GIS implementation. For other deployment considerations, such as migrating from a legacy system, please refer to appendix A.

Step 1: Understand and Prioritize Your Business Needs

To apply the components of ArcGIS for Water Utilities effectively and efficiently, it is important to understand the organization's business needs and how ArcGIS for Water Utilities solutions can support these needs. In the past, the typical approach to implementing ArcGIS in a water utility followed a waterfall approach, starting with planning and design, then development, and finishing with implementation. This waterfall approach tended to require too much customization, took too long to deploy, and resulted in an implementation that either didn't meet the needs or was version locked to outdated systems by the time it was complete.

The approach for aligning your organization's business needs with ArcGIS for Water Utilities should be addressed using this agile approach:

a. Meet with business managers to understand their high-level needs and have them prioritize needs according to how they align with the goals of the organization. As you gather this information, begin to form each need into an information product, such as a map, report, or application that is produced by the GIS.

b. Evaluate ArcGIS for Water Utilities to determine whether there is an existing solution to meet the business needs as defined by the information products.

c. Discuss and/or demonstrate each existing solution with business managers to determine how well the solution lines up with the business need. If there are gaps, determine how critical they are relative to the time and effort that would be required to close those gaps. Communicate this information to your business managers. In many cases, you'll find that using an existing solution that meets 80 percent of the requirements but can be readily deployed will suffice versus the time and effort it would take to create a custom application that meets 100 percent of the requirements.

d. Determine whether a data migration or integration is required. If a data migration is required, consider using industry-standard models versus custom models (see appendix B for more information about data models). If data integration is required, understand the frequency and consider using standard web services through APIs or routine ETL data movements.

e. For business needs that are not currently supported by ArcGIS for Water Utilities, continue to evolve the information products. These needs can be addressed by third-party apps from Esri partners; do-it-yourself (DIY) configurations of ArcGIS; or, in some unique cases, customization by in-house development teams, Esri partners, or Esri Professional Services.

Steps a through e above can be accomplished incrementally, meaning that you don't have to meet with all the business managers or understand all the requirements before starting the configuration of a solution. If there is a clearly defined need and a solution that will support the need, start to deploy the solution while continuing to meet with other managers. These steps can also be iterative, meaning that business needs as well as solutions that are already implemented should be periodically reviewed. For example, a new solution may enhance one that has already been deployed. Water utilities sometimes get stuck on this first step. To avoid getting stuck, do not over plan. Consider the level of effort as part of the needs prioritization process, look for quick wins, and get started deploying solutions.

Step 2: Deploy Your Mapping Portal

Every water utility needs to share information and collaborate. This information typically exists in multiple enterprise systems but may also exist in files such as spreadsheets and stand-alone databases. Because the most common element to water utility data is location, GIS serves as the foundation for integrating this information and presenting it in the form of intuitive maps that are used for better understanding. Therefore, deploy the enterprise mapping portal, using either ArcGIS Online (software as a service [SaaS]) or Portal for ArcGIS (on-premises), to enable the ArcGIS platform. Establishing the mapping portal first immediately provides the utility with the capabilities to start cataloging, publishing, sharing, and analyzing the enterprise information.

In a traditional GIS implementation, sharing and analyzing data were the last implementation steps. This resulted in delayed value to the utility as they were unable to benefit incrementally as the system was deployed. Deploying the mapping portal immediately gives utilities ready-to-use applications, integration capabilities, spatial analysis capabilities, and data resources, providing the foundation for immediately putting information into action.

ArcGIS portal technology also enables a key capability of the ArcGIS platform: the web map. The web map includes collections of web services, their rendering, and specific behaviors such as editing and creating pop-up window content (including controls). The web map is consumable by all ArcGIS APIs, software development kits, and applications, and so it enables consumption of the same content, rendering and behavior in desktop, web, and mobile environments.

ArcGIS portal technology also governs access to web maps; hosted and registered services; and other items, such as images and PDF documents, using an identity management framework that enables sharing these items with designated groups of users. This same mechanism governs which users can access and edit hosted content.

ArcGIS for Water Utilities provides an industry-specific configuration of ArcGIS Online (or Portal for ArcGIS) to assist utilities with setting up their enterprise mapping portal (solutions.arcgis.com/utilities/water/help/arcgis-online-for-water-utilities). This model organization provides a pattern to help utilities manage content and deliver focused maps and apps to the users. The model organization guides utilities in the following areas:

- Configuring ArcGIS Online as a mapping portal for the organization
- Creating groups that support sharing and the functional needs of the organization
- Organizing map services and authoring relevant web maps and apps for users
- Leveraging the ArcGIS for Water Utilities solutions to create and deploy useful maps and apps
- Inviting users into the organization to fill key roles in the mapping platform

Next, connect the mapping portal with other enterprise systems. For example, Esri Maps for Office can be used by anyone in the organization to create maps from their spreadsheets and share those maps. Finally, do not let the mapping portal remain as your organization's best-kept secret. Use every opportunity to communicate and demonstrate how the mapping portal can transform how your organization uses geospatial information in everyday workflows.

