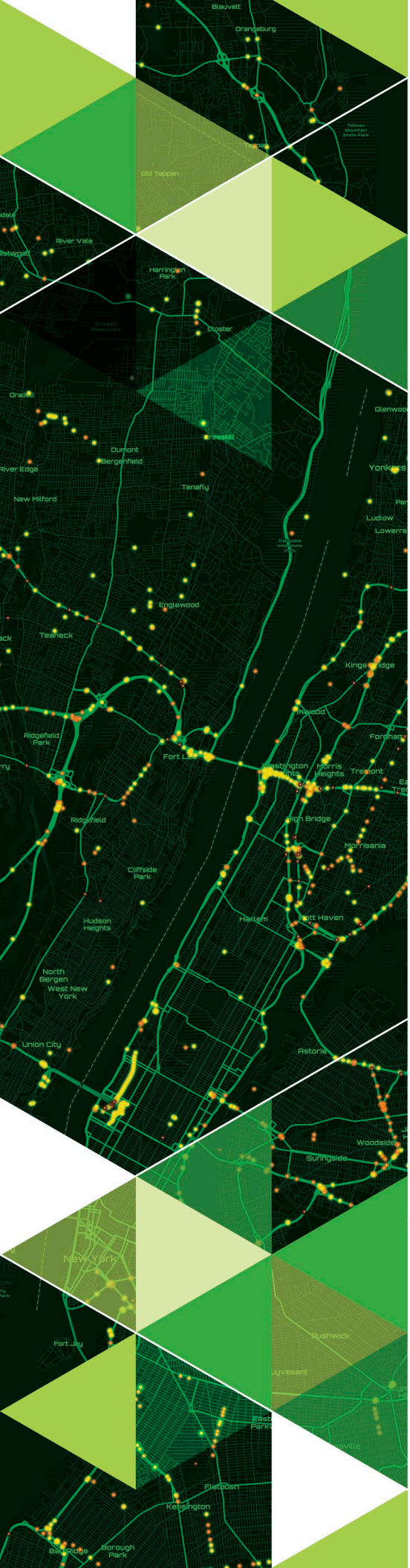

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Understanding the ArcGIS Utility Network: A Guide for Water Utilities

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Understanding the ArcGIS Utility Network: A Guide for Water Utilities

Executive Summary

Water utilities today face myriad challenges including coordinating daily operations, responding to customer service requests, asset management, and responding to emergencies. To help address these challenges, Esri has developed next generation data models and tools delivered via ArcGIS® software and the ArcGIS Utility Network.

ArcGIS and the Utility Network provide the foundation for creating a digital twin of a utility's infrastructure and promote modern network management practices. Improved data design enables utilities to model their assets in detail while maintaining a highly performant web-based geographic information system (GIS) experience for end users. Next generation analysis tools provide enhanced capabilities for tracing and visualizing network information. Analysis results and asset information can be shared across the entire organization in real time. This provides an up-to-date and accurate operational view of the system, enabling more efficient workflows and better decision-making.

ArcGIS provides a centralized system of record that can be accessed by properly credentialed users on any device at any time. This access to information by staff in the office or the field results in increased efficiencies in operations, planning projects, and emergency response. ArcGIS can also be connected with other enterprise business systems such as customer billing, work order management, and SCADA for a fully integrated operational view in real time. Connecting ArcGIS to other enterprise systems breathes life into a utility's digital twin by breaking down data silos and making all your enterprise systems information available and findable in one location and provided with the spatial context of a map.

The Utility Network enables utilities to not only store the location and associated information of assets but also model internal configurations of complex assemblies such as pump houses, meter pits, and valve assemblies. Network connectivity of assets within complex assemblies is maintained, yet assets within assemblies can be hidden from view to keep maps from becoming cluttered.

The Utility Network is designed to allow new levels of specification in analysis such as identifying areas of water loss or determining valves to close in the event of a water main break. Assets and customers affected by outages can also be identified. Subnetwork management enables the isolation of subsets of the network based on common attributes such as pressure. This drives additional analysis capabilities and visualizations of the network.

Network diagrams can be created from the Utility Network that provide a schematic view of network connections. These diagrams deliver a clear visualization of connectivity and relationships between features in the network that is not always apparent in a traditional map view.

