Water and Sewer Enterprise GIS Deployment in the Jersey Pinelands

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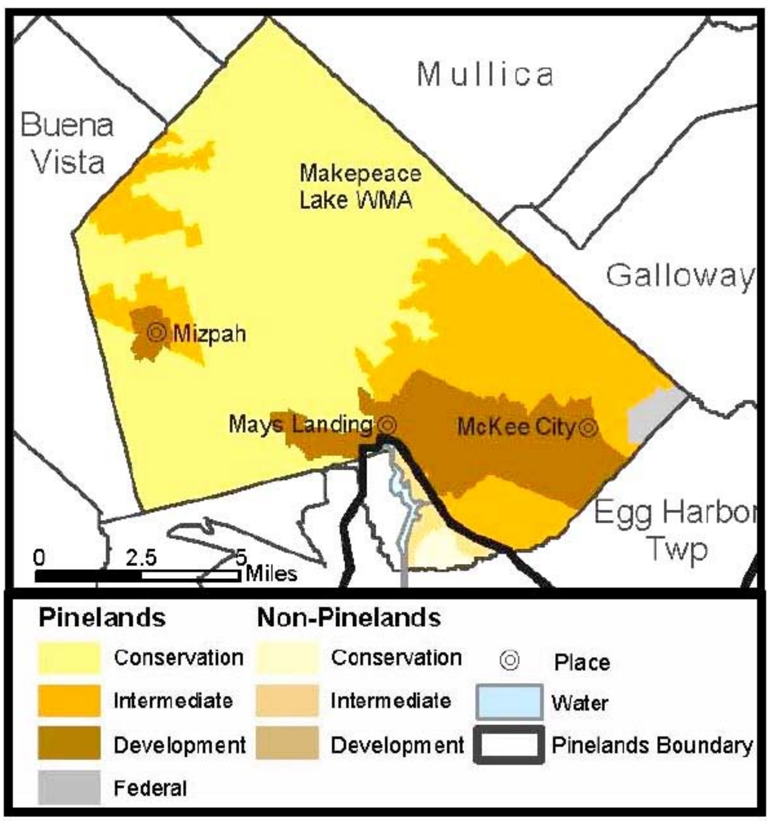
Introduction

The Township of Hamilton's origins are directly tied to the Great Egg Harbor River and its tributaries, which run through the Township. George May, after whom the village of Mays Landing was named, built a shipyard and trading post near Babcock Creek in 1756. By the mid 19th century that Mays Landing reached the height of its shipbuilding. From 1830 to 1880, over one hundred vessels were built in Mays Landing along the Great Egg Harbor River with lumber from native forests and iron from Weymouth foundries. In 1813, the Township of Hamilton was incorporated and at ± 115 square miles is the largest municipality, land wise, in the State of New Jersey. In 1837, Mays Landing became the County Seat of Atlantic County.



