water writes

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GIS for Water/Wastewater

In This Issue

Denver's Metro Wastewater Reclamation District Develops Custom Asset Management Web Application Using ArcGIS Server

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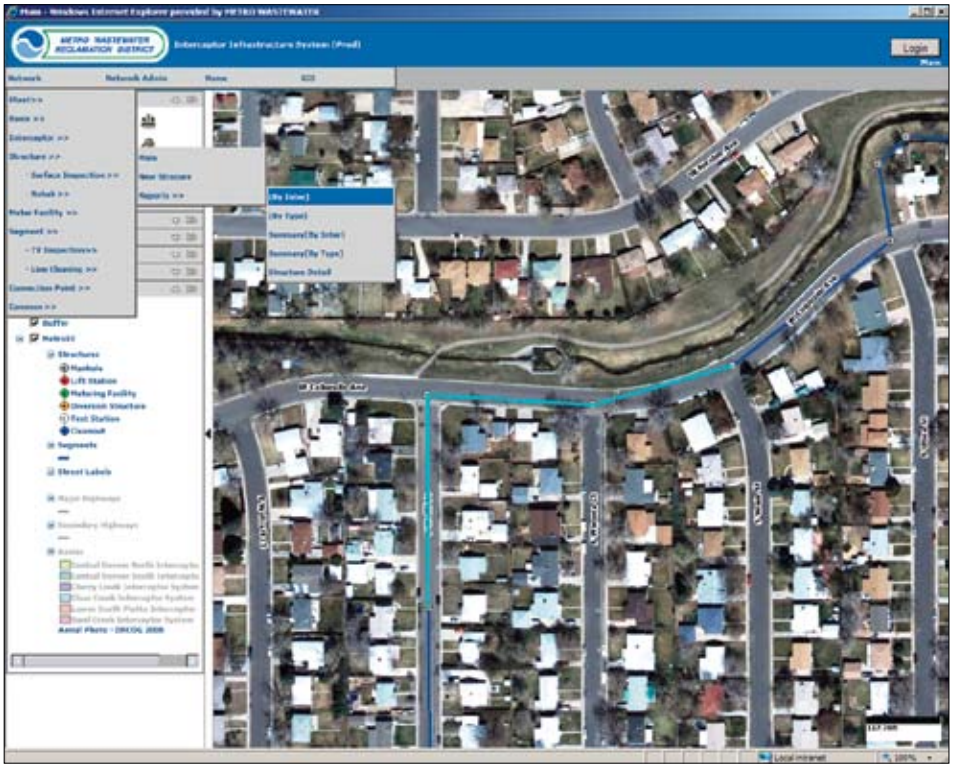
The Metro Wastewater Reclamation District is the primary wastewater treatment agency for metropolitan Denver, Colorado. The Metro District operates a noncombined interceptor system that collects sewage from 45 member municipalities and special connectors spread across 620 square miles and four major drainage basins. The Metro District operates a wholesale sewage treatment service to our members, who in turn provide retail service to approximately 1.5 million people. Most of the flow is gravity fed to the Robert W. Hite Treatment Facility (RWHTF), located along the South Platte River in north Denver. When the facility was first built in 1966, the Metro District's reach consisted of 50 miles of interceptor sewers. As needs have increased over the years, the district has expanded to include 260 miles of interceptors. On an average day, the plant returns approximately 130 million gallons of treated water to the South Platte River. Its 185-million-gallons-per-day capacity makes it the largest wastewater treatment plant between the Mississippi River and the West Coast. The Metro District is currently developing an aggressive 10-year plan to expand and refurbish our infrastructure to handle increasing demand for capacity and changes in its Discharge Monitoring Permit.



The online application offers tools for generating a report such as this manhole surface inspection.

Over the years, several information systems have been developed and implemented to manage an increasingly complex infrastructure. These systems have included applications to handle asset management, warranty tracking, work order generation, project management, and other daily operational tasks. Prior to the Metro District's geographic information system (GIS) project, an asset management reporting application was developed in-house to track interceptor infrastructure information and support field operations such as line cleanings and TV inspections. This application, called the

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Dublin San Ramon Services District Moves to ArcGIS Server

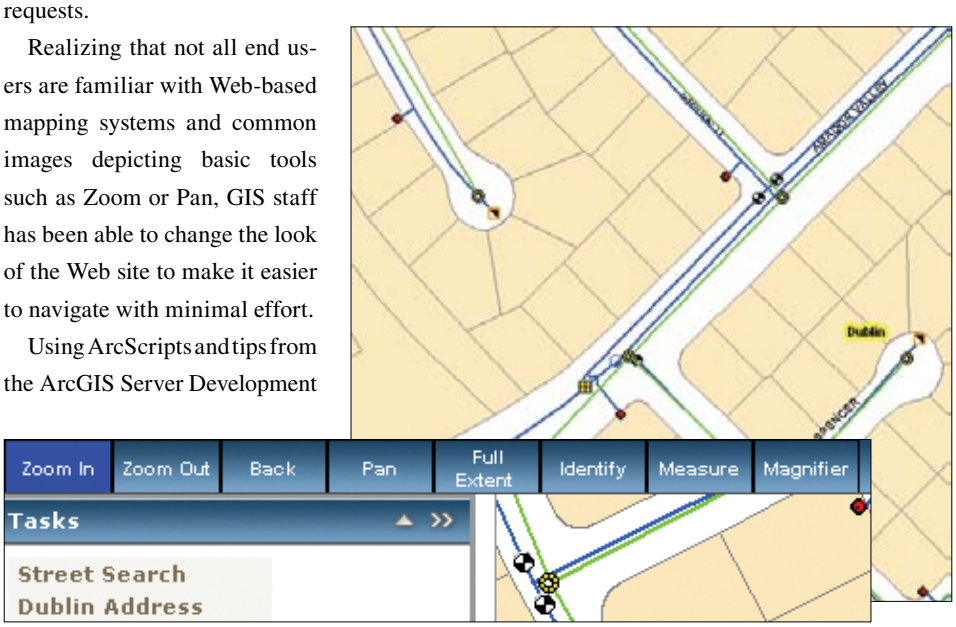
Aaron Johnson, Senior Engineering Technician/GIS Specialist, Dublin San Ramon Services District

With a need for an out-of-the-box, Web-based GIS solution that can be easily updated and modified while requiring minimal code writing, Dublin San Ramon Services District (DSRSD) has made the move to ArcGIS Server. We now have a product that will allow our GIS staff to have more control of the look, feel, and functionality of the online GIS Web application.

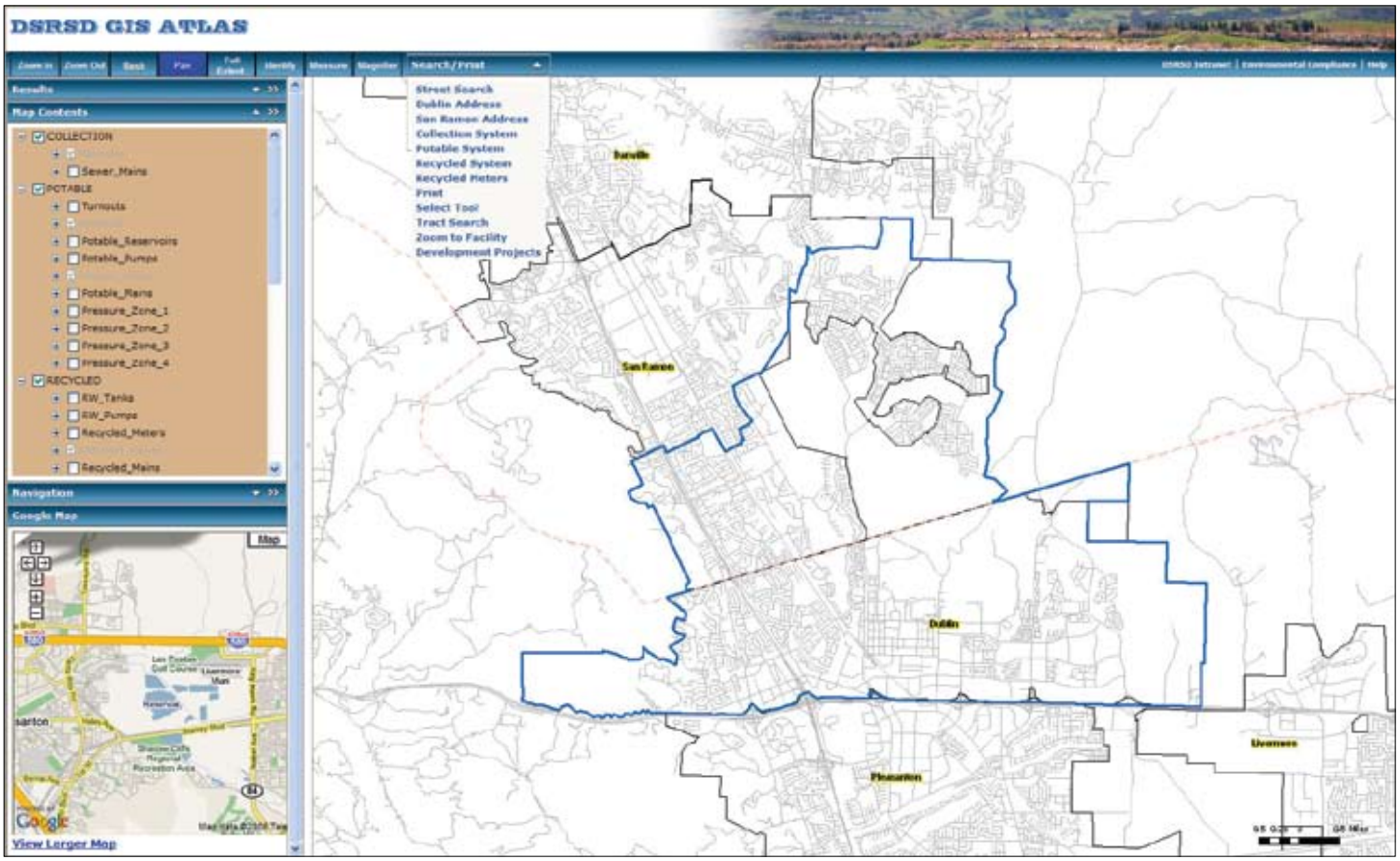
Depending on the level of expertise, GIS staff is able to create Web applications, publish services, and manage the server through ArcCatalog or the Web-based Manager interface or take the application a step further. ESRI has made it easy to utilize the abilities of Microsoft Visual Studio. With ArcGIS Server, publishing data has never been easier. Being able to quickly create a service from .mxd files is extremely helpful. Having the option to use the symbology built into the desktop GIS and then serve that same map over the Web while maintaining the stylization is not only efficient but also very important. As new data services become available, there is little effort required to get custom search or query tasks set up to go along with them. This would previously have required additional staff time or even support requests.

