Implementing ArcGIS® for Water Utilities

An Esri® White Paper
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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 the utility 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, extendable to support enterprise-wide workflows, support multiple implementation patterns, and have a robust ecosystem of partner solutions and implementers.

Esri® ArcGIS® software is the geography 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 in 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 stormwater 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

Five common solution patterns of GIS form a framework to align water utility business needs with ArcGIS platform technology. Each pattern denotes a functional element of an enterprise GIS. These are asset management, planning and analysis, field mobility, operational awareness, and constituent engagement.

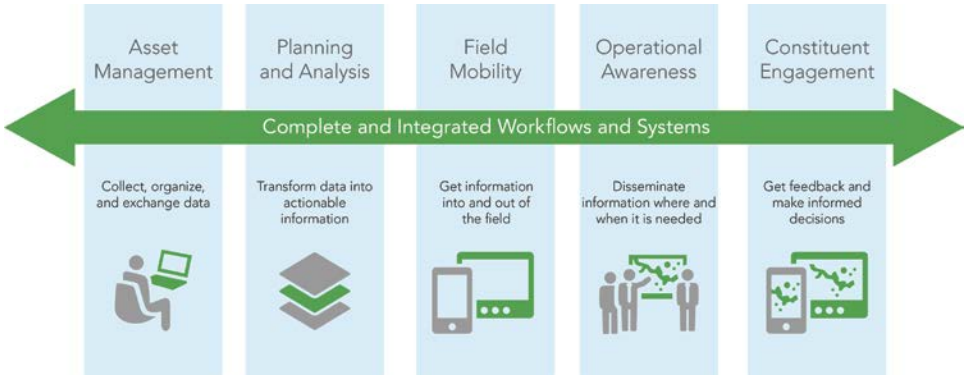

Figure 1: Solution Patterns of GIS for Water Utilities

Asset Management

GIS solutions for asset management include the process for storing, managing, and accessing spatial data. For water utilities, this is the authoritative repository for asset data such as pipes, valves, hydrants, meters, and other network features, as well as operational data such as pressure zones, work routes, main breaks, and inspection locations. Asset 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.
- Procedures to conduct quality control checks.
- Procedures to manage multiuser editing.

Sound asset management practices provide the foundation for the sustainable management of water, wastewater, and stormwater infrastructure.

Planning and Analysis

GIS solutions for planning and analysis involve transforming raw data into actionable information through the application of analytical techniques. 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 the two most common are through scripts and models. 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. 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 order, 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 into 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.

Operational Awareness

An up-to-date and accurate picture of organizational activities and projects is a critical component to understanding current operational status. Operational awareness applications are sometimes referred to as common operating pictures (COPs), operational dashboards, or executive dashboards, and they provide windows into relevant information supporting intelligent decision making. This information becomes obvious through proper planning and analysis techniques, collected in part from the field on mobile devices, and created and stored in the geodatabase. From a technology perspective, this pattern involves the combination of both 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 (i.e., executive and non-GIS domain levels) but is often 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.

These patterns are interwoven. Several enterprise-wide workflows are supported by two or more of these common solutions patterns of GIS. For example, responding to a water main break may leverage all five patterns through the various stages of the event. Also, these workflows do not rely solely on GIS information. Many of these crosscutting workflows will require information from other enterprise systems. Since the vast majority of data at a water utility has a spatial component (e.g., assets, customers, service areas, work locations), location can be effectively utilized as the common factor to bring information from other enterprise systems together in a map.

To overcome the common water utility challenges and support the common solutions patterns of GIS, utilities need a single geospatial platform. This single geospatial platform is ArcGIS and the configuration of the platform for water utilities is called ArcGIS for Water Utilities. ArcGIS for Water Utilities is a configurable COTS technology that supports foundational needs, integrates enterprise workflows by geoenabling other enterprise systems, and can be deployed on top of a variety of enterprise deployment patterns. This white paper provides an overview of the ArcGIS platform, describes ArcGIS for Water Utilities, and offers a best practice implementation approach using several solution examples.

ArcGIS Platform

The architecture of the ArcGIS platform and ArcGIS for Water Utilities (figure 2) consists of the following:

- At the foundation of the platform is **infrastructure** consisting of hardware and operating systems. This can be hosted or on-premises.

- **Content and capability** refers to GIS servers and the functionality they expose, as well as databases and file systems where content is stored. In the case of ArcGIS℠ Online, Esri's software-as-a-service (SaaS) system, content, capability, and infrastructure are all combined.

- **Application programming interfaces (APIs)** and **software development kits (SDKs)** expose interfaces to ArcGIS capability and are used to construct the elements of subsequent tiers. This includes ArcGIS API for JavaScript as well as ArcGIS Runtime SDKs and ArcObjects™ software. Esri, Esri partners, and customers can use these APIs and SDKs to extend ArcGIS and build new application templates and focused applications.