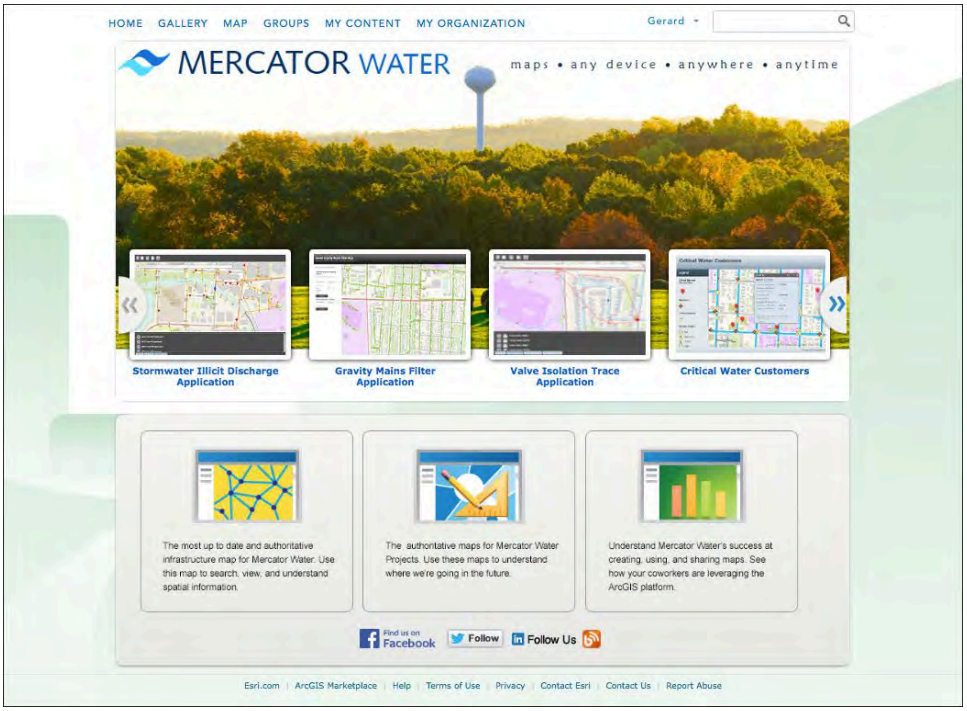

Figure 5: Deliver Useful Maps and Apps to Your Organization through Your Mapping Portal

As mentioned above, there are two portal options: **ArcGIS Online** and **Portal for ArcGIS**. ArcGIS Online is a collaborative, cloud-based platform that allows members of an organization to use, create, and share maps, apps, and data,

including authoritative basemaps published by Esri. (doc.arcgis.com/en/arcgis-online/reference/what-is-agol.htm)

Portal for ArcGIS and ArcGIS Online provide similar functionality; however, they run in different environments. With ArcGIS Online, the software components run as SaaS in an Esri-administered cloud infrastructure, whereas with Portal for ArcGIS, these components run on the organization's own hardware or in a privately hosted cloud environment. Portal for ArcGIS may be required if computers in the organization cannot connect to the Internet. In addition to Internet connectivity and infrastructure considerations, security policies may play a role in determining which option to choose. As with any deployment of an on-premises system, prior to deploying Portal for ArcGIS, a system architecture and capacity estimation should be performed. The examples provided in this paper are based on the deployment of ArcGIS Online, which is the most common deployment pattern for water utilities. However, the approach would be similar with Portal for ArcGIS. (esri.com/software/arcgis/arcgisserver/extensions/portal-for-arcgis)

How a utility chooses to power ArcGIS Online will depend on the maturity of the organization's GIS implementation, security policies and protocols, classification of data (e.g., sensitive/nonsensitive), the need for computational elasticity, and the state and flexibility of the IT infrastructure. The ArcGIS Online deployment should be dynamic, constantly evolving with the capabilities and the needs of the organization. For example, ArcGIS Online could immediately be leveraged to support a few key workflows using only hosted content, then enhanced and expanded iteratively as other dependencies are met, such as on-premises IT infrastructure, integrations with other systems, or the completion of a data migration project. For more information on ArcGIS Online deployment scenarios, see appendix C.

Following the deployment of ArcGIS Online (or Portal for ArcGIS), additional components of the ArcGIS platform will need to be deployed. These include ArcGIS for Desktop, ArcGIS for Server, and the enterprise geodatabase. The amount of planning and time spent deploying these components will vary based on the size of the utility, the existing IT environment, the state of the GIS data, and integrations. For example, a small utility may be able to quickly deploy a recommended best practice configuration of these components on existing infrastructure without conducting a detailed capacity analysis, whereas a large utility may have to spend more time carefully assessing the capacity needs and building out the infrastructure necessary for optimal performance.

Step 3: Iteratively Deploy Solutions

The ArcGIS platform and ArcGIS for Water Utilities provide a comprehensive foundation for water utilities to adopt a COTS-based agile methodology for implementing GIS for the entire organization. An agile approach for implementing ArcGIS is both iterative and incremental and has three guiding principles:

1. Shape human workflows to leverage the capabilities of the ArcGIS platform. This sometimes requires changing the way people work to fit within the workflows of the system.

2. Configure existing tools first; use customizations sparingly and only if deemed absolutely necessary by project leadership.

3. Interface with other systems using web services or routine ETL data movements.

Using the agile approach, illustrated in figure 6, utilities can quickly put meaningful apps into the hands of their staff. A single iteration typically includes planning, design, configuration, and testing. However, consider that the design may already be complete if leveraging one of the ArcGIS for Water Utilities solutions. Once the app has been configured and tested, it can be deployed to users. The next iteration may be adding functionality to an existing app or implementing a new app or workflow to facilitate a different need. In many cases, because ArcGIS for Water Utilities is based on common industry needs, the apps will meet the business need on the first iteration.