Realizing that not all end users are familiar with Web-based mapping systems and common images depicting basic tools such as Zoom or Pan, GIS staff has been able to change the look of the Web site to make it easier to navigate with minimal effort.

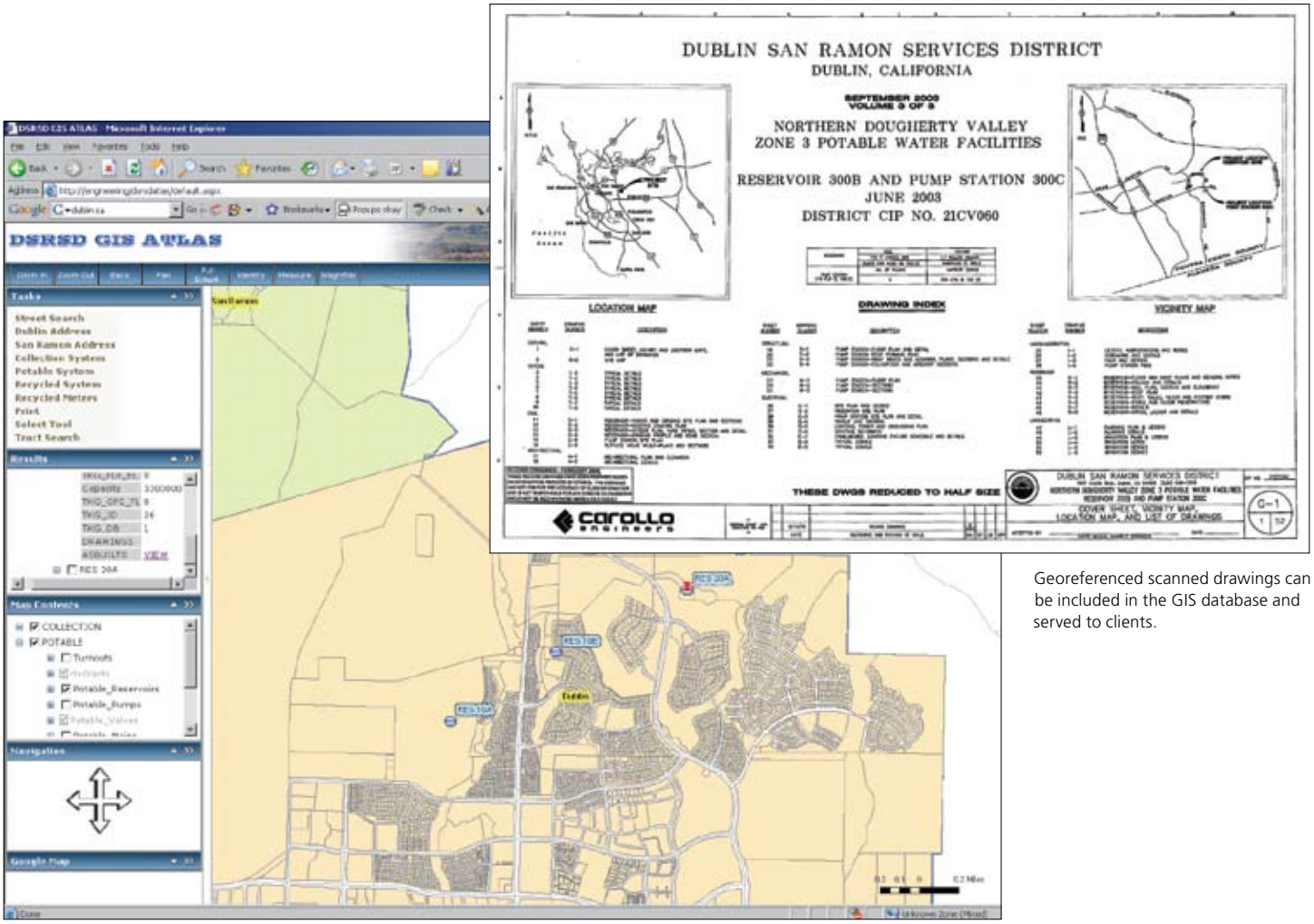
Using ArcScripts and tips from the ArcGIS Server Development Blog, the staff has added custom tools and tasks to give the user increased functionality. Some of the customization that has been done is simple yet effective. From the ArcGIS Server



Online GIS tools give users the tools they need such as this magnifier for clear viewing.



ArcGIS Server offers intuitive tools that make the company's IT administration design tools easy for employees to use. The above drop-down list is customized for the job.



Georeferenced scanned drawings can be included in the GIS database and served to clients.

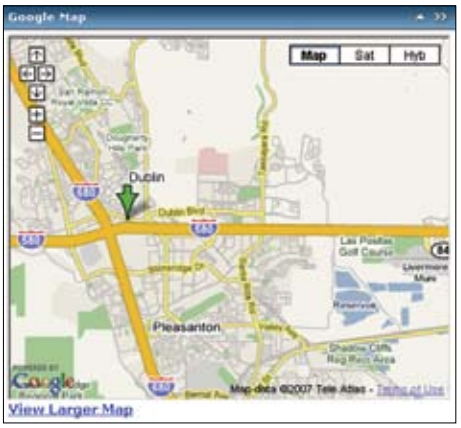
Map shows potable reservoirs.

Development Blog, we were able to utilize a tip to get hyperlinks added to the results table after a feature select. These hyperlinks now allow us to have scanned, as-built drawings attached to the facilities, such as a reservoir or pump station, for quick access by field crews. This has not been available until now. Also from the ArcGIS Server Development Blog, a Highlight Feature task has been added so users can quickly see a street location with minimal mouse clicks.

Other customization includes a Print task added to the task menu. From the ArcScripts site, staff was able to include a custom feature select tool, allowing access to information on only the specific layer the user needs. Both of the above-mentioned tasks were added to the Manager task menu, which allows them to be easily included in future Web applications. An embedded Google Map was also added to the Web application. Because DSRSD is a utility services district, access to data is sometimes limited. The Google Map will give users the option to search for businesses or locations outside the existing information our GIS data can provide.

With the ability to publish data as a service, in combination with the georeferencing tools of ArcGIS Desktop, we can publish georeferenced, scanned drawings of our treatment facilities over aerial imagery. This will help provide staff with a quick look at what development has occurred at a specific location without having to go through the plan library. The same publishing of as-built information over the intranet can also be used in the distribution or collection system.

On the menu, the print task aids fast publication.



Data from many resources can be added to the project such as this Google Map.

Building an Enterprise GIS at Providence Water Supply Board

Chris Labossiere, Project Manager, Providence Water Supply Board
Skip Heise, Regional Business Manager, EMA, Inc.
Brian Schrantz, Project Manager, EMA, Inc.

Providence Water Supply Board (PW), Providence, Rhode Island, serves water to approximately 600,000 people and provides wholesale water to nine other systems. Its service territory covers the cities of Providence and Cranston as well as the towns of Johnston and North Providence. In these four communities, PW has a large number of assets, such as distribution reservoirs (5), pump stations (10), water mains (more than 900 miles), hydrants (more than 5,700), meters, and service connections (approximately 72,000), through which it provides potable water and fire protection to its customers.

For years, PW considered the benefits that would follow the implementation of a GIS within its organization. During early 2003, PW conducted a needs assessment to discover areas where GIS data and technology would be beneficial to improving the organization's daily operations. During the assessment, PW learned that many groups within the organization had difficulty accessing sufficient and accurate documentation about the water infrastructure assets in a timely manner. The Records Management section of the engineering department is responsible for the management and maintenance of the organization's asset records, and the transmission and distribution (T&D) department requires these records to support its daily work activities to maintain and operate the water system. Requests from T&D come into the records management group to be fulfilled, which takes time away from maintaining the records. The records were maintained as distribution maps in paper, images, and CAD format. There was no seamless representation of the water system in GIS. In 2005, PW began a significant initiative to design and develop an enterprise GIS to enable better access to and management of its existing records.

Goals and Vision

PW's vision was to use GIS to manage the geographic location of the water distribution system assets in a graphic environment that links to tabular information regarding the asset attributes and work performed on the assets. The in-