- The **application and content management** tier consists of ArcGIS portal technology, including both ArcGIS Online and Portal for ArcGIS, an ArcGIS for Server extension. ArcGIS Online is the SaaS implementation of Esri's portal technology, whereas Portal for ArcGIS is implemented on-premises. In each case, ArcGIS portal technology serves to govern access to content and ties in with web-based and federated identity management capabilities.

- The **solutions** tier is composed of configurations of the ArcGIS core technology provided by the tiers below it in the diagram. ArcGIS for Water Utilities is a set of configurable solutions for water, wastewater, and stormwater utilities. These solutions provide focused applications supporting common water utility business needs and workflows. The solutions tier consists of the content and capabilities of the platform that deliver their business value to the enterprise.

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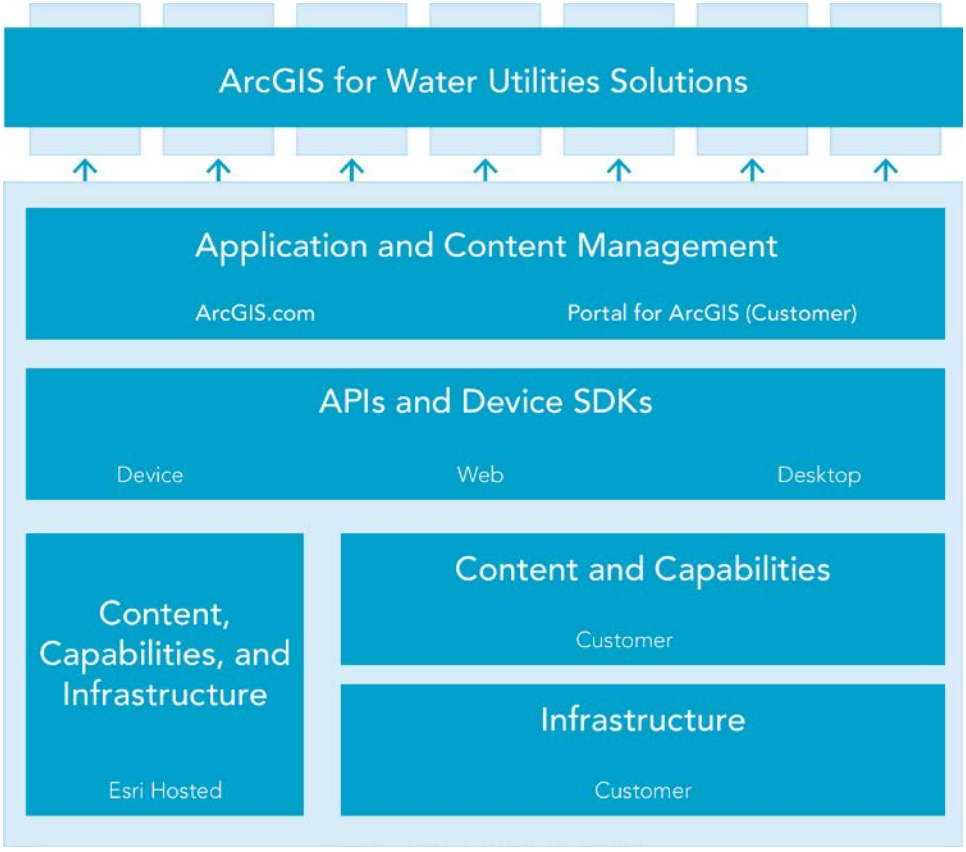

Figure 2: The ArcGIS platform delivers business value to water utilities.

The ArcGIS platform gives water utilities significant advantages, allowing the easy sharing of information with mobile users, 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 time to deployment, 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 five 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 configuration, meaning that it 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 stormwater organizations by making it easier to deploy ArcGIS and quickly deliver GIS content and applications throughout the entire organization. This

gives water utilities a geospatial platform that can be leveraged by everyone in the organization, regardless of his or her 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 and are freely available for water utilities to deploy on their Esri licensing platform. Esri fully supports these maps and apps 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 few 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** (solutions.arcgis.com/local-government/water-utilities/help/network-editing) tools can be used by mapping technicians to maintain comprehensive water distribution, wastewater, and stormwater records. The toolbars contain a series of editing and reporting tools that accelerate data editing speed when working with infrastructure data.

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

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

- **Map Change Request** (solutions.arcgis.com/utilities/water/help/map-change-request) is a configuration of ArcGIS Online for use on a mobile device with the Collector for ArcGIS application. The 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.

- **Proposed Water Design** (solutions.arcgis.com/utilities/water/help/proposed-water-design) is a configuration of ArcGIS Online for water engineers and developers to quickly sketch in proposed water infrastructure projects using a web app.

