



Title: GIS in Public Works: Atlanta - Save Our Sewers Initiative

Clare Brown, Keith Toomer

ABSTRACT

Under the *Clean Water Atlanta* (CWA) Program, KHA FRA has been tasked to build an enterprise-wide GIS system for the City of Atlanta (COA), Wastewater Management Department. KHA FRA is in the process of implementing a system, whereby GIS information can be accessed/distributed via the Internet using ArcIMS and conventional web-based tools. These data are stored in an Oracle database and accessed through Spatial Database Engine (SDE). In addition, KHA FRA has built on-line tools to ingest, QA/QC, track and report weekly work performed by the sewer operation field crews as well as automatically upload data to the Hansen Work Management system.

INTRODUCTION

The City of Atlanta contracted the Program Management Team (PMT) under *Clean Water Atlanta* to assist them with compliance to a Consent Decree, issued by the U.S. Department of Justice in 1999, to reduce the number of overflows from their sanitary sewer collection system. PMT is comprised of a joint venture between Montgomery Watson-Harza and KHA FRA, as well as numerous sub-contractors. This paper will focus on how web-based mapping tools can dramatically change and improve the method in which cities conduct day-to-day sewer operations and hopefully, aid in compliance to the Consent Decree.

Working side by side with the City's Watershed Management Engineering Information System Division, KHA FRA has assisted in the effort to improve the city's mapping system by converting their CADD based sewer drawings to a GIS format. Having their collection system in a GIS database provides sewer operations employees with a powerful tool to perform complex spatial calculations and queries especially when combined with other layers such as topography, hydrology, soils, geology and transportation to name a few. It also serves as an extremely helpful planning tool for Maintenance Operations Management System (MOMS).

KHA FRA also implemented a system, whereby this GIS information can be accessed/distributed via an Internet Mapping interface and conventional web-based tools. This effort allows every employee access to the GIS information, through their web browser, without requiring the user to maintain and license GIS software on their personal computer system.

In addition, KHA FRA was tasked with building an enterprise-wide GIS system. These data are stored in an Oracle database and accessed through ESRI's Spatial Database

Engine (SDE). Enterprise-wide GIS is a term used to indicate that many different users can access and update a GIS database simultaneously without loss of information or corruption of datasets. This becomes very important in large organizations where multiple departments need access to and assist with maintaining different datasets used in the Geographic Information System.

Another application that is being explored is field reporting using handheld computers or tablet PC's. With the recent advances in technology, handheld wireless devices are not only feasible but also affordable offering powerful processors and direct Internet connections through a cell phone or other wireless device. Internet Mapping Services can be built to be displayed, real-time, over the Internet on a handheld wireless device. In this way, limitations with storage capacity are no longer a concern. GPS receivers can be added to the handheld device to accompany field investigations. Through internet mapping software a website can be built that displays maps of a whole city/county/state/country etc. including sewer lines, manholes, wastewater treatment plants, pump stations, aerials or satellite imagery. What would usually take hundreds to thousands of megabytes worth of storage now can be housed on a website server. Using ESRI ArcPad software, a user can load data from the hard drive or load a map from the website, where all the processing is performed on the server side, the client (handheld device) is just making the requests i.e.... zoom in, zoom out, pan, identify. The server can process these requests relatively quickly and send ~2k images to the handheld device. Using ArcPad's development kit, customizing user input screens is a relatively simple task. The input screens will be built around a local database stored on the handheld device. This in turn could be synchronized when returning to the office or sent directly to the office via email or another wireless method. The applications being considered for development for the COA are creek crossing inspections, spill reporting and easement inspections. If these are successful, other field applications will be explored.

Currently eleven customized mapping websites have been implemented to assist COA and PMT members with their day-to-day tasks. Several of these were designed as search engines – search for map by manhole identifier, search for map by street address etc... Other mapping websites were designed with additional GIS functionality for more experienced users. Both types have greatly aided the COA and PMT employees and their usefulness will continue to grow as they become a standard operating procedure.

METHODOLOGY

Throughout the past 20 years, the City of Atlanta has undergone the monumental task of capturing their wastewater collection system from a paper medium to an electronic medium. The collection system was captured from as-built drawings and entered manually into Microstation CADD files. This allowed the city to produce maps of the sewer system and distribute among their staff. The consent decree mandated that the city maintain a mapping system that contained the collection systems attributes such as age, diameter, slope, elevation etc... The city asked the PMT to assist them with this task. Conversion to a fully functional GIS system seemed appropriate so that these attributes could be associated with each pipe segment and manhole.

The Microstation file was converted from a .dgn format to a GIS coverage. As many attributes as possible were assigned automatically to the GIS file. The rest was accomplished through labor-intensive manual methods. The City of Atlanta also undertook the task of conducting macro and micro surveys of the sanitary collection system. The Macro survey encompassed surveying all pipes between 18" or larger and visible manholes. The Micro survey encompassed pipes from 10" to 18" and their associated (visible) manholes. With this new GIS system, the city has transformed a purely graphical representation of the city's collection system to a multi-dimensional information based system.

In addition, the city is also conducting a Sanitary Sewer Evaluation Survey (SSES) for all manholes and pipe segments. All manholes (including those covered) will be inspected not only for location, elevation and size but also for condition. The pipe segments will be surveyed for condition (using Closed Circuit TV - CCTV) and connectivity. The SSES contractors are required to deliver their data in a stringent data format so that a rigorous QA/QC process can take place before accepting the data. Automated processes have been developed by the PMT to assure correct geographic coordinates, pipe size, slopes, elevations, manhole/ pipe identifiers and connectivity. Once these data have been quality assured, they are compared to the existing GIS data. The GIS data are updated where appropriate. After the completion of the SSES any new changes that occur within the collection system will have to be recorded from as-built construction drawings. In this way the City of Atlanta will maintain current and accurate GIS. Those of us familiar with GIS understand that a GIS is a database system that includes a spatial component. The spatial component is its X-coordinate and Y-coordinate. This XY coordinate gives us a location associated with this feature or record. This is what transforms the GIS into a much more powerful tool than a typical database. With a typical database associations can be made between records and fields within the database – essentially it is an asset management tool. A GIS allows the user to make spatial associations or associations based on location. This cannot be done with most databases or asset management systems. Another powerful feature of a GIS is that it can be manipulated or programmed to perform specific functions, such as work management. GIS is really an asset management system with a mapping or spatial component.

Our approach to MOMS, asset management and mapping is to allow easy to use website access to our GIS. We quickly realized that one website could not adequately accommodate all of our users. With this realization we were committed to producing many mapping websites, which would be designed and customized for each PMT task or subgroup. In this way, we could include only the tools that were pertinent to that subgroup making the website easier to understand and use. Minimum training is needed for each subgroup since the website is created in a fashion to be intuitive to that task. This methodology has proven successful for our program.

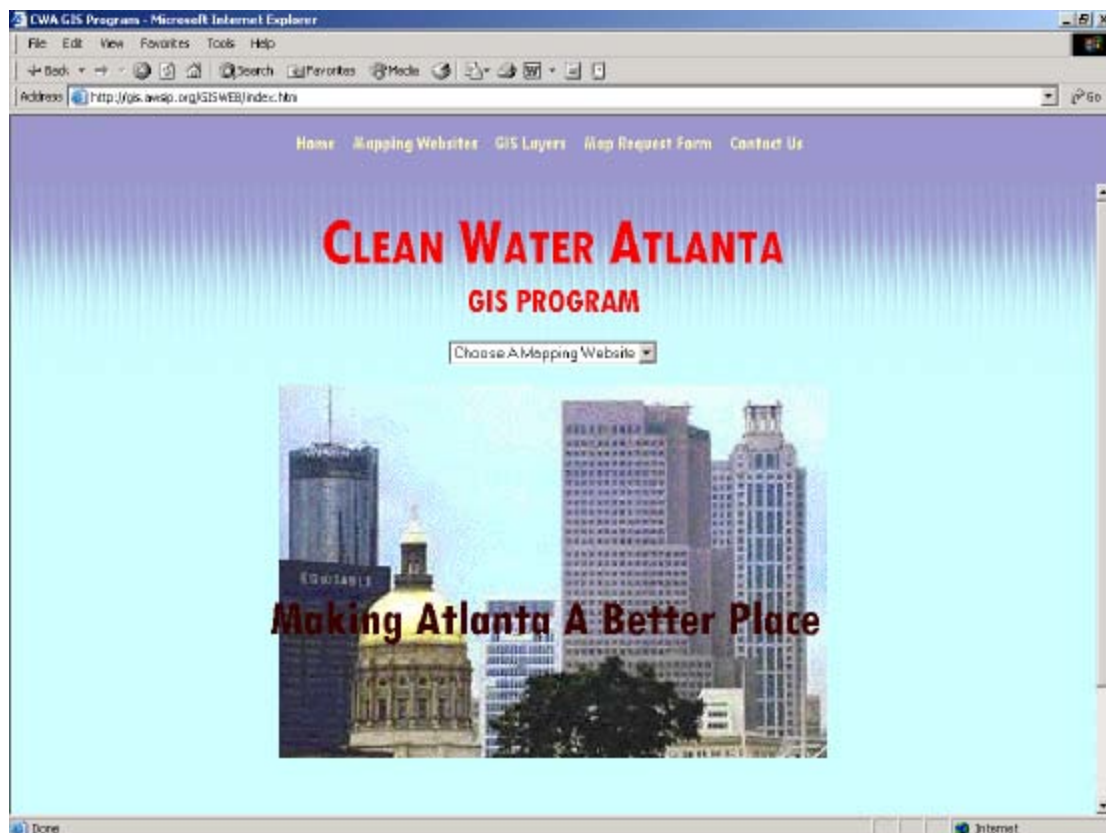
DATA DISSEMINATION

The CWA GIS website is arranged into several components (Figure 1). The three main components are Mapping Websites, GIS Layers and Map Request Form. The Mapping Websites component contains interactive mapping websites each designed for a specific

CWA task. These will be discussed in further detail in this paper. The map request form component takes the user to an online map request form. In many instances our users are in need of a printed or mounted map. They can request the map at our site and send it directly to the GIS group. The map request form prompts the user to choose map size, media, title, scale, asks the user to describe what needs to be depicted by the map and the intended audience. We contact the user with any further questions and to let them know we have received their request.