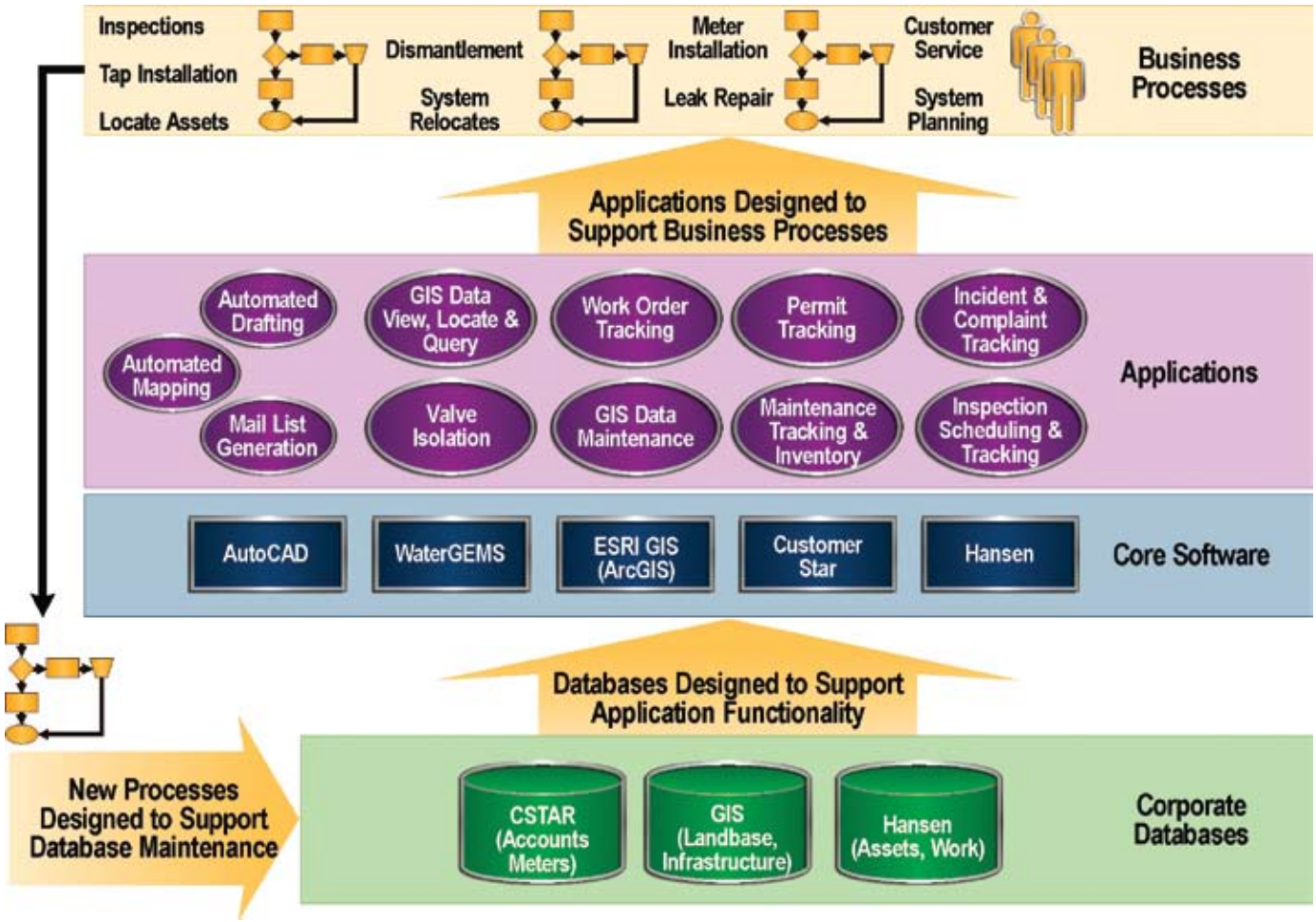


Figure 1. GIS supports the Water Supply Board's business processes by integrating with core IT databases and software to deliver applications from automated mapping to valve isolation.

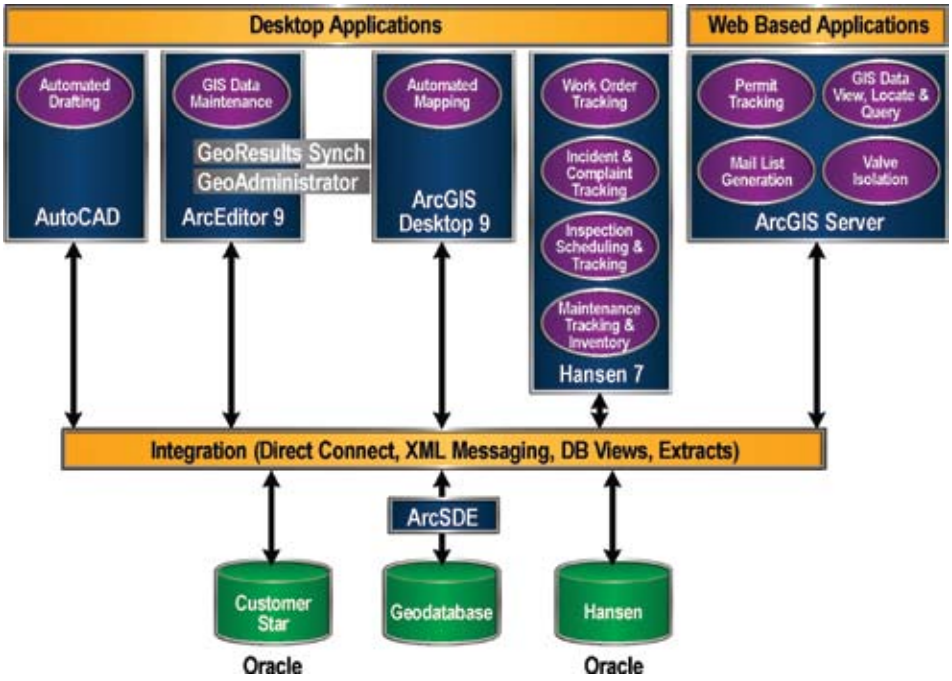


Figure 2. Architectural design of GIS throughout the enterprise.

formation is maintained in its Hansen work and asset management system. In addition, both the GIS and asset management system will link to common and related information maintained in the Customer Star (CSTAR) customer information and billing system. The integration of GIS with Hansen and CSTAR will provide a single common asset and customer information registry for PW. When combined with formalized processes for maintaining the data and technology for deploying the information, efficiencies will be gained by providing access to accurate and up-to-date information required to support the organization's business practices.

The Design

With assistance from EMA, Inc. (www.emainc.com), PW developed an enterprise GIS design based on a core set of business processes to be supported by the technology. Figure 1 is a diagram showing the business-driven approach used for enterprise GIS design.

EMA facilitated a number of workshops with PW staff to fully document both as-is and to-be business processes related to the GIS. This exercise pointed toward a number of capabilities that could be provided through the GIS to support the organization's business needs. These capabilities were further described in terms of applications that could be implemented based on core software technology from ESRI and other business partners. Figure 2 shows the technology architecture for the enterprise GIS.

Geodatabase

At the center of the enterprise GIS is the water geodatabase. The geodatabase was designed to integrate with PW's existing Hansen asset and work order management system. GIS feature classes were determined based on the asset classes in Hansen, and common attributes were aligned. Populating the new geodatabase with data from various sources, including AutoCAD files, paper maps, and Hansen, would be a major part of the project. The James W. Sewall Company performed data conversion and related QA/QC activities to ensure the new system would be built on a foundation of accurate data.

Initial Application Rollout

Applications were prioritized based on their importance for maintaining the spatial databases as well as delivering value to the end users. PW realized that end-user applications would not be of much value if the underlying data was not properly maintained. This placed emphasis on establishing data maintenance and synchronization tools so that PW staff could actively maintain the water geodatabase as it was being created by Sewall. Since the geodatabase must integrate with the Hansen asset and work order management system, off-the-shelf solutions called GeoResults Sync and GeoResults Toolbox from Marshall GIS were implemented. The GeoResults tools are specifically designed to work with ArcGIS and Hansen to keep the two databases in sync.

Importance was also placed on providing the end users with an easy and efficient means of accessing the enterprise GIS data. A Web-based GIS viewer called eMap became part of the initial application deployment. This allowed PW staff to get a taste of how they might begin to access water infrastructure records via a Web-based application. The applications bring information from GIS, Hansen, and CSTAR into a single viewing environment. End users are just beginning to experiment with the application's ability to bring together Hansen work orders,

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Trade Shows

WEFTEC 2008
October 19–22
Chicago, IL
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CA-NV AWWA Fall 2008
October 20–23
Reno, NV
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Building an Enterprise GIS at Providence Water Supply Board

CSTAR service requests, and water infrastructure in the GIS into an easy-to-understand map display that supports their daily work activities. Figure 3 is a screen shot of the eMap ArcGIS Server application.

To get end users actively involved in maintaining the data, a Redliner tool was incorporated into the eMap application. The Redliner tool allows users to identify errors or changes in the data by sketching on or marking up the map. All end users would have access to the Redliner and could submit redline sketches to the GIS data editors. The editors then would determine what changes were appropriate and do the actual data editing. The Redliner application takes advantage of the eyes and ears of many users to help maintain the datasets without relinquishing editing power to everyone. Figure 4 is a screen shot of the Redliner.

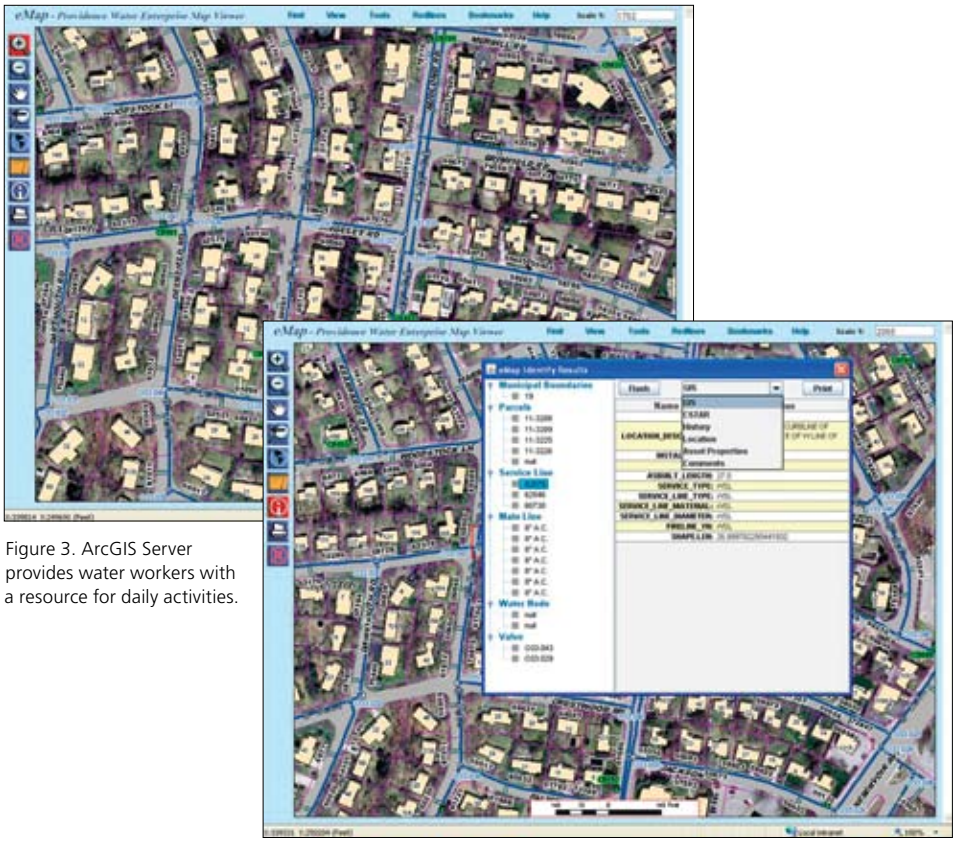

Figure 3. ArcGIS Server provides water workers with a resource for daily activities.

