Practical Uses of a Geodatabase Built for Hydraulic Modeling
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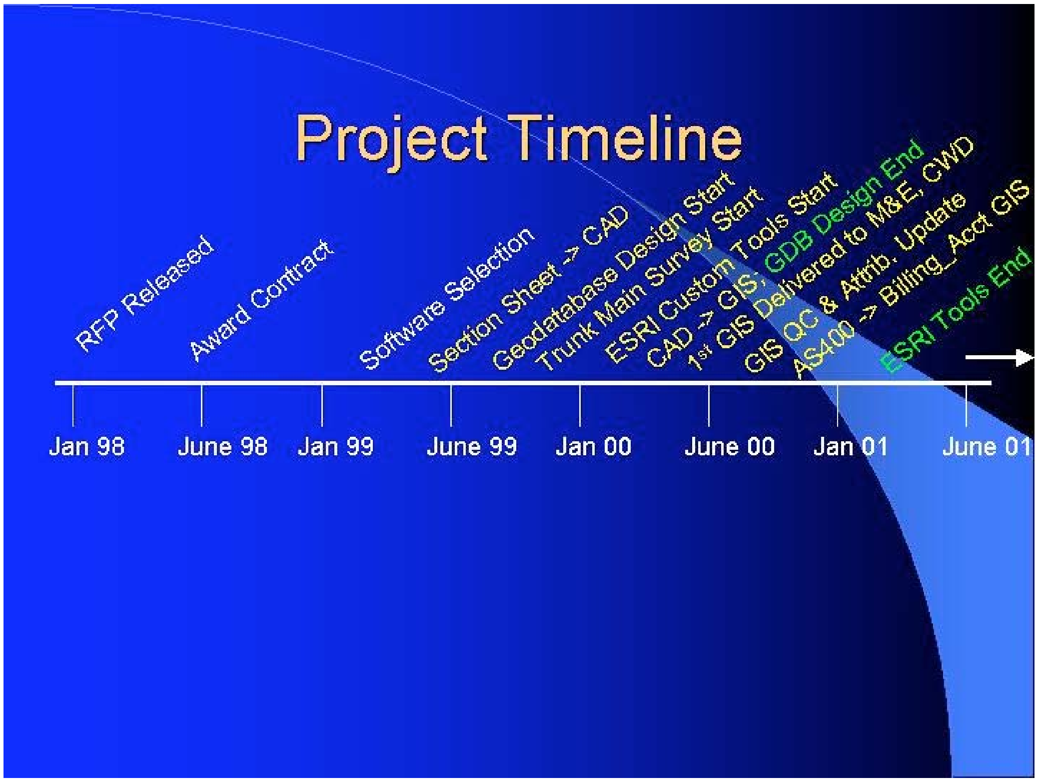
Abstract:
The City of Cleveland Division of Water has developed a GIS to work in combination with a hydraulic model. The City of Cleveland provides water to more than 1.5 million people in 76 communities. Although the GIS was developed with the primary purpose of storing, maintaining and serving the data used for the hydraulic model, there are many practical GIS applications used by the Cleveland Division of Water employees which save considerable time. Examples of these applications include spatial queries on a number of features, such as hydrants etcetera, outage traces in emergencies, and rapid calculation of pipe footage for planning improvements.

Project Background
Providing water to more than 1.5 million people in 76 communities, The City of Cleveland Division of Water is a large utility that has many facilities to operate and manage. Recently, the City began developing a GIS to work in combination with a hydraulic model to help make decisions about how to manage these facilities. The purpose for the GIS was to hold information related to the hydraulic model, but it was also expected that there would be many practical benefits to non-modelers at the Division of Water. The ability of a GIS to perform spatial analysis has reduced the need for CWD staff to spend time looking up data and doing manual calculations.

In 1998, an RFP was released asking for a consultant to help build the GIS and hydraulic model. The result was a contract to convert information from paper and existing databases into the GIS and from that, build hydraulic models for each pressure zone in the system. A project timeline is shown in Figure 1.