The GIS Layers component catalogs all the GIS layers or themes that we maintain. We divide our layers into three categories: wastewater, planimetric and boundary. The first category contains the GIS layers which are related to wastewater; these include sewer lines manholes, wastewater treatment facilities, CSO facilities, sewershed areas, sewer basins, sewer creek crossing segments, overflows, CIPP, etc... The next category contains planimetric layers such as parks, creeks and rivers, topography, building footprints, streets and highways, soils, etc... The final category contains layers that denote boundaries such as parcels, council districts, neighborhood planning units, city quadrants, counties, city boundaries, etc... In the GIS Layers component not only do we include a JPEG image of each type of layer or theme, we also include a metadata link for it.

Figure 1 – CWA GIS Website Home Page



Metadata

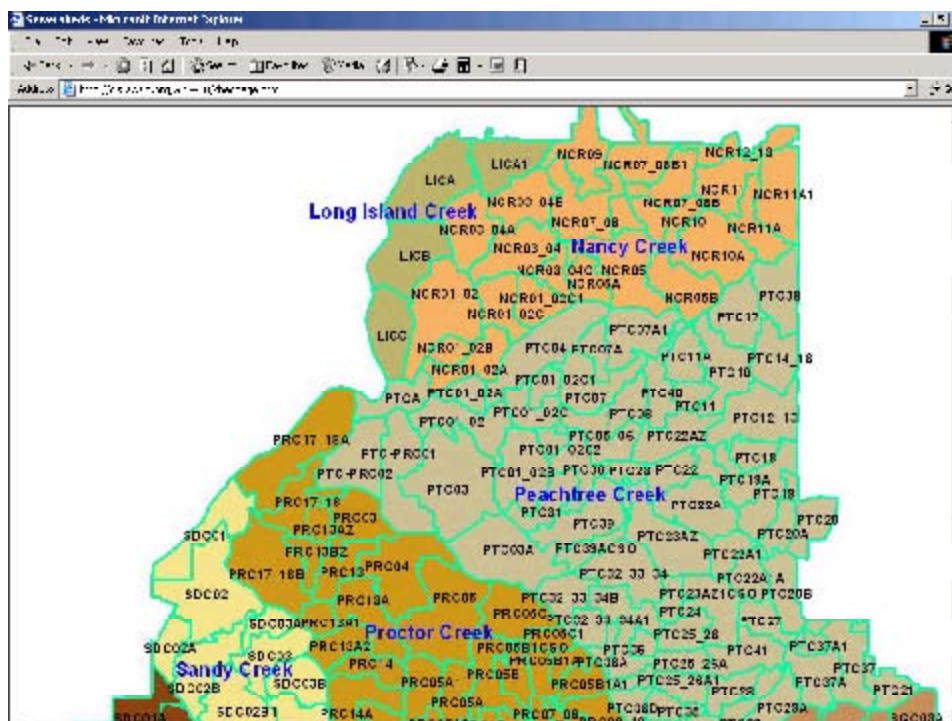
Metadata is another important aspect of any GIS or database system. Metadata or "data about data" describe the content, quality, condition, and other characteristics of data. When using map layers to perform GIS analysis or to depict features in a map, one needs to have some knowledge about the source and accuracy of their datasets. Parameters included in metadata are precision, accuracy, date acquired, datum, projection, author or owner of the data and a list of other pertinent information about the GIS layer. We have included metadata on our website so that any user who requests a map or uses our mapping website will have access to this information. We followed the Federal Geographic Data Committee (FGDC) guidelines for Digital Geospatial Metadata for reporting our data.

Static vs. Interactive Mapping Websites

The CWA GIS program has employed the use of both static and interactive mapping websites. A static website is one where the data remains static or does not change. Each time the user selects a static map it remains the same. The user is not given the opportunity to specify parameters or customize the map in any way. An interactive mapping website is one where the user can choose different parameters to specify what they are interested in seeing and the map changes based on what the user specifies. In this way the user has some control over what the map will look like or what information it will contain.

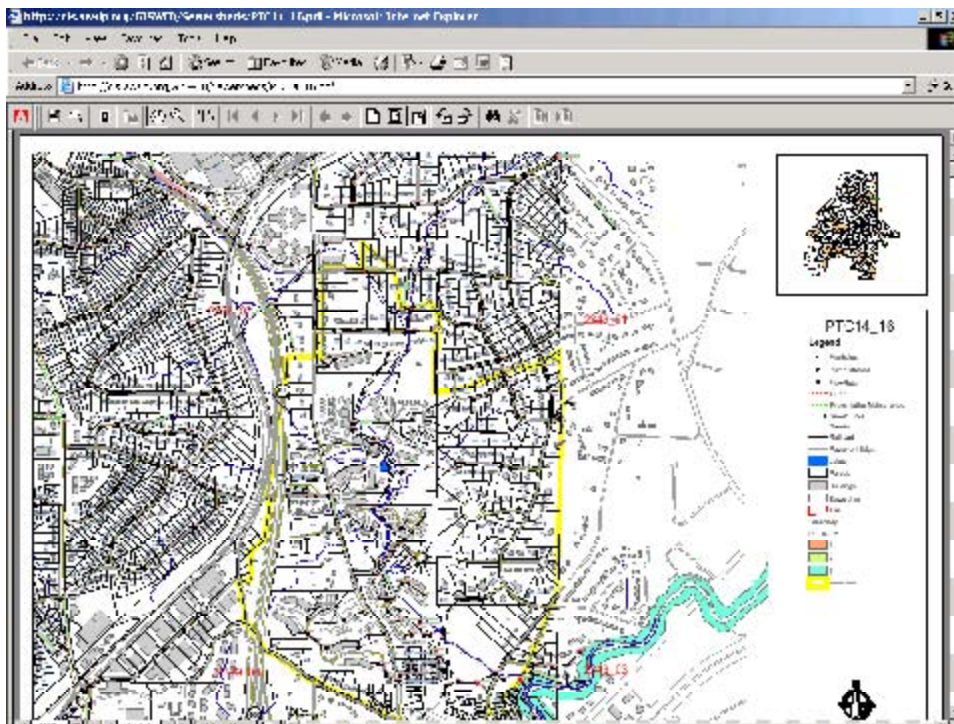
Based on the appropriateness of the application the CWA program has use of both static and interactive mapping websites. An example of a static mapping website is the sewershed map website. The user is presented with a map of the city of Atlanta depicting its sewershed divisions (Figure 2).

Figure 2 – Sewershed Map Website



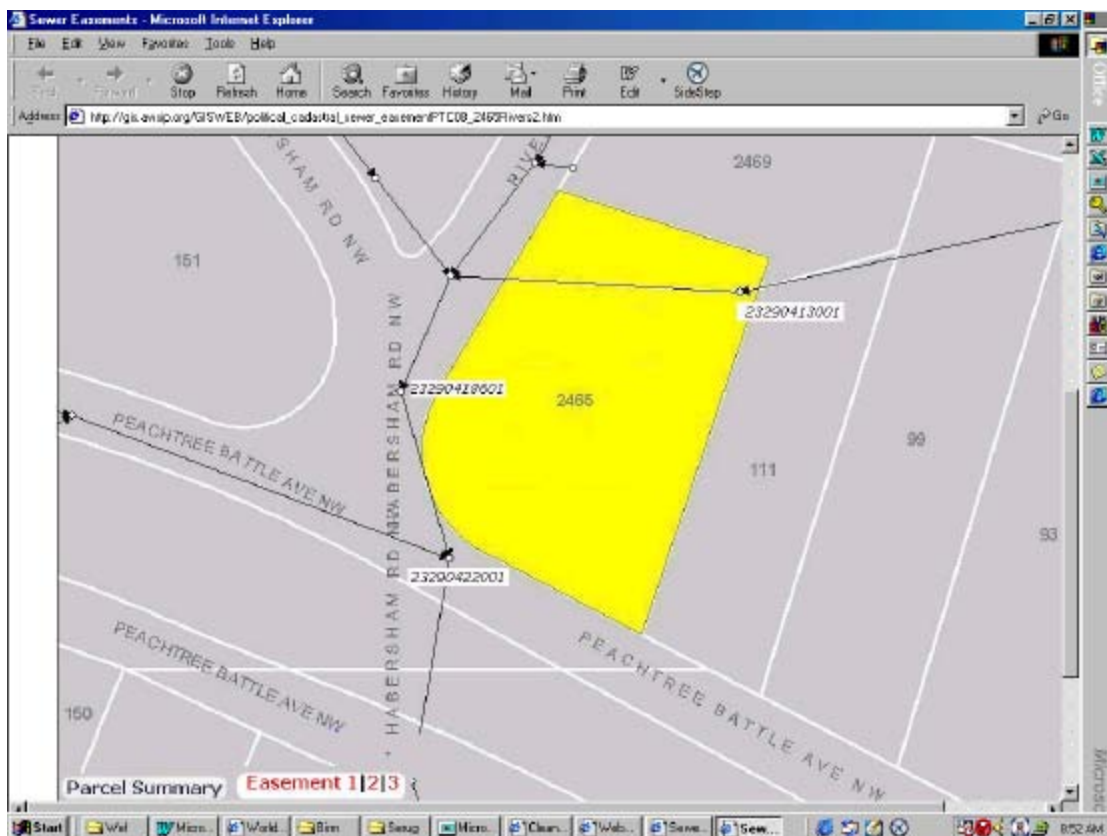
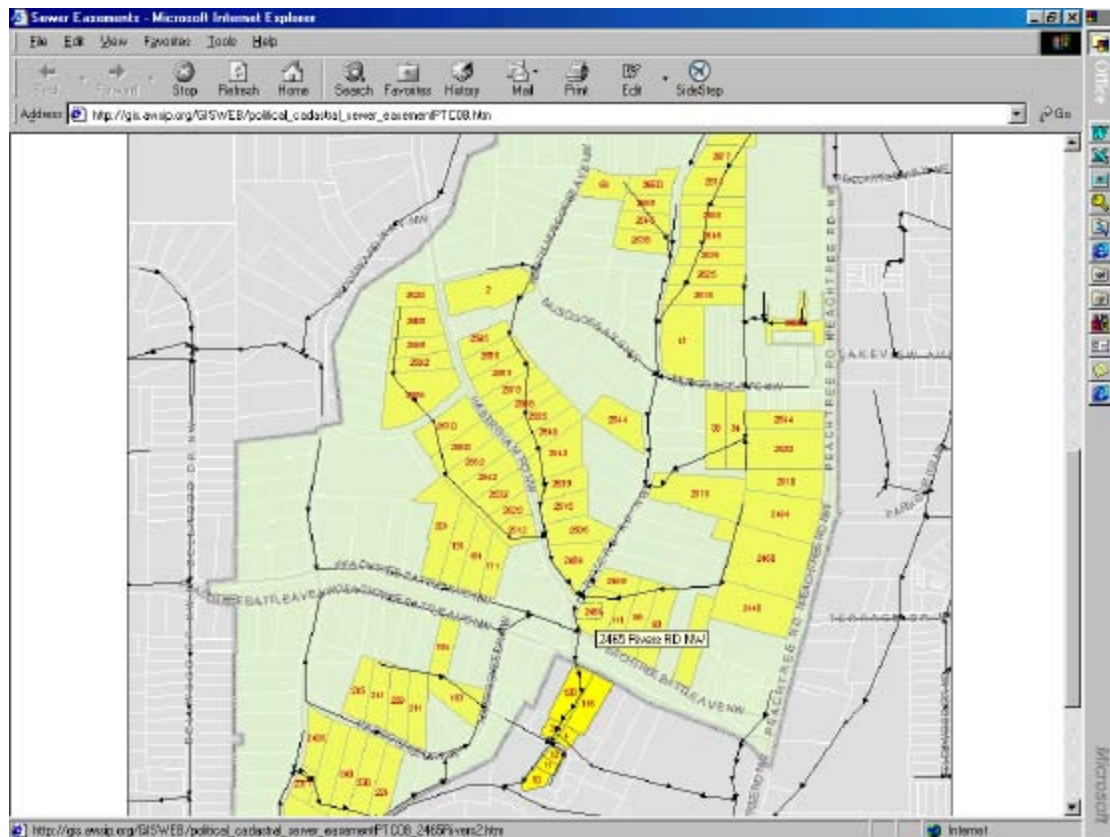
The user can then select a sewershed and is presented with a map in adobe .pdf file format (Figure 3). They can then print the map directly to a printer or plotter. These maps were generated at an ANSI E size format (34" x 44") so they are most usable at that size but a user can print them out at any size. These maps are defined as static since they have no interactive capability. The user is not given the chance to modify these maps. The maps are updated on a monthly basis to reflect new information about each sewershed. (Most users have Adobe Acrobat Reader loaded on their computers but if they do not we have also presented the user with a link so they can download this free software. Once the software is loaded on the users' computer, the map opens up automatically on their screen.)