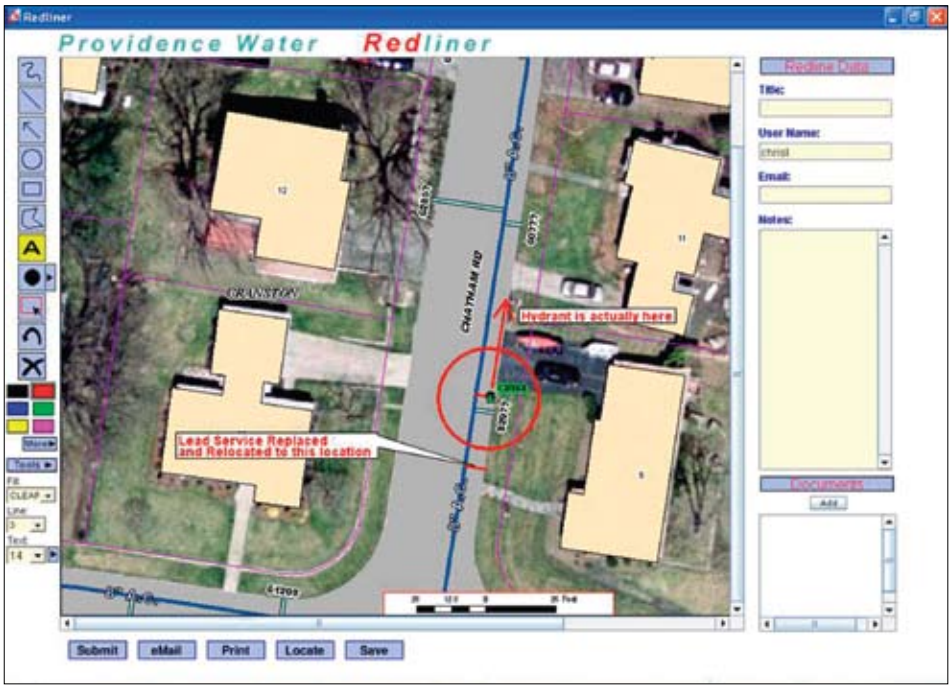

Figure 4. The GIS Redliner tool identifies errors or changes in the data to help ensure accuracy.

Next Steps

While just beginning to enjoy some of the benefits of its new GIS capability, PW considers its next steps to expand and improve its system. One of the front-running projects is the deployment of a mobile solution to provide crews with system access in the field. Other smaller changes continue as well. As users grow more accustomed to the new GIS system, they have started to ask for additional functionality. PW recognizes that this is not a static system but one that will continue to evolve and grow as technology changes, users' needs increase, and other systems are integrated. User requests are prioritized and handled as time and budget allow. The system, by design, is highly flexible to accommodate these needs and changes, as it was standardized on common core technologies to ensure a long life cycle.

The enterprise GIS system project at PW has brought about increased functionality and organizational evolution. With disparate critical systems being linked and synchronized, data accessibility and accuracy have increased. PW is beginning to realize its vision and the associated benefits of this technology.

Norfolk's Department of Utilities Leverages the Enterprise Geodatabase to Improve Access and Accuracy

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Nate Davis, GIS Mapping Manager, Department of Utilities, City of Norfolk, Virginia
Jonathan H. Soulen, AICP, Project Manager, Michael Baker Jr., Inc.
Tracy Wamsley, Task Manager, Michael Baker Jr., Inc.

The City of Norfolk's Department of Utilities in Virginia has successfully deployed an enterprise geodatabase architecture that uses ArcSDE technology that serves as the foundation for the continued improvement of the water distribution and sanitary sewer infrastructure assets. In addition, this effort establishes direct connectivity between the utility GIS and Norfolk's Hansen work order management system, allowing the strengths of these two systems to fully complement each other.

The project started in October 2006 with the selection of Michael Baker Jr., Inc., as the consultant to guide the effort and Marshall Associates as the subconsultant for software and support. This initiated a careful planning and deployment process that has resulted in both Baker and the city jointly digitizing the water and sewer infrastructure to save both time and money.

Project Background

The City of Norfolk moves millions of gallons of water and wastewater each year through more than 1,500 miles of pipe. The majority of this infrastructure and plan sets are more than 60 years old. Historically, the city used several different methods for planning, managing, and maintaining this infrastructure. Over the years, these methods resulted in a variety of both paper and digital inventories that were required to support critical business processes and analyses.

Because of the ever-increasing challenges of maintaining this infrastructure in an active urban environment, the city determined that it was necessary to upgrade the mapping and asset management system and initiate the Utility Enterprise Geodatabase project.

Through this important project, the city is achieving several primary goals:

1. A conversion plan that reflects a variety of different historical documents including intersection drawings, as-built plan documents, shapefiles of water and sewer infrastructure, and Hansen asset records
2. A comprehensive and complete geodatabase design for utilities infrastructure
3. A data management plan that addresses map updates, the city's work order management system, and data distribution across the organization

Project Approach

The deployment of any new mapping program

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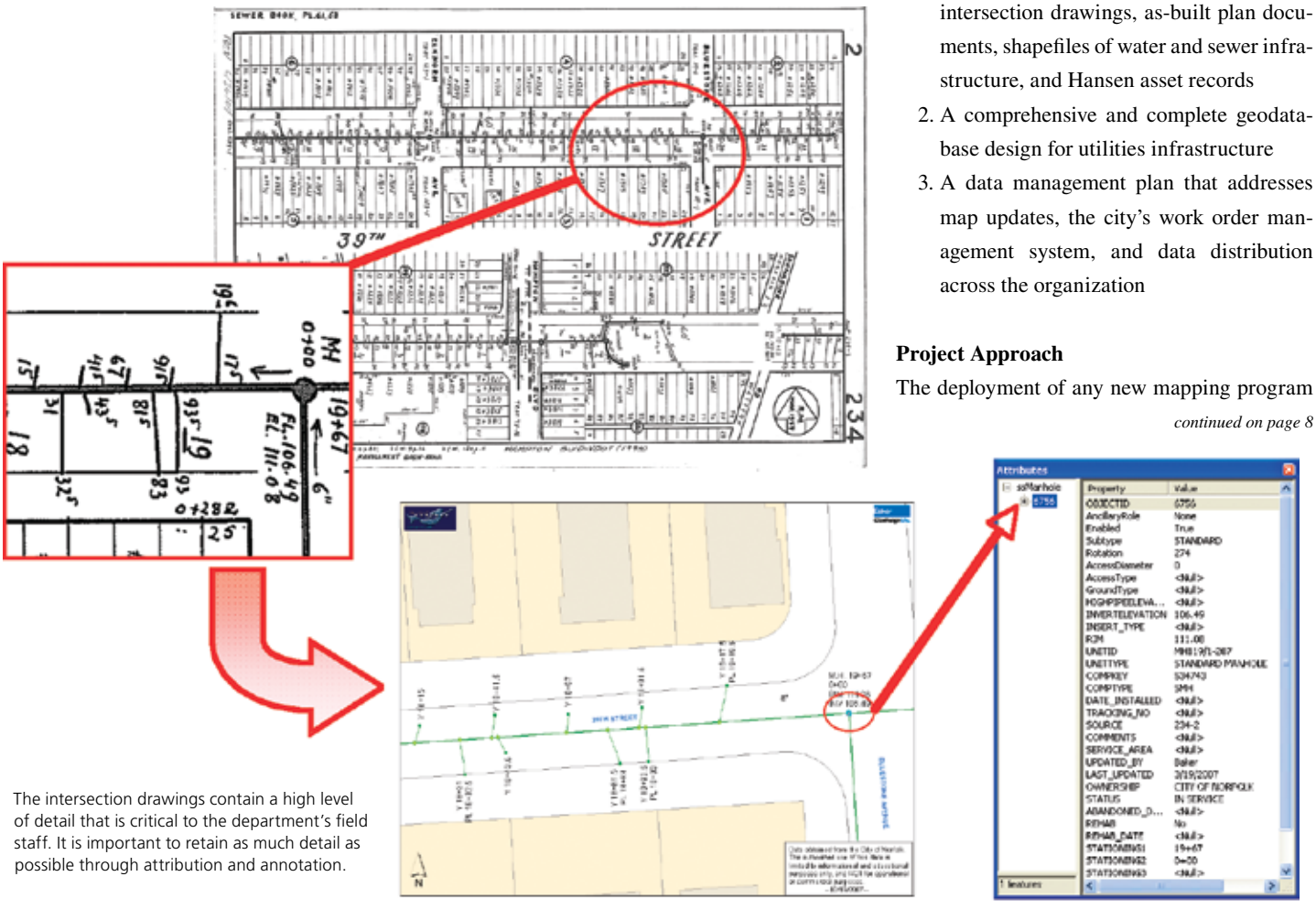

The intersection drawings contain a high level of detail that is critical to the department's field staff. It is important to retain as much detail as possible through attribution and annotation.

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Norfolk's Department of Utilities Leverages the Enterprise Geodatabase to Improve Access and Accuracy

will have impacts across the entire Department of Utilities. Therefore, it was important to consult and gather input from all parts of the department on their needs. Meetings and interviews were conducted with a variety of different groups within the department including Engineering, Operations, and Mapping divisions. The interviews resulted in a clear direction for Baker.

It was determined that one of the top priorities was to develop a utility GIS that retained the level of detail present on the drafted intersection drawings. The department did not want to lose the rich detail available in the intersection drawings.

To accommodate such detailed information, a specialized data model had to be constructed. The original data was placed in the existing water and sewer database models, provided by ESRI. Then a workshop was held with representatives from all groups in the department to determine the customizations to the model needed to create a database design that would incorporate all the necessary attributes.