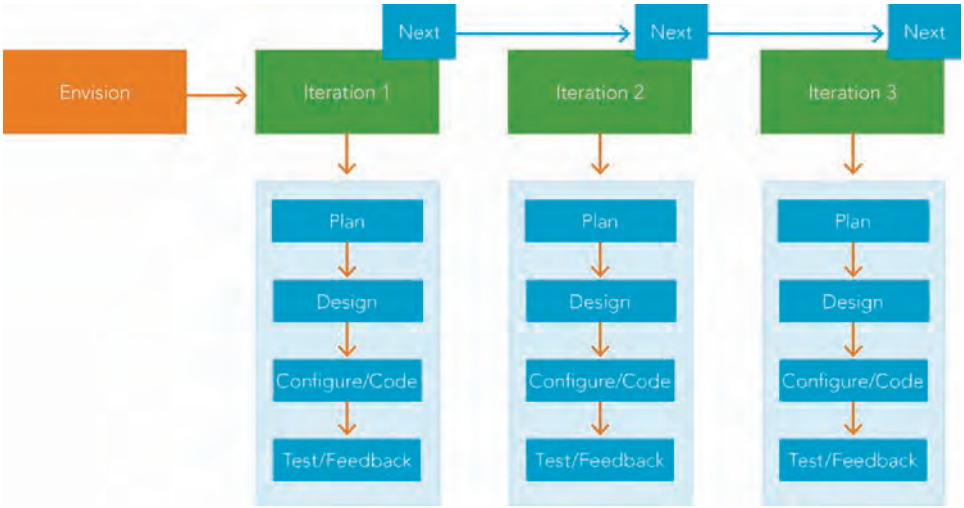

Figure 6: Agile Approach to ArcGIS for Water Utilities Implementation

One of the benefits of this approach is that iterations can stop and start at any time and, when properly focused, do not impact other, already completed iterations. Iterations should be brief, ranging from a few days for simple apps to 30 days for complex apps or workflows. This methodology will help to simplify the implementation, minimize customizations, avoid point-to-point integrations that can version lock systems, and accelerate delivery of useful apps.

Solution Examples

The ArcGIS for Water Utilities examples below are intended to provide additional guidance on how to deploy the solutions and illustrate how these solutions can quickly meet the immediate needs of water utilities. These examples support the core solution patterns of GIS, have been deployed by a number of water utilities, and continue to evolve based on the feedback provided by the ArcGIS water utility community.

Example 1: Water Conservation

The selection of initial application(s) should consider what the existing on-premises GIS can support (if there is one) as well as the level of effort, data availability, and time to deploy. For example, a utility may have on-premises GIS content and capabilities but may not yet have enabled ArcGIS Online to securely communicate with the on-premises GIS. In this scenario, the utility could begin to deploy an application (or applications) supported by hosted feature services in ArcGIS Online (see appendix C for ArcGIS Online deployment scenarios).

Many organizations suffering from tenuous water supplies or drought want to quickly and efficiently manage a water conservation program. The key pattern in this workflow is field mobility. ArcGIS for Water Utilities provides a suite of apps that support water conservation including responding to main breaks, issuing water violations, and managing green infrastructure and rebates (solutions.arcgis.com/utilities/water/water-conservation). Crowdsource Reporter can be configured to allow the general public to sign in with their social media credentials (Facebook, Twitter, etc.) and report watering violations. The solution suite also includes a dashboard configuration, bringing all the information related to the program into one comprehensive view for managers and executives. (http://solutions.arcgis.com/local-government/help/crowdsource-reporter/)

For this example, it is assumed that information about the locations of main breaks, water violations, and green infrastructure does not currently exist in the utility's GIS, and these types of data are not considered to be sensitive. Also, the on-premises servers have not been enabled to communicate with ArcGIS Online. However, if some of this information were available, it could be migrated to the app data models or created from spreadsheet data by using Esri Maps for Office, which allows you to quickly create dynamic, interactive maps of your Excel data. (doc.arcgis.com/en/maps-for-office)

Since in this example there is no concern about storing the data necessary to enable these water conservation workflows in an SaaS system, the water conservation apps could be deployed immediately using hosted feature services in ArcGIS Online. This is just one example of why deploying the mapping portal is an important first step—it provides quick, agile deployment that doesn't rely on on-premises infrastructure and systems.

Once the initial applications have been selected, the next step is to download the app configurations. After following the instructions on how to configure the Main Break, Water Violations, and Green Infrastructure apps and sharing them with the users they are intended for, they are ready to be used in the field, employing a native ArcGIS app such as Collector for ArcGIS. Edits made to the maps by any user will be saved and stored in the hosted feature service in ArcGIS Online. The data can be retrieved from ArcGIS Online at any time manually or by using automated scripting.

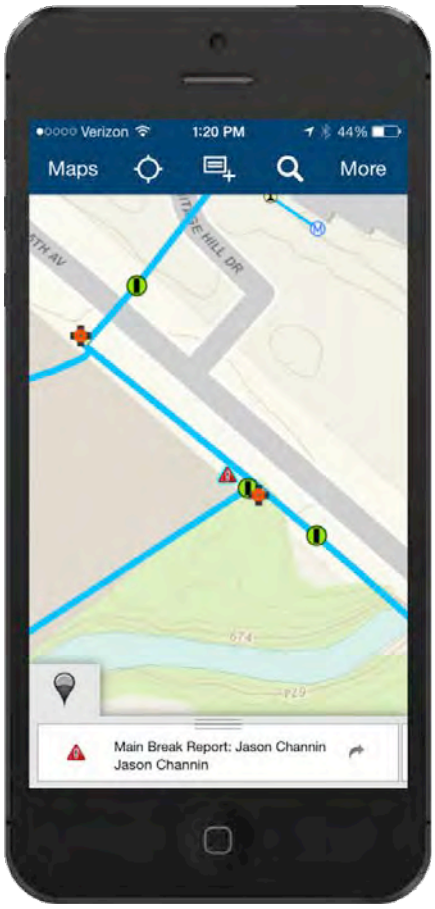

Figure 7: Collect Main Break Locations and Information

Example 2: Maintain Asset Information

All water utilities need to create and maintain asset information. One of the most commonly implemented ArcGIS for Water Utilities solutions is the **Water Utility Network Editing** app. Previously, this was often the first, most expensive and time-consuming step of a traditional GIS implementation. Now, with the ArcGIS platform and ready-to-use apps, utilities have the option to deploy simpler app configurations that solve discrete business needs first, such as in the water conservation example, and then utilize ArcGIS to manage asset information in a later deployment iteration. (solutions.arcgis.com/utilities/water/help/network-editing)

