MANAGING WATER UTILITIES WITH GEOGRAPHIC INFORMATION SYSTEMS: THE CASE OF THE CITY OF TAMPA, FLORIDA

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Managing Water Utilities with

Geographic Information Systems:

The Case of the City of Tampa, Florida

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Abstract

This thesis presents a review and evaluation of diverse Geographic Information System (GIS) applications developed for the water utilities of the city of Tampa, Florida. This review encompasses the process from planning to replacement/refurbishing and supports all engineering activities to keep track of assets, while handling the relationship between physical elements and quality of service. The specific City of Tampa Water Department GIS plan has to be developed within the framework of the city GIS strategic plan. The main objective of this thesis is to make significant contributions to the design of a useful plan with real applications within the department and that can be used as a model for other departments in the city of Tampa, without affecting or disturbing the general plan of the city.

One important conclusion of this thesis is that GIS plans require new methodologies different from those adopted for the traditional IT departments. It is necessary to set up new models and proposals for this planning field. The traditional IT methodologies can generate conflicts and result in a waste of money and collapses that affect the perception of GIS by the city managers and that could affect deeply not only the economy, but also the health of communities in cases of failure and collapse.

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ACKNOWLEDGMENTS

Thanks to all the workmates in the Palm Beach County Water Utilities Department, the City of Orlando Wastewater Division, and the City of Tampa Water Department. They provided enthusiasm and made important contributions to this project.

CHAPTER 1

INTRODUCTION

In this thesis, the author wants to show how geographic information systems (GIS) can provide the tools necessary to manage processes to control the operation of water utilities, including the collection, treatment, and distribution of reclaimed water through final disposal.

Water utilities are designed and built to serve a population spread over a geographic area and have a high impact on the quality of life in communities. Urban areas have multiple activities and diverse water demands and demonstrate vigorous dynamic behavior through time. Every community contends with intrinsic constraints such as population densities, economic activities, transportation infrastructure, and natural characteristics like political boundaries, water courses, lakes, topography, contours, railroads, streams, wetlands, zones of environmental protection, water availability, and soil characteristics (Maidment 2002). On the other hand, capital investment projects in this field demand substantial funds from taxpayers, who want city managers to do their best to create cost-effective projects and optimal maintenance within a cost-effective frame of the water utilities (Water Environment Federation 2004). Tampa, Florida, is a good example of a city that needs to balance all these factors.

Communities have an obvious and remarkable sensitivity about failure of water utilities, but they can withstand some hours without a water supply. However, they will not accept even one hour of wastewater spilled over the streets, and they will further object to bad odors coming from manholes or lift stations (Florida DEP 2008).

The planning process will benefit from the use of GIS to model the demographic dynamics in a service area, integrating all factors that affect urban growth and finding trends and future requirements of the land and infrastructure to support growth and the associated economic activities. The daily operations of maintenance and reparation of physical assets of the water utilities will benefit from the use of GIS to support the work of crews with mobile technology in performing quick search and analysis assessments of failures or in providing adequate responses to requests of new customers. GIS can provide quick answers to locate, with precision, every structure in the system and all the related data (Coats and Jarnagin 2005). Mobile GIS eliminates paper postprocessing at the office (Shamir 2005).

Each element, such as pipes, can be linked to as-built drawings, maintenance records, failure records, photos or videos of previous inspections, a year of installation, and all the attributes that engineers and operators must deal with in an emergency. GIS can provide a computerized maintenance management system capable of automatically creating work orders from mains inspections, can engage proper and quick responses to customer complaints, and can identify failures in the sewer pipes or other associated elements. For this project, the author wants to show how GIS are the keystone to implementing the *four M management strategy* of water utilities (i.e., mapping, monitoring, modeling, and maintenance; Shamsi 2005); additionally, as an example of GIS application, the author intends to set up a model information system for the city of Tampa to conduct business, provide appropriate quality service on a daily basis, plan for the needs of an ever-growing community, and support the city manager’s role.

CHAPTER 2

LITERATURE REVIEW

Importance of Infrastructure

In the United States, economic and social development, good quality of life, and good health heavily depend on physical infrastructure for delivering essential services to communities. Good infrastructure leads to good quality of life (Hudson *et al.* 1997).

Infrastructure, a Latin word meaning "the structure underneath," encompasses all the systems that provide a society with diverse and valuable services—for example, sewers, pipes, pumps, and manholes are elements of the water infrastructure—and decisions related to these components require important economic resources. This means that all decisions influencing infrastructure development and use-asset management without an appropriate and technical evaluation method inevitably misuse economic, environmental, social, and cultural funds (Lemer 1998).

Public and private organizations in the United States have recognized that the nation's water and wastewater infrastructure faces important challenges over the coming decades in maintaining, operating, and renewing infrastructure assets like pipes, treatment plants, and other related components (Congressional Budget Office 2002). Some organizations (Water Infrastructure Network 2001) have reported that over the next 20 years, America's water systems will require capital improvements of over $20 billion a year to comply with and meet the needs of new developments and to replace or renew aging and obsolete infrastructure. Some estimates state that for years 2000–2019, annual costs for investment will average between $13 billion and $20.9 billion for wastewater systems (Congressional Budget Office 2002).

Those organizations (Water Infrastructure Network 2001, Congressional Budget Office 2002) point to diverse problems with existing water infrastructure, including the collapsed storm sewers in various cities, the 1.2 trillion gallons of wastewater that overflow every year from sanitary sewer systems and commingle storm water and wastewater, and the estimated 20 percent loss from leakage in many drinking water systems. Such scenarios will grow in coming years, and costs to construct, operate, and maintain the nation's water infrastructure can be expected to rise significantly in the future (Congressional Budget Office 2002). The Congressional Budget Office also projects that annual costs over the 2000–2019 period for operations and maintenance (O&M) will average between $25.7 billion and $31.8 billion for drinking water systems and between $20.3 billion and $25.2 billion for wastewater systems. The funding required for the water-wastewater infrastructure gap has been estimated by different entities, as follows:

Environmental Protection Agency:	$76–534 billion
Congressional Budget Office:	$292–822 billion
Government Accountability Office:	$300 billion to $1 trillion
Water Infrastructure Network:	$1 trillion

The water infrastructure needs of the United States are comparable in scope and importance to those facing the highway and aviation infrastructure (Satch 2003).

If changes in management practices and the adoption of new technologies can increase efficiency and reduce costs, each 1 percent of the resulting national savings would be around $5 billion. Those funds could pay for training in and the purchase of new technological improvements in water-wastewater companies. The bottom line is that the adoption of effective management technologies is a cost-effective solution in this critical phase of our national infrastructure status. Many organizations have started to use GIS in the management process of infrastructure. There is wide room to develop more advanced tools and methodologies to increase efficiency in the diverse phases of infrastructure management.

Technological Improvements

Recently, based on the tremendous developments in computer technologies, new information technologies, science, and mathematics are helping us to understand and analyze infrastructure and to set up long-term management responsibility philosophies. Supervision, control, and data acquisition (SCADA), GIS, and decision support systems (DSS) are some of these emerging technologies (Lemer 1998).

All new emerging concepts have to be used at a higher level and conceptual frame to improve the management models we have been using in the past. *Asset management*, *infrastructure management*, and *municipal infrastructure investment planning* are phrases now more frequently used in the practice of infrastructure management, and there is a need to develop new management models. Previous figures show that the nation has to improve skills to manage those water and wastewater systems using advanced management technologies and improve all the phases of design, finance, construction, operation, and maintenance. Public and private organizations in charge of those utilities have to be reengineered and redesigned around new concepts. Information technology has proven to be one of the most effective tools in reshaping the public utility industry. That means that many organizations will need to make the transition to being information-based organizations (National Regulatory Research Institute 1995).

Geography is a basic element of the water utility service delivery system; many utility companies have employed GIS across the country with outstanding results (National Regulatory Research Institute 1995). The National Regulatory Research Institute sees GIS as a key information technology that has the capability to assist utilities and regulatory commissions in their transition to information-based organizations.

GIS can provide vital support in a comprehensive sanitary sewer maintenance-management system. Some propose the use of GIS in sanitary sewer operations not only at the system function level, but also at the database design level. GIS can be the hub of a municipal sewer management system, including GIS as key components and providing functionality for public sewer system maintenance, private sewer system investigation, sewer system modeling, customer complaints, and accounts processes (Wang 1999). Accordingly, there is a need for new management models to help engineers, engineering managers, nonengineering managers, and even customers understand the framework under which water systems are conceived, designed, financed, constructed, operated, and maintained (Hudson *et al*. 1997).

For the infrastructure managers, it is essential to share coordinated data in a GIS and database format, available on a common basis for different sections involved with infrastructure management processes. Nevertheless, GIS are relatively new. They have revolutionized planning and management in water infrastructure industries (Grigg 2002). New tools and management technologies demand a different skill set than many managers currently possess and therefore are pushing the limits of some managers' abilities (U.S. Environmental Protection Agency 2005). Modern managers of infrastructure need to know how to link data to functional management and how to use GIS and databases together (Grigg 2002). In addition, there is a need for change in organizational culture and mind-set. This key component of U.S. development requires new organizations with different cultures, new managing technologies, and new managers with appropriate skills for the new challenges.

Geographic Information System (GIS) Contributions to Better Management Practices

Modern management practice requires a full knowledge of the infrastructure assets, including not only attributes, but also location in a geospatial frame and the relationship among all those components. This is clear if we know that more than 80 percent of all the information used in utilities is geographically referenced. A key element of the information is its location relative to geographic features, other objects, and established boundaries (Shamsi n.d.).

Modern management of water infrastructure should also encompass the use of geospatial information systems. These systems provide valuable data for master planning or water infrastructure rehabilitation (Sægrov 2006). The basic objective is to enable the utility manager to select, rehabilitate, renew, or remove the right component at the right time, with the right technology, and thus save money (Sægrov 2006).

There is a consensus about the importance of information in all phases of utilities management. GIS can be used to schedule the repair, replacement, extension, or addition of new components resulting from growth and development of urban environments. GIS offer great value when performing utility master planning and capital improvement planning by combining data collections from past scenarios and projected scenarios (Water Environment Federation 2004). Some utilities have adopted a business planning approach for managing their infrastructure and addressing some organizational issues. Once again, GIS have proven to be good tools to set up an asset database and an efficient resource for tracking and planning maintenance needs (Freeman and Mosteller 2005).

The National Research Council of Canada (NRCC) has developed a set of tools, procedures, and practices to help infrastructure managers make strategic and cost-effective planning and management decisions. In the municipal infrastructure investment planning project developed by NRCC, researchers describe potential opportunities to improve the efficiency of maintaining constructed assets and the immediate need for business process reengineering related to infrastructure asset management and enabling technologies: maintenance management, life cycle economics, service life prediction, user requirement modeling, risk analysis, and product modeling (Vanier and Danylo 1997). One of the conclusions of this research project is that it is highly recommended that any software developed in the domain of investment planning interface with an organization's GIS (Vanier *et al*. 1998).

Successful experiences show the benefits of using GIS in wastewater and sanitary sewer evaluation studies. The key aspect in these evaluations is the link of GIS with relational database management systems (RDBMS). A RDBMS links inventory and inspection data with a visual map interface and provides the access gate for data collection, data analysis, and capital investment project (CIP) planning phases (Waldron and Ratchisnky 1997).

The U.S. Environmental Protection Agency (EPA) funded the National Decentralized Water Resources Capacity Development Project, supporting research and development to improve our understanding and strengthen the foundations of training and practice in the field of on-site and/or decentralized wastewater and storm water treatment. The report of this project highlights the role of GIS within different management tasks related to infrastructure systems and reliability assessment (Etnier *et al*. 2005).

Some cities have developed GIS-based sewer rehabilitation data management systems (SRDMS). Baldwin Borough municipality implemented a SRDMS to assist in the planning and design phases within a rehabilitation project of the sewer system. This data management system includes mapping data, TV inspection video data, pipe lining, bursting, pipe replacement, and manhole maintenance. Microsoft Access was used concurrently to apply unit costs for all necessary repair work and generate a variety of reports for use in bid document submittals. This SRDMS is fully integrated into the municipality's GIS (Farmer and Sarapa 2002).

Fairfax County, Virginia, has implemented several applications related to wastewater infrastructure management and into building a GIS. In a second level, Fairfax County has implemented—using GIS as the fundamental platform—an automated application for engineering management functions. The first approach was to convert WWM's sanitary facilities maps into a digital format compatible with the county's existing GIS. The originators of this work believe that major benefits will be realized after linking these GIS maps to the major enterprise systems such SCADA, the customer information system, and the land development system (Osei-Kwadwo n.d.).

The second level aimed to take GIS beyond graphical services for municipal government and develop a GIS for engineering management service functions and a model for a sanitary sewer reimbursement program. The research undertaken by the Fairfax County Department of Public Works and George Mason University concluded that several complex engineering service management functions could be automated on GIS platforms to realize substantial productivity gains. Automating multiple tasks in an integrated environment can increase productivity even further (Venigalla and Baik 2007).

Tao Zhang (2006) used GIS and an application called Computer Aided Rehabilitation of Water Networks to show how it is possible to help decision makers determine when and how to rehabilitate their networks. The strength of this proposed model is based in the model of a geodatabase.

In the field of water infrastructure management, very often, the funds do not match the growth and rehabilitation needs. Therefore it is necessary to develop methodologies to prioritize renewal and CIPs. Kilmeny and Jackson (2003) developed a GIS-based methodology to prioritize the rehabilitation projects in the Orange Water and Sewer Authority, Orange County, North Carolina. ArcGIS was used to provide the background data tables and to display the results of the calculations.

The city of Arlington, Texas, developed a frame to consolidate data information and standardize methods to set up a list of water infrastructure components in need of renewal or rehabilitation (Hunt and Lemus 2007). The result is a ranking system based on information derived from GIS, work order management systems, relational databases, knowledge management, and custom application development in the prioritization process.

Some other models have introduced more sophisticated tools to develop comprehensive models to prioritize projects in the water infrastructure management process. PARMS-Planning and PARMS Priority models are DSS for use within water utilities to support the decision-making process in the pipe renewal process (Moglia *et al*. 2006). This DSS includes a basic GIS and has a strong focus on data exploration.

Use of GIS in the design and construction of pipelines and in the selection of optimal routes has saved money in many cases. The GIS application permits great amounts of pipeline cost-related data to be collected, stored, and documented for each feasible alignment. One reported case is a good example of how GIS can help civil engineers select cost-effective routes, among multiple feasible alternatives, avoiding issues from environmental constraints, right of ways, and soil characteristics that influence construction costs (Luettinger and Clark 2005). Additionally, preventive maintenance is a vital task, especially in large-diameter force mains. Some GIS models have been developed to keep track of pipeline integrity. Technical tests and lab results of integrity of pipes can be handled in a GIS frame and have been shown to be a highly powerful and flexible tool for management of pipeline data (Garaci *et al.* 2002). In the same area, GIS have been proposed for planning for preventive maintenance and monitoring in water infrastructure systems. For some authors, GIS are providing useful tools in plotting areas of water system infrastructure deterioration and how it corresponds with various soil properties (Doyle and Grabinsky 2003).

Garaci *et al.* (2002) highlighted the importance of GIS finding spatially based correlation and data presentation for analysis and for management of pipeline data in preventive maintenance activities, especially in prestressed concrete pipe. These authors provided examples of the roles of GIS models, inspection data, and data management as part of a strategy for pipeline integrity management or risk management. Risk management, probability of failure of an infrastructure component, and consequences of that failure are key aspects to be considered in infrastructure management plans.

The city of Seattle developed a sewer pipe risk model as a tool to manage the risk of sewer pipe failures. The model identifies high-risk sewers and pipes and works in close interaction with city GIS. The model extracts information pertaining to each pipe (i.e., elevation, installation date, material type, proximity to geologic features, etc.). It uses this information to calculate individual monetary consequences of failure and probabilities of failure based on these attributes. The model forecasts, on a probabilistic schema, the chances of failure due to age-specific problems (Martin 2007).

Some researchers have proposed GIS as the best tools to establish a database of main break and asset management (Wood *et al*. 2007). Wood *et al.*, based on a report from NRCC (2005), highlighted the importance of the analysis of water main breaks because of their close relationship with potential contamination of the water distribution system and related health risks for customers. Whelton *et al.* (2007) developed a system based on GIS and customers who are located throughout the distribution system in a geographic service area. These authors, based on recognition by the EPA of the worthy contribution made by customer complaints, proposed a system that linked spatial location of complaints with clear procedures for customers' feedback data. According to the authors, customers' feedback helps water utilities uncover water quality, operations, and infrastructure access problems, and utilities should integrate customer feedback with GIS and hydraulic and water quality models.

Booth and Rogers (2001) used Environmental Systems Research Institute (ESRI) MapObjects to develop an infrastructure capital asset management plan. This assessment model examines the usefulness of implementing GIS technology (MapObjects) within an asset management tool. This model is focused on the usability of a system that visually tracks infrastructure assets, while allowing for examination of risk factors and other critical data.

Some municipalities began using GIS for different needs in different departments and implemented independent applications for each infrastructure. Managers with a municipal perspective have identified the need for integrated applications. Integrating independent infrastructure management systems after their full development carries some issues and needs that have to be fully understood and considered. Linear referencing, a GIS tool, plays an outstanding role in this proposed integration (Ferreira and Duarte 2005).

The integrated approach requires standardization and planning to ensure compatibility. However, it is necessary to preserve some degree of autonomy in the departments in charge of the specific infrastructure. The integrated approach largely requires the ability to share, exchange, and manage asset life cycle information, and therefore interoperability of various asset managements systems is crucial. Some researchers have proposed data models to handle this interoperability, including cases for sewer systems (Halfawy *et al*. 2006).

Recently, protection of infrastructure has become an important aspect for managers and homeland security strategists. Some authors have proposed a holistic approach that integrates GIS and hydraulic modeling to help utilities determine which locations are susceptible to intrusion (Lindley and Buchberger 2002). Intrusions are defined as the introduction (accidental or deliberate) of an undesirable agent into the potable water distribution system or any other water infrastructure. The model shows, in a spatial service region, the weak points susceptible for intrusion.

Some related infrastructure systems, like storm water drainage systems, can be handled using the same tools and GIS-based methodologies. The city of Tampa has used GIS in many different ways for storm water system management (Jones 2007). Jones shows how GIS help staff members during the budget process and increase reliability in front of customers.

Heaney *et al*. (2001) conducted deep research using GIS in urban storm water management. Heaney *et al.* showed how GIS are critical for the analysis of all the data needed in the management process. However, the authors remarked that the value of GIS is enhanced by their use in the context of a complete DSS.

Some organizations, like the American Society of Civil Engineers, have recommended making GIS a more prominent feature in urban storm water modeling and promote the use of this technology by engineers, who should be trained in this field or learn to work closely with specialists in this information technology area (Indranil *et al*. 2006). The authors recognize explicitly the tremendous potential of GIS in the technological advance of this engineering branch in the 21st century.

Synthesis

In this literature review, the author has found that much effort is devoted to setting up prioritization models to select the renewal/rehabilitation projects. This fact can be explained by the large amount of funds required for those operations and for CIPs. The proposed models use attributes of the physical components of the infrastructure systems. The most used criteria include items such as the following:

- age of pipe
- pipe material
- soil
- water main failures and work order history

Many researchers have found that the higher conceptual level in the infrastructure management process is a DSS. Some organizations, such as American Water Works Association Research Foundation and Water Environment Federation, are sponsoring research programs to develop DSS models in this specific field. However, there is still a need to research the role of GIS within a DSS.

It is common to find infrastructure elements 50 years old, and even older. This fact means that often, little or no data are available to make a sound analysis of probability of failure. Traditionally, worthy data were kept in the brains of senior employees, who never made hard copies or filed that data before their retirement. This shows that all the systems require substantial improvement in the data management process for the new developments and for the old components. This is a good field for research focused on this specific field of infrastructure management, and it is related with interoperability of GIS software with other packages like AutoCAD and programming possibilities using object-oriented languages like Visual Basic and SQL to manipulate databases. The need for development of unified standards and national data repositories has been identified and requires immediate attention.

There are some areas with a notorious lack of research, including uses of GIS to analyze spatial-temporal processes or chains of events along time, to make them accessible for visualization and spatial queries. The urban cycle of water and the demand for water within communities is a very dynamic and time-linked process. Demography and the spatial distribution of customers fluctuate with time. Water demand changes from daily patterns (diurnal curves) to seasonal patterns and annual changes. The use of reclaimed water will change in the future, and there is a need to analyze the effect on water consumption patterns. The GIS possibilities for analyzing real-time data coming from SCADA systems or remote-sensing devices have to be evaluated, and there is great room to develop useful applications in this field.

One additional field needing urgent research is the new security environment in which we are living and the government requirements to protect critical infrastructure. GIS can be used to evaluate risk and potential hazards from terrorism, identify weak areas within the systems, and support emergency management planning, preparedness, response, and recovery. Vulnerability assessment and impact analysis are now part of the routine activities of management staff and require tools to predict consequences, provide rapid response, and mitigate impacts.

The Value Proposition of GIS for Water Utilities

The Water Environment Federation (2004) has listed the following areas in wastewater systems management where GIS can provide substantial support to engineers and infrastructure managers:

- mapping and databases

- facility atlases
- management decision-making tools
- facilities planning
- GIS for complying with federal regulations
- GIS for business process reengineering
- GIS for enhancing public perception

Four *M*s Model

This work is based in the four *M*s model proposed by Shamsi (2002, 2005, n.d.). The four *M*s model can be used to manage all the phases of water and wastewater systems, including mapping, monitoring, modeling, and maintenance. The author proposes adding a letter for planning and prioritization of projects, in the following sequence:

- mapping
- modeling and planning
- monitoring
- maintenance and projects prioritization

CHAPTER 3

CITY OF TAMPA: DESCRIPTION OF THE STUDY AREA

The city of Tampa is located in central Florida, in the southeastern area of the United States. It is the seat of Hillsborough County, though its metropolitan area also includes portions of Pinellas, Pasco, and Polk counties. It is located approximately 150 miles from the Florida-Georgia border, in an area irrigated by Hillsborough River. The city of Tampa is located at 27°56′50″N, 82°27′31″W on the coast of the Gulf of Mexico (City of Tampa 2008a).

According to the U.S. Census Bureau (2008), the city has a total area of 170.6 square miles (441.9 km^2), of which 58.5 square miles (151.6 km^2) is water (34.2% of its area). The city of Tampa is, on average, 48 feet above sea level. The population of Tampa in 2000 was 303,447. According to the 2006 census estimate, the city has a population of 332,888 and a density of 2,969.6 persons per square mile (City of Tampa 2008a).

Tampa is the hub of the denominated "Tampa Bay Area." This metropolitan area includes Tampa, St. Petersburg, and Clearwater, with a total population of roughly 2.7 million, and is the third largest metropolitan area in the southeastern area of the United States, behind Miami and Atlanta (Tampa Bay Partnership 2008). Tampa is bordered by two bodies of water, Old Tampa Bay and Hillsborough Bay, which both flow to form Tampa Bay, which is adjacent to the Gulf of Mexico. Hillsborough River is the main source of water for the city and passes right in front of the downtown area. The Hillsborough River watershed is vital for the region and plays an outstanding role in the urban water cycle.

The water in this region is under South Florida Water Management District jurisdiction. The stakeholders decided to create a second entity to regulate water usage: Tampa Bay Water (http://www.tampabaywater.org/). Tampa Bay Water is a special district created by interlocal agreement to supply wholesale water to Hillsborough County, Pasco County, Pinellas County, Saint Petersburg, New Port Richey, and Tampa. The City of Tampa Water Department (COTWD) provides water supply services and wastewater removal and disposal beyond the limits of the city and sells bulk water to some communities and some cities in the regional neighborhood. The city, as a part of a strategy aiming to reduce water consumption per capita, has implemented a reclaimed water distribution service, based on the wastewater treatment plant. This water is intended to replace water used for irrigation during dry seasons (Wade-Trim 2008).

Figures 1 and 2 show the geograpic location of the city of Tampa and Hillsoborough County in Florida and United States. Figure 3 shows the road networks in the region. The southern end of the Tampa peninsula houses the McDill U.S. Air Force Base, which is one of the largest customers of the Tampa water distribution system. Figure 4 shows the topography and the general slope toward the sea of the region and how the Hillsborough River crosses the region. Figures 5 and 6 show the use of land, both present and future, according to forecasts from the Planning and Zoning Department and the Planning Commission (http://www.theplanningcommission.org/).

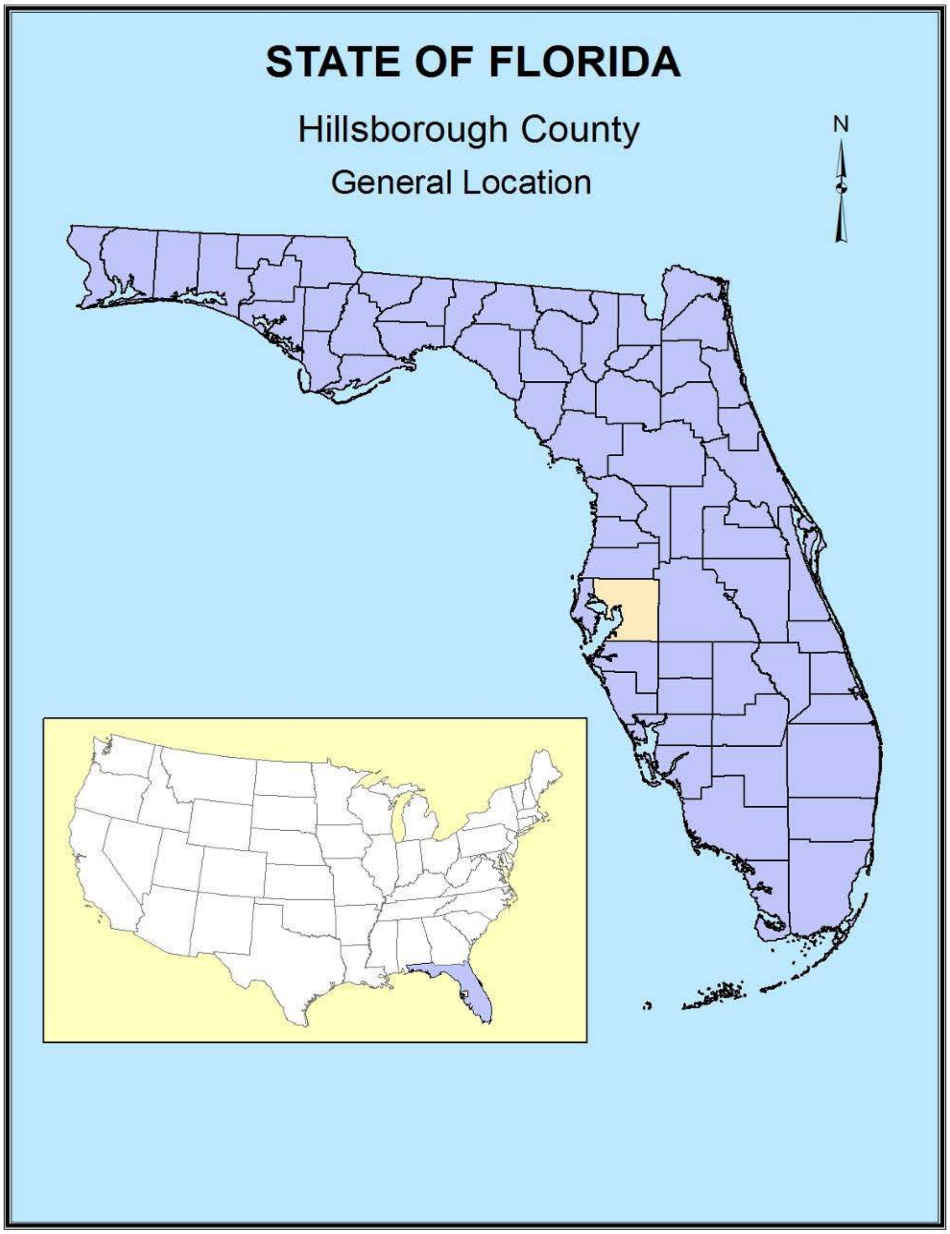


Figure 1. Hillsborough County within State of Florida

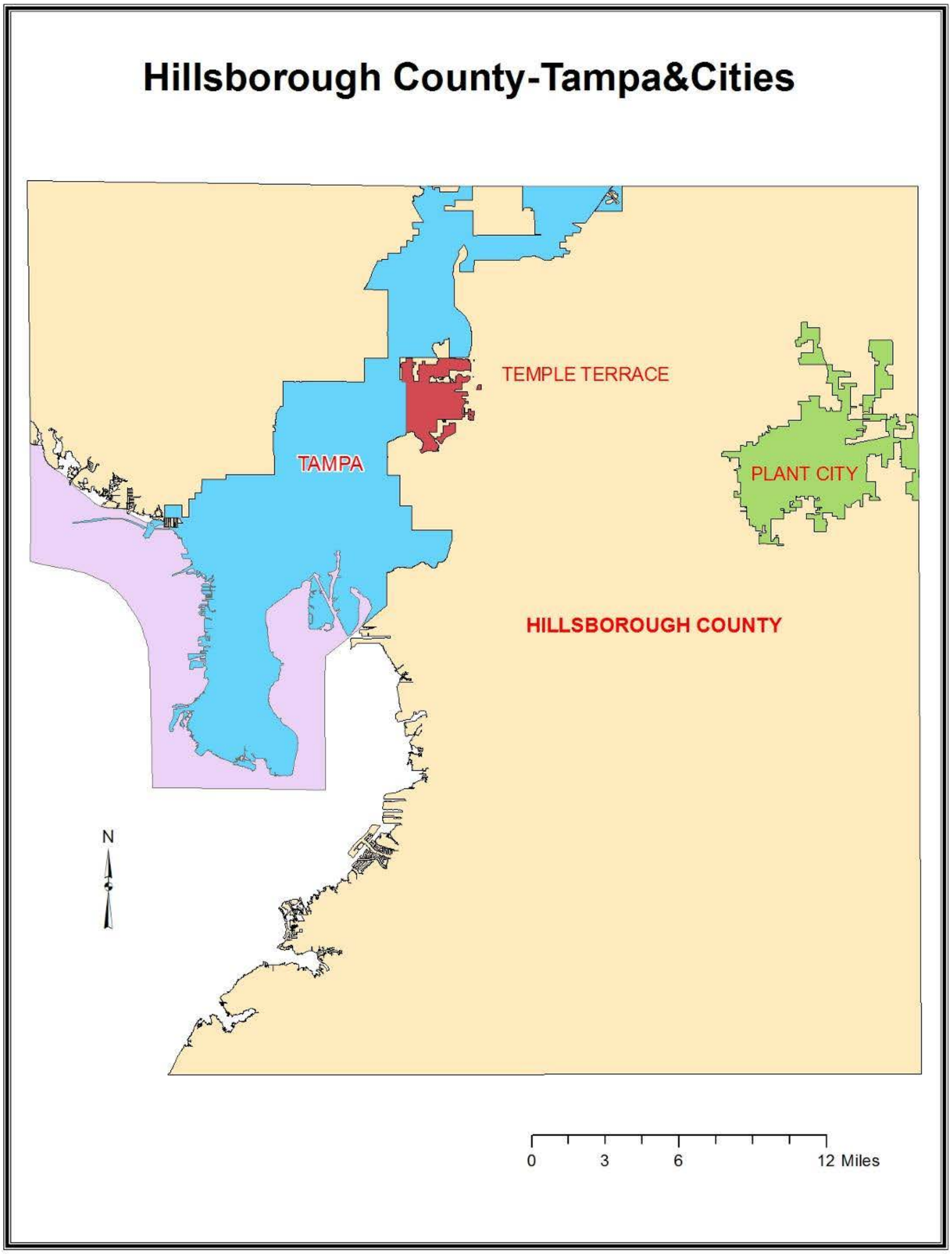


Figure 2. Hillsborough County and Cities

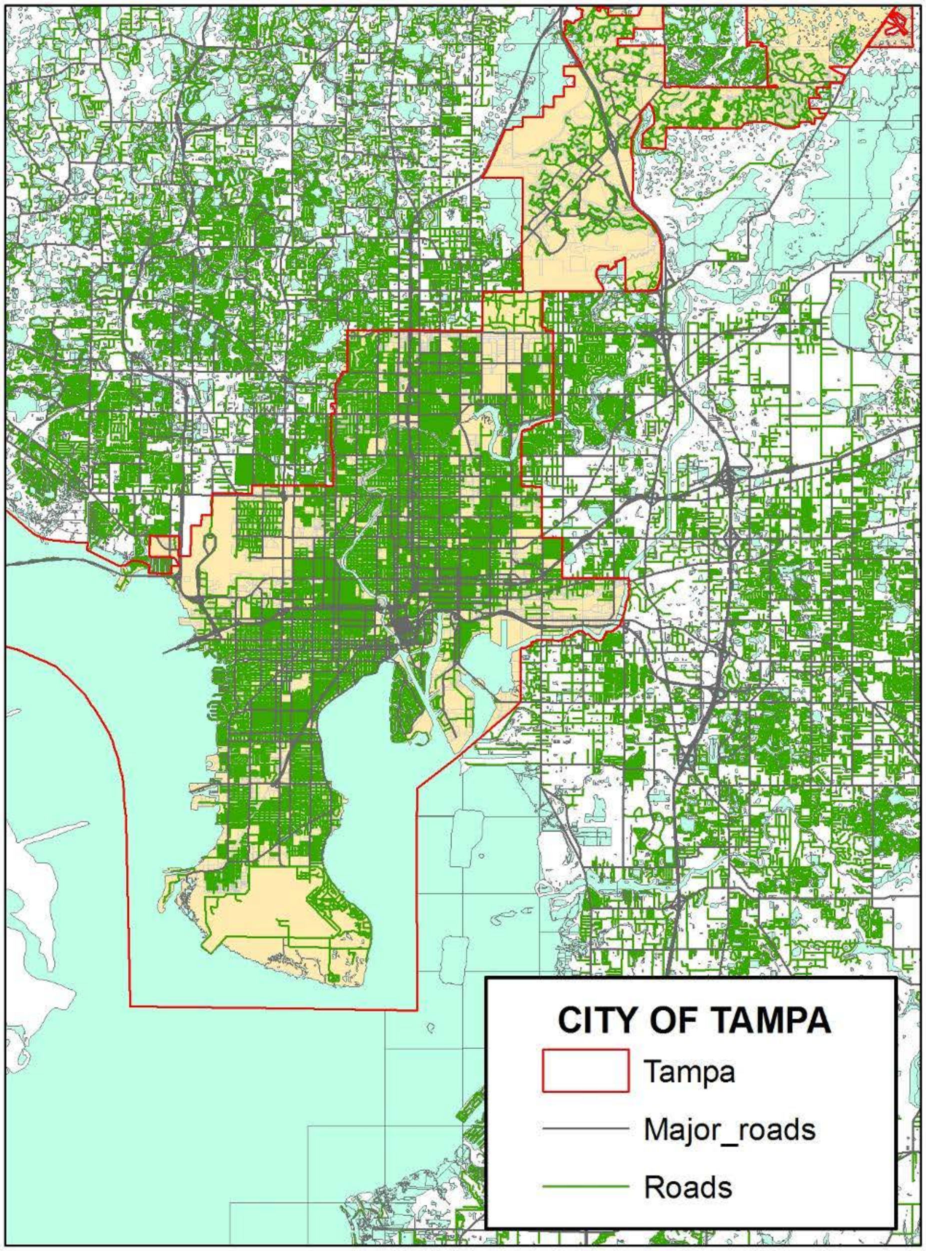


Figure 3. City of Tampa Transportation Infrastructure

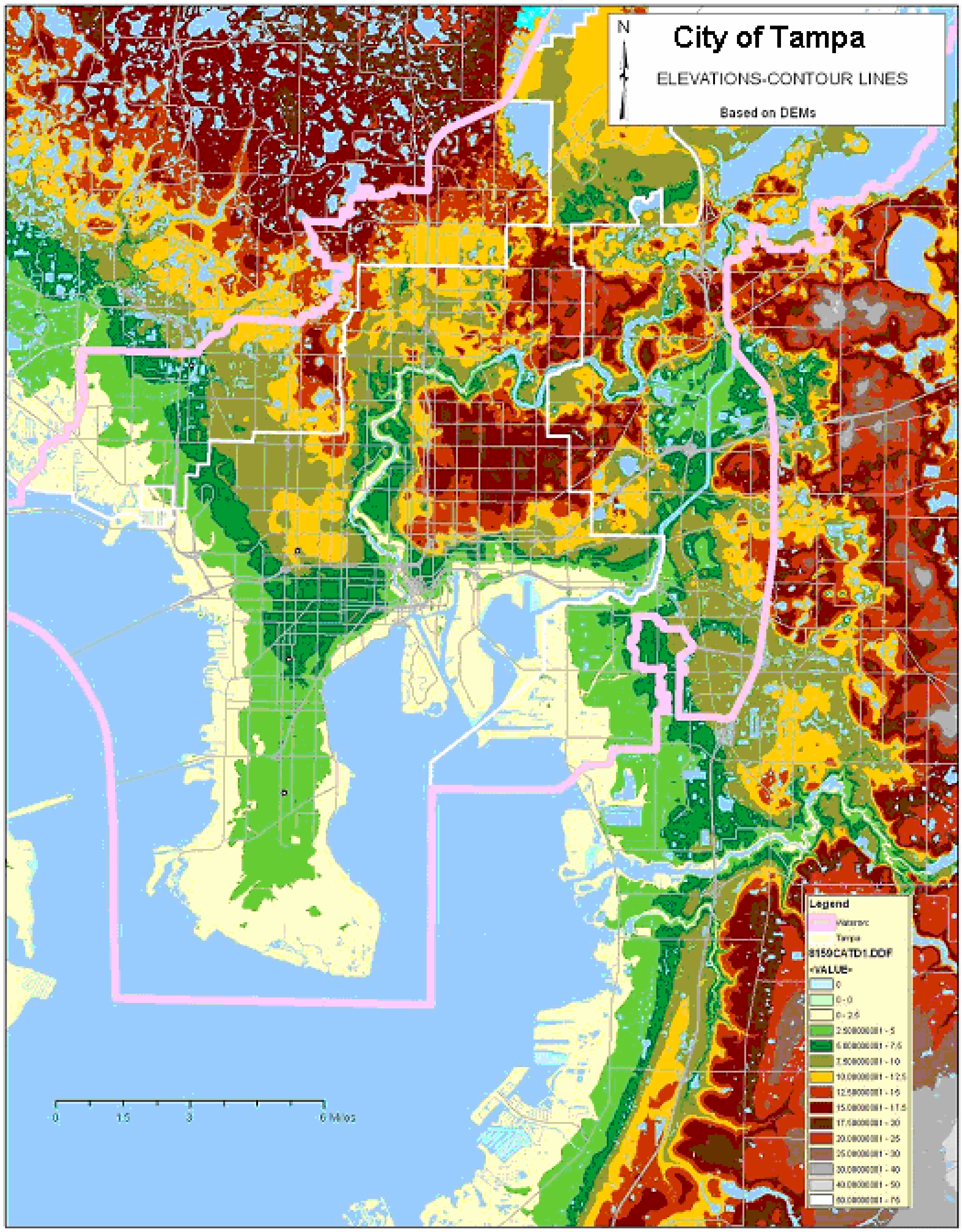


Figure 4.City of Tampa .Topography with Contour Lines and Elevations
(U.S. Geographical Survey n.d.)

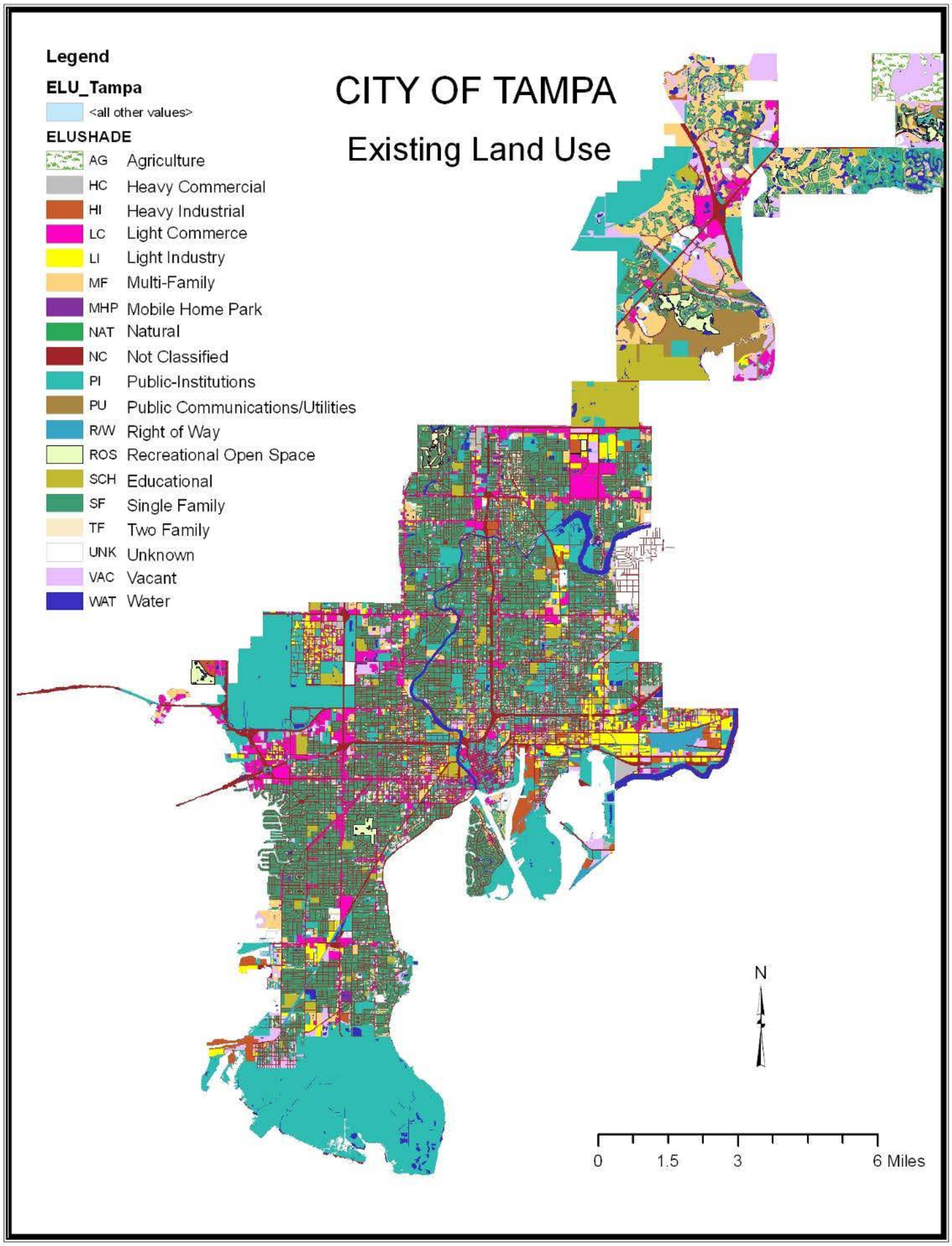


Figure 5. City of Tampa Existing Land Use

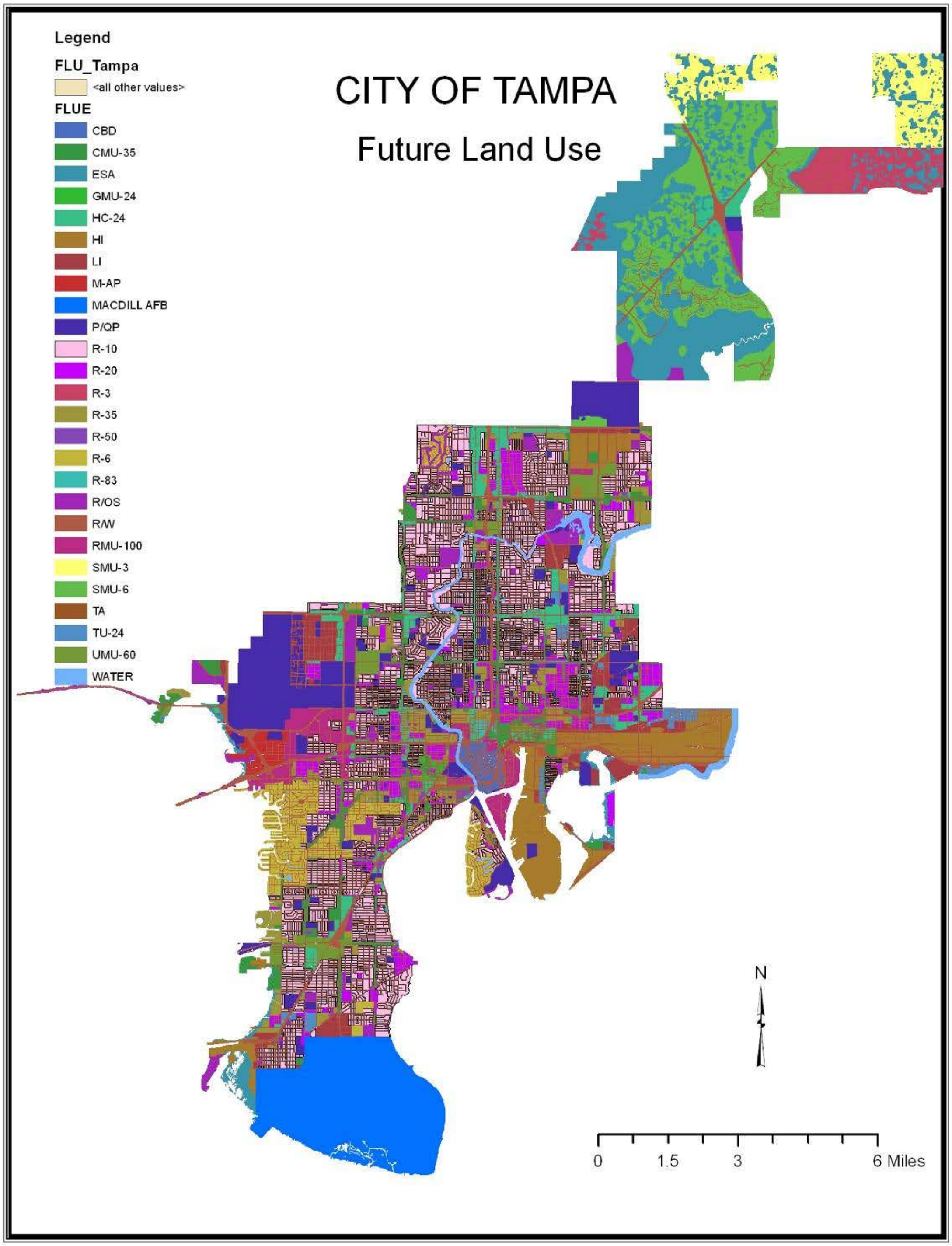


Figure 6. City of Tampa Future Land Use

CHAPTER 4

DESCRIPTION OF THE WATER DISTRIBUTION INFRASTRUCTURE

The COTWD serves a customer population of approximately 500,000 people, through 120,000 connections, and a service area that spans 211 square miles. About one third of its customers are located in unincorporated Hillsborough County. Tampa is the largest surface water supplier in Florida. It was established in 1923, with a historic plant built in 1925 and rededicated in 2002.