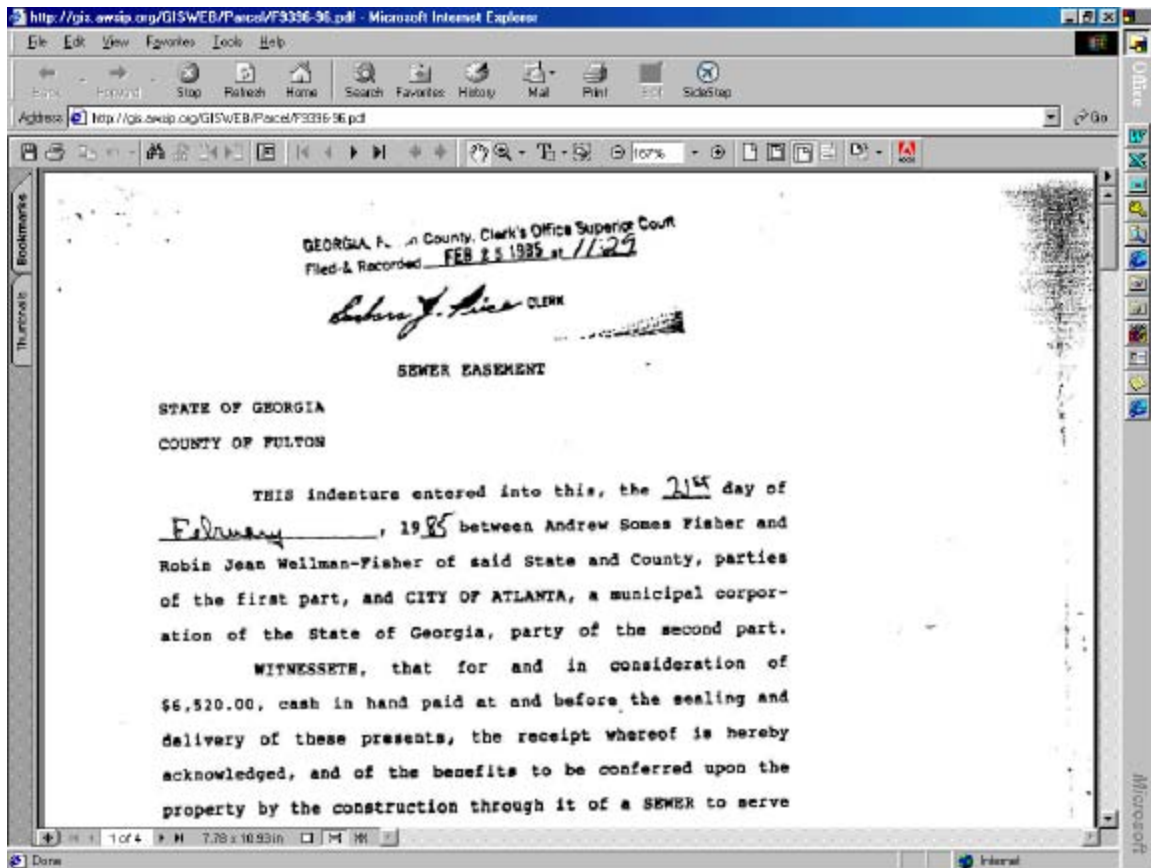
Figure 3 – Adobe .pdf file



The CWA GIS program is in the process of developing another static website to aid in cataloging easement documentation. Easement research must be conducted for all properties that contain a wastewater collection facility (sewer, manhole, pump station) to perform SSES operations. Easement information is gathered from the local county courts for each parcel affected by SSES operations. This research can be a lengthy process. A copy of the easement information was copied and filed for SSES records. The space alone to store these documents for all effected parcels within the city limits can be extensive not to mention the inconvenience of paper documents being mis-filed. A prototype was developed to scan each easement, convert to .pdf file format, and generate a map depicting each parcel within a sewershed where a wastewater collection facility intersected its property line (Figure 4). The user can find the easement of interest by drilling down to the exact location or parcel and selecting that parcel (Figure 5). The scanned easement will be displayed on the screen and can be printed directly from the website (Figure 6).

Figure 4, 5 & 6 – Parcel Easements Website

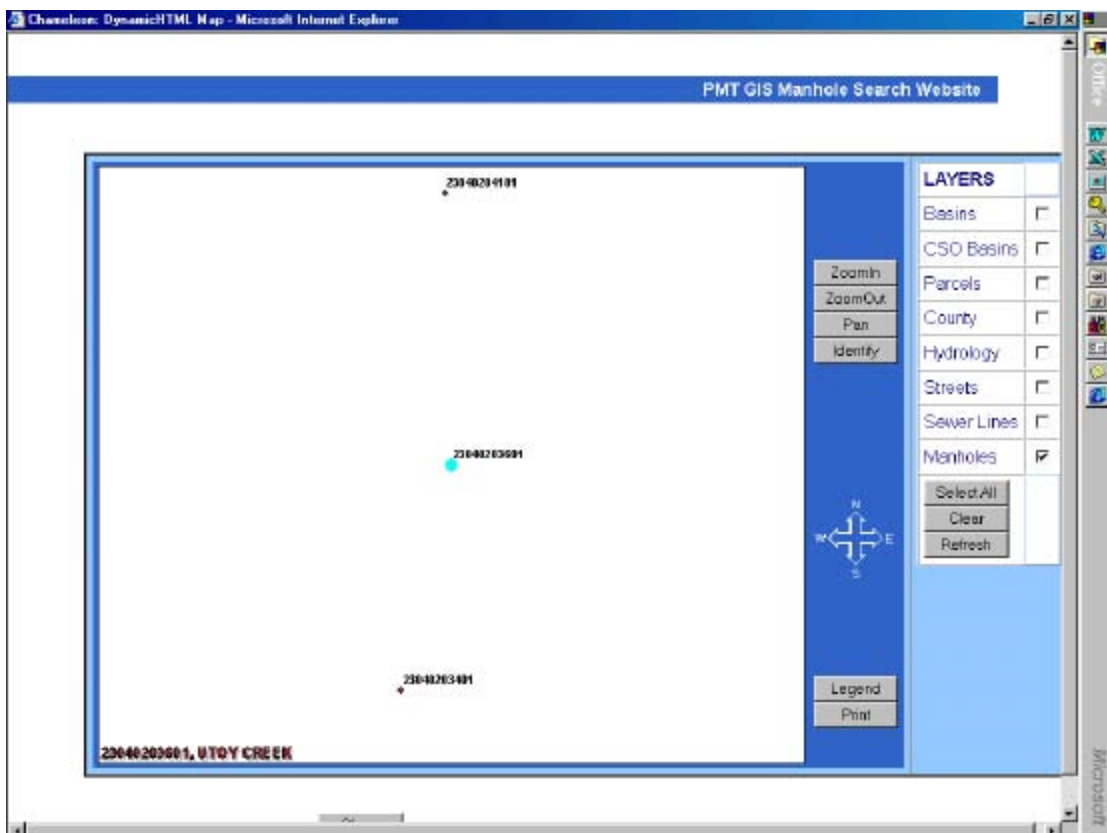
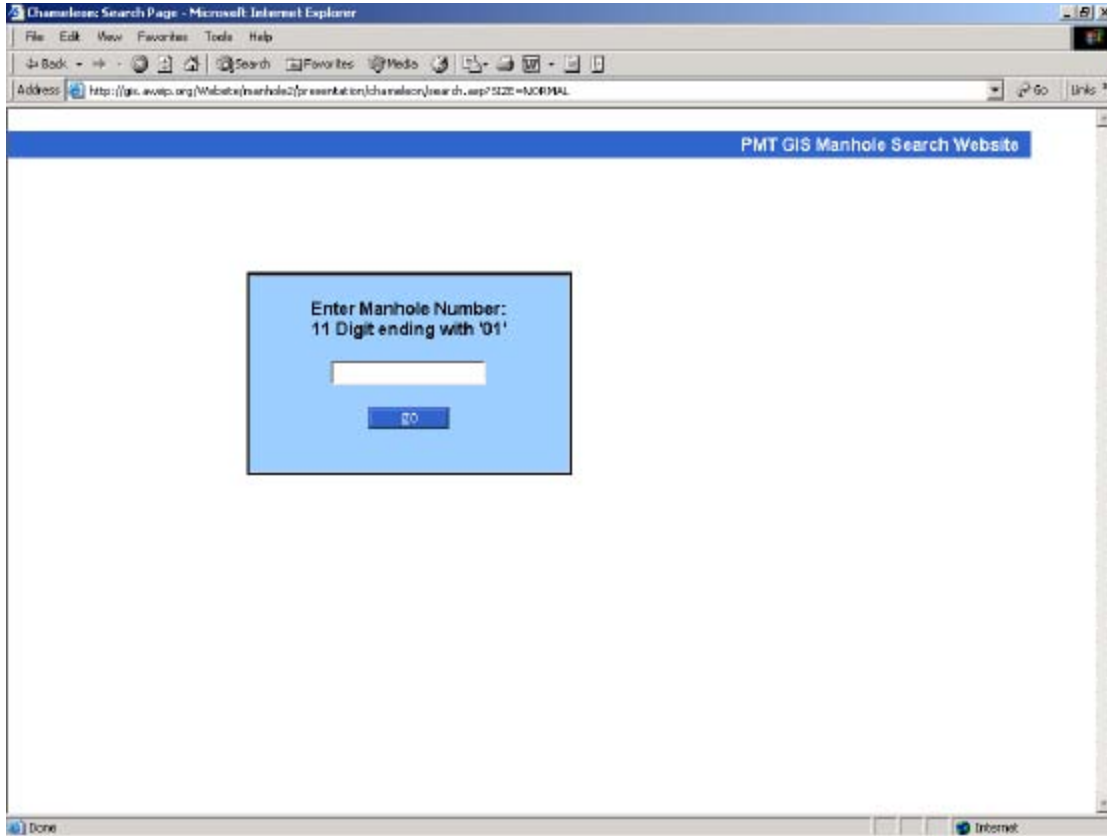