The Water Utility Network Editing application supports network data management, and the configuration download includes two ArcGIS for Desktop add-ins, an information model for the network datasets, an ArcGIS for Desktop toolbar that includes the editing tools, a map document, and a shortcut to the ArcGIS Online help. The Water Utility Network Editing app is preconfigured for the included information model; however, a utility may choose to use a custom information model (see appendix B for data model considerations). Once downloaded, the next steps are to

- Install the **Water Utility Network Tools add-in**. The Water Utility Network Editing toolbar, Water Utility Network Reporting toolbar, and Water Utility Network Editing construction tools included in the add-in are required by the Water Utility Network Editing map.

- Install the **Attribute Assistant add-in**. Attribute Assistant streamlines editing and attributing tasks.

The behaviors of the tools can also be modified to perform additional functions by editing the configuration file shared by the add-ins. The behaviors of the tools are controlled by the configuration file and two tables that specify how IDs are generated and fields are populated. The Generate ID table consists of two fields used to generate unique identifiers for features, and the Dynamic Value table consists of 10 fields that define the rules and how they interact with features. One of these fields, **ValueMethod**, defines how fields are populated when a feature is created or modified, such as copying a value from an intersecting feature or populating fields with the current data and time of an edit.

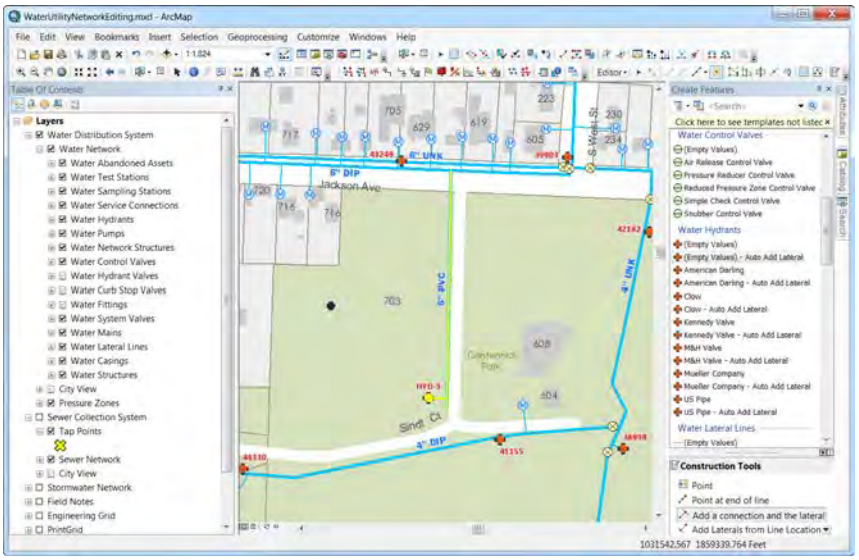

Figure 8: Maintaining Your Water Utility Network Data

In addition to increasing the speed and quality of data editing, the Water Utility Network Reporting tools provide a number of useful functions such as tracing the network, creating profiles, and exporting selection results. Together, the ArcGIS for Water Utilities editing and reporting tools enhance the core functionality of ArcGIS for Desktop, providing added value to water utilities through configurable solutions.

Example 3: Coordination of Field Operations

Efficiencies in the workflow can be realized by the technician's ability to create and update work orders in the field, improving the ability to track work, update inventories, and access and update condition information. This significantly reduces the time and effort required to update these systems after an event has occurred or work has been completed.

Often, water utilities want to integrate the ArcGIS platform with other enterprise business systems to achieve better operational awareness. One of the most commonly employed business systems in a water utility is a work or asset management system, typically referred to as an enterprise asset management (EAM) system. These systems are used to track and manage work conducted on assets.

Accessing and managing work information from a map provide a tremendous amount of value to a water utility:

- Staff members can locate their assets in the field.
- Workers can understand how they might impact the system within a certain area.
- They can be aware of and notify other staff members or customers around them.
- Managers and executives can quickly understand how the system and their staff are performing.

The ArcGIS platform can consume any service using the GeoServices REST Specification including map, feature, image, geoprocessing, and geometry services. Many EAM systems have the capability to publish and/or consume these types of services and can therefore integrate directly with the ArcGIS platform.

Most commonly, these are services supporting work orders and service requests for assets. This means that ArcGIS for Water Utilities apps can be enhanced by adding valuable information such as the location and status of work being conducted on assets.