Designing and Planning for Capital Improvement Projects

The Water Utility Capital Improvement Planning app configuration 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, **Capital Improvement Planning** (solutions.arcgis.com/utilities/water/help/capital-improvement-planning), to rate the condition of infrastructure networks and estimate the cost of capital improvement projects.

For publishing and sharing this data, ArcGIS for Water Utilities includes a set of configurable web applications for sharing project information internally and/or externally, for example, pavement coordination for sharing internally and/or communication for sharing externally to inform the public about where projects are occurring or planning to occur.

- **Capital Projects** (solutions.arcgis.com/utilities/water/help/capital-projects) is designed to be consumed by the public as an ArcGIS Online web app or as an embedded map on the utility's website. This app is configurable to inform customers of how and where money is being spent by showing capital projects in the service area.

- **Pavement Project Coordination** (solutions.arcgis.com/utilities/water/help/pavement-project) is a configuration of ArcGIS Online for use by the utility and other local agencies. The series of interactive maps enable agencies to add and edit project information, as well as view other pavement projects within the service area.

Optimizing Field Operations

ArcGIS for Water Utilities includes a collection of maps and apps that enable field mobility to be used by 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 to respond to main breaks, maintain fire hydrants, exercise valves, inspect manholes, and capture field notes or request map changes. These applications are configurations of ArcGIS Online for use on a mobile device with the Collector for ArcGIS application and have been designed to be easy to use, work on smartphones and tablets, and automatically synchronize field data with the office.

Understanding the Status of Operations

An example of understanding the status of operations with ArcGIS for Water Utilities is our Water Conservation solution suite (solutions.arcgis.com/utilities/water/water-conservation), which includes apps for green infrastructure verification, leak and main break response, and issuing watering violations using ArcGIS Online and Collector for ArcGIS applications. Operations managers can view the progress and results of these field operations using the **Water Conservation Dashboard** (solutions.arcgis.com/utilities/water/help/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 data with statistics, 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.

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 into 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 **Citizen Service Request** (solutions.arcgis.com/utilities/water/help/citizen-service-request) application allows the general public to submit requests for service in their community from a smartphone, tablet, or desktop computer.

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

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

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 for technologies, such as Microsoft Office, SharePoint, IBM Cognos, SAP, Salesforce.com, or 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, a significant amount of cost and time is saved on design and development that would otherwise be required 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 agilely add new capabilities in the form of new platform and app capabilities.
- Reducing the risk of version lock.
- 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 customers and stakeholders.

Implementing Strategy

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 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 agilely.

The order in which the ArcGIS components get deployed and which maps and apps of the ArcGIS for Water Utilities solution are implemented 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 result in 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 if 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 required to close those gaps. Communicate this information to your business managers. In many cases, you'll find that using an existing solution that can be readily deployed meeting 80 percent of the requirements will suffice versus the time and effort it will take to create a new custom application that meets 100 percent of the requirements.

d. Determine if 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, 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 of 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 should be periodically reviewed as well as solutions that are already implemented. 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, but do consider the level of effort as part of the needs-prioritization process, look for quick wins, and get started deploying solutions.

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Step 2: Deploy Your Mapping Portal

Every water utility needs to share and collaborate around its organization's information, which typically exists in multiple enterprise systems and 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 (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 was time-consuming. Now, deploying the mapping portal immediately gives utilities ready-to-use applications, integration capabilities, spatial analysis capabilities, and data resources, providing the foundation to immediately put 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 pop-up window content (including controls). The web map is consumable by all ArcGIS APIs, SDKs, and applications and so enables consumption of the same content with the same rendering and same 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. It uses an identity management framework that enables sharing of these items to 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 your organization
- Organizing map services and author 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 your 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 and share maps from their spreadsheets. 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.

