

BY BRIAN M. BALCHUNAS AND CHARLES E. HUCKS

## MANAGEMENT TOOLS AT YOUR FINGERTIPS

# tapping the power of the Web

STORING ARCHIVAL AND OPERATING DOCUMENTS ON THE WEB CAN SHAVE DAYS OFF DESIGN TIME, SAVE DOLLARS IN COSTLY CHANGES WHEN CONSTRUCTION BEGINS, AND MAINTAIN CURRENT RECORDS CRITICAL TO THE OPERATION OF WATER AND WASTEWATER UTILITIES.

**W**ater and wastewater utilities have their own versions of time capsules. They exist in musty, windowless rooms, offsite storage facilities, even attics. Inside these spaces rest dust-covered flat files, shelves, and file cabinets in gray metal, sometimes sturdy oak. The drawers are labeled with facility names, project titles, or simply years. Occasionally, the blueprints, vellums, and binders inside live up to the labels' promises. Rarely, they reside in chronological order.

During the design and construction of plant upgrades, engineers and operators enter these makeshift time capsules. They seek a piece of history—the right as-built drawings, a set of maintenance records, an operations and maintenance (O&M) manual that has long been superseded. If found, the information can shave days off design time and save dollars in costly changes when construction begins. But finding that particular piece of history, if it can be found, takes time and resources as well.

Physically storing and searching through original drawings and hard copies soon will be another thing of the past. Today's Web technology can make as-builts, shop drawings, and other record documents available with a click of a mouse. The same technology can facilitate seamless project management during the design and construction of current upgrade work.

Once construction is complete, the applications can be used to prepare an online O&M manual. Compared with hard-copy O&M manuals stored in multiple binders, these digital documents are far more easily and accurately updated.

### BEST USE OF RESOURCES

No one understands the importance of as-builts and other project documentation more than managers, engineers, and operators at water and wastewater utilities. Upgrades are a certainty as communities grow and regulations

become more stringent. Yet when one upgrade project is completed, a utility's resources typically are channeled to daily operations as well as the next, immediate problem. Utilities rarely have the resources to allocate staff solely for cataloging and maintaining as-builts. The task, which serves some uncertain, future need, falls several notches down on the to-do lists.

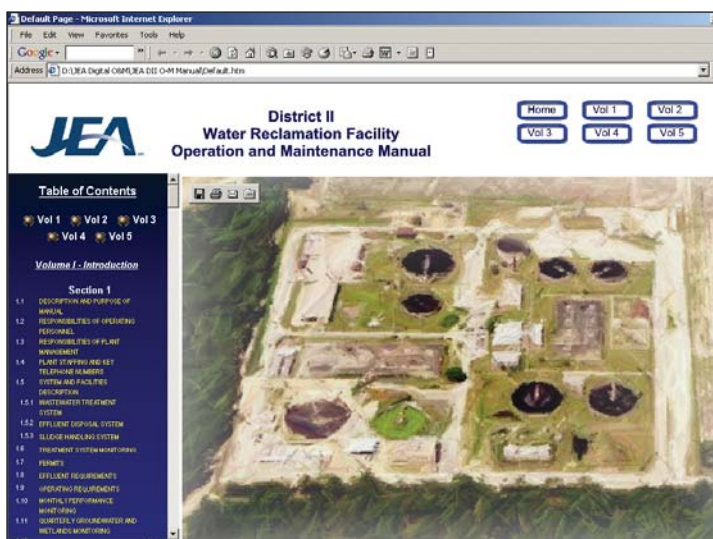
The volume of record documents for a typical 40- or 50-year-old plant can overwhelm available space. As a result, the inventory of record drawings and other documents may be relegated to a remote site, or the full complement of documents may be split among offices, the division based on assumed need. Over time, with office relocations, reorganizations, and staff turnover, finding a specific document can turn into a lengthy investigation.

### KEEPING UP WITH UPGRADES

The ready availability of as-builts, shop drawings, and manufacturer's information is especially important during water and wastewater treatment plant upgrades. Designs to augment performance or replace equipment for a particular process can rely heavily on data from the original installation.

During construction, accurate as-builts avoid costly changes from differing site conditions. The construction phase benefits as well when real-time project schedules and field notes are available to all team members. Because most plants remain online and must continue to meet drinking water standards or wastewater permit requirements during upgrade work, accurate data available around the clock mean strict schedules can be met and critical staging can be achieved to keep the plant operating.

Upgrade projects at water and wastewater treatment plants are



becoming more common as communities grow and costs to build new plants escalate. This trend foreshadows a need for a better way to combine both document management and project management for all phases of upgrades.