In addition, it was important to develop a seamless workflow process that would establish and maintain a link between the new GIS database and the Hansen asset management system. Often, when GIS and asset management systems are operated independently, they become out of sync. Given the current regulatory environment that municipal governments must comply with, it is essential to be able to track and maintain investment across all infrastructures.

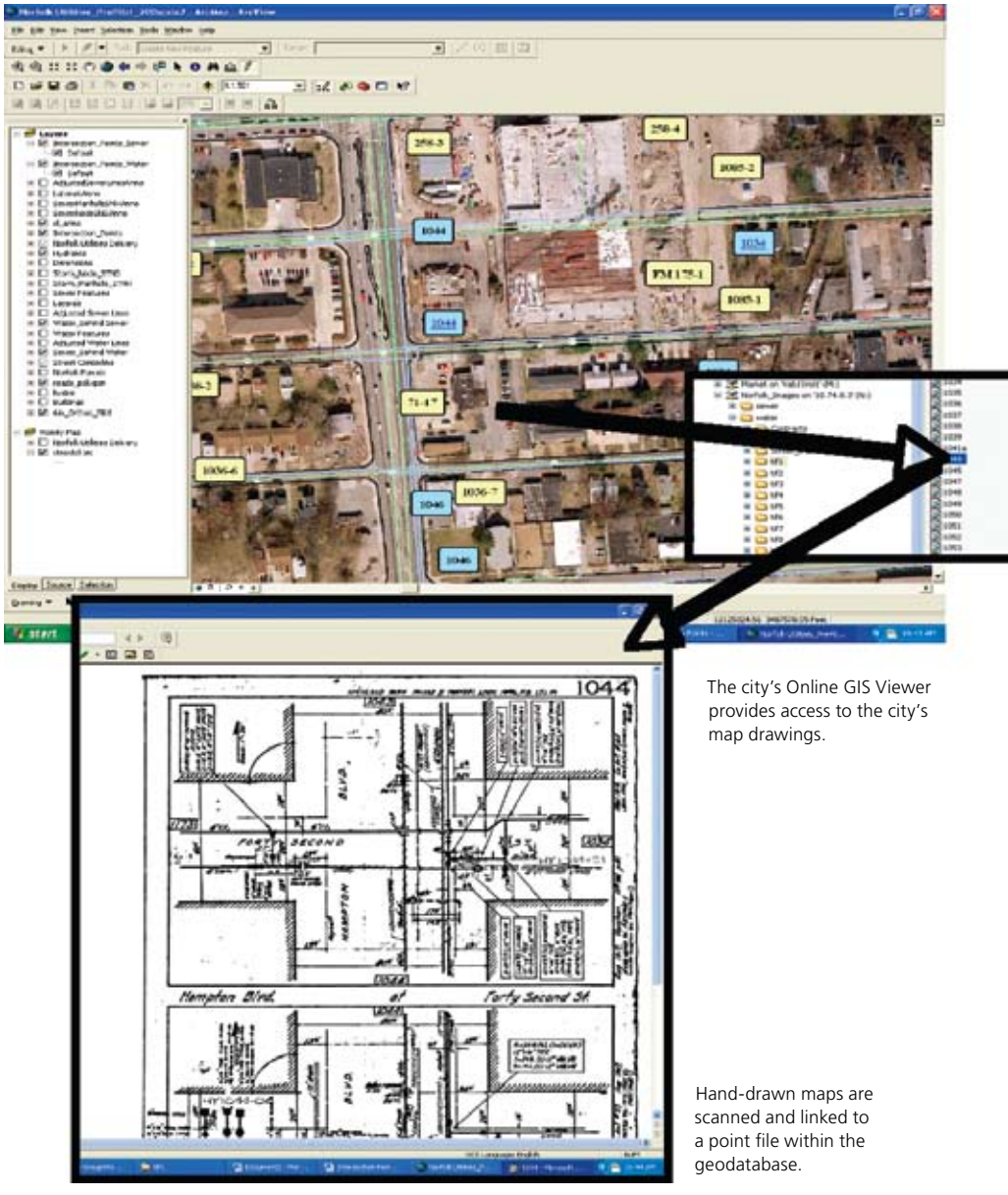
Finally, the deployment of a new mapping system has required the implementation of new digitizing and data maintenance techniques. Staff training is necessary for a successful project but is frequently given insufficient priority or simply ignored entirely. Baker and the department developed a training program that would extend over a transition period of several months. This approach allows key staff to become accustomed to the process rather than having to climb a steep learning curve.

Early Deliverables

Deploying an enterprise GIS presents many challenges. Through the employment of a proactive approach, constraints such as data accessibility and complications with the transition to the new system can be minimized.

Providing early deliverables gives staff the ability to familiarize themselves with the data while utilizing the new technology. The first deliverable included the existing water and sewer dataset transformed into the new database design. This data was loaded onto the network and made available for viewing through an intranet GIS viewer.

An important early deliverable has been the intersection drawing points. The city maintained hand-drawn maps, based on a grid system, that showed what source documents (intersection drawings) represented the water and sewer infrastructure at each intersection. A number was written on the map that corresponded to the drawing file name. To enable the staff to begin looking at the data and using the technology to locate information, Baker linked the scanned, hand-drawn maps to a point file within the geodatabase. Now, intersection drawings can be accessed via the city's GIS intranet viewer.



The city's Online GIS Viewer provides access to the city's map drawings.

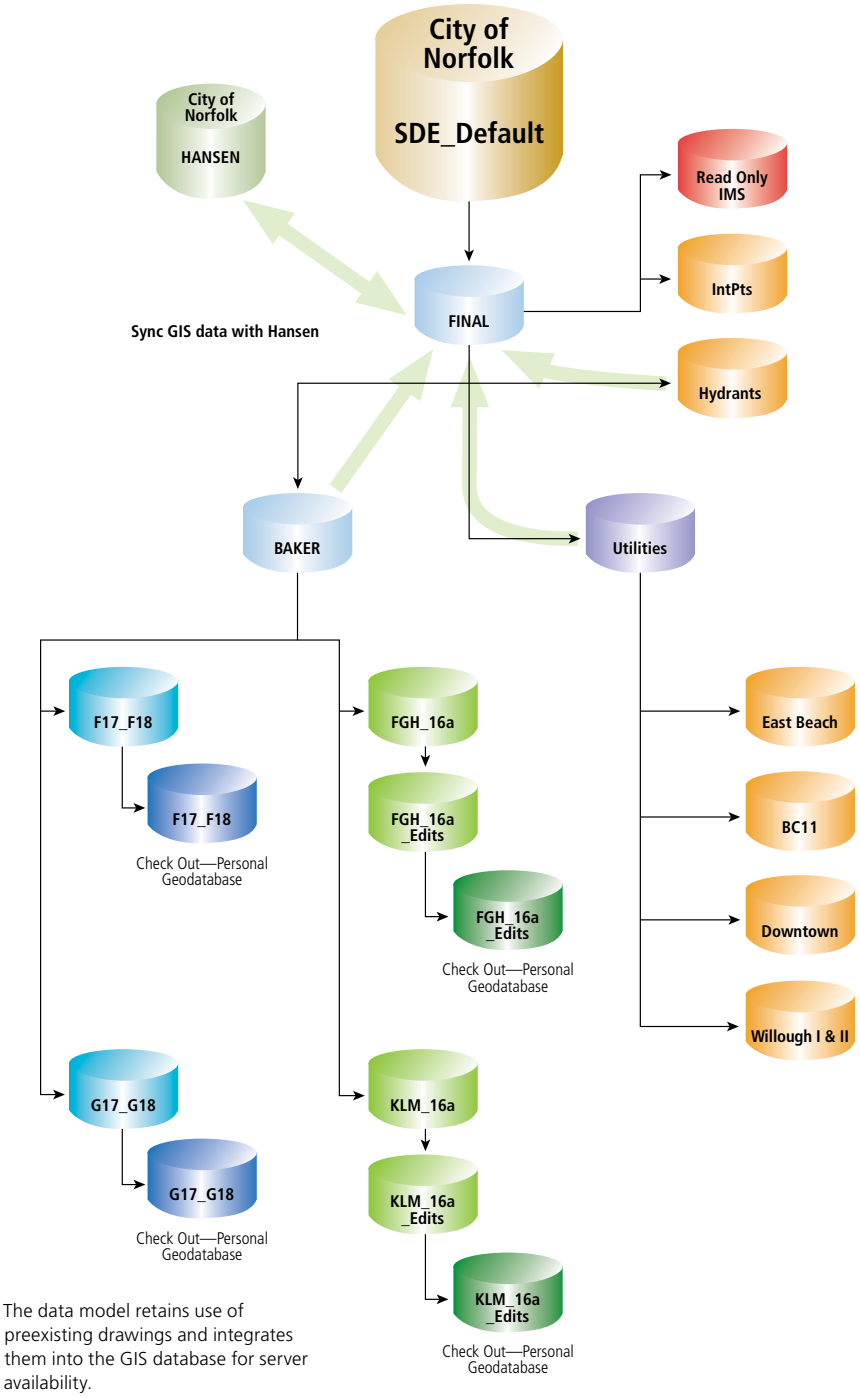
Hand-drawn maps are scanned and linked to a point file within the geodatabase.

Pilot

The pilot effort began in March 2007. The department recommended a geographic area that had experienced redevelopment over the past several years. This ensured that the Baker team would encounter a variety of different source materials including both the older intersection drawings and new as-built drawings.

Working closely with the department, Baker developed annotation specifications that replicated the detail found on the source documents as closely as possible. Using the City of Norfolk's GIS basemap, which included streets, curb lines, parcels, and building outlines, Baker digitized and adjusted water and sewer infrastructure to align with existing data layers.

Using Marshall Associates' GeoResults suite of software products, Baker successfully established a link between the GIS and the Hansen system. Combined with Baker's disciplined digitizing procedures, Marshall's software automatically retires, creates, and updates assets in Hansen to match the GIS database as it is updated.



The data model retains use of preexisting drawings and integrates them into the GIS database for server availability.

Partnering to Complete the Project

One primary result of the pilot was an improved understanding of the work effort required to complete the digitizing and database population of the city's entire water and sewer network. Given a budget phased over three years, it was necessary to deploy a strategy that would allow the project to be completed within a reasonable time frame.