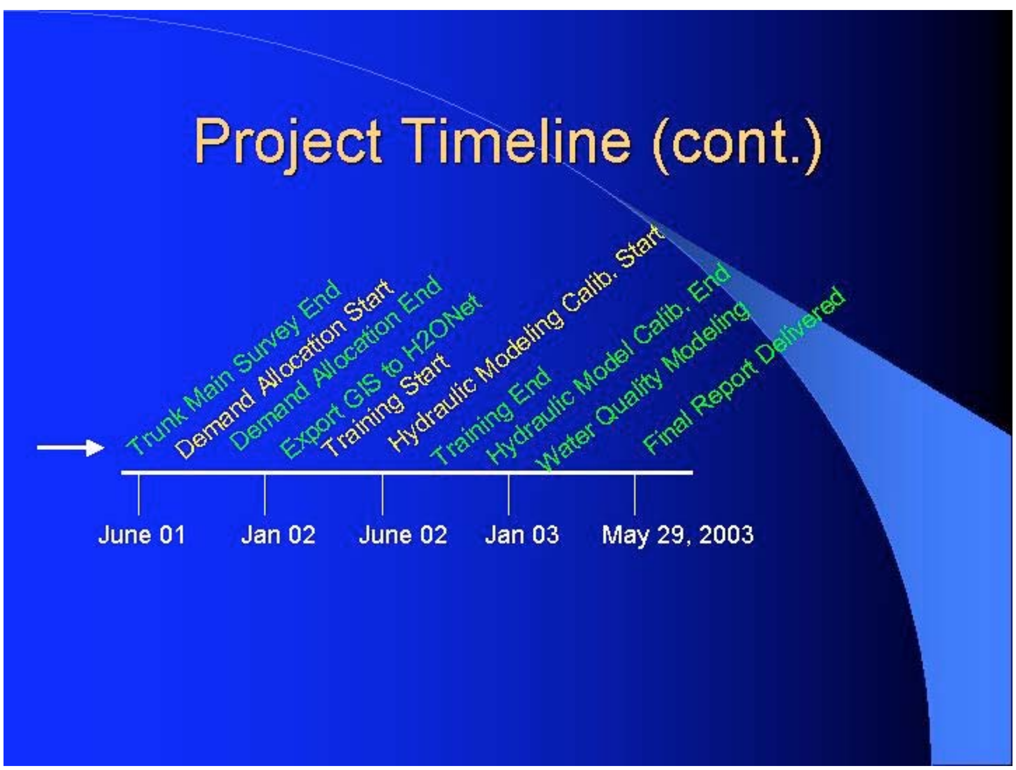


Figure 1. Project Activity Timeline.

Existing data included the 1” = 400’ section sheets, a manual survey of record drawings for all trunk mains in the system 12” and larger and existing databases regarding tanks, regulator valves and pumps. Data from the Supervisory Control and Data Acquisition (SCADA) system was used for modeling and calibration. For user demands, the City’s AS400 billing database information was converted to Microsoft Access for use with the geodatabase. Also included were GIS-based data available through Cuyahoga County, and state and federal government. These layers include the parcels planimetrics, city and county boundaries and TIN data.

Much of the data required for modeling had to be developed from the existing data. For example, since physical tests cannot be performed for all underground pipes in the distribution system, pipe condition was estimated based on pipe age and material. Only the trunk mains had as-built drawings reviewed for age and material information, so an estimate was used for all other mains. The pipe’s model roughness, an indication of pipe condition, was estimated based on the age of the oldest connection on the pipe or the age of the hydrant (2-eared hydrants stopped being used in 1955 in Cleveland). Whichever was older, the oldest hydrant or connection, that was the date used for the age of the pipe.

Each table in the geodatabase was carefully designed during the early stages of the project. The goal was to include all information that may be required by a hydraulic modeler as well as leave room in the geodatabase for other information that may be incorporated in the future. These placeholders include tables and features for work orders, project tracking, and data archiving.