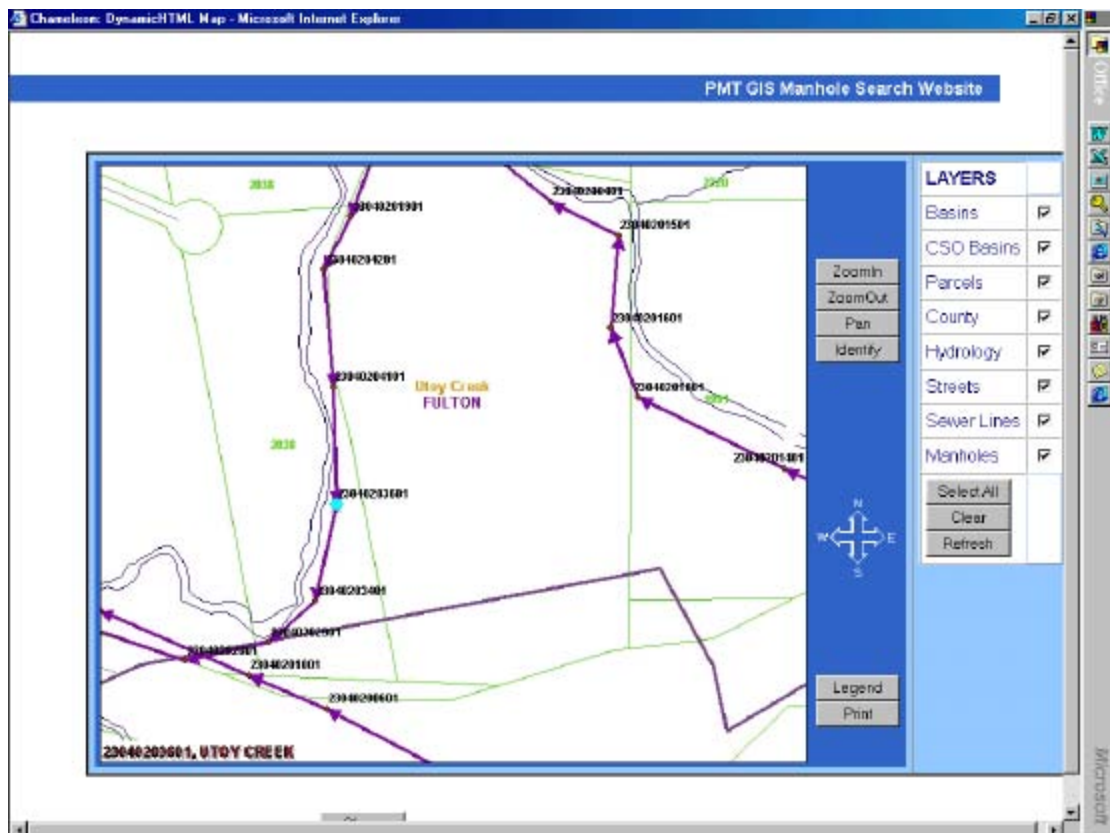


Manhole and Street Search Engines

Two other helpful tools developed by the PMT to assist CWA employees were the manhole search and street search engines. These are very basic 'Map Quest-like' websites to assist the user in finding specific sewer related information. The user would only need to know the manhole identifier (Figure 7) or the street name and enter that in on the opening page. This would then bring up a map that is zoomed into the location of that manhole (Figure 8) or street. The user can then view other information such as the sewer line and its direction, the parcel boundaries and street address, if there are any creeks or rivers in the area, the sewer basin name and whether or not that manhole or street is located in a combined sewer area (Figure 9). The user can also zoom in, zoom out, pan and print a small map. The functionality with the street search works much in the same way. The user types in the street name and a list of matches are presented. Each street block is represented as a street segment in the GIS and therefore is represented as an individual record. In order to find the correct street segment or block the 'FROM' street address and 'TO' street address are also listed (Figure 10). The user scans down to the correct address range and is then presented with a map zoomed to the correct block.

Figure 7, 8, 9, & 10 – Manhole and Street Search





Channel: Results Page - Microsoft Internet Explorer

Back Forward Stop Refresh Home Search Favorites History Mail Print Edit SideStep

Address <http://gis.enr.org/website/street2/presentation/Channelon/results.asp?Name=MART>

Street Search Website

Search Results
156 records found

From St Number	To St Number	Name	
104	195	MARTHA AV NE	[MAP]
108	285	MARTHA AV NE	[MAP]
48	81	MARTIN AV SE	[MAP]
84	102	MARTIN AV SE	[MAP]
110	141	MARTIN AV SE	[MAP]
0	0	MARTIN CT SE	[MAP]
0	0	MARTIN L KING JR DR NW	[MAP]
0	0	MARTIN L KING JR DR NW	[MAP]
422	470	MARTIN L KING JR DR NW	[MAP]
475	547	MARTIN L KING JR DR NW	[MAP]
548	579	MARTIN L KING JR DR NW	[MAP]
581	615	MARTIN L KING JR DR NW	[MAP]
617	687	MARTIN L KING JR DR NW	[MAP]
688	739	MARTIN L KING JR DR NW	[MAP]
741	762	MARTIN L KING JR DR NW	[MAP]
771	779	MARTIN L KING JR DR NW	[MAP]
781	792	MARTIN L KING JR DR NW	[MAP]
801	809	MARTIN L KING JR DR NW	[MAP]
811	825	MARTIN L KING JR DR NW	[MAP]
827	913	MARTIN L KING JR DR NW	[MAP]
915	951	MARTIN L KING JR DR NW	[MAP]

Internet

Interactive Mapping Websites

As the program developed so did the Program's need for more sophisticated mapping websites. Interactive mapping gives the user much more flexibility allowing them to query, modify, customize and draw conclusions from database and map information. The following are a few examples from the CWA program.

Data Selection and Formatting for Hydraulic Models (SWMM)

One of the earliest users of our mapping websites were the engineers working with the hydraulic modeling software. As they constructed their data sets to use in the model, they were interested in getting as much up-to-date data as possible. They used the GIS constantly to confirm the data they already had and to fill in gaps where needed. The modeling software they use is SWMM. As the SSES confirms and adds new information to the GIS, the modeling team will rely almost exclusively on the new GIS information for input data as they continue to refine their models. With this in mind the CWA GIS group designed a website that allows the modelers to zoom to an area on a map, select specific sewer pipes for their model and automatically create an excel spreadsheet with the correct parameters and formatting to be automatically ingested into the SWMM software (Figure 11 & 12).