This type of integration increases operational awareness through the use of operational views. Operations Dashboard for ArcGIS provides a common operating picture—accessible across a group of people within an organization—for monitoring, tracking, and reporting an event or system of events. Operations Dashboard uses data sources that are published in web maps. Operations Dashboard can easily be configured to provide a comprehensive operational view with indicators (also referred to as widgets) for items such as the following characteristics:

- List of unrepaired main breaks
- List of main breaks repaired within the last seven days
- Main break details
- Charts of main breaks organized by size and/or material
- Total number of main breaks over a specified period

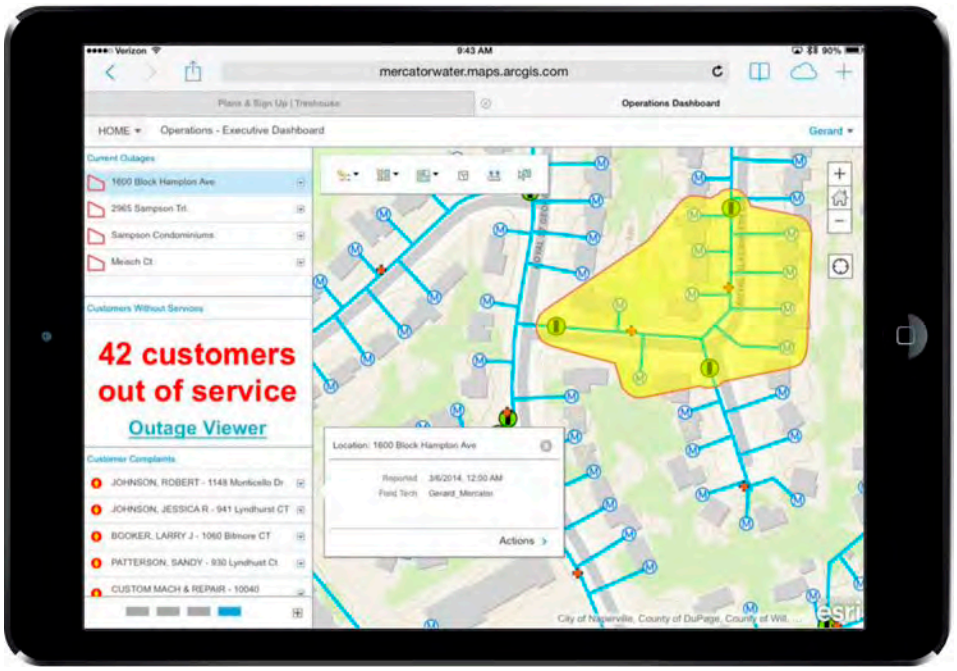

Figure 9: Understand the Status of Your Water Utility Operations

Using the services provided by an EAM system, adding work order information could enhance this comprehensive view. In addition to being able to view the location and status of these features, additional indicators can be configured to show information from the EAM system such as the number of currently open main break-related service requests and work orders, average length of time to respond to a work order, total cost of main break work orders, and estimated gallons lost.

Many water utility organizations have successfully integrated their GIS and EAM. In the past, the most prevalent method has been point-to-point integration at the database level facilitated through either custom development or third-party software solutions. These approaches can expose the utility to a significant amount of risk for version locked systems and costly upgrade projects. While less common, some past integration projects were successful using web services through an enterprise service bus.

Today, EAM integrations are becoming more common through EAM vendors providing COTS integration with ArcGIS, using standard web services and, in some cases, even embedding ArcGIS web maps within their own systems. In cases where COTS integrations are not available, water utilities are successfully using ETL-based integrations—where real-time information exchange is not required—because they are less expensive to configure (versus develop) and are easier to maintain. Figure 10 illustrates a contemporary GIS-EAM workflow with ArcGIS Online bringing together information from both systems and making it available to field and office users.

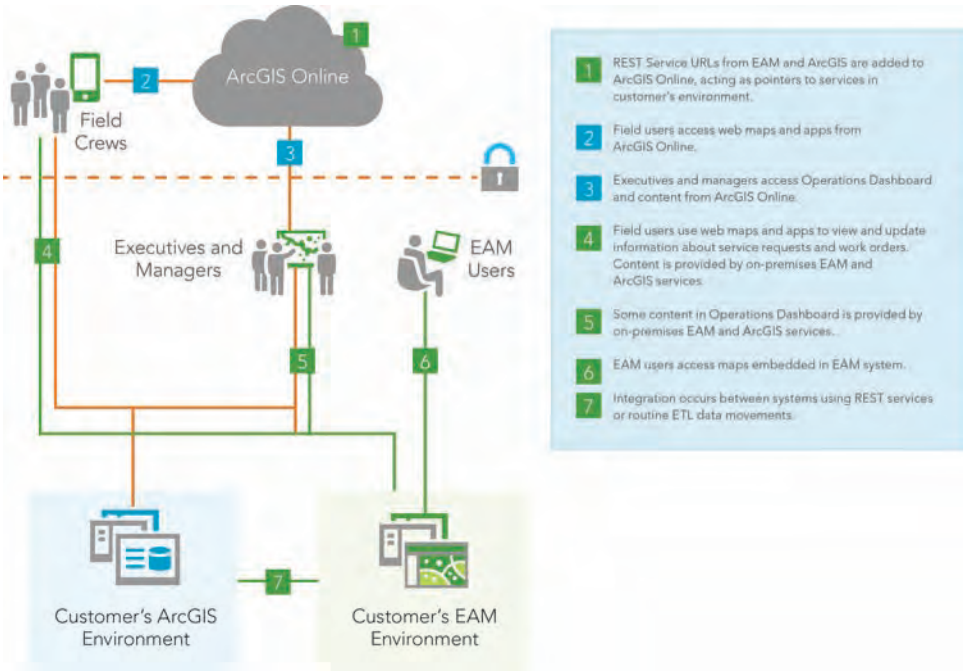

Figure 10: GIS and EAM Workflow with ArcGIS Online

Example 4: Maximizing Cost Recovery

Identifying where theft may be occurring, where meters are not registering, or where potential data errors can help utilities better recover costs. The ability to show customer consumption information on the map enables utilities to analyze spatial patterns. Using these patterns, analysts can identify meters to inspect for accuracy or signs of tampering or theft, and potential data errors in the billing system can be recognized.