Hydraulic Model-Related Uses of the GIS

After all the existing data was loaded into SDE, the GIS was prepped for modeling. Another set of custom tools was developed with help from ESRI to export data from the GIS to H2Onet, the hydraulic modeling program. Besides distribution network features like pipes, hydrants and system valves, was the information about water demand and initial conditions for modeling runs. Out of the 210 tables that are a part of the geodatabase, 55 contain data that is exported to H2Onet. Figure 2 shows the process for the export.

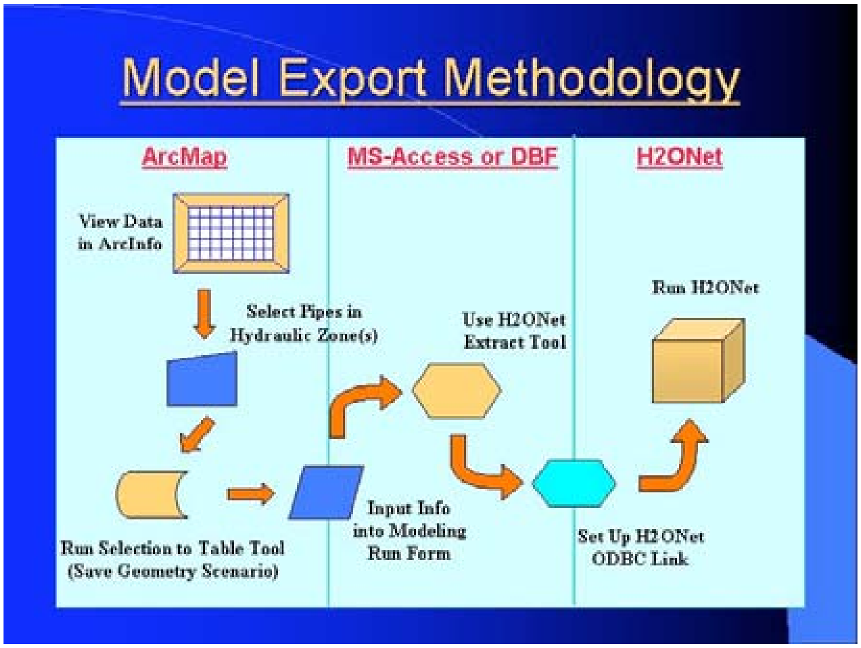


Figure 2. Model Export Methodology.

The portion of the network to export is selected using the Geometry Selection Tool (Figure 3). The modeler can select individual pipes or an entire pressure zone, or the entire network or any combination needed for the model.

