Prioritize Capital Improvement Projects

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Abstract

Long Beach Water Department (LBWD) provides water and wastewater services in the 5th largest city in California. Its potable water system contains 912 miles of mains with over 121,000 services. LBWD is replacing its aging infrastructure at an affordable and responsible pace. It has a capital improvement program (CIP), and replaces 85,000-100,000 feet of potable water mains a year. Prioritizing CIP projects and replacing water mains just in time present a challenge. Mainbreaks data for the past 12 years have been grouped by pipe material, diameter, age, job number, etc. Mainbreaks intensity was calculated and sorted in a descending order. Then pipe segments in more critical need of replacement were selected. The GIS application supports decision making in CIP planning, budgeting, and operations.

I.   Introduction

1. Long Beach Water Department

Long Beach Water Department provides water and wastewater services to the citizens and businesses in Long Beach. Since its formation in 1911, LBWD has been delivering a dependable water supply meeting or bettering all applicable water quality standards. LBWD is committed to strive toward becoming the most effective, efficient, and competitive municipally run Water Department.

2. LBWD GIS

LBWD is in the forefront of breakthrough technology, and is the only water agency in the U.S. with its own patented desalination technology. LBWD has also been taking advantage of the latest state-of-the-art GIS technologies to enhance its productivity.

LBWD has been using GIS in its daily operations since 1994. Its Oracle-based GIS, which consists of ESRI software suite, is running on IBM UNIX servers with networked Windows 2000/NT computers over its Intranet. Its comprehensive GIS databases contain detailed information on 2,000 miles of water systems (potable and reclaimed water), wastewater (sanitary sewer and storm sewer systems). Veritas NetBackup DataCenter has been utilized for protecting this valuable asset.

The GIS team has developed many GIS applications to support: water and wastewater systems master planning, capital Improvement Program (CIP) planning, engineering design and mapping, emergency response, valve

operations, survey, inspection, underground system alert marking, infrastructure site selection, customer services, complaints tracking, maintenance planning, property and land and management. The GIS team continues to develop more applications, and enhance the system to meet new challenges.

The GIS users include managers, analysts, engineers, and field crews. They effectively use GIS to query and analyze information (locations, conditions, trends, and patterns), explore "what if" scenarios, and map out sound strategies for facility management. Benefits that have been realized include increased productivity, improved decision making capabilities, expanded capabilities in performing large tasks previously deemed impractical, improved record management and accessibility, eliminated redundant data and activities, saved time and money.

3. Capital Improvement Program (CIP)

LBWD has been replacing aging infrastructure at an affordable and responsible pace. LBWD has a capital improvement program, replaces 85,000-100,000 feet of potable water mains a year. Prioritizing capital improvement projects, and replacing water mains before they break again present a challenge.

Mainbreaks data for the past 12 years have been captured and analyzed. Majority of the mainbreaks occurred on cast-iron mains. In the potable water systems, over 30% mains are made of cast iron. The 6" cast-iron mains have higher break frequency, especially occurred on the ones installed in the periods of 1925-1932 and 1951-1955. A mainbreak analysis application has been developed for support capital improvement program (CIP) planning and prioritizing.

II.   Application Design and Development

1. Application Objectives

The mainbreak operational application is an integral part of the Mainbreak Data Management System (MBDMS) at Long Beach Water Department. It is mainly developed for LBWD managers to use for the purpose of planning and prioritizing the water main replacement. For this reason, the ESRI ArcView 3.2 software is selected for the application development rather than using more sophisticated GIS software like ArcInfo 8.

With this application at hand, now the LBWD managers can easily answer the questions such as "Where are the 100,000 or 85,000 linear feet water main replacement for the next fiscal year?" by simply clicking a couple of

buttons. And a map of showing those selected water pipes can be generated immediately.

2. Mainbreak Data for Analysis

LBWD has well established its water and sewer Geographic Information System (GIS) and Work Order System (WOS) that are used in the daily operations of the Department. The WOS includes many years of mainbreaks data and has been used primarily as an information system for the maintenance crews and for customer service representatives. This historical information provides a valuable source of data that is used to forecast mainbreak events and allow a proactive maintenance program.