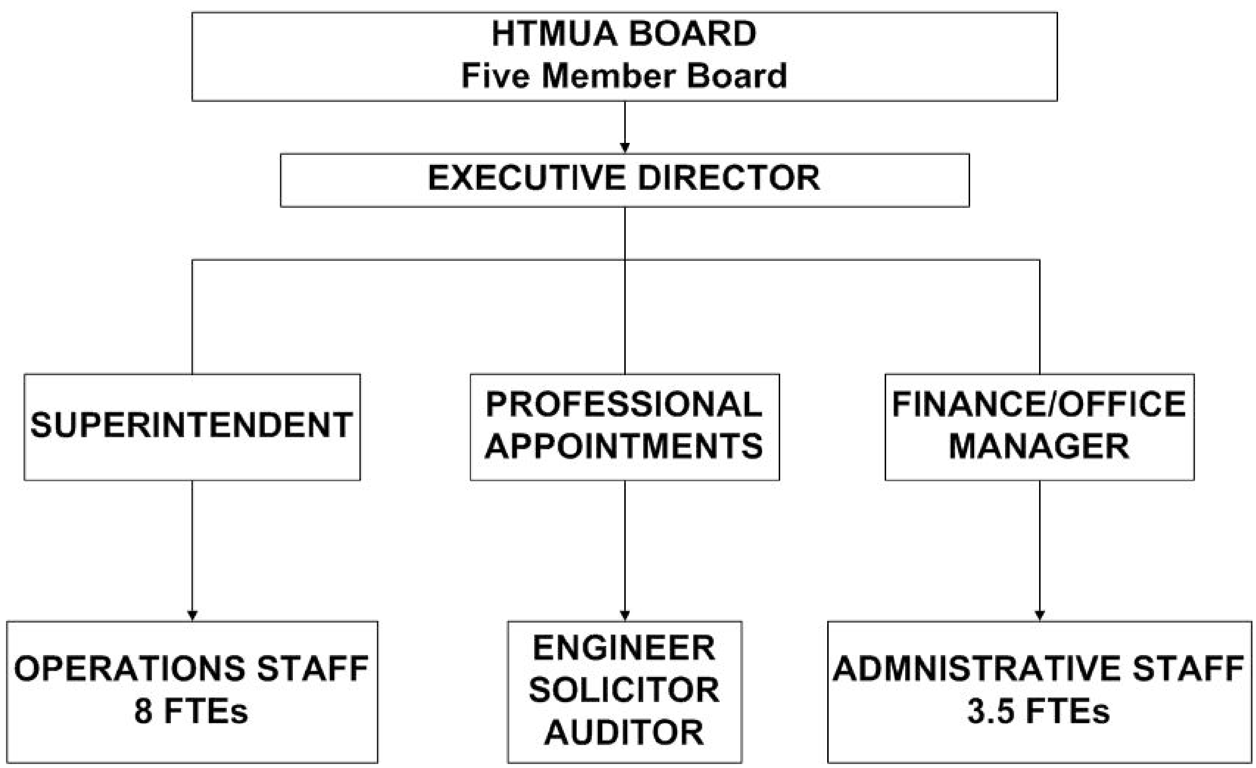
Today, Hamilton is a unique mix of two worlds: rural forest and bustling suburb. The western three-quarters of the township is rural pine forest and protected from dense development by Pinelands Commission restrictions and large preserved tracts of land. The eastern quarter falls within the Pinelands Regional Growth Area (RGA) and has developed a suburban character that provides housing and commercial services that support the casino growth in neighboring Atlantic City. The eastern quarter is also home to the Atlantic Cape Community College; the

Atlantic County Institute of Technology; the Atlantic County Justice Facility; the County Court Complex and the main branch of the Atlantic County Library.

Hamilton Township MUA History

The Hamilton Township Municipal Utilities Authority (HTMUA) was established in 1963 with the purpose of establishing a sewerage system to service the Mays Landing, Harding Lakes and Clover Leaf Lakes area. At that time, the Township also transferred the existing water system over to the HTMUA. From that point on, the HTMUA acquired the remaining private water utilities servicing the area and expanded into its present service area.

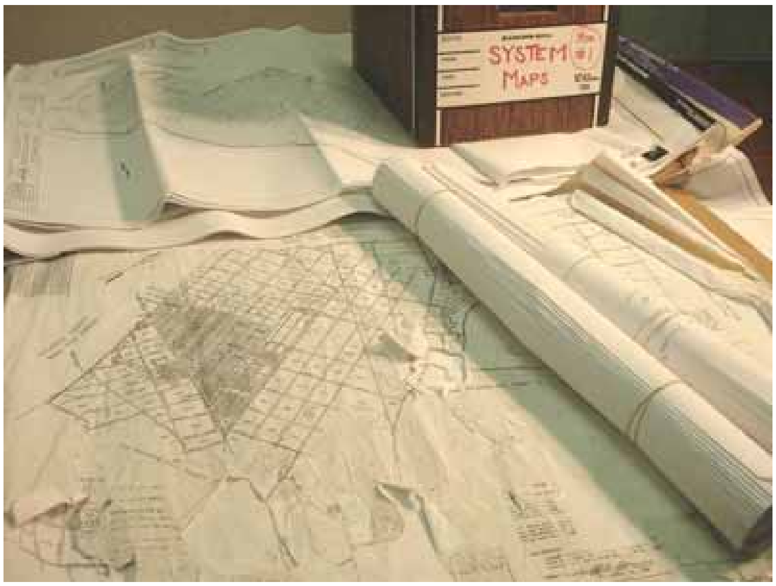
The HTMUA is a semi-autonomous body that is overseen by a five-member board, whose members are appointed to staggered five-year terms by the Township Committee. The HTMUA sets its own budget and raises its own revenue to operate and maintain the water and wastewater collection systems. The HTMUA's day to day operations are overseen by the Executive Director and is divided into two divisions: Administrative and Operations. The HTMUA employs 14 full time employees and 1 part-time employee. The current year operating budget is $4,722,000, with a current capital budget of $7.4 Million. The HTMUA services 4,150 accounts encompassing over 8,800 service units.



