Using GIS and GPS for Sanitary Sewer I/I Detection

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Abstract: This paper will show how geographic technology can enhance the detection and management of inflow and infiltration (I/I) into sanitary sewer systems. Inflow and infiltration into sanitary sewers can mean unnecessary and expensive wastewater treatment costs. Detecting sources of I/I and prioritizing their repairs can be most efficiently done using Geographic Information Systems (GIS) and Global Positioning Systems (GPS) in conjunction with smoke and dye testing. By capturing a spatial attribute and a digital picture for each sanitary sewer defect, one can then streamline defect reports and analyze defects in the system in a way to prioritize those repairs that would have the most impact on reduction of I/I. Field computers with live maps, GPS, and digital cameras can document and locate defects in a spatially enabled database, thus eliminating paper sketches and notes. When all data is in a digital media, reports and analysis are much more efficient and productive. GIS and GPS in the field and the office can greatly enhance the detection and repair prioritization of I/I into sanitary sewer systems. Anyone who works in sanitary sewer system management and maintenance should find this a useful topic.

INTRODUCTION

This paper will discuss the use of GIS, GPS, and digital documentation devices to detect, evaluate, and document sanitary sewer defects. By using technology, one may collect and analyze defects in sanitary sewer systems more efficiently and in ways that lead to better solutions for repair and maintenance of these systems.

USING TECHNOLOGY FOR SANITARY SEWER I/I DETECTION

Applying technology to the age-old task of detecting and repairing leaks in sewers makes the work more efficient and revealing. By combining GIS, GPS, and digital camera technology into a system for detecting and evaluating sanitary sewer defects, one may most efficiently collect and analyze I/I problems. The technology consists of a GIS application running on a Windows Table PC system connected to a GPS and digital cameras. The application has tools for data capture and tools for digital mapping. See **Figure 1** of the Tablet PC field crews use. While any Windows-based computer would work for this type of work, mobile computers ready for outdoor-use are better equipped for Sanitary Sewer Evaluation Studies (SSES). GPS equipment and digital cameras are discussed more in detail in the sections below.


(Fujitsu PC Corp.)

Figure 1. A mobile field computer. This computer has external USB ports for connecting data capture peripherals such as digital cameras and GPS.

Geographic Information Systems

Geographic Information Systems are extremely useful for digitally mapping sanitary sewer defects. By locating defects that are spatially referenced to other GIS layers, one may make inferences about the cause of the defect, the type of repair, and an assessment of its repair priority and whether it is hazardous to public safety or the environment. Using field data collection computers, field crews are able to collect defect features with digital maps in the background. After locating the defect either manually according to background layers or by using GPS, the user attributes the defect with a predefined set of attributes. See **Figure 2** to view the application. Tabular attributes for defect features generally include the following:

- Date Tested
- Inspected By
- Ground Condition (wet, dry, moist)
- Precipitation Type (none, rain, snow)
- Leak Type (main line, manhole, public service line, private service line
- Leak Category
- Degree of Smoke (low, medium, high)
- Leak Cover
- Comments
- Defect Picture(s)