With more than 1,500 miles of water and sewer infrastructure, combined with budget constraints, it is estimated that the project could take more than three years to complete using vendor labor alone.

By leveraging enterprise geodatabase functionality, the department's mapping staff and Baker are sharing the workload. This not only facilitates a shorter project duration but also allows the department to assume data ownership now rather than at the end of the project.

The city maintains all of the data in an ArcSDE environment housed on its GIS servers. Using versions to manage data, the city has created a workflow that allows version QC and synchronization with Hansen.

Baker accesses and updates the data through disconnected editing. Personal geodatabases are checked out of the city's ArcSDE and updated on-site at Baker's Virginia Beach office. Once the data edits are complete, the data is delivered to the city by checking the personal geodatabase back into the city's ArcSDE. The data is then run through QC by city staff and ultimately reconciled and posted to the Baker version. The Baker version is then reconciled against the final version and synchronized with Hansen, and all edits are posted to the final version. At that point, all the Baker edits are fully integrated with the city data.

While the project is still in the first year of implementation, the proper foundation is now in place for successful completion.

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Denver's Metro Wastewater Reclamation District Develops Custom Asset Management Web Application Using ArcGIS Server

Interceptor Infrastructure System (IIS), was developed using ASP.NET 1.1 (Visual Studio 2003) and Oracle Reports Server.

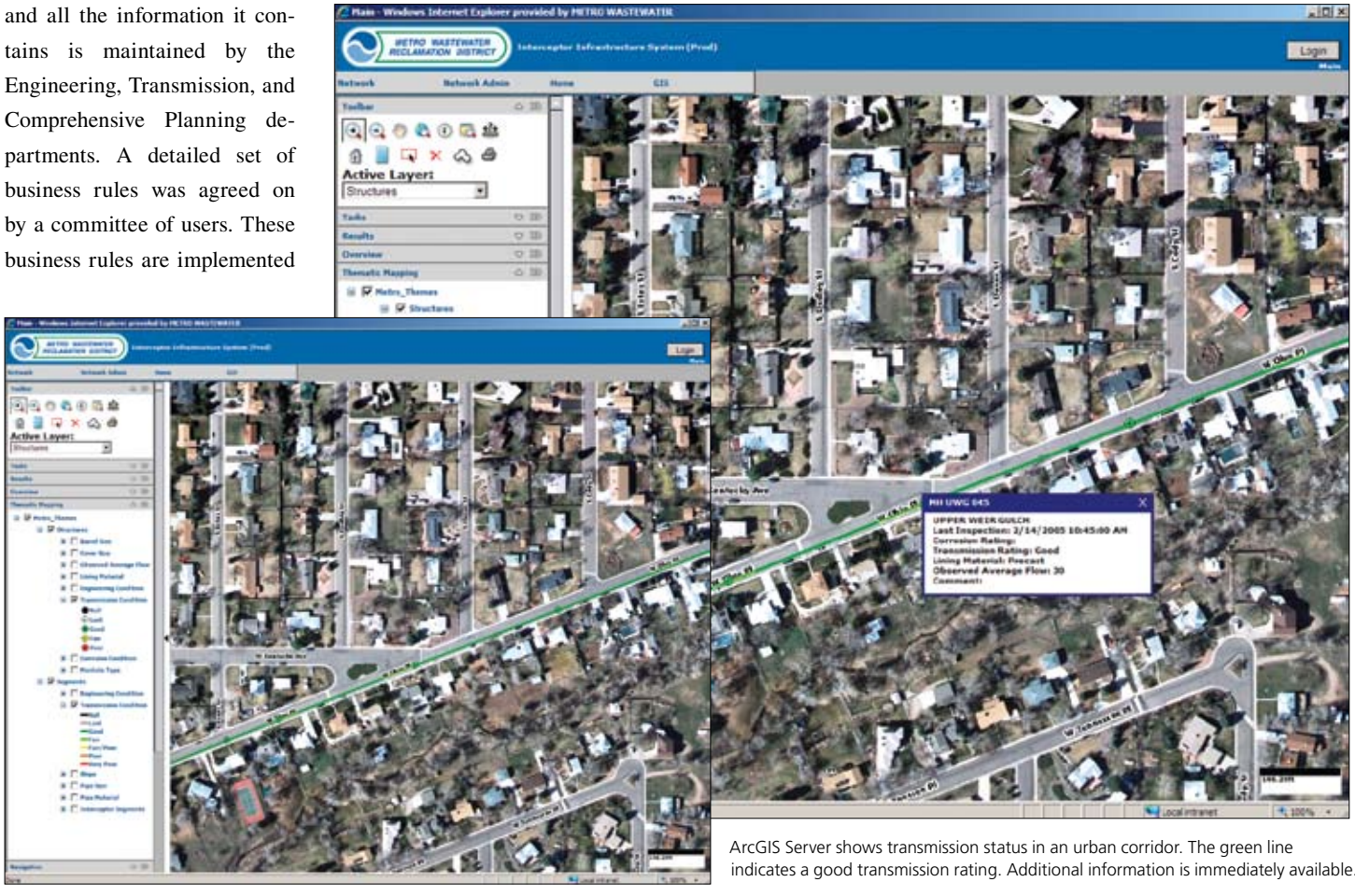
To operate the application, a user selects a report query page from a drop-down menu and fills in the filter criteria to generate a report containing relevant information. For example, a user may want to see the results of all manhole surface inspections on the Aurora Westside (AW) interceptor in 2006. To get this information, the user would select the Surface Inspections report under Structures in the Network drop-down menu, set the Interceptor Abbreviation field to AW and the year field to 2006, then click the run report button. The application then parses the filter criteria into a URL string that is sent to the Oracle Reports Server. The application can return a report in PDF, Excel, Word, or HTML format. The report can also be sent directly to a network printer or to an e-mail address.

The IIS application is supported by the Information Services Division, and all the information it contains is maintained by the Engineering, Transmission, and Comprehensive Planning departments. A detailed set of business rules was agreed on by a committee of users. These business rules are implemented by mechanisms in the application and underlying database to control editing functions. Only certain users have the ability to edit, update, or delete IIS data entries. These privileges are controlled by Windows Integrated Authentication against Active Directory. Editing actions are further controlled by prohibiting business rule violations such as the creation of a segment with the same name as a currently existing segment. This approach has worked well and resulted in a relatively low-maintenance application that continues to meet users' needs.

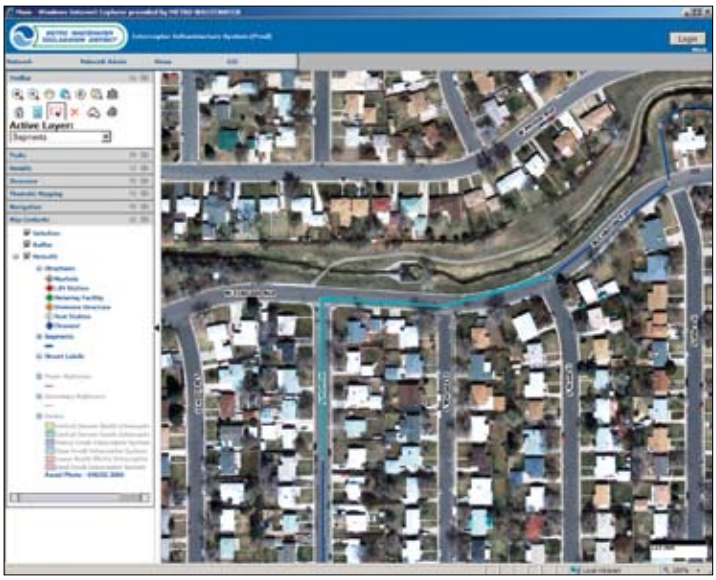
In 2003, the Metro District selected a team consisting of Camp Dresser & McKee Inc. (CDM) and Woolpert, Inc., to perform a GIS needs assessment to determine how GIS technology could improve business practices. A number of applications were identified, and a phased implementation approach prioritized applications based on the most cost-effective solutions. Until this time, the only GIS program available was a land-use model based on ArcView 3.2, and the Metro District did not have an enterprise-wide geographic information system in place.

The first step was to purchase the hardware and software required to implement a foundational architecture for an enterprise GIS. This setup consists of ArcSDE, ArcGIS Server, and several ArcInfo and ArcEditor desktop licenses. ArcSDE runs on Oracle 10*g* R2 on a Linux Red Hat ES 4.0 server in a storage area network (SAN) environment, and ArcGIS Server runs on a stand-alone Windows 2003 server.

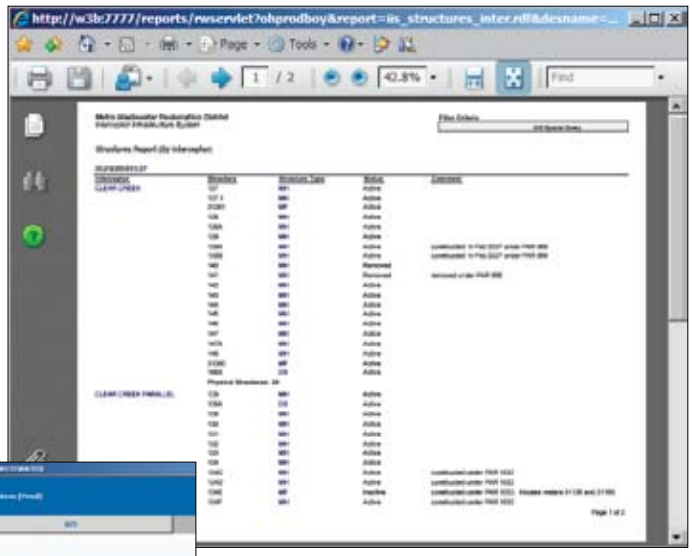
Data acquisition was the next step. At a minimum, the district would need GIS layers representing manhole structures and interceptor segments, geocoded street centerlines, and up-to-date aerial photography. The geocoded street centerlines were purchased from a vendor, and the aerial photography was received through a partnership with an aerial photography project

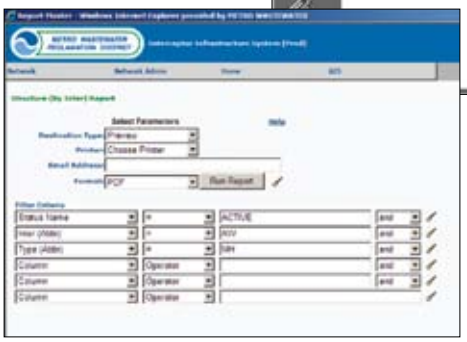


ArcGIS Server shows transmission status in an urban corridor. The green line indicates a good transmission rating. Additional information is immediately available.