HTMUA ORGANIZATIONAL CHART

HTMUA Record Document History

Infrastructure was procured by the HTMUA in one of two ways: 1) it was built by the HTMUA or 2) it was built by a developer and transferred to the HTMUA. "As-built or "record" information was provided to the HTMUA via paper and/or mylar prints. The Operations Division was charged with receiving and maintaining any record information that was presented to the HTMUA, as the HTMUA never developed its own Engineering Division.



Initially this system may have worked fine, but as time progressed and the HTMUA infrastructure grew, the record information did not keep pace. Since the HTMUA did not have a formal Engineering Division, the HTMUA's appointed Engineers became the "official" record depositories and the Engineer would then prepare line schematic drawings of the water and wastewater collection system and provide them to the Operations Division.

As the complexity of developer agreements and new infrastructure grew, the HTMUA continued to rely on "paper" records and outside professionals to keep track of all pertinent information.

In 1999, the HTMUA decided to modernize its information system by hiring an outside professional to develop a "GIS" system and to install a computer network to be utilized by the Superintendent and Administrative staff. Unfortunately, the GIS implementation did not follow the development standards currently in place, but instead utilized the "we will tell you what you need" approach.

In 2000, the GIS professional started submission of water and sewer project deliverables. The deliverables did not utilize the ESRI's ArcGIS Data Models for Water Utilities. Training was not provided to HTMUA staff and there were no provisions for an independent QA/QC effort of the deliverables.

In late 2000, the HTMUA hired an Executive Director/Staff Engineer with the intention of taking back control of the HTMUA's record and development information. Steps were taken to inventory the developer records and convert the information from a paper product to a digital product utilizing Microsoft Office and scanning software. After this was completed, the HTMUA brought on Nobel Systems to review the GIS data to date and to assist in developing and overall GIS and record information strategy.

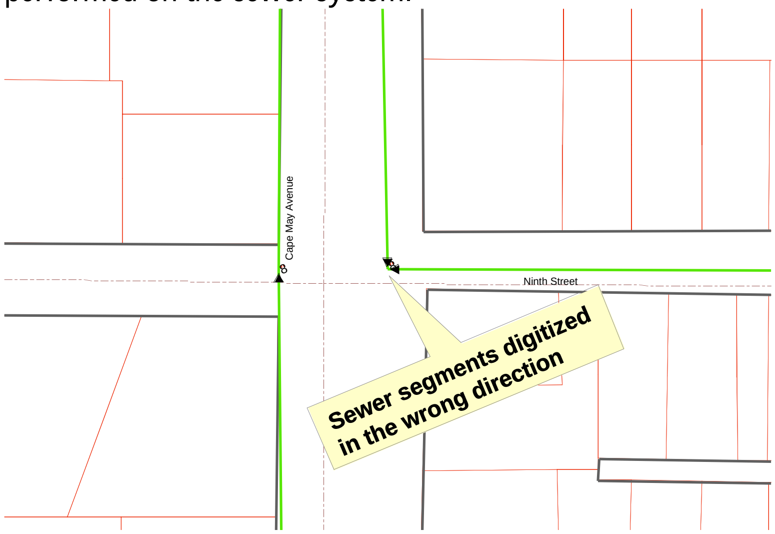
GIS Data Clean Up

HTMUA's initial GIS design consisted of multiple ArcView shapefiles which were derived from water and sewer system maps that were maintained by their engineer using CAD. When plotted at 200-scale the maps appeared to be graphically accurate, however, close inspected within ArcMap revealed a number of glaring issues which would need to be corrected. These issues included:

- Network Topology Errors – HTMUA's GIS data for water and sewer did not have sufficient network topology to perform basic utility tasks such as network tracing or valve isolation. In performing a basic quality control procedure Nobel found that 1283 of the 1561 water point features (valves, hydrants, tees, etc.) were not even physically connected to their respective water main line features.
- Spatial Inaccuracies – There were numerous instances where water and sewer facilities were out of alignment and needed to be spatially corrected. The example below shows a water main that is running within the private right-of-way and, in this instance, underneath a building corner.

- Duplicate Records – A number of the features in HTMUA's GIS had duplicate records such as fire hydrants. Point features such as hydrants and manholes were maintained in multiple shapefiles (i.e. GPS-hydrants and GIS-hydrants). One GIS layer was derived from as-built drawings (295 hydrants) and another layer derived from field survey (663 hydrants). As part of the data clean up effort these duplicate layers were combined into one asset database with fields added to denote the source of the feature (i.e. from record drawing or from field survey).

- Sewer Network Issues – Nobel found many network topology errors associated with HTMUA's sewer data. Since the original system maps were maintained using CAD it was not standard practice for the engineer to digitize the sewers in their correct direction of flow. Sewers needed to be digitized in their correct direction of flow if accurate hydraulic models and flow traces were to be performed on the sewer system.



- GIS Data Format Issues – The HTMUA's GIS data was in ESRI shapefile format. Although it is acceptable to manage utility data in this format, there are many limitations such as system performance and scalability that greatly diminished the HTMUA's GIS return on investment. One of the goals of this project was to migrate this GIS data into a geodatabase to allow the HTMUA to integrate their GIS data with current IT systems (i.e. customer billing) and to enhance the ability to be integrated with future systems like hydraulic models, work order management, and capital program management.

HTMUA GIS Project Scope

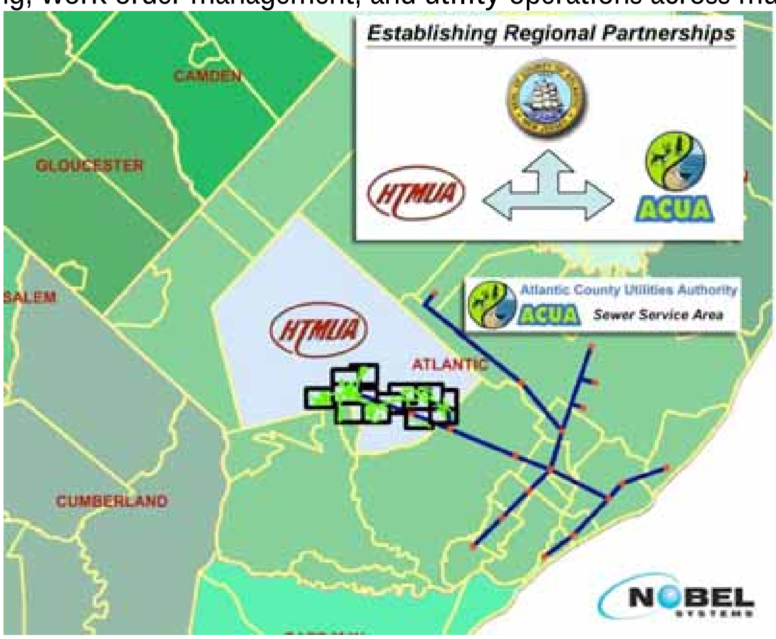
Base Mapping Layers - One of the goals of this project was to utilize as much existing GIS data as possible to eliminate redundant data maintenance. Besides water and sewer GIS layers, HTMUA was maintaining a number of base mapping layers such as tax parcels and aerial photography on their local servers. Most of these base mapping layers were already being maintained by Atlantic County's Office of GIS, one of the more advanced GIS programs in the state. Nobel was able to work with HTMUA to obtain and utilize the freely available base mapping information from the County and State and develop a GIS program that focused on improving the accuracy and functionality of the utility's water and sewer data. Eliminating the need to maintain base mapping layers provided the HTMUA with immediate savings.