Benefits of the ArcGIS Utility Network

With ArcGIS and the Utility Network, utilities can store, manage, and analyze their asset information. Asset information and analysis capabilities are delivered to staff in the office and the field via desktop, web, and mobile apps. Analytical tools give staff actionable information for planning projects, operational oversight, and responding to emergencies. This enables more informed decision-making and improved efficiency in overall operations.

Key benefits of ArcGIS and Utility Network include the following:

- Access information and network intelligence from any device.
- Store and manage asset information using detailed industry-standard data models.
- Use powerful analysis tools that answer questions and enable informed decision-making.

Access information from any device

Utility network data is accessible by staff in the office and the field. This provides asset information and network analysis capabilities to office staff on local networks and field staff with access to the web via Wi-Fi or cellular connections. Asset information in the utility network can be accessed via web browsers, desktop apps, mobile apps, Esri® partner solutions, APIs, and other clients. By taking advantage of these access capabilities, changes to the network updated from the office or the field can be validated and seamlessly incorporated to provide staff with up-to-date and accurate information at all times. This seamless transfer of information to and from the field greatly enhances efficiency and improves the visibility of the overall operating picture.

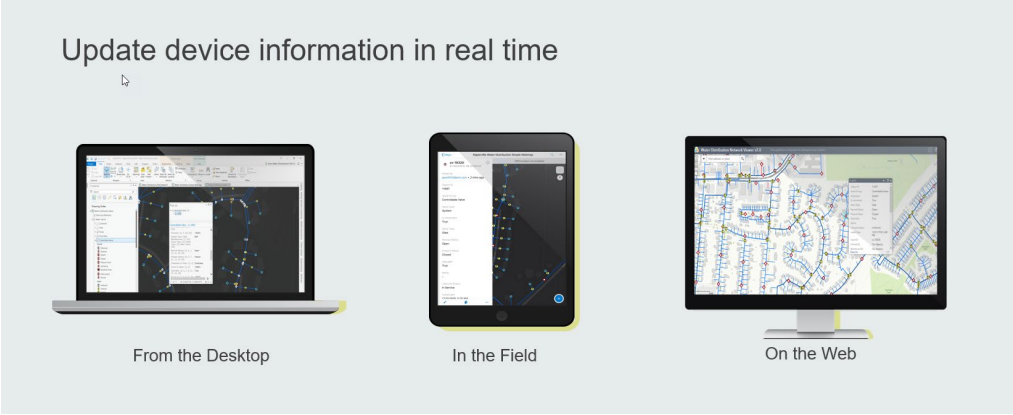


Figure 1: Asset information in Utility Network can be accessed and updated from any device, anywhere, anytime.

A common use case for water utilities is the exchange of information during a water main break or outage. Crews responding to a break can quickly identify valves to close to stop the flow of water and isolate the damaged section of pipe using tracing analysis on a mobile device using the ArcGIS Field Maps mobile app or from a web browser. As crews perform work and close valves, they can set the status of the valve to closed on their mobile device. The valve's status is then immediately visible to staff in the office, other field staff, or anyone using maps that contain those network assets.

Detailed data models ensure data integrity

Utility Network industry-specific data models (water, wastewater, and stormwater) are designed to provide fast, efficient data retrieval even with large datasets that contain highly detailed representations of assets in the real world. More granular asset modeling results in the ability to track asset history and maintenance records for individual components of assemblies. Examples include the components within pressure reducing valve (PRV) assemblies, pump houses, or meter stations.

Utilities can model the connectivity between features that are geometrically coincident as well as features that are offset. These connections between offset features enable optimized feature placement for display purposes. This also enables connectivity of features that are adjacent yet don't have a length of pipe connecting them such as adjoining features in a valve assembly.

While the Utility Network data model allows modeling features in greater detail, this can result in cluttered and difficult-to-read maps due to the density of features. Containers solve this problem by allowing dense clusters of features to be hidden from view within another feature. These features are only displayed when viewing this container. Example use cases for containers include pump stations, meter pits, and valve assemblies.

Figure 2: Features in containment can be hidden from view to declutter the map view.