### CHANGING TECHNOLOGY

The widespread use of computer-aided drafting (CAD) since the 1990s has allowed utilities to move away from hand-drawn contract documents. Many utilities have converted hard-copy documents into raster digital files using high-resolution scanners. Advancements in web technologies such as Internet

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mapping and online databases have led to the development of document management systems designed to suit users' needs.

The next phase, in which secure, Web-based management tools integrate geographic information system (GIS)-based and database applications, has arrived. Web-based tools can be used to facilitate successful planning and execution of plant upgrade projects and to aid plant operators once construction is com-

Completed. Two case histories—a large water treatment plant upgrade completed on an aggressive schedule and a small, phased wastewater treatment

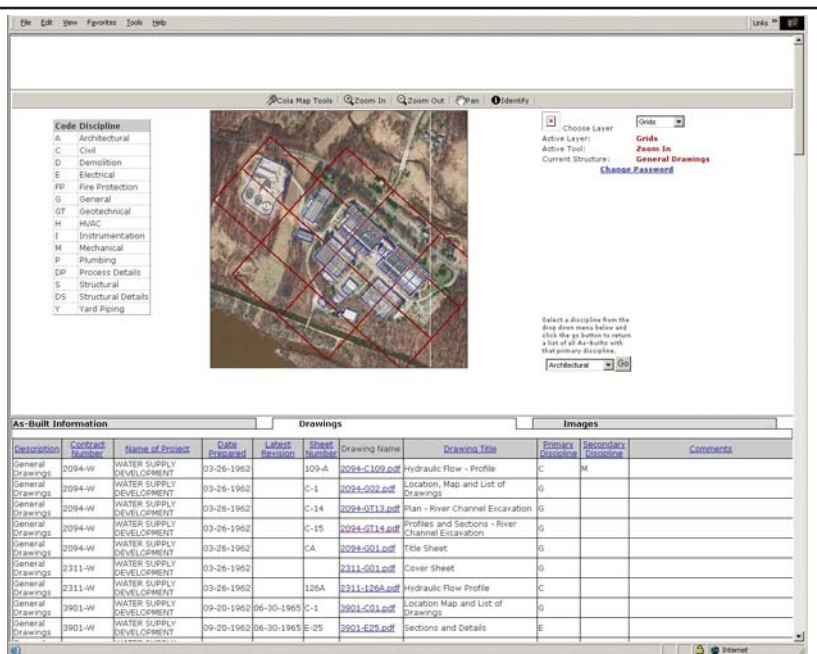
plant upgrade—illustrate the ease of use and the value provided by these applications.

### AMBITIOUS APPLICATION

In 2003, work began on a 288 mgd (1,090 ML/d) water treatment plant upgrade undertaken by a large municipal utility. Project goals included enhancing water quality and increasing process reliability to meet anticipated future drinking water quality regulations. Introduction of ultraviolet (UV) disinfection and installation of upgraded flocculation facilities, new rapid mix facilities, and a new backwash system, intermediate pumping station, and lime

system, along with related electrical improvements are to be completed by 2009. For security purposes, the specific utility and plant will not be named.

In the plant's 40-plus year history, at least 40 engineering and construction projects had been carried out to meet regional population growth and changing regulatory requirements. As a result more than 1,800 as-built drawings existed, with no single set containing all of the



Using the secure, GIS-based central online as-builts (COLA) application, users can select as-built drawings by clicking on a particular building or facility at the water treatment plan. As-built drawings can also be selected by specific discipline, such as mechanical, electrical, or architectural.

Once the COLA user selects a particular as-built, a digital image of the as-built comes on screen. The application eliminates the time and effort previously needed to seek out hard copies of as-builts.

drawings from remote locations. Each drawing was catalogued by the following parameters:

- drawing description;
- contract number;
- project name;
- date prepared;
- latest revision;
- sheet number;
- drawing name;
- drawing title;
- primary discipline, e.g., civil, electrical, instrumentation;
- secondary discipline; and
- special comments.

The plant site was divided into a series of grids and structures. Grid identifiers were used for civil, yard piping, and electrical site drawings. Structure identifiers were used for mechanical, structural, architectural and electrical drawings. No limits were placed on the number of grids or structures with which a drawing could be identified.

In the next step, the drawings were converted to digital format. The utility already had many of the required files in TIF format. Drawings not available digitally were scanned using a wide-format high-resolution scanner. For ease of printing and manipulation, drawings were converted to PDF format to maintain their original size and be printed at the proper scale.