After reviewing the various base mapping layers it was therefore decided that the primary base map for HTMUA's infrastructure would be the State's 2002 orthophotography. The Atlantic County parcel and roadway data would serve as the secondary base mapping layers for the infrastructure and the primary base layers for customer billing data integration.

Geodatabase Design – The HTMUA elected to develop a custom water and sewer geodatabase design based on the ESRI Water Utilities Data Model. Nobel customized the ESRI data model based on the review of HTMUA source documents, existing information systems, and interviews with key staff. It was agreed the features and attributes of the ESRI model would be customized to incorporate various regional conditions.

HTMUA also had the foresight to plan the development of a GIS that would incorporate the infrastructure of other utility companies and private operators within their service area. HTMUA's GIS design would include infrastructure for the regional sewer utility (Atlantic County Utilities Authority (ACUA)), the regional airport (Atlantic City/NAFEC for National Aviation Facilities Experimental Center), and many of the small private systems maintained by private operators. This would help improve operations through a better understanding of the system and how it interconnects with other utilities.

The regional approach adopted by HTMUA led Nobel to start working with ACUA to develop a regional sewer data model that could be used by all sewer utility operators, private and public, within Atlantic County. A regional data model will be used to improve hydraulic modeling, work order management, and utility operations across municipal boundaries.



Data Migration Plan

Landbase Issues – One of the keys in developing a complete asset inventory is to utilize an accurate landbase. The initial HTMUA GIS data utilized aerial photos created in 2000, internally maintained tax parcels, and field survey data. One of the first issues identified in the data clean up phase of the project was the spatial inconsistencies of the County tax parcel data. Mapping utilities relative to the County's parcel layer presented a number of challenges because this data only depicted property boundaries and not physical features such as curblines. Also, the boundaries themselves were digitized from paper tax maps and not very accurate. For this reason HTMUA elected to use the State's 2002 digital orthophotos as the primary base layer. All utility lines and points were to be located at their relative positions based on the source document and the photos. The State's aerial photos were at 1' pixel resolution which made it easy to distinguish physical features such as curbs, parking lots, and buildings needed for the correct placement of features.

Source Prioritization – The data clean up and migration involved reviewing the available sources for each section of the water and sewer system and determining which source contained the most accurate information. The following sources were used throughout the data clean up phase:

- Engineering As-builts - Water and sewer pipelines were matched as per the 'Engineering As-builts' using the 2002 aerial photos as the landbase. However, during the QA/QC process Nobel found that some of the "as-builts" contained information that was designed and never actually constructed. In these cases other sources were used and HTMUA was made aware of the issues in the source.
- GPS data – Nobel found that the information previously collected by the HTMUA engineer using GPS was inconsistent. There were cases where features were collected in the field but did not appear on source documents (i.e. a gas valve may have been collected and coded as a water valve by mistake). There were also instances where features were collected but their location did not make sense (i.e. valves located inside of a private property). Although the GPS data was not always reliable, it was decided that X, Y co-ordinates would be added as attributes for point features such as manholes, hydrants and valves.
- Systems Maps (CAD drawings) – The HTMUA system maps that were maintained by the engineer were used as a "last resort" during the data clean up process. Features were located using CAD source map whenever they could not be located using as-builts and/or GPS data.

