Paper No. 306
Inspector: Using GIS/GPS/Digital Photography for Asset Management in Public Works

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Submitted Abstract: Some of the most persistent questions for a Public Works Director are: Where are the worst streets, alleys, water lines, and sewer lines? How soon will they be repaired? How much will it cost? Can we apply economies of scale to the construction?

The City of Richardson, Texas has developed a methodology for assessing its infrastructure assets. This methodology provides for the analysis of single critical map layer or to combine two or more layers to identify the worst of both and thus provide economies of scale. This methodology provides decision makers with information valuable to the scheduling and prioritization of construction projects.

About the City of Richardson

The City of Richardson, Texas is located in the northeast section of the Dallas-Fort Worth Metroplex. The 2000 US Census stated that we had approximately 90,802 persons. Our city limits surround approximately 27 square miles of land, most of which has been built-out. The City of Richardson is known as the "telecom corridor" since, at the peak of its success, there were approximately 500 telecom companies in the city.

The GIS Division has 3 full-time staff members. They serve the GIS needs of all city departments. A centralized enterprise server using SQL Server 7.0 and SDE 8.3 holds all GIS data. One hundred fifteen map layers are maintained and used for various applications, including Intranet ArcIMS, ArcView 3.3 and ArcGIS 8.3, ArcSDE 8.3. All city staff with LAN connections have access to the enterprise GIS. Daily users of custom applications include the following departments: Building Inspection, Tax, Public Services, Capital Projects, Development Services, Planning and Police. Over a 5-year period the GIS database has transitioned from Needs Assessments, to Database Planning, to Implementation. We are currently in Maintenance Phase.

City of Richardson Public Works

The City of Richardson's Public Services Department is responsible for the maintenance and operation of all street systems, water and sewer facilities, public buildings and the provision of solid waste disposal services to citizens and commercial customers. The department has six divisions: Administration, Solid Waste Services, Street Maintenance, Water and Sewer, Geographic Information Services, and Facilities Services, with a total of 185 positions and an annual budget of approximately of $35 million.

The resounding questions from the Public Services department to the GIS Division are the following: Where are the worst water lines? Where are the worst sewer lines? Where are the worst alleys? Where are the worst streets? Answers to these questions are imperative to running an efficient public works department. One would not want to repair the surface of a street on a given day, only to have to break it up the following year to repair the water line under

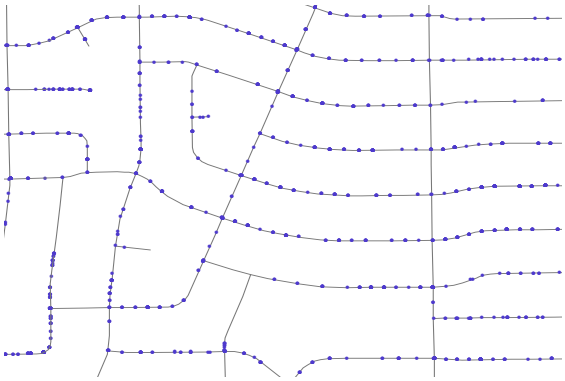
it. If we know the condition and history of the water line while we were repairing the street, we might consider repairing both at the same time.

Where are the worst water and sewer lines?

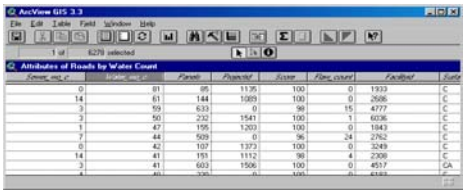
The answer to these questions was relatively simple since we had all data already collected. The City of Richardson uses H.T.E. software to record work order information. Approximately 85,000 records exist in this system. We arranged with programmers from the City of Richardson Information Services Department to write code to extract all pertinent work order data on a daily basis. This data comes in the form of a text file and is downloaded to a network file server. On a daily basis, jobs exist on the GIS server that create the following process, in this order:

1. Work orders associated with water & sewer are filtered from the list,
2. Filtered work orders are grouped by either water or sewer types,
3. Grouped work orders are geocoded to street centerline file (graphic 1.)
4. Sewer points locate the nearest sewer line and move over the sewer line,
5. Water points locate the nearest water line and move over the water line,
6. The points are then related to the street or alley record that they are nearest to,
7. The sum of all points over each alley or street record are then collected and the centerline attribute table is updated with the new information (graphic 2).