The database was linked geographically to the website using a GIS-based application built on a Microsoft.Net™ framework as the base component for the document

most recent information. Because the new upgrade project involved the majority of the plant's facilities, quick, easy access to existing as-built information was necessary.

Engineering consulting firm PBS&J was retained to develop the water treatment improvements. In addition to designing plant upgrades, the firm developed online applications to access as-built drawings and to facilitate smooth project management among team members. Rather

than having to collate, copy, and distribute paper copies of as-built and project information to all team members, the information was shared using Web-based applications.

### AS-BUILT ACCESS

As-built drawings were stored in digital form and shared using the secure, GIS-based central online as-builts (COLA) application. Engineers developed the website in stages. First, they collected all relevant as-built

management system. The database was georeferenced to actual locations using a high-resolution aerial photo of the plant and CAD drawings converted to GIS layers. This image provided details of the structures' geospatial relationships to one another.

### **QUICK, ACCURATE SEARCHES**

All project team members can access COLA through a secure socket layer. Once at the website, users select whether they want to identify information by grid or structure. By clicking on the digital image of a building or facility, the appropriate grid or structure is highlighted, and a list of drawings associated with that grid or structure is displayed. A hyperlink allows each drawing to be opened within the Web browser or saved to another location. The application also includes zoom- and pan-features to quickly navigate the image and find the desired location. Photographs of areas covered by as-builts are provided as well.

The list of drawings can be sorted using any of the database fields. For example, a user can locate a drawing from a specific contract or within a specific discipline. Additionally, all drawings available from a specific discipline can be listed at once. This helps electrical, structural, and instrumentation subconsultants find drawings pertinent to their work on the current upgrade project, an especially valuable and reassuring tool before demolition or excavation work begins. Photographs from the site can be accessed by database field as well.

Utility staff responded positively to the application. In the past, no one person or group had been the keeper of record documents. Now the most accurate information is retrieved without personnel having to leave the plant or office. Time and money to prepare and distribute paper copies of drawings and other documents is saved.

### **A MODEL USE**

COLA was so successful that the utility expanded its availability to

# Online O&M More Than Convenience

In Florida, as in other states, a draft operations and maintenance (O&M) manual must be available before starting up newly constructed or modified municipal wastewater treatment plants or other effluent disposal or reuse facilities. Operators must notify the Florida Department of Environmental Protection (FDEP) that the draft O&M manual is available before start-up and, within six months, that the final manual is complete.

Meeting these requirements becomes a more manageable task when an O&M manual is created and managed online. Contract documents, as-builts, submittal data, and operating procedures are input in digital form. Easy updating capability ensures the most recent data, such as changes in processes, new equipment, or revised permit conditions, are included and available for inspection. The innate potential for error in updating multiple hard copies of an O&M manual is eliminated.

Even in digital form, O&M manuals must be more than a collection of design drawings, cut sheets, and telephone contacts. Florida law requires the manuals to be consistent with the system's complexity and developed in accordance with the plant's unique requirements. Typical components for a digital O&M manual include

- hydraulic and engineering design criteria for the plant and its facilities;
- information and procedures required for normal control and distribution of wastewater, residuals, chemicals, and effluent;
- process control information and a performance evaluation of the plant;
- equipment and procedures required for emergency operating conditions;
- instructions for regular maintenance and repair of all equipment and lists of recommended on-hand spare parts;
- monitoring procedures and a description of laboratory testing equipment required;
- safety and personnel requirements; and
- a troubleshooting guide specific to the plant.

Online O&M manuals offer a further advantage with their ability to link to existing documents, such as a utilitywide safety manual, regulatory requirements listed on another agency's website, or digital copies of permits. Text can be cross-linked to drawings, drawings cross-linked to pictures, pictures cross-linked to databases, and databases cross-linked to operations or maintenance procedures.

other engineers and staff working at the plant. PBS&J is also placing the digital information into a 3-D plant model. The model includes all process and drain piping as well as electrical and instrumentation duct banks. Utility staff, design engineers, and contractors will see how potential future upgrades will look. Contractors will better see the relationship of existing facilities, such as underground utilities, before they start work.

This 3-D model could also be converted to GIS format and the database expanded so that users could

one, whether working on the upgrade or other projects, required access to the same information.

To address the need for secure, accurate, up-to-date information, PBS&J developed TeamAccess, an online project management application. The project-specific website offers a collaboration tool for team members 24 hours a day, seven days a week from any location with Internet access.

Users can access a complete team member directory and a calendar with real-time updates of scheduled meetings and deadlines. Calendar

- Engineer level, with access to specifications and drawings only; and
- CAD operator, with access to drawings only.