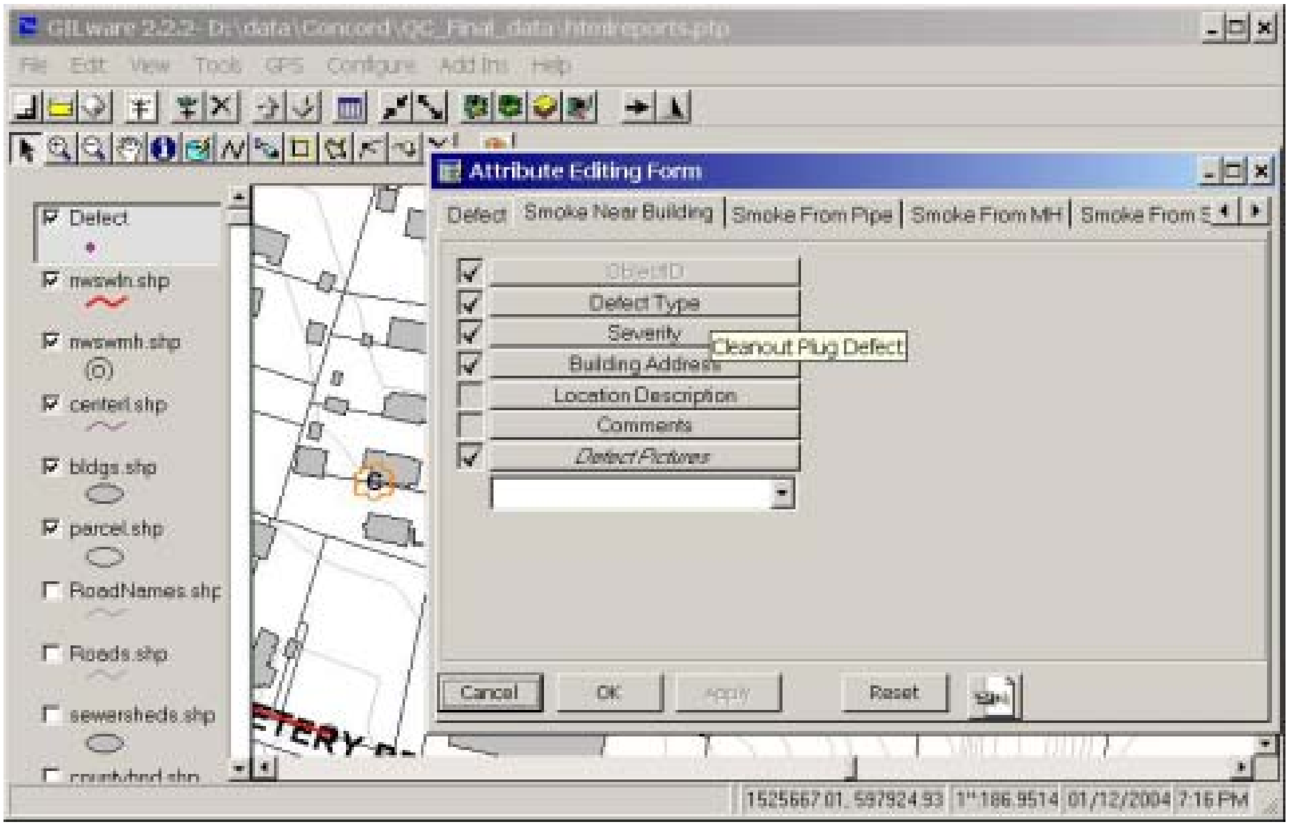

Figure 2. A GIS application that allows field crews to attribute defects with both location and tabular data. Also, the application relates one or more digital pictures to the defect at the time of capture.

Global Positioning Systems

Real-time mapping using GPS can accurately locate defects and sanitary sewer structures. By using GPS, field crews may locate defects more accurately to better relate them to a sanitary sewer layer or other layers. Field crews use GPS equipment with accuracy varying from sub-meter to 3 meter. It is recommended that GPS accuracy be at least 3 meter in order to place defects relatively accurate as compared to any sewer inventory layers. GPS equipment with the ability to use a differential GPS source such as a marine beacon, WAAS, or commercially available DGPS source will generally provide 3-meter or better accuracy. It is important that defects be located with relatively high accuracy in order to be able to relate the defects to other features. For example, when locating a clean-out plug that has a leak, it is important to locate it at least within the correct parcel in order for repair crews to easily find it. **Figures 3**, **4**, and **5** show different GPS receivers used in SSES projects with varying degrees of accuracy requirements.

(Garmin LTD.)

(Trimble Navigation LTD.)

(Garmin LTD.)

Figure 5. A Garmin GPS antenna with integrated receiver. It uses WAAS as the DGPS and provides 3-meter accuracy.

Figure 3. A Trimble antenna. The receiver resides in a backpack and uses OmniStar, a commercially available DGPS source, to get sub-meter accuracy.

Figure 4. A Garmin handheld unit. Although it has its own map display, it connects to the field computer to send its location data. Real-time mapping is performed on the field computer where there are richer background layers and GIS functionality. It uses WAAS for 3-meter accuracy.

Digital Cameras

Digital picture documentation greatly helps one determine the type and magnitude of the defect. It also cues repair crews to what they can expect and the type of equipment and materials they will need to make the repairs. **Figure 6** shows an example of a digital camera. **Figures 7** and **8** show examples of digital photographs. The application relates digital photographs to the feature at the moment the image is captured so as to maintain data integrity. Digital cameras are mounted onto the field computer. Additionally, pipe cameras (PipeCam) are special cameras mounted at the end of long poles that are rugged for entering sewer pipes and are equipped with their own lighting. All cameras feed live video to the GIS application where field crews may capture a single frame from the video stream to use as the digital documentation.

(Logitech)

Figure 6. An example of a video camera used for capturing pictures.

Figure 7. Smoke from a hole in the ground. A picture communicates much more than just tabular attributes. It also indicates the severity of the defect.