Physical Components

Tampa Water Distribution System has 2,300 miles of water mains, including 470 miles of undersized pipe, 74 miles of which requires “looping,” plus an additional 148 miles of pipe with renewal and/or replacement needs. The undersized mains require replacement and supplemental interconnecting main construction to obtain fire protection and adequate service. The replacement program requires a careful planning process because of budget restrictions and a critical funding situation. This program will enhance water quality and minimize customer complaints and concerns related to both water pressure and water quality (color/appearance, taste, and odor). The COTWD water distribution system has 41 million gallons of ground storage. There is a close relationship between land use, human and economic activities, and water infrastructure, as shown in Figure 7 (see Figure 8 for an aerial view). Pipes and related structures convey the water to where people live.

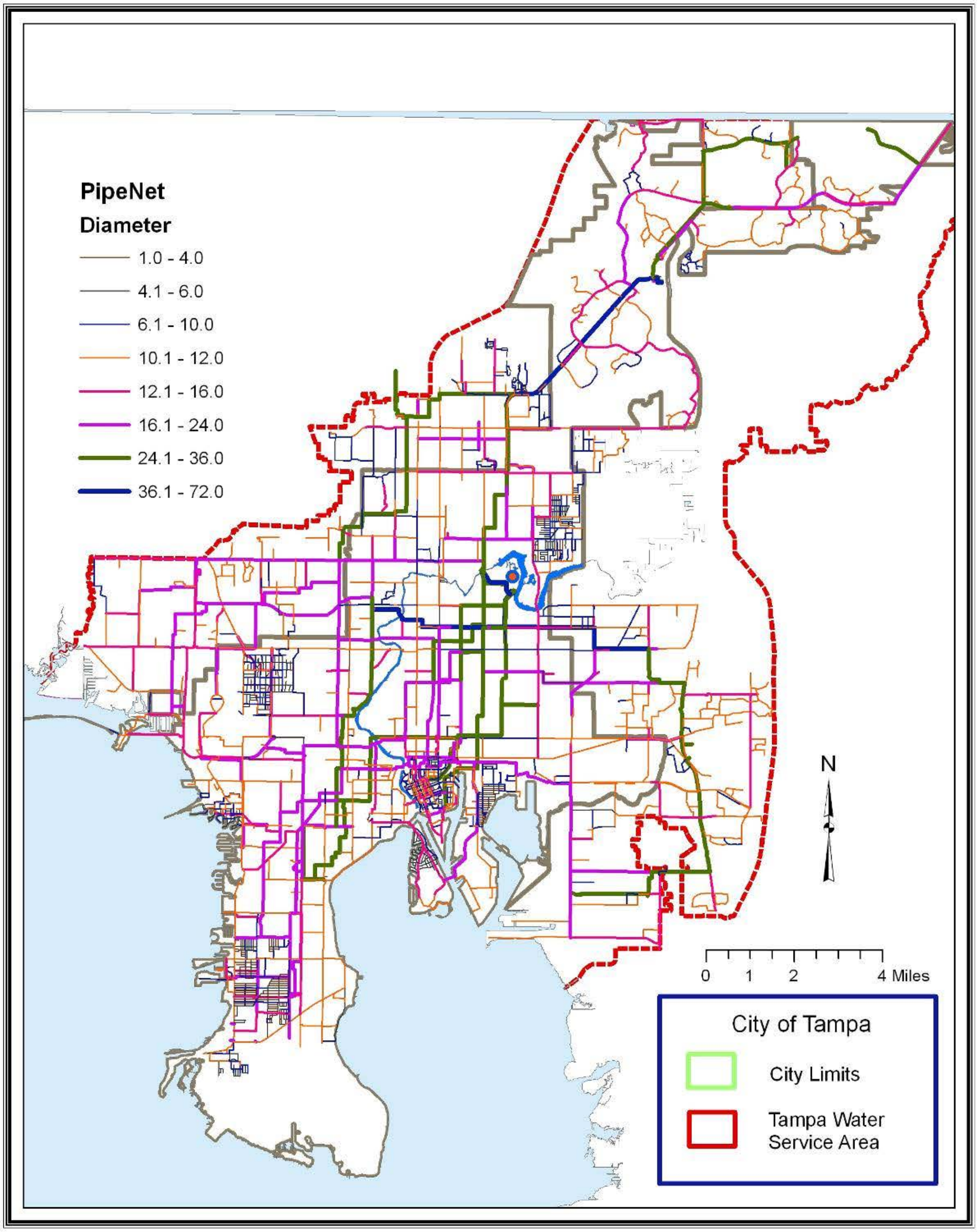


Figure 7. City of Tampa Water Department (COTWD) Service Area and Water Infrastructure

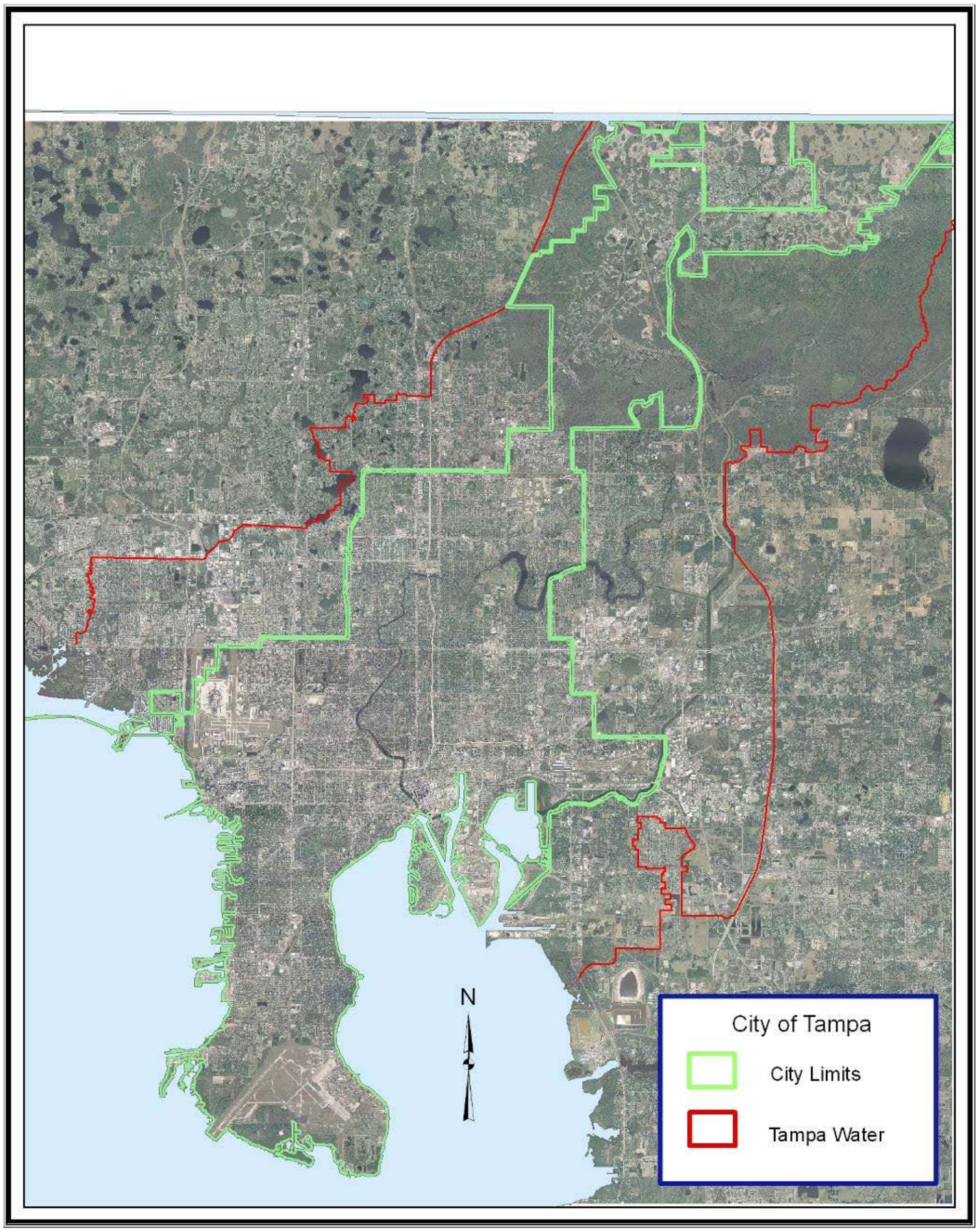


Figure 8. City of Tampa Service Area: Aerial View

Water Resources

The primary water resource is the Hillsborough River, which has its headwaters in the Green Swamp and is spring fed along its course to the Hillsborough River Reservoir. Figures 9 and 10 show the COTWD's existing and proposed water sources and supply connections, which include the Hillsborough River Reservoir, the Blue Sink and Sulfur Spring System, and Tampa Bay Water (Morris Bridge interconnect, North Boulevard interconnect, Tampa bypass canal, Morris Bridge sink, and other interconnects). The Southwest Florida Water Management District (SWFWMD) is the water authority in the Tampa and Hillsborough area. SWFWMD has developed a Comprehensive Watershed Management program to conduct water resource assessment and planning on a watershed basis, including all users in the jurisdictional area.

The Hillsborough River watershed encompasses parts of Hillsborough, Pasco, and Polk counties and a diversity of surface water features and connections to the Floridian aquifer system. This watershed is highly developed, particularly in and near the cities of Tampa, Temple, Terrace, Plant City, and Lakeland. The Hillsborough River Reservoir is the primary source of potable water for the residents of Tampa and many adjacent areas. Strong population growth in this watershed will continue to create numerous issues between land and water resource use and planning.

Figure 9 shows the Hillsborough River basin and the geographic area within the SWFWMD. Figure 10 shows the sources of water for the COTWD system. A regional organization, Tampa Bay Water, is in charge of water resources in the Tampa Bay area.

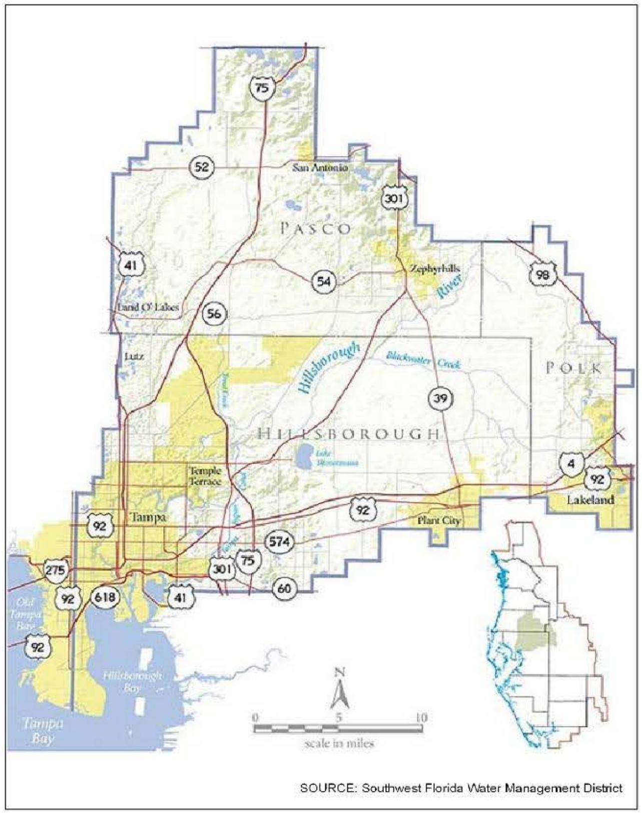


Figure 9. Hillsborough River Basin (Southwest Florida Water Management District 2008)

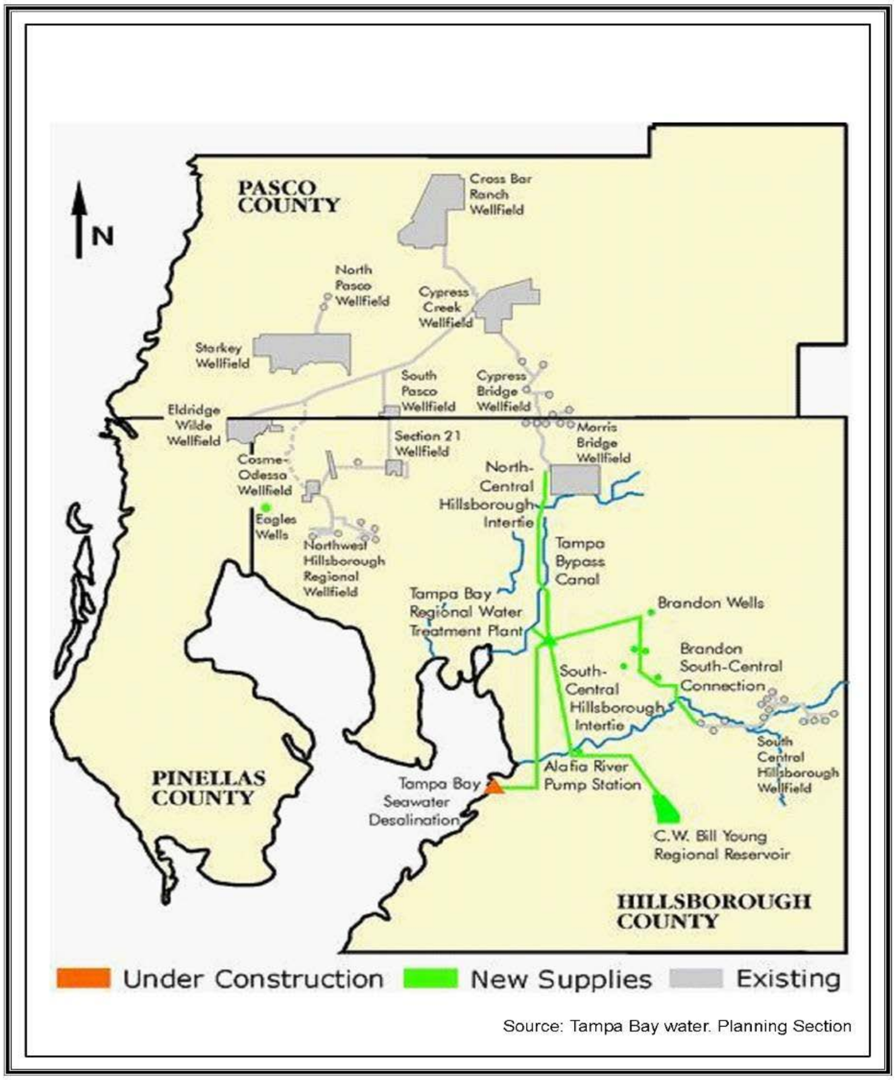


Figure 10. Sources of Water for City of Tampa System (Tampa Bay Water Planning Section 2008)

Organization of Tampa Water Department

The COTWD is composed of three divisions: engineering, production, and distribution. Water Information Technology and Administration Fiscal Management are two staff sections that provide management support to the executive director. Figure 11 shows the structure of the COTWD and its sections. The organization is designed following the workflow of the main business processes: planning, design, production and operation, and maintenance. Some business processes overlap the three divisions, whereas others keep their cycle entirely within each division. Water Information Technology acts as a liaison with the city GIS plan and manages many of the basic data required within the COTWD. In accordance with the latest changes caused by a budgeting crisis, that unit will move to a centralized unit working for the organizational units in the city.

The COTWD controls the growth of the water distribution infrastructure, and it encompasses internal and external projects. External projects come mainly from developers. Design activities are performed mainly within the COTWD by a group of engineers and engineering technicians. Major projects are assigned to external contractors and consultants.

Current Problems with Spatial Data

Currently some problems are affecting the normal operation of the business processes and cause waste of important resources. Following are the most significant problems with data:

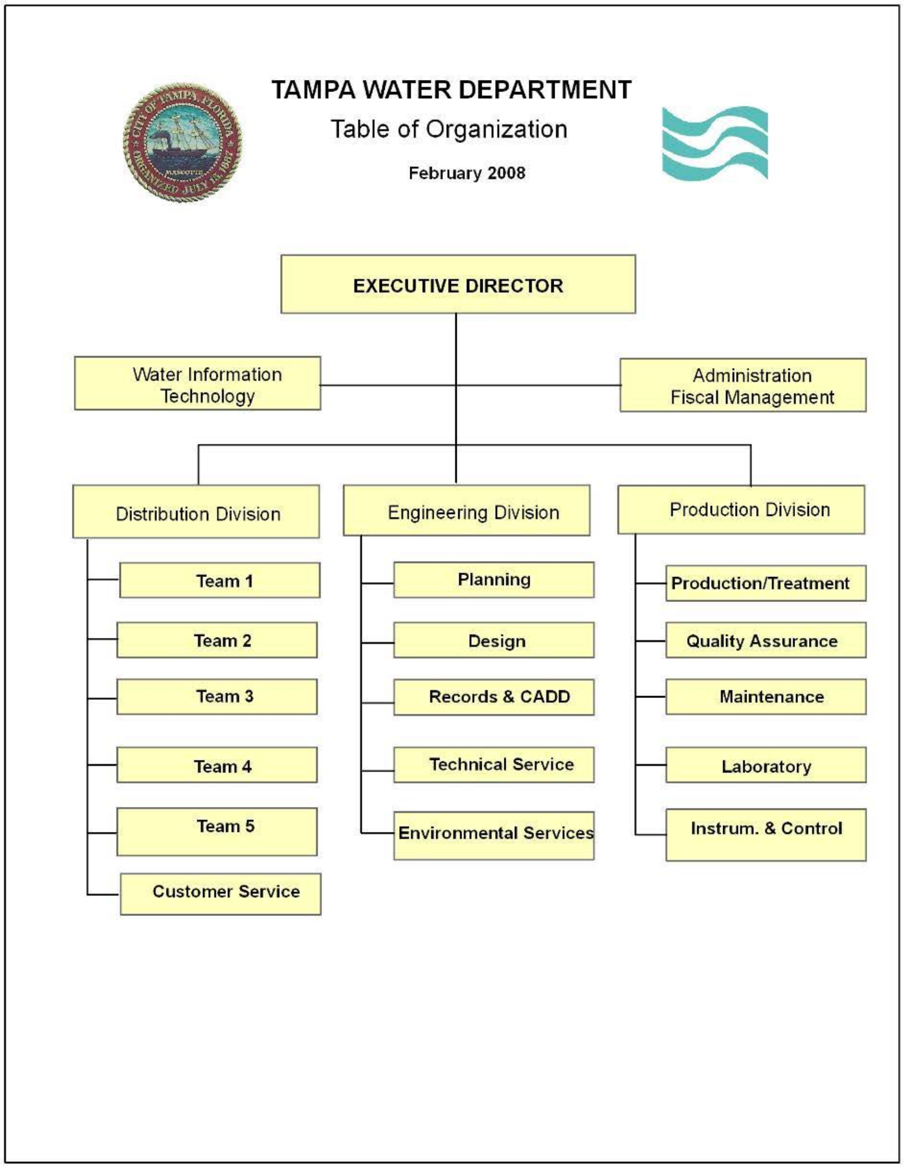


Figure 11. COTWD Organizational Structure

1. The physical characteristics and attributes of buried assets are frequently unknown and the huge amount of data coming from maintenance and operations are not statistically manipulated to determine trends or spatial correlations.
2. A SCADA system captures and stores huge amounts of operational data every day, but those data are used mainly for day-to-day solutions within a very local frame or focus. There is a lack of spatial analysis (geostatistics) and definitions of the relationships among the different components. Figure 12 shows the distribution of SCADA points within the service area.
3. The GIS data come from different sources and do not contain metadata. It is impossible to define the validity of the data, and it is impossible to identify the authors or the data when they were elaborated.
4. There are many different sources of GIS data, but all the authors have the same problems in the production of basic data. The standards are different, but the common case is the absence of standards for GIS and CAD data.
5. There is no unified source of data for customers. That is a risk for the city because frequently, the data provided for the city have legal implications that could derive in conflicts. Some organizations use MapInfo, and others use ArcGIS, but the translation process does not follow QA/QC protocols.

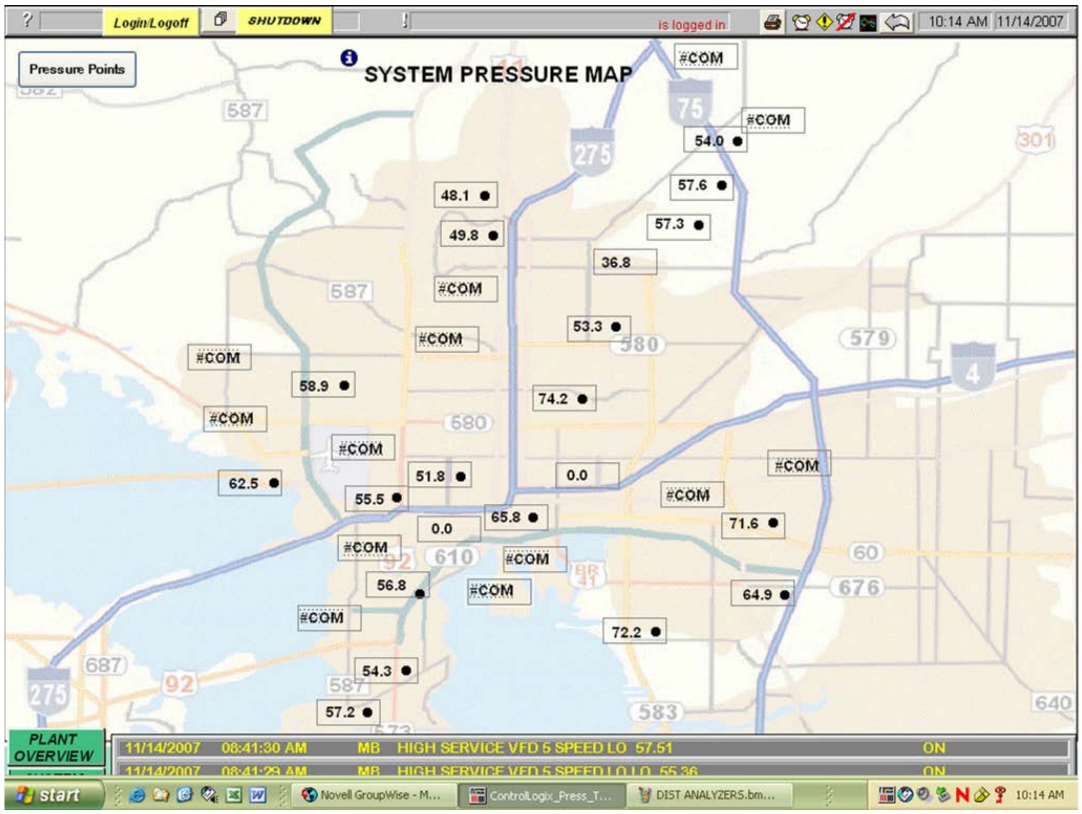


Figure 12. Supervision, Control, and Data Acquisition (SCADA) Points in the Service Area.

CHAPTER 5

METHODOLOGY

User Profile

The group of users in the COTWD was analyzed and classified according to level of education, age, time in the organization, and previous experience with GIS (Table 1). It is important to note that the employees' profiles did not include skills or education in GIS fields. The group of users was divided into four categories:

1. engineers with management functions
2. engineers with technical functions exclusively
3. technicians (engineering technician I, II, II)
4. administrative personnel

Group 1 was focused on those reports that support management decisions related to budget or cost-effective solutions (costs, reparation records, etc.). Group 2 was focused on those reports that support technical decisions and selection of alternatives and spatial locations of events (frequency of events, failure statistics, age, etc.). Group 3 was focused

Table 1. Classification of Users

Category	Percentage	Experience using GIS	Years in the organization
1	5	Low to 0	15
2	15	Low to 0	18
3	20	Low	8
4	25	0	15

Note: Personnel from the Planning section are not included.

on those reports about locations of customers, statuses of processes, and analyses of customer requests.

The most important finding was the low knowledge, in all levels, of GIS technical possibilities. A second finding was the perception of GIS as a mapping tool to display locations of structures in the spatial frame of the service area. Most of the technical personnel (engineers in all categories, technicians, and even administrative personnel) have skill and experience using AutoCad, from novice to advanced levels, and understand the technical contribution to the engineering activities of the COTWD.

In the group of engineers, the average age was 45 years, and the number of years in the organization was 12. This implies that this group completed undergraduate and graduate studies before 1985 and the GIS era. During their professional life, they have not been users of GIS software. Even among the group of young professionals (engineer I, technician I), training in GIS subjects is very low to nonexistent. A second implication is that very soon, engineers from both categories will retire or will leave positions for new employers or for promotion from other levels. This is both a problem and an opportunity.

All groups have from intermediate to advanced ability using Microsoft Office packages: Word, Excel, Paint, and, to a lesser degree, Access or database management packages. Many have some skill using Photoshop or Paint It software.

One important characteristic is that personnel with some knowledge of GIS software only know the basic package and do not have knowledge or experience using specialized extensions, such as Spatial Analyst, Geostatistical Analyst, Network Analyst, or 3D Analyst, or understand the concepts of the geodatabase or interoperatibilty with AutoCAD.

Methodology

The first step was to explain to users the possibilities of GIS applications and to improve and change their perception of GIS software. It is necessary first to introduce personnel to the new applications, and then users will use the software on their own.

During the first months of the study, users will be required to deliver reports to the Planning section, but after some time, users will find the reports in K drive and will use them according with their needs and even will propose improvements. Personnel of the Planning section have developed skill using GIS software. Only the author of this thesis has academic background in GIS, with the chief planning engineer having some experience in a lower degree. Technicians have some training from the chief planning engineer and planning engineer II. The best scenario is to have personnel with technical engineering knowledge and GIS training and knowledge. The applications will be transferred, for maintenance purposes, to the GIS analyst of the Water Information section. Further improvement will be made jointly by the GIS analyst and the author of this thesis.

All the applications, exhibits, and tables presented in this thesis were developed entirely by the author, using existing basic shapefiles or MapInfo tables. The basic shapefiles, such as parcels, streets, roads, and water or service area borders, are set up and updated permanently by the COTWD GIS team. The author of this thesis is in charge of the applications for water distribution management.

The reports were presented and approved by users, who quickly started to propose new reports or applications. People from the Planning section were requested to start a training program for different levels using ArcGIS software, which includes ArcReader, ArcExplorer, and ArcMap. Once the budget restrictions end in 1 or 2 years, the COTWD will set up an ambitious training program involving the University of South Florida and ESRI.

Many of the reports and applications will have multiple users, including the Planning section, which will result in better communication and permanent use of the reports and continuous improvements. The GIS analyst from Water Information Systems has been requested to develop manuals for the use of the applications, to solve minor issues, and importantly, to set up and perform maintenance for the metadata of all the files and applications developed in this process.

CHAPTER 6

CRITICAL ANALYSIS OF CITY OF TAMPA GIS STRATEGIC PLAN

Since the COTWD is embedded in the general structure of the city of Tampa organization, it is necessary to describe that structure and the goals and contributions of this department to the overall plan and how it articulates to the shared data of the other departments. The current plan is under Technology and Innovation Department leadership, and version 11.0 of the city of Tampa GIS document can be downloaded from the city Web site (City of Tampa 2008b).

Some adjustment has been made to the original plan, mostly because of recent technological improvement and recent trends. As an example of these changes, the initial software widely used for GIS applications was MapInfo and ProViewer; now the city is moving slowly toward the ESRI software, and Oracle is the core database. Oracle is the best known industry standard enterprise database supporting the storage of geometry.

General Overview

The city of Tampa recognized some years ago the advantages and benefits of an integrated citywide GIS plan. The GIS plan has been under constant development during the last 8 years, and now the city is poised to move to a higher level of efficiency and effectiveness that will result in overall improvement and better service for customers and citizens.

After recognizing the benefits and the potential gains from a citywide GIS system, in December 2003, the city of Tampa's chief of staff chartered a GIS Working Group to develop an enterprise level of GIS capability. In that moment, the group did not recognize some nonformal issues arising from the diverse practices and diverse backgrounds and skills of the personnel in the GIS field. The plan was set up to focus on four general areas:

- organizational structure
- data standards
- systems integration
- training

Experts in organizational design and strategic planning always recommend that the organizational structure follow the strategy (Chandler 1969). For this reason, the logical sequence of activities in the managing process are linked in the planning, organization, integration, and controlling sequence, which is valid for both short- and long-term projects.

Very soon, the group found problems caused by a lack of formal policy and data standards. The group also faced difficulties with integration and quality control due to the lack of authority and the employees' resistance to change in many departments with legacy applications with no documentation. The group failed to identify its own weaknesses and quickly focused mainly on the creation of new positions, hiring personnel, and proposing hardware and software solutions. The group members assumed, because of their long permanence inside the organization, that they knew the objectives and the goals of information technology (IT) in the city and simply tried to implement the GIS solution as an extension of the existing IT structure. They failed to understand that GIS is IT, but with specific characteristics and intrinsic needs.

In contrast, the COTWD will start its own implementation, meeting the citywide system but using an extensive needs assessment process. The final result will articulate with the general system. The group recommended the following goals for each planning area:

Organizational Structure

Goal 1. Establish an independent Core GIS Group at the division level, charged with the mission of spatially enabling enterprise data to drive greater effectiveness in meeting specific business needs.

Goal 2. Hire a GIS coordinator to lead the GIS Division.

Goal 3. Define the required resources and associated skills to be successful and provide those resources to the GIS Division.

Goal 4. Establish the proper standard operating procedures and service level agreements that balance roles and responsibilities between the Core GIS Group and department personnel.

Goal 5. Evaluate the service center concept for the GIS Division.

System Architecture and Integration

Goal 1. Develop an environment in which everyone benefits from geographic information and services made available across any network, application, or platform.

Goal 2. Establish a central GIS relational database with robust geographical capabilities that meet open GIS standards.

Goal 3. Integrate and/or interface existing and future systems into the enterprise GIS (where appropriate) and establish policies and standards that govern that integration.

Goal 4. Evaluate, identify, and acquire robust Web-mapping tools to filter, query, extract, and export geographic data for internal and external users.

Goal 5. Identify and implement application tools to geographically reference and maintain utility asset data.

Data Structure and Maintenance

Goal 1. Develop a central GIS database for spatially enabling enterprise data.

Goal 2. Procure and customize an enterprise data model.

Goal 3. Establish and implement citywide GIS Data Standards.

Goal 4. Evaluate and improve the processes that provide important base layer information, such as addresses and parcel data, to ensure the timeliness and quality of the data.

Goal 5. Evaluate a citywide GPS system to facilitate spatial referencing of city asset infrastructure.

Training

Goal 1. Perform a comprehensive survey of all GIS training needs based on the identified competencies for GIS positions.

Goal 2. Restructure the GIS training program to meet the comprehensive needs of the city.

Goal 3. Establish MapInfo and AutoCAD user groups and/or communities of practice to increase flow of knowledge.

Once again, these goals do not follow the philosophy of strategic planning at all. There is no analysis about strengths and weakness within the organization, and the lack of analysis of the external environment of the organization caused many problems right after starting the implementation. Quick changes in technology and practice trends forced consecutive changes in the plan. The goals do not establish a time frame and are general statements without a measurement scale or defined numeric values.

The training key area goal 1 aims to perform a comprehensive survey of all GIS training needs based on the identified competencies for GIS positions. That statement implies a defined number of positions and defined profiles for each position. That objective without a previous evaluation of the work load does not allow jumping to the second step, related to budget and financial requirements. The bottom line is that the plan is more focused on IT personnel needs and does not include real strategic components nor user needs. If users do not know the possibilities of the GIS resources and the technician or analyst does not evaluate the engineering needs, it is impossible to satisfy real needs, and the plan could be at risk of failure.

The lack of searching for potential threats in the external environment resulted in unexpected scenarios without a plan to handle them. The group had to recognize that given the new troubles in the national economy, the city had to adopt a policy on zero growth in overall city positions and that without additional manpower, the transition from the current state to an enterprise-level capability will be extremely slow and will most likely fail in achieving the needed improvements.

The group, or TGIS Working Group, supposedly representing the wide spectrum of people interested in GIS, based their work on numerous meetings, providing the opportunity to meet one another, receive training, and share thoughts, ideas, and problems with one other. The result was a tightening community that should, according to the group's own words, continue to share knowledge across organizational boundaries to increase the effectiveness of what they already know.

The lack of planned communication and contact with users is quite evident, especially in the case of advanced and technical users like engineers and technicians in the COTWD and users of specialized software like AutoCad and sophisticated modeling software. To begin moving toward an enterprise-level program, the initial group formed six committees:

- Data Standards Committee
- Systems Integration Committee
- Organizational Requirements Committee
- Web Page Development and Maintenance Committee
- Strategic Planning Committee

Figure 13 shows the committees organized around the objectives of the planning group, but without articulation mechanisms and a communication protocol. These committees were designed only to share the experiences of the members and to make suggestions about how to reach the proposed enterprisewide system.

Current Situation

The complicated landscape of national and world economics, the real estate crash, and fuel prices have affected counties' and cities' development plans. The GIS plan has entered with very slow progress because of fund constraints, and the city management

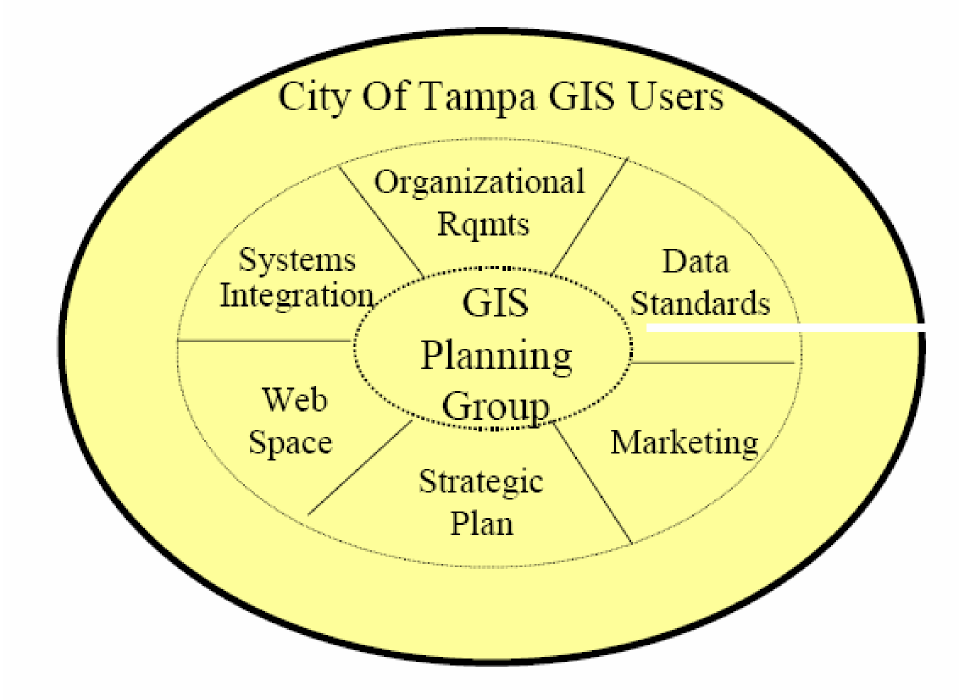


Figure 13. City of Tampa Geographical Information System Community (GIS)
City of Tampa (2006)

has orders to cut unessential programs. In the middle of this crisis, there is an opportunity to change all the flaws of the current plan and to develop a pilot plan top-down for the COTWD but replicable in other areas.

GIS in City Departments

An initial evaluation of the use of GIS throughout the city departments and this first evaluation are shown in Table 2 and included in the plan document. This initial survey is not quite accurate because the basic definition of GIS usage was based on use of AutoCAD and MapInfo, and that introduced a kind of bias because users had developed their own solutions. Some users, for example, use free viewers with public data from

Table 2. Extent of Geographical Information System Usage in City of Tampa Departments

Department	Not used	Light use	Moderate use	Heavy use
Revenue and Finance		X		
City Attorney	X			
City Clerk	X			
Internal Audit		X		
Police				X
Fire			X	
Neighborhood and Community Relations	X			
Community Affairs	X			
Code Enforcement	X			
Parks and Recreation		X		
Communications	X			
Cable Communications	X			
Intergovernmental Relations	X			
Purchasing	X			
Strategic Planning and Technology				X
Human Resources	X			
Arts and Cultural Affairs		X		
Convention Center and Tourism	X			
Minority Business Development	X			
Business and Housing Development				X
Urban Development			X	
Storm Water			X	
Wastewater		X		
Water			X	
Solid Waste		X		
Public Works: Operations				X
Public Works: Transportation			X	
Public Works: Parking		X		

Source: Adapted from City of Tampa (2006), Table 2-1

Web sites that provide GIS data and use graphic design software like Corel, Adobe packages, or Photoshop. These kinds of users do not report their solutions as GIS practice and do not consider that they are basically manipulating spatial or geographic data.

The survey identified that each department is focused on department-specific tasks without visibility of what other departments have, need, or could use in its own production. This finding led the group to identify an initial important topic: knowledge management. Nevertheless, the group was focused initially on persons and positions in discovering the importance of avoiding private storage areas. Such storage areas are inefficient and use a great deal of memory that very often is lost as soon as people retire or move to other positions. One additional important finding was the role of interoperability among the diverse software currently in use in different platforms. The group promoted true interoperability to enable the city to use the right tool for the job, skipping data transfers and multiple and diverse copies of the same data throughout the entire organization.

One failure of the group was in considering the packages according to their mapping capabilities. In some areas, like Planning, the analysis and query capabilities could be even more important than the pictographic display of maps. One good example is the analysis of fire hydrant protection, according to city rules and the fire marshall. In this case, area and distance calculation capabilities are more important than the graphical display of the radius of buffers around each fire hydrant.

Employees who have been working for the city for many years recognize the existence of hundreds of stove pipe and legacy applications hidden and protected by their users, who do not want to share them or even let people know about their existence. This behavior is a characteristic in some organizations where teamwork is not part of the culture. The city of Tampa has adopted teamwork as one of its core values and is trying to change the work philosophy and attitudes of each employee in an attempt to integrate and improve team efforts.

The Water Department Plan: Crisis and Opportunities

The COTWD has some advantages compared with other departments. Some engineers and technical personnel in this department have advanced knowledge of GIS and skills integrating these capabilities in planning, design, and O&M projects. Since the city has delayed the creation of a GIS position for the COTWD, the engineers will be in charge of the implementation of the GIS Strategic Plan, and the author of this work will have the opportunity to lead the process and to change the planning methodology, showing immediate results and wide acceptance among users. On the other hand, the department has to develop a vulnerability analysis involving safety and emergency situations to be handled only by the department.

The output of the Water Department Plan will follow the general rules of the Citywide Plan. Some fundamental and very basic layers, such as parcels, roads, and fire hydrants, require external maintenance by other departments, such as the Property Appraiser Office and the Zoning and Planning Group, but the most important goal will involve the technical personnel in developing new applications to take advantage of GIS capabilities.

This thesis will be focused on the needs assessment; the implementation of the applications required by users in planning, design, construction, operation, and asset management; and the creation of the water geodatabases and maintenance procedures of specific data layers, based on AutoCad as-builts. The creation of applications in a joint effort with users will develop creativity and enthusiasm and will promote the use of more advanced applications with a good sense of data and information. The design of this plan will be based on the following essential premises:

- contribute to setting up a central GIS relational database
- enhance the current addressing process
- promote and develop contributions to ArcGIS, AutoCAD, and data submissions standards
- develop a utility asset database that is geographically referenced; this may require the development of a plan goal for a citywide GPS system to facilitate spatial referencing

The design has to be done in a way that can adopt easily a central and accurate group of basic layers, for example, city of Tampa parcels, addresses, street centerlines (major roads and roads), building footprints, and rights of way.

After researching GIS practice in the city of Tampa and some of its departments, the author found an important issue that should be addressed in this and all plans: technology acceptance. Technology acceptance is a hidden factor that very often is a big obstacle that is difficult to measure and to handle because nobody wants to recognize it. This hidden factor is closely related with the employees' profiles. In the COTWD, 85 percent of the employees have been working for the city for at least 15 years. Some key employees will retire in the next 4 years, after 30 or 35 years of permanence. Some employees, especially those who have been working many years using their own methods or technologies they have learned and used successfully during many years, are reluctant to adopt new technologies and require a longer time to fully implement and adopt the solutions in their work.

CHAPTER 7

NEEDS ASSESSMENT

Business Processes Analysis

The first step in a GIS study for the COTWD is the identification of critical business processes. A business process is a set of coordinated tasks and activities, conducted by both people and equipment, that will lead to accomplishing a specific organizational goal. Business processes have starting points and ending points, and they are repeatable. In a business process, it is of paramount importance to know the workflow and answer the who, what, and when questions:

- Who are the participants involved in the flow of the business process?
- What is it that the participants do?
- How do participants know when to start? When is the work finished?