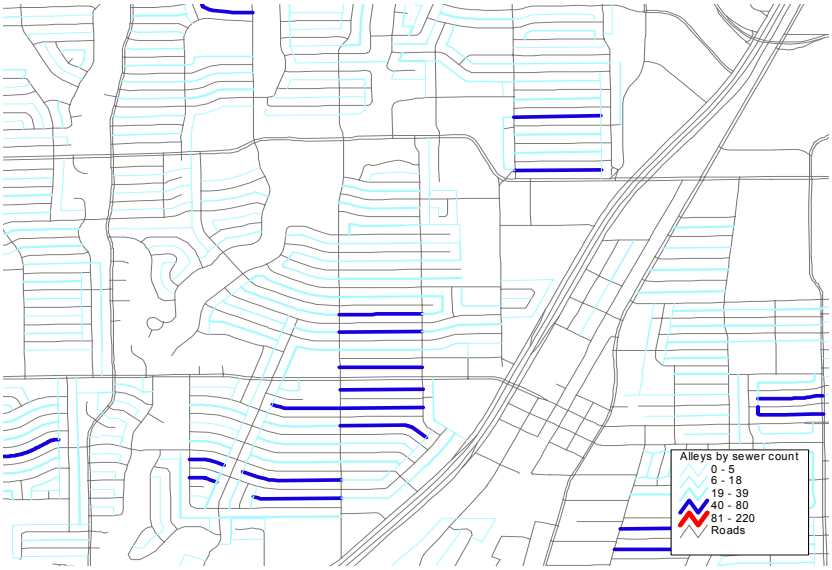
Adding the work order count to each corresponding street or alley segment helps to standardize the comparison calculations that we will do later, to compare intersections between water lines and streets / sewer lines and alleys (graphic 3).



Graphic 1



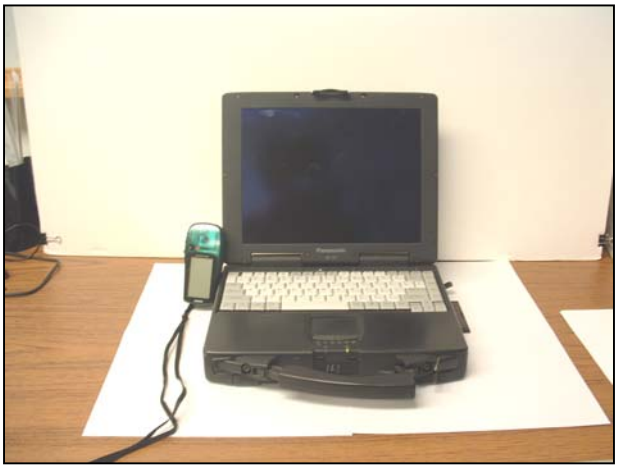
Graphic 2



Graphic 3

Where are the worst streets and alleys?
The more difficult analysis involves identifying the worst streets and alleys. In recent times, City of Richardson staff routinely rode their trucks on streets with paper and pencil in hard to identify streets in poor condition. Streets and alleys received ratings based on staff opinion and complaints from residents. Standardizing and digitally recording these evaluations would create an accurate and permanent picture of surface conditions, and eliminate inadvertent biases.

Field Inspector
For this analysis, the City of Richardson opted for a mobile laptop/ GPS solution to evaluate streets and alleys (graphic 4). We use a customized ArcPad software program that records data through a GPS receiver. The laptop and GPS are powered by the automobile's cigarette lighter (graphic 5).