Figure 8. Smoke from a manhole. This photo indicates that either the frame or the manhole seal requires repair. Crews can estimate the time, materials, equipment required to perform the repair, and accessibility.

RESULTS

There are many advantages of collecting and storing all sanitary sewer defect data in a digital format. Many of these advantages have not yet been fully realized. However, one advantage is the ability to use automated spatial processes to analyze defects. For example, **Figure 9** shows a map of sewer defects by type for a particular drainage area. By looking at the map, one can prioritize repairs for a given drainage area. Also, by generating statistics across all drainage areas, one can prioritize drainage areas according the estimated amount of infiltration and inflow into the system.

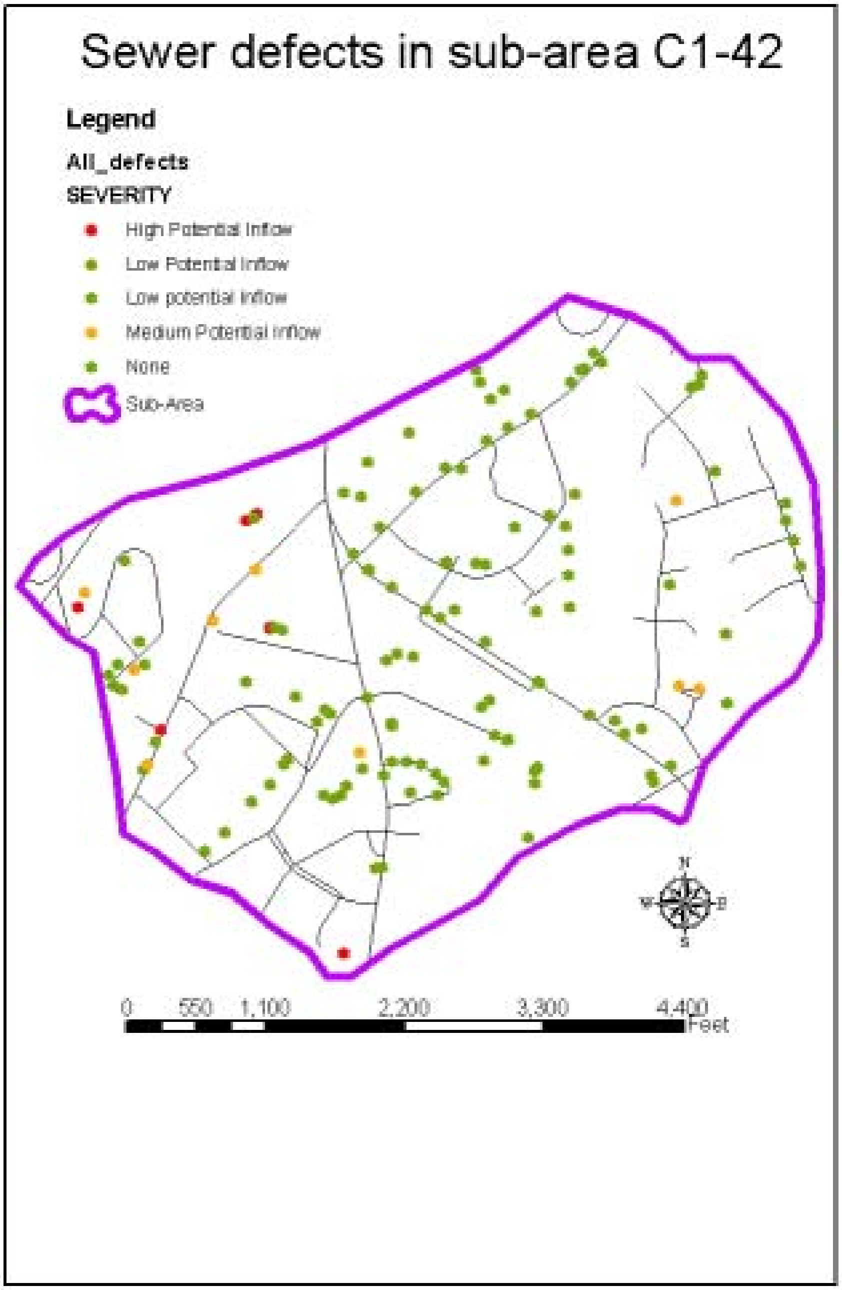

Figure 9. Map showing defects by severity in a particular drainage area. By using spatial overlay techniques, one can generate potential inflow for each drainage area.

Another example of having defect data in a digital format is the ability to generate automated reports or work orders. **Figure 10** shows an example of a defect report. The report is in HTML format and is suitable to be incorporated into an organization's digital document management system, work order system, or posted to an Internet or Intranet site.