A business process begins with a customer's need and ends with a customer's need fulfillment. The customer, in many cases, is the following process, which is the recipient of the previous process outcome. The business process analysis is the first step in the GIS analysis and one of the most important to understanding an organization's business and provide a definition of GIS.

The definition of the business processes within the COTWD was set after a meeting with the director of the department and the leaders of the sections, acting as a project steering committee. A consequent group of interviews was planned after these definitions, with all the people involved directly in each identified process (Table 3).

Table 3. Business Process Interviews

	Description
Date	Date of the interview
Process	Process name
Participants	Staff involved in the interview
Overview	An overview of the entire process divided into defined "steps"
Related process	Related processes that are initiated
Tracking method(s)	Method of uniquely identified data
Tabular data	Tabular data that interact or drive process
Maps	Graphic information used during process
GIS applications needs	Potential GIS applications that would enhance process
GIS data	Potential GIS spatial data that would be necessary for above applications
Interview summary	Summary of process and ability of GIS to play a role in refinement and efficiency gains

This first step helped to identify the business processes, starting and ending points, and the implicit tasks with the responsible people in each step. The second group of interviews is at the task level, with the actors, and highlights information needs. The logical result is the definition of applications to be developed, the GIS functions required, the data needed in the GIS database, and the data maintenance procedures.

The Business Plan for the city of Tampa integrates three fundamental segments:

- development and growth planning
- capital improvement planning
- operation and maintenance using an asset management frame

These segments were selected to face threats in the environment of the city. Following are the external forces that drive the management of the water utilities in the city of Tampa:

- aging infrastructure that shows signs of obsolescence after 70 and more years in operation

- budgeting restrictions
- economic crises in several fundamental areas, including real estate and transportation
- reduced water availability and growing competition for this resource

Top-Level Interviews

The first meeting with top-level management allowed the identification of the key business processes and focused on the related taks for the second group of interviews. The following business processes were determined to be important:

- capital improvement planning
- asset management
- plan review
- water quality
- emergency response
- customer service

Although the objective is to define the GIS- and IS-specific applications and to design a system that meets the requirements of both, it is not an issue of identifying needs within different organizational units, but one of identifying requirements based on business processes that overlap several organizational entities.

The interview of users and potential users help to identify specific GIS/IS needs based on the business process characteristics. The methodology should focus on trying to identify business processes that very often involve cross-functional interaction. Additionally, the interviews help in understanding the whole picture from a systems perspective and the input-output process.

One basic requirement when conducting process interviews is the understanding of the process under analysis. In this specific case, people with knowledge in both fields have a full understanding of the specific and related processes and can identify hidden needs. It has made the work easier than in the case of people with a unique perspective from only the IT field.

Second-Level Interviews

After collecting the results of the first group of interviews, some information products were defined and used for the second group of interviews with the people involved in the different tasks. Tables 4–8 provide descriptions of these information products.

Conclusions

The interviews showed several needs of the users in the different divisions of the COTWD:

1. Users need access to a complete source of water distribution system information that includes attributes about all the assets in the system. Current hard copies or cards make these tasks tedious, time consuming, and full of error.
2. The location of assets should be within a 1-foot accuracy. Design tasks require this level of accuracy.
3. Users have a need to define an effective plan for map updates and physical growth of the distribution system. A basic template should be used by contractors and developers to get approval of their infrastructure projects.

4. Customers' calls and complaints should be coordinated and managed through a GIS application.
5. Emergency plans should have important support from GIS applications. Office and field staff should have the ability to trace the relationship between unexpected events and the rest of the distribution systems and previous similar events in the same area.
6. It is necessary to have a unique geodatabase that supports all the applications and the modeling needs for service planning, fire flow, and what-if analysis during the land use scenario analyses.

Table 4. Information Product 1

	Description
Name	Capital Improvement Plan or Water Master Plan
Required by	Pam Iorio, Major of the City of Tampa; Brad Baird, Director of the Water Department
Description	A CIP is a tool to assess the long-term capital project requirements of a government entity and to establish funding of high-priority projects in a timely and cost-effective fashion.
Map requirements	The document will contain a map showing the spatial location of each one of the projects. The planning horizon is 20 years, but the map will contain the group for every year (i.e., 2009), and the map will show the selected projects for the year. If the projects are grouped, it will be necessary to have one map for each group of projects. The selected scale has to be appropriate to read the name of roads and streets and the alignment of the projects.
Tabular data requirements	The document will contain a list of projects with the respective description like pipe diameter, type of pipe or material, length, cost, project name, CIP identification number, and a prioritization category. It will serve to set up the budget requirements.

Table 4. (continued)

	Description
Text documents	The document will justify the included projects and explanations about how the selected projects fit within the strategic plan and how they will contribute to solving the target problem.
Steps required in making the product	The following chapter will describe extensibly the steps and the use of GIS competence to set up this Master Plan.
Users	director of Water Department; Fire Department; City Commissioners

Table 5. Information Product 2

	Description
Name	Water Quality Map
Required by	technical staff, management staff
Description	Engineers and technicians in charge of water production want to know the spatial distribution of quality throughout the entire distribution network. Water quality is linked to the hydraulic behavior of the physical network and the travel time to the different demand points. Chlorine residuals, fluoride concentration, bacteria sampling counts, turbidity, color, and smell are parameters that measure the quality of the delivered water.
Map requirements	The document will contain a GIS map including the values reported by the SCADA system and sampling points. The map will also show the number of complaints from customers about quality.
Tabular data requirements	This application will have the ability to report, in a spreadsheet format, the data of water quality in the area during the last year and the actions taken to solves issues.
Text documents	The document will justify the asset replacement projects and will contain descriptions of proposed assets to be discarded and recommend new enhancements of the system.
Steps required in making the product	The following chapter will describe extensibly the steps and the use of GIS competence to set up this Asset Management Plan.
Users	director of Water Department; Finance Department; city commissioners; mayor of the city, management staff

Table 6. Information Product 3

	Description
Name	Asset Infrastructure Performance
Required by	technical staff, management staff
Description	Engineers and technicians in charge of water distribution and the management staff want to know the distribution of the main problems in the distribution network. A monthly map-based report should show the breaks, failures, and related incidents affecting the hydraulic performance of the distribution system. Emergency situations can demand quick reports in specific areas or specific water mains.
Map requirements	The document is basically a GIS map displaying the monthly incidents and failure incidents with respective categories. Pressure data from the SCADA system, water main failures, and customer complaints about pressure will be added to this report as well.
Tabular data requirements	The application can report costs of maintenance activities.
Text documents	The document will justify the asset replacement projects and will contain descriptions of proposed assets to be discarded and recommend new enhancements of the system.
Steps required in making the product	The following chapter will describe extensibly the steps and the use of GIS competence to set up this Asset Management Plan.
Users	director of Water Department; Finance Department; city commissioners; mayor of the city, management staff

Table 7. Information Product 4

	Description
Name	Fire Hydrants Report
Required by	technical staff, management staff
Description	Fire hydrants are one of the most important components of the distribution system and city managers and citizens wants to know the degree of protection of the fire hydrant system. City managers want to be sure that in case of fire events or disasters, the fire hydrants enabled to face them. Insurance rates are linked to the degree of protection against fire in each zone in the city.
Map requirements	The report will show the fire hydrant installation program, the current protection, and the fire flow test results in each fire hydrant.

Table 7. (continued)

	Description
Tabular data requirements	Technical description of specific fire hydrants or groups of fire hydrants in a specific spatial unit. Maintenance records and results of fire flow tests.
Text documents	No text documents
Steps required in making the product	The following chapter will describe extensibly the steps and the use of GIS competence to set up this Asset Management Plan.
Users	director of Water Department; Finance Department; city commissioners; mayor of the city, management staff

Table 8. Information Product 5

	Description
Name	Customer Service Application
Required by	technical staff, management staff
Description	All the calls from customers about complaints have to be linked to spatial locations. The application will store the call, the type of complaint, and will allow the manager to follow the problem and to analyze the issue from a regional perspective.
Map requirements	The document is basically a GIS map displaying the monthly calls and their respective nomination.
Tabular data requirements	The document will contain a list of calls classified according the type of complaint, the geographic location, date, and time.
Text documents	No text document
Steps required in making the product	The following chapter will describe extensibly the steps and the use of GIS competence to set up this Asset Management Plan.
Users	director of Water Department; Finance Department; city commissioners; mayor of the city, management staff

CHAPTER 8

GIS PLAN

After defining the information products, it was clear that GIS could support all the businesses processes and related tasks in the COTWD, and they can be the hub of all the information for an effective management of the distribution system. Figure 14 illustrates the roles of GIS in the cycle and sequence of those processes.

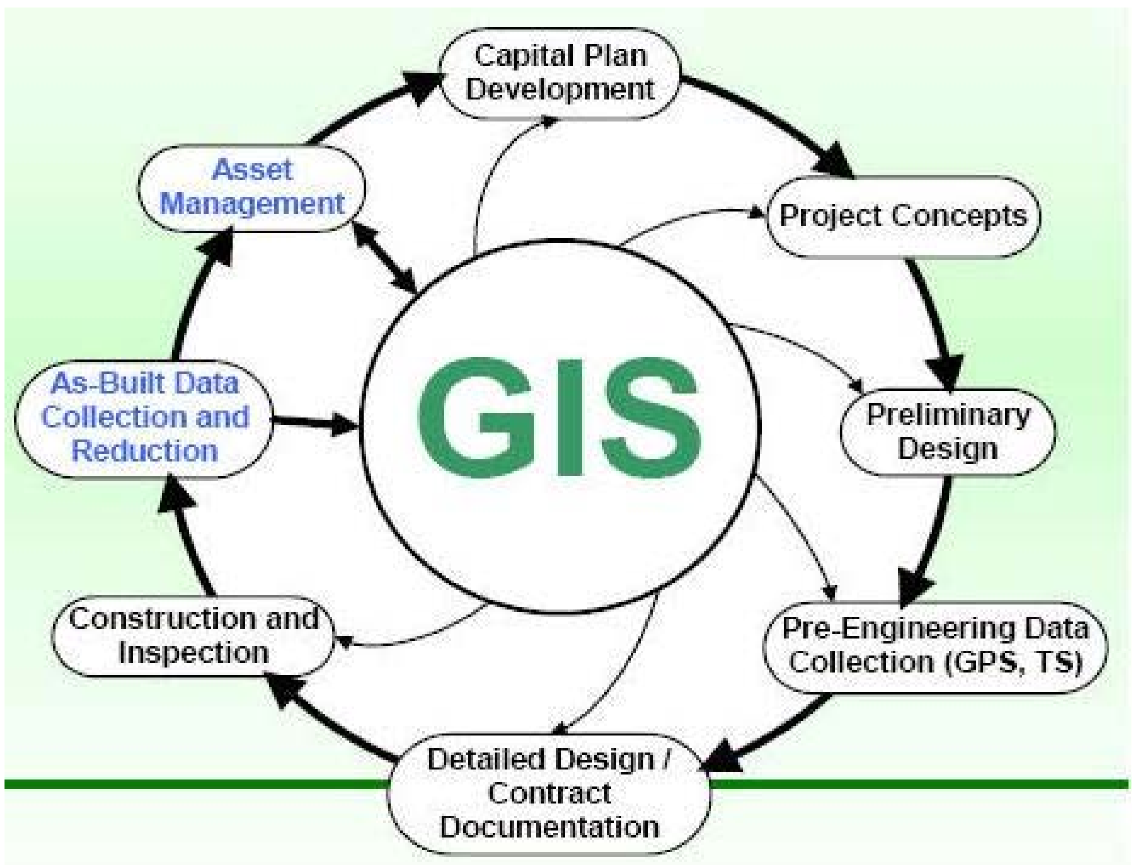


Figure 14. Role of GIS in COTWD Business Processes (Walter A. 2007)

The Geodatabase

The COTWD GIS geodatabase will be created from multiple sources of existing data and maps. This is a dynamic and parallel process: the permanent new developments and the existing asset digitization load into the geodatabase. The flowchart in the Figure 15 provides an illustration of the different data streams, including the external sources and the permanent internal processes (see Figure 16 and Figure 17 for the CAD and GIS data flow, respectively). The Master GIS is the base for many information products already identified and requested by users. One important consideration is the hyperlink with the as-built imagery for engineering details.

Quality Control in the Internal Processes

The following rules outline the quality control efforts to be conducted as part of the project:

- The storage of all files will use a strict directory structure to maintain consistency and to ensure repeatability.
- Progress will be tracked in the TRS field located in the geodatabase.
- A data dictionary will be set up to ensure standardized values and adherence to unique values. A common error in previous databases is the existence of many pipe diameters because of the existence of nominal and real diameters.
- Pipe diameter values will be compared against a predetermined list of diameters (i.e., 4, 6, 8, 10, 12, etc.) and examined when the technical specifications provides different values.

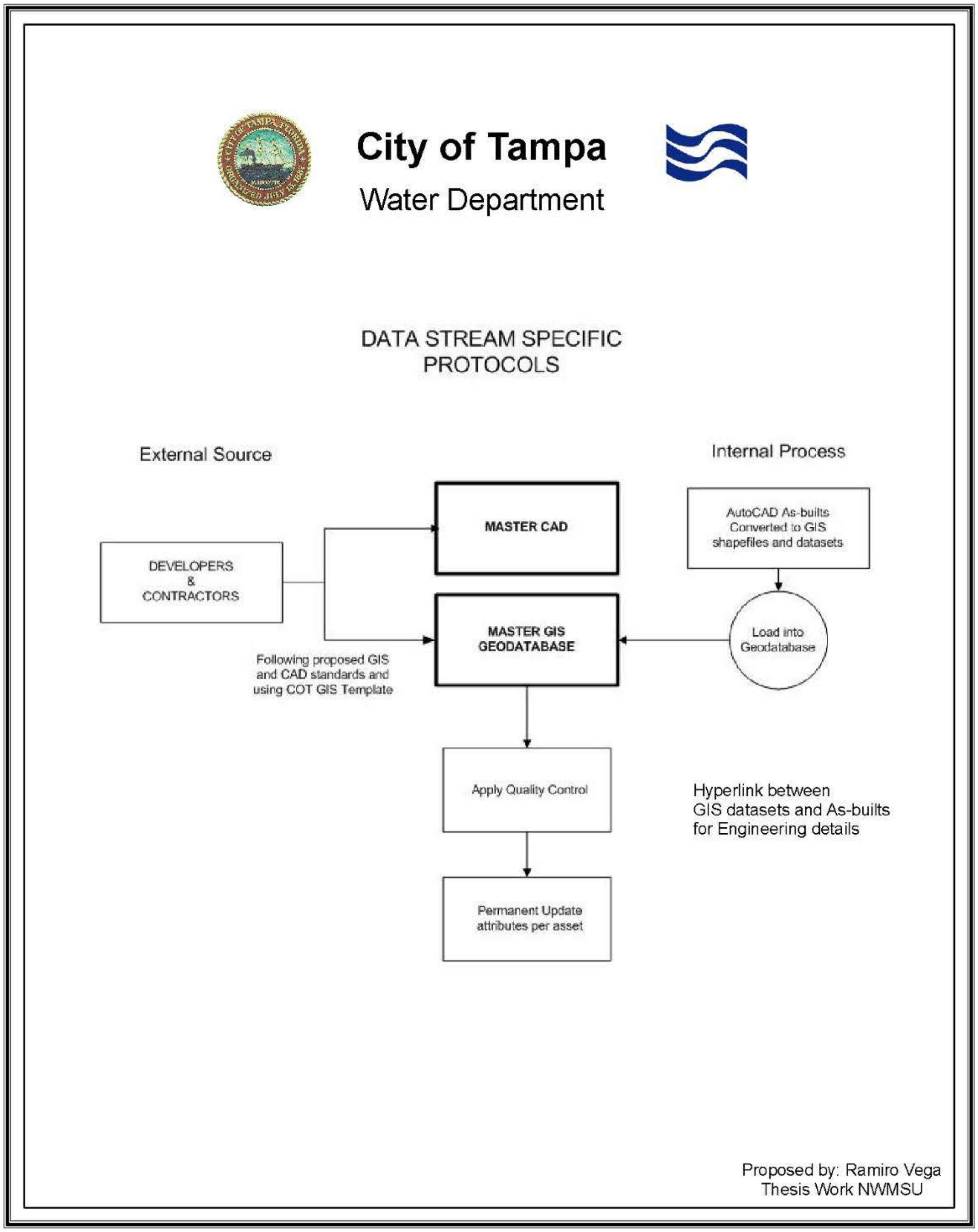


Figure 15. Data Stream Protocols

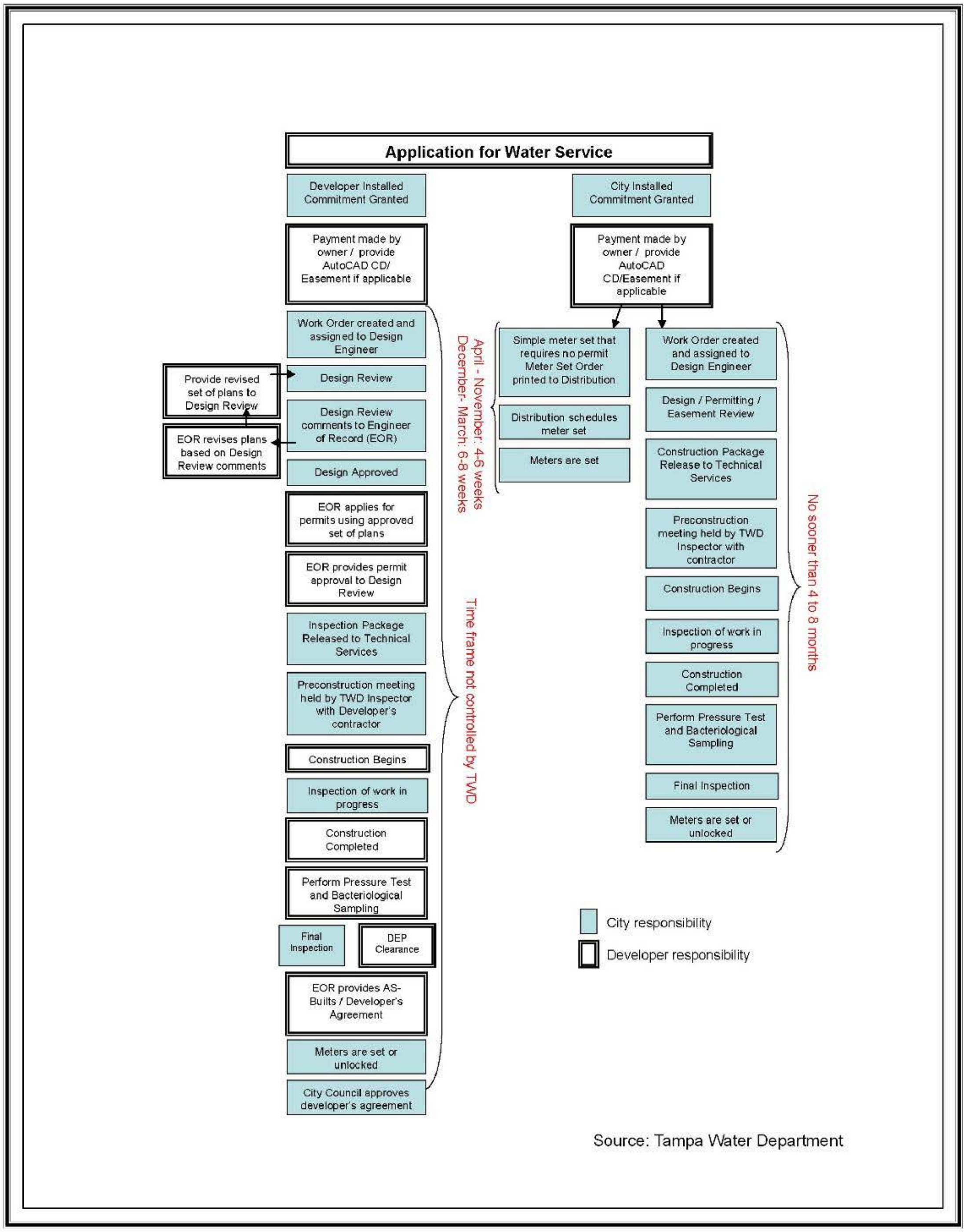


Figure 16. CAD Data Flow

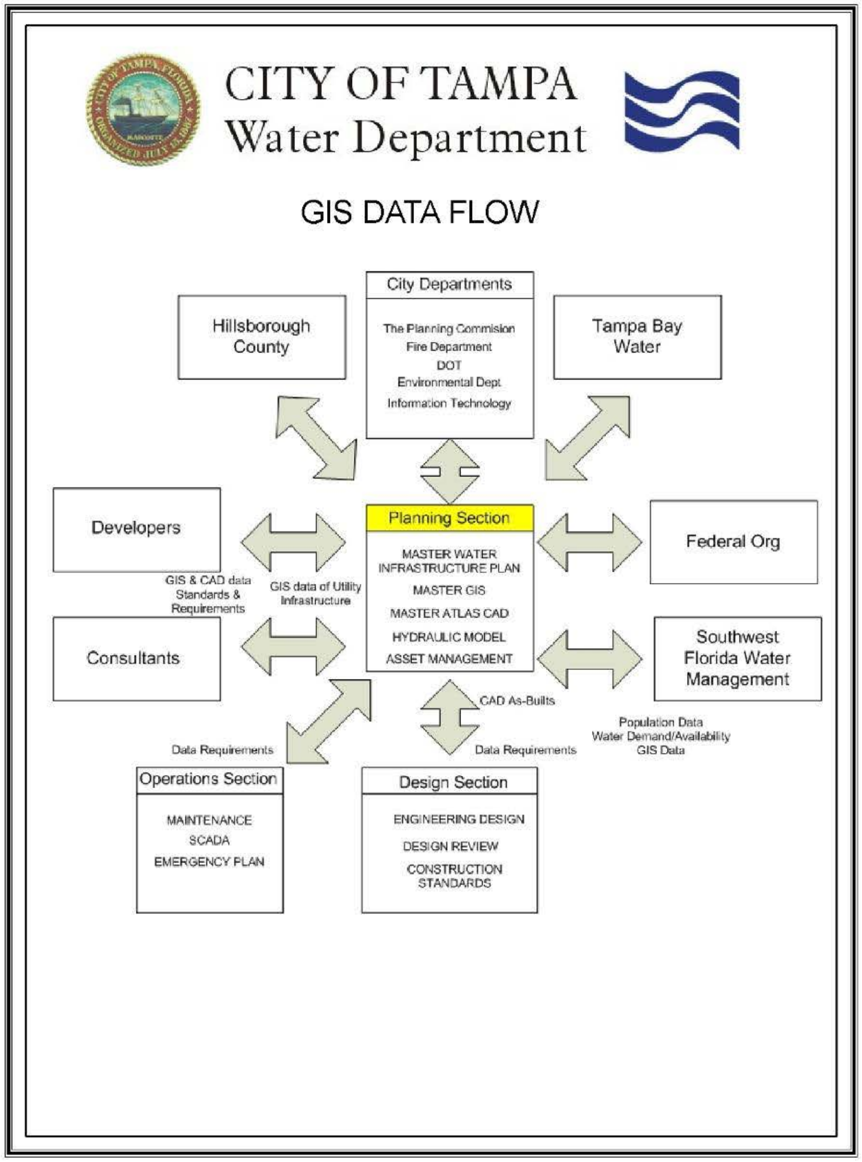


Figure 17. GIS Data Flow

- New assets, for example, corpstop on double detector check valves, need to have the as-built and work order number populated from the surrounding assets.

The Spatial Unit of Analysis

The city of Tampa has been storing CAD data of the sections for many years. That is good reference and helps in manipulating information into an appropriate size and scale for many projects.

The Public Land Survey System is a legal land reference system created to facilitate the inventory and transfer of property. This system is divided into township, range, and sections and is usually referred to as TRS (Figure 18).

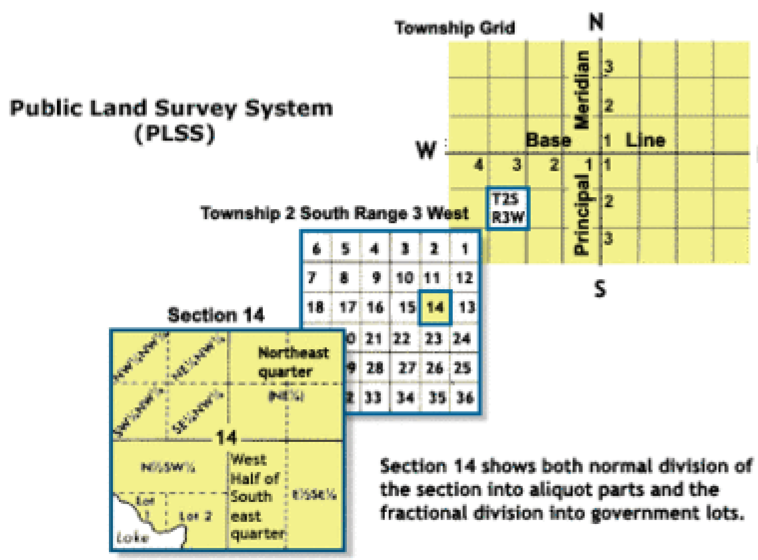


Figure 18. The Public Land Survey System (National Atlas 2007)

For all the purposes in the GIS design, the section has a special reference, and many of the reports are based on this spatial unit. Each one of these sections is an approximate 1 square mile on each side. There are TRS sections and section quarters. Figure 19 shows the section grid in the Tampa service area.

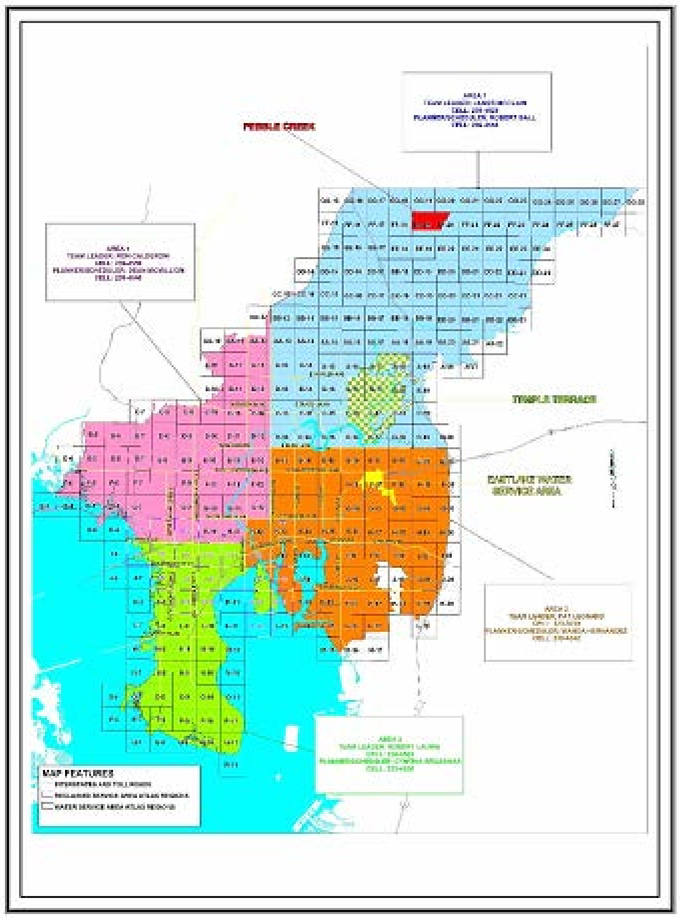


Figure 19. The TRS Land System in the City of Tampa Service Area

GIS-Based Cartography: The Map Book

For all the GIS users in the COTWD, the first information reference is the Atlas T-R Sections. The CAD imagery and the GIS base maps are based on that grid. The first step is the creation of the map book to simplify the search of data in the geographic zone of the city of Tampa. The map book is a multipage document based on a data set or group of data sets and an index grid representing the pages (Shepard *et al*. 2002). This application is the first response to the users' needs in the COTWD.

This utility automates map production and allows the user to print or export any or all of the pages in a map book. It also contains some tools for getting the maps out, both as hard-copy plots and digital graphic files. In addition, the utility allows printing and exporting of a single page, a set of pages, or the entire series.

In the case of Tampa, the index grid contains 304 sections, and very often, it is not easy to locate each section. The utility provides easy and quick access. The index grid/layer must contain polygon features with a string field containing the name of each tile/page.

All the needed elements to develop the map book were downloaded from the Samples > ArcMap > Map Production folder at the Arconline Web site. The map book developer consists of two Visual Basic (VBA) projects and documentation on installation and use. The first project (DSMapBookPrj.vbp) includes the code for MapBook, MapSeries, and MapPage objects used within the second project (DSMapBookUIPrj.vbp). Basically, the map book application is an extension to ArcMap and the MapBook, MapSeries, and MapPage objects can be obtained from the extension.

This provides the user with the possibility of writing additional code using VBA to manipulate objects that fit his or her needs.

The Toolbar

The options in the toolbar include the following:

- create map book
- add identifier frame
- create/update map grids
- create stripmap grids

The index grid polygon shapefile is based on the TRS Florida Land System, and it is a square polygon of a mile on each side, approximately. The index grid is the same for all departments in the city, and it helps to analyze information coming from different sources. A common case is the pavement plan and resurfacing projects within the city. GIS and the grid-based organization of data allow the departments to consult the cleared projects for every year and avoid water, wastewater, and reclaimed water projects in areas recently paved or to coordinate the projects and schedule their simultaneous execution, saving time, funds, and inconveniences for the neighborhoods. The layout of the application (Figures 20 and 21) was designed following the specifications of the COTWD for this kind of map, and it has some elements that change depending on the date of the printing or the page to be printed.

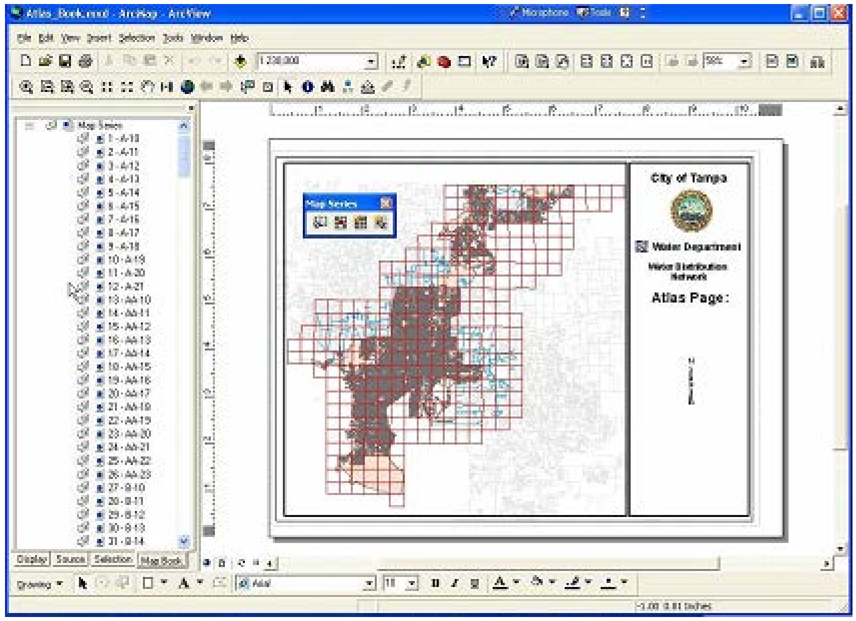


Figure 20. City of Tampa Service Area Map Book

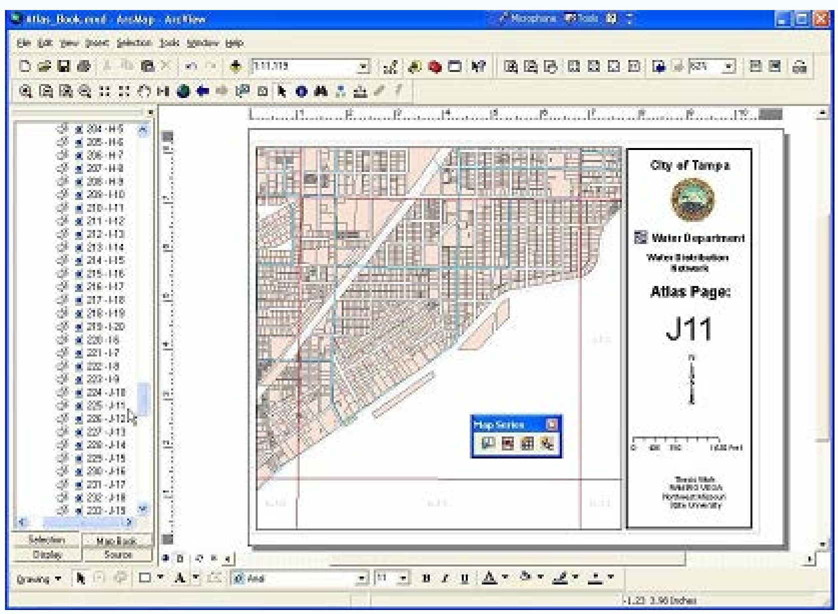


Figure 21. City of Tampa Map Book: Cell Location

The items that can be updated on a page-by-page basis are the following:

- Date: will be updated to the current date each time a page is generated
- Title: will be updated to the name of the page when the page is generated
- Extra item: will be updated based on the value in the specified field from the index layer
- Identifier (local and global): show the position of the page being shown in relation to the other page/tiles

One interesting option was added to the MapBook code: the ability to create an index for the features in the databases (i.e., a street index). The toolbar provides the alternative of creating a series index from the map series context menu.

The group of files downloaded from the ArcUser Web site contains a doc file that explains the details of map book generation. The ESRI Web site contains many contributions, enhancing and adding some tools to this utility.

Benefits for the Water Department

The simultaneous analysis of projects within the department and outside the department is enhanced with this utility. Some specific areas (i.e., New Tampa Development Area) can use a different index grid with 0.25-mile squares. This possibility provides more detail and allows engineers to focus on specific regions with complex issues.

It is possible to have one application for each size of the maps according to the requirements of each user. From letter size to 44 × 36 inches, sizes can be trimmed according to specific requirements.

Collection and Reduction of GIS and CAD Data

Regional Strategy

The counties located in the State Plane Coordinates FIP Zone 0902 have been proposing a common system to capture GIS data and make it compatible. In many cases, the water utilities overlap the political divisions, and the water management overcomes the cities' and counties' limits. Another good reason is the fact that many consultant companies work for the same counties in this region, and the manipulation of GIS data in different systems makes it a task prone to error and confusion. This zone is almost the same as the SWFWMD.

Figure 22 shows the counties within the zone 0902. That zone is defined by the State Plane Coordinate System and is appropriate for engineering projects within the area. On the other hand, this projection is enforced by Florida state law. The proposed application tries to follow some recommendations from the group that promotes the standards and templates to capture GIS data in the West Zone. Pinellas County, Pasco County, and Polk County are currently implementing their standard GIS templates to facilitate the flow of spatial data coming from developers and external consultants.

It is necessary to get some enforcement to use this format because for some small companies, it could be an additional cost, but the advantage of having the same template for the counties in the region has helped in the adoption of the system. In some cases, the level of accuracy requires advanced GPS equipment, but in the future, a proposed GPS regional system can overcome that issue.

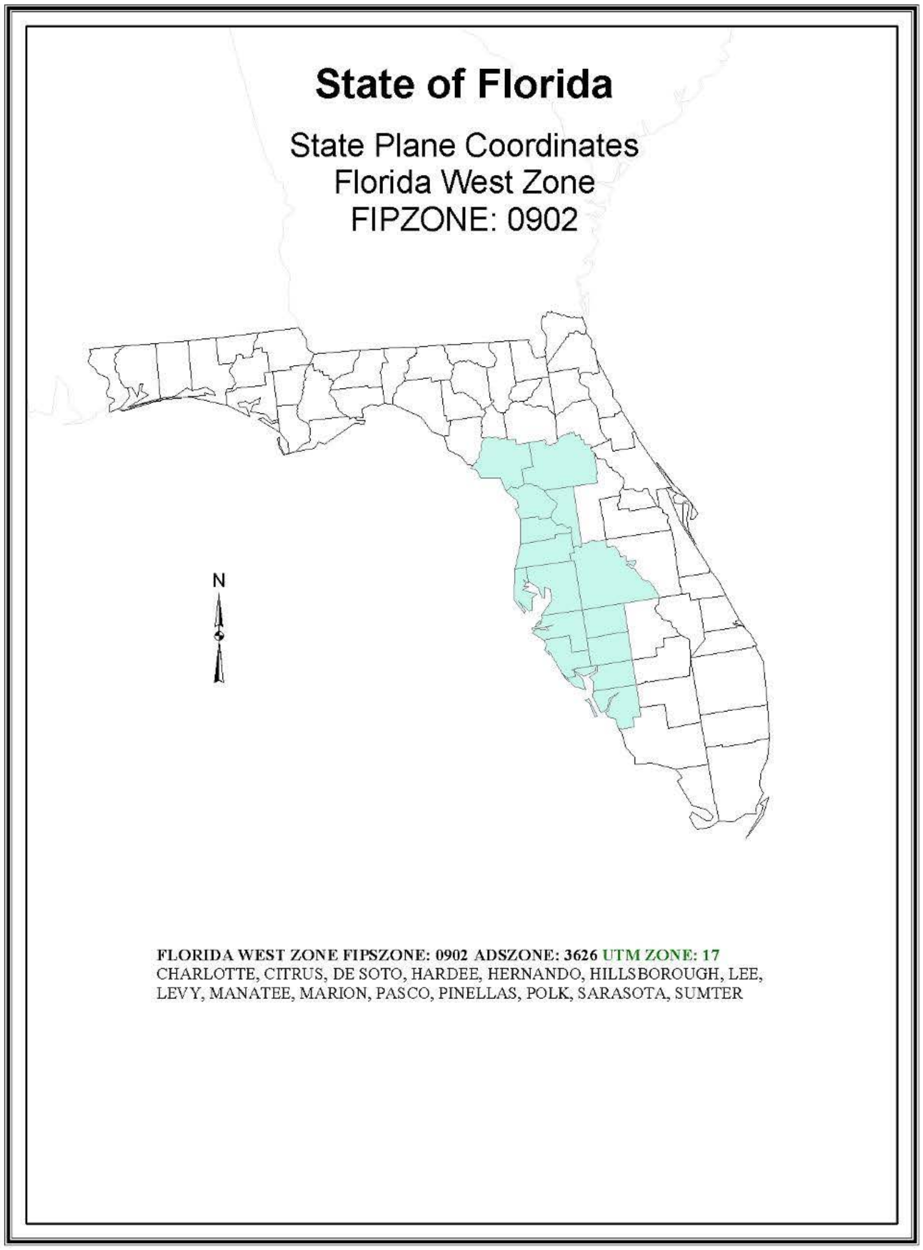


Figure 22. State Plane Coordinates: West Zone

GIS Standard for External Source of Data

Any process resulting in a change to the municipal water distribution infrastructure needs to be recorded in GIS. In the COTWD, the Planning section leads the GIS flow process. GIS and CAD data are closely related, and therefore this proposal includes the design of

- GIS and CAD Records Standards and Requirements
- GIS Water Infrastructure Template

Every contractor or developer will have to meet the proposed requirements for GIS and CAD data and use the city of Tampa GIS Template prior to acceptance of the utility infrastructure project or contract.

The turnover of utility infrastructure should not be possible without the full observance of these guidelines. A regional goal for the Tampa Bay counties is to adopt the same kind of standards to facilitate the flow of data in the common areas or in future projects. The objective is to use standardized guidelines and templates within the NAD 1983 Florida State Plane, West Zone, U.S. Foot and the Southwest Florida Management District authority.

Proposed Digital Requirements

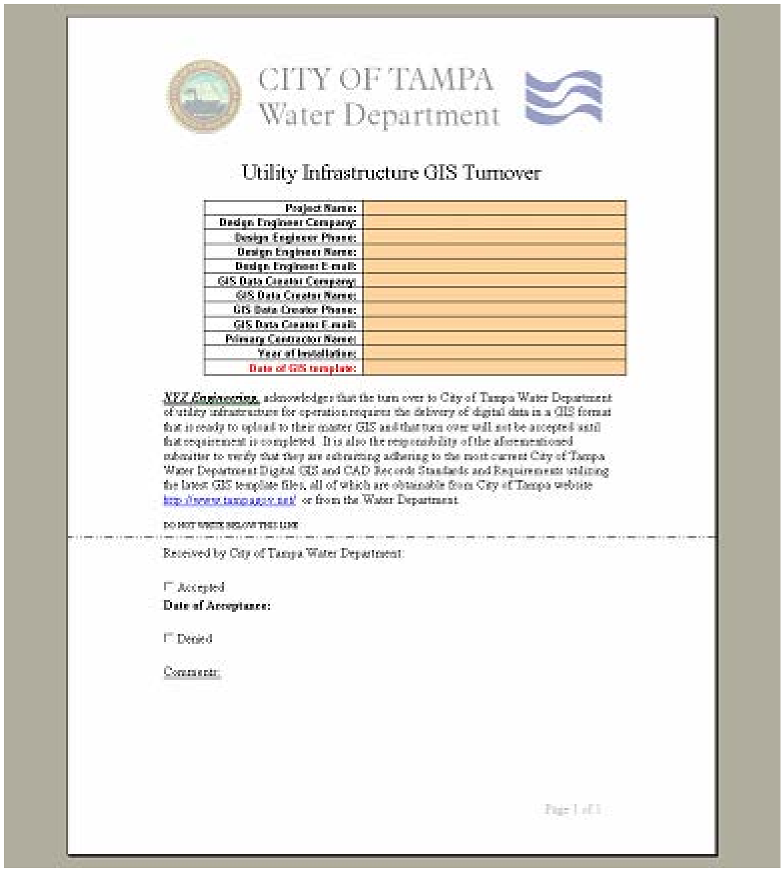
Prior to acceptance of the utility portions of the project by the COTWD, the developer or engineering firm must submit respective GIS data to COTWD, created using the COTWD template and ready to upload to the COTWD Master GIS without additional manipulation or data entry. These files shall meet the criteria as described in this document.

The files to be submitted on a CD-ROM are to include the Utility Infrastructure GIS turnover document, shown in Figure 23, with the engineer or company's name entered in place of XYZ Engineering as acceptance of the disclaimer listed; the ESRI template map document (.mxd) used to capture the GIS features; the personal geodatabase (.mdb) associated with the aforementioned map document; and the CAD files(s) as outlined in the City of Tampa Standards. The GIS software package employed by COTWD is ESRI's ArcGIS 9.2 and Microsoft SQL Server. Autodesk Map and Microsoft Access are also used to capture data to be uploaded into the GIS. The accepted format for GIS submittals is an ESRI personal geodatabase. This will smooth the progress of uploading to the Master GIS managed by COTWD.

Data are to be set in the coordinate system known as NAD 1983 Florida State Plane, West Zone, U.S. Foot (FPS 0902). This coordinate system will be set in the personal geodatabase and digital CAD files delivered. Vertical elevations will be NGVD 29 Datum. The provided GIS template already has the correct coordinate system set.

The GIS data have to agree with the information depicted on the record drawings. The project will not be accepted until the record drawings or GIS data are corrected. The warranty deed/bill of sale and any easement legal descriptions and documentation must also match what is submitted in the GIS turnover package.

The provided template contains the features of individual components to be uploaded:



CITY OF TAMPA
Water Department

Utility Infrastructure GIS Turnover

Project Name:	
Design Engineer Company:	
Design Engineer Phone:	
Design Engineer Name:	
Design Engineer E-mail:	
GIS Data Creator Company:	
GIS Data Creator Name:	
GIS Data Creator Phone:	
GIS Data Creator E-mail:	
Primary Contractor Name:	
Year of Installation:	
Date of GIS template:	

XYZ Engineering, acknowledges that the turn over to City of Tampa Water Department of utility infrastructure for operation requires the delivery of digital data in a GIS format that is ready to upload to their master GIS and that turn over will not be accepted until that requirement is completed. It is also the responsibility of the aforementioned submitter to verify that they are submitting adhering to the most current City of Tampa Water Department Digital GIS and CAD Records Standards and Requirements utilizing the latest GIS template files, all of which are obtainable from City of Tampa website http://www.tampagov.net/ or from the Water Department.