A user-defined network rule base specifies exactly which type of features can be connected and associated with one another. For example, certain types of fittings are only allowed to connect to certain types of mains. The network rule base for the Utility

Network is referenced during editing operations to prevent the creation of incorrect connectivity and associations between features. Upon creation of a utility network with preexisting data, features that violate network rules are flagged on the map for correction. The creation of new features that do not adhere to network rules is not allowed.

ArcGIS uses attribute rules to streamline the editing experience and improve data integrity. Attribute rules are user defined and can be used to autopopulate attribute values, prevent invalid edits, and perform quality assurance checks. Attribute rules are used in tandem with existing geodatabase tools such as domains and subtypes for improved data consistency. Attribute rules are defined with ArcGIS Arcade scripting expressions. Arcade is an expression language that can be used across ArcGIS. To learn more about ArcGIS Arcade, see the ArcGIS Arcade web page.

Employ powerful analysis tools to answer questions and enable informed decision-making

ArcGIS and the Utility Network provide advanced analysis tools and capabilities that enable utilities to more easily detect patterns and answer questions that enable better decision-making. For example, tracing analysis can identify the valves that need to be closed to isolate an area in the event of a water main break. This can be done from the office or the field. Tracing analysis can also be used to identify customers and hydrants affected by water outages. Tracing analysis is made available to field crews via web apps and mobile apps with the out-of-the-box functionality of utility network services. This out-of-the-box tracing functionality removes the need for stand-alone tracing services that lack real time updates to network data and require regular maintenance.

Figure 3: Isolation tracing identifies valves to close to stop the flow of water to a portion of the network as well as to customers and hydrants affected by outages.

Subnetwork analysis

A utility network is a collection of subnetworks through which a commodity can flow. Examples of subnetworks include pressure zones, district metering areas (DMAs), and sewer basins. Subnetworks can be used to perform analysis such as summary statistics. Examples of summary statistics include a count of the total number of service connections, valves, or hydrants per pressure zone or total length of gravity main in a sewer basin.
Subnetworks can be updated when the state of the system changes such as when valves are opened and closed. Devices such as valves that define the extent of resource flow within a subnetwork are called subnetwork controllers. Examples of subnetwork controllers that could defines a pressure zone subnetwork are a pump or a pressure reducing valve.

Figure 4: Subnetworks enable pressure zones to be defined, visualized, and analyzed. This dashboard shows water consumption by pressure zone.

Network Diagrams

The ArcGIS Utility Network provides integrated tools for creating and interacting with network diagrams. Network diagrams provide a schematic representation of the network and help to visualize how assets are connected. Diagrams can be created from the results of a tracing analysis or any features selected on the map.

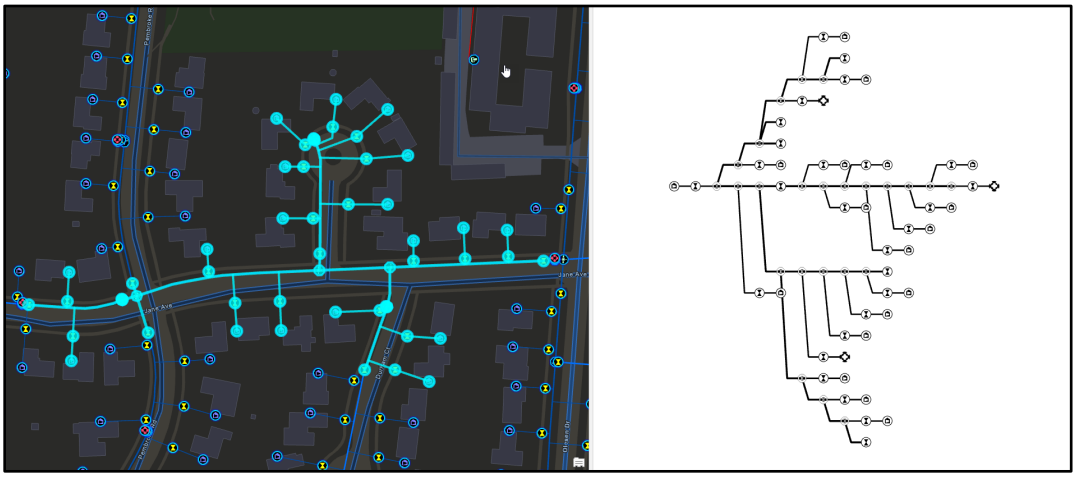


Figure 5: Network diagrams can be used to identify dead ends in the network or understand connectivity in an area experiencing an outage.