The application can also be tailored to make some documents available for public access on a separate website without risking unintended access to other project data.

In spite of the project management advances represented by TeamAccess, utility staff and the consultant reported it was easy to use. Training took only a few hours during a workshop where team members were already gathered. As more proof of the application's

## The online technology also helps the utility meet state regulatory requirements to provide and maintain a complete, accurate O&M manual for the plant.

quickly find all drawings relative to an individual utility. In addition, PBS&J has been asked to develop a similar, yet more advanced, tool for one of the utility's wastewater treatment facilities.

The water utility spent less than \$100,000 for the development of COLA and the project management tools described in this article. In addition to smoothing the path toward a completed upgrade project, the utility expects the technology investment to benefit future work. The estimated cost to design and construct upgrades will be inherently lower. Consultants will no longer need to factor in the time to locate pertinent as-builts. Contractors will have the best site information available during the bid process and construction. Upon completion, new design and construction documents can easily be added to the existing COLA.

### ONLINE PROJECT MANAGEMENT

The project team for the water treatment plant upgrade included seven other consultants and the plant owner. At the same time, three additional projects at the site were in either design or construction phases. For optimum coordination, every-

and directory information can be imported to users' own Microsoft Outlook®. The application also includes a message board to start discussion threads and advance communication among team members.

An integrated e-mail engine sends, receives, and stores e-mails. The utility uses PBS&J's e-mail server to relay e-mails to utility accounts. That way, a copy of the e-mail can always be made available if needed. By storing all project documents in the application, team members can retrieve and respond to the most recent project information.

Project executives can check on upgrade project status at any time without waiting for reports. This capability also made available resources that would have been spent compiling reports likely out-of-date by the time hard copies would have been distributed.

### SECURE, EASY TO OPERATE

For security, four access levels were established:

- Administrator level, offering access to the entire site and the ability to add users to the system;
- Project manager level, offering access to the entire site;

inherent simplicity, it was built using off-the-shelf components (see the Nuts and Bolts sidebar on page 99).

Although not used for this upgrade project, a TeamAccess application could share requests for information (RFI) and change-order forms. When used in conjunction with the built-in e-mail application, team members could circulate an RFI for quick review and turnaround. The RFI and its response could then be stored electronically with other project documents.

### WEB-BASED O&M MANUALS

JEA, the largest community-owned electric utility in North Florida, began operating the city of Jacksonville's water and wastewater systems in 1997. At that time, O&M manuals at treatment plants in the system looked like those at any other water or wastewater treatment plant—a collection of hand-drawn process diagrams, equipment cut sheets, and reduced-sized drawings. Written information was prepared on typewriters or word processors long obsolete or incompatible with newer software and equipment.

The manuals were prepared as required for each plant upgrade, then

set aside once operators mastered plant maintenance and operations. Before computers were commonplace at the plants, operators could not easily change or update the contents of the manuals. Rewriting and reassembling the O&M manuals after upgrade projects became the simplest approach to ensuring an accurate document.

## PHASE MANUALS FOR A PHASE UPGRADE

For the JEA District II wastewater treatment plant, a new or revised O&M manual had been supplied after a plant expansion in the late 1970s. In 2002, the JEA plant was modified to provide reclaimed water and to reduce nitrogen levels discharged to nearby surface waters. The project was divided into three phases to maintain the plant's operation through either its north or south treatment facilities.

In phase 1, flow was diverted to the north plant while equipment was installed at the south plant and effluent filters and UV disinfection were added. In phase 2, flow was diverted to the south plant, allowing a process modification to a two-stage anoxic/aerobic process at the north plant and the addition of a blower building. In phase 3, flow was diverted again to the north plant while the south plant basins were modified for two-stage operation.

Each phase operated independently. Therefore, JEA decided to produce an interim manual to address the modified operations. PBS&J developed an online manual during phase-1 work and designed the manual so it could be modified as needed during each additional phase without having to rewrite or recreate information. The online technology also helps the utility meet state regulatory requirements to provide and maintain a complete, accurate O&M manual for the plant (see the More Than Convenience sidebar on page 97).

## O&M MANUAL COMPONENTS

The utility established the criteria listed below for developing the manual:

# Nuts and Bolts

TeamAccess represents the latest in Web-based applications integrating geographic information systems (GIS) and database applications. Yet it was created using off-the-shelf components.

The components used to create central online as-builts (COLA) include an integrated development environment, a GIS application with a Web-mapping application server, and a relational database management system. First, existing computer-aided design files were converted to GIS shape files. The next step, a bigger challenge, was taking flat data, such as hard-copy as-builts, and relating it to files in the application. To achieve this, a GIS application was used to build shape files to be georeferenced correctly to true north. In all, for the water treatment plant upgrade project, about 3 GB of drawings were scanned in with an average drawing size of 2 MB.

