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Project Summary

Lawrence Avenue Underflow Sewer System: Monitoring and Evaluation

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A bold concept in the design of urban drainage systems was developed to help solve combined sewer overflow problems. A deep tunnel in bed rock 61 to 76 m (200 to 250 ft) below the surface was designed and constructed for the Lawrence Avenue drainage basin in Chicago. The tunnel also serves as a reservoir for capturing small storms and trapping a significant portion of the first flush of pollutants from large storms. The entrapped, combined sewage is pumped to the treatment plant at the end of each storm. Flows and pollutants to the Chicago River and treatment plant from selected outfalls in the Lawrence Avenue drainage basin were monitored, and the U.S. Environmental Protection Agency Storm Water Management Model was calibrated with the measured data. Performance of the tunnel system in capturing flows and pollution was evaluated with the help of the calibrated model. Groundwater monitoring was conducted for preproject and postproject conditions, and results were analyzed to assess the influence (if any) of the deep tunnel system on the underground aquifer.

The results of the study show that the use of deep rock tunnels in conjunction with a pumping station is a very effective means of reducing the spillage of combined sewer flows and pollutants to the waterway. Use of modern tunnel-boring machines has improved the economics of this design and installation is also less disruptive to traffic and to the general public.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, and Region V, Chicago, IL, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

Many of our cities are faced with pollution problems associated with combined sewer overflows. Reduction or elimination of these overflows (into the receiving waters) requires some kind of storage and treatment facilities, which can be quite costly, particularly in large cities where land is scarce. Construction of deep rock tunnels to serve as main outlets for the combined sanitary and storm flow offers an attractive means of minimizing this problem. The sewer, being below the river level, provides storage and captures a large portion of the pollution from combined sewers. Disruption of streets, utilities, sidewalks, etc., and interference with commercial activity are completely avoided. The planning, design, and construction of such a deep tunnel by the City of Chicago for their Lawrence Avenue drainage basin was described in an earlier report (Lawrence Avenue Underflow Sewer System, Interim Report - Planning and Construction, EPA-600/2-80-124, U. S. Environmental Protection Agency, Cincinnati, OH 1980). The present report describes the monitoring of the combined sewer flows to the Chicago River and the treatment plant, monitoring of the quality of groundwater in the project vicinity, and evaluation of the performance of the Lawrence Avenue Underflow Tunnel System in reducing overflows and pollution to the waterway.

Scope of Study

Chicago is located on a low plain adjacent to Lake Michigan at the mouth of the Chicago River near the Illinois-Indiana border. The City comprises about 544 km^2 (210 miles^2) and is part of a combined sewer system of 971 km^2 (375 miles^2) in the Chicago Metropolitan Area. Dry weather flow from the City is treated at three sewage treatment plants operated by the Metropolitan Sanitary District of Greater Chicago (MSDGC). These plants (the North Side, West-Southwest, and Calumet) all discharge their effluents into the Chicago River System.

Storm and sanitary sewage is handled by combined sewers feeding interceptor systems leading to the various treatment plants. These interceptor systems are generally designed to carry twice the normal dry weather flow. During large storms, runoff in excess of interceptor capacity flows by gravity or is pumped to the river. The City of Chicago has an ongoing program of building relief sewers, known as auxiliary outlet sewers, to augment the discharge capability of the existing drainage system. This program was started more than a century ago.

The Lawrence Avenue Underflow Sewer System was designed in the late 1960's as part of the auxiliary sewer system. The innovative design uses deep rock tunnels for temporary storage as well as for conveyance of combined sewer flows. As the first of its kind in the nation, this project received a demonstration grant by the U.S. Environmental Protection Agency (USEPA) (then the Federal Water Pollution Control Administration).

The objective of the early study was to assess and demonstrate the effectiveness of the Lawrence Avenue underflow sewer system in reducing spillage of combined flows and pollutants to the north branch of the Chicago River. The following tasks were implemented to accomplish this objective:

- Preproject monitoring of the flows and pollutants to the river and the treatment plant from selected outfalls in the Lawrence Avenue Sewer System drainage area.
- Calibration of a computer program (EPA's Storm Water Management Model) with the data collected.
- Evaluation of the system performance for a variety of storms using the calibrated simulation model.
- Implementation of a groundwater monitoring program and evaluation of the impact of the Lawrence Avenue tunnels on the underground aquifer.
- Documentation of the actual operating and maintenance experience with the Lawrence Avenue underflow sewer system.

Findings

Study results show that the use of deep rock tunnels in conjunction with a pumping station is an effective means of reducing the spillage of combined sewer flows and pollutants to the Chicago River. Modern tunnel-boring machines make this design economically competitive with conventional sewers and have the added benefits of easy construction, no disturbance to traffic, and minimal inconvenience to the public. Specific findings include the following:

- The Lawrence Avenue underflow sewer system reduces the combined sewer overflow annual volume by 84 percent for an average hydrologic year. The annual mass load reduction in spillage of BOD and suspended solids into the waterway is 90 and 94 percent, respectively, compared with the preproject condition for an average hydrologic year.
- The Lawrence Avenue system does not create any noticeable adverse effect on the quality of groundwater in the surrounding aquifer, and it does not cause any pollution hazard for the Wilson Avenue water tunnel.
- Recently improved technology in the field of tunneling has improved the economics of this method and promises certain advantages over large, conventional, open-cut sewer construction. The former involved little interference with traffic, parking, and commercial activity, minimal inconvenience to the public, no risk of accidentally disrupting the numerous utility lines found in large cities, and no surface restoration costs.
- Drilled tunnels using rock-boring machines (moles) are relatively smooth and need not be lined with concrete if the rock is structurally sound and impermeable to exfiltration of polluted water into the aquifer. Such tunnels would save on lining costs and increase the tunnel storage capacity.
- To convey wet weather flow some 61 to 76 m (200 to 250 ft) from high-level sewers to the deep tunnel, an air-entraining dropshaft (Type E-15) based on hydraulic model testing at the St. Anthony Falls Hydraulic Laboratory, Minneapolis, MN, was used for the Lawrence Avenue system. In actual operation so far, these shafts have performed satisfactorily for the Lawrence Avenue system and other similar systems in Chicago.
- For larger dropshafts, the sloping crown of the air collection chamber requires huge excavations with associated high costs. The size of the air chamber may be able to be reduced by venting air through a separate shaft wherever feasible. This possibility was indicated by tests carried out later at the St. Anthony Falls Hydraulic Laboratory in conjunction with development of dropshafts larger than 2.75 m (9 ft) in diameter for the tunnel and reservoir plan (TARP) for the MSDGC. In the TARP design, a separately-vented dropshaft is desirable for sizes 3.66 m (12 ft) or larger in diameter, and the divider wall in the dropshaft is thereby eliminated. This type of dropshaft (known as Type D-4) has a flat roof in the air collection chamber that contractors find desirable for handling equipment. Construction costs have been considerably less than for Type E-15 shafts designed for comparable flows.

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The complete report, entitled "Lawrence Avenue Underflow Sewer System: Monitoring and Evaluation," (Order No. PB 83-229 468; Cost: $16.00, subject to change) will be available only from:
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