DO NOT WRITE BELOW THIS LINE

Received by City of Tampa Water Department:

☐ Accepted

Date of Acceptance:

☐ Denied

Comments:

Page 1 of 1

Figure 23. GIS Infrastructure Data Turnover Document

- water mains (potable, raw, fire, hydrant, service)
- valves (gate, air release valve [ARV], blowoff, DCCV backflow devices)
- hydrants
- fittings (tees, crosses, elbows, etc.)

The hydrant shutoff valve is to be drafted separately.

A water service is the line that connects the water main to the water meter and is usually of a smaller diameter than the water main. Easements are to be captured as polygon features. IT has to include the public easement in the respective feature class included in the geodatabase template to accommodate this. Users should use the termination easement if an existing city of Tampa easement (or portion thereof) is to be terminated, as in the case of approved road vacation. When capturing the public utility easement, it is necessary to capture only the buffer (usually 10 feet) outside of the ROW. The as-built CAD file used to create the GIS data is also required to be submitted with all layers, including existing utilities. This file must be georeferenced into the correct coordinate system. GIS data to be uploaded are to include only new construction. Care should be taken to exclude any existing facilities from this data set so as not to duplicate information in the GIS system.

If existing infrastructure is to be modified and not replaced (e.g., replacing an undersized water main), users do not need to capture those features. COTWD will make the modifications to existing GIS features as needed. It is necessary to capture up to and including the backflow preventor for service 2″ and smaller. For service larger than 2′, it is not necessary to capture the backflow device since they are customer owned.

For fire systems, COTWD only owns up to and including the first line gate valve. Any line, backflow, or hydraulic device past this point is not maintained by the COTWD; therefore they do not need to be captured in the GIS, and no easement is required for said features. However, these features must be in the submitted CAD file(s).

Submittals Using an Environmental Systems Research Institute Personal Geodatabase

Components to be uploaded will be segregated into feature classes to include only the features for that component. Not all feature classes will apply to all projects. Exact name matching is required for proper functionality. These layers are set in the template provided by COTWD:

1. **wControlValve** (water control valves; ARV, blowoff, backflow, check, etc.)
2. **wHydrant** (subtypes are the different hydrant manufacturers)
3. **wLateralLine** (fire, hydrant, water service)
4. **wPressurizedMain** (raw, potable)
5. **wSystemValve** (water system valves: gate [in-line, service, hydrant, fire], butterfly)
6. **easements** (polygon feature class)
7. **wFitting** (tees, elbows, cross, reducer, coupling [sleeve])

The following data sets are provided as a reference and help to locate projects quickly or to request Atlas CAD files in the area of the project, but they are not to be modified by the users:

- COT Parcel
- Atlas Sections
- Streets

ArcGIS data shall be created for the utility line segments and associated components by using the Edit Tools created by ESRI using the appropriate ArcGIS license. All line work and objects are to be created using snapping commands, ensuring proper joining to the features. Objects inserted as valves, hydrants, and so on, will be snapped to the appropriate endpoint.

Lines will end in a change in pipe size or pipe class. Lines should be broken at all tees and crosses, including hydrant tees, but not water taps and wyes. It is not necessary to break lines at ARV locations. The intent is to be able to identify on the GIS system line segments between valves, different pipe sizes, and pipe materials.

If a water main line is case and there is no change in size, material, or pipe class, it is not necessary to break the lines; however, note the casing and its attributes in the comments field of the associated line feature (length, material, size, alignment). Although it is not necessary to draft casings as a separate feature, it is necessary to set the casing field to true for cased line features. The submerged type field of the water main will be used to note jacks and bores or directional drills. The crossing type has been added to denote aerial or submerged line features. Lines under rivers, canals, or water bodies will be noted differently than those along a bridge above the waterway.

Where water mains are not broken at ARVs and service lateral taps, add a vertice to the main at that intersection of features. That applies to the water services that intersect one another.

ARVs are to be drafted on the associated water main or force main. If the ARV is actually off of the associated main by *x* feet in *y* direction, still capture the ARV at the point of connection on the main, adding a vertice at said connection point. At this point of connection, denote in the comments field where the actual ARV is located. It is strongly recommended not to draft the ARV off of the associated main with a connecting line segment.

The geodatabase is a MS Access file, and that means that it is possible to edit the data outside of the ArcGIS application using Microsoft Access, but this practice is likely to cause problems that users should avoid. Users are advised not to change fields, subtypes, or domains of the geodatabase.

The only metadata required along with the digital files is that contained in the MS Word file Utility Infrastructure GIS Turnover. That file will be used to track the review status and house comments by the GIS department. Users are allowed to rename the .mxd and. .mdb files to their specific project's name so that it is easier to track files and verify the correct .mdb files are the source data for the correct .mxd. It is recommended not to use previous project's files and rename them and to start always with a blank copy of the template from the Web site or one stored in a specific location.

The provided .mxd template is installed in a folder and has been addressed with relative notation. In that way, when the user opens the .mxd template, it will have the right link to the Atlas section and Landuse data set, and the graphical display will act properly as the interface to the geodatabase. This practice avoids repair tasks to specify the right source of each data set.

ArcGIS software allows users to add AutoCAD data as a background or base reference. Simply by using the add button, the CAD file will display in the area of the project in the base map of the template. If the CAD file has been properly georeferenced, it will fit in the right location. The streets, the parcels, and the sections in the template map help with correctness of the project location.

Figures 24 and 25 show the base map of the template before and after adding the water project in the BB-18 section. The Atlas map is composed of one CAD file for each section, as shown in Figure XX.

Snapping

Point Feature layers need to have the vertex selected in the snapping option. This option is in the Editor pull-down menu. Line and polygon features can be snapped at the

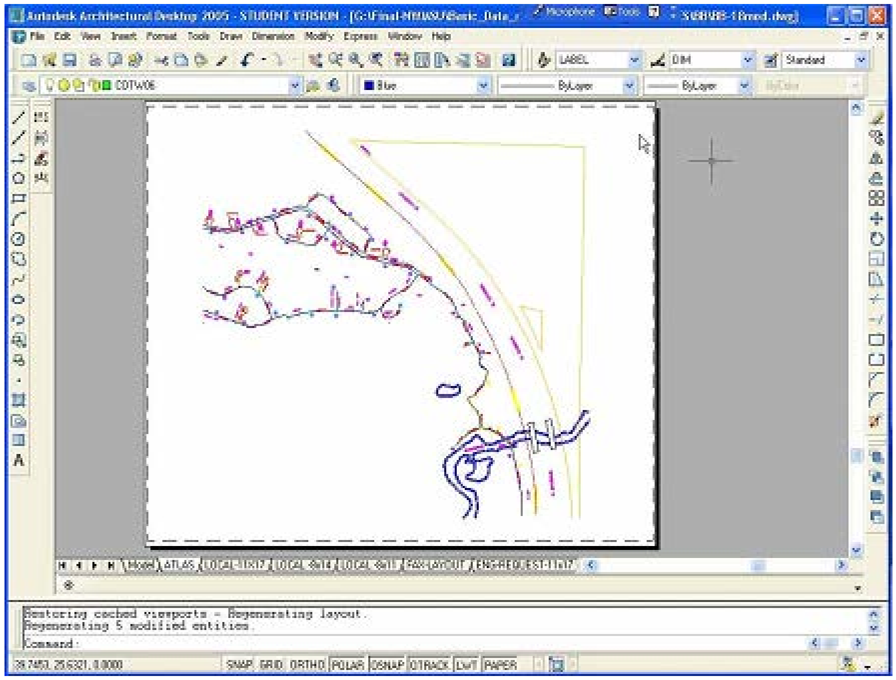


Figure 24. Geodatabase Template: A Project Example CAD File from the Developer

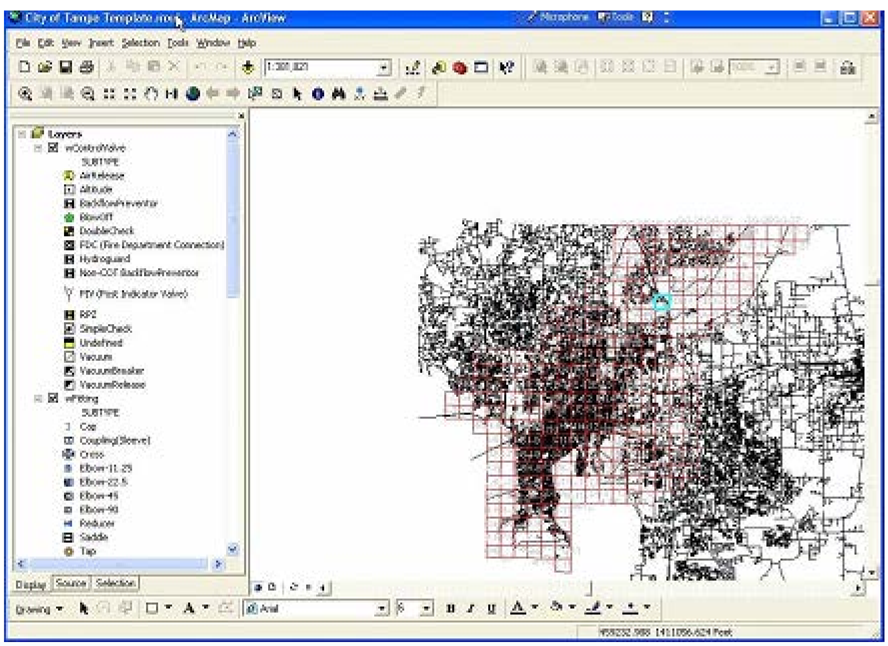


Figure 25. Geodatabase Template: Location of the Project

edge, endpoints, and vertices. The order of the layers in the snapping window sets the snapping preference. Snapping can be suspended at any time by holding down the space bar.

Required Fields

Some of the fields have a default value to facilitate work in preparing GIS turnover files. The user can change the default values in the template as necessary and depending on the most frequent values. Users do not need to populate the latitude and longitude fields (decimal degrees and degrees, minutes, seconds). These fields will be populated automatically with already set VBA scripts.

Users do not need to populate fields when the value is not known. The database operation is enhanced leaving the null value, instead of zero. Those features with the field "Year Installed" use the year that the utility infrastructure is incorporated into the city of Tampa system.

Positional Accuracy

This field has the options shown in Figure 26:

Aligned to orthophotography. This is not a real option since new infrastructure cannot yet be seen on current orthophotography. It is used in-house to correct older infrastructure, depending on the quality and resolution of the orthophotos.

Digitized. It is not used anymore with the current modern technology.

Estimated. It is an approximate value of a feature location.

Field Measurement from ROW or EOP. Users measure directly in the field using conventional surveying equipment and without a surveyor license.

Value	Label
<all other values>	<all other values>
<Heading>	**Positional Accuracy**
8	Aligned to orthophotography
6	Digitized
7	Estimated
3	Field measurement from ROW or EOP
9	From Legal Description
1	GPS sub-cm survey
2	GPS sub-m survey
-1	Other
4	Referenced from record drawing or as-built
5	Traced from digital CAD file
0	Unknown

Figure 26. Positional Accuracy Options

From legal description. The polygon of an easement can be derived from an actual legal description following the legal requirements for that type of description.

GPS sub-cm survey. This is the case when a licensed surveyor has certified the data to this level. These are the most accurate data.

GPS sub-m survey. Using good GPS handheld units, users can get accurate data without involving a licensed surveyor. This is the second level of accuracy.

Referenced from record drawing or as-built. This means using a plan set and trying to duplicate the data manually without the help of a CAD file. This option is a little better than estimating.

Traced from digital CAD file. This is the most frequent case when GPS equipment is not available. In this case, the GIS data are created using CAD data as a background or copying and pasting the added CAD drawing features like lines, points, and so on.

Other. User adopted another method not listed in the options.

Unknown. The user does not have an idea about the accuracy level. An educated estimate could replace this option.

Status

All the utilities should be **Active** when turned over to COTWD (Figure 23). This is the default option; however, it includes **Proposed** and **Removed.**

The structure of the geodatabase (Figure 27) was defined taking into account the needs of the users of each application based on this database. In this case, the most important elements were considered, and specific rules about their location and about their visual display were presented.

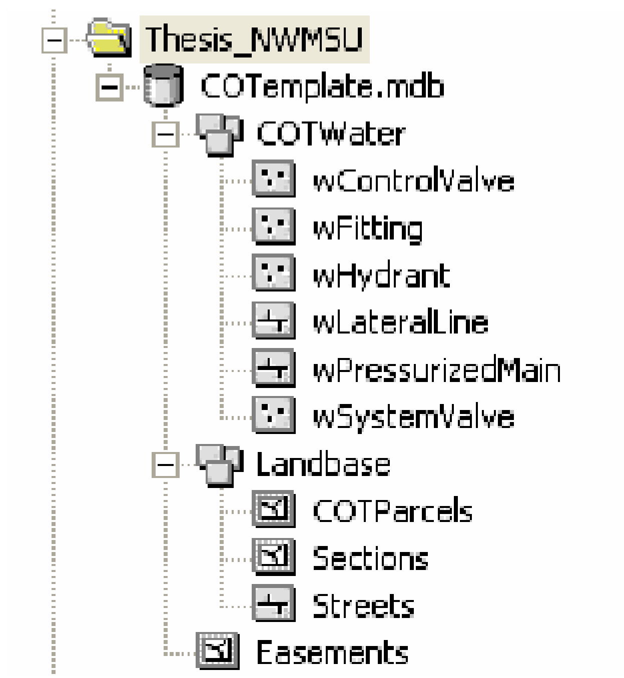


Figure 27. Geodatabase Structure

Figure 28 is the display of the template, and the external user only has to edit each type or subtype, depending on the project. The street layer and the parcels are updated by entities outside the COTWD. Figures 29–35 show the table of attributes and the description of all the files included in the template used by the external sources of GIS data. This is basically the same structure as the Master GIS geodatabase, and the updating process is smooth and simple.

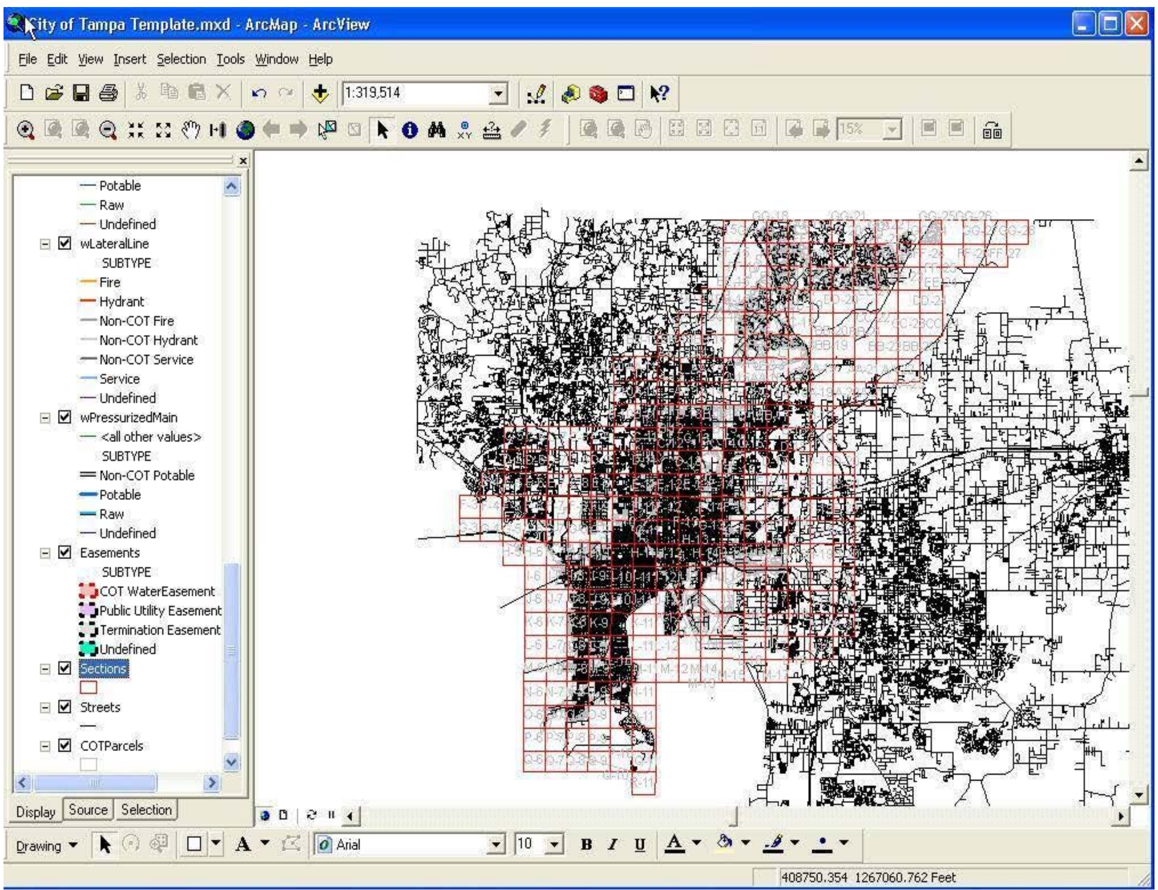


Figure 28. Geodatabase Template

Name	Alias	Type	Length	Precision	Scale	Number Format
OBJECTID	OBJECTID	Object ID	4	0	0	
Shape	Shape	Point				
YEARINSTALLED	Year Installed	Long	4	0	0	Numeric
SUBTYPE	Subtype	Long	4	0	0	Numeric
POSITIONALACCURA...	Positional Accuracy	Long	4	0	0	Numeric
COMMENTS	Comments	Text	255	0	0	
INSTALLEDCOST	Installed Cost (EA)	Double	8	0	0	Numeric
DIAMETER	)	Long	4	0	0	Numeric
MODEL	Model #	Text	25	0	0	
MANUFACTURER	Manufacturer	Text	5	0	0	
X_DD	)	Double	8	0	0	Numeric
Y_DD	)	Double	8	0	0	Numeric
X_DMS	Longitude (DMS)	Text	20	0	0	
Y_DMS	Latitude (DMS)	Text	20	0	0	
SOURCEDATA	Source Data	Text	25	0	0	
POINT_X	State Plane X	Double	8	0	0	Numeric
POINT_Y	State Plane Y	Double	8	0	0	Numeric

Symbol	Value	Label	Count
	<all other valu	<all other values>	
	<Heading>	**SUBTYPE**	
	1	AirRelease	?
	2	Altitude	?
	3	BackflowPreventor	?
	5	BlowOff	?
	4	DoubleCheck	?
	16	FDC (Fire Department Connection)	?
	6	Hydroguard	?
	12	Non-COT BackflowPreventor	?
	17	PIV (Post Indicator Valve)	?
	7	RPZ	?
	8	SimpleCheck	?
	0	Undefined	?
	9	Vacuum	?
	10	VacuumBreaker	?
	11	VacuumRelease	?

Figure 29. Geodatabase Template: System Valve

Name	Alias	Type	Length	Precision	Scale	Number Format	
OBJECTID	OBJECTID	Object ID	4	0	0		
Shape	Shape	Line					
YEARINSTALLED	Year Installed	Long	4	0	0	Numeric	...
SUBTYPE	Subtype	Long	4	0	0	Numeric	...
MATERIAL	Material	Text	10	0	0		
POSITIONALACCUR...	Positional Accuracy	Long	4	0	0	Numeric	...
COMMENTS	Comments	Text	255	0	0		
INSTALLEDCOST	Installed Cost	Double	8	0	0	Numeric	...
DIAMETER	)	Long	4	0	0	Numeric	...
SIZEDIMENSIONRA...	Size Dimension R...	Text	10	0	0		
RECORDEDLENGTH	Recorded Length...	Double	8	0	0	Numeric	...
PRESSURERATING	Pressure Rating	Text	20	0	0		
DEPTH60	Deeper than 60"?	Short	2	0	0	Numeric	...
SOURCEDATA	Source Data	Text	25	0	0		
CASING	Casing?	Short	2	0	0	Numeric	...
Shape_Length	Shape_Length	Double	8	0	0	Numeric	...

Symbol	Value	Label
	<all other values>	<all other values>
	<Heading>	**SUBTYPE**
	2	Fire
	3	Hydrant
	5	Non-COT Fire
	6	Non-COT Hydrant
	4	Non-COT Service
	1	Service
	0	Undefined

Figure 30. Geodatabase Template: Lateral Line

Name	Alias	Type	Length	Precisi...	Scale	Number Format	
OBJECTID	OBJECTID	Object ID	4	0	0		
Shape	Shape	Line					
YEARINSTALLED	Year Installed	Long	4	0	0	Numeric	...
SUBTYPE	Subtype	Long	4	0	0	Numeric	...
MATERIAL	Material	Text	10	0	0		
POSITIONALACCU...	Positional Accuracy	Long	4	0	0	Numeric	...
COMMENTS	Comments	Text	255	0	0		
INSTALLEDCOST	Installed Cost (LF)	Double	8	0	0	Numeric	...
DIAMETER	)	Long	4	0	0	Numeric	...
SIZEDIMENSIONR...	Size Dimension Ratio	Text	10	0	0		
RECORDEDLENG...	Recorded Length (FT)	Double	8	0	0	Numeric	...
PRESSURERATING	Pressure Rating	Text	20	0	0		
DEPTH60	Deeper than 60"?	Short	2	0	0	Numeric	...
SOURCEDATA	Source Data	Text	25	0	0		
CROSSINGTYPE	Crossing Type	Short	2	0	0	Numeric	...
SUBMERGEDTYPE	Submerged Type	Short	2	0	0	Numeric	...
CASING	Casing?	Short	2	0	0	Numeric	...
Shape_Length	Shape_Length	Double	8	0	0	Numeric	...

Symbol	Value	Label
	<all other values>	<all other values>
	<Heading>	**SUBTYPE**
	4	Non-COT Potable
	1	Potable
	2	Raw
	0	Undefined

Figure 31. Geodatabase Template: Pressurized Main

Name	Alias	Type	Length	Precision	Scale	Number Format
☑ OBJECTID	OBJECTID	Object ID	4	0	0	
☑ Shape	Shape	Polygon				
☑ SUBTYPE	Subtype	Long	4	0	0	Numeric ...
☑ EASEMENTNO	Instrument #	Long	4	0	0	Numeric ...
☑ COMMENTS	Comments	Text	50	0	0	
☑ POSITIONAL	Positional Accuracy	Long	4	0	0	Numeric ...
☑ ORBOOK	Official Records Book	Text	25	0	0	
☑ ORPAGE	Official Records Page(s)	Text	25	0	0	
☑ STRAP	STRAP #	Text	50	0	0	
☑ GRANTORNAM	Grantor Name	Text	50	0	0	
☑ SHAPE_Leng	Shape Length	Double	8	0	0	Numeric ...
☑ Shape_Length	Shape_Length	Double	8	0	0	Numeric ...
☑ Shape_Area	Shape_Area	Double	8	0	0	Numeric ...

Symbol	Value	Label
	<all other values>	<all other values>
	<Heading>	**SUBTYPE**
	1	COT WaterEasement
	4	Public Utility Easement
	5	Termination Easement
	0	Undefined

Figure 32. Geodatabase Template: Easement

Name	Alias	Type	Length	Precision	Scale	Number Format
OBJECTID	OBJECTID	Object ID	4	0	0	
Shape	Shape	Line				
STREET	STREET	Text	35	0	0	
FROMLEFT	FROMLEFT	Double	8	0	0	Numeric
TOLEFT	TOLEFT	Double	8	0	0	Numeric
FROMRIGHT	FROMRIGHT	Double	8	0	0	Numeric
TORIGHT	TORIGHT	Double	8	0	0	Numeric
COTLID	COTLID	Double	8	0	0	Numeric
LFJUR	LFJUR	Text	1	0	0	
RTJUR	RTJUR	Text	1	0	0	
LFESN	LFESN	Text	3	0	0	
RTESN	RTESN	Text	3	0	0	
CODE	CODE	Text	3	0	0	
JOG_CODE	JOG_CODE	Text	3	0	0	
TO_FROM_CO	TO_FROM_CO	Text	3	0	0	
LESS_125	LESS_125	Text	3	0	0	
NOTES	NOTES	Text	50	0	0	
TPD_NOTES	TPD_NOTES	Text	50	0	0	
FIRE_NOTES	FIRE_NOTES	Text	50	0	0	
FRSTNM	FRSTNM	Text	35	0	0	
TOSTNM	TOSTNM	Text	35	0	0	
STCODE	STCODE	Double	8	0	0	Numeric
SEGNBR	SEGNBR	Long	4	0	0	Numeric
FRSTNBR	FRSTNBR	Double	8	0	0	Numeric
TOSTNBR	TOSTNBR	Double	8	0	0	Numeric
FRNODE	FRNODE	Double	8	0	0	Numeric
TONODE	TONODE	Double	8	0	0	Numeric
LFEXP	LFEXP	Text	1	0	0	
RTEXP	RTEXP	Text	1	0	0	
AUTHRTY	AUTHRTY	Text	1	0	0	
FUNCLAS	FUNCLAS	Text	1	0	0	
HSS_DIR	HSS_DIR	Text	2	0	0	
HSS_ONSTNM	HSS_ONSTNM	Text	30	0	0	
HSS_TYPE	HSS_TYPE	Text	4	0	0	
HSS_SUFFIX	HSS_SUFFIX	Text	2	0	0	
MSAG_STREE	MSAG_STREE	Text	35	0	0	
MSAG_DIR	MSAG_DIR	Text	2	0	0	
MSAG_ONSTN	MSAG_ONSTN	Text	30	0	0	
MSAG_TYPE	MSAG_TYPE	Text	4	0	0	
MSAG_SUFFI	MSAG_SUFFI	Text	2	0	0	
POSTAL_STR	POSTAL_STR	Text	35	0	0	
DOR_STREET	DOR_STREET	Text	35	0	0	
ALIAS_STRE	ALIAS_STRE	Text	35	0	0	
FR_DIR	FR_DIR	Text	2	0	0	
FR_ONSTNM	FR_ONSTNM	Text	30	0	0	
FR_TYPE	FR_TYPE	Text	4	0	0	
FR_SUFFIX	FR_SUFFIX	Text	2	0	0	
TO_DIR	TO_DIR	Text	2	0	0	
TO_ONSTNM	TO_ONSTNM	Text	30	0	0	
TO_TYPE	TO_TYPE	Text	4	0	0	
TO_SUFFIX	TO_SUFFIX	Text	2	0	0	
LAST_UPD	LAST_UPD	Date	8	0	0	
Shape_Length	Shape_Length	Double	8	0	0	Numeric

Figure 33. Geodatabase Template: Roads (Street)

Name	Alias	Type	Length	Precision	Scale	Number Format
OBJECTID	OBJECTID	Object ID	4	0	0	
Shape	Shape	Polygon				
PIN	PIN	Text	28	0	0	
FOLIO	FOLIO	Text	11	0	0	
SITUSNO	SITUSNO	Text	7	0	0	
SITADDR	SITADDR	Text	40	0	0	
SITUNIT	SITUNIT	Text	10	0	0	
SITSTAT	SITSTAT	Text	4	0	0	
SITTYPE	SITTYPE	Text	3	0	0	
BLDCOND	BLDCOND	Text	2	0	0	
OWNER1	OWNER1	Text	50	0	0	
OWNER2	OWNER2	Text	50	0	0	
ZONE_PRIME	ZONE_PRIME	Text	6	0	0	
ZONE_SECON	ZONE_SECON	Text	6	0	0	
MAILTO	MAILTO	Text	50	0	0	
M_ADDR_1	M_ADDR_1	Text	30	0	0	
M_ADDR_2	M_ADDR_2	Text	30	0	0	
M_CITY	M_CITY	Text	30	0	0	
M_STATE	M_STATE	Text	2	0	0	
M_ZIP	M_ZIP	Text	10	0	0	
M_COUNTRY	M_COUNTRY	Text	30	0	0	
DOR_CD	DOR_CD	Text	4	0	0	
VAL_METHOD	VAL_METHOD	Text	6	0	0	
MILL_CD	MILL_CD	Text	3	0	0	
NH_CD	NH_CD	Text	10	0	0	
VAC_IMPR_F	VAC_IMPR_F	Text	1	0	0	
YR_IMPR	YR_IMPR	Text	4	0	0	
YR_ANNEXED	YR_ANNEXED	Text	4	0	0	
SPLT_DT	SPLT_DT	Text	11	0	0	
DSC_CD	DSC_CD	Text	2	0	0	
BASE_YR	BASE_YR	Text	4	0	0	
MKT_AR1	MKT_AR1	Double	8	0	0	Numeric
PR_STRAP	PR_STRAP	Text	25	0	0	
PROB_DEED	PROB_DEED	Text	1	0	0	
HX_VAL	HX_VAL	Double	8	0	0	Numeric
DIS_VAL	DIS_VAL	Double	8	0	0	Numeric
WX_VAL	WX_VAL	Double	8	0	0	Numeric
JST_VAL	JST_VAL	Double	8	0	0	Numeric
CLS_VAL	CLS_VAL	Double	8	0	0	Numeric
ASD_VAL	ASD_VAL	Double	8	0	0	Numeric
SOH_VAL	SOH_VAL	Double	8	0	0	Numeric
TAX_VAL	TAX_VAL	Double	8	0	0	Numeric
CUR_BASE	CUR_BASE	Double	8	0	0	Numeric
PCT_SOH	PCT_SOH	Double	8	0	0	Numeric
MKT_SOH	MKT_SOH	Double	8	0	0	Numeric
MKT_MKT	MKT_MKT	Double	8	0	0	Numeric
AG_X_VAL	AG_X_VAL	Double	8	0	0	Numeric
TOT_BLD_VA	TOT_BLD_VA	Double	8	0	0	Numeric
TOT_XF_VAL	TOT_XF_VAL	Double	8	0	0	Numeric
TOT_LND_VA	TOT_LND_VA	Double	8	0	0	Numeric
CLS_LND_VA	CLS_LND_VA	Double	8	0	0	Numeric
AG_LND_VAL	AG_LND_VAL	Double	8	0	0	Numeric
ASD_LND_VA	ASD_LND_VA	Double	8	0	0	Numeric
NCON_VAL	NCON_VAL	Double	8	0	0	Numeric
DEMO_VAL	DEMO_VAL	Double	8	0	0	Numeric
COMB_VAL	COMB_VAL	Double	8	0	0	Numeric
SPLIT_VAL	SPLIT_VAL	Double	8	0	0	Numeric
PX_VAL	PX_VAL	Double	8	0	0	Numeric
PR_VAL	PR_VAL	Double	8	0	0	Numeric
AG_X_FLG	AG_X_FLG	Text	1	0	0	
YR_CREATED	YR_CREATED	Double	8	0	0	Numeric
PR_DOR_CD	PR_DOR_CD	Text	4	0	0	
LIFE_EST	LIFE_EST	Text	1	0	0	
JT_FLG	JT_FLG	Text	1	0	0	
INC_FLG	INC_FLG	Text	1	0	0	
LND_SALE_F	LND_SALE_F	Text	1	0	0	
CONF_FLG	CONF_FLG	Text	1	0	0	
MORTGAGE_C	MORTGAGE_C	Text	12	0	0	
LOC_ADDR	LOC_ADDR	Text	50	0	0	
LOC_UNIT	LOC_UNIT	Text	6	0	0	
LOC_CITY	LOC_CITY	Text	20	0	0	
LOC_ZIP	LOC_ZIP	Text	10	0	0	
STR_AUTH	STR_AUTH	Text	1	0	0	
SPCL_FTR	SPCL_FTR	Text	4	0	0	
ZONING_ID	ZONING_ID	Text	7	0	0	
RES_UNITS	RES_UNITS	Double	8	0	0	Numeric
COM_UNITS	COM_UNITS	Double	8	0	0	Numeric
ADL_STRUCT	ADL_STRUCT	Text	7	0	0	
BLDG_FLRS	BLDG_FLRS	Text	7	0	0	
BLDG_CONST	BLDG_CONST	Text	2	0	0	
SLUC_CODE	SLUC_CODE	Text	6	0	0	
RENTAL_CER	RENTAL_CER	Text	1	0	0	
HIST_BLDG	HIST_BLDG	Text	1	0	0	
STR_IND	STR_IND	Text	1	0	0	
ZIP_IND	ZIP_IND	Text	1	0	0	
PLAN_DIST	PLAN_DIST	Text	1	0	0	
REG_IMPACT	REG_IMPACT	Text	1	0	0	
AVIATION_L	AVIATION_L	Text	1	0	0	
SIT_FIRE_L	SIT_FIRE_L	Text	1	0	0	
SIT_HIST_D	SIT_HIST_D	Text	1	0	0	
SIT_STORM	SIT_STORM	Text	1	0	0	
SIT_CURIO_	SIT_CURIO_	Text	1	0	0	
PARCEL_ARE	PARCEL_ARE	Double	8	0	0	Numeric
SIT_OVERLA	SIT_OVERLA	Text	3	0	0	
SIT_WINDSP	SIT_WINDSP	Text	2	0	0	
STCODE	STCODE	Text	6	0	0	
SEGNBR	SEGNBR	Text	4	0	0	
COTLID	COTLID	Text	6	0	0	
TAX_DIST2	TAX_DIST2	Text	3	0	0	
Shape_Length	Shape_Length	Double	8	0	0	Numeric
Shape_Area	Shape_Area	Double	8	0	0	Numeric

Figure 34. Geodatabase Template: Landbase Parcel

Name	Alias	Type	Length	Precision	Scale	Number Fo
OBJECTID	OBJECTID	Object ID	4	0	0	
Shape	Shape	Polygon				
STR	STR	Text	6	0	0	
ATLAS	ATLAS	Text	7	0	0	
ATLAS_HANS	ATLAS_HANS	Text	7	0	0	
REDI	REDI	Text	5	0	0	
ARCSEC	ARCSEC	Text	7	0	0	
AERIALS	AERIALS	Text	6	0	0	
TWP_RGE	TWP_RGE	Text	4	0	0	
WATER_ZONE	WATER_ZONE	Text	6	0	0	
ORD	ORD	Short	2	0	0	Numeric
Shape_Length	Shape_Length	Double	8	0	0	Numeric
Shape_Area	Shape_Area	Double	8	0	0	Numeric

Figure 35. Geodatabase Template: TRS Sections

Figures 36–39 show the rules about segments and physical components of the network. These requirements are based also in the hydraulic model structure. The asset management protocols require a precise definition of the segment and appropriate description of its characteristics. That is the reason for breaking segments at specific points.

Figures 24, 25, and 40–42 show an example of adding a new project to the template and the use of a CAD drawing as a background in the given section. The Master CAD Atlas is based on the TRS section.