Solutions

ArcGIS Solutions is a collection of industry-focused data models, maps, apps, and tools that helps address challenges in your organization. The solutions leverage your authoritative data and are designed to improve operations, provide new insight, and enhance services.

Utility Network solutions for ArcGIS are available for utilities that manage water distribution, sewer, and stormwater networks. Detailed descriptions of Utility Network solutions, functionality, and deployment instructions can be found on Esri's ArcGIS Solutions site using the links below:

- Water Distribution
- Sewer
- Stormwater

A utility network data model or schema can be created and configured manually to meet a utility's asset management requirements, business demands, and asset modeling needs. However, this involves a high level of effort and familiarity with Utility Network components and functionality. To streamline utility network implementations, Esri provides industry-specific data configurations for water distribution, sewer collection, and stormwater as asset packages. The asset packages provide an industry-specific data model that includes asset classification, network rules, network definitions, and subnetwork properties. Asset packages are delivered as file geodatabases and can be extended as needed. Removing features and fields from the asset package schema is not recommended as it may affect functionality built into current and future Esri Utility Network solutions.

System Architecture and Software Requirements

ArcGIS Utility Network features and information are stored in an enterprise geodatabase and shared through services published to ArcGIS Enterprise. Utility network features and information can then be accessed and managed via those services with ArcGIS Pro desktop software or in web maps via a web browser or mobile devices.

The enterprise database required to store the utility network can be deployed in Oracle, SQL Server, SAP HANA, or PostgreSQL. Utility network capabilities such as editing and performing analysis are enabled by the ArcGIS Utility Network user type extension. Users without the ArcGIS Utility Network user type extension can still view and query Utility Network data in web maps and applications.

Due to the added intelligence and capabilities of the utility network, additional system architecture resources are recommended beyond a standard Enterprise base deployment. The recommended approach is to extend an Enterprise base deployment with an additional instance of ArcGIS Server with it's own dedicated server machine (physical or virtual) and resources to support utility network services. With a dedicated ArcGIS Server instance, you provide dedicated memory and request processing capacity to the utility network services to ensure proper system performance. This also allows for scalability of resources and independent software version management at the server tier.