All documents are encrypted for security purposes using a 128-bit secure socket layer. The application is password-secured, and passwords are required to have a certain number of digits and characters. Cookies also are encrypted so that users can browse files securely. In other words, no point of access exists outside the utility.

Engineers advise that a utility's computer systems must be up-to-date and include adequate storage, or the TeamAccess and COLA applications will run slowly. At the same time, this does not mean expensive equipment is needed. A basic color printer is adequate to obtain hard copies of plans or schematics for use as reference documents.

- The manual would be developed and produced for delivery on digital media, and there would be no hard copies of the manual.

- The manual would reside on the JEA intranet and be accessible to intranet users as well as being accessible from a desktop computer or a CD.

- The manual would provide direct links to the existing online JEA safety manual and online asset management software system Maximo® Enterprise, as well as relevant websites accessible on the Internet.

- All major valves controlling flow through the facility would be located with a global-positioning system (GPS) unit and the locations entered in a database for use by staff.

Data requirements and plant operations were reviewed during weekly meetings between PBS&J and the operating staff. The manual was installed on the JEA network, and

PBS&J conducted training for plant staff. To allow future modifications and updates by JEA staff, the manual was developed using Microsoft Word and converted to HTML using Microsoft FrontPage®.

The manual was developed as several volumes:

*The Introduction and Manual User's Guide* presents an overall description of the facility and summarizes operating, monitoring, and reporting requirements specified in the plant operating permit. Appendixes include the facility design criteria and Florida Department of Environmental Protection (FDEP) permit and regulations governing the operation and monitoring of the facility.

*The Operator's Handbook* presents a process control manual covering the sampling, testing, and record keeping necessary to operate and control the plant's biological

process. An operating strategy designed to assist the staff in operating the facility efficiently and effectively is also presented.

An *Equipment Operation and Control Guide* provides startup, operation, control, and troubleshooting information for equipment at the facility. This volume maximizes the use of self-explanatory figures and tables, minimizes the use of text, and is cross-referenced to the vendor O&M manuals.

## HELPFUL LINKS

As required by JEA, the utility's previously existing systemwide safety manual is accessed through an intranet link. Treatment plant maintenance data are also available through a link to the utility's Maximo system.

Also included in the online manual are direct links to operating permits and websites linking operators to FDEP rules, regulations, monitoring requirements, approved testing procedures, staffing requirements, and operations certification program information. Links to useful sites such as the US Environmental Protection Agency and Water Environment Federation are also provided.

In addition to the manual sections, PBS&J and JEA staff located each valve controlling flow through the system using a GPS unit. Images of the valves were taken with a digital camera. A database naming and describing the function and normal operating position of each valve was developed. The database was linked to each picture and to a CAD drawing of the system piping and valves.

## BETTER O&M MANUALS

Once a digital O&M manual is in place on a network or a desktop with intranet access, additional links may be made. These include but are not limited to

- access to policy and procedures manuals,
- online submission of reports and permits,
- links to manufacturer websites and maintenance manuals for plant equipment, and

- digital equipment maintenance manuals.

In fact, utilities should begin modifying specifications to require digital submissions rather than hard-copy manuals to further complete the transition to online documentation.

Applications such as COLA can assist a utility in creating an O&M manual once upgrade work is completed. With all contract documents provided in AutoCAD® or other vector formulas, the drawings can easily be converted to GIS formats for linkage to the georeferenced database. Once construction is completed, shop drawings, equipment maintenance information, and other data can be added and directly accessed from the website as well. The website in essence becomes the plant's new O&M manual, an easily updated, living document that reflects new upgrades as they occur.

## THE NEXT WAVE

Engineers anticipate all design and construction data will be placed in a geo-database in the near future with all access transferred to Web services. Users will hold only the data they require frequently and obtain data from other sources to meet specific needs.

For example, an engineer could obtain roads information from one Web source and contours from another source to create a map without his or her system having stored or updated either of the original data sets. This pay-as-you-go approach yields cost savings by eliminating the need to store and maintain surplus data. Data will be shared easily between entities that need it, as they need it.

Although pay-as-you-go data-sharing applications may seem a far-off possibility to some, the Web-based tools available today are accessible and affordable. Water and wastewater utilities will find that moving into these new applications is really more of a natural step than a leap. Given the convenience and cost savings of online as-builts, project man-

agement tools, and O&M manuals, that step is more desirable than another trip to a utility's dusty time capsule.

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