Detailed Functional Review

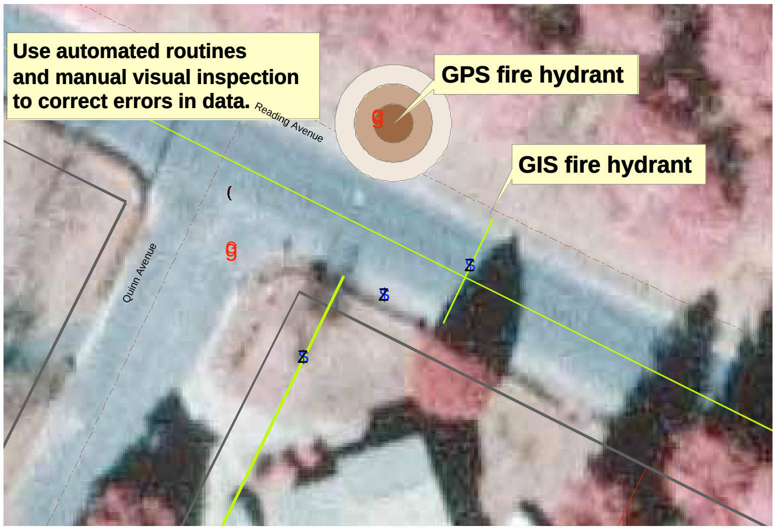
A pilot area of the HTMUA service area was selected to test out the data migration process. Nobel generated an empty geodatabase that matched the approved HTMUA object model and converted a sample set of HTMUA data to match the design. During the pilot conversion Nobel set up the GeoViewerIMS Online application/data hosting service to allow HTMUA staff to gain hands-on experience with the Internet mapping system and to review the converted data.

The following is a breakdown of some the types of subtasks that were performed during the data conversion process:

- Snapping Features. Nobel fixed all snapping errors using a QC tool called Check Accuracy which identified errors pertaining to snapping (valves not fixed to water mains, etc.).
- Water and sewer line segments were broken at appropriate points (i.e. valves, manholes, bends) to insure correct network topology.
- Duplicate water and sewer features were located and removed from the GIS database.

Quality Assurance/Quality Control

Nobel developed a number of automated QA/QC routines to insure correct network topology, eliminate dangling polylines and duplicate points, and verify attribute accuracy. These routines were also used to check the positional accuracy of features such as select all water features that are located outside of the public right-of-way.



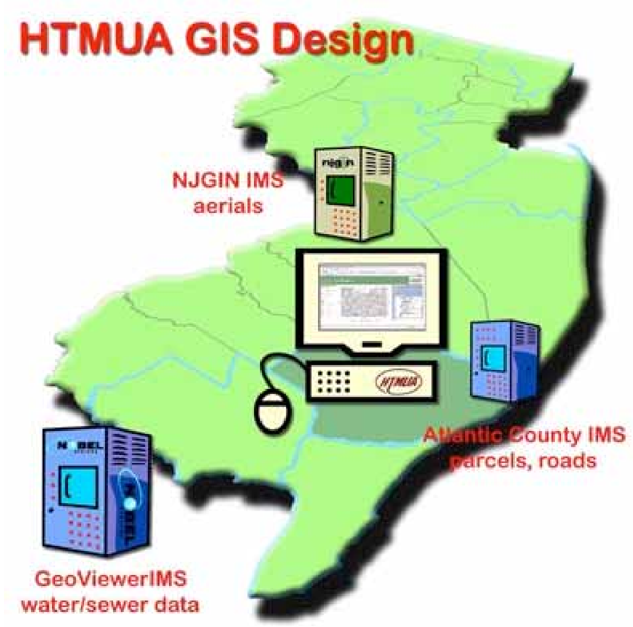
The following is some of the QC checks that were performed on HTMUA's data:

- Feature Count QC: This QC check is required to ensure the number of features that were present in the source data is equivalent to the number of features in the GIS data, after clean up.
- Check Accuracy Tool: This tool was used to identify, Dangling Arcs, Under Shoots, Over Shoots, etc.
- FDAT Tool: This tool checked for consistent attribution in the data such as Blank Nodes / Points, Uncoded Arcs, etc
- Flow Direction QC: This tool checked for proper flow directions of the sewer features to match the connectivity rules established in the data model.

Manual Inspections - After completion of automated QC routines for a map sheet a QC Plot was generated and used for manual inspections of the data. The purpose of the QC plot was to perform a 100% audit of HTMUA's source documents against the plot. Using a process called "Table QC" Nobel's staff completely checked both graphic and attribute data.