ArcGIS Server offers a map representing current data layers of structure, streets, and aerial photography. Basic map tools help users navigate and view specifics.





The GIS map links to several reports via an identifier that ties the GIS layers to data in the city's information system.

conducted by the Denver Regional Council of Governments. To develop a geometric network of the interceptor system, a submeter GPS survey was performed by Woolpert, Inc., to collect GPS coordinates for all aboveground structures such as manholes and metering facilities. The survey captured more than 3,900 points and was an excellent inventory exercise. Metro District found that about 100 manholes had been paved over, buried, or otherwise lost. The GPS survey provided a means for finding these types of missing structures. This data will also help Metro District find missing structures in the future. Before the GPS survey, missing structures were located with metal detectors, divining rods, and CAD maps. Metro District employees can now take a GPS device with them to find a missing structure more quickly.

The survey also provided RWHTF with a basic model of the interceptor system. The points from the GPS survey became the Structures layer. Straight lines were then drawn between upstream and downstream structures to create a Segments layer. Together, these two layers form the geometric network representing the Metro District's interceptor system. Due to bends in the pipes, the connect-the-dots process does not result in a Segments layer with a horizontal accuracy equal to that of the Structures layer. Most of the Metro District's sewer lines are modern, and curvature between structures is limited. However, some older sections of pipe made of brick can curve sharply between structures. A current data improvement project is under way to correct these few segments.

Once the necessary hardware, software, and data were in place, the first priority of the Metro District's GIS project was to enable the IIS application with GIS. The front page of the application was redeveloped using ArcGIS 9.1 to include a dynamic map, a table of contents, and several map tools. The map contained the Structures, Segments, Streets, and Aerial Photography layers, and the table of contents allowed users to turn those layers on or off at their discretion. The set of map tools contained basic navigational tools, an Identify button, an address locator, a select features tool, a clear graphics button, and a measuring tool. The Structures and Segments layers pulled their attributes from materialized views exported nightly from the IIS database, keeping the GIS layer information current with the latest database edits.

The GIS features on the IIS front page were also linked with several reports. A user could zoom in to an area of interest, select segment and/or structure features, and pass those features to a report. A user could also use the report pages to find features on the map. If a manhole has been buried by a recent housing development, a transmissions operator can plug the name of that manhole into a structure report in IIS to quickly see where that manhole is located. A Comprehensive Planning engineer who needs to know the condition of a stretch of interceptor parallel to an upcoming rehabilitation project can select that stretch of pipe on the map and pass it to a segment report to retrieve that information. This link is provided via the unique identifier that ties the GIS layers to the information in the IIS database. When a GIS feature is selected, that unique identifier is stored in a session variable. When the user navigates to a report page, that session variable is passed to the first filter parameter of that report. In the report-to-map case, the report query sent to the Oracle Reports Server returns a set of those unique identifiers that is then used by fine-grained ArcObjects in a WHERE clause to select the matching GIS features.

The address locator is another important addition to the application. This stems from a need to review locate requests from the Utility Notification Center of Colorado (UNCC).

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Denver's Metro Wastewater Reclamation District Develops Custom Asset Management Web Application Using ArcGIS Server

Typically, if individuals or companies need to dig in metro Denver, they will call UNCC to help them locate any underground utilities in the area. UNCC will forward the request to Metro District for further review if the dig area is within a certain distance of interceptors. The information clerks receive will usually be distances from an intersection. For example, "500 ft. south of 84th and York" would be a typical locate request. Exact addresses, street types, and ZIP Codes are rare.

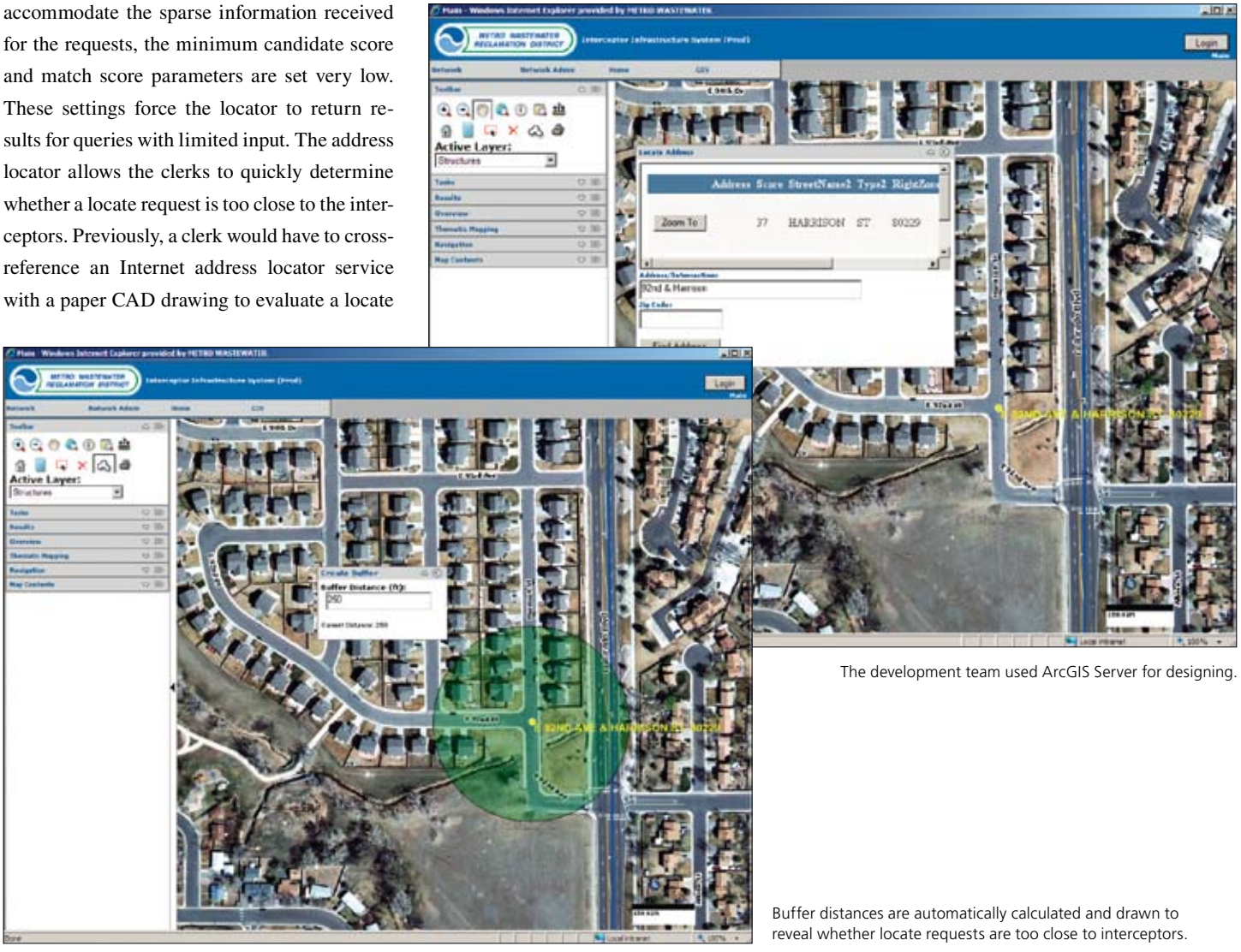
The Metro District receives approximately 6,000 of these locate requests every year. To minimize the risk of an incorrect locate request approval, we purchased one of the best geocoded street centerline datasets available. This data was loaded into the ArcSDE geodatabase, and a geodatabase address locator was created. To accommodate the sparse information received for the requests, the minimum candidate score and match score parameters are set very low. These settings force the locator to return results for queries with limited input. The address locator allows the clerks to quickly determine whether a locate request is too close to the interceptors. Previously, a clerk would have to cross-reference an Internet address locator service with a paper CAD drawing to evaluate a locate request. Those minutes saved, multiplied by the volume of locate requests, resulted in an incredible efficiency gain for the Metro District.

The project that GIS-enabled the IIS application was a success. Users were pleased with the new GIS functionality, and a training program was put in place so that people unfamiliar with the technology could become comfortable with the new tools.

In November 2006, ESRI released ArcGIS 9.2. The decision was made to upgrade IIS to the new version to take advantage of the numerous improvements made to ArcGIS Server. Client-side scripting had become available via AJAX-enabled ESRI Web controls, and much of the functionality previously available only through fine-grained ArcObjects was now delivered in the coarse-grained ADF objects. The system responsiveness and versatility opened the door for more robust solutions. Work on the upgrade began in February 2007, using the Web Mapping Application sample from ESRI as a springboard.

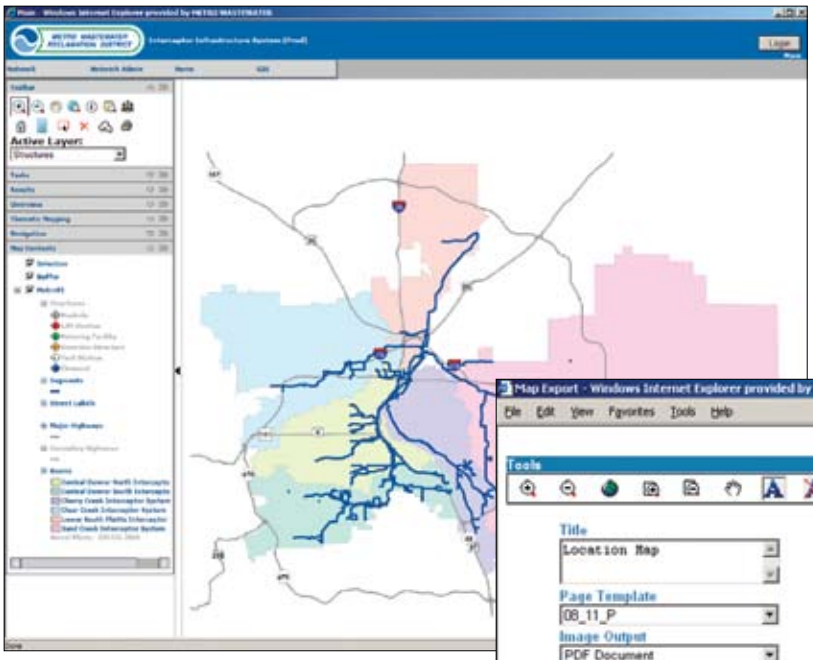
Upgrading the .NET 1.1 Web application to a .NET 2.0 Web site was the first challenge. Visual Studio provides a conversion tool that completes most of the work. What's left after the automatic conversion is cleanup: migrating constants to the ApplicationCode directory, changing "CodeBehind" to "CodeFile" in the <@Page element on .aspx pages, and deleting redundant event handlers.