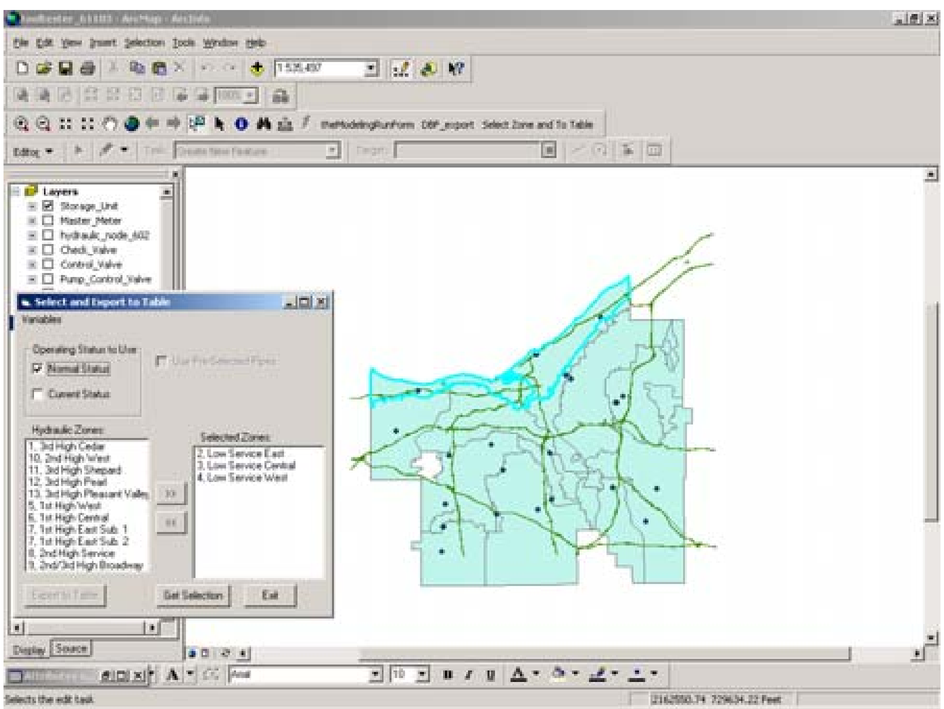


Figure 3. Geometry Selection Tool – Low Service District Selected.

Then the user populates fields in the Modeling Run Form (Figure 4) to identify which demand set to use and any model-specific parameters such as extra fireflow demands to add, which SCADA data to use for initial conditions, and the saved geometry set to export. All of the populated values relate to data in the geodatabase that will be exported. That data is exported to an Access database or directly into the H2Onet DBF format. The advantage to the Access database is the export time is quicker, but that option requires the user to link each field from the 40+ Access tables to the H2Onet database via the ODBC connection in H2Onet. The H2Onet export tool form is then used to select the appropriate model run information and populate the DBF or Access export files (Figure 5).