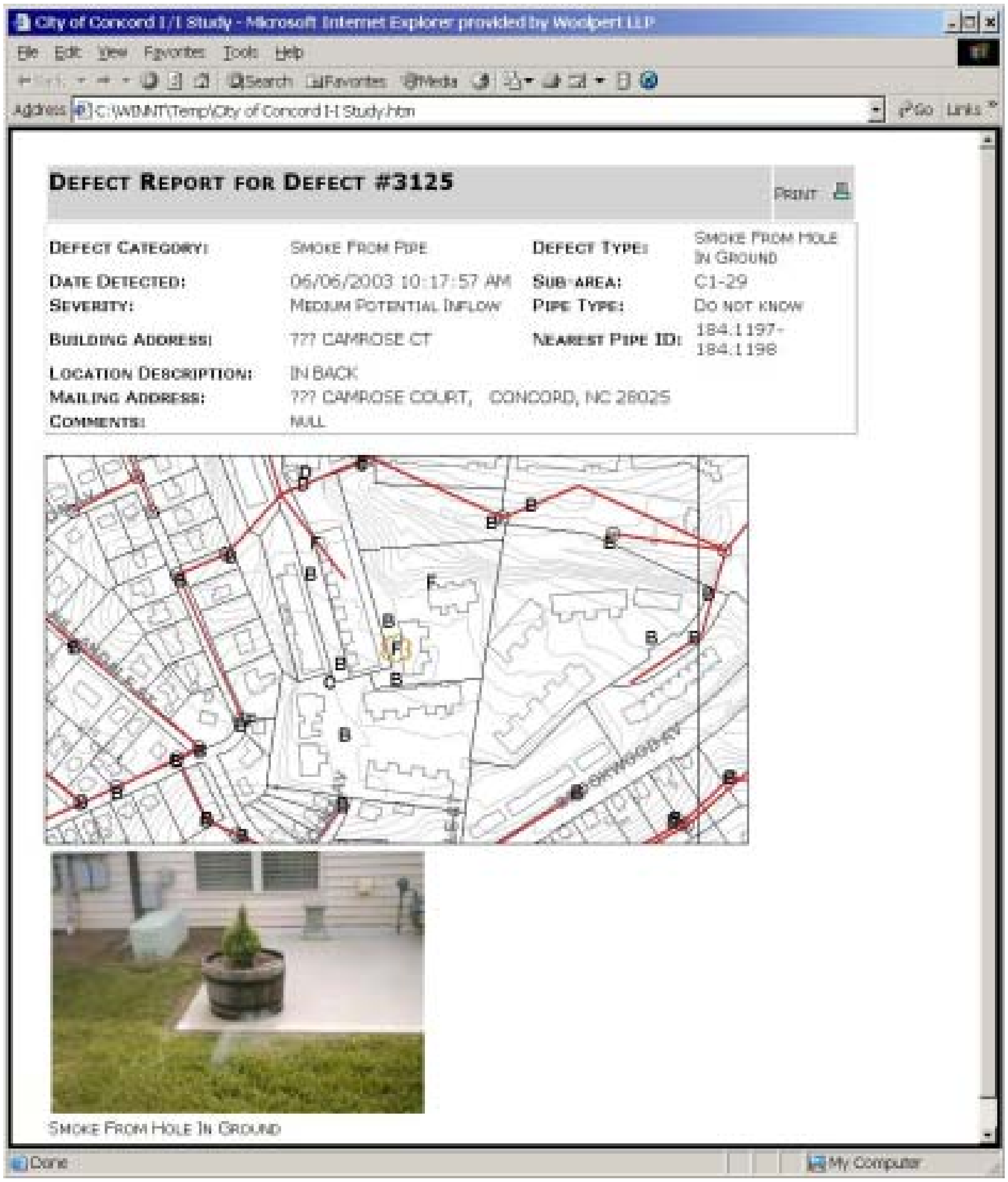

Figure 10. An example of a defect report. This report and over 1,500 others were generated automatically for each defect for this project.

CONCLUSION

GIS and GPS technology can help reduce unnecessary flow to wastewater treatment plants and thus reduce cost for operating these facilities or reduce cost of fees for discharging to the facility. Also, by approaching the method of prioritization analysis using GIS, one can assign repair crews to those leaks that most impact the reduction of infiltration and inflow into the system. One may collect and analyze defects in sanitary sewer systems more efficiently and in ways that lead to better solutions for repair and maintenance of these systems.

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