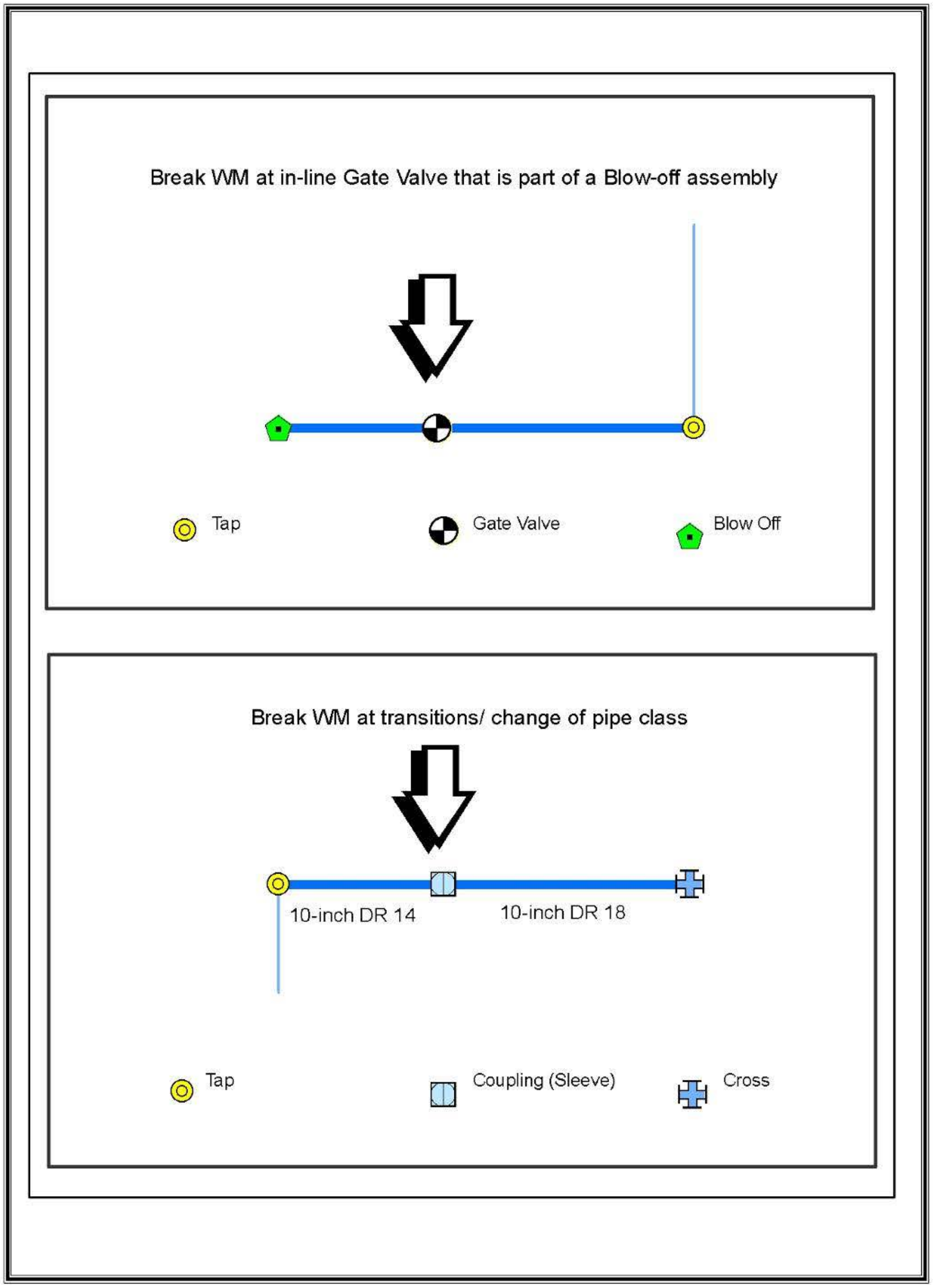


Figure 36. Geodatabase Template: Blowoff Assembly

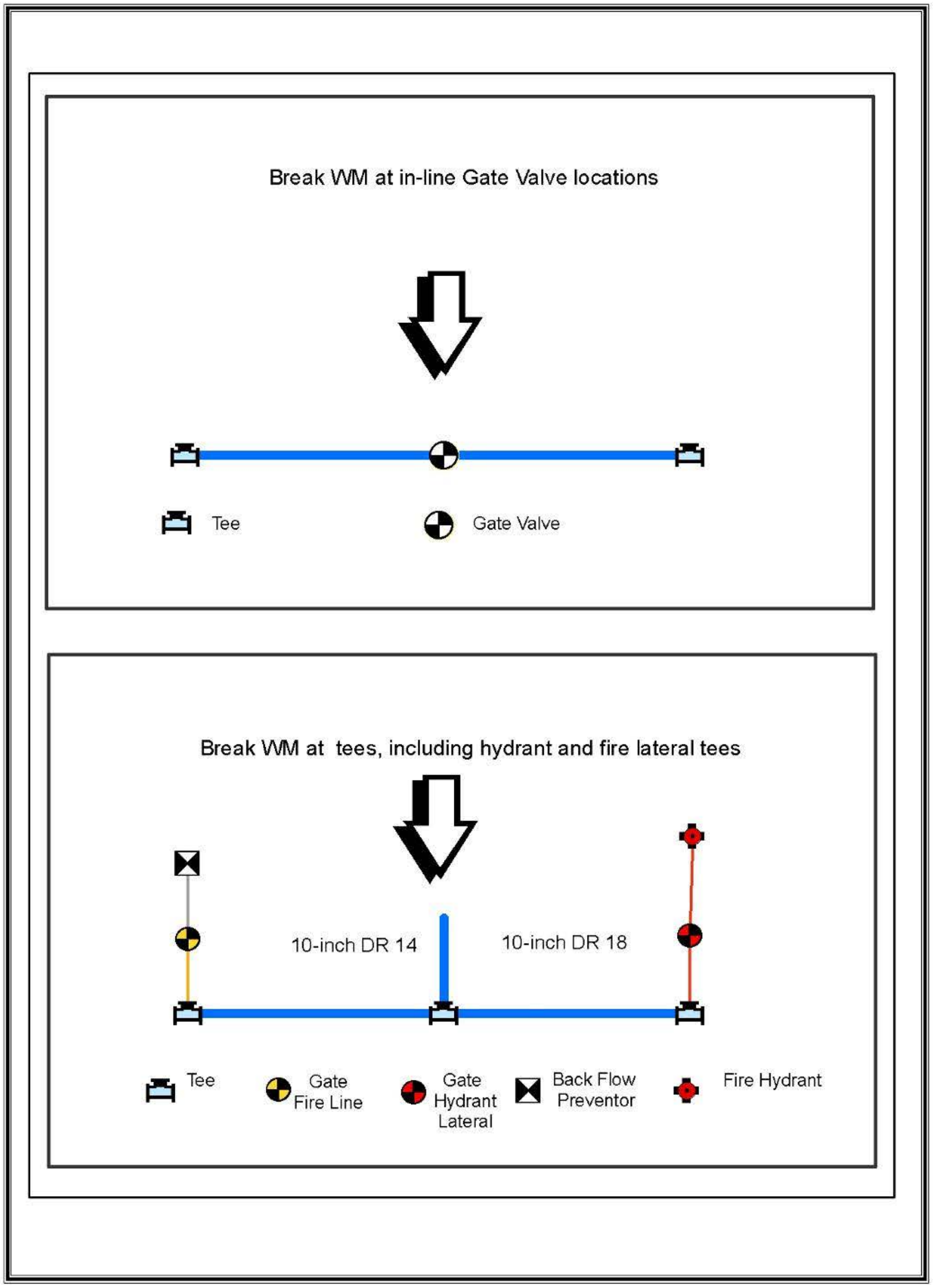


Figure 37. Geodatabase Template: Valve Locations and Fire Laterals

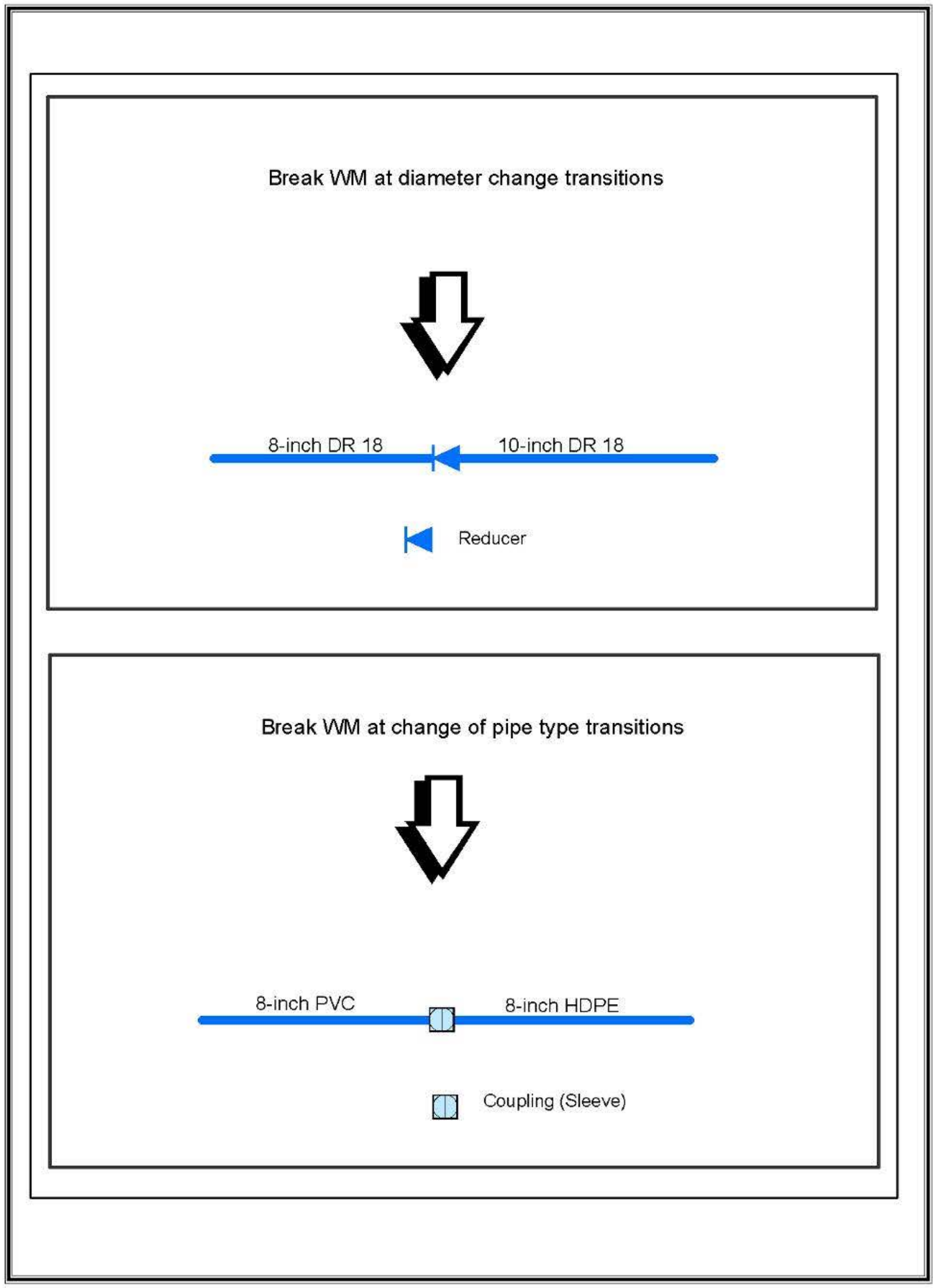


Figure 38. Geodatabase Template: Diameter and Pipe Transitions

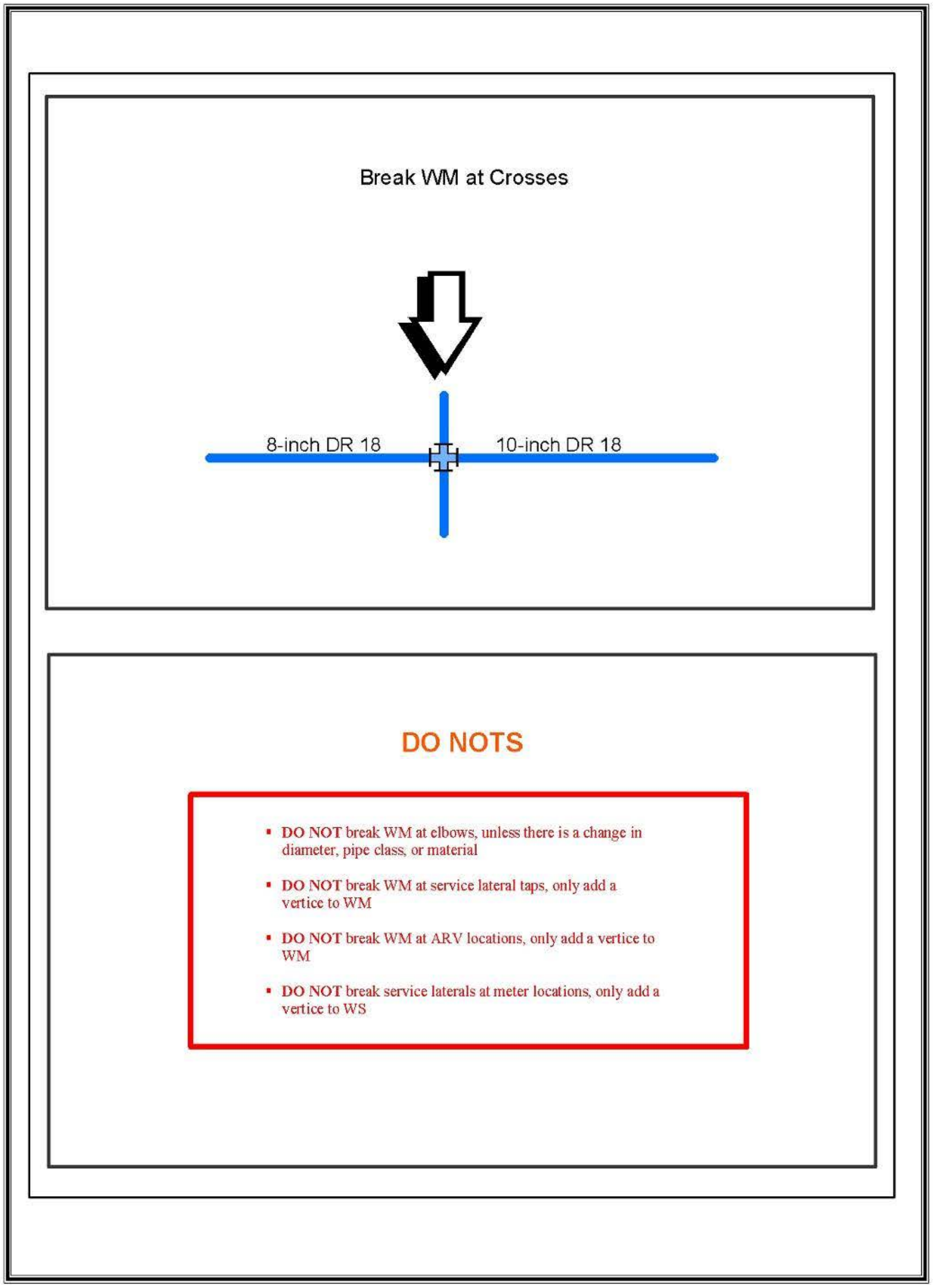


Figure 39. Geodatabase Template: DO NOTS

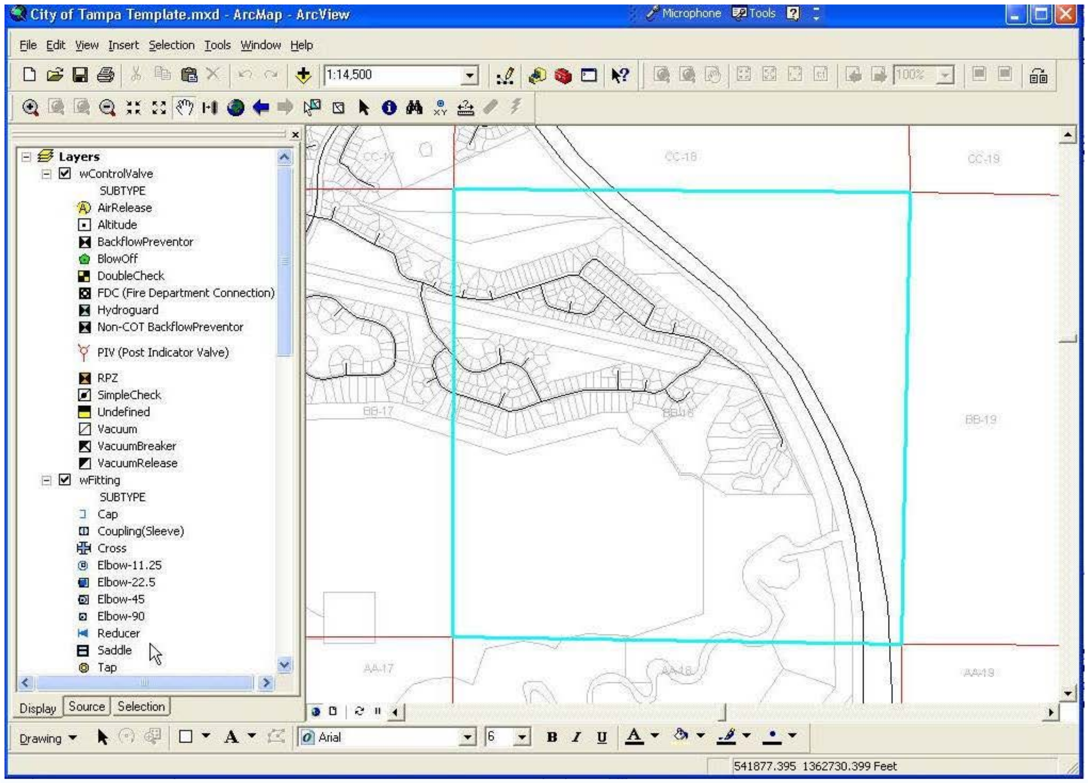


Figure 40. Geodatabase Template: Template Section

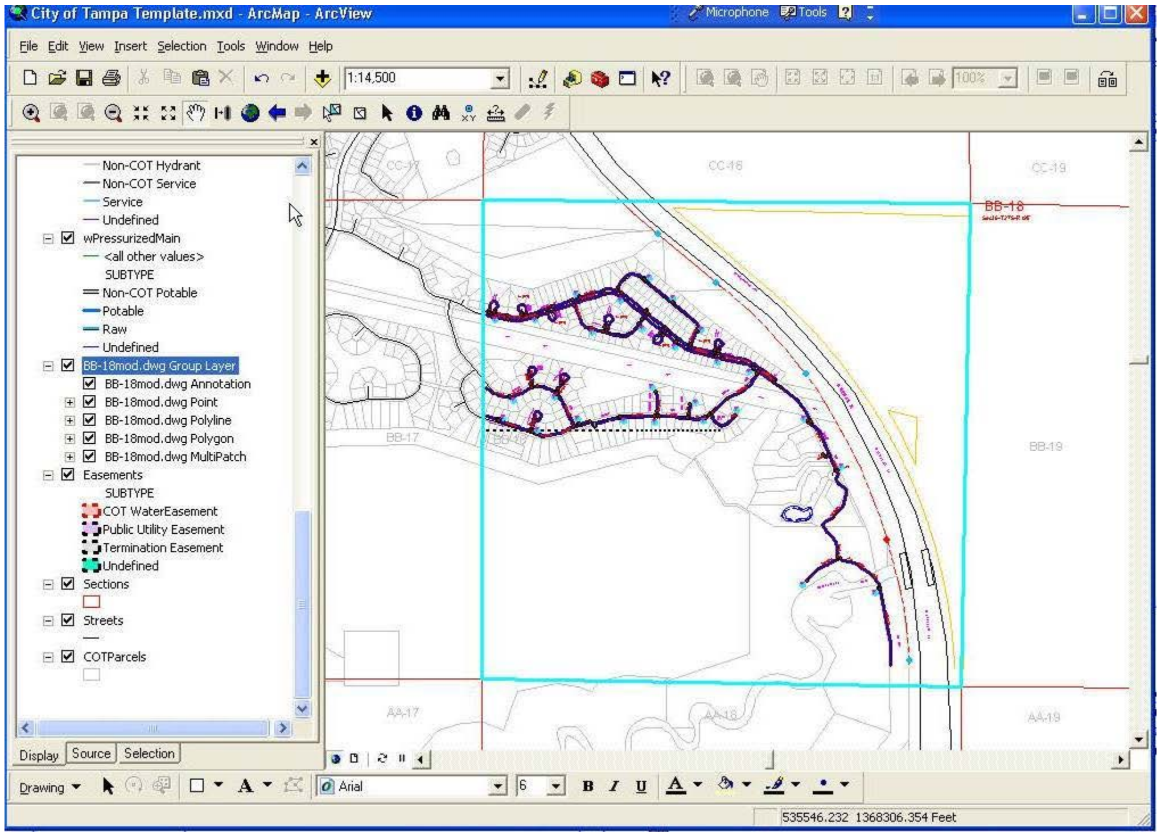


Figure 41. Geodatabase Template: The GIS Construction

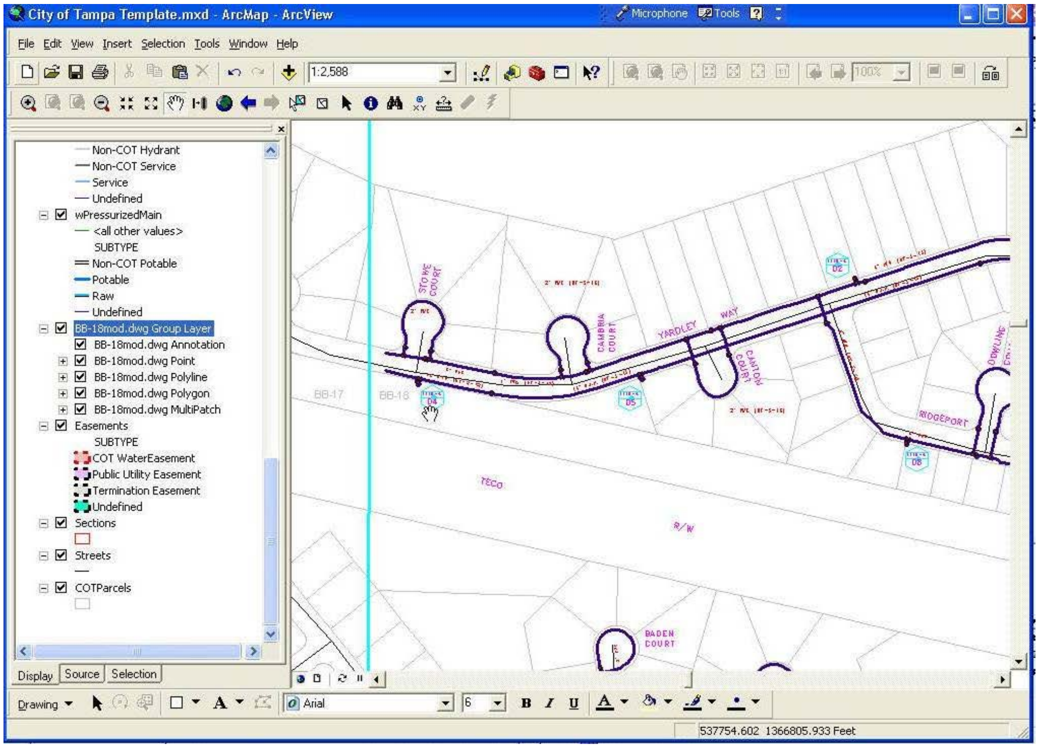


Figure 42. Geodatabase Template: The GIS New Development

Spatial Analysis of Population and Water Demand

SWFWMD has developed the population projection for the district area. The consultants retained by SWFWMD developed a model combining different GIS-based methodologies that includes floating population, seasonal peaks, and historic trends (Figures 43–45). SWFWMD used the new type of geodatabase (.Gdb File Geodatabase), and the model is not editable with Microsoft Access.

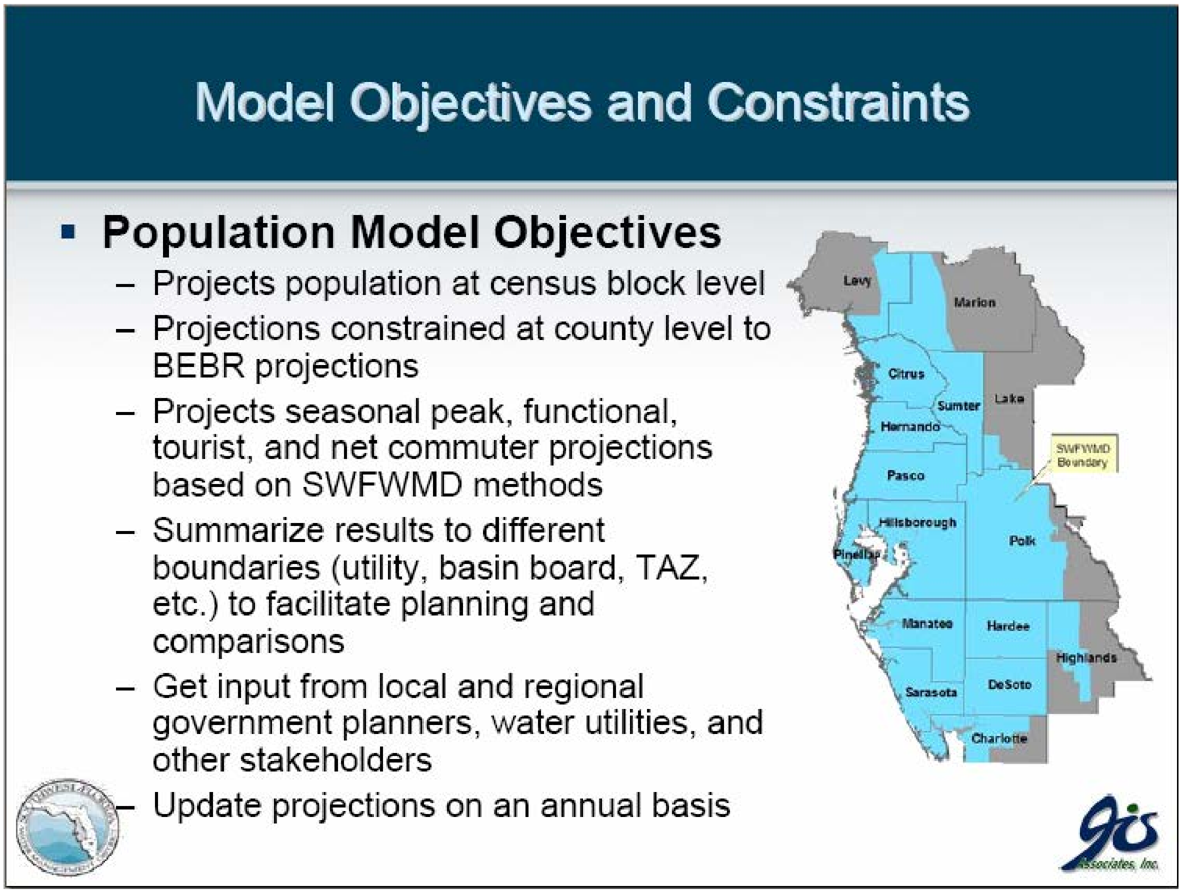


Figure 43. Population Model Overview: Southwest Florida Water Management District (SWFWMD) (Southwest Florida Water Management District 2008)

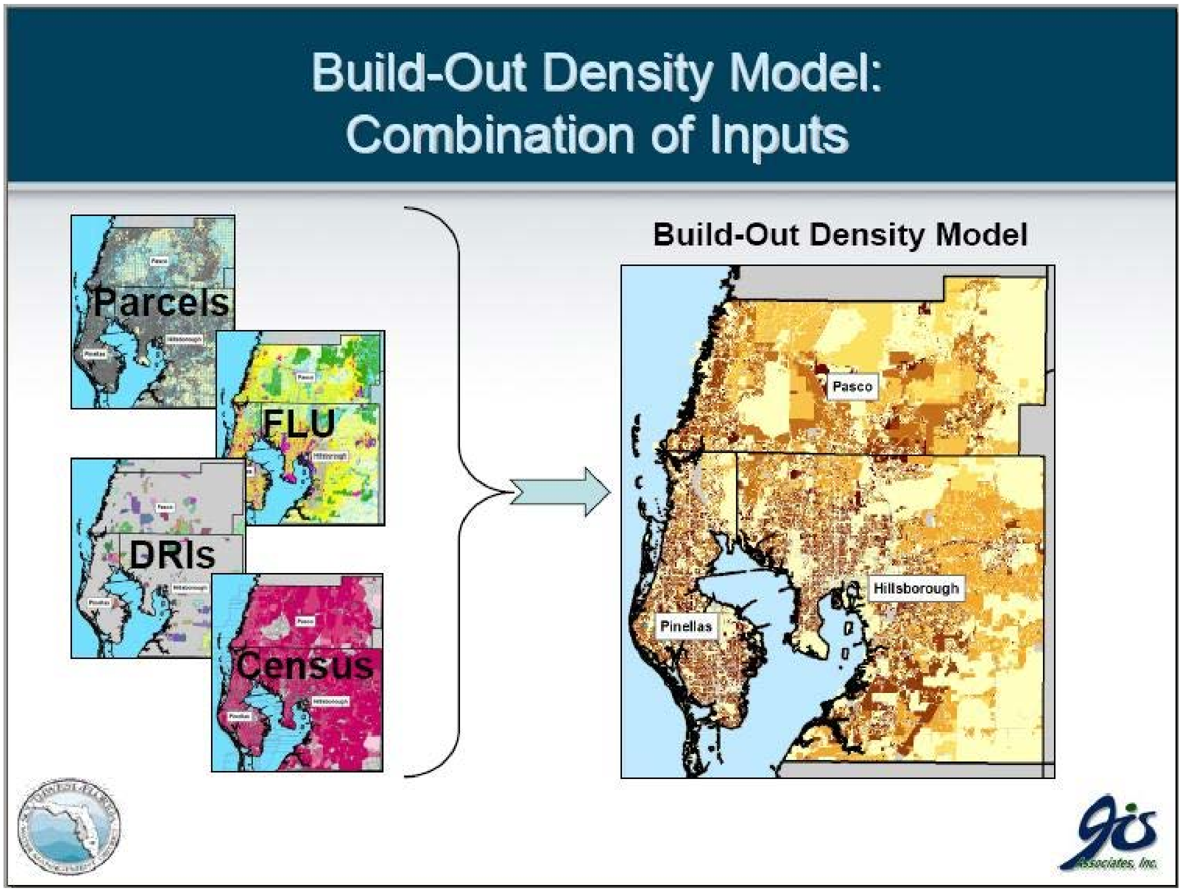


Figure 44. Population Model Overview: SWFWMD 2 (Southwest Florida Water Management District 2008)

This parcel-oriented model provides projections based on the possible increase of density at each parcel level. The model also provides a tourist population and net commuters, but allocates this floating population to specific locations in the county. The information is aggregated at the county level, and then it was necessary to clip the county polygon with the service area shapefile to get the parcels within the service area.

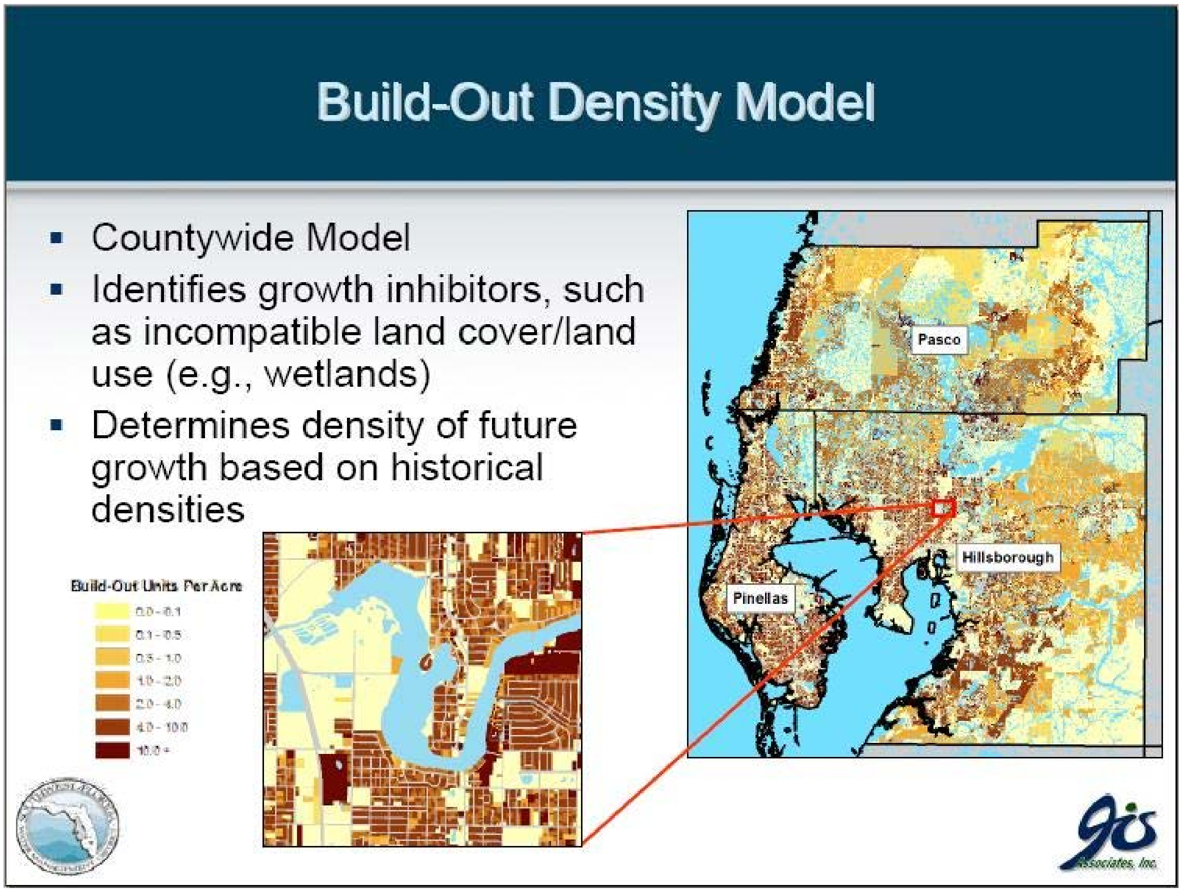


Figure 45. Population Model Overview: SWFWMD 3 (Southwest Florida Water Management District 2008)

This methodology is appropriate for the calculation of water demands in specific areas or sections. Let us say we need to calculate the population in section I-13 for the year 2020. We select the parcels within the given section cell. The statistical operation of the POP20 field in the table of attributes shows the results. In 2020, section I-13 will have 7,091 people. Figure 46 shows this case.

Figure 46. Population Model Overview: Section I-13 Analysis

Infrastructure Performance Monitoring Plan

The daily operation of a water distribution system over the service area requires permanent supervision to ensure that the system is behaving properly and operating in a suitable range. Pipe breaks are common and acceptable within given percentages. A dramatic increase in the rate of failure in a period requires immediate attention of the managers or field crews to determine a potential water outage or health threats to the served population. The failures and breaks have to be kept in a database and analyzed periodically to determine trends or hidden negative processes. The GIS users demanded a series of reports showing the spatial distribution of each type of failure (Figure 47). The database should contain the failure characteristics and the pipeline data.

Figures 48–63 are reports designed to show a whole picture of the performance of the physical components of the distribution system. The Engineering Division, Operations Division, and Production use these GIS-based reports to grade the effectiveness of their work and to plan their tasks each period.

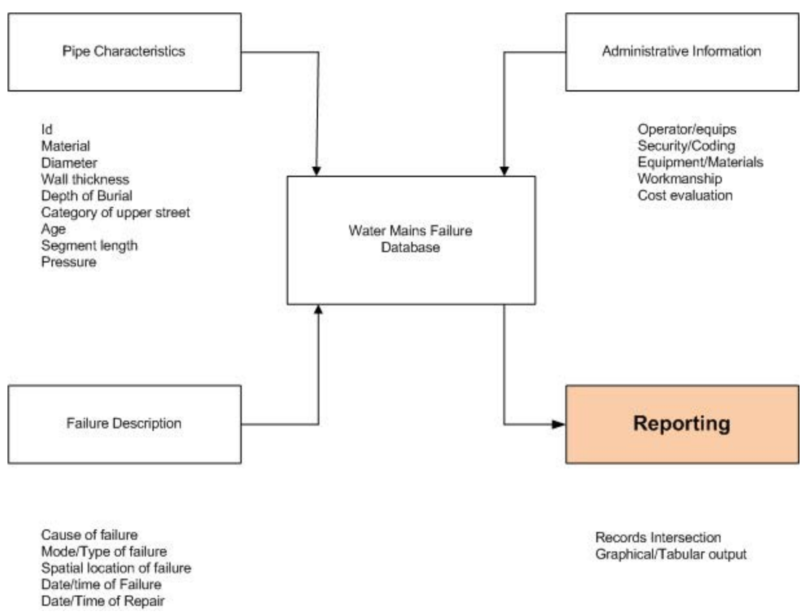


Figure 47. Pipe Failure Reporting Process (Asnashari and Shahrour 2007)