Graphic 4

Graphic 5

Field Inspector works under the assumption that streets are in good condition unless it receives a GPS point. The point is not used to locate a pothole, it is more simply used to just count the flaws in a particular area of street. The street is divided into 10 ft by 10 ft areas. The question posed to the evaluator is simply, "Does this 10 by 10 area need replacement?" The answer is always either yes or no. Simplifying the evaluation assures assessment reproducibility between evaluators and over a period of years.

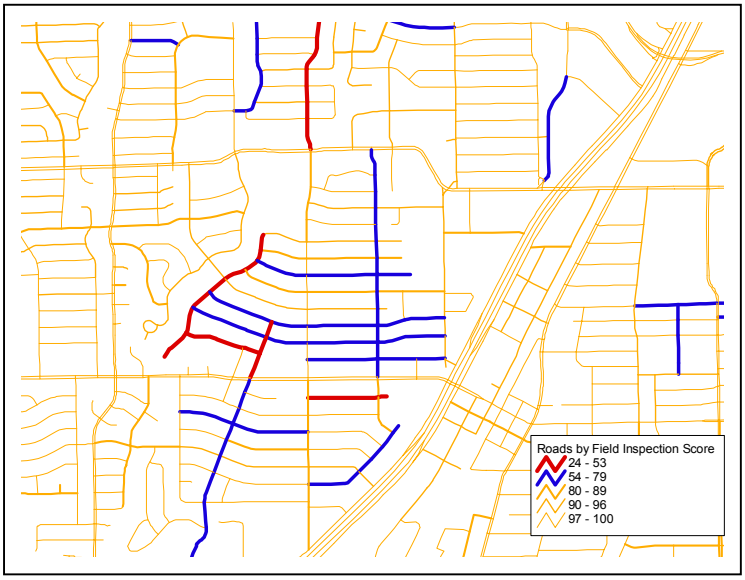
Following are specific calculations used to create a score for the street or alley segment in question:

Street / Alley Calculations:
1 panel = 10' * 10'
Number of panels = record length / 10'
% Failure = 100 – (failed panels / total panels) * 100

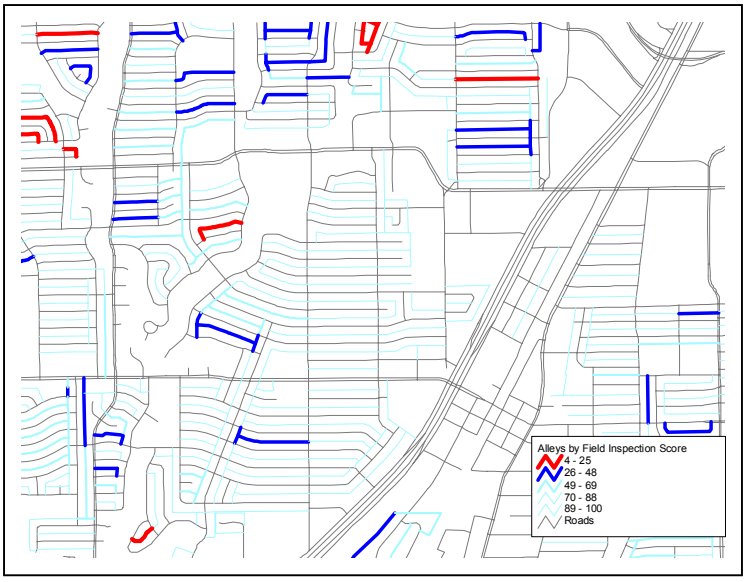
Alley Calculations:
% Failure = 100 – (failed length/total length)*100

Once the data is collected in the field, the laptop is returned to City Hall and plugged into the LAN network. Services stored in the laptop's operating system and the geodatabase synchronized the information, transferring new GPS points to the geodatabase, and updating base map files to the laptop. Once the points are in the geodatabase, a process similar to the geocoding process, described above for water and sewer lines, is run. This process populates

fields in the alley and street centerline attribute tables with the calculated record score (graphic 6 & 7).