Figure 11 – SWMM Model Input Tool

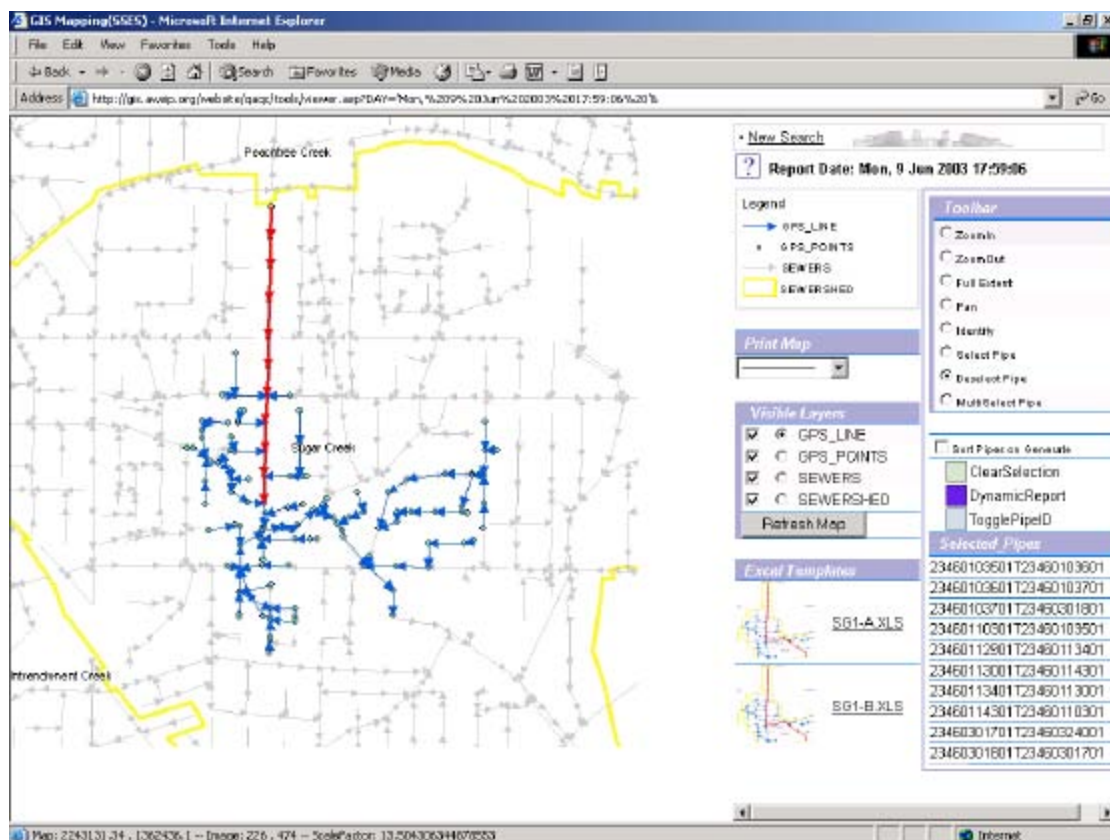
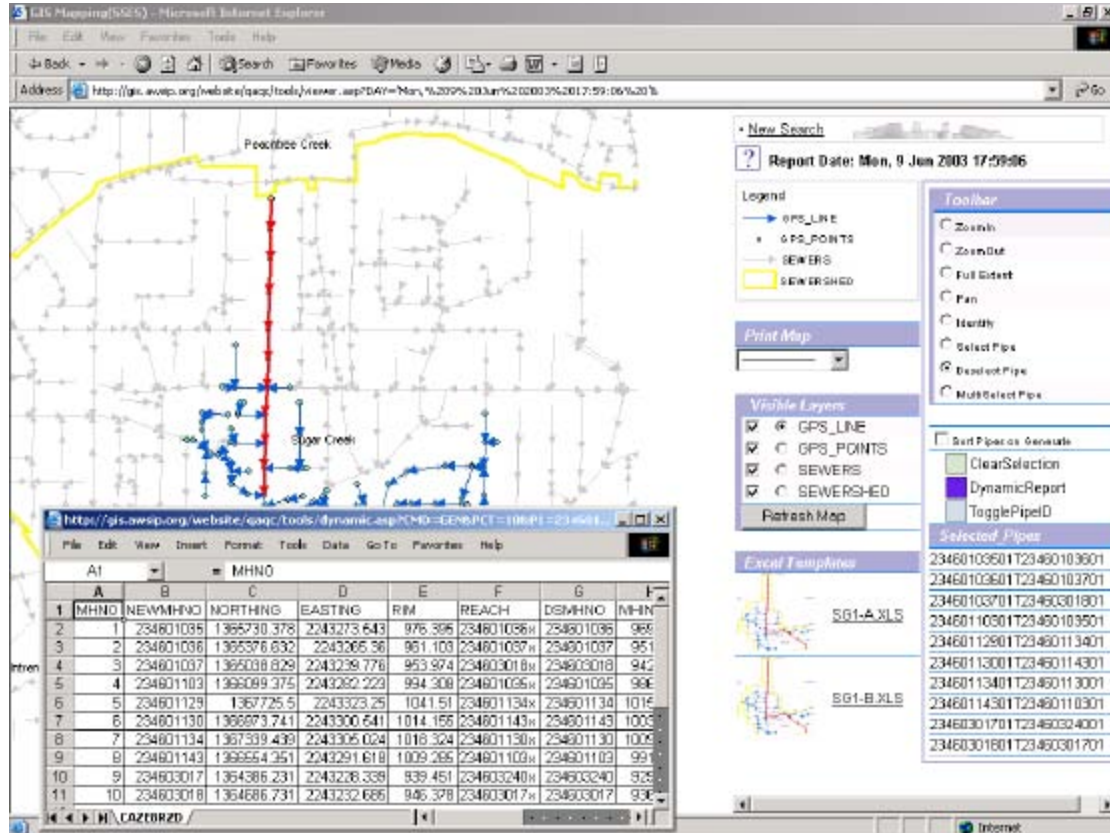


Figure 12 – SWMM Formatted Excel Worksheet

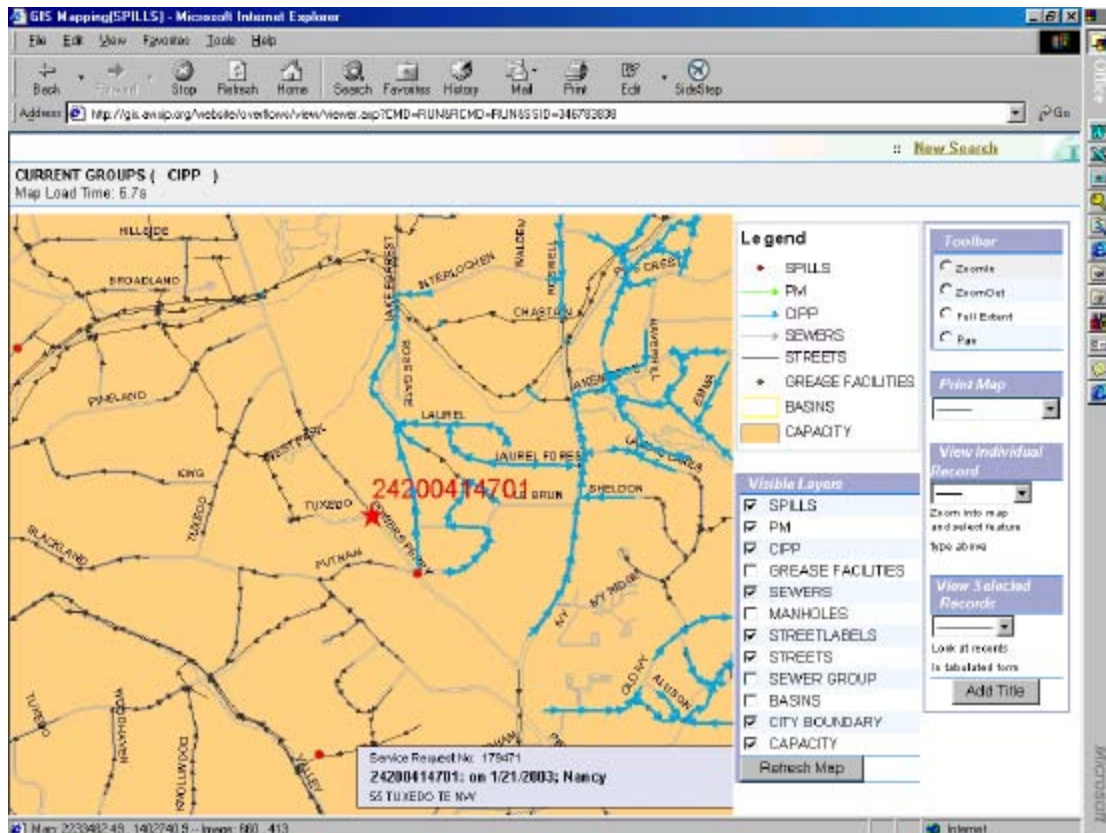
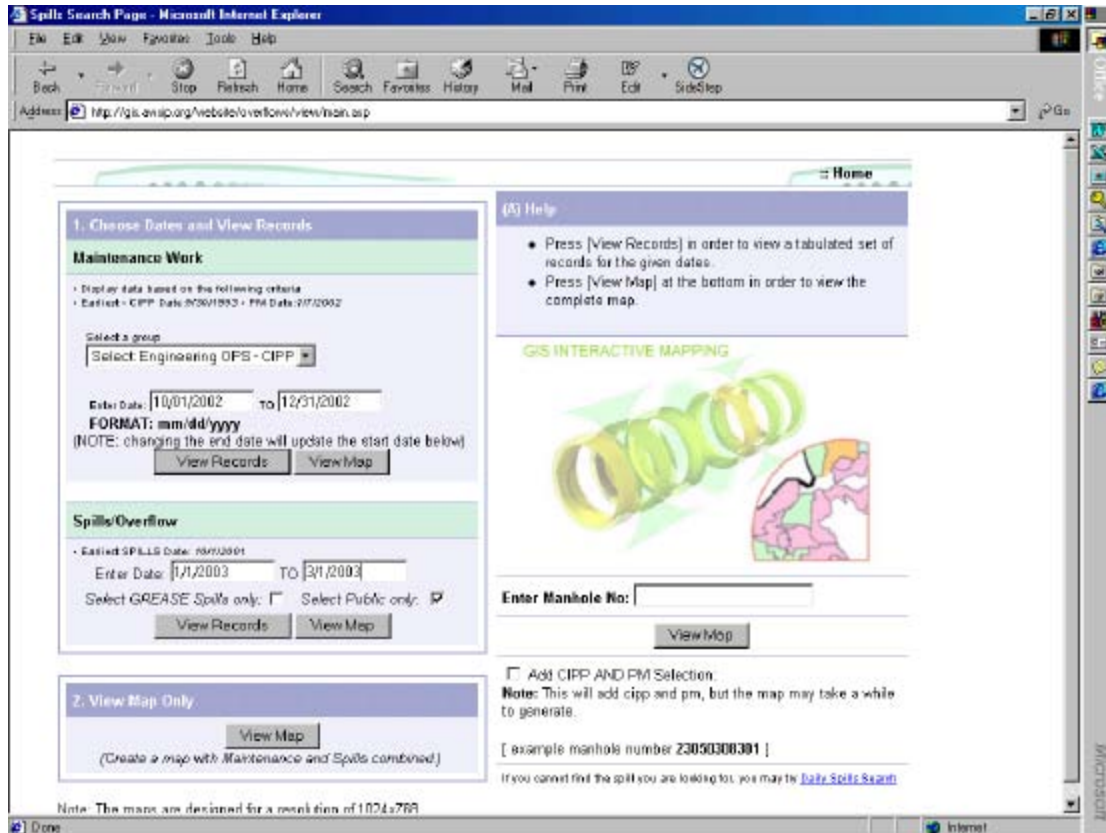