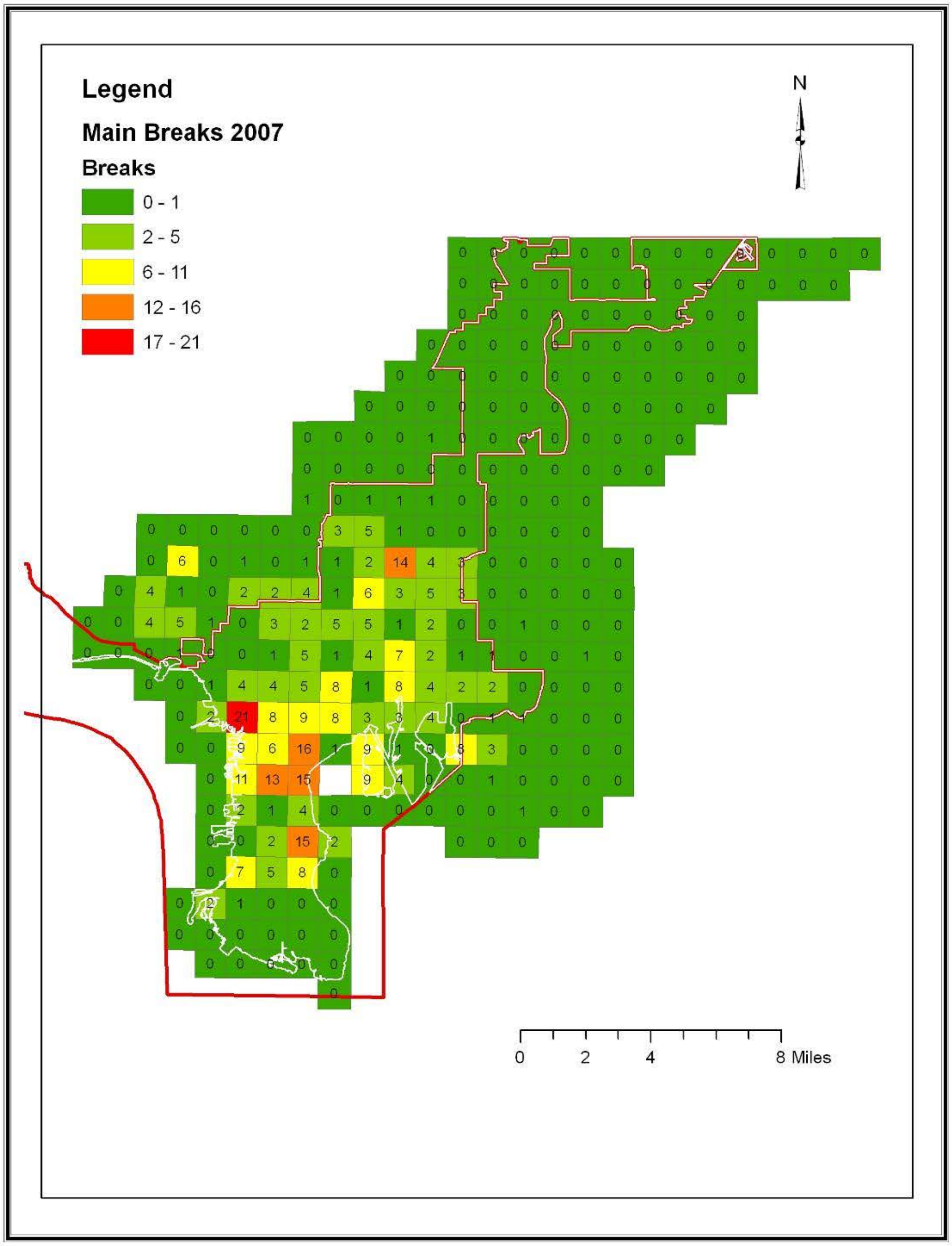


Figure 48. Main Breaks 2007

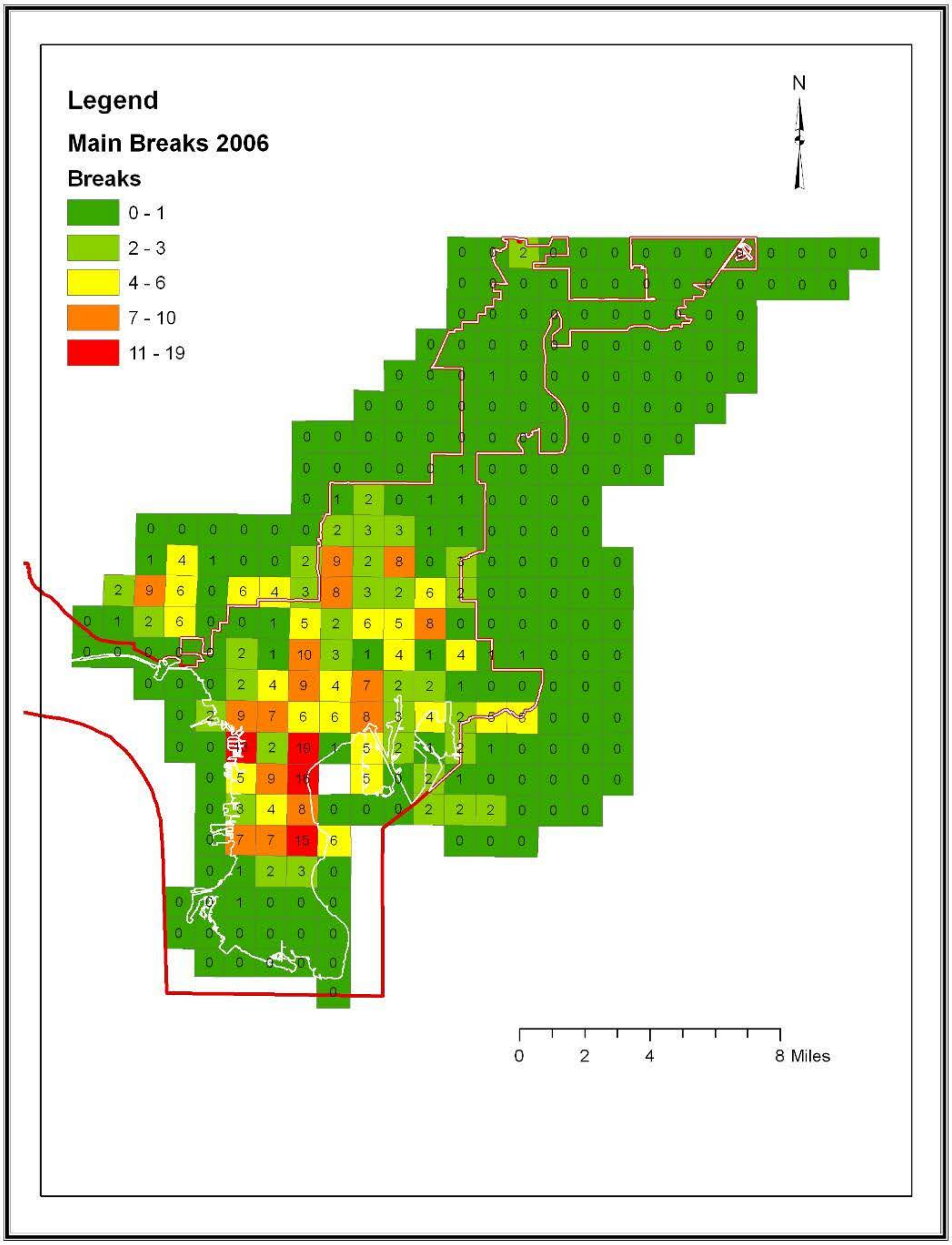


Figure 49. Main Breaks 2006

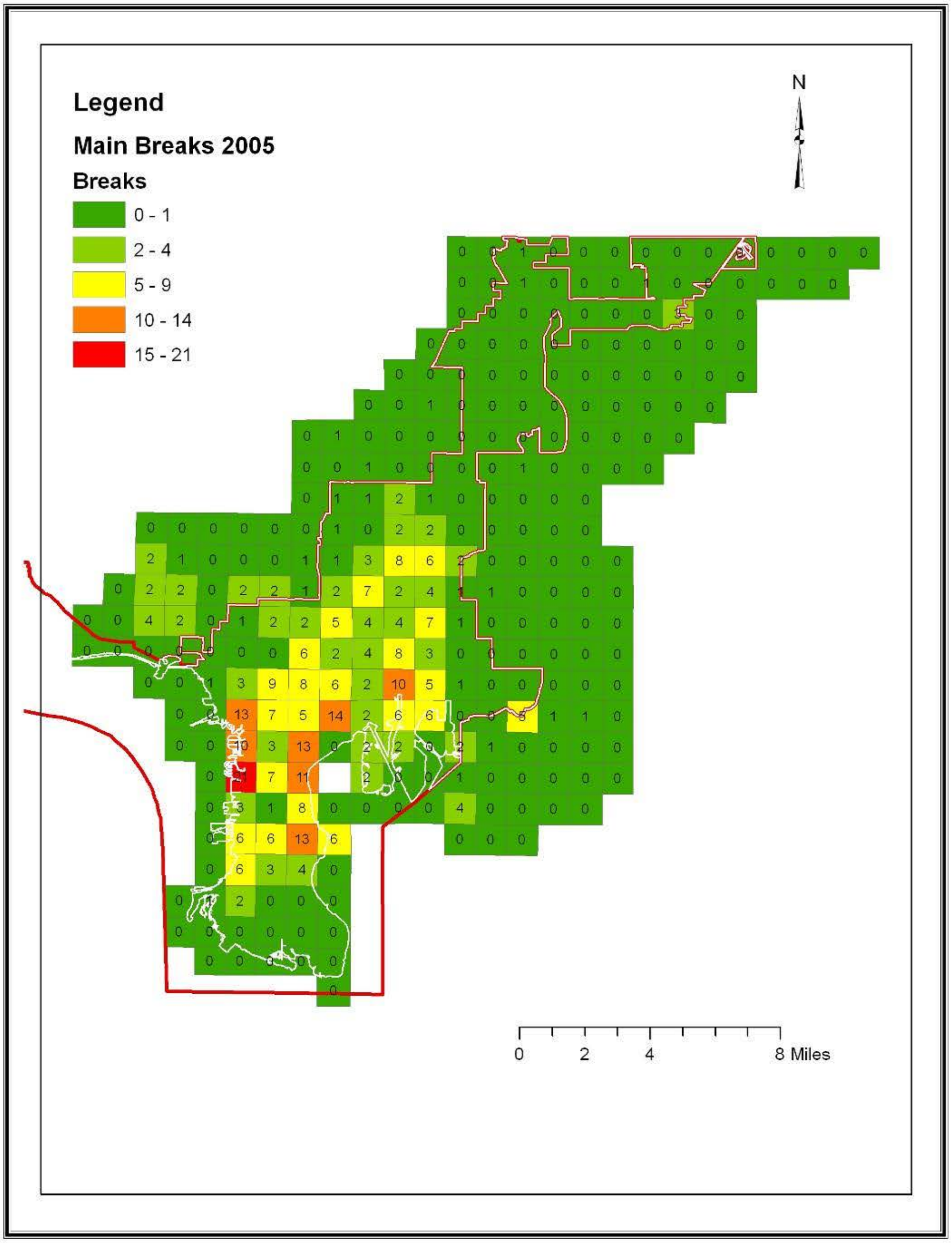


Figure 50. Main Breaks 2005

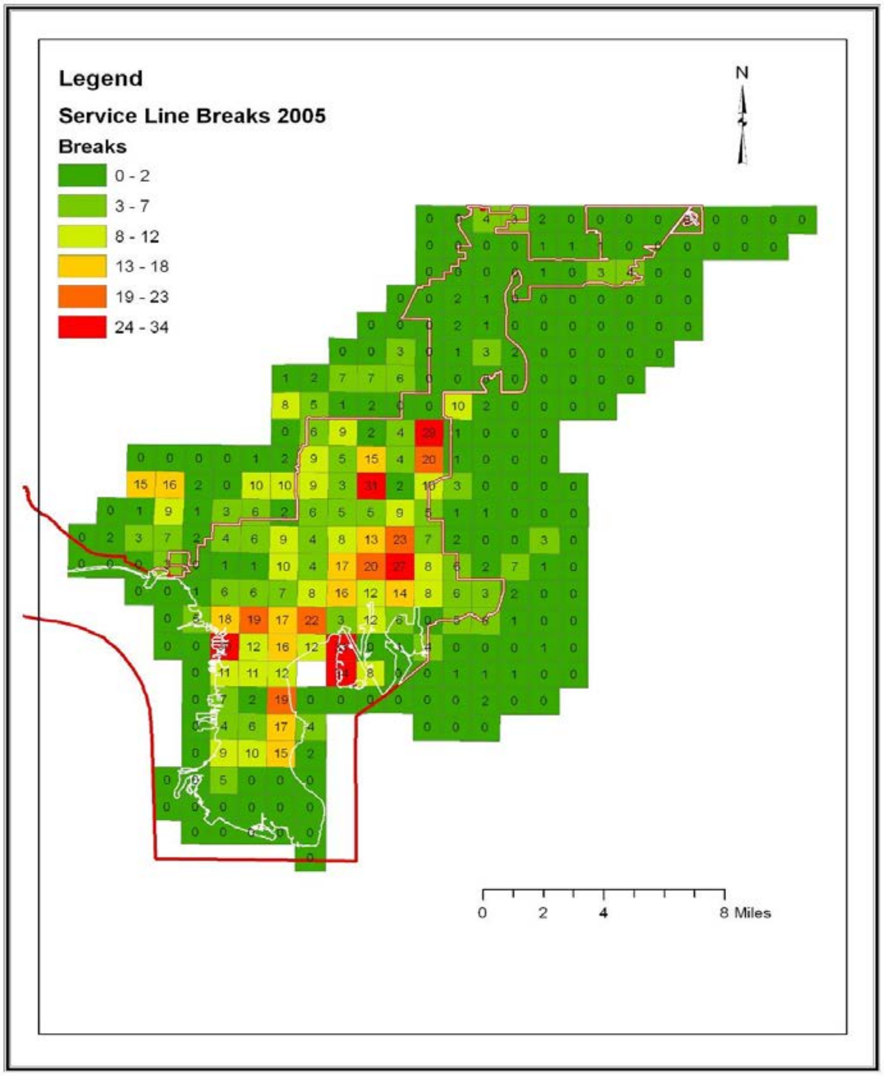


Figure 51. Service Line Breaks 2005

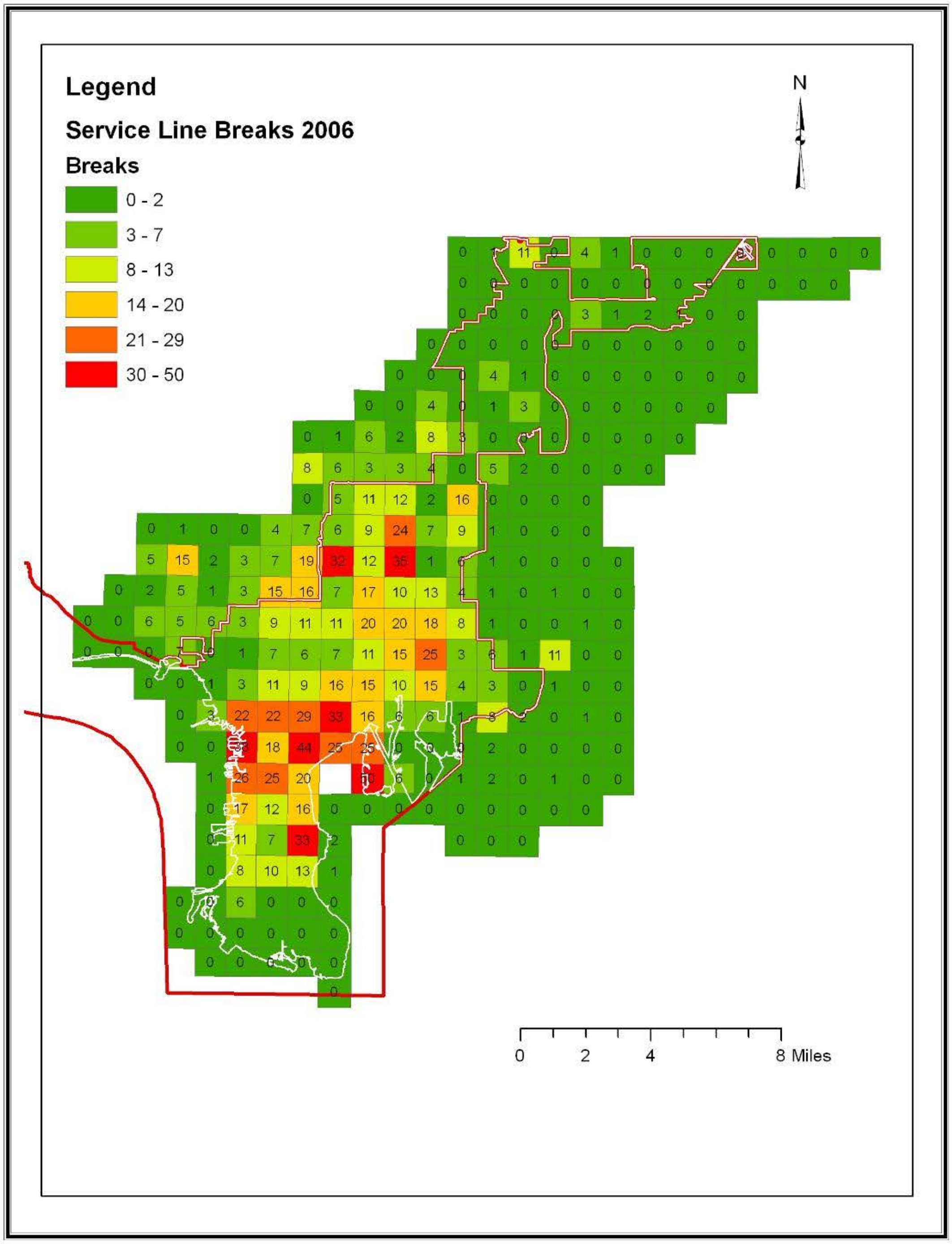


Figure 52. Service Line Breaks 2006

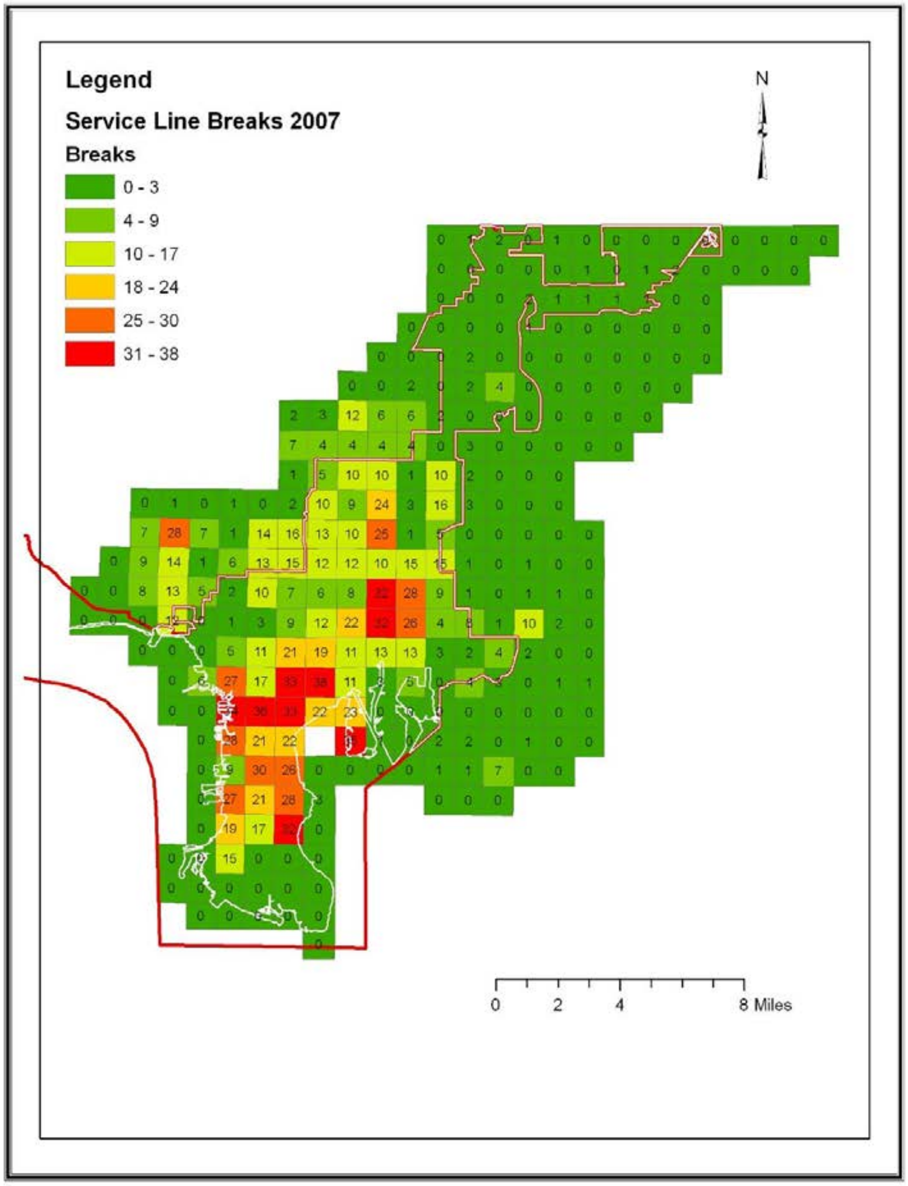


Figure 53. Service Line Breaks 2007

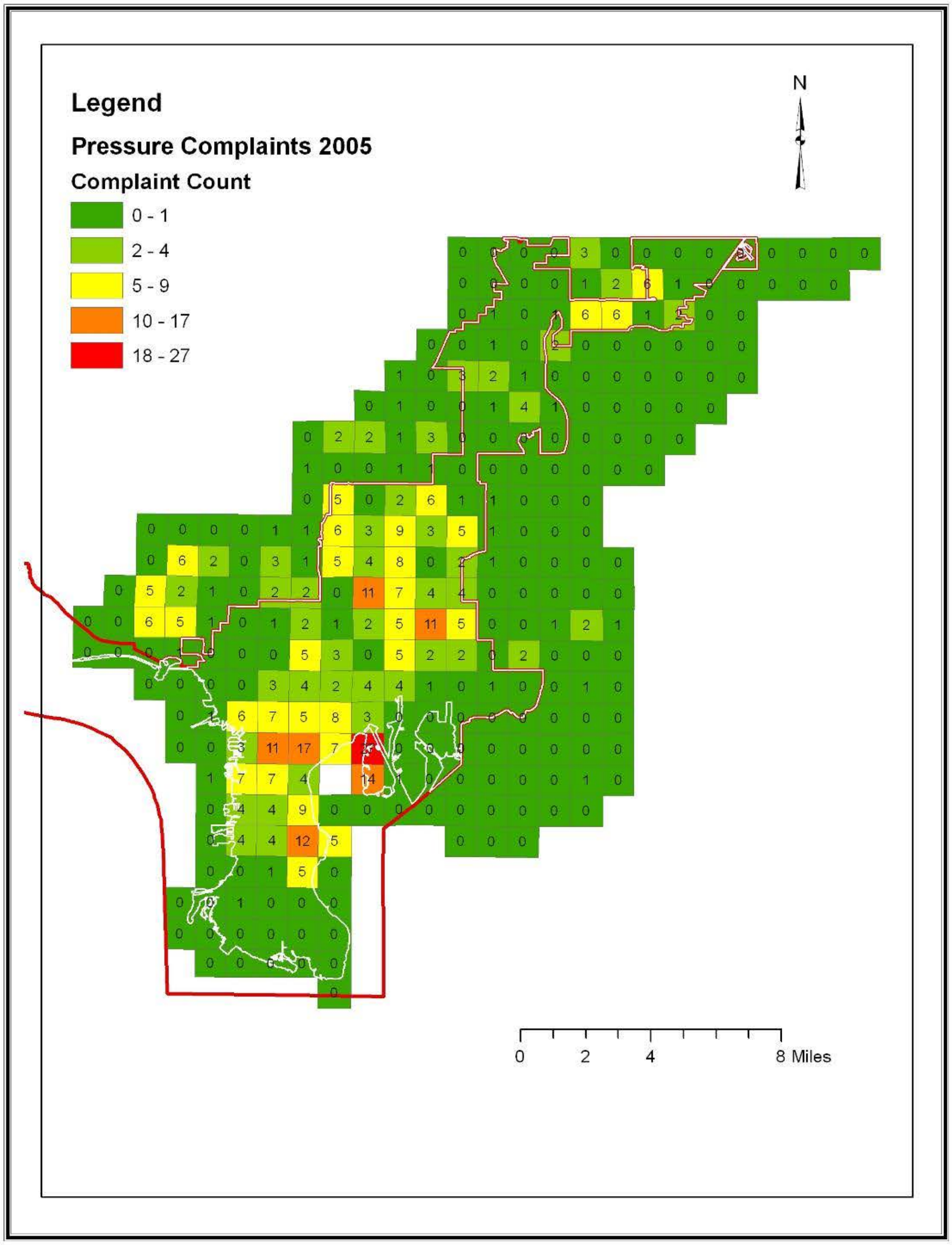


Figure 54. Pressure Complaints 2005

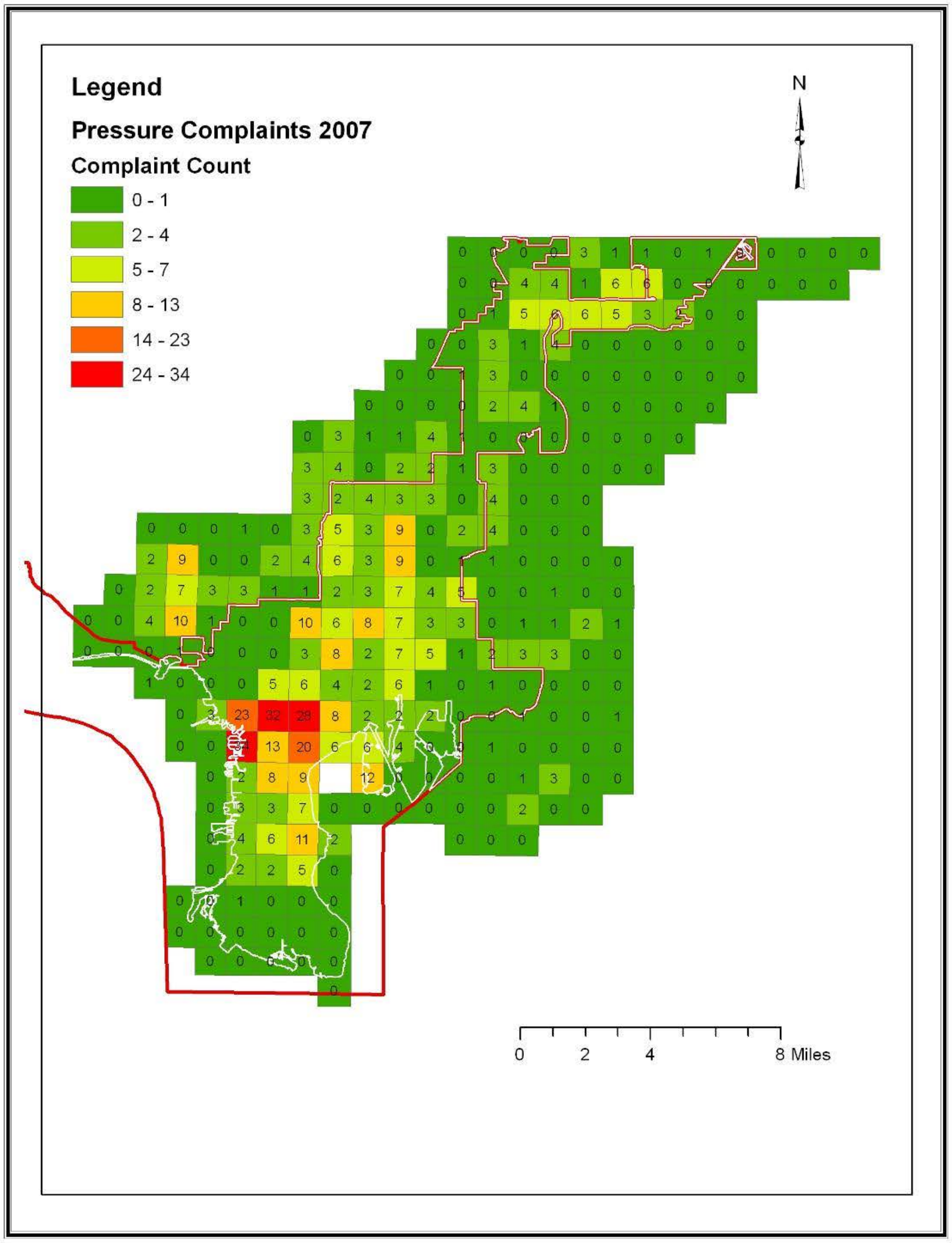


Figure 55. Pressure Complaints 2007

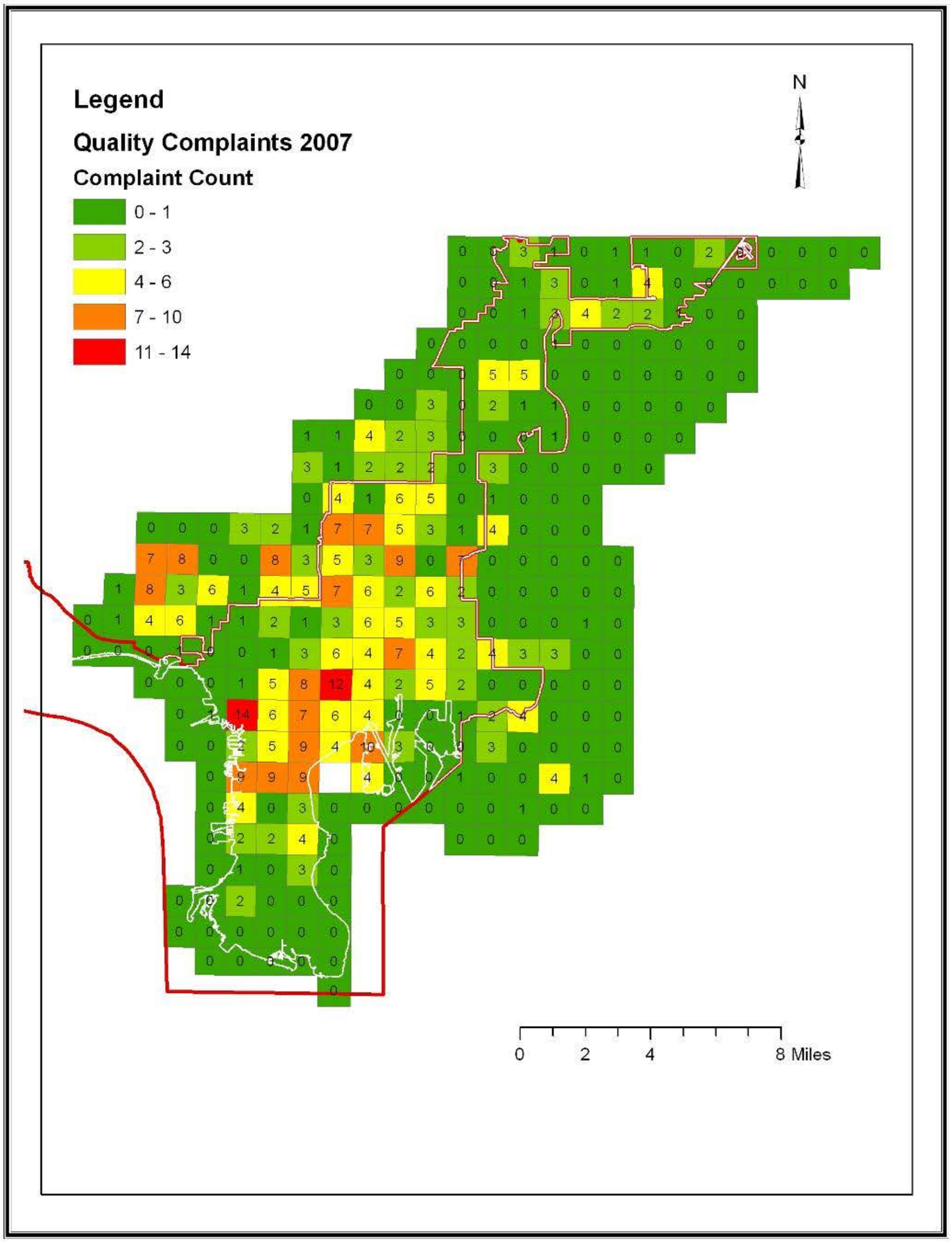


Figure 56. Quality Complaints 2007

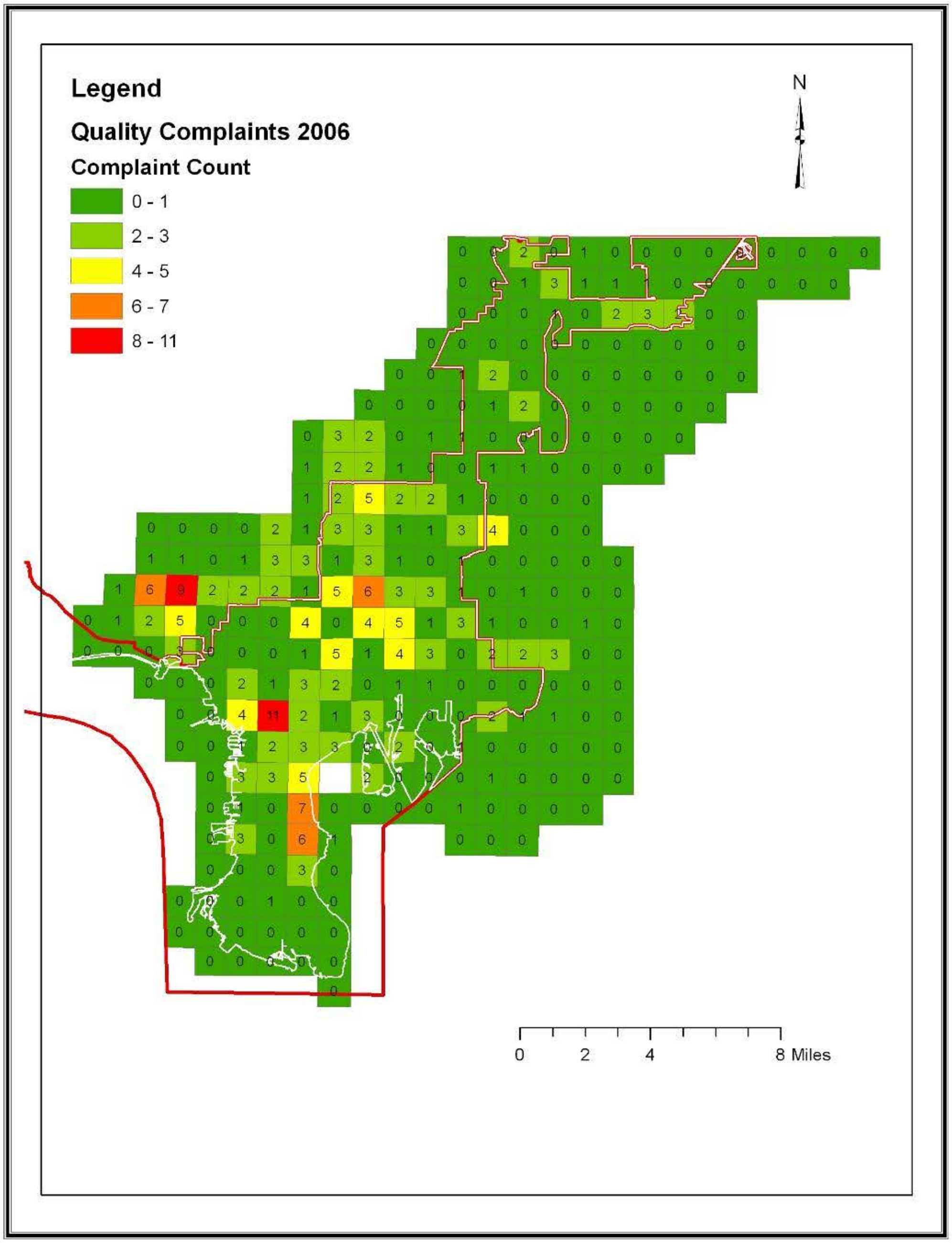


Figure 57. Quality Complaints 2006

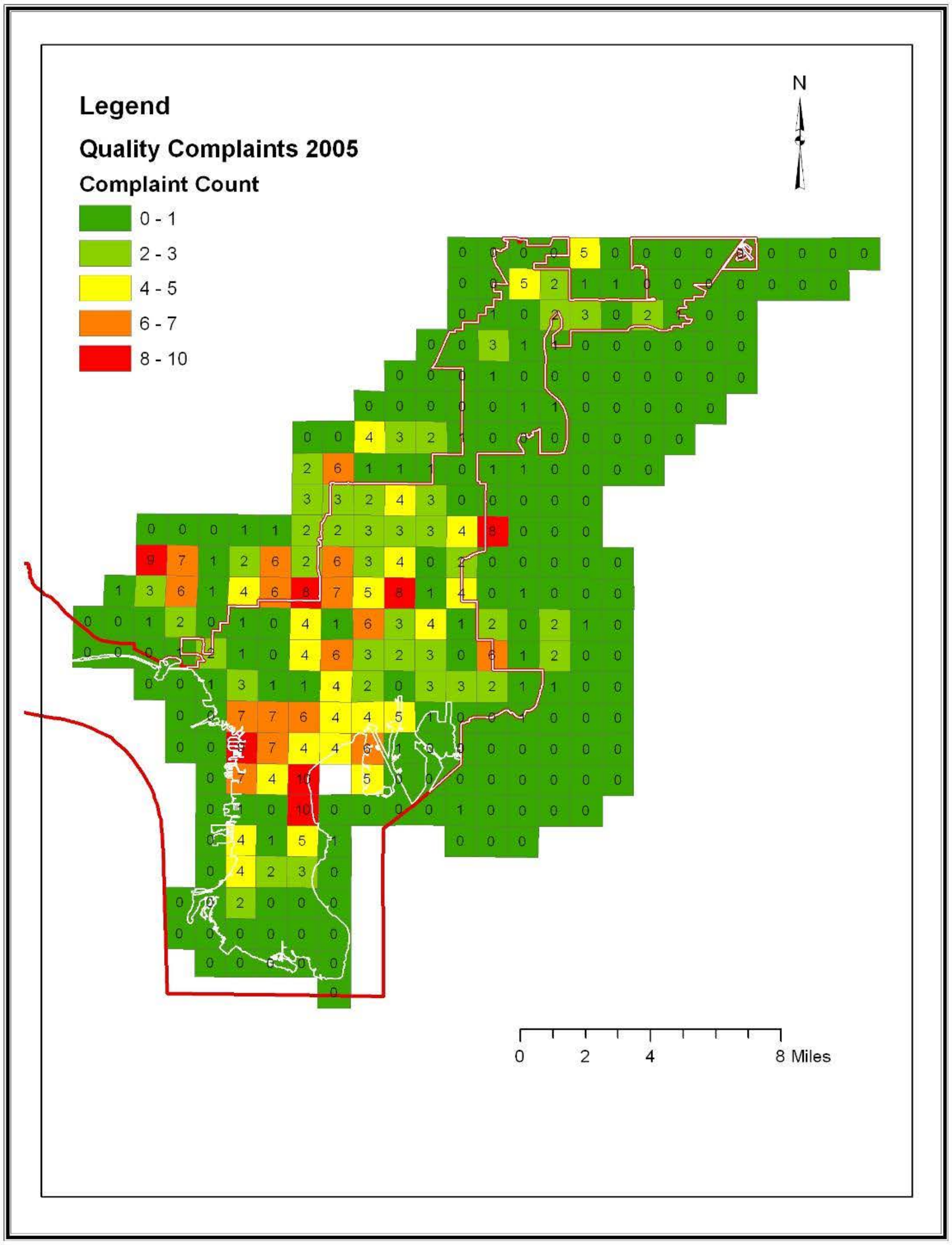


Figure 58. Quality Complaints 2005

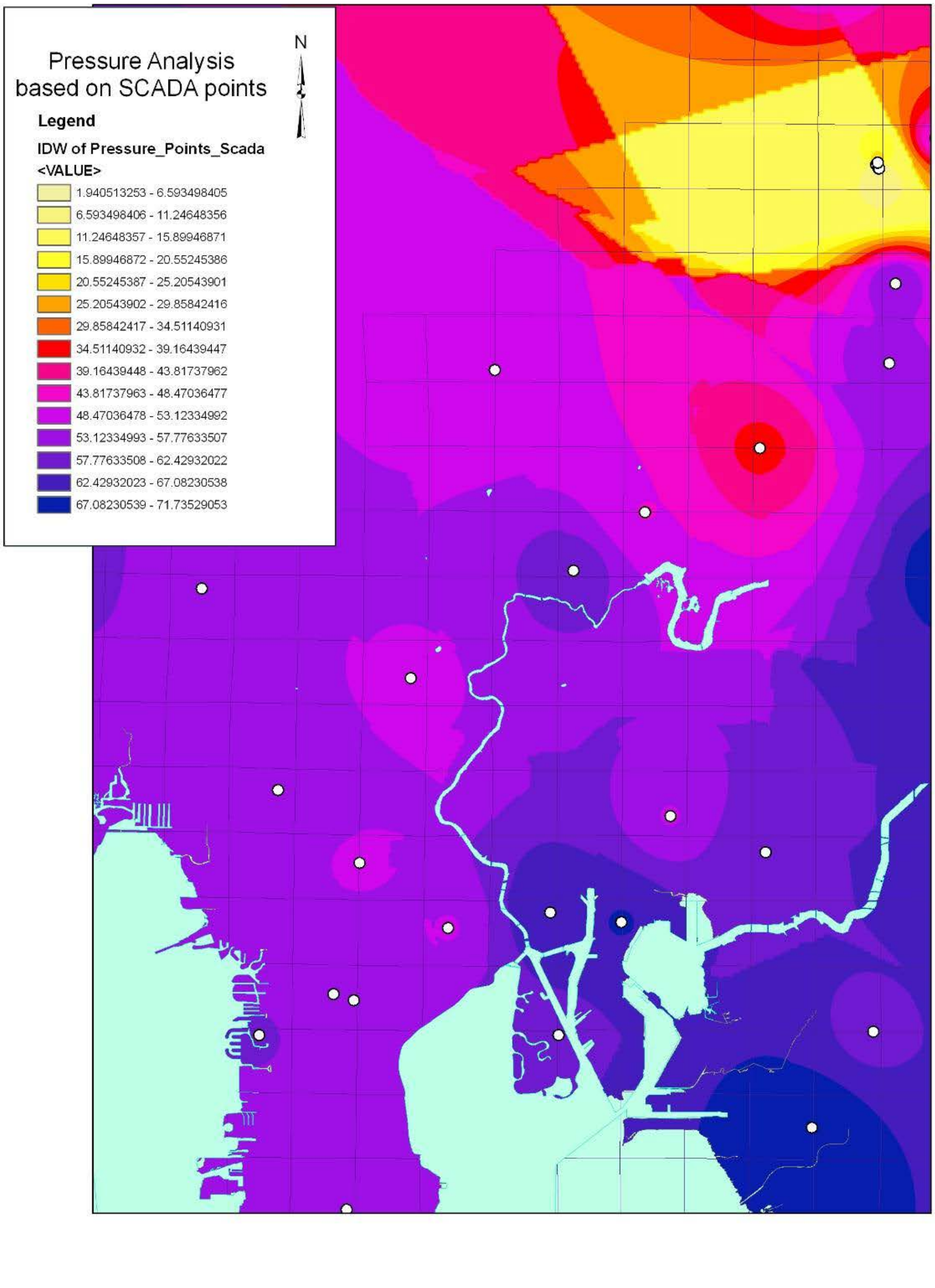


Figure 59. SCADA-Based Spatial Analysis of Pressure

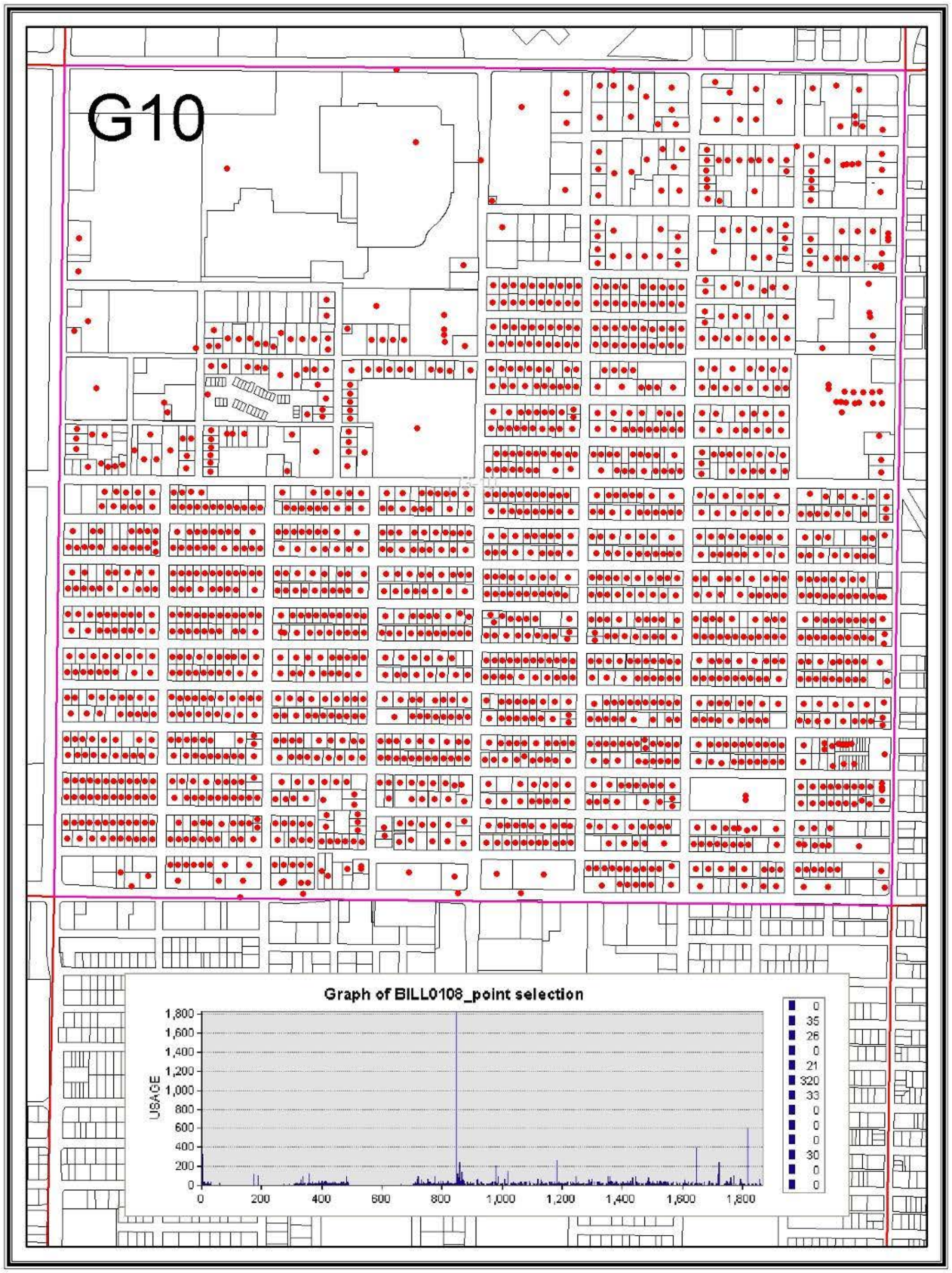


Figure 60. Spatial Distribution of Meters and Water Usage Statistics

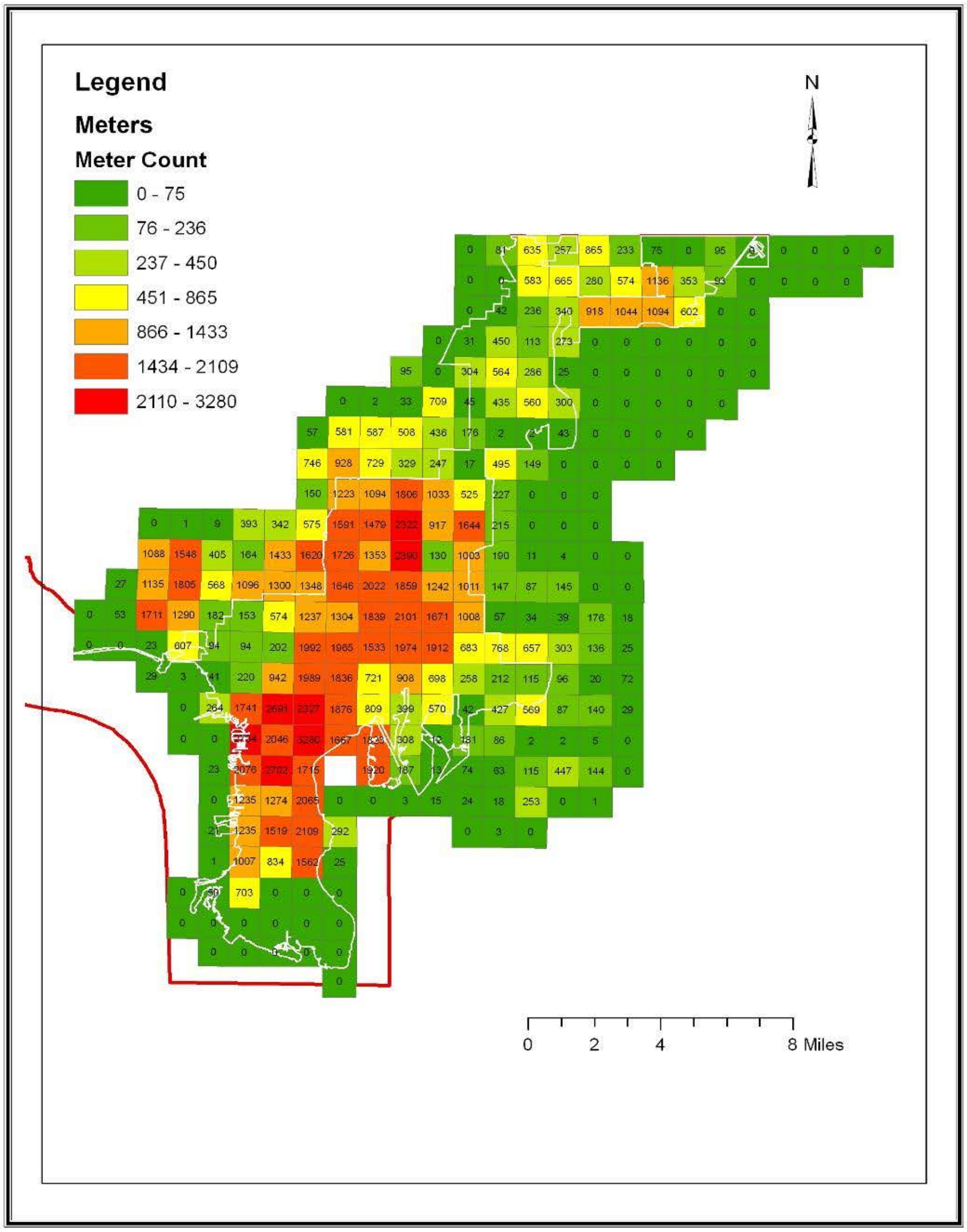


Figure 61. Meters by Section: Spatial Distribution of Customers

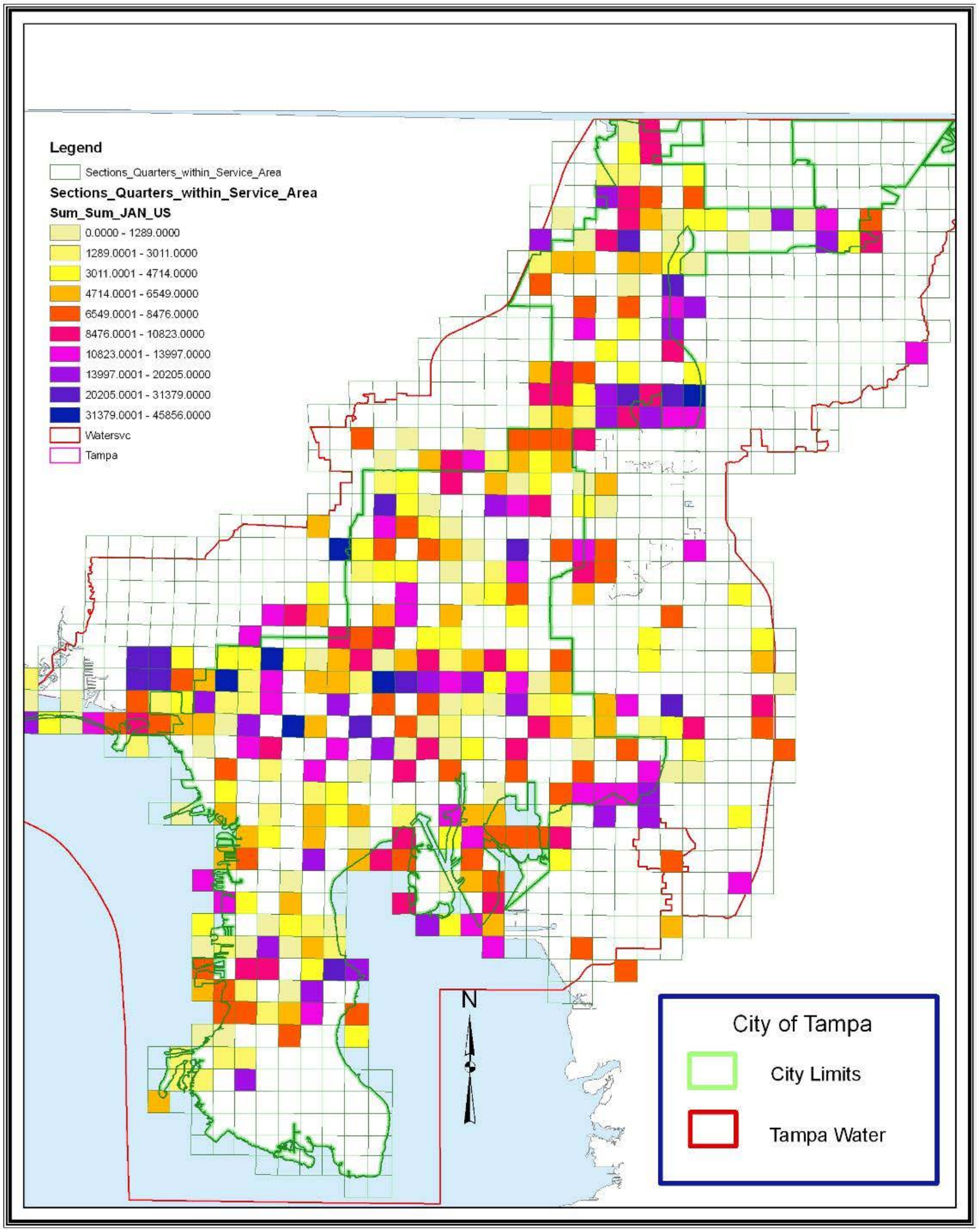


Figure 62. Water Usage by Section: Quarter

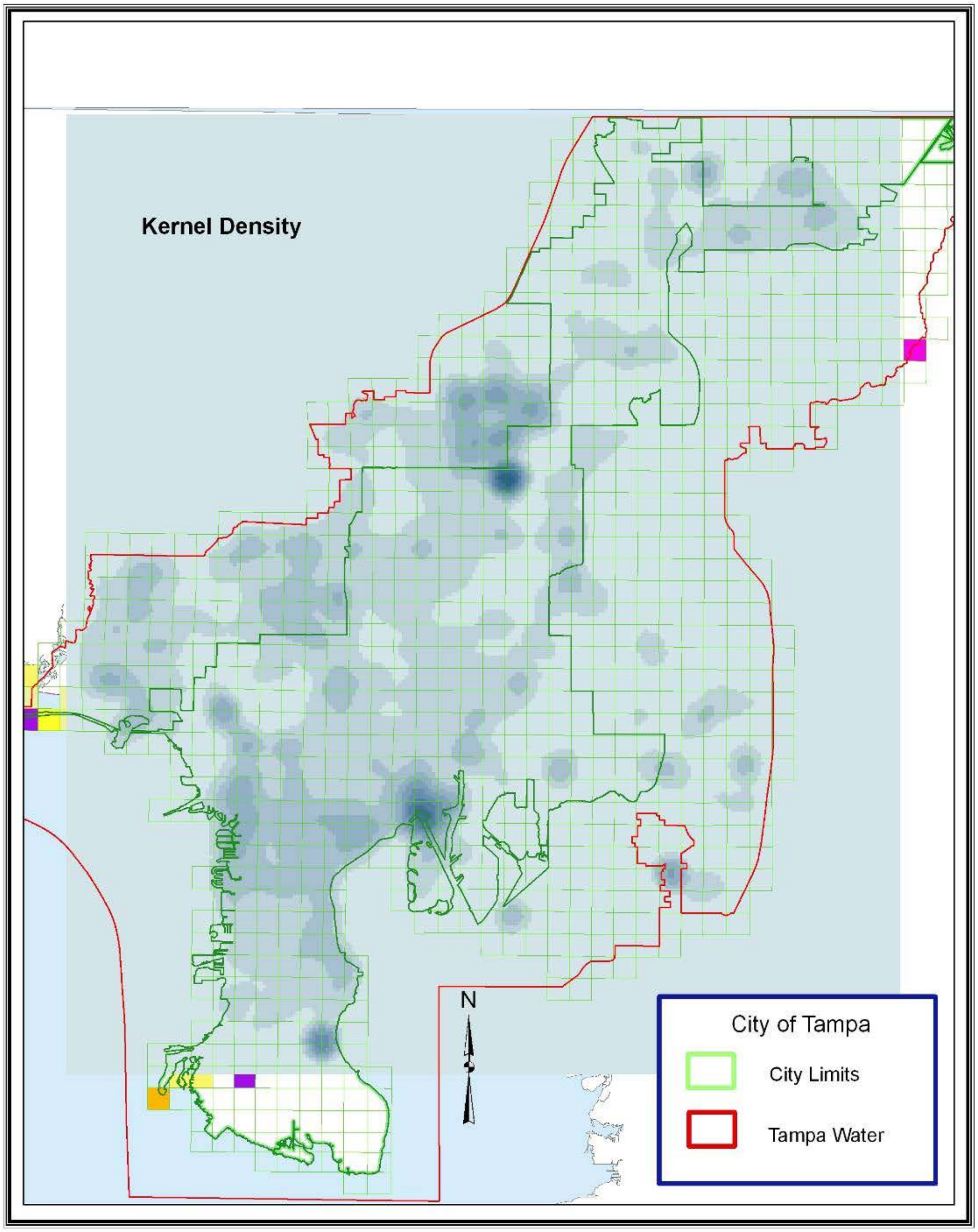


Figure 63. Critical Pressure Areas: Kernel Density

Water Quality Monitoring

The quality of the water is the most important topic in the process of delivering water to the community. Federal and local regulations are controlling the quality of the water and the community is highly sensitive to this point. Each day, regulations are more stringent and the community is demanding better product from the water utilities (U.S. Environmental Protection Agency 1997).

Safe drinking is fundamental to life, and history shows dramatic cases where water was the bridge to epidemic and mortal experiences. While effective treatment is crucial, the infrastructure that receives and conveys the water to the spatially distributed community is equally important.