As mentioned previously, a common method of integrating enterprise systems is through the use of routine ETL data movements. This methodology includes extracting data from outside sources (e.g., customer information system [CIS], EAM), transforming it to fit operational needs, and loading it into a target table or geodatabase.

ETL routines are a cost-effective way of bringing data from the CIS into ArcGIS to support water conservation efforts and ensure revenue capture. The water consumption solutions provide customers with a configurable script to periodically join water consumption data from the CIS to meters or delivery points of customers in the GIS. Bringing data into the GIS enables spatial analytics and visualizations in useful information products such as a zero/low consumption map to assist with identifying theft, meter registration issues, or billing problems.

Traditionally, consumption data is updated monthly in the CIS, and a periodic (daily or weekly) extraction from the CIS is adequate for updating the GIS. However, with the emergence of smart water grid technologies such as Automated Meter Infrastructure (AMI), data is available at increasingly frequent intervals (15 minutes, each hour, every 4 hours, etc.).

For data that is updated on a more frequent basis or in real time, **ArcGIS GeoEvent Extension for Server** is another option for integration. GeoEvent Extension can stream real-time data directly to ArcGIS clients (desktop, web, or mobile applications) or into a geodatabase. Using the CIS example, GeoEvent Extension can be configured to read data from a flat file, which is a common output format of a CIS. As the flat file is being updated by the CIS, GeoEvent Extension can stream the updates into the GIS, making near real-time CIS data available to all users of the ArcGIS platform. (esri.com/software/arcgis/arcgisserver/extensions/geoevent-extension)

Summary

The purpose of this paper is to provide a starting point for water utilities that are interested in updating their current implementation of GIS technology or starting fresh with a new GIS project. Water utilities continue to adopt agile methodologies to deploy new systems that support the daily operation of their organization. As a best practice, GIS in a water utility can also be deployed using this agile methodology to support a single department or the entire utility.

The agility of this method offers faster return on invested time, effort, and funding. These returns are planning reduction, rapid creation of prototypes by using configuration, and quicker deployment using COTS applications. Additionally, by adopting an approach of configuring first and customizing second, utilities are able to quickly test and adopt new applications supporting critical utility workflows or focus on integration with other critical systems like EAM.

A guiding principle for this agile methodology is to adhere to core business functions or GIS solution patterns that are common to all water utilities. The six solution patterns discussed above allow a utility to focus its efforts on areas that will return the most benefit. ArcGIS for Water Utilities expands on this core solution pattern approach and provides a configurable suite of applications designed specifically for water utilities. Water utilities now have a starting point that doesn't require extensive consulting and development efforts.

Ultimately, the intent is that a utility can find a suitable starting point and iterate through a series of manageable solution deployments, resulting in useful maps and apps that support everyday workflows. Additional planning information is provided in the appendixes, and more information regarding the ArcGIS for Water Utilities solutions is available at solutions.arcgis.com/utilities/water. Once you have deployed a geospatial platform to support your entire utility, you are ready for current and future releases of the ArcGIS for Water Utilities solutions to support the needs of your utility.

Appendix A: Migrating to ArcGIS for Water Utilities

There are two fundamental scenarios for how the ArcGIS platform and ArcGIS for Water Utilities are implemented in a water utility. The first scenario involves starting from nothing. In this scenario, the approach is fairly straightforward:

- Understand your needs
- Implement the mapping portal and other platform technologies (ArcGIS for Desktop, ArcGIS for Server, etc.)
- Configure, deploy, and integrate the ArcGIS for Water Utilities apps that apply to your needs

In many cases, this first scenario will include at least a data migration of legacy mapping data, typically from a CAD system.

The second scenario describes migrating from a legacy ArcGIS implementation or other GIS technologies. In this scenario, the presence of existing systems may add considerations for implementation including the following:

- Repurposing of existing infrastructure
- Conformity to existing security measures
- Failover and backup procedures
- Migration of both data and other enterprise systems
- Integration with other systems
- Redeployment of legacy applications

While these are undoubtedly important considerations, the ArcGIS platform and ArcGIS for Water Utilities have several characteristics that reduce risk in these areas and increase the likelihood of a cost-effective migration.

- The ArcGIS platform provides flexible deployment options that include deploying on-premises, in public or private clouds, or within Esri's SaaS system (ArcGIS Online) or using a mix of these environments, referred to as a hybrid approach. These options provide the flexibility to deal with information technology infrastructure and security and reliability issues.
- If the existing GIS data does not already reside in the ArcGIS format, the ArcGIS platform and ArcGIS for Water Utilities provide standard tools and data models to simplify the migration process.

- There are several proven integration methods that geoenable other enterprise systems such as standard ETL routines using scripts and models, web services, and COTS integrations built into other technologies (e.g., Esri Maps for Office).

- ArcGIS for Water Utilities solutions were designed to be both configurable and task focused. These two features are incredibly important because they enable water utilities to perform implementation in an agile manner. While there are many benefits to an agile approach, a key point here is that water utilities can tailor the deployment of solutions through configuration and eliminate the need to deploy everything at once (i.e., legacy applications can be replaced iteratively if there are other dependencies). These characteristics have helped water utilities perform successful migrations from legacy systems to the contemporary ArcGIS platform and ArcGIS for Water Utilities.