The mainbreak data in the MS Access based WOS has been extracted and converted to the shapefiles for the past 12 years and related to water pipe data in the GIS by job numbers. The water pipes are then evaluated based on a normalized statistics indicator to identify pipes with a high priority for replacement.

3. Problems and Solution

Formerly LBWD managers had to rely on a manual process for planning water pipe maintenance and replacement without help from GIS. That manual process was time-consuming as well as inaccurate. Sometimes the water pipes less urgent for maintenance were picked up and ones most needed for replacement were ignored.

GIS shed light on this situation and we understood a computer driven process could be carried out. Soon we have found a new problem. If previous manual selection process was 100% correct, it would have matched the results from computer-aided automatic approach. It is obvious the results are not the same for them because the high probability of error involved in the manual process.

The first round computer processing results need excluding the linear footage of water mains currently under construction, ready to construction and optionally planned construction. Then the computer program needs to run again to get a new set of selected water mains to reach the specified LF (for example, 85,000 feet). This process may need repeat multiple times to reach the final conclusion. A well-designed algorithm is seemingly imminent.

4. Programming Logic

This ArcView project contains the following major data layers:
- Historical main breaks point data for the past 12 years
- Water main line data
- Water main construction line data - They are divided into three categories: under construction; design completed, ready to construct; and planned construction project
- Several landbase data layers, including parcels, parks, schools, street centerlines, etc.

Considering this application is mainly for managers to use, we tried keeping the user interface more user-friendly and make the buttons as few as possible. We have left some existing ArcView buttons, and created several customized buttons on the button bar in the view document. (see next section for the detailed functions of these buttons.)

The main break points which are within 50 feet of water pipe constructions are first filtered before their attribute table is joined with the water mains table. The user will be prompted to specify a designated linear footage number (default 100,000 ft) and whether he wants excluding all main breaks close to water pipe constructions (including planned) or only excluding the main breaks close to current pipe construction and designed (not including planned).

Then the program will join the main break data and the water mains data by the common field of job number. After joining, a new statistics field will be derived for the total main break number per 1000 feet of pipe length for each job number. This normalization field is sorted and the designated length of water mains with high mainbreak intensity value are highlighted on both summary table and the map in the view window.

5. Application Functions

This ArcView project contains several customized buttons. Each button is associated with one or more Avenue scripts. When the user clicks the button, certain tasks are executed. They are summarized as follows:

- Mainbreaks Count Button
  - Generate an updated summary table for total number of mainbreaks by job number.
- Water Mains Summary Button

- • Generate an updated summary table for all water mains by job number. Also listed are their installation year and total pipe length for each job.
- • Join Summary Button
  - • Prompt user to specify a linear footage for water main replacing (default is 100,000 LF).
  - • Prompt user to choose if he wants to exclude mainbreaks close to all main constructions or only close to "under construction" and "designed and ready to construct" (not including "planned construction").
  - • Join the mainbreak summary table and water main summary table together by job number.
  - • Create a new statistics field which will be calculated by dividing total main break number with the total length of each job normalized per 1000 feet.
  - • Do multiple sorting for the normalized statistics field and then the job installation year field.
  - • Create a Cumulated Pipe Length field for helping selecting certain length of water mains which need replacement.
  - • Selected water mains will be highlighted in both Join Summary Table and the map of view window by linking the Join Summary Table with water main attribute table.
- • Customized Zoom In/Zoom Out Buttons
  - • Zoom In/Zoom Out buttons are customized as scale-dependant, i.e., the visibility of data layers and auto-labeling depend on the scale. For example, the parcel polygons only display at large scale not at small and mid scale. The names of streets, parks and schools will be displayed at large and mid scale but not at small scale.
- • Output Functions
  - • The user has the capability to print out the map and the table, or export the table to a different format.

III. Summary

The GIS application for analyzing water mainbreaks provides support to water mains replacement prioritizing, capital improvement program planning and budgeting. The mainbreaks analysis, via the GIS, is being used as a benchmark to compare more traditional methods of selecting mains to be replaced. The prioritized capital improvement program effectively addresses serious infrastructure deficiency issues before they become major problems and hardship to customers - residents and businesses.

Acknowledgements

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