

increasing the usage of existing facilities (such as basements, yards, and streets) and may, therefore, be looked upon as part of a "reclamation" program. The importance of careful and efficient design of sewer systems is an important factor affecting quality.

2. EXISTING CAPITAL PLANT OF STORM SEWERS

(a) *The History of Storm Sewers*

When our country was first settled, sewers were generally nonexistent except for natural ditches and hastily constructed surface swales. It was possible to locate buildings and farm areas in favorable locations and the extent of damages suffered during flooding was small measured in terms of today's consequential damages.

As the urbanization of the country expanded and moved westward, the increased population, commercialization and industrial development imposed demands upon citizens, particularly property owners, to develop means of safeguarding their health and property. One of these safeguards developed through primitive stages (from the hand-dug ditch to the paved gutter, the rubble masonry ditches, and the underground wood sewer) and later developed into the modern underground conduit systems, provided with inlets, manholes, and catch basins; all integrated into a system of laterals, mains, trunks, and outfall sewers.

The development of systems of sanitary sewers naturally received priority as communities became congested. This was necessary to reduce the incidence of epidemics of disease and to provide for the esthetic demands and living standards of a progressing people. As communities grew, transportation became a problem. The horse and wagon, the surrey, and later the horseless carriage, again placed demands upon the citizens to provide negotiable transportation arteries through the growing communities. It was necessary to divert water away from the unpaved roadways. Later, storm sewers were the outgrowth of the communities' progress, and generally developed simultaneously with the construction of street pavements as cities modernized and developed into urban communities.

In many rapidly developing urban areas it became evident that a single system of sewers could be designed to serve both the need for disposal of sanitary waste as well as the surface drainage. Many cities thus began to construct systems of combined sewers. A 1964 publication of the U.S. Department of Health, Education, and Welfare² names large cities, including Boston, Chicago, Cleveland, District of Columbia, New York, St. Louis, and many others, as being served by combined sewers. Many large urban areas in the United States are served almost entirely by systems of combined sewers. A noteworthy example is the city of Chicago, Ill. Chicago, as of the year 1965, has approximately 4,000 miles of combined sewers and only a few miles of separate storm sewers.

Combined sewers satisfactorily convey sanitary wastes to disposal points during periods of dry weather but during periods of rainfall, they are generally unsatisfactory, when judged by today's living standards and functional and legal requirements. For example, with the advent of stringent laws regulating the disposal of untreated wastes into lakes and natural watercourses, it became necessary for

² U.S. Public Health Service, Division of Water Supply and Pollution Control, "Pollutional Effects of Stormwater and Overflows From Combined Sewer Systems—A Preliminary Appraisal," Washington, D.C., November 1964; 39 pages; publication No. 1246.