Graphic 6



Graphic 7

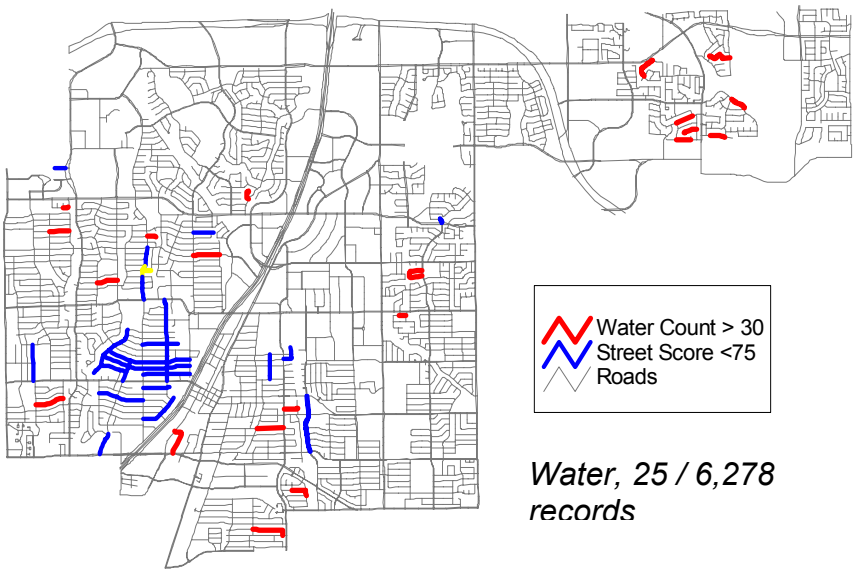
Do any intersect?

Using the above-mentioned techniques, the following shape files were created:

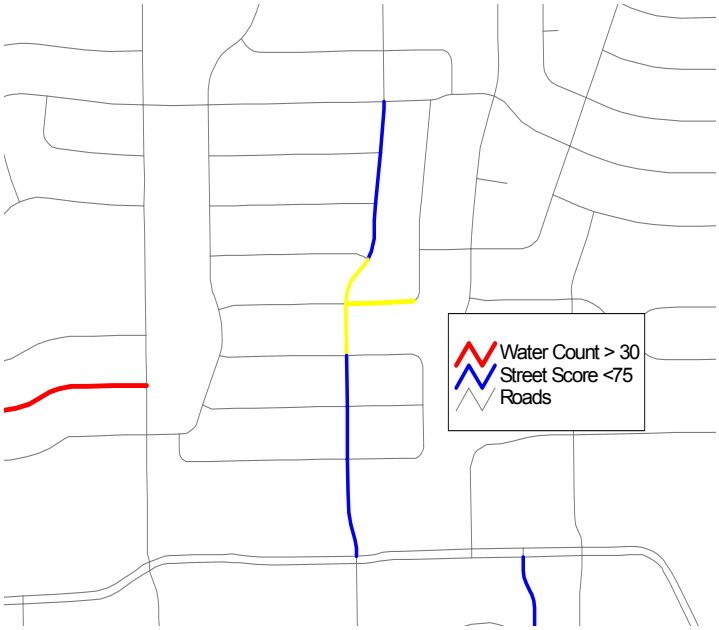
1. Water line breaks under streets
2. Sewer line breaks under alleys
3. Street Evaluations
4. Alley Evaluations

This information provides a critical snapshot of the conditions of infrastructure during a specific time. Once several iterations of this process have been collected, we will be able to calculate deterioration rates and create long rate repair plans and budgets.

Using basic ESRI selection tools, we were able to identify which low scoring alleys had bad sewer lines under them and which low scoring streets had bad water lines under them (graphic 8,9,10,11,12). Since both surface and subsurface infrastructure are in poor condition, the construction priority for these streets and alleys is elevated above the needs of others.