Appendix B: Information Model Considerations

While each app configuration includes an information model, the included information model is not required; the app could be reconfigured to a different model. For the lighter-weight applications, these models can be as simple as one or two feature classes with a couple of attributes; for more robust apps like the **Water Utility Network Editing** tools, the model can be more complex. One of the primary benefits to using the included information model is that the apps are already configured to work with that information model. So using the included information model significantly speeds up app deployment. If a utility chooses to use a different information model, additional effort will have to be put into modifying the apps to work with it. An additional benefit of using the included information model is that it embodies best practices for using a mapping platform to accomplish a given workflow, and time does not need to be spent performing data modeling exercises.(solutions.arcgis.com/utilities/water/help/network-editing)

There are typically three scenarios that lead to utilities using the included information model:

- A utility is migrating geospatial data from a different system into ArcGIS.
- A utility does not have any existing GIS data.
- A utility is modernizing its system and wants to update its information model with a contemporary, industry-standard model.

This decision is usually the result of the utility realizing the benefit of leveraging an industry-standard model and minimizing changes to configuration parameters of current and future ArcGIS for Water Utilities applications. It is important to note that while the information model supports the majority of the data requirements for a typical water utility GIS implementation, it is not uncommon for a utility to have a few unique requirements.

If there are unique requirements, the model can be extended to support them. Extending the model involves adding features or fields to support the unique needs and leaving the rest of the model as is. The process of migrating to the information model provided with the application includes the following:

- Conducting an analysis of the utility's data requirements
- Extending the included information model (if required)
- A one-time migration of the utility's data into the information model using the ArcGIS Data Interoperability extension (esri.com/software/arcgis/arcgisserver/extensions/data-interoperability-extension).

A utility may choose to use its own information model. A utility might take this approach if there are applications or system integration dependencies on the water utility's existing information model. Any app can be configured for any information model, assuming that it contains the proper data. For example, to configure the Add Lateral tool in the Water Network Editing map, the data model must contain a lateral feature class.

The level of effort to configure the ArcGIS for Water Utilities apps when not utilizing the provided data model is driven by how different a utility's model is from the information model included with the application. More configurations will be required because the variation from the included information model increases. The decision on whether to use the information model provided, extend the model, or use an existing model will be dependent on the data requirements, willingness of a utility to adopt an industry standard, willingness to potentially modify the existing processes and workflows, resources available to implement the solution, and the implementation approach—out-of-the-box versus customization or somewhere in between.

Appendix C: ArcGIS Online Deployment Considerations

ArcGIS Online offers three options for managing and sharing content:

- Fully hosted deployment—Using ArcGIS Online for both its SaaS and data storage capabilities with no on-premises data
- On-premises deployment—Using ArcGIS Online for only its SaaS capabilities, with data being stored on -premises
- Hybrid deployment—Using ArcGIS Online for both its SaaS and data storage capabilities and using on-premises data

Fully Hosted Deployment

The first option is using **ArcGIS Online** to host some or all of an organization's geospatial content. When hosting data in ArcGIS Online, hosted feature and tile services are used to manage the spatial data. Feature services support vector feature querying, visualization, and editing. As an example, a feature service might contain information about hydrants. Each feature represents a single fire hydrant and includes the manufacturer, installation date, and condition. Users could update the information in the feature services accessing a web map in a web browser, on mobile devices, or in ArcGIS for Desktop.

Feature services are most appropriate for operational layers that go on top of reference layers such as a basemap. Tile services are typically used for basemaps. However, a water utility could use the basemaps provided by ArcGIS Online. Hosted feature and tile services are created in ArcGIS Online using ArcGIS for Desktop. Data can be periodically transferred from ArcGIS Online to the local network and vice versa.

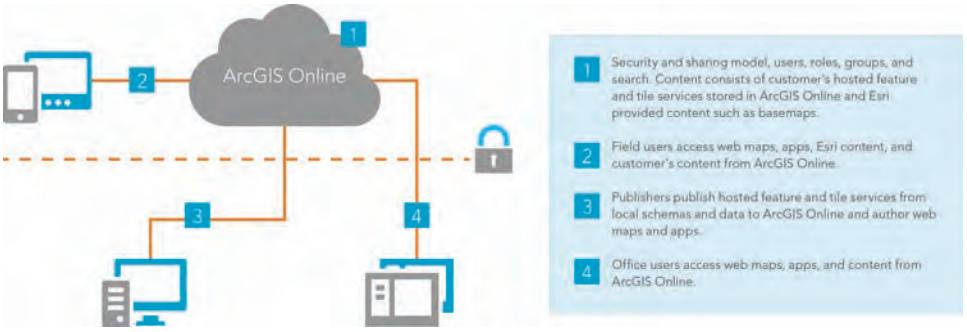

Figure 11: Fully Hosted ArcGIS Online Deployment Architecture

On-Premises Deployment

The second option is using the portal capabilities of ArcGIS Online with data provided from the utility's on-premises GIS deployment. While this is a deployment option, using ArcGIS Online as a mapping portal does not require storing data in ArcGIS Online, so for this option, the utility would store none of its own data in the cloud.

This option requires communication between the on-premises GIS and ArcGIS Online. When a service is added from the on-premises system, the service's REST endpoint (URL) from ArcGIS for Server is registered with ArcGIS Online. When publishing a web map with a service from the on-premises server(s), the client (web browser, mobile device, or ArcGIS for Desktop) must be able to access that server to retrieve the information via the URL. In the office, when a user is on the local network, this is not an issue because the client will be able to access the URL. But users outside the office need to be provided with secure access to the local network to be able to access the URL.

There are several ways to ensure access to the URL for users away from the office, including accessing the local network through a virtual private network (VPN), configuring a reverse proxy web server within a perimeter network (also known as a demilitarized zone [DMZ] or a screened subnet), or replicate data to and publish the service from ArcGIS for Server in a DMZ that is not connected to the local network. ArcGIS Web Adaptor (IIS) can be deployed on a web server in the DMZ to serve as a proxy. Web maps that use on-premises services can also include content from services provided by ArcGIS Online such as a variety of basemaps, imagery, or demographics.