GIS Data and Application Hosting

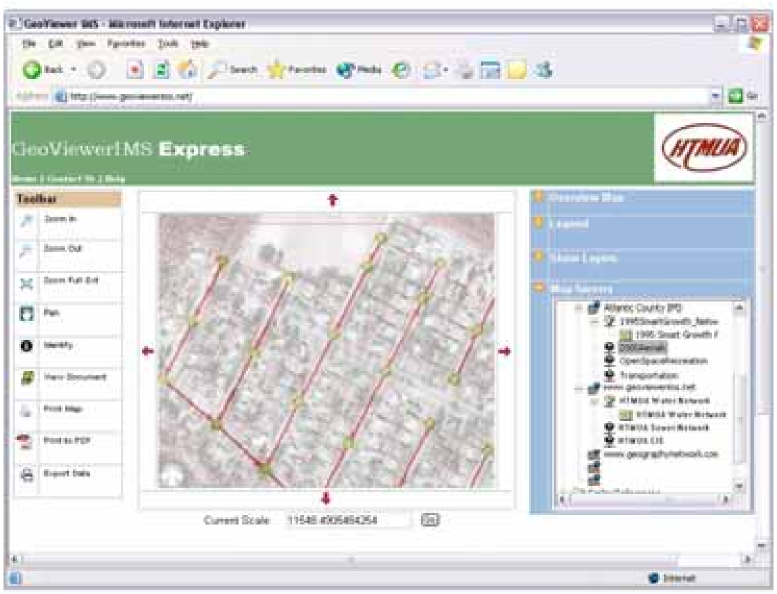
HTMUA's initial GIS program called for an investment in various pieces of hardware (PCs, laptops, and GPS receivers) and software (ArcView, MS Access, etc.). One of the key approaches for this phase of HTMUA's GIS program was to utilize the investments in hardware, software, and data made by the County and State. Base mapping data would be dynamically accessed by the HTMUA via the free map servers maintained by the government agencies. This would eliminate the need to store these large files locally which would reduce hardware costs.



The HTMUA also elected to utilize Nobel's private GIS data and application hosting service, GeoViewerIMS, in place of storing and deploying utility data on its local area network. For HTMUA, setting up and managing an Internet map server was not possible due to budget constraints and a lack of the necessary IT skill sets. Furthermore, turning over sensitive utility information to state and county GIS offices to be hosted on public map servers was not an option at a time when security and emergency management is so important.

Nobel's GeoViewer service leverages proven ESRI technology and allows clients to host their data and maps on its secure, private, Internet map servers. Utilizing a private hosting service provided HTMUA with the flexibility of deploying information to anyone within the organization, at any location, without the overhead involved with hardware, software, and GIS/IT staff. Nobel's service also included custom tools for utilities such as sewer network traces, valve isolation, and mailing label wizards which provided HTMUA with functionality beyond, but on top of, the standard ArcIMS interface. The service was also be connected to other Internet map servers to provide the end user with a seamless gateway to volumes of data.

For example, HTMUA has some experienced GIS users (<1% of staff) with needs that require the advanced GIS capabilities of ESRI's ArcView. Nobel set these users up with an ArcView project file that dynamically connects to the various map servers (GeoViewerIMS, Atlantic County, NJGIN) to access the appropriate datasets and also has the ability to add data stored locally on the network or hard drive. There are other moderate GIS users (2-5% of staff) that connect to these same map servers via ESRI's free ArcExplorer data browser and a custom project file that gives these users functionality beyond the standard web browser. Lastly, the remainder of the staff (90+%) and other authorized users gain access to the utility's data via a standard web browser using the GeoViewerIMS service.



With a private hosting service HTMUA has enterprise GIS functionality without much of the overhead attributed to GIS hardware and software. HTMUA also has the ability to control access to their water and sewer data by providing user accounts to engineers, surveyors, and other utilities.

Future Outlook

The HTMUA recognizes that GIS is not a project, it is a tool used for better information management. The key to leverage our investment will be to integrate GIS with our existing information systems and implement new systems that will include spatial functionality such as: work order management, capital planning, and hydraulic modeling. We also look forward to sharing data with other agencies and providing access to our staff in the field. The use of a good geodatabase design and enterprise technology, such as Internet map servers, will provide us with the functionality and scalability we need for the future.