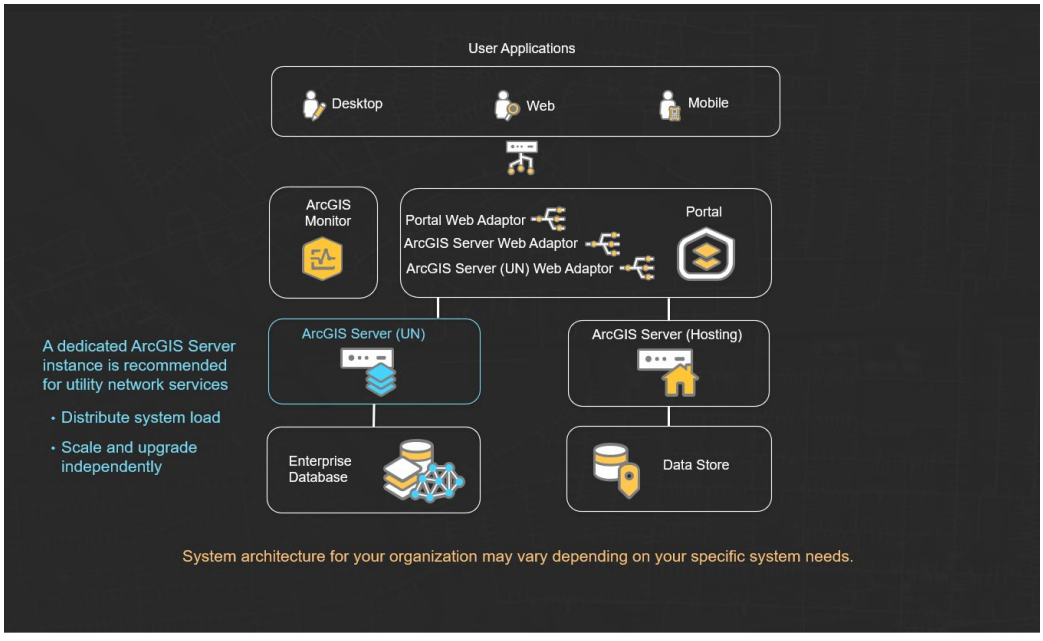


Figure 6: Example ArcGIS Enterprise system architecture with dedicated ArcGIS Server for Utility Network Services

For further guidance on deploying ArcGIS Enterprise and system requirements, see the Esri technical paper Architecting the ArcGIS System: Best Practices.

Implementing ArcGIS Utility Network

When implementing ArcGIS Utility Network for your organization, a number of important factors must be considered. Ensuring data quality, planning migration strategies, and documenting current workflows are key examples of these. With planning and close attention to the factors listed here, your Utility Network implementation will go smoothly and efficiently.

1 Ensure data quality

When implementing a utility network with preexisting data, issues with your current data may be exposed, particularly when it comes to a lack of connectivity between features or missing information. Therefore, we recommend performing rigorous data quality checks and data cleanup prior to migration. Doing so will make data migration smoother and overall network implementation easier.

ArcGIS Solutions for Water includes tools and workflows for cleaning up your data using ArcMap™ and the ArcGIS Data Reviewer extension. For more information, please see the Data Reviewer for Water Utilities solution page.

2 Document data migration strategies

It is very important to understand the differences between your current data schema and the industry-specific utility network data models. Be sure to familiarize yourself with the data models for your industry(s), and document migration strategies to transfer your data into the utility network data models as well as fields and domains you want to include.

Esri can provide sample workbenches for the Data Interoperability extension and FME to assist with migration. These are based on the migration of data using the Local Government Information Model schema. If your utility's data is in that schema, these tools could greatly reduce the level of effort needed for migration strategy planning.

Another option to aid in the migration process is the use of Data Loading tools.

3 Start using ArcGIS Pro

If your organization or department has not started using ArcGIS Pro, now is the time! You will need to use ArcGIS Pro to create and administer your utility network. ArcGIS Pro is the primary client for editing and analyzing data in the utility network. There are many valuable resources to learn about ArcGIS Pro on the Esri Academy site, including the free web course Getting Started with ArcGIS Pro. Another great training resource is the Learn ArcGIS site.

It is important to note that ArcMap can manage and edit geometric networks, and ArcGIS Pro can manage and edit utility networks but not vice versa. Once you

move to Utility Network, ArcGIS Pro will be your interface for managing and editing your network data.

4 Document integrations with other enterprise business systems

Your utility likely has multiple enterprise business systems, such as billing, computer maintenance management system (CMMS), SCADA, and document management, that are either directly integrated with or dependent on output from ArcGIS. We recommend identifying and documenting the following:

- Systems that are deployed in ArcGIS
- Third-party systems that integrate with ArcGIS
- Database views from third-party systems
- Workflows/Systems that require export from ArcGIS

Special attention should be given to asset identifier fields that are used to tie GIS datasets to other business systems. These could be used to pull data into the GIS from other systems or where data in the GIS is pushed out to other systems. To enable these integrations, any asset identifier fields that will be used in the utility network to join with other business systems must be included in the utility network schema during migration.

5 Document custom tools and information products

If your organization has created custom tools or information products that are still in use, document these and ensure that equivalent functionality is delivered to users when the utility network is implemented, for example, if you have deployed any of the following:

- Custom editing tools
- Database triggers
- Web maps or apps consuming network data
- Custom tracing web apps

There may be situations where custom tools will need to be re-created with Utility Network, but there may also be instances where the Utility Network provides functionality that replaces the need for custom tools. It is important to understand the capabilities of the Utility Network to take advantage of these capabilities before custom tools are re-created.

