benefits and costs. The annual total cost of a storm sewer system can be expressed as the sum of the amortized capital investment, interest on investment, operating and maintenance expenses and estimated annual damages occurring after installation of the system.[1] If such costs, when amortized over the estimated life of the system, are less than the annual damage expected to be inflicted under existing or anticipated circumstances, there is economic justification for the installation of the system as designed. However, if the annual cost is estimated to exceed the annual expected damage, the design should be revised and further cost analyses made until the benefit-cost ratio equals or exceeds unity. Further analyses may be made, assuming sufficiency of available data, until the optimum design is determined. Naturally, the economic consideration presented above constitutes only one of the many factors influencing the decisions regarding the need or desirability of a sewer project.

The adequacy of a storm sewer system of an urban area may also be described in terms of the percentage of total urbanized area that is provided with sewer systems, regardless of the design capacities. Unlike many other public services, the contribution made by sewers toward a community's environment is not normally measured per capita.

In summary, the quantitative standards of performance of systems of storm sewers, within an urban area, are generally described in terms of (1) the capacity for handling the runoff from an assumed hypothetical storm, (2) the percentage of the urbanized area which is sewered, and (3) the percentage of the total runoff sewered.

(d) *Qualitative Standards of Performance and Design*

Esthetics can influence the design of storm sewer systems and may be considered as a quality measure. As an example, a very large underground conduit may be constructed to carry runoff from a large drainage area; whereas, an open, paved, trapezoidal channel, constructed more economically on the ground surface may suffice quantitatively. The underground conduit would often be demanded to satisfy the esthetic requirements of many communities, and would also be demanded in some developed areas where the loss of usable land areas creates serious problems.

Construction material and workmanship are also quality measures. Materials and workmanship of the specified quality may usually be assumed. However, an entirely satisfactory design may, if construction inspection is superficial or missing, result in unsatisfactory performance of the system due to the use of materials and workmanship which do not meet the requirements of the plans and specifications of the design engineer.

Systems of "combined" sewers are not regarded as entirely acceptable in most communities because of the pollution often resulting from overflows carrying sanitary wastes, during period of rainfall. The installation of combined sewers is no longer permitted in some areas.

The installation of sewer systems, designed and constructed to meet both quantitative and qualitative standards of performance, often benefits adjacent properties by enhancing land values and by

[1] Knapp, John Williams. "An Economic Study of Urban and Highway Drainage Systems." Johns Hopkins University, Department of Sanitary Engineering and Water Resources, storm drainage research project, Baltimore, Md. 21218, June 1965; 175 pages. Technical Report No. 2.