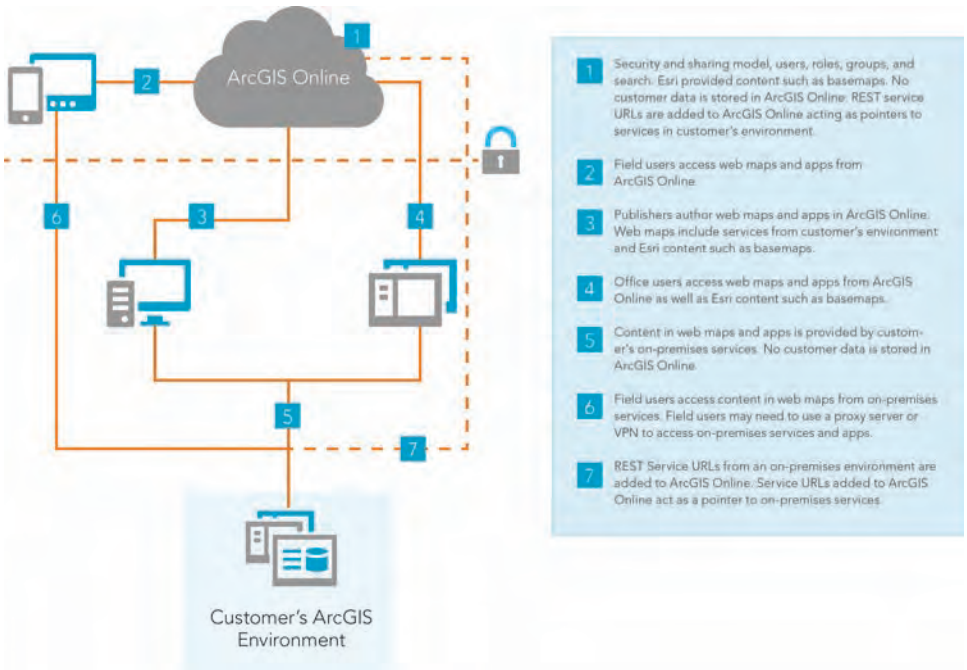

Figure 12: On-Premises ArcGIS Online Deployment Architecture

Hybrid Deployment

The most common ArcGIS Online approach is to use a hybrid of the two options described above—meaning that some of an organization's data that is accessible via its ArcGIS Online mapping portal is served by the on-premises GIS, and some of an organization's data is served as hosted data directly from ArcGIS Online. Using a hybrid approach gives water utilities the flexibility to use the platform in a variety of ways. Web maps can be created using services from on-premises servers, hosted feature services, and content provided by ArcGIS Online.

In some instances, a water utility may be required to use on-premises services when providing sensitive water network information to field workers, while in other instances, it may want to share nonsensitive information with other organizations such as hydrant data with fire departments or meter data with contractors installing customer services. Increasingly, water utilities are thinking about their data on a layer-by-layer basis to determine which data the organization deems appropriate to store only on-premises or store in a SaaS system.

Therefore, the only difference between the on-premises deployment and the hybrid deployment of ArcGIS Online is that publishers can publish data in ArcGIS Online in the form of hosted feature or tile services. Some data resides in ArcGIS Online and some is provided by REST services in the on-premises environment. (items 1–4 in figure 13).

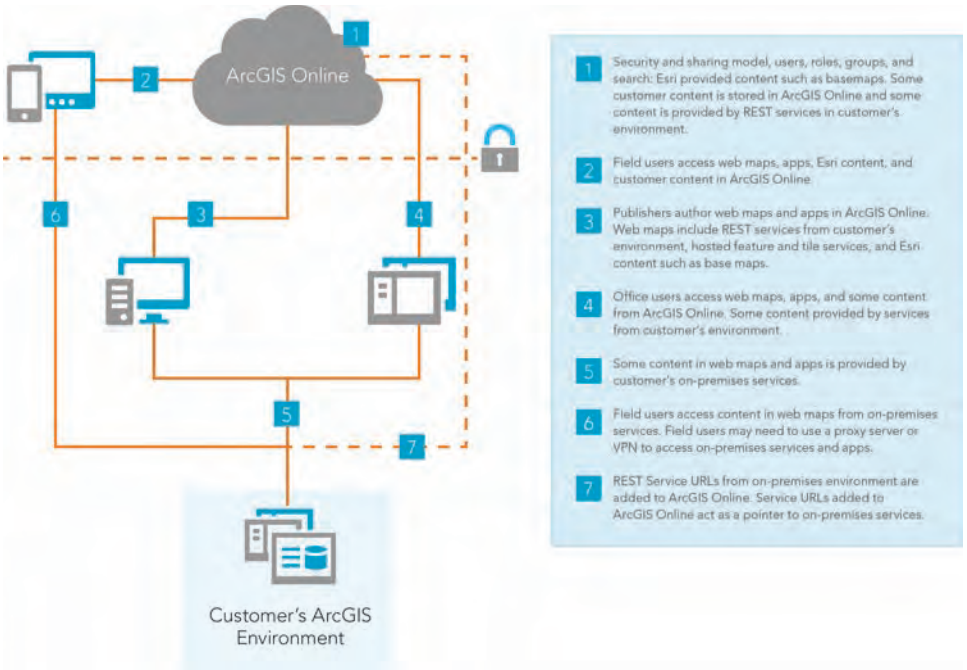

Figure 13: Hybrid ArcGIS Online Deployment Architecture

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