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GIS Integration Proves Successful for Managing Salt Lake City's Water, Wastewater, and Storm Water Utilities

Michael Beedie, P.E., Engineering Services Manager, Bentley Systems, Inc.;
Nick Kryger, GIS and IT Manager, SLCPU; Brandon Arnold, GIS Specialist, SLCPU

Overview of Salt Lake City Public Utilities

Salt Lake City Public Utilities (SLCPU) operates the largest water, wastewater, and storm water utilities in the state of Utah. Since 1990, SLCPU has played an active role in using ESRI geospatial technology to manage its utilities and survey and utility location activities within the department. Nick Kryger, GIS and IT manager for SLCPU, and Brandon Arnold, GIS specialist for SLCPU, have spearheaded the effort to keep SLCPU's GIS system up-to-date with the latest GIS technology and innovative applications throughout their systems. With a growing population nearing 190,000 within the city and more than 400,000 customers being served by their water system, the use of GIS has helped SLCPU become more efficient and save money.

Recently, SLCPU was awarded ESRI's 2004 Special Achievement in GIS Award for its advanced use of GIS products. Some of the tools SLCPU has used for GIS include ESRI's ArcStorm, now ArcSDE for SQL database; ESRI's ArcInfo Workstation and ArcGIS Desktop; ESRI's ArcIMS for Web mapping; Bentley's Haestad Methods WaterGEMS for water distribution modeling; and CATS HPAC with Cameo and Aloha for Homeland Security.

SLCPU's GIS programs are used for homeland security purposes within the department and throughout the city. Since the GIS software is continuously updated, the fire and police departments use the system to protect the public. For example, the fire department accesses the GIS data to determine locations of fire hydrants and the availability of fire flow in specific areas of the city. During the 2002 Olympics, SLCPU was part of the security team selected by the federal government to provide mapping and technical support to keep the Olympics safe.

Water, Wastewater, and Storm Water System Overview

Salt Lake City's water system encompasses a 135-square-mile service area in Salt Lake City and eastern Salt Lake County. It includes 49 separate pressure zones and receives water from six sources. In the summer, the network increases its water supply by using 26 deep wells throughout the system. A majority of the distribution system is fed through gravity flow and consists of 20 distribution reservoirs (95.32 million-gallon capacity), 10 distribution tanks (7.53 million-gallon capacity), four storage reservoirs (6,513 million-gallon capacity), and three other reservoirs (78.57 million-gallon capacity). The network also contains 29 pump stations with 104 pumps, and the water treatment system includes five water treatment plants.

A majority of the water supply is received from four local creeks. City Creek, Parley's Creek, and Big and Little Cottonwood Creeks supply approximately 57 percent of the demand. Deer Creek Reservoir, which is 40 miles southeast of the city, supplies approximately 27 percent of the demand. The remainder of the demand is supplied by artesian wells southeast of Salt Lake City and from deep wells throughout the Salt Lake Valley. The Little Dell Project, completed in 1992, provides an additional 21,000 acre-feet of storage. The Central Utah Project's Jordanelle Reservoir will provide additional water, as required, to account for population growth through 2025.

The average daily water demand is currently more than 81 million gallons per day with peak demands exceeding 230 million gallons per day during the summer months. The system includes 1,400 miles of pipeline and approximately 15,000 valves and 8,500 fire hydrants.

SLCPU's wastewater system serves more than 181,000 customers with more than 48,000 wastewater connections and treats an average of 29 million gallons of wastewater per day. The collection and transmission system includes 636 miles of sanitary sewer pipe and collection lines along with 31 lift stations. The treatment system includes one water reclamation and treatment system and one pretreatment plant.

SLCPU's storm water system also serves more than 181,000 customers with more than 47,500 connections. The conveyance system consists of 24 lift stations and 23 detention basins along with approximately 450 miles of storm water pipe and collection lines.

SLCPU also manages 190 square miles of watershed that encompass a seven-canyon area between Salt Lake City and Park City.

GIS Initialization

The storm water utility for commercial properties was the first utility in Salt Lake City to incorporate a GIS. GIS was implemented to convert paper maps to digital maps to better track the city's land use and storm water retention and detention systems. The storm water utility GIS layers include commercial parcels, pervious areas, and building footprints.