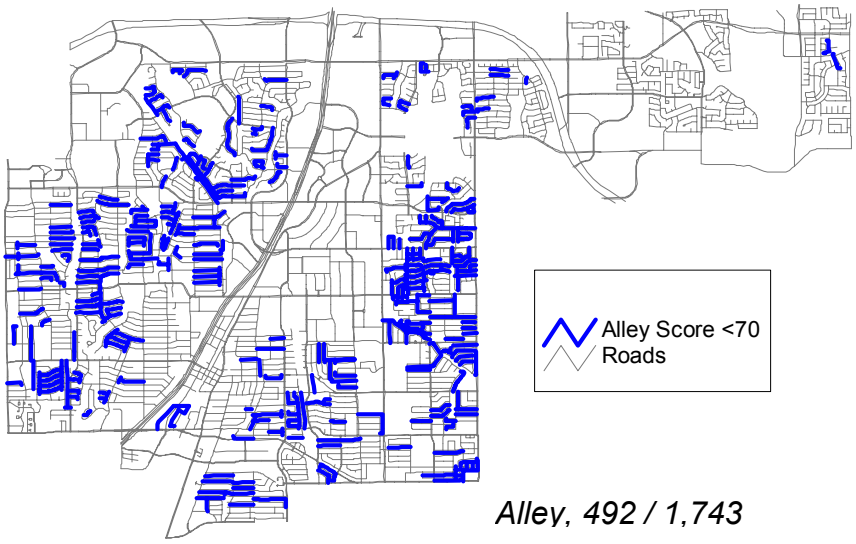


Graphic 8



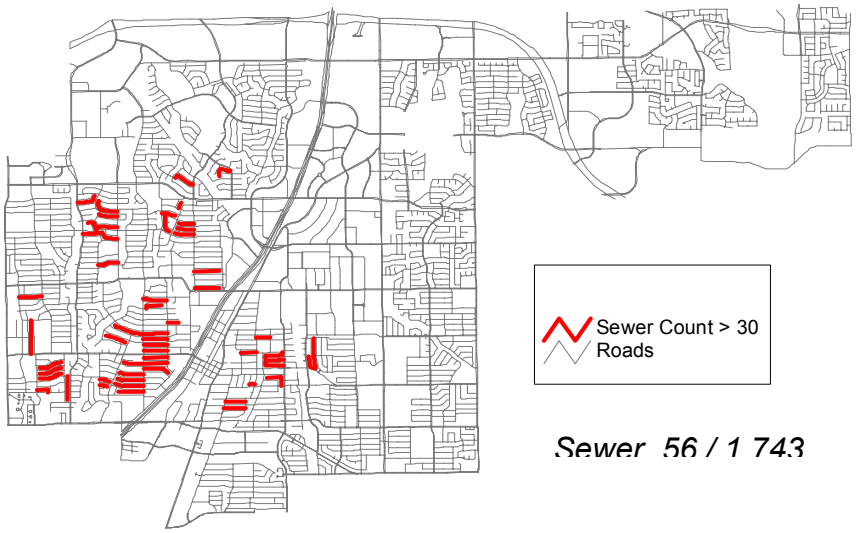
Yellow line indicates Bad Water, Bad Street intersection.

Graphic 9



Alley, 492 / 1,743

Graphic 10



Sewer, 56 / 1,743

Graphic 11

Yellow line indicates Bad Sewer, Bad Alley intersection.

Graphic 12

Geolocating digital photographs

The software we use also has the capability of georeferencing digital photos to a GPS point. The point is recorded as a shape file and loaded onto the geodatabase. The digital images are loaded on a document management server (Filenet) that has the ability to retrieve images based on a geographic point. Any digital camera with a TWAIN device can be used to take digital pictures (graphic 13).

Graphic 13

How the automated process works

A family of batch scripts, run by Task Manager on a timer basis -- on both the client and the server--- ensures that the information flows between the field laptops and the geodatabase. Scripts consist of VB-based ArcObjects programs and AML. Additionally, the scripts create full log files and send e-mail anytime there are errors.

Technical Support

Our thanks to GIS Technology, Inc., who provided countless hours of service to perfect this process. We are especially grateful to Malcolm Ross of GTI, project lead in this project.

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