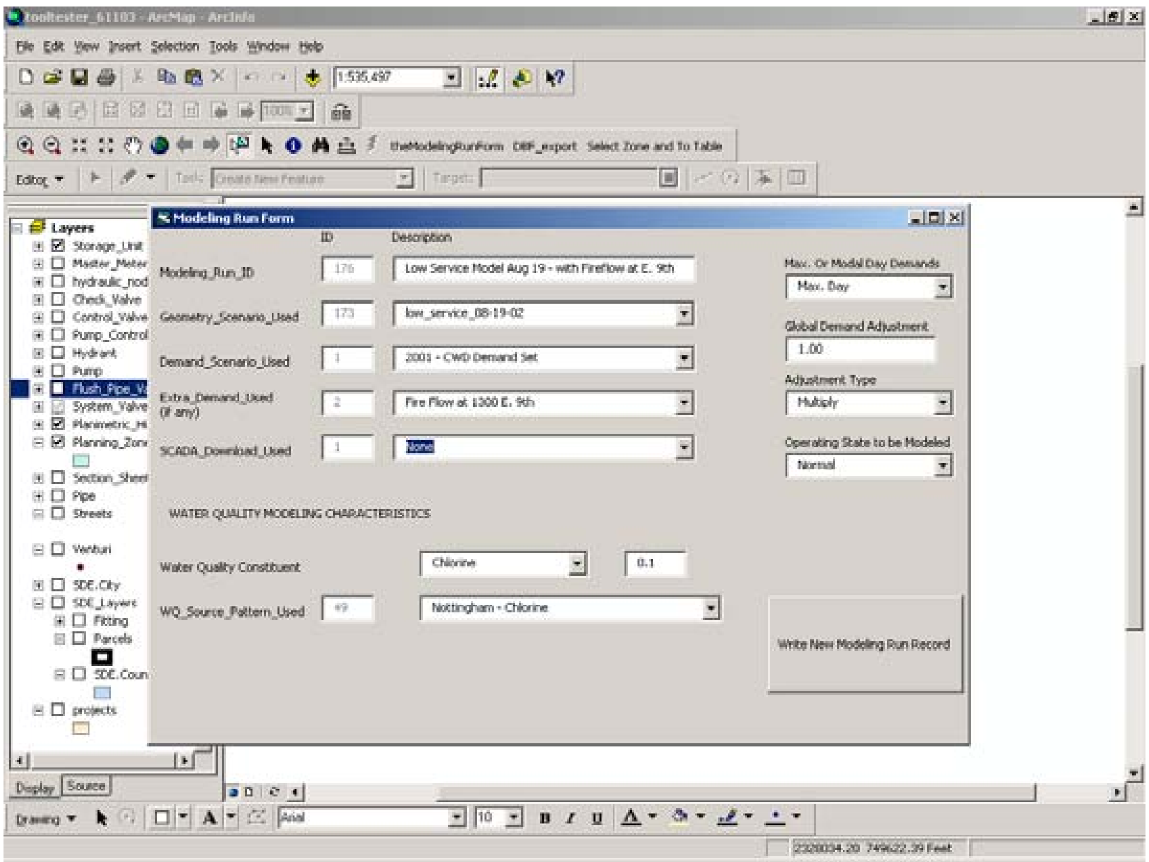


Figure 4. Modeling Run Form.

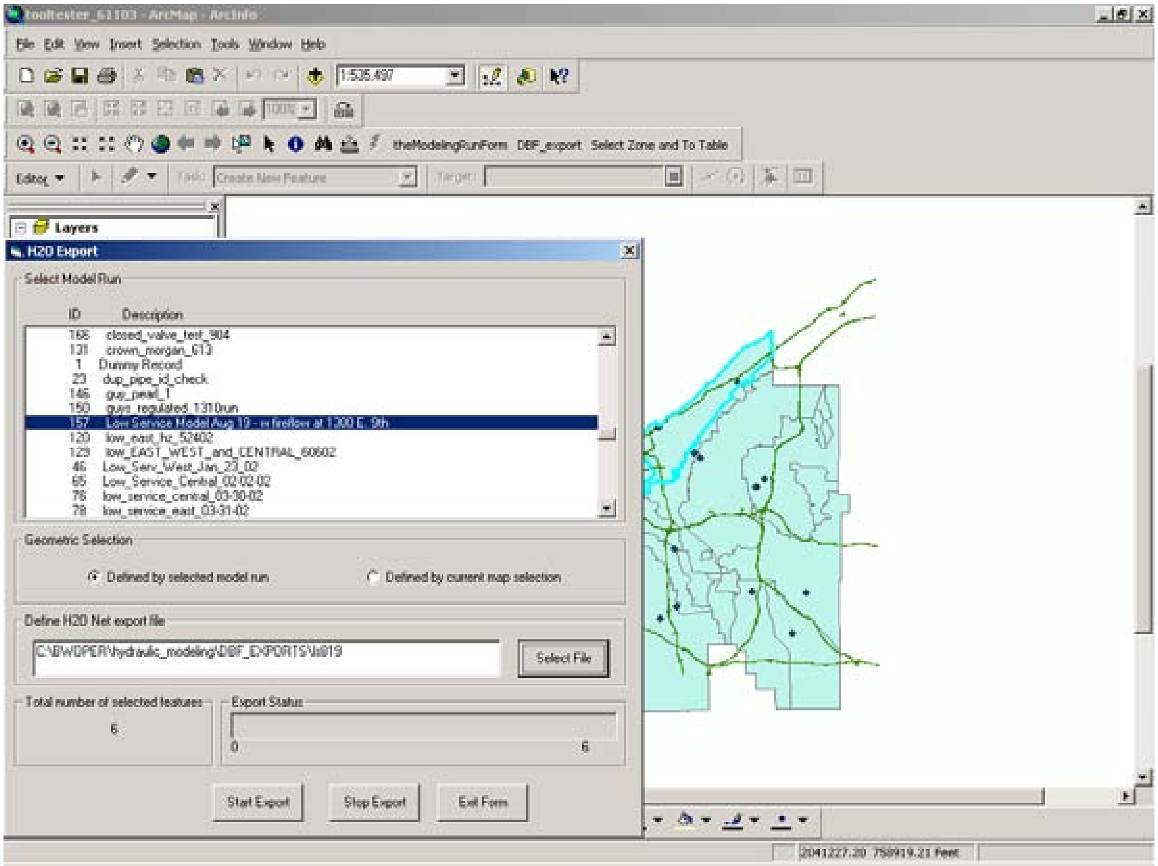


Figure 5. H2Onet Export Form.