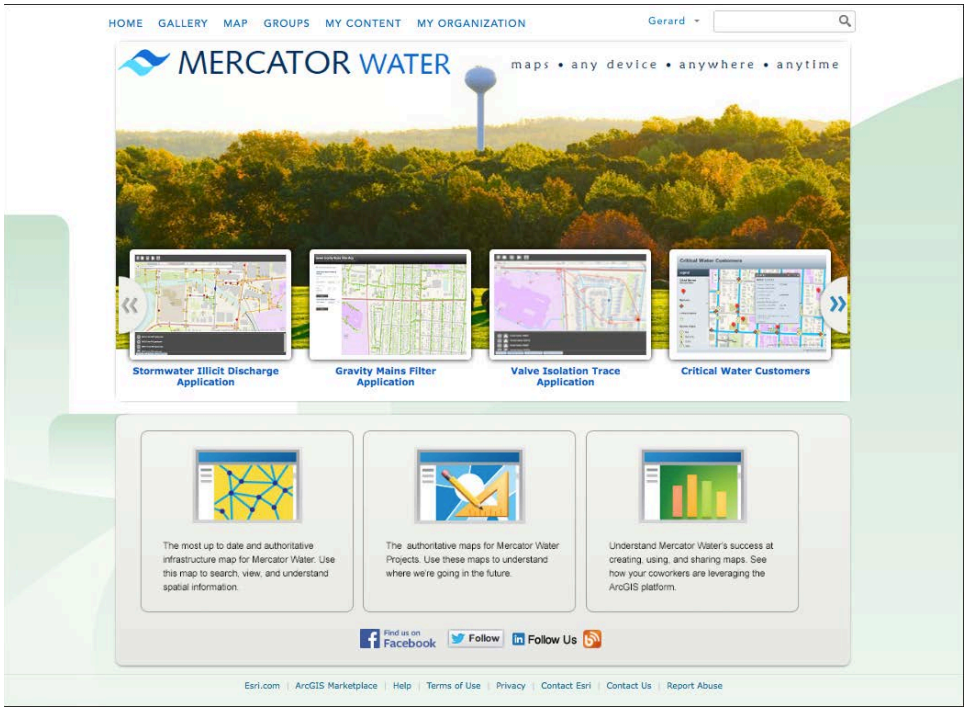

Figure 3: Deliver Useful Maps and Apps to Your Organization through Your Mapping Portal

As mentioned above, there are two portal options: **ArcGIS Online** and **Portal for ArcGIS**. ArcGIS Online (doc.arcgis.com/en/arcgis-online/reference/what-is-agol.htm) 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.

Portal for ArcGIS (esri.com/software/arcgis/arcgisserver/extensions/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 also play a role in determining which options 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.

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 from utility to utility 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 to 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 2, utilities can quickly put meaningful apps in 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 new 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.

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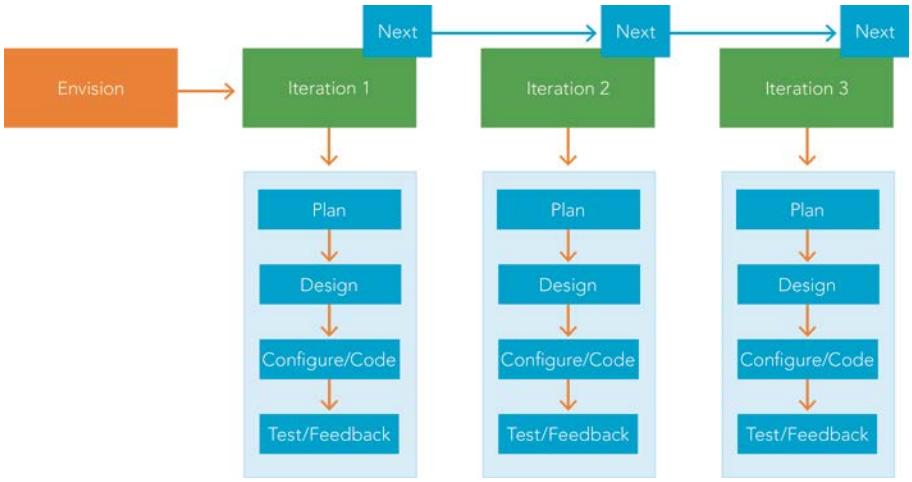

Figure 4: Agile Approach to ArcGIS for Water Utilities Implementation

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 from more 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 take into consideration what the existing on-premises GIS can support (if there is one), 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 (solutions.arcgis.com/utilities/water/water-conservation) including responding to main breaks, issuing water violations, and managing green infrastructure and rebates. The solution suite also includes a dashboard configuration, bringing all the information related to the program into one comprehensive view for managers and executives.

For this example, it is assumed that the locations of main breaks, water violations, and green infrastructure do not currently exist, and these types of data are not considered to be sensitive. Also, on-premises servers have not been enabled to communicate with

ArcGIS Online. However, if some of this information did exist, it could be migrated to the app data models or created from spreadsheet data using Esri Maps for Office (doc.arcgis.com/en/maps-for-office), which allows you to quickly create dynamic, interactive maps of your Excel data.

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—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 using 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.

