COMPREHENSIVE WATER RESOURCES MANAGEMENT THROUGH GEOGRAPHIC INFORMATION SYSTEMS

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Abstract. As water and wastewater utilities take on greater responsibility for managing water resources, the tools required to manage them have become increasingly sophisticated and comprehensive. Geographic Information Systems (GIS) have taken a central role in analyzing, modeling, and managing a wide range of water resource information. This data ranges from water, wastewater, and stormwater infrastructure, to surface and groundwater quality and flow, to constructed and natural wetlands, to regional water balances. Clayton County Water Authority (CCWA) manages Clayton County's water resources using a GIS that includes a comprehensive network of features describing the flow path from intake to discharge. This paper will provide a comprehensive GIS virtual tour through Clayton County's water cycle and detail how CCWA is using GIS to manage and protect its water resources.

INTRODUCTION

CCWA is one of Georgia's largest water utilities in terms of customers served and miles of pipe. Clayton County was one of the first counties to develop in the metro Atlanta region, and aside from a small percentage of land in the southernmost portion of the county, it is approaching "build out" status, with development opportunities limited to small undeveloped tracts scattered among the developed portions of the county. With a recent intergovernmental agreement tasking CCWA with managing a Stormwater utility, the management of water resources within Clayton County will be further integrated.

WATER CYCLES

The term water cycle is used to describe the flow of water from the atmosphere to the ground through precipitation, overland or underground to rivers, lakes and the oceans, and back to the atmosphere through evapotranspiration. GIS has been used as a tool to model these pathways, in particular the surface and groundwater flows. Sophisticated geodatabase (geographic database) models have been developed to describe the hydrology for watersheds, streams, wetlands and reservoirs.

At the same time, CCWA has created a secondary water cycle, which moves water from groundwater wells, streams and reservoirs to treatment plants, through 1,340 miles of pipe to homes and then back through 993 miles of sewer lines to treatment plants and to discharge points. This secondary cycle is also being modeled through GIS.

CCWA's process of indirect potable reuse, a process where wastewater is treated to a high level and mixed in reservoirs for eventual treatment as potable water, involves additional GIS data, since water treated in water reclamation facilities requires additional treatment through spray irrigation and constructed wetlands before it can be used. The water from these additional treatment facilities is discharged into drinking water reservoirs, where after a holding time is then "recycled," passing again through the entire cycle. Both the spray irrigation facility containing approximately 289 miles of pipe and 20,000 sprinkler heads and constructed wetlands are contained in the geodatabase.

Although these water cycles are considered separate systems, in fact, many similarities and interconnections exist. Interconnections occur from both intentional fresh water withdrawals and unintentional inflow and infiltration. Raw water is taken directly from the natural water cycle, in this case either the Flint River or groundwater wells, and passed to the CCWA water cycle. From here, the water distribution system is mostly a closed system, with the exception of leaks from the system, which represent a fairly small percentage.

The wastewater system, however, contains a great number of interconnections with the natural cycle. From the homeowner's tap, to the final discharge point, water is continuously entering the wastewater collection system, resulting in costs both to convey and treat it. Water can infiltrate through cracks in sewer lines, open cleanouts, and cracked or open manholes. Untreated wastewater can likewise escape through manhole overflows, and broken pipes. Since most of the wastewater collection system flows by gravity, the sewer lines follow the natural watershed basins, and flow downhill to streams, where they parallel stream banks to treatment plants. This creates greater potential for interconnection as leaks in the sewer system can discharge directly to streams. Streams can likewise top manhole rims and enter sewer lines. Stream bank erosion and currents can also damage sewer lines that cross them or are located within the flood plain, resulting in further mixing of the two systems.

With the advent of natural treatment system, the artificial water cycle mimics the natural one. Spray irrigation fields apply treated wastewater to forested or cultivated land, allowing the water to percolate through the soil, where nutrients are removed through various processes including the soil adsorbtion, microbial breakdown, and plant uptake. Similarly, constructed wetlands perform the same function as natural wetlands in taking up nutrients from treated wastewater, while providing habitat for numerous plant and animal species. Natural treatment systems are also open systems, affected by precipitation. Output from these systems is a combination of treated and natural waters.

INTEGRATION: VIRTUAL TOURS

GIS provides a means to monitor and manage both the natural and artificial water cycles. GIS provides a framework for integrating numerous datasets including tabular data, aerial orthophotography, digital images, in addition to the GIS layers themselves, which include elevation contours, soil coverage, wetlands, and water and wastewater. GIS forms the core database for hydraulic and water quality modeling of both the natural and artificial water cycles. CCWA has completed modeling of both its water and wastewater systems and is currently in its second phase of modeling its water distribution system. One of the key components of the wastewater model is calculating the degree to which stormwater infiltrates the collection system.

CCWA uses ESRI's ArcGIS software suite, including ArcInfo, ArcEditor, ArcView and ArcReader. The data, compiled over the course of four years when the GIS program began in 2000, resides in an ArcSDE (spatial database engine) enterprise geodatabase running on SQL Server and consists of water, wastewater, raw water, hydrology, land management, and basemap feature datasets. The basemap feature dataset contains a variety of feature classes such as streets, political boundaries, and non-residential building footprints. To date Clayton County has not yet developed parcel level data.

Various sensors are being used to develop an integrated "view" of both water cycles. CCWA uses SCADA (Supervisory Control And Data Acquisition) systems to monitor both the water and wastewater systems in real time. Flow monitors are used in the wastewater collection system to determine the rise and fall of water levels in manholes as flows change with stormwater events. Sewer lines are televised using in-pipe cameras, which can be linked to the GIS representation of these pipes, and digital panoramic photos are used to provide a "virtual" view of facilities. GIS provides the natural framework for these datasets, enabling an intuitive means to navigate these systems and integrate existing and future data from sensors and other sources.

With the implementation of the Cityworks computerized maintenance management system (CMMS), CCWA has a direct link between the various physical assets, their condition, and the work performed on them. Every work order that is created is linked to specific assets in the GIS system, and a complete history can be viewed. This history allows for proactive maintenance, rehabilitation and replacement based on asset condition and maintenance history.

Other databases and applications are tied to the GIS, including a sanitary sewer spills database, manhole inventories, exposed pipe inventories, water quality sampling. In addition, the Cityworks system allows for multiple reports to be generated for specific maintenance programs, such as EPA's CMOM (capacity, management, operation and maintenance) program.

CONCLUSIONS

CCWA has taken a proactive role in managing Clayton County's water resources, treating both the natural and artificial water cycles as valuable resources that must be monitored, protected, and enhanced. GIS provides an increasingly important tool to integrate these complex systems, and ensure that despite the increasing pressures on these resources that they are managed in a sustainable manner.

During the next five years, as the cost drops for technologies such as flow monitors, organic vapor sensors, pressure and flow sensors, and various geodetic data collectors (GPS, LiDAR, ground laser ranging devices), GIS will provide the integration point for managing resources not only in a more quantitative fashion, but also in near real-time.