Demand data was allocated proportionally to the nearest node from the address where the demand was listed in the AS400 database (Figure 6). A custom tool was developed by ESRI to perform this task. Although their location was not perfectly spatially accurate, a tool was also developed to draw a lateral pipe from the water main to the parcel where the demand originated. This allows the GIS to appear similar to the Division of Water's 1" = 50' roll maps which are commonly used for planning purposes (Figure 7).

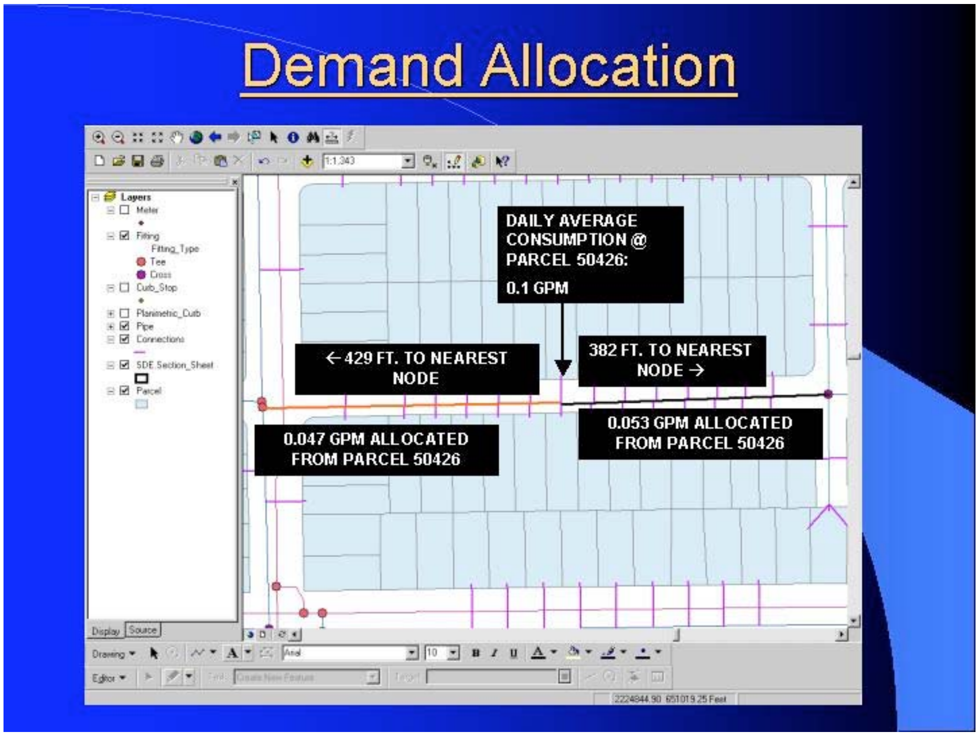


Figure 6. Demand Allocation Process.