The chemical process in the water starts in the water treatment facility but lasts all the way to the final consumer and goes to the final receptor of the wastewater. The physical components of the distribution network live a continuous and permanent deterioration process and are becoming vulnerable to many factors that may contribute to water deterioration.

During the transportation process, many diverse and complex biological, chemical, and physical events take place far from the direct inspection of the technical staff. Many of those processes result in loss of disinfectant residuals, increasing the risk of bacteriological failures (Lansey and Boulus 2005).

Reports about quality of water show the higher required frequency and demand permanent attention from technical and management staff. Figure 64 shows the spatial distribution of the chlorine residual, and Figure 65 shows the residual for fluoride.

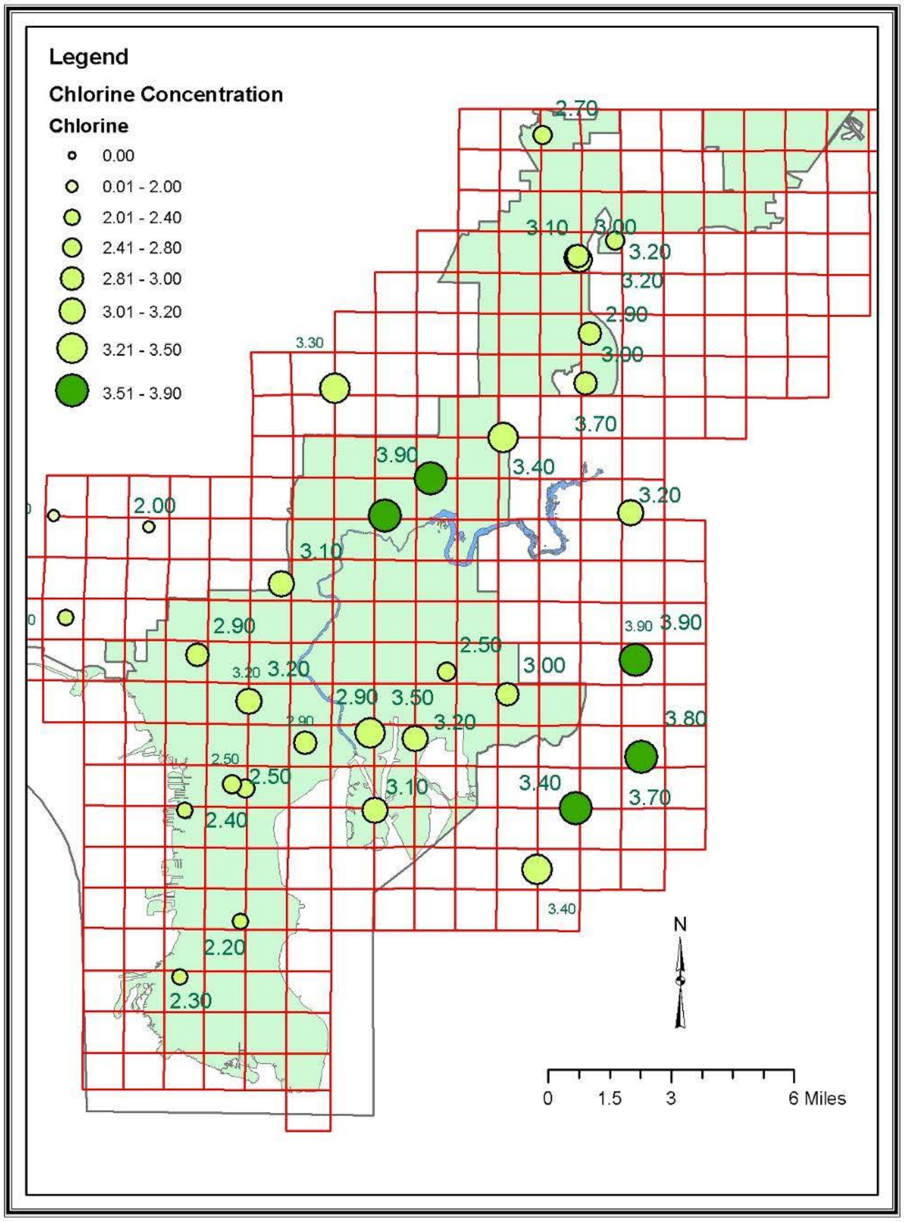


Figure 64. Spatial Distribution of Chlorine Residual

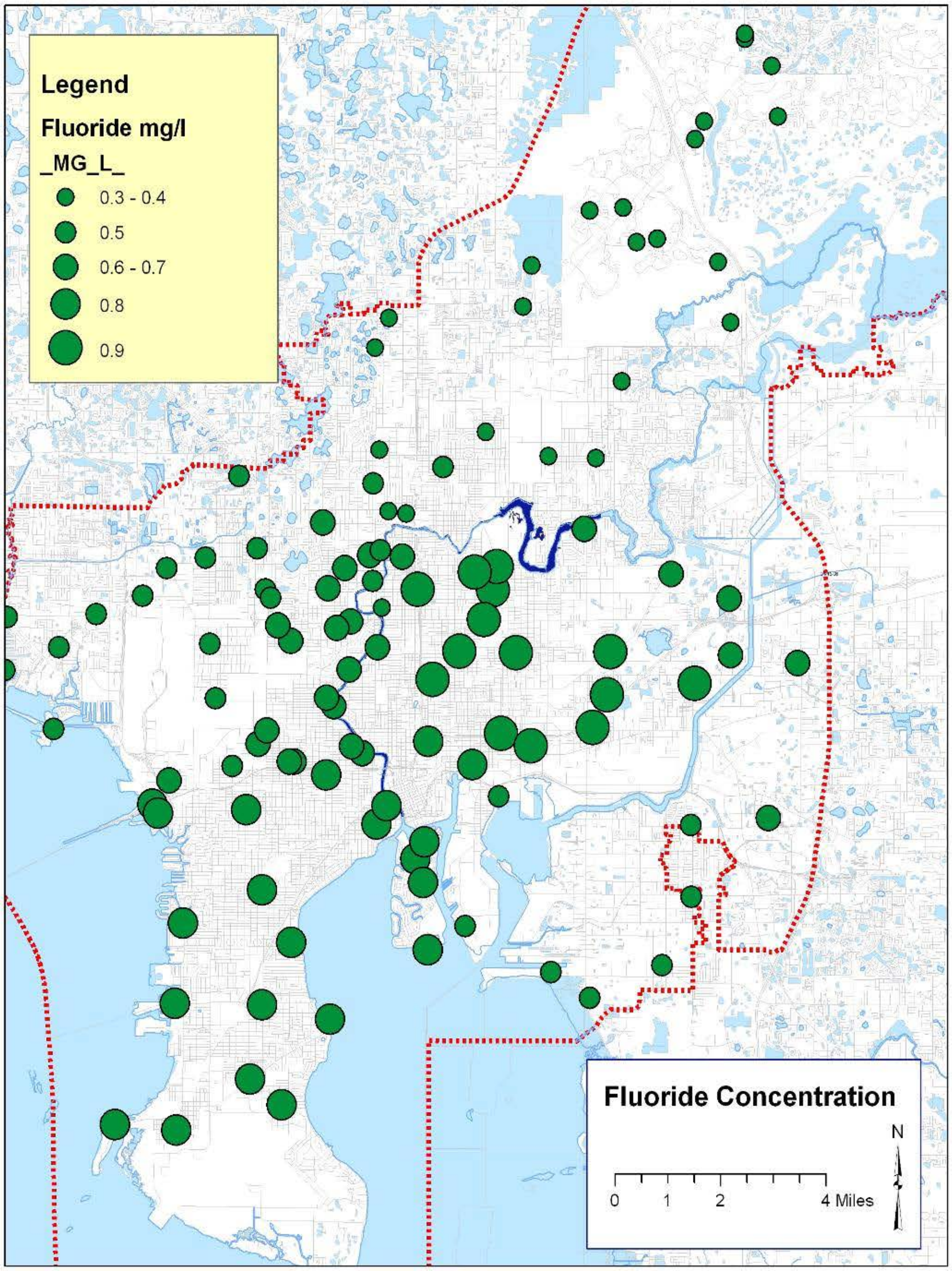


Figure 65. Spatial Distribution of Fluoride Concentration

Fire Protection Monitoring

The city of Tampa community is highly sensitive to fire protection and related municipal capabilities to face fire events. On May 2000, a terrible fire hit the historic zone of the city of Tampa (Figure 66). By the time the flames were extinguished hours later, the partially completed, 450-unit apartment complex called the Park at Ybor City and the Ybor City Post Office were destroyed. Property damage was estimated at $40 million—$30 million for the apartments (Tampa Tribune Online 2000).

Low capacity of the water mains to provide the required flow to extinguish the flames, the bad condition of fire hydrants, and poor regulations controlling building construction can result in fatal events with economic losses and threats to human life. The fire protection of the city is based under the supervision and direct control of the Fire Marshall Office and the design standards to provide hydraulic capacity to the distribution system. The fire hydrants require an appropriate spatial distribution in the city to protect all properties. Every fire hydrant should have appropriate pressure and flow capacity to support the tasks of the firefighters.

The second level of protection is the fire stations distributed throughout the city to minimize the response time in case of fire events. Many entities are related to a fire event, and all need to have a common source of information to have synergic action against the tragedy.

Figure 66. Devastating Fire Event Sweeps Ybor City
(Tampa Tribune Online, 2000)

Figures 67–69 show the degree of protection. The interactive application provides technical data about available pressure at every fire hydrant and how to operate valves to direct more flow to the point of the event.

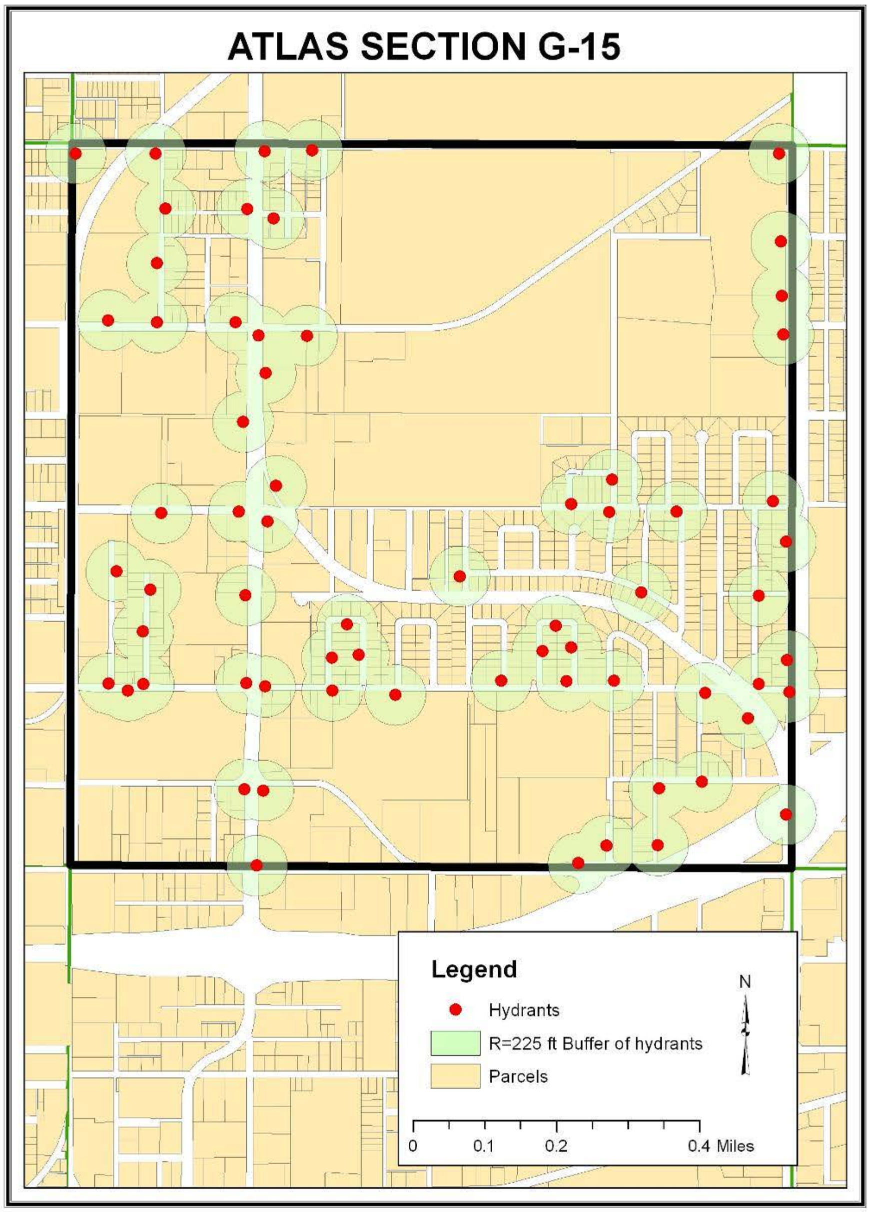


Figure 67. Fire Hydrants and Protected Areas by Section

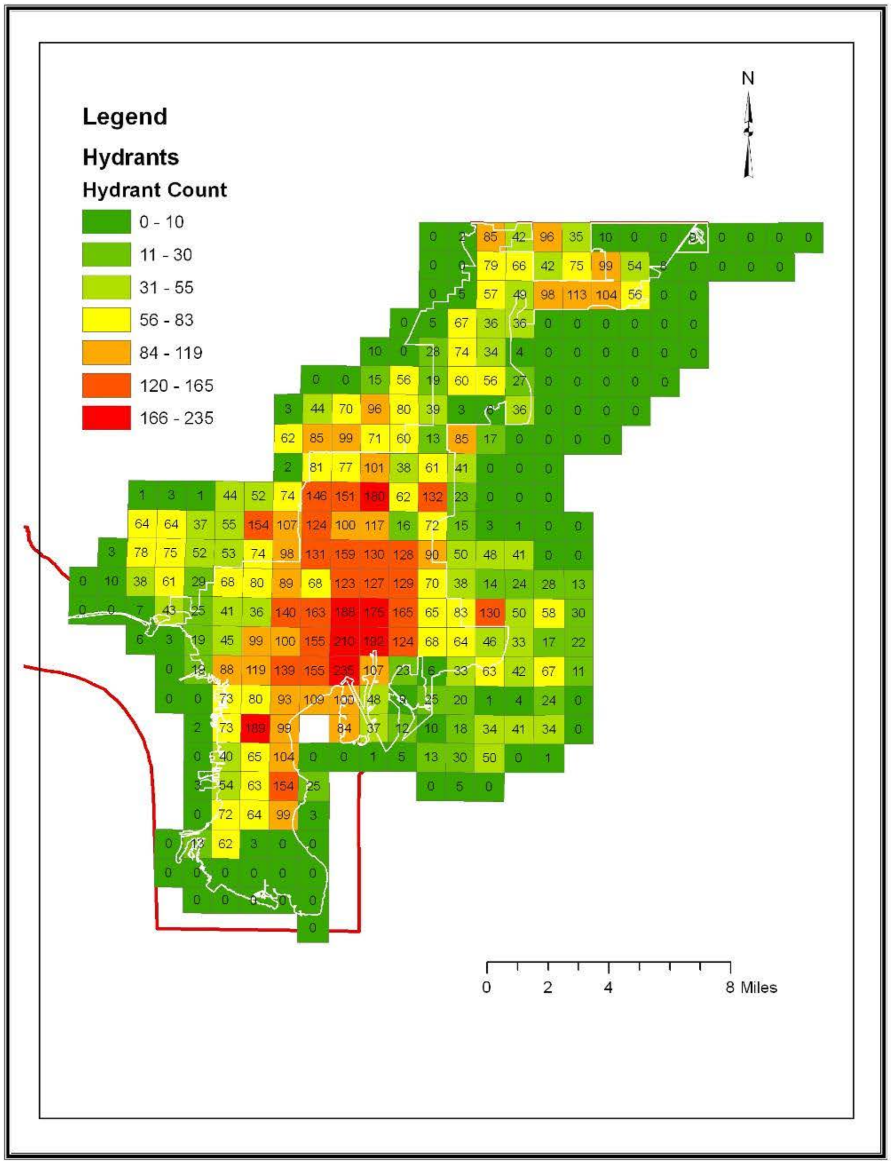


Figure 68. Spatial Distribution of Fire Hydrants in the Service Area

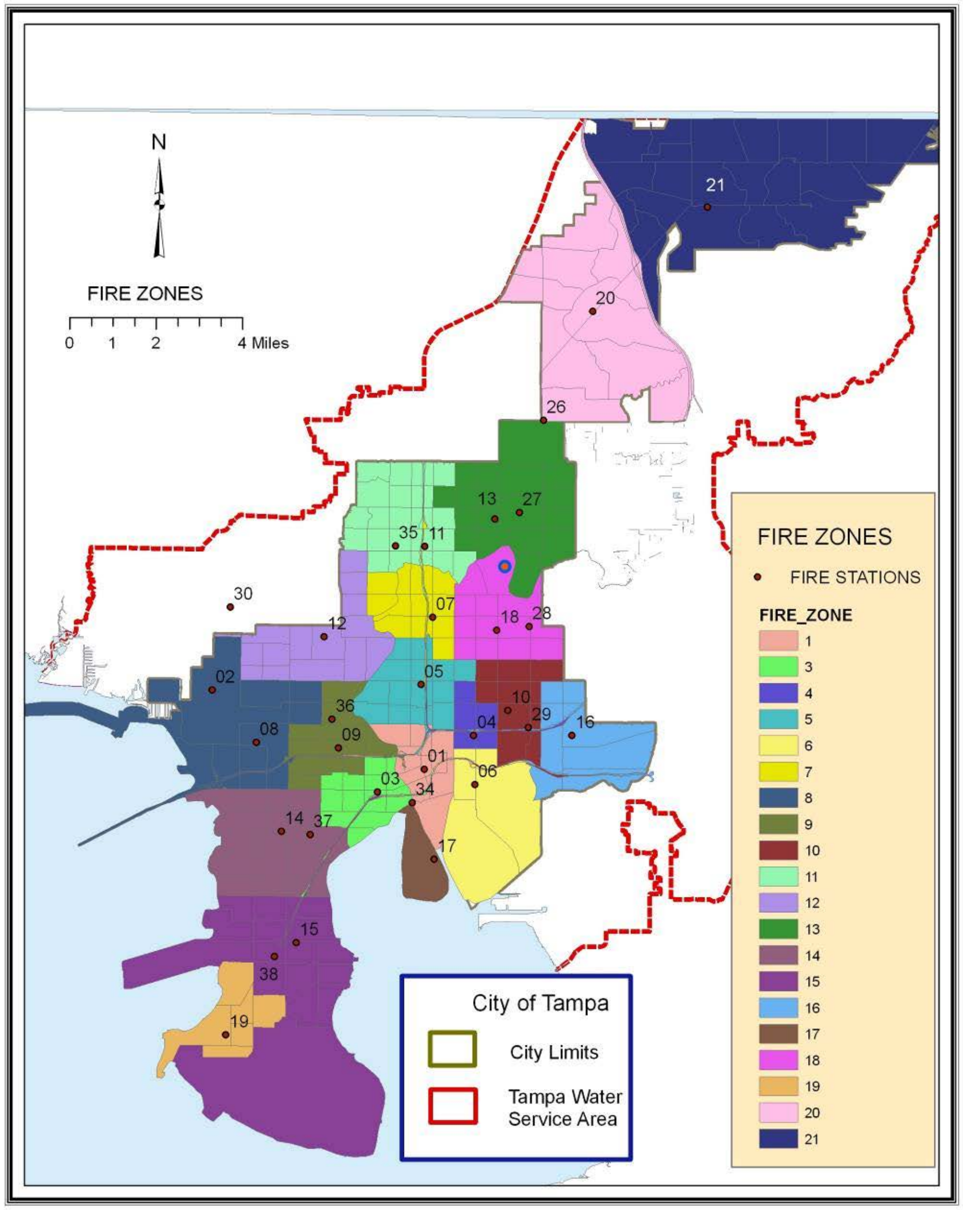


Figure 69. Fire Zones and Fire Stations in the Service Area

Fire Hydrant Preventive Maintenance

The fire hydrants require maintenance, and the city of Tampa has around 13,000 fire hydrants (Figure 70). The maintenance of this infrastructure is time consuming and demands many man-hours. Routine maintenance includes the following:

- greasing of the steamer cap threads
- replacement of gaskets
- corrosion protection
- repainting for the color codes of the fire hydrants
- exercising the valves to verify they are working properly
- cutting grass and removing objects around the fire hydrant

Lack of maintenance results in bitter experiences such as no flow or reduced flow in case of fire events, and citizens are very sensitive to this type of experience.

In the past, the department hired external contractors to accomplish the task of checking around 50 percent of fire hydrants each year. On March 2008, the City Council rejected a contract to hire a private company to inspect fire hydrants, saying that doing the work in-house could be less costly and help reduce the number of city employees who might be laid off (Tampa Tribune Online 2008).

COTWD suffered tremendous censure from the public and the media when a fire hydrant in Northdale failed when firefighters tried to battle a blaze in August 2007. The fire caused about $300,000 damage to the single-story, concrete block home and destroyed about $75,000 worth of contents (Tampa Tribune Online 2007). Figure 71 shows some details of the TV and newspaper publications about that event. The loss of image and trust among customers is evident.

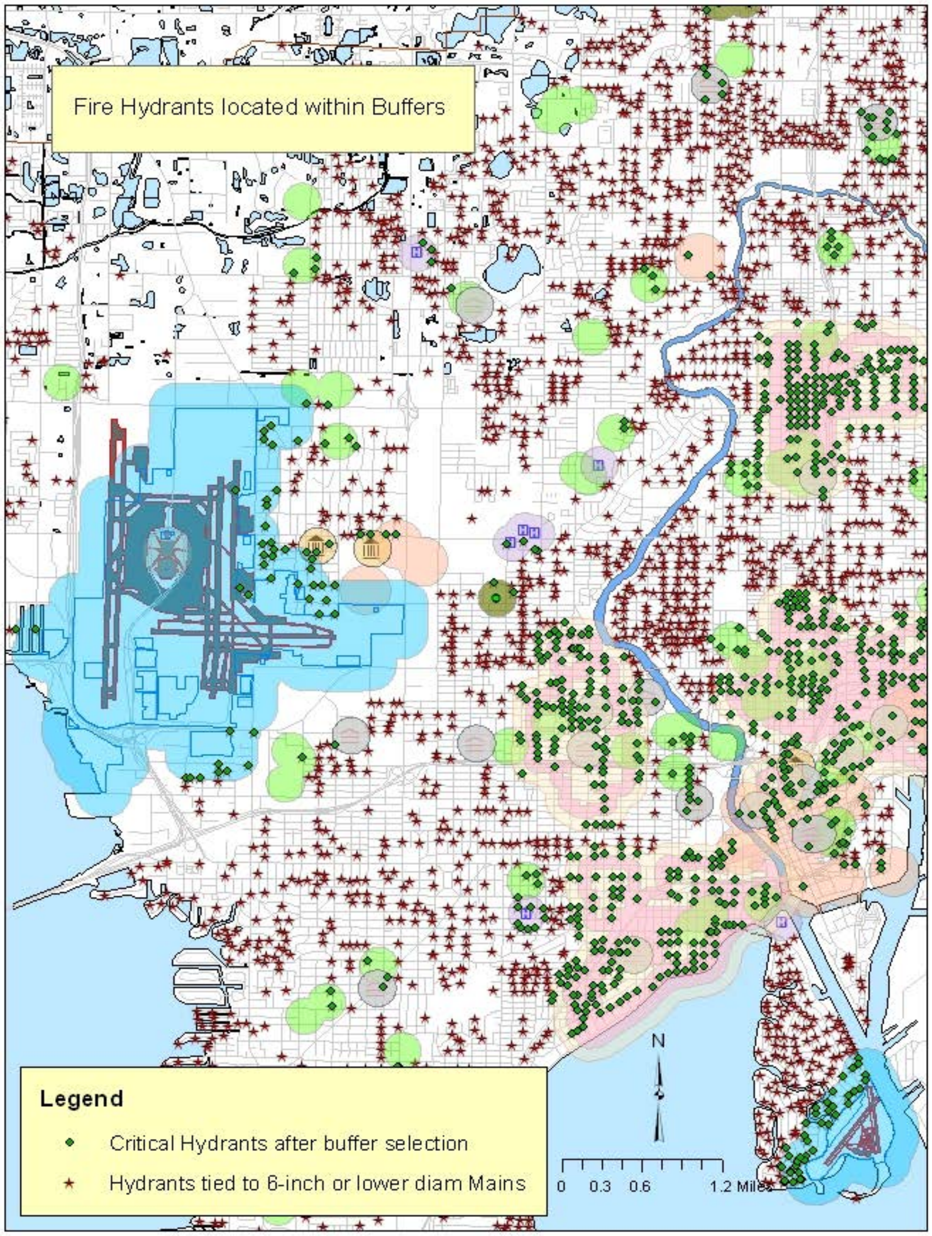


Figure 70. Fire Hydrant Coverage

Figure 71. City of Tampa Fails to Check Fire Hydrants
(Tampa Tribune Online 2007)

GIS-Based Solution

Due to budget restrictions and the need to be in compliance with state regulations, the Planning section decided to implement GIS-based fire hydrant preventive maintenance, selecting the critical units and reducing the risk of low performance of fire hydrants under fire events. The author proposed to design a GIS-based maintenance program based on the selection of critical hydrants to be inspected by the department. The author based his proposal on the methodology developed in Colorado Springs Utilities (Allender 2007), using some different parameters.

Methodology

The method for performing the analysis is focused on establishing the criticality of each hydrant based on five parameters. Each parameter was scored, and a composite score for each hydrant was calculated. These five criteria included the following:

Proximity to target hazards. This includes schools, universities, hospitals, prisons, libraries, museums, large commercial areas, and cruise ship terminals.

Hydrant flow capacity. This is assumed by the diameter of the main to which the hydrant is connected; 6-inch mains or less are considered to have lower capacity

Historic districts. These areas include old-fashioned buildings with poor fire preventive design.

Pressure issues. Those already identified areas with low pressure issues require fire hydrants in good shape and maintenance.

Density of population. (Single-family or Apartments)

Buffer Definitions

Schools and universities: 750 ft

Hospitals:	750 ft
Shelters:	750 ft
Special points:	1,000 ft
Airports and McDill:	1,000 ft
Historic districts:	1,000 ft
Libraries:	750 ft
Prisons:	750 ft
Large commercial areas:	1,000 ft

Selection of Critical Fire Hydrants for Maintenance

First step: Selection of those fire hydrants tied to 6-inch or lower diameter mains

Second step: Using the previous selection, apply buffers to reselect fire hydrants

Asset Management Plan

GIS enables asset and service management users to view the physical components in a geospatial context and therefore visualize the spatial relationship among managed assets and the rest of the infrastructure such as roads, buildings, and other related features in their environment (Halfawy *et al*. 2006). GIS can provide a framework to capture the performance of assets along time and to understand the physical relationships among the other components. Spatial trends along time are a strong base in the process about taking decisions. The analysis and visualization of geospatial patterns help to identify trends and forecast events and to focus the CIPs to those areas with higher probabilities of failure (Rostum 2000).

After the interviews already described in this work, all users have acknowledged the importance of the visual capabilities of GIS, especially in the case of critical assets. The visualization of events along time in a geospatial context provides intuitive diagnostics about trends, but it also allows the use of rigorous statistical tools to measure technically the real pattern and the chances of future events.

Since the available funds never are enough to meet all of the possible CIP and renewals needs, the adopted methodology is a risk-based approach to asset renewal. The basis of the risk-based prioritization of water infrastructure asset renewal is to categorize the installed assets according to their condition and the potential consequences of failures.

The risk-based methodology calculates, for every asset, the product of the structural condition score (a measure of the probability of structural failure) and the consequence of a failure score (a measure of the asset criticality). This resulting product can be used for every asset, including water mains and pumping stations.

Figure 72 shows the role of GIS in the steps of the risk-based methodology. The compilation of the asset information is performed during the population of the proposed Master Geodatabase. All the physical attributes are included in the table of attributes shown in Figure 73 and the Pressurized Main data set. The only modification we needed to do was to include a field for both scorings. The assessment of the overall factors has to be done manually using functional processes like distance, within buffer area, and so on, using the Spatial Analyst extension.

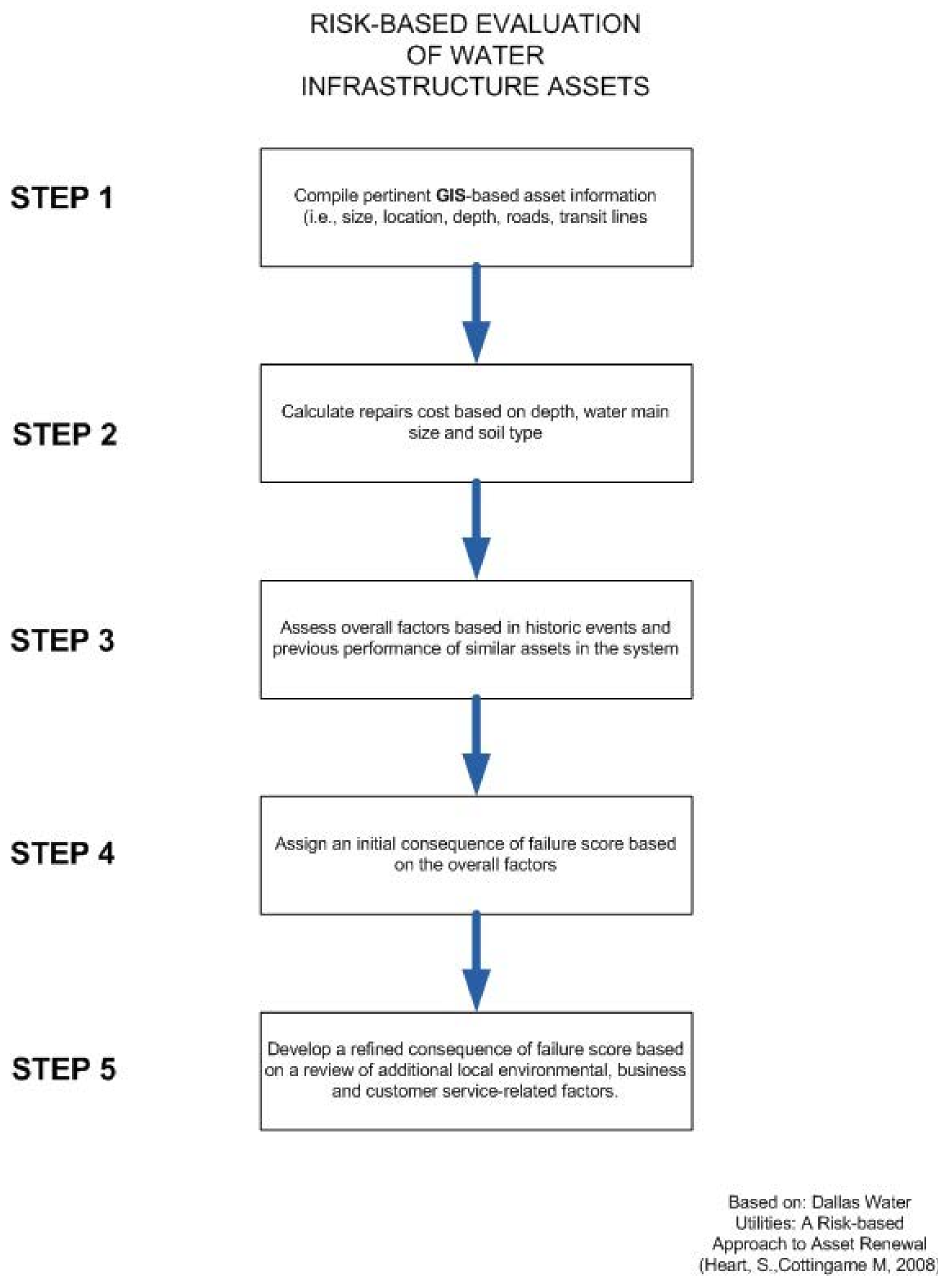


Figure 72. Risk-Based Asset Management

Name	Alias	Type	Length	Precisi...	Scale	Number Format
OBJECTID	OBJECTID	Object ID	4	0	0	
Shape	Shape	Line				
YEARINSTALLED	Year Installed	Long	4	0	0	Numeric
SUBTYPE	Subtype	Long	4	0	0	Numeric
MATERIAL	Material	Text	10	0	0	
POSITIONALACCU...	Positional Accuracy	Long	4	0	0	Numeric
COMMENTS	Comments	Text	255	0	0	
INSTALLEDCOST	Installed Cost (LF)	Double	8	0	0	Numeric
DIAMETER	)	Long	4	0	0	Numeric
SIZEDIMENSIONR...	Size Dimension Ratio	Text	10	0	0	
RECORDEDLENG...	Recorded Length (FT)	Double	8	0	0	Numeric
PRESSURERATING	Pressure Rating	Text	20	0	0	
DEPTH60	Deeper than 60"?	Short	2	0	0	Numeric
SOURCEDATA	Source Data	Text	25	0	0	
CROSSINGTYPE	Crossing Type	Short	2	0	0	Numeric
SUBMERGEDTYPE	Submerged Type	Short	2	0	0	Numeric
CASING	Casing?	Short	2	0	0	Numeric
Shape_Length	Shape_Length	Double	8	0	0	Numeric

Symbol	Value	Label
	<all other values>	<all other values>
	<Heading>	**SUBTYPE**
	4	Non-COT Potable
	1	Potable
	2	Raw
	0	Undefined

Figure 73. Attributes of Water Mains in the Geodatabase

Figure 74 shows the conceptual structure of the proposed asset management system. The upper step includes the GIS data collection and the condition assessment to implement the risk-based asset management system. These tasks, joined to the already presented performance indicators, set up the asset management system.

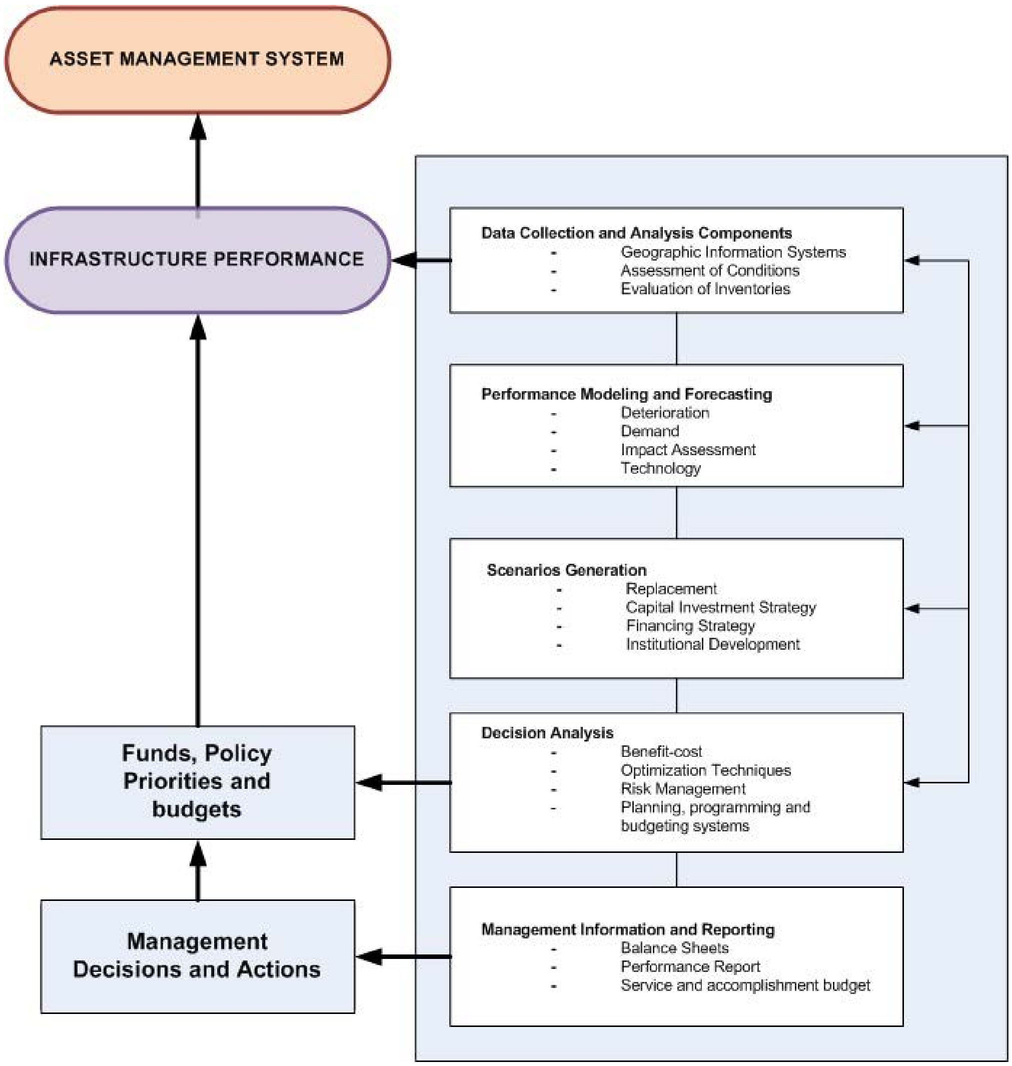


Figure 74. Conceptual Structure of an Asset Management System (Sidh and Tripathi 2006**)**

For water utilities, asset management is defined as managing infrastructure capital assets to minimize the total cost of owing and operating them, while delivering the custom service customers desire (Booth and Rogers 2001). The scoring, according to the risk-based methodology of the pipes, allowed the COTWD to select around 2,000 projects for asset replacement (Figure 75). The reports about pipe failures and quality complaints supported the prioritization of those projects and the life cycle of the assets as well.

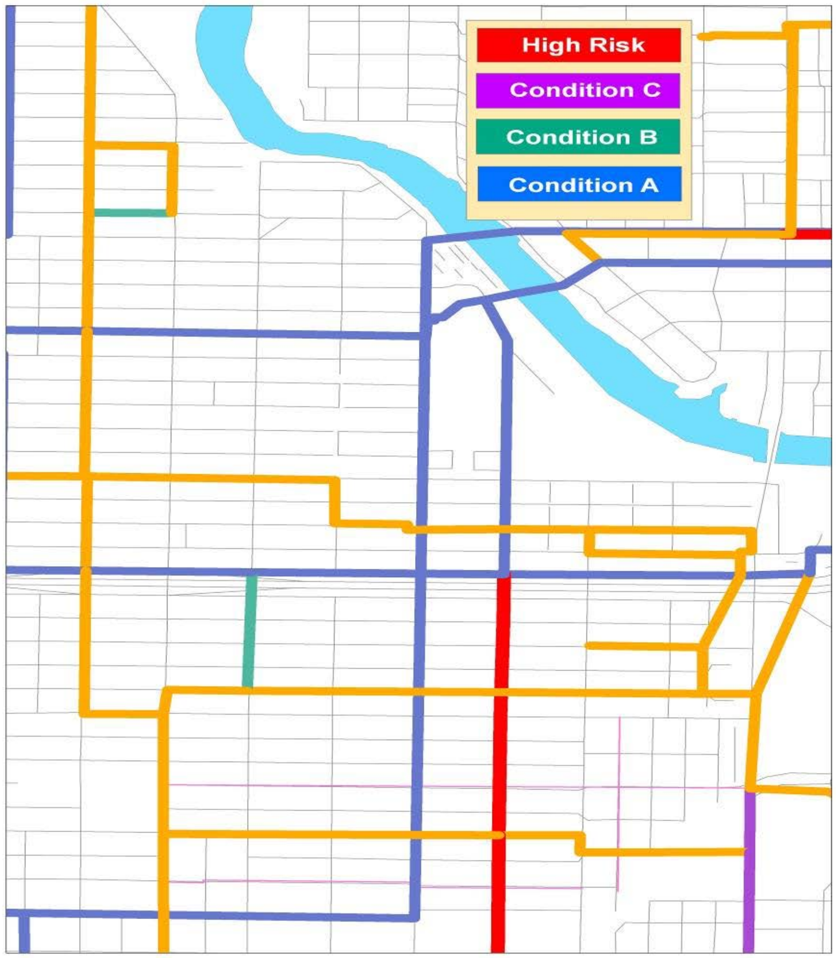


Figure 75. Tampa Water Infrastructure Assets after Risk Scoring

Figures 14 and 76 show the cycle of a CIP plan and the importance of the asset management system in setting up the CIP Master Plan. Basically, the Master Plan has to be based on a systematic reconciliation of technical requests and restrictions with the city budget and financial capacity of the community.

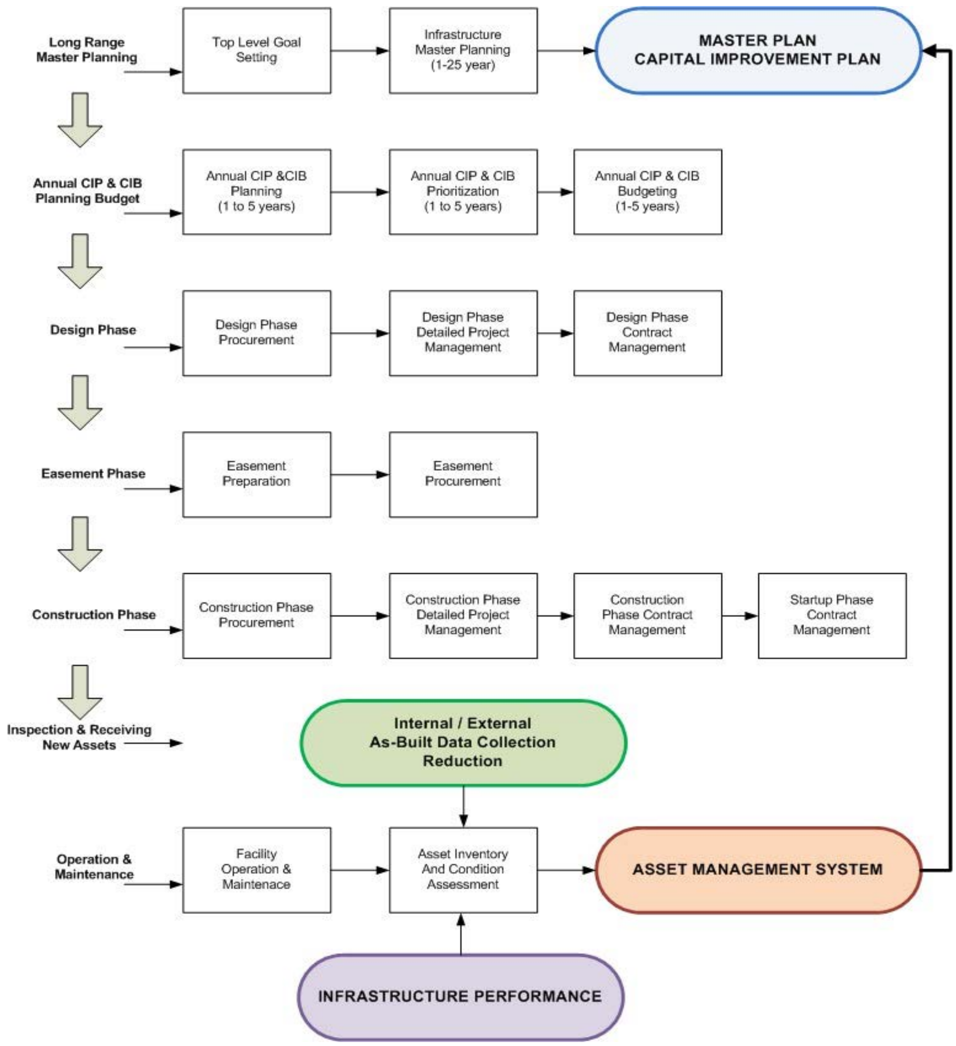


Figure 76. Conceptual Cycle of the Master Plan (Rundio *et al*. 2008)

The scale of the investment in water CIPs makes the decision processes the most important step in the future of the utility. Wrong decisions will be costly and very difficult to remediate. The Master Plan and the quality of the prioritization process are strongly based in the GIS already developed because the quality of the information will allow better informed decisions.