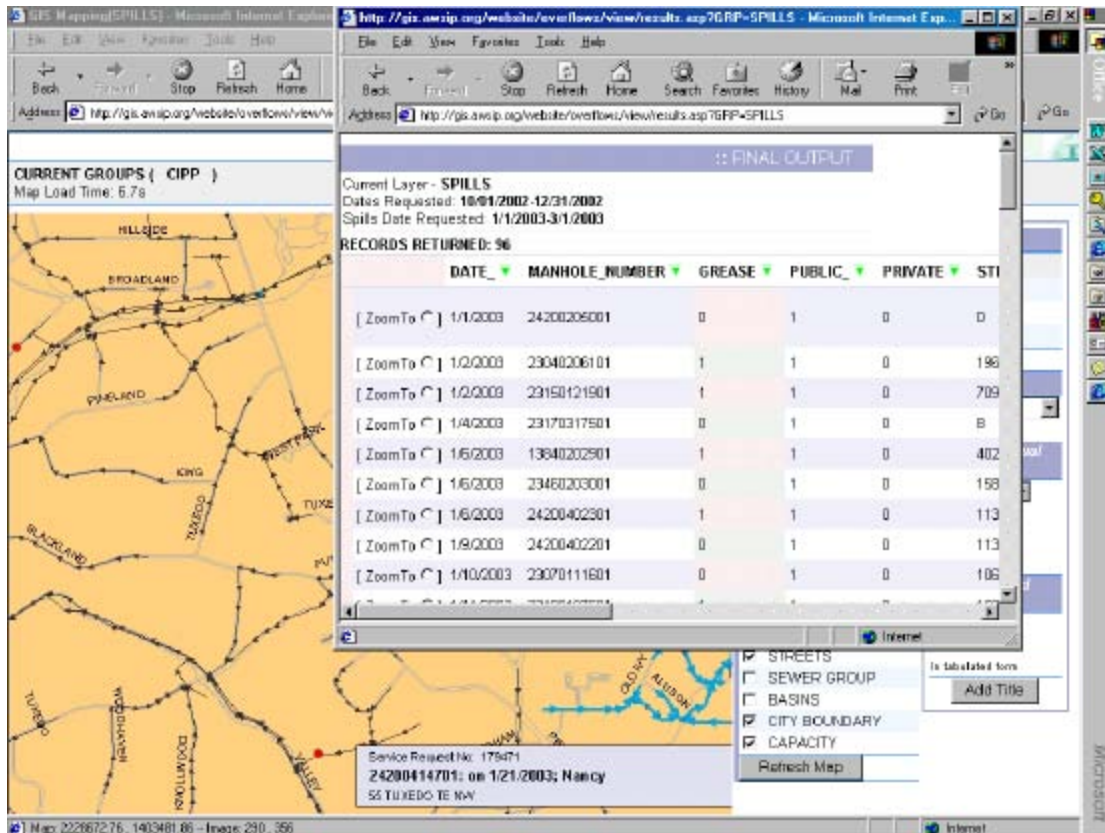
This website saves the engineers the tedious job of manually typing in the pipe segment identifier and all its defining parameters. The Excel sheet created automatically captures information that is already in the GIS such as pipe diameter, slope, pipe material, upstream and downstream manholes, elevations etc... It also reduces the chance of input or typing errors and significantly reduces the time it takes the engineers to create an input file.

Overflow and Maintenance Reporting

Another tool designed by the CWA GIS group is the Maintenance and Spills Assessment website. This allows a user to view a map and/or a database of both the maintenance work performed and overflows. One could potentially overlay spills with maintenance work to make a case to the EPA that the CWA program had been taking steps to fix and maintain a sewer segment even though a spill may have occurred in that area. This is a case of due diligence and can sometimes help to reduce fines leveled by the EPA. This tool allows the user to view specific spills or maintenance work but also allows the flexibility to view several or many occurrences defined by dates. One can type in a period of time to query spills or maintenance by dates (Figure 13) and then view a map (Figure 14). The website also allows you to view the database containing the records within the dates that were specified (Figure 15). This website has become a valuable maintenance management and operations tool.

Figure 13, 14 & 15 - Overflow and Maintenance Reporting

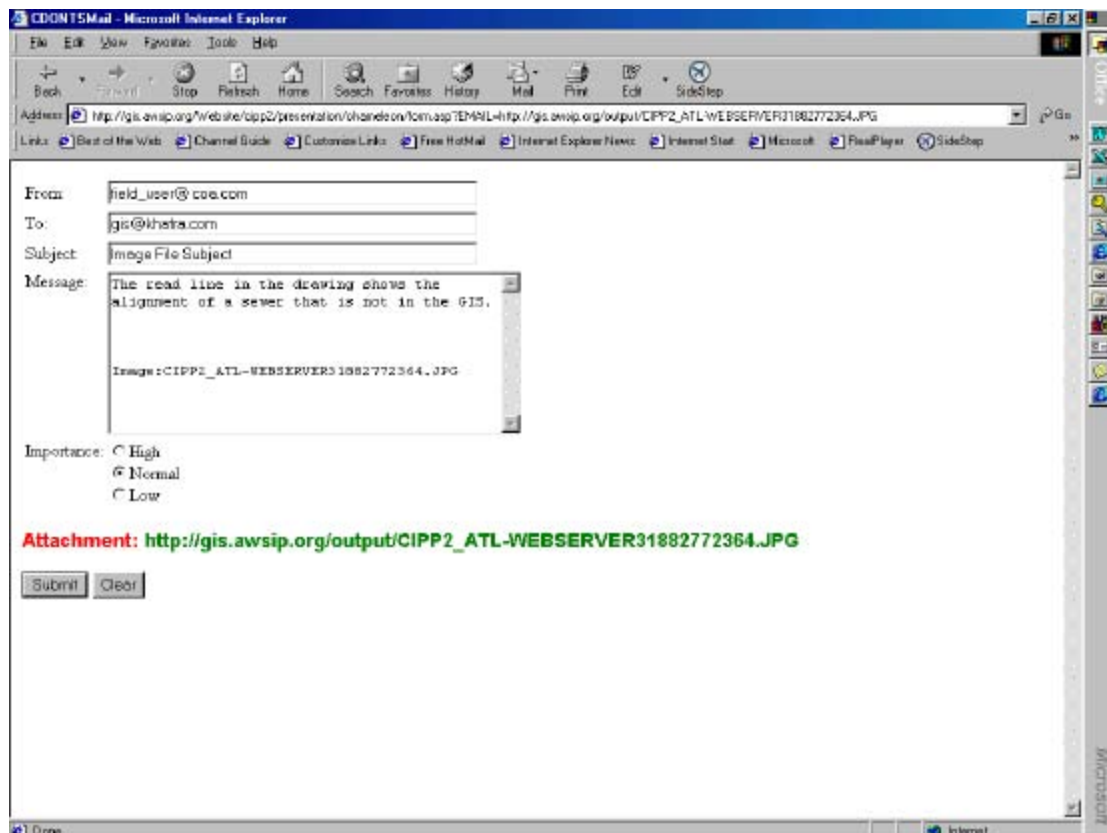
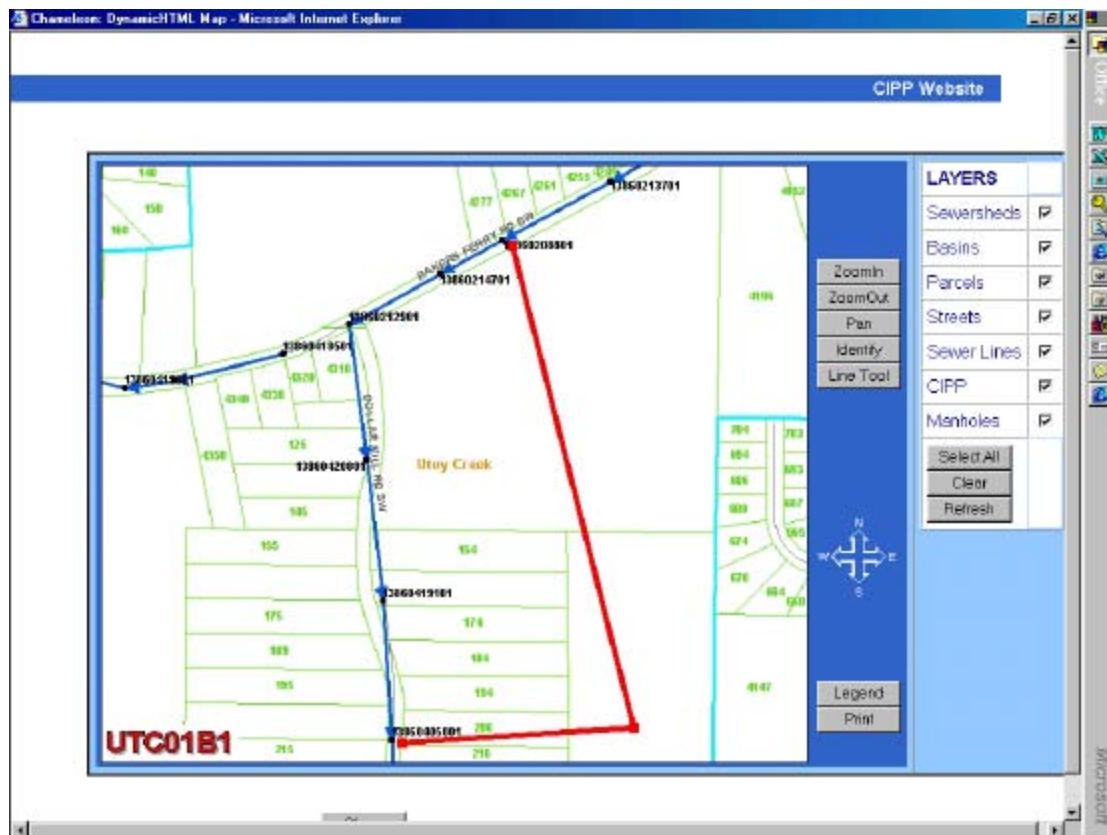




Field Input

This site was designed by the CWA GIS group to allow people who work in the field a method to graphically communicate information to the GIS team. It works much the same as the manhole and street search however it contains an extra tool that allows the user to depict a feature or problem by drawing or sketching on top of the map (Figure 16). This modification or sketch is captured as a .JPEG image and is automatically emailed to the GIS team (Figure 17). This tool is useful for people performing work on the sewer line (i.e. CIPP, preventative maintenance, point repairs) who want to report the work. It is also useful for field crews to convey problems with our base data. If they see differences between what our maps convey and what actually is taking place in the field, they can indicate these problems by drawing on the map. The GIS team then verifies the information before updating the database and map accordingly.