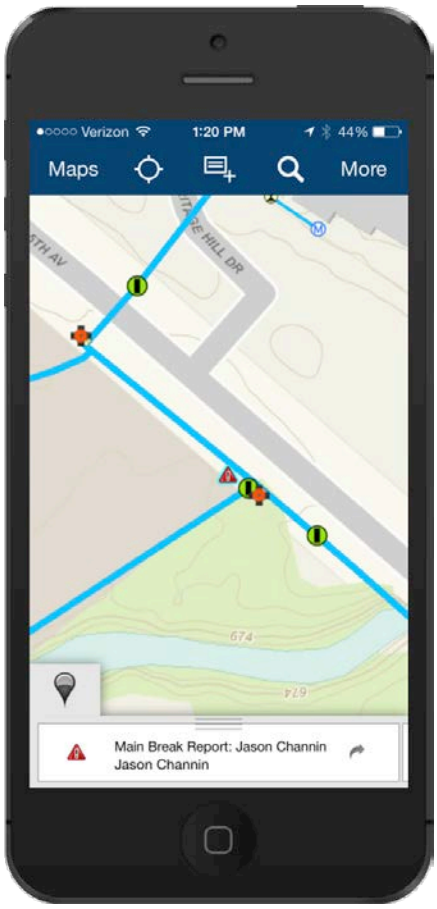

Figure 5: Collect Main Break Locations and Information

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 (solutions.arcgis.com/utilities/water/help/network-editing). Previously, this was often the first, most expensive, and longest 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 the water conservation example, and then utilize ArcGIS to manage asset information in a later deployment iteration.

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 application is already 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, complete the following steps:

- 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**: The 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 included in the configuration that control 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 the current data and time of an edit.

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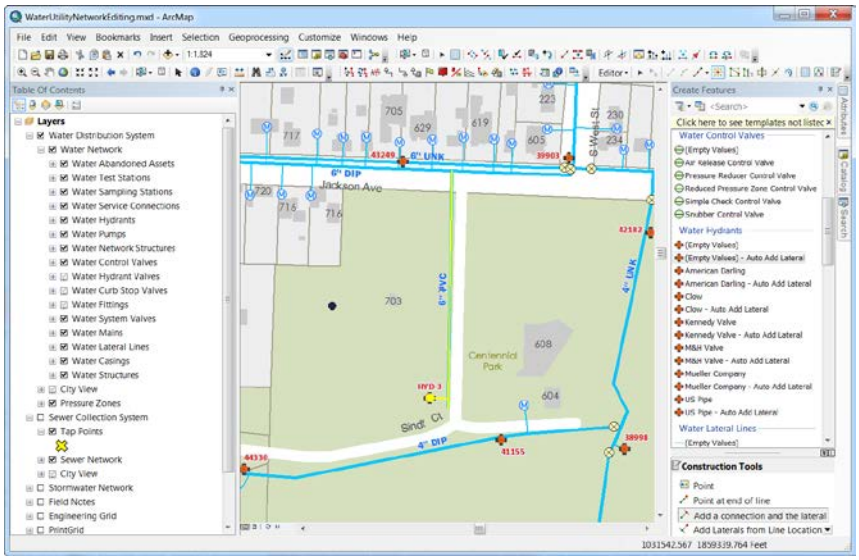

Figure 6: Maintaining Your Water Utility Network Data

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 field 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 had 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 add a tremendous amount of value to a water utility:

- Staff members can locate their assets in the field.
- They 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 services, feature services, image services, geoprocessing services, 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 for monitoring, tracking, and reporting an event or system of events across a group of people within an organization. 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) such as the following:

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

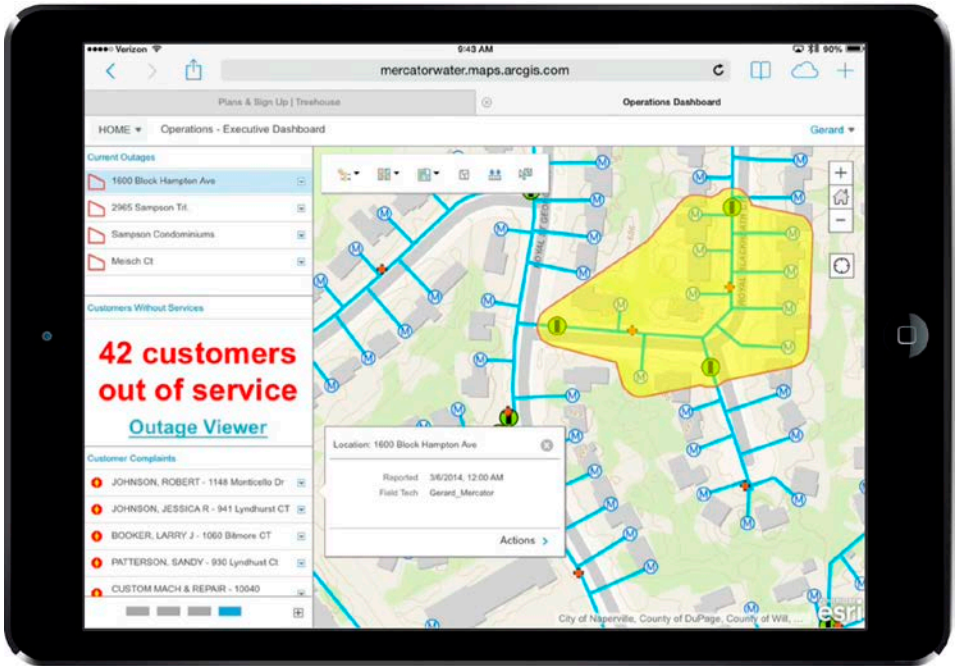

Figure 7: Understand the Status of Your Water Utility Operations

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 through custom development or facilitated through 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 increasingly becoming more common through EAM vendors providing their own COTS integration with ArcGIS using standard web services. In some cases, they even embed ArcGIS web maps within their own systems. In cases where COTS integrations are not available, water utilities are successfully using ETL-based integration for situations where real-time information exchange is not required. These integrations are less expensive to configure (versus develop) and are easier to maintain. Figure 8 illustrates a contemporary GIS-EAM workflow. ArcGIS Online brings together information from both systems and makes it available to field and office users.

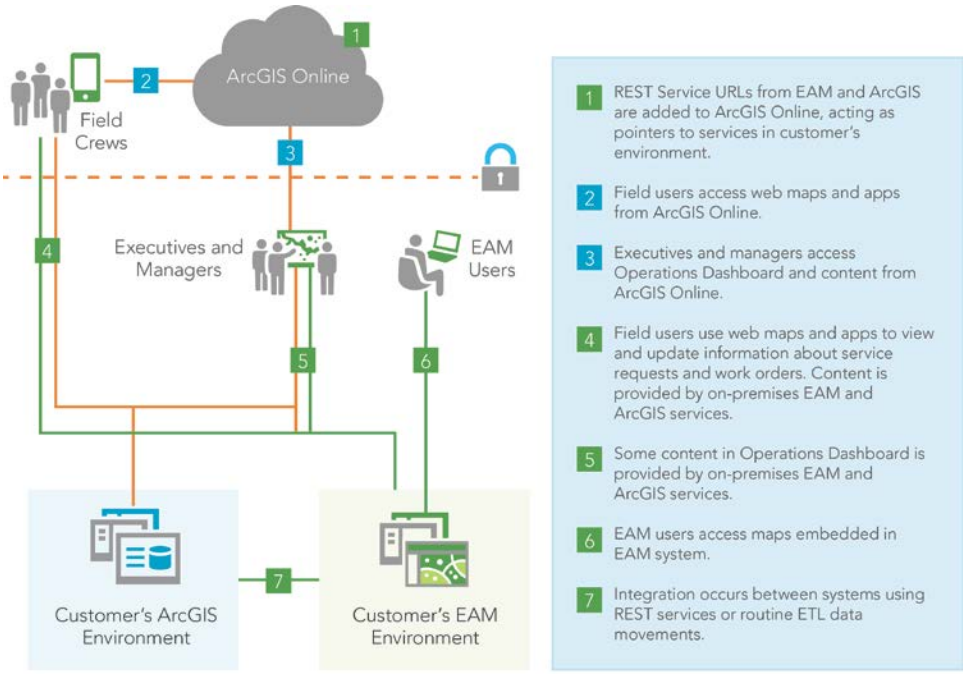

Figure 8: GIS and EAM Workflow with ArcGIS Online

Example 4: Maximizing Cost Recovery

Identifying where theft may be occurring, where meters are not registering, or potential data errors, can help utilities better recover costs. The ability to show customer consumption information on the map provides utilities with the capabilities to analyze spatial patterns. This helps managers identify meters to inspect for accuracy or signs of tampering or theft. They can also see potential data errors in the billing system.

As mentioned previously, a common method of integrating enterprise systems is to use 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 to bring data from the CIS into ArcGIS, support water conversation 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 extraction (daily or weekly) from the CIS is adequate for updating the GIS. However, with the emergence of smart water grid technologies such as Automated Meter Infrastructure (AMI), increasingly, data is available at more frequent intervals (15 minutes, hourly, 4 hours, etc.).

To update on a more frequent basis or in real time, another option for integration is **ArcGIS GeoEvent Extension for Server** (esri.com/software/arcgis/arcgisserver/extensions/geoevent-extension). GeoEvent Extension streams real-time data directly to ArcGIS clients (desktop, web, or mobile applications) or into a geodatabase. Using the CIS example, GeoEvent Extension is 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 streams the updates into GIS, making near real-time CIS data available to all users of the ArcGIS platform.

Summary

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 reduced planning, rapid prototyping using configuration, and quicker deployment using COTS applications. Additionally, by adopting a configure first and customize second approach, utilities can 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 five 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 does not require extensive consulting and development efforts.

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Ultimately, the intent is that a utility can find a suitable starting point and iterate through a series of manageable solution deployments. The outcomes are useful maps and apps that support everyday workflows. Additional planning information is provided in the appendixes. 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.