Some fairly significant changes were introduced in the ArcGIS Server 9.2 ArcObjects

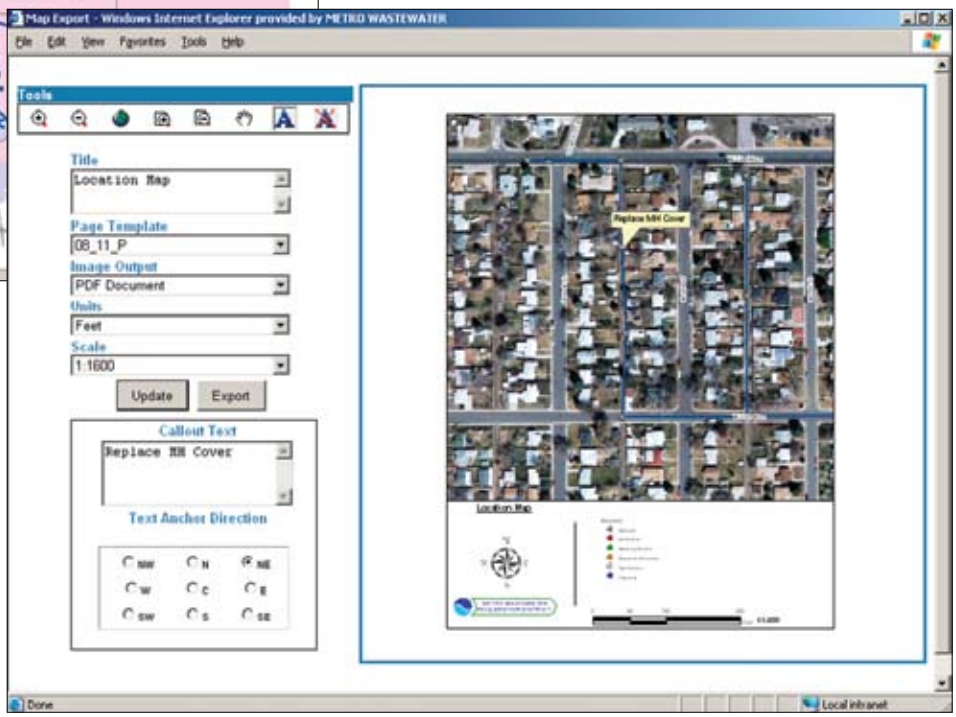


The development team used ArcGIS Server for designing.

Buffer distances are automatically calculated and drawn to reveal whether locate requests are too close to interceptors.



The water facilities map has 10 zoom levels to pinpoint work details.



Developers used ArcGIS Server to provide these map tools to aid employees working with the database.

model that impacted development efforts. Much of the functionality that had been developed in the 9.1 architecture had to be rewritten. Although it was frustrating to see some of the hard work become obsolete, it was also refreshing to work with the improvements of the new ADF model.

RWHTF initially experienced some performance issues in ArcGIS 9.2. For example, the many street labels for a metropolitan area of more than 600 square miles proved the primary culprit of slow performance. Map caching was used to improve the display speed of the basemap. The development team created a fused cache with 10 zoom levels to provide an enhanced user experience. All the functions worked seamlessly with the cached map, just as they would for vector data in a noncached service. The only exception was a code for a zoom-to-point method, which was solved using code provided by ESRI that steps through the cache scale levels.

There were other challenges: There was a lack of user forums activity, customer support was in high demand, and some features were not fully developed. To combat this, the development team provided some innovative custom solutions to meet the project requirements. For example, the map printing feature actually uses an ArcGIS Server 9.1 page layout control that allows the user to interact with various map items including title, callout boxes, page size, and export type. The entire printing feature resides as its own Web page, which accepts a cookie with the specific map information. This allows the print feature to be used by other Web sites that may be developed in the future.

Many IT project managers will agree that managing projects that incorporate new or cutting-edge technology can pose many challenges in budget, schedule, and quality objectives. Project control was essential to meet the Metro District's requirements. For example, throughout the project, our team was faced with development efforts that were unprecedented using ArcGIS Server 9.2. The team monitored the effort, and when it became apparent that the team could not develop the solution, it logged the issue with ESRI and moved on to another requirement. It is important to note that the development team embraced the technology culture by participating in the ArcGIS Server support network, which included the ESRI online forums and developer blogs. As another control measure, the Metro District chose to host developers on-site. This allowed the development team to use a test-driven development method by completing functional, integration, and system testing concurrently.

Testing was completed when new functionality was introduced, which was critical to ensure the new functionality did not disturb existing functionality. Most importantly, the team maintained a positive, roll-with-the-punches attitude toward the challenges we faced. The end result was the integration of GIS into IIS that has not only met the project requirements but opened the eyes of stakeholders and the user community to the power of GIS as a business solution.

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Michael Baker Jr., Inc., is a diversified consulting firm with more than 4,400 employees worldwide and more than 60 years of experience in the mapping sciences. It possesses one of the largest mapping and GIS practices in the United States, with nationwide delivery of services through its regionally dispersed offices. Baker provides its wide range of high technology mapping and geographic information system services to federal, state, and local government agencies; public and private utilities; and commercial sector customers. Its customers have grown accustomed to its strong project managers providing leadership for complex tasks while addressing the specific needs associated with each unique mapping and GIS project. Following is a sampling of its comprehensive service offerings for water, wastewater, and storm water providers.

Needs Assessment and Implementation Planning

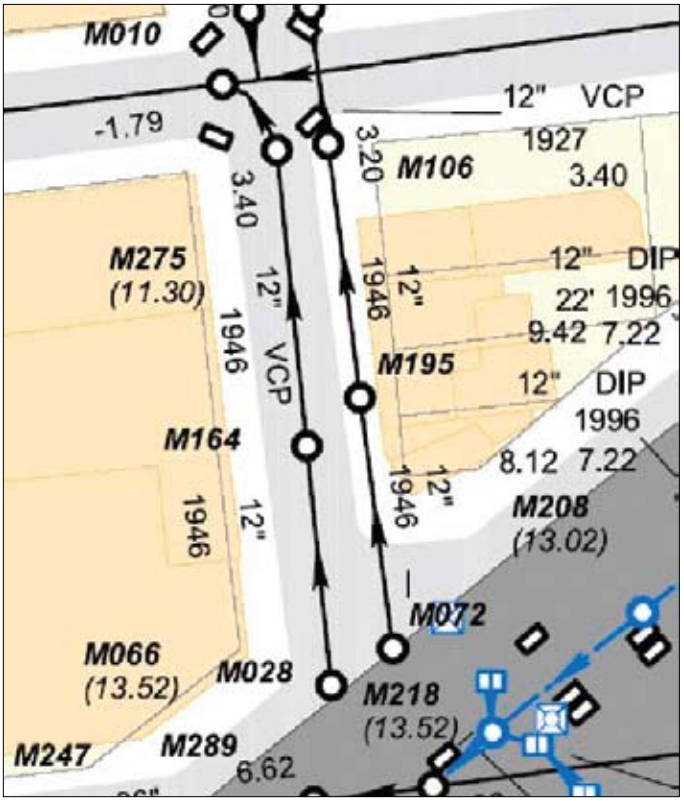
Today's progressive utilities must link the deployment of enterprise mapping and asset management with proper implementation planning. The days of isolated databases and applications are over. Baker understands the necessity of leveraging the needs assessment process to foster communication and cooperation to achieve organization goals. Through staff interviews and a strategic approach to workshops, a clear vision is established that cuts across all organizational structures.

Utilities Data Development

Baker provides the full range of utility-focused data services. Data development is an essential element in creating a GIS that meets the needs of users. Information derived from source documentation, such as as-built plans, intersection drawings, hydrant databases, legacy digital files, and supporting database systems, must contribute to the final data product. Several layers of quality control processes ensure that data meets and/or exceeds industry standards. Quality checks include field-based observation and GPS testing for spatial accuracy.

Work Order Management Integration

Its experience, coupled with a thorough understanding of infrastructure management procedures and their challenges, allows Baker



Data in the municipal database, the water utility database, and other databases is visualized through GIS to aid asset management.

to develop an effectively implemented utility asset management system. Today's tough regulatory environment requires strict accounting of system maintenance and annual investment strategies. Regardless of any computerized maintenance management system (CMMS) or work order software, Baker's focus is to develop GIS programs that integrate seamlessly with any asset management database. Creating a one-to-one match between the GIS and water/wastewater asset data adds real value to asset management productivity.

Mobile Work Force Planning

Workforces are mobile. They must find and repair infrastructure in the field, sometimes under the most difficult circumstances. They complete work orders and track maintenance activities. To be effective, the maps, data, and applications that they use need to be mobile. Baker designs enterprise utility GIS architecture that supports the mobile workforce. Its GeoLink field GPS/GIS solution is deployed for field collection, verification, and inspection of assets to provide real-time information on their condition and status.

Application Development

Baker's software developers understand business as well as software applications, networks, and computers. Its skilled team of software professionals is backed by world-class engineers and scientists, providing an integrated team that doesn't just speak in bits and bytes but in the language of any business. Baker's goal is to streamline the transfer of information to allow clients' staffs to make well-informed decisions.

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