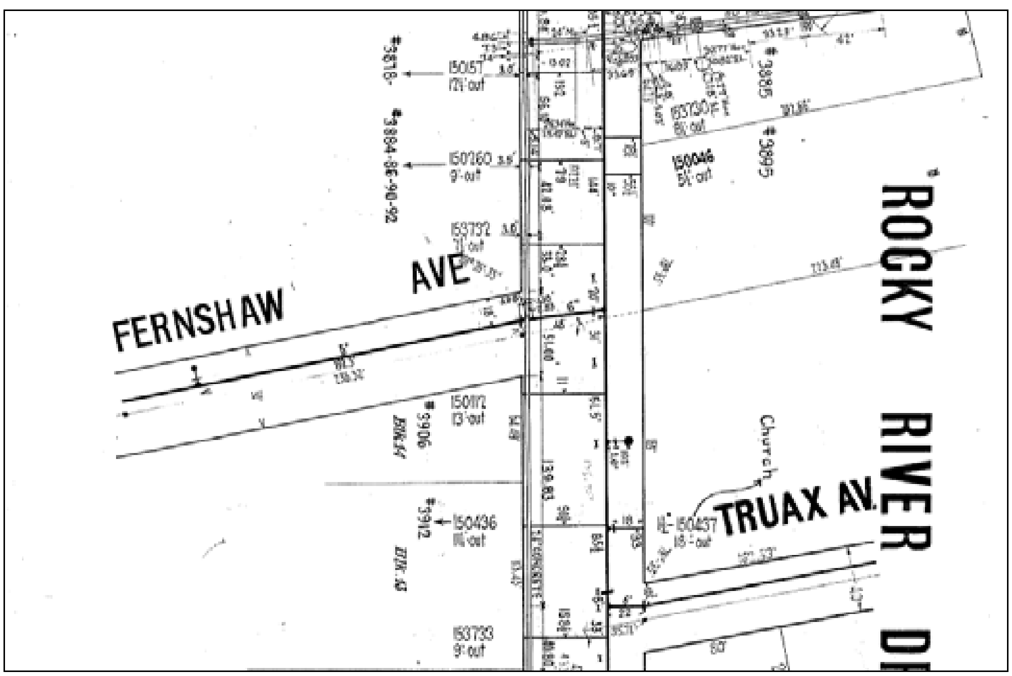


Figure 7. Example of Cleveland Water Roll Map.

With this system developed by the Division of Water, new models of the network using up-to-date data can be run on a few days notice, where previous modeling relied on assumptions about the system and not every main would be included in the model. Besides the ability to generate models, there have been several significant benefits to the GIS for CWD staff, many which are unrelated to hydraulic modeling.

Other Practical Uses to CWD from Development of the Hydraulic Model GIS

Soon after the first delivery of GIS data to CWD, many everyday applications for GIS were discovered. Presentations included maps of pertinent information; from soil type to building footprint to water main age. Other existing data such as water main break locations could be entered into the GIS and spatial analysis could be done to evaluate areas of high break rates. Requests for hydrant counts from customer suburbs were delivered quickly where previously it would require a time-consuming manual count on paper maps.

One practical application was to identify old 4" water mains scheduled to be replaced ward-by-ward in Cleveland. Instead of scaling pipe lengths off maps, the lengths of 4" main per ward could be calculated in a matter of seconds.

Anytime a question about who owns a site, whether it be for a new pump station, or a service issue, the parcel data is very beneficial to have on the desktop. This information, if up-to-date, can be very valuable for planning new projects and communicating with property owners who may be affected by a change in service.

Another tool developed in conjunction with ESRI was the Isolation Trace Tool. Using this tool – a user could identify the location of an broken water main and get which system valves should be shut to minimize the number of users out of service. The result of the trace would be the connections out of service and the valves to shut. Using the customer information included in the connection records in the result, customers could be informed quickly regarding the matter.

All of these applications include the ability to map on demand. While CAD-based software allows users to map specific information quickly, ArcInfo or ArcView makes it easy to develop professional looking maps that include a map legend and scale, tabulated statistics, labels, and other annotation. Depending on the speed of the computer and the plotter, maps can be created for any purpose related to the available data in a short amount of time.

Conclusion

Developing the GIS for hydraulic modeling and other future needs required significant planning from all involved parties at the Division of Water. The current GIS water data model is being revised for better performance. Originally a goal of the database design was to ensure data integrity by developing a database as normalized as possible. During the use of the GIS over the past couple years, it has been realized that several attributes in related tables would be nice to have in the main table so that the tables do not need to be joined.

The benefits seen from the Hydraulic Model GIS will be enhanced by the Cleveland Citywide GIS project ongoing currently. This will improve the spatial accuracy of the water data from section-sheet quality (1": 400' scale) to roll-map quality (1": 50' scale). There are also several custom applications being developed under that project, such as a custom data editor and CAD-to-GIS conversion tool.