Appendix A: Migrating to ArcGIS for Water Utilities

Two fundamental scenarios show how the ArcGIS platform and ArcGIS for Water Utilities are implemented in a water utility. The first scenario is to start 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 is to migrate from a legacy ArcGIS implementation or other GIS technologies to ArcGIS for Water Utilities. Here the presence of existing systems may add more 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

Although these are undoubtedly important considerations, the ArcGIS platform and ArcGIS for Water Utilities have several characteristics that reduce these risks 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, 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.

- Several proven integration methods 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 have been designed to be both configurable and task focused. These two features are incredibly important because they enable water utilities to implement solutions in an agile manner. An agile approach has many benefits. Also consider that water utilities can tailor the deployment of solutions through configuration and eliminate the need to deploy everything at once. 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 ArcGIS for Water Utilities app configuration includes an information model, the included information model is not required. An app can 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** (solutions.arcgis.com/utilities/water/help/network-editing) tools, the model can be more complex. One of the primary benefits to using the included information models is that the apps are already configured to work with that information model. So using the included information models significantly speeds up app deployment.

If a utility chooses to use a different information model, then additional effort will have to be put into modifying the apps to work with a different information model. Two additional benefits of using the included information models are that they embody best practices for using a mapping platform to accomplish a given workflow and time does not need to be spent performing data modeling exercises.

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

- A utility is migrating geospatial data from another non-ArcGIS 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.

A utility's decision to use the included preconfigured information models is often based on having previously benefited from other industry-standard data models. ArcGIS for Water Utility information models minimize change to these types of models. 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.

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ArcGIS for Water Utility information models can be extended to support those unique requirements. This involves adding features or fields and leaving the rest of the model as is. To migrate to the information model provided with the application, first conduct an analysis of the utility's data requirements. Next, if warranted, extend the included information model. Finally, complete 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 if it has applications or system integration dependencies on its existing information model. Any app can be configured for any information model, assuming 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 amount of effort it takes to customize the ArcGIS for Water Utilities apps is driven by how different a utility's data model is from the information model included with the application. Greater variations from the included information model increase the configurations that will be required. The decision on whether to use the provided information model to extend the model or to use an existing model depends on the utility's data requirements, willingness to adopt an industry standard, and willingness to potentially modify the existing processes and workflows, as well as resources available to implement the solution. The implementation approach—out-of-the-box, customized, or a blend—also makes a difference.

Appendix C: ArcGIS Deployment Considerations

ArcGIS offers three options for managing and sharing content:

1. Fully Hosted Deployment: Using ArcGIS Online for both its SaaS and data storage capabilities with no on-premises data.

2. On-Premises Deployment: Using ArcGIS Online for only its SaaS capabilities; data is stored on-premises.

3. 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. For example, a feature service might contain information about hydrants. Each feature represents a single fire hydrant and includes the manufacturer, date installed, and condition. Users can 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 using ArcGIS for Desktop and shared via ArcGIS Online. Data can be periodically transferred from ArcGIS Online to the local network and vice versa.

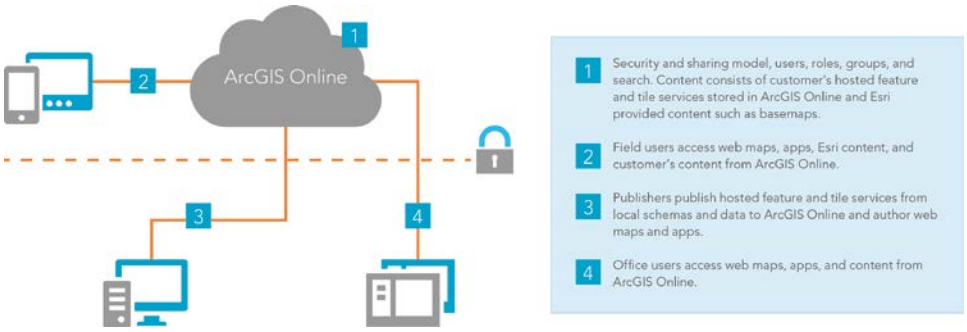

Figure 9: Fully Hosted ArcGIS Online Deployment Architecture

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 it 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 the 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 of 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 accomplish 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 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. The ArcGIS for Server Web Adapter 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.