6 Validate data and auto populate fields

If you currently use Attribute Assistant for data validation to automatically populate fields while editing, you should document all the Attribute Assistant methods in your dynamic value table. Equivalent functionality of these methods will need to be created using Attribute Rules in ArcGIS Pro. Attribute Rules in ArcGIS Pro are written using Arcade scripting language. If you are not familiar with Arcade, there are resources available to help you get started here.

When you are documenting your Attribute Assistant methods, be sure to capture both the workflow and the business reason for the workflow to determine if all are

still valid. This may be a good opportunity to update some legacy workflows and eliminate unnecessary processes or workflows.

7 Deploy a development environment

To implement the ArcGIS Utility Network, you should use the current Network Management Release version of ArcGIS (currently ArcGIS Enterprise 10.9.1). We recommend that you create a development environment specifically for working with and understanding Utility Network. This environment should be separate from your production GIS and can easily be set up in a virtual environment. This will enable you to provide hands-on learning of the Utility Network as well as testing prior to migration. Beyond using the development environment as a learning tool, you can build and test all necessary information products here before moving the development environment into production.

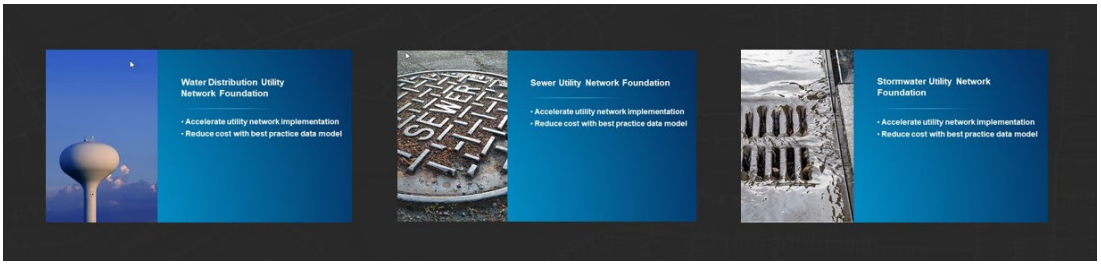
Single Machine vs Fully Resourced Enterprise Deployment for Development

Your development environment can be a single machine deployment of ArcGIS Enterprise deployed with the Enterprise Builder tools. The set up for this can be quickly accomplished with minimal IT resources and made available to core GIS staff as they gain familiarity with the utility network and the new environment. This option is the fastest and most cost effective route for the short term if you want to get a development environment going quickly or if IT resources need to be budgeted for in the future. That said, if you go the single machine route, keep in mind that this will **not** be your new production environment for the utility network. That will need to be set up additionally down the road. See the *System Architecture and Software Requirements* section of this paper for recommendations on the approach for your production utility network environment.

Another option is to fully build out your future production environment as development to streamline the process of converting from development to production in the future. When your utility network is ready, new workflows and apps have been tested, staff is properly trained, and your organization is ready for the transition then you can switch over to the development environment in place making this your new production environment.

8 Deploy the Utility Network Foundation solution(s)

The Utility Network Foundation solutions are a bundle of maps, data models, and tools that enable you to deploy and manage a utility network. Configurations are available for water, sewer, and stormwater networks.



Each Utility Network Foundation solution includes the following:

- A data model supplied as an asset package
- Maps for network publishing, editing, and viewing
- Example workflows
- Sample data

It is not required that you use the Esri-supplied solutions to configure your Utility Network implementation. However, because of the complexity of the networks, the solutions are a good starting point. The provided data models can be extended to accommodate additional data fields you may require, but it is not recommended that you remove or rename existing components.

9 Leverage Esri resources and partners

If migrating to the ArcGIS Utility Network seems daunting, consider engaging with Esri professional services or a Utility Network specialty partner for activities such as data health checks, data cleanup, data migration, and pilot deployments. Specialty partners have demonstrated their knowledge and expertise assisting customers with utility network implementations and are an excellent option for utilities looking for support when migrating to the utility network.

Esri offers a wealth of information on the ArcGIS Utility Network. The following are links to information on Esri training and services that will make the transition to the ArcGIS Utility Network seamless and efficient.

- Utility Network help documentation
- Esri Academy
- Esri consulting services
- Utility Network specialty partners

Additional resources can be found on the ArcGIS Utility Network web page.

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