Data for the storm water utility GIS was gathered through property surveys. Currently, utility information is surveyed with survey grade GPS equipment. For new projects, record drawings are created by surveyors and the data is updated by SLCPU in the GIS database.

Today, SLCPU's GIS system has been expanded to include its water distribution, wastewater conveyance, and storm water conveyance networks. The utility utilizes its GIS programs for everything including linking to the billing and maintenance work order systems.

GIS and Hydraulic Modeling

SLCPU has been involved in hydraulic modeling for its water distribution system since 1995. The initial hydraulic model was proprietary and was not integrated with the GIS system. The department began looking at other modeling programs to analyze the additional demand from the 2002 Winter Olympics and to integrate the model with its GIS. After trying several programs with little or no success, SLCPU ultimately transitioned to Haestad Methods WaterGEMS hydraulic analysis model because of its seamless integration with ESRI's ArcGIS platform. Arnold stated, "Haestad Methods WaterGEMS was selected because of its model building tools using our existing GIS and its ability to work within the ArcMap framework. We were able to simply import our GIS data directly into the model and keep the two synchronized as new data was added to the GIS."

Since its adoption, the WaterGEMS model is continuously updated and has been used for numerous projects. To create the model, features in both WaterGEMS and ArcGIS were initialized to transfer the data within the geodatabase to the water model. SLCPU utilized WaterGEMS' ModelBuilder feature to streamline construction of the initial water model from the GIS data. ModelBuilder provides a link between the geodatabase and the underlying WaterGEMS database and imports pertinent data into the model as specified by the user.

WaterGEMS also has a demand loading feature called LoadBuilder that incorporates the water meter data from 92,000 water meters, which is linked to the billing database, and assigns the demands based on nearest-node allocation to assign real demands to the junctions in the model. Prior to LoadBuilder, this type of demand allocation was an extremely tedious process.

To assign elevations to the junctions in the model, SLCPU used WaterGEMS' TRex feature to extract the elevation information from 10-meter digital elevation models (DEMs). Elevations for the tanks and pumps were surveyed. TRex saved the utility hundreds of man-hours, eliminating the need to manually read elevations from topographic maps.

Overall, the developed model includes 35,000 pipes and 31,000 junctions along with the 39 storage tanks, 29 pump stations with 104 pumps, and 125 pressure reducing valves.

The model was calibrated based on the water meter data and flow tests performed throughout the system. Pump curves were also input for each of the 104 pumps.

Uses of the Hydraulic Model

Arnold stated "SLCPU uses WaterGEMS on a daily basis as part of our planning/development review process. We are able to run analyses to verify that a new home or business will have adequate fire protection or that we will be able to provide enough water for a proposed subdivision." One large modeling project occurred in the South Temple region of the city. While the water model was being used to determine the cause for low water availability during a large fire in the area, it was discovered that some of the fire hydrants in the area were not working properly.

The model is also used to evaluate water availability for new subdivisions, to evaluate the effects of system rehabilitation, and to analyze different scenarios connected to homeland security.

Water quality analysis is another important feature of WaterGEMS. In 2003, SLCPU examined the possibility of adding fluoride to the water treatment process. Different fluoride concentrations were input into the model using WaterGEMS' Scenario Control Center feature. The concentrations were traced over time to determine the optimum injection concentration required for the system. These concentrations were verified in the field by installing sampling ports throughout the system to monitor the fluoride levels, which proved to be amazingly close to the model results.

The future goals of the hydraulic modeling program are to develop a master plan for the water distribution system based on the results of the model for existing and future conditions. "In the near future, we will be working with WaterGEMS to help determine new well sites and to do major water conveyance studies," said Arnold. SLCPU is encouraged by its successes and anticipates transitioning all hydraulic modeling in-house. This move will give the department greater control over its planning and design budget and help it better target consulting expenditures for more specialized tasks. SLCPU is also actively pursuing the development of similar hydraulic models for its wastewater and storm water systems that are integrated with ArcGIS. SewerGEMS and StormGEMS from Haestad Methods will incorporate many of the same features that are available in WaterGEMS to develop and analyze wastewater collection and transmission system and storm water conveyance models, respectively.

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