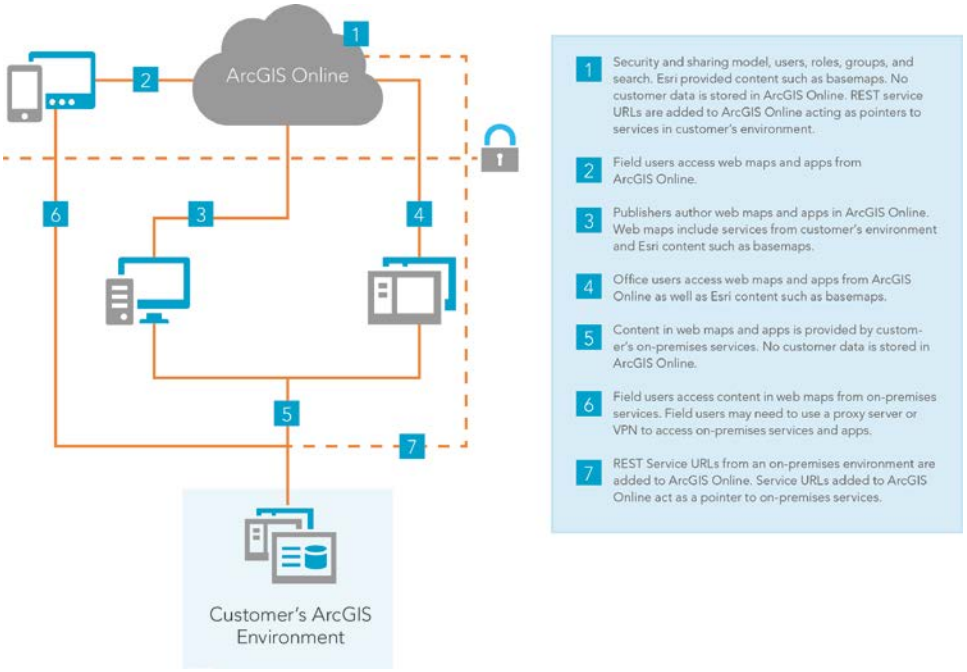

Figure 10: On-Premises ArcGIS Online Deployment Architecture

Hybrid Deployment

The third option is the most common ArcGIS Online approach. It is a hybrid of the two previous options. Some of an organization's data is accessible via its ArcGIS Online mapping portal and is served by the on-premises GIS. Other data is served as hosted data directly from ArcGIS Online. Using a hybrid approach, water utilities have full flexibility to use the platform in a variety of different ways. Web map users create content by using services from on-premises servers and hosted feature services, as well as content provided by ArcGIS Online.

In some instances when providing sensitive water network information to field-workers, utilities will use on-premises services. In other instances, they 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 hybrid deployment of ArcGIS Online is that publishers can publish data to ArcGIS Online in the form of hosted feature or tile services. Some utility data resides in ArcGIS Online and users can access some of their data via the ArcGIS Online portal (items 1–4 in figure 11).

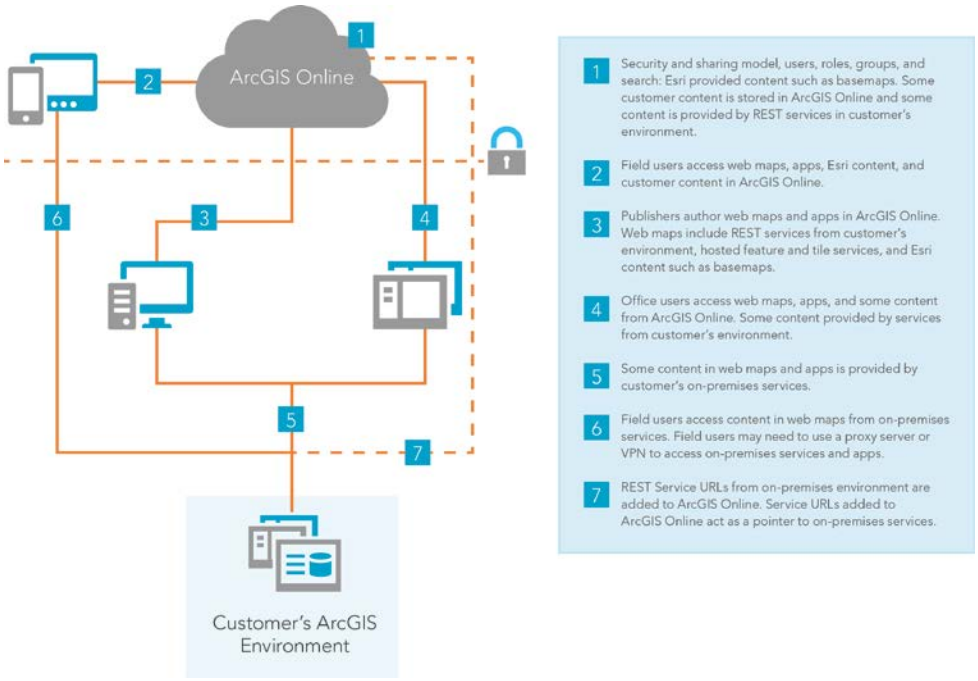

Figure 11: Hybrid ArcGIS Online Deployment Architecture

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