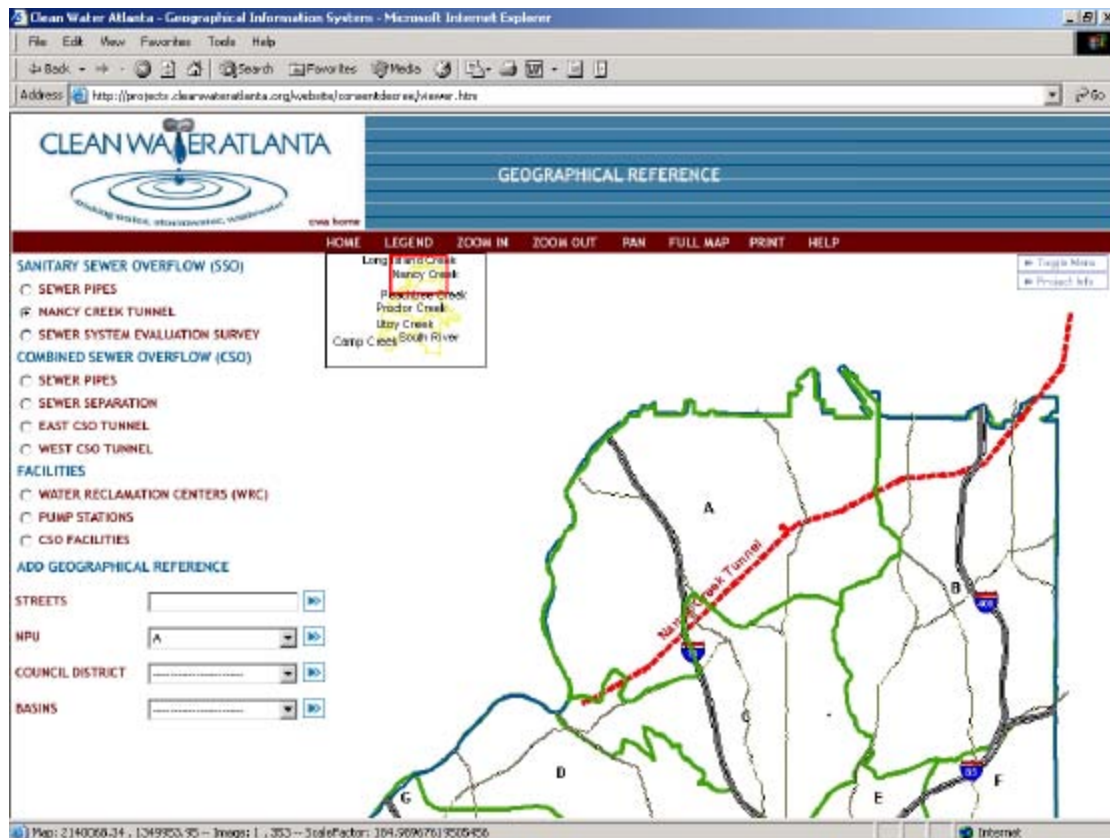
Figure 16 & 17 - Field Input

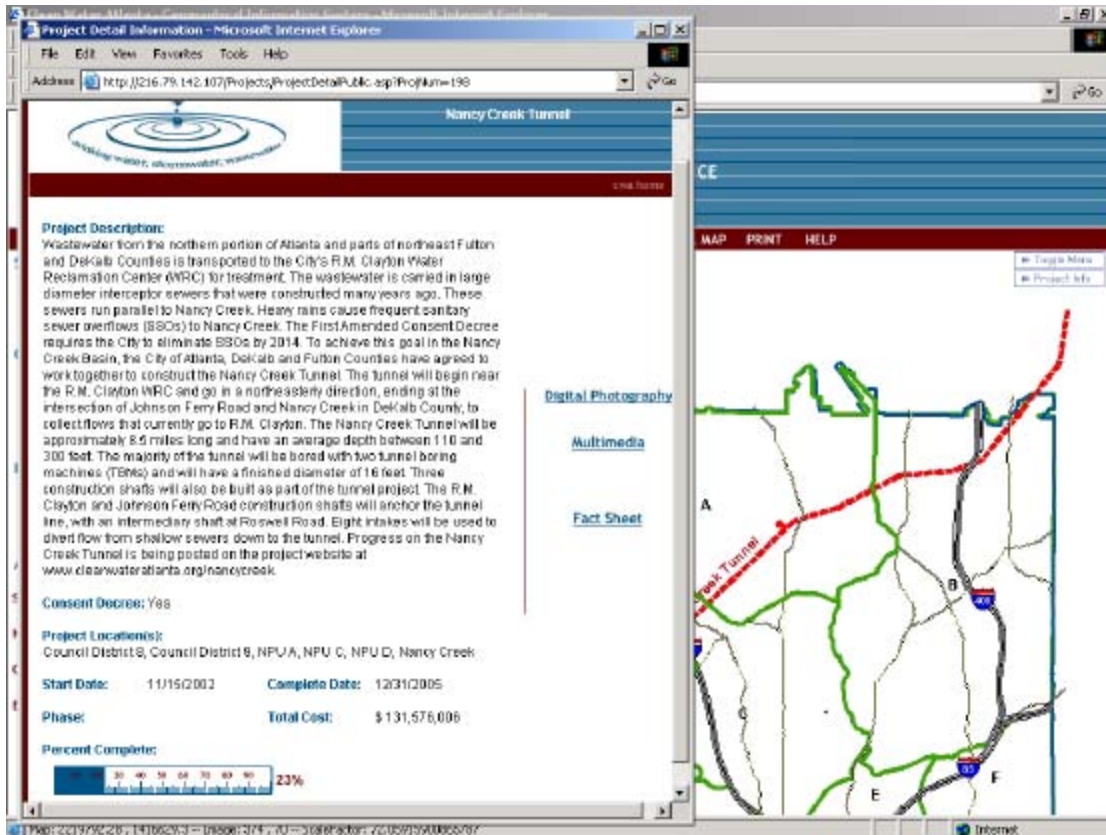


COA Public Involvement

The Public Involvement Department for the Wastewater Management Division is constantly trying to distribute information to the public concerning ongoing sewer work, which may affect their neighborhood. They envisioned GIS websites as a great tool to graphically display neighborhoods and streets that were undergoing fieldwork. They requested that we create a number of mapping websites, which would allow the public to query a map based on a geographical boundary. These websites allow the public to search by Neighborhood Planning Unit, Council District or sewer basin, as well as street name, and have a map zoom to that area (Figure 18). Different kinds of repair or maintenance activities are represented on the map with different symbols and colors. The public can select an activity and a description of that activity is displayed with its schedule and any other pertinent information (Figure 19). In this way the public can constantly stay up to date about sewer rehabilitation activities in their neighborhood.