The selection of the project and the prioritization are strongly based on the asset management system, and in both plans, GIS plays a vital role. In the case of the city of Tampa, GIS will serve as a tool for tracking the status of all the projects under construction. The changes in the geodatabase coming from the renewals will be handled by the already set up plan to capture GIS data. The budget and the costs will be linked from a spreadsheet.

Figure 77 shows a general report of the current planned CIP in the long term (2007–2025). Figures 78 and 79 show a selected group of CIPs in section G-11. This is a very good report when customer or community groups ask about improvements in their neighborhoods. This data set will update the field of replacement cost, joining tables with the updated costs coming from accounting and the Financial Department. Figure 80 shows the spreadsheet that will become a table to be joined with the dataset based on the CIP ID.

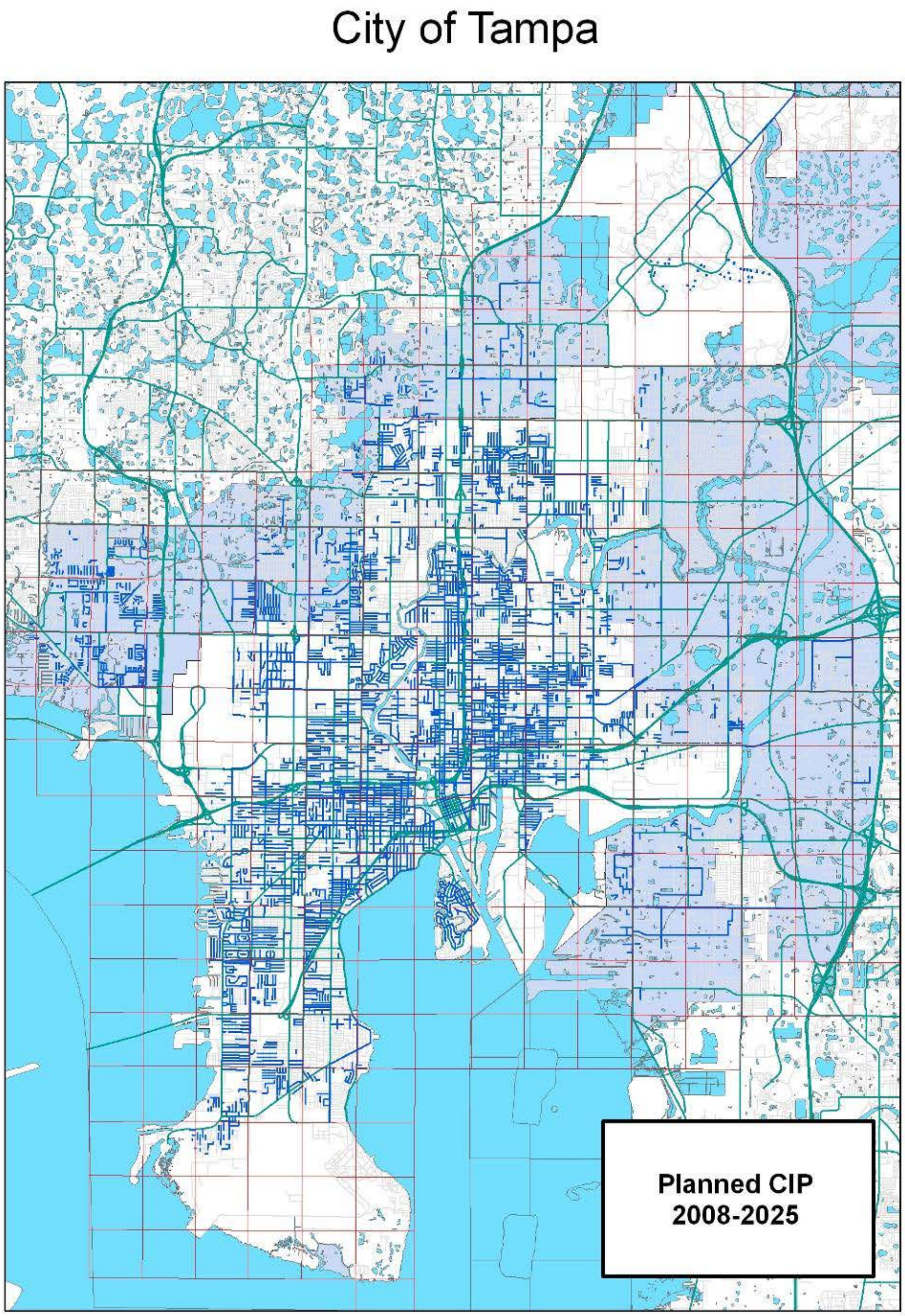


Figure 77. Planned CIP 2007–2025

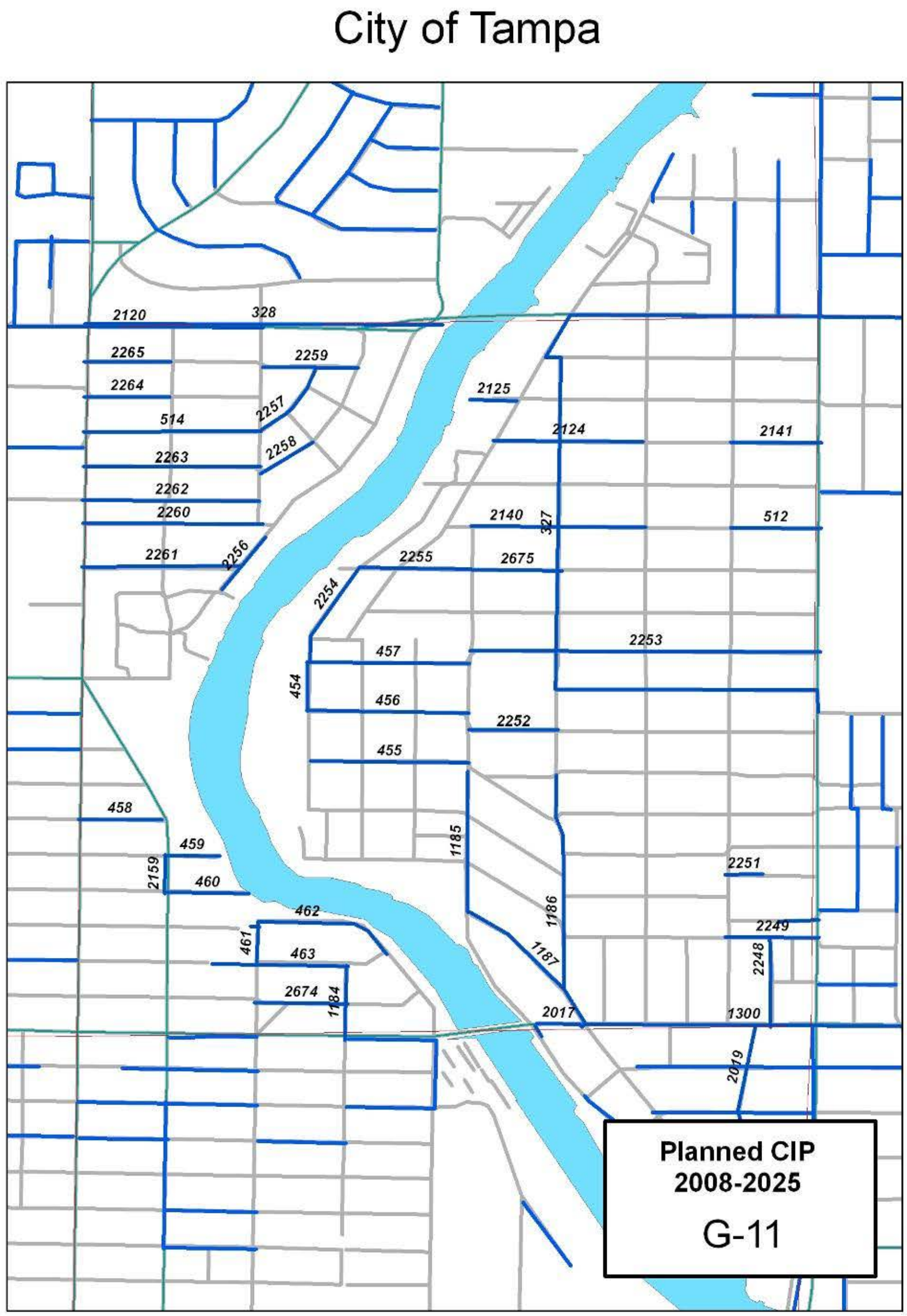


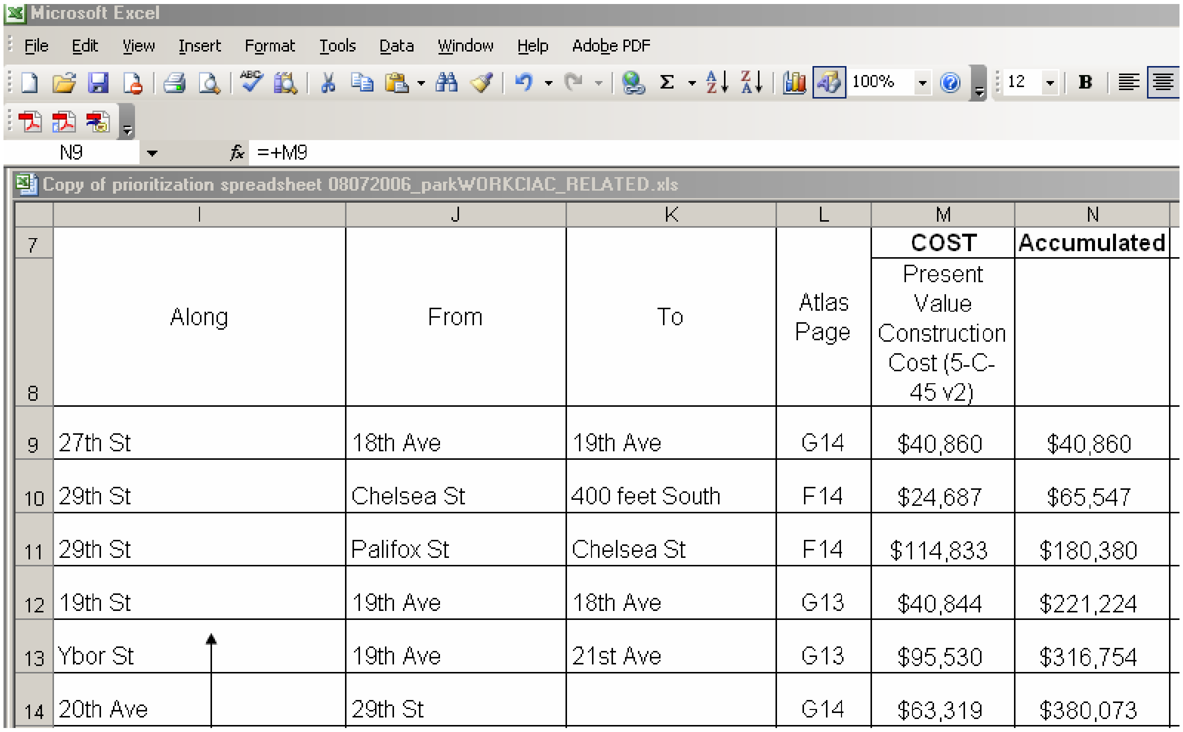
Figure 78. CIP 2009 Section G-11

Attributes of planned cip selection

PROJECTID	ALONG	PROGRAM	CIP_ID	TO	WORKORDER	ATLAS1	DIAMETER	FROM	LENGTH	PRIORITY21
0	Riverside Dr	UMR	162	70 feet South	0	H11	8	Columbus Dr	91.768793	
0	MLK & Oakdale	DEL	327	Woodrow Ave	0	G12	12	Ola Ave	8331.96787	
0	MLK Blvd	DEL	328	Armenia Ave	0	G11	16	Rome Ave	2683.871724	
0	Perry Ave	UMR	454	26th Ave	0	G11	8	Adalee St	364.0127	
0	Braddock St	UMR	455	Kinyon Ave	0	G11	8	Decatur Ave	1189.822025	
0	Adalee St	UMR	456	Kinyon Ave	0	G11	8	Perry Ave	1219.144076	
0	26th Ave	UMR	457	Kinyon Ave	0	G11	8	Perry Ave	1225.347037	
0	Dewey St	UMR	458	Howard Ave	0	G11	8	Armenia Ave	629.554016	
0	Abdella St	UMR	459	410 feet East	0	G11	8	Howard Ave	413.138938	
0	Ivy St	UMR	460	Albany Ave	0	G11	8	Howard Ave	623.732876	
0	Albany Ave	UMR	461	Rome Ave	0	G11	8	Aileen St	324.810433	
0	Rome Ave	UMR	462	Albany Ave	0	G11	8	Aileen St	1048.200316	
0	Aileen St	UMR	463	Fremont St	0	G11	8	Albany Ave	673.377948	
0	Ohio Ave	UMR	512	Myrtle Ave	0	G12	8	North Blvd	681.952373	
0	Kentucky St	UMR	514	Albany Ave	0	G10	8	Armenia Ave	1338.97428	
0	Fremont Ave	UCIMR	1184	Aileen St	0	G11	6	Columbus Dr	559.317635	
0	Kinyon Ave	UCIMR	1185	Braddock St	0	G11	6	Ridgewood St	1055.818115	
0	Oakdale Ave	UCIMR	1186	Columbus Dr	0	G11	6	Braddock St	1933.024469	
0	Ridgewood Ave	UCIMR	1187	Oakdale Ave	0	G11	6	Riverside Dr	945.114386	
0	Columbus Dr	UCIMR	1300	Riverside Dr	0	H12	12	Highland Ave	3500.676671	
0	Columbus Dr	UMR	2017	Ridgewood Dr	0	H11	8	Riverside Dr	343.42038	
0	Glenwood Dr	UMR	2019	Columbus Dr	0	H11	8	Ross Ave	1317.094076	
0	MLK	UMR	2120	Albany Ave	0	G11	6	Habana Ave	2630.422968	
0	Kentucky St	UMR	2124	Poplar Ave	0	G11	8	Ridge Ave	1124.487462	
0	Virginia St	UMR	2125	355 feet West	0	G11	8	Ridge Ave	353.614752	
0	Ohio Ave	UMR	2140	Poplar Ave	0	G11	8	Kinyon Ave	1313.67219	
0	Kentucky St	UMR	2141	North Blvd	0	G12	8	Myrtle Ave	684.126339	

Record: 0 Show: All Selected Records (0 out of 51 Selected) Options

Figure 79. Table of Attributes of CIPs in Figure 78



Microsoft Excel

File Edit View Insert Format Tools Data Window Help Adobe PDF

N9 =+M9

Copy of prioritization spreadsheet 08072006_parkWORKCIAC_RELATED.xls

	I	J	K	L	M	N
7					COST	Accumulated
8	Along	From	To	Atlas Page	Present Value Construction Cost (5-C-45 v2)	
9	27th St	18th Ave	19th Ave	G14	$40,860	$40,860
10	29th St	Chelsea St	400 feet South	F14	$24,687	$65,547
11	29th St	Palifox St	Chelsea St	F14	$114,833	$180,380
12	19th St	19th Ave	18th Ave	G13	$40,844	$221,224
13	Ybor St	19th Ave	21st Ave	G13	$95,530	$316,754
14	20th Ave	29th St		G14	$63,319	$380,073

Figure 80. Cost of Projects

A very important capability is the fact that these CIPs can be contrasted with other kinds of infrastructure projects like pavement (e.g., Figure 81), energy, cable, gas, and so on. The coordination among the execution of diverse projects has resulted in substantial savings for the city. Citizens used to complain about projects each year digging up and repaving the streets without any kind of coordination.

Customer Service

Communication with customers is of paramount importance for water utility management. The customers are distributed over the entire service area and are the first judges of the output of the water system. The city has to guarantee good communication with citizens and pay special attention to their complaints and requests.

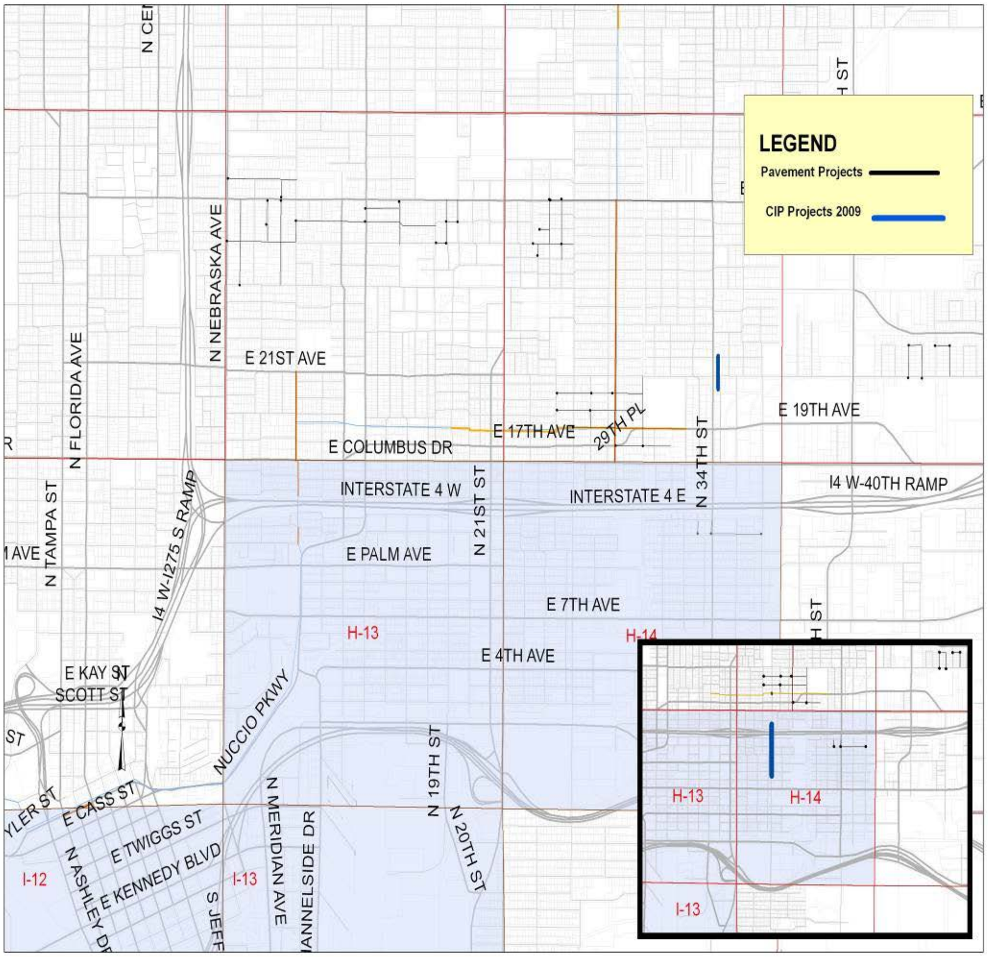


Figure 81. Pavement Projects and Water CIP

In the COTWD, customers are like an extension of the sensors, and they detect failures of or suspicious activities around water infrastructure assets. The big problem with communication is the lack of a standard language to describe what customers perceive. This problem makes it almost impossible to process the data using statistical tools. It is quite difficult to have a common definition of many issues among different types of customers.

The city of Tampa has decided to implement a program centralizing the calls to a unique center for all the departments. The COTWD has been assigned to provide a standard list of key words and definitions to facilitate the capture of verbal data and has proposed assigning a code to every water bill, using the section quarter code. In that way, the customer can identity the zone in a reduced area of the geographic service area. The COTWD has adopted the proposed check sheet (Whelton *et al.* 2007) shown in Figure 82. The second proposal to the calling center was to gather the possible communications in groups with the most frequent call cases. The only proposed change is the inclusion of a code based on the section of the calling source.

The calls were proposed to be grouped into the list provided by the same author (Whelton *et al*. 2007). We tested that proposed grouping, and it was appropriate for 88 percent of the calls; 12 percent of the calls had to use the category miscellaneous.

The second suggestion is to route the referrals in some specific cases almost in real time to given divisions. Suspicious activity and water quality around specific and strategic areas such as air bases, fuel deposits, and so on, deserve coordinated attention with other organizations.

The following are the proposed groups for the calls:

SUSPICIOUS ACTIVITY

OPERATIONS

- Facilities
- Pressure

WATER QUALITY

- Appearance

PWSID No. 000000000

Water Plant #: (000) 000 - 0000
Customer Service #: (000) 000 - 0000

RECEIVING INFORMATION

Customer Name:	Date:	Follow-Up Needed? Yes / No
Address:		Go to Work Order
Telephone:	Time:	Department Notified? Yes / No

CODING

OPERATIONS

FACILITY ISSUES

√	Descriptor
	Hydrant
	Storage Tank
	Intake
	Building
	Fencing
	Other

PRESSURE ISSUES

√	Descriptor
	No Water
	Low Pressure
	High Pressure
	Other

WATER QUALITY

APPEARANCE ISSUES

√	Descriptor
	Cloudy / Milky
	Rusty
	Floating particles
	Settling particles
	Red / Brown
	Black
	White
	Green / Blue
	Other

WATER QUALITY

TASTE AND ODOR ISSUES

√	Descriptor
	Sweet
	Sour
	Bitter
	Salty
	Metallic
	Earthy/Musty
	Septic / Sulfur
	Chemical / Medicinal
	Chlorine / Bleach
	Gasoline
	Other

ILLNESS ISSUES

√	Descriptor
	Skin / Rash
	Diarrhea/ Stomachache
	Headache / Dizzy
	Fever / Flu
	Cough / Breathing
	Bleeding
	Vision / Speech
	Other

WATER QUALITY

MISCELLANEOUS ISSUES

√	Descriptor
	Pet / animal
	Stains
	Scale / spots
	Plant / garden
	Other

SUSPICIOUS ACTIVITY

COMMENTS

(additional description space should be available on backside of paper)

Water Investigation ID No. 000000000

Figure 82. Check Sheet for Incoming Calls
(Whelton *et al.* 2007)

Taste and odor

Illness

Miscellaneous

OTHER

Inquiry billing

Meter reading

CHAPTER 9

APPLICATIONS AND CONCLUSIONS

Future Work and Further Applications

In this thesis, the author has shown several different applications that have proven to be useful in the management practice of a water distribution utility. However, there are some other applications and enhancements that need to be developed in the near future to have an efficient GIS.

One important area that requires advanced technology and third-party solutions is the hyperlink between each component of the water distribution system and all the stored data such as scanned hard copies of drawings or exhibits, surveying records, and mail and e-mail correspondence related to each element.

Other areas mentioned by maintenance staff are the possibility to store in the GIS database photos of the assets and the catalog of pieces for maintenance purposes. There are some experiences under study. Charlotte County and their consultant firm Malcom Pirni Inc. has developed a GIS model (Simmons *et al*. 2008). Instead of managing the assessment data of assets in the water treatment plants, using stagnant spreadsheets and word processing software, the data were managed in an Access Database (Db) and GIS so that the data could be easily plugged into a larger asset management system. The CAD drawings have been used as visual backdrops. This is a model that the author would like to develop in the COTWD. In this case, the asset information has been imported into ArcReader and can be deployed easily among crews.

Conclusions

All water utilities need to refine their planning tools to successfully face budget restrictions and conflicts between growing water demand, while facing dwindling supplies. GIS has all the tools and capabilities to enhance the management techniques of water utilities, optimizing the use of scarce resources and reaching cost-effective solutions in daily operation.

The COTWD has started to optimize technical data flow and is saving money in many processes. At the same time, the COTWD is providing substantial contributions to the City GIS Plan and serves as a pilot model for other city organizations.

Some emergencies that occurred during the elaboration of this work were metusing geospatial data and cartography from the GIS base map. Crews worked more efficiently and everybody understood quickly the nature and implications of the problem. Engineers felt more comfortable during the decision process in trying to delimit the crisis to specific areas and protect the rest of the service area. The analysis of alternatives and impact evaluation were strongly supported by the geodatabase and the GIS-customized reports.

COTWD has gained a better understanding of geospatial queries. The technical staff is able to more precisely locate fittings in response to water main failures, the most common incident in the COTWD system, and to monitor any breakage and perform maintenance operations like unidirectional flushing. COTWD GIS users have recognized the power of GIS to meet their information requirements and are now proposing ideas for other possible information products.

Water supply systems and water consumption are spatial-based systems where inputs and outputs are placed in the environmental resources. Locations and relative position play an important role in the management process. In water supply systems, the first law of geography is quite evident: “everything is related with everything else, but near things are more related than distant things” (Tobler 1970, p. 3).

Geographic information is playing a crucial role in water management because it provides innovation and strong tools for planning, performance monitoring, and life cycle asset management. The vision in the water utilities management field includes an environment where financial, asset performance, and physical components information are available for technicians and management staff in real time. GIS is the hub for different technologies to reach that envisioned scenario.

GIS helps to interchange experiences around the world and is basically a technical language that overcomes multiple barriers and promotes international collaboration in water asset management. GIS can provide scalable solutions from the very local environment with desktop solutions to Web-based solutions, including enterprise and citywide applications. In the COTWD, geospatial data from GIS integrates well with other mainstream business information deliveries (SCADA and IT systems).

Contributions

The most important contribution of this thesis to the COTWD is the change of perception about GIS at the management level. GIS practice has moved beyond mapping and now supports business processes. The planning process has been enriched by the technical use of data to support engineering decisions in the short and long terms.

Engineering has a new vision of the entire distribution system and understands better the spatial relationships of the components.

The geostatistical analysis has allowed the engineers and managers to understand the trends of some processes along time and through the space of the service area. The asset management process has been empowered, and now technical staff use a rational approach for the replacement of mains and other components of long life cycle.

GIS practice has improved communication and coordination with other areas of the city and favored the integrated analysis of many infrastructure projects. Pavement projects; sewer and storm sewer projects; and gas, electrical, and cable projects can be analyzed in a common frame to reduce conflicts and save money. The winner is the customer because the customer is less affected by the normal infrastructure projects, and the service improvements are performed at a smoother pace. Finally, but not least important, the proposed report is a model for the other departments and for the coordinators of the GIS Master Plan in the city of Tampa.

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APPENDIX

UNIVERSITY OF SOUTH FLORIDA PROPOSAL

Based on a previous agreement, and aiming at only the asset management process, the city of Tampa requested from the University of South Florida (USF) a proposal to create a geodatabase to manage the assets of the water distribution system. The author of this thesis work proposed fundamental changes to the geodatabase design to accomplish the following:

- integrate other needs, such as hydraulic modeling, replacement/refurbish planning processes
- facilitate input data from different sources (contractors, consultants, internal departments)
- facilitate crossing queries involving other geodatabases from other systems like the Department of Transportation, storm sewer, Planning and Zoning, wastewater, and so on

The work to be performed by the USF is important to improving the connectivity of the water mains. The CAD data have been developed using the TRSs by different technicians, and this has resulted in many alignment problems. This is the opportunity to fix those bugs. The USF proposal did not include any vertical data and was not accepted by the author of this work because of the following issues:

1. Underground infrastructure is reaching higher densities. Under public areas, there are many different systems, including storm sewer, sanitary sewer, TV cabling networks, gas networks, electrical wires, and so on. The chances of conflicts during the installation/refurbishing activities are high and difficult to

handle. It is quite important to include vertical data of all the assets in the distribution system, and the same rule should be applied to the other underground infrastructure.

2. This is the right moment to adopt the new elevation system NAVD88. Although federal and state agencies are switching their vertical datum of 1929 (NGVD29) to the North American Vertical Datum of 1988 (NAVD88), the city has been delaying the adoption of this new system, and that implies error in some engineering projects.
3. By making this change, the city of Tampa would benefit from more accurate and consistent data and improved communication with other agencies. Since there is no direct method of conversion between these two systems because the two ellipsoids are not concentric, the author developed a grid of key points and calculated the difference between the two systems at each one of those points. The selected points were the centroids of the sections. Based on the geographic coordinates of each point, the author used the VERTCON (http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html) application from the National Geodetic Survey Web site to find such values.
4. Hillsborough County has already made the calculation of the NAVD88 elevations for all the benchmarks of the county system (http://data.labins.org/2003/XtraData/county/hillsborough/).

Another additional requirement to modify the USF proposal was the need to be more consistent with the proposed regional models of other counties and cities in the West Florida State Plane Coordinates group. The objective is to have a unique GIS water infrastructure template and use the same vertical datum for all the infrastructure projects within that group that have diverse interconnection points.

Water Department Asset Digitization Protocol Living Document

Last Updated By: Williams, Cheran 5/2/2008) @ 5:43:30 post meridiem

Data Stream Specific Protocols

A consolidated Water Department GIS asset inventory will be created from multiple sou rces of existing data and maps. The flowchart below (Figure 1) provides an illustration of the different data streams as well as the contact person responsible to answer any ques tions. Each individual data source is described briefly in the section below.

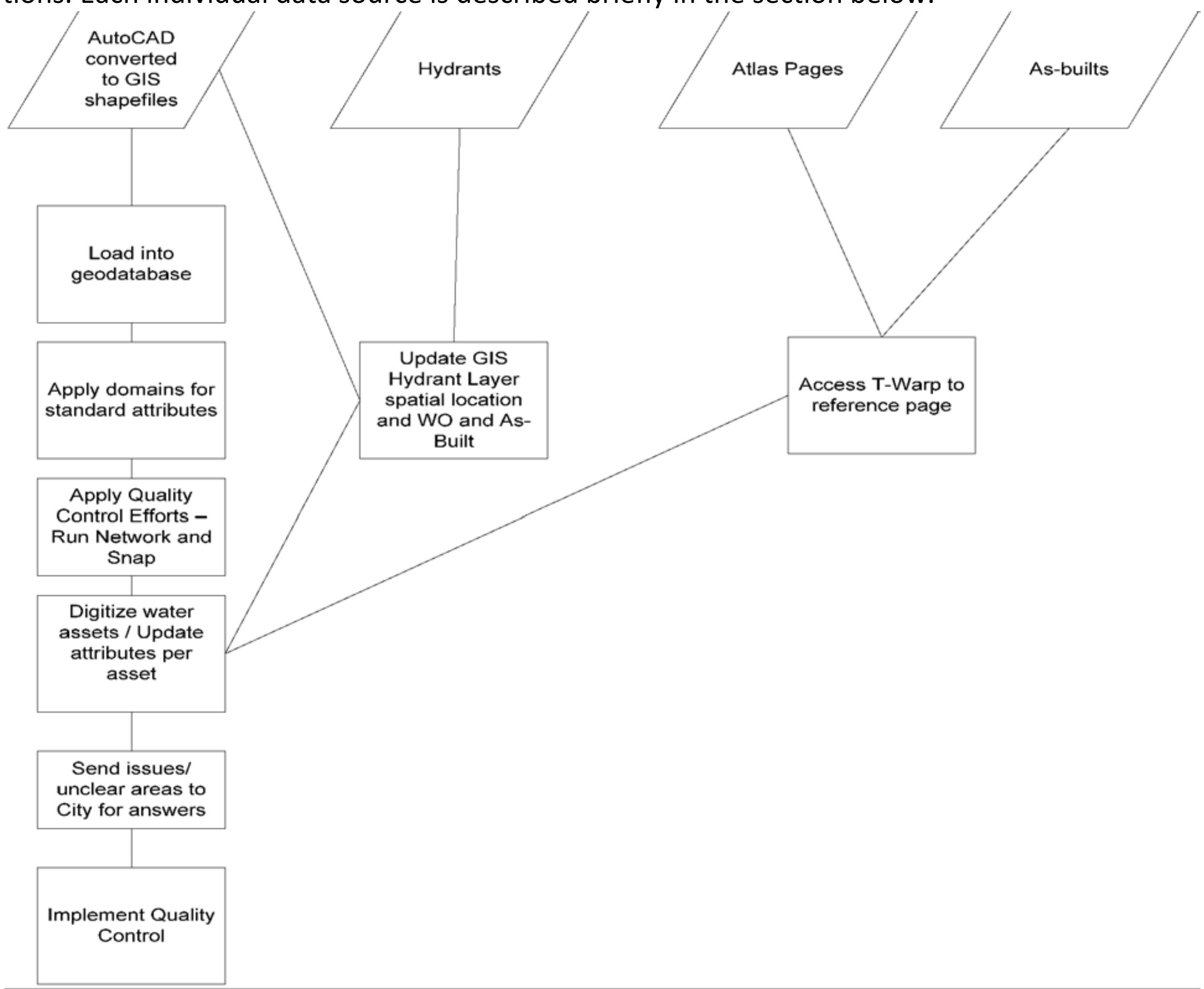


Figure 1. Generalized flowchart of work efforts related to each data stream.

Existing AutoCAD Data and GIS Layers

Over 40% of the City of Tampa AutoCAD data has been updated by Tampa; areas to the s outh of atlas pages D
have not been updated by Tampa. Munsys has exported the existing AutoCAD data into a compatible GIS format. The University will convert these data to the standardized data di ctionary and utilize as the starting point for all asset information. Efforts will be required t o ensure the accuracy and completeness of these data, as well as to mer
ge with data digitized from Atlas Pages and As-built documents and a separately maintain ed GIS hydrants layer.
The following guidelines will be used to convert the AutoCAD data to a final GIS format:

- The University will import all Munsys derived shapefiles or City provided shapefiles into a file geodatabase (108,268 SPWatNode originally sent to USF; 87,117 SPWatPipe).

- The University will digitize water pipes, hydrants, water meters, valves and other asset s that did not export
from the AutoCAD file, particularly the detailed areas that are called out.

- Data will be cleaned up by moving lines and points to establish connectivity.

- The hydrant layer will incorporate AutoCAD attributes, e.g. as-built number

- The AutoCAD atlas pages will be referenced during digitization. Other reference layers such as high-resolution
aerial imagery and road centerlines will be used to assist with spatial accuracy.

- Vaults and casings will be converted to polygon features.

- Digitization will occur one Atlas page (i.e. section) row at a time moving from East to W est beginning in the North areas of the City of Tampa boundary and moving south.

- Digitization/tabulation will start with the system output (residence, building) and work to the
mains which run along major streets. Digitization from Atlas Pages and As□Built docum ent

As-Built documents will be used for any areas where there have been changes to the sys tems since the atlas pages were produced. This situation is common in areas of new con struction. As-Built documents will also be used to clarify any unclear atlas page data or A utoCAD data. For purposes of standardization, the symbology used during digitization ha s been established in advance and will be used by all staff members (see Figure 2).

Figure 2. Symbolization to be used during digitization.

The following guidelines will be used to digitize data to a final GIS format:

•The University will digitize water pipes, hydrants, water meters, valves and other asset s that did not export from the AutoCAD file, particularly the detailed areas that are called out.

• Call-out areas were captured by AutoCAD, but need to be spatially aligned in their corre ct location.

•The AutoCAD atlas pages will be referenced during digitization. Other reference layers such as high-resolution aerial imagery and road centerlines will be used to assist with spatial accuracy.

• Vaults and casings will be converted to polygon features.

•Each digitizer will only be responsible for the assets within their assigned TRS, e.g. the digitizer will break the pipe to snap to the asset within their TRS and will update the pipe attributes but will not continue to digitize the system if it continues into someone else's assigned TRS.

• New assets, e.g. corpstop on double detector check valves, need to have the as-built an d work order number populated from the surrounding assets

Data Dictionary

The GIS asset inventory includes many objects and attributes important for the manage ment of Water Department operations. Asset objects include water pipes, hydrants, wat er meters, valves of multiple types, reducers, caps, tees, sleeves and other assets.
The attached Tampa Water Geodatabase data dictionary PDF file provides detailed infor mation about each object and attribute

Quality Assurance and Quality Control Efforts

The University will assist City staff to conduct quality assurance by spot-checking digitize d assets and attribute information, utilizing database tools to maintain attribute domain s, and working closely with City staff to identity known issues for digitizing staff to look f or when working with the data. The following sections outline the quality assurance and control efforts to be conducted as part of the project.

<u>Quality Control Efforts Conducted During Digitization Efforts of Each Section</u>

1.The storage of all files will use a strict directory structure in order to maintain consiste ncy and to ensure repeatability.

2. Progress will be tracked in TRS file located in the geodatabase.

3.All issues related to interpretation of Atlas Pages or As-Builts will be reviewed with Tampa Staff, resolved and documented.

4.Neighborhood Atlas Pages will be digitized one at a time such that work efforts to digitize one section will be able to access the completed work efforts of the neighboring section.

5.Geodatabase attributes will be examined to ensure standardized values and adherence to the data dictionary. All attribute values included with the final data validate when compared to the data dictionary. See Appendix B for a list of the QC steps performed for each attribute.

6.Pipe diameter values will be compared against a common list of diameters (i.e. 8, 10, 12, etc) and examined when there is a low occurrence of any specific diameter value.

Quality Control Efforts for the Incorporation of Individual Sections into a Single Final Geodatabase

1.Verify attribute values match domain values. Fields without a domain are examined for erroneous values.

2.Network rules will be enforced for connectivity and direction of flow of pipes and structures. Snapping tolerances will be set and indication of pipe flow will be symbolized.

3.
Examine the edges of the atlas pages to ensure the final data layers do not contain duplicate structures, especially in areas with a detailed call out.

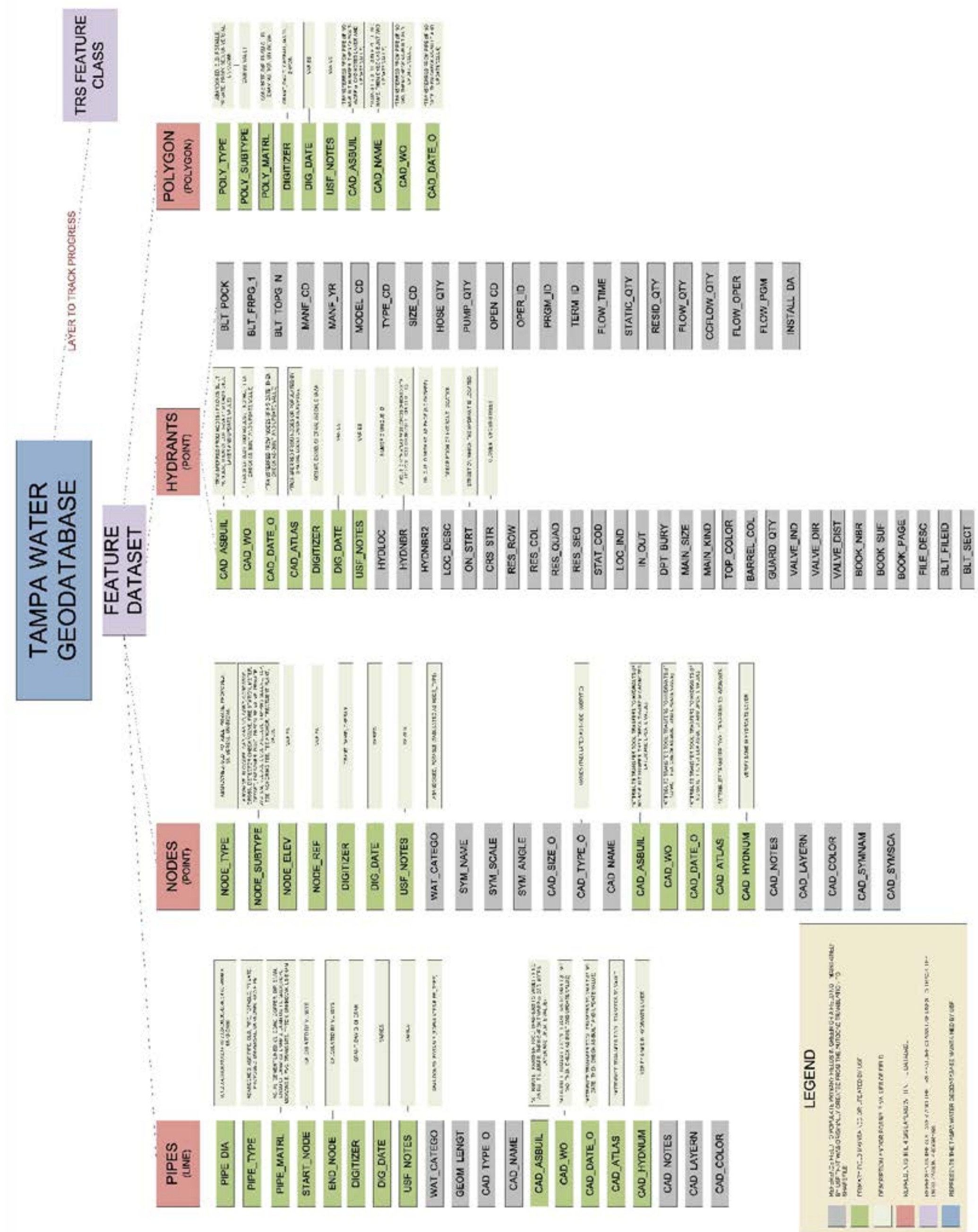
Final Quality Assurance Efforts on the Citywide Final Geodatabase

1.Spot-check techniques to verify all assets have been digitized and that all attributes have been entered from the atlas page or as-built upon completion of the atlas page or as-built.

2.
Verify attribute values match domain values. Fields without a domain are examined for erroneous values.

3. Examine final data layers for duplicate assets.

4. Verify connectivity and flow of all pipes and structures.



TAMPA WATER GEODATABASE
FEATURE DATASET
TRS FEATURE CLASS
LAYER TO TRACK PROGRESS
PIPES (LINE)
PIPE_DIA
PIPE_TYPE
PIPE_MATRL
START_NODE
END_NODE
DIGITIZER
DIG_DATE
USF_NOTES
WAT_CATEGO
GEOM_LENGT
CAD_TYPE_O
CAD_NAME
CAD_ASBUIL
CAD_WO
CAD_DATE_O
CAD_ATLAS
CAD_HYDNUM
CAD_NOTES
CAD_LAYERN
CAD_COLOR
NODES (POINT)
NODE_TYPE
NODE_SUBTYPE
NODE_ELEV
NODE_REF
DIGITIZER
DIG_DATE
USF_NOTES
WAT_CATEGO
SYM_NAME
SYM_SCALE
SYM_ANGLE
CAD_SIZE_O
CAD_TYPE_O
CAD_NAME
CAD_ASBUIL
CAD_WO
CAD_DATE_O
CAD_ATLAS
CAD_HYDNUM
CAD_NOTES
CAD_LAYERN
CAD_COLOR
CAD_SYMNAM
CAD_SYMSCA
HYDRANTS (POINT)
CAD_ASBUIL
CAD_WO
CAD_DATE_O
CAD_ATLAS
DIGITIZER
DIG_DATE
USF_NOTES
HYDLOC
HYDNBR
HYDNBR2
LOC_DESC
ON_STRT
CRS_STR
RES_ROW
RES_COL
RES_QUAD
RES_SEQ
STAT_COD
LOC_IND
IN_OUT
DPT_BURY
MAIN_SIZE
MAIN_KIND
TOP_COLOR
BARREL_COL
GUARD_QTY
VALVE_IND
VALVE_DIR
VALVE_DIST
BOOK_NBR
BOOK_SUF
BOOK_PAGE
FILE_DESC
BLT_FILEID
BLT_SECT
BLT_POCK
BLT_FRPG_1
BLT_TOPG_N
MANF_CD
MANF_YR
MODEL_CD
TYPE_CD
SIZE_CD
HOSE_QTY
PUMP_QTY
OPEN_CD
OPER_ID
PRGM_ID
TERM_ID
FLOW_TIME
STATIC_QTY
RESID_QTY
FLOW_QTY
CCFLOW_QTY
FLOW_OPER
FLOW_PGM
INSTALL_DA
POLYGON (POLYGON)
POLY_TYPE
POLY_SUBTYPE
POLY_MATRL
DIGITIZER
DIG_DATE
USF_NOTES
CAD_ASSUIL
CAD_NAME
CAD_WO
CAD_DATE_O
LEGEND