Figure 18 & 19 – Public Involvement Websites

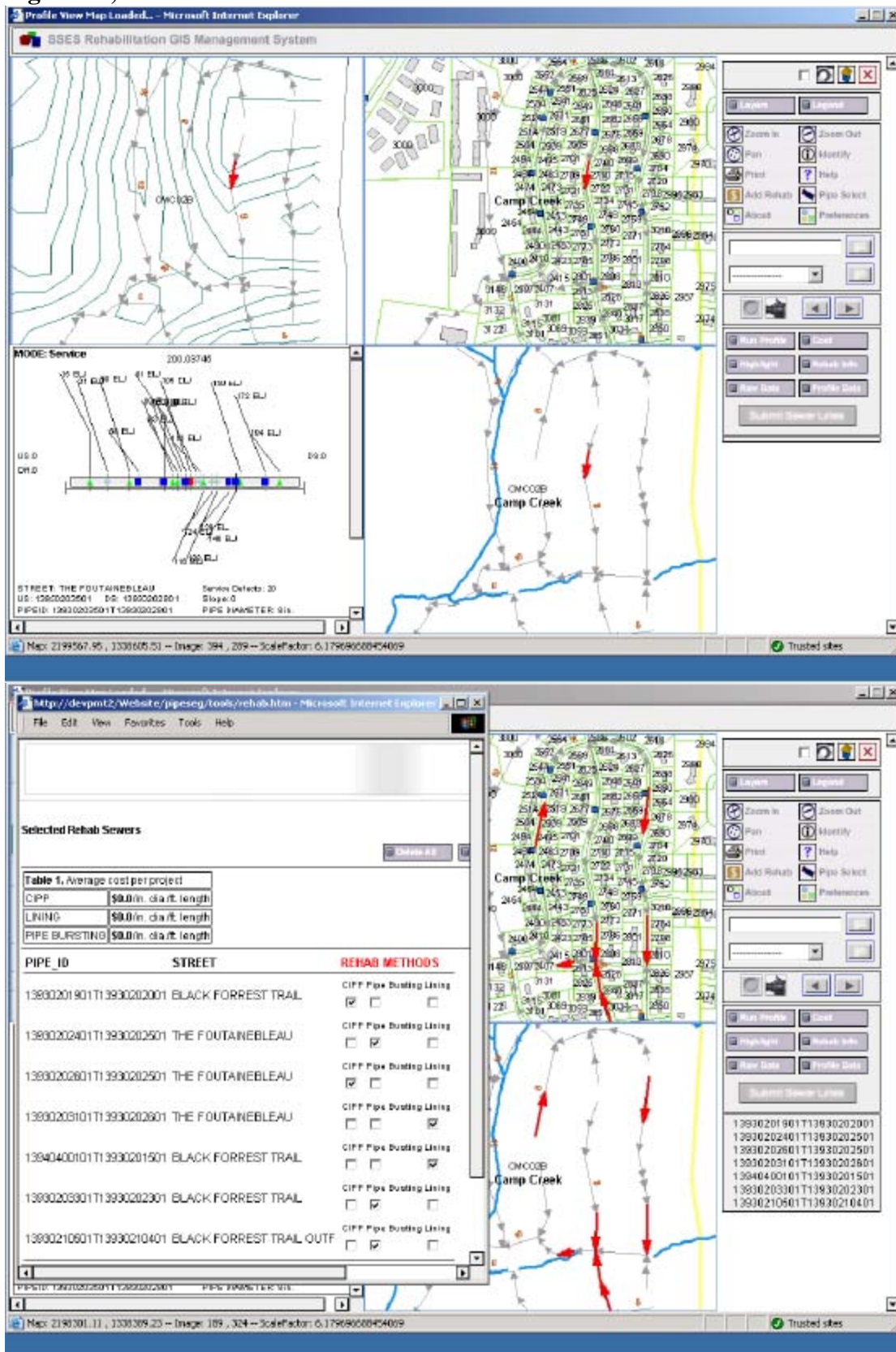


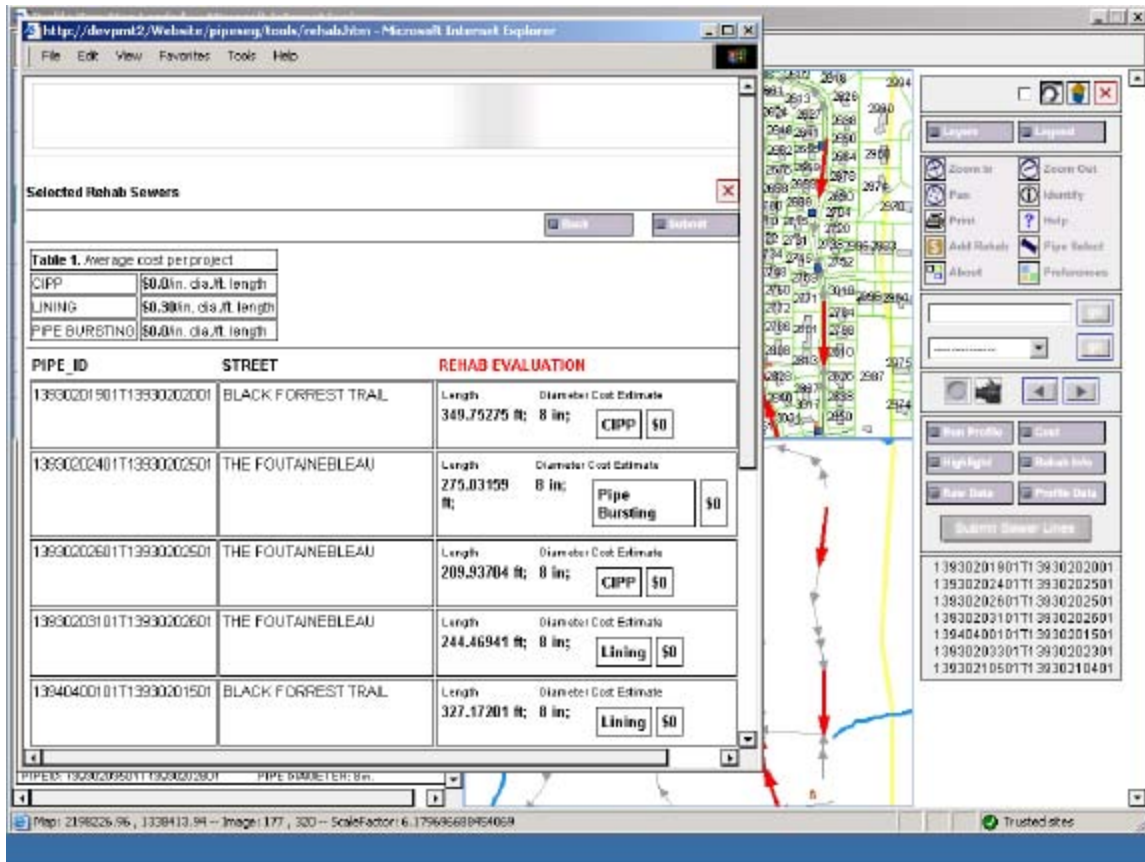


SSS Rehabilitation and Cost Estimates

One of the more exciting projects the GIS development team is now undertaking is the SSS rehabilitation and cost estimate tool. This website allows the SSS rehabilitation team to review information collected during SSS field work to determine which rehabilitation approach makes sense for a given problem and estimates a cost based on the length and diameter of pipe segment, soil condition, traffic conditions, elevation, criticality and several other parameters. To help accommodate the process this website has three maps displayed at once. Each map displays different types of data for the same area (one displays topology, soils and CIPP, another displays building footprints, critical sewers, streets and traffic counts and the last displays streams, pipe diameters, and severity of sewer defects). As you zoom and pan in one window the others follow likewise. One last display is a profile view of a sewer segment. The user selects a sewer segment and a profile of that segment is drawn (on-the-fly). The profile displays the length of sewer, diameter, invert elevations and slope. It also indicates defects and their location on the line determined from the CCTV data (Figure 20). This tool is completely interactive and allows the user to envision several scenarios for rehabilitation (Figure 21) along with their cost estimates (Figure 22). Determining rehabilitation methods demands an iterative process and this website accommodates the user.

Figure 20, 21 & 22 - SSES Rehabilitation and Cost Estimate

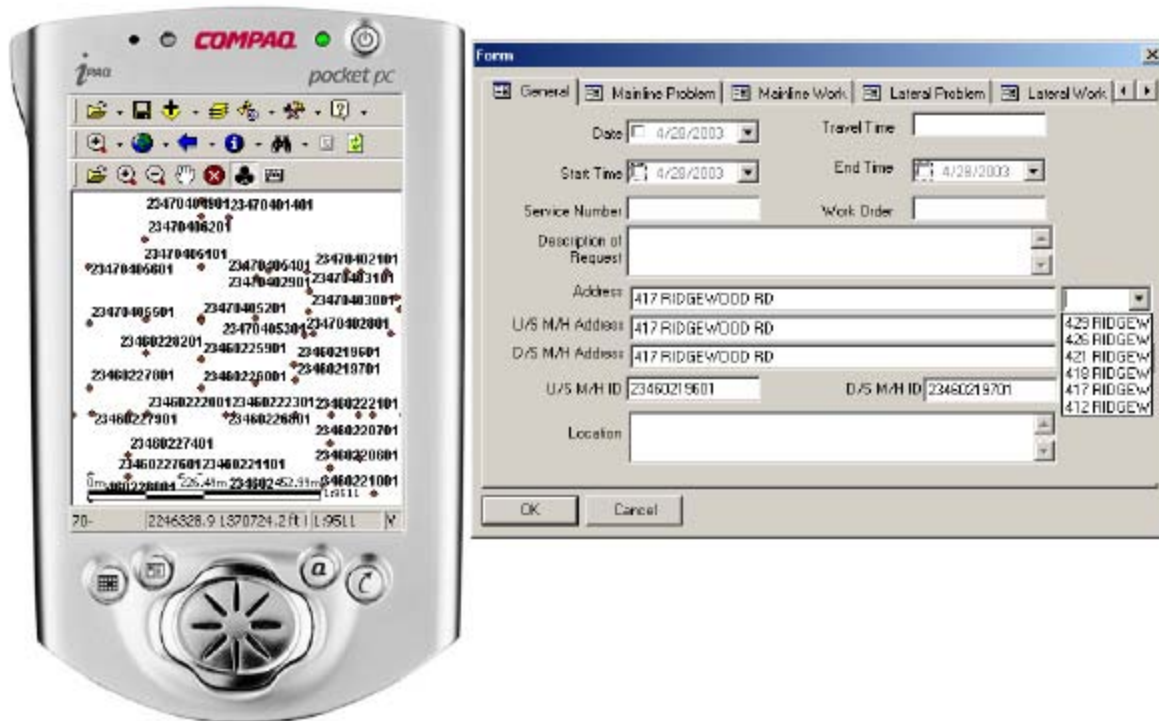




Wireless Field Reporting

One last application that the GIS development team is prototyping is a tool that explores the use of wireless and GPS technologies for field reporting. Using ESRI ArcPad software, menus were written to aid the field employee to capture their data. However, the power of this tool relies on the ability of the user to access Gigabytes of mapping information over the Internet. A mapping website was set up so that the wireless device could access these data. The application pulls up the map based on the GPS coordinates the device is reading. The map moves as the user moves. As the user zooms in on the map, more information is displayed. The user can even have access to aerial photographs of the area they are inspecting. These maps and images are displayed quickly. Most wireless devices cannot accommodate this kind of data storage and access but because the data sharing is occurring on the server side, the wireless client is not overtaxing the handheld device. When the user has identified an asset in the field that needs to be reported, the user will select the asset on the map and the application menu pops up with certain fields automatically populated (such as manhole identifier, address, street...) (Figure 23). The employee must fill in the remaining menus consisting of check boxes and pull down menus. This type of deployment reduces the amount of paper work a field crew must complete. Once the data is collected on the handheld device, the employee can either transfer the data wirelessly to the home office or download it to their desktop computers once they return from the field.

Figure 23 – Wireless Field Collection



DISCUSSION

The Clean Water Atlanta (CWA) program is in its third year and, like any program has made significant progress in regards to MOMS implementation. However, any progress made in the maintenance of the sewer system without proper asset management does not benefit your maintenance plans for the future. Accurate asset management will allow future generations to plan properly and more efficiently and hopefully protect the environment in doing so.

Internet-based GIS has proven to be a powerful tool in asset management and maintenance operations for the City of Atlanta and the Program Management Team allowing real-time dissemination of information to affected parties in an affordable manner. Expanding this approach to team members in the field is further empowering the City to meet regulatory requirements and its organizational goal of a cleaner more environmentally friendly city.

AUTHORS

Clare Brown, GIS Manager, cbrown@khafra.com
Khafra Engineering Consultants Inc., www.khafra.com
230 Peachtree St. Suite 200, Atlanta, GA 30303
404 979-6999 x7237 (Office), 404 979-3131 (Fax)

Keith Toomer, Chief of Technology Services, ktoomer@ci.atlanta.ga.us
City Of Atlanta, Department of Watershed Management www.ci.atlanta.ga.us
68 Mitchell St. S.W., Atlanta, GA 30335
404 330-6237 (Office), 404 658-6909