Value and Use of System Records in Long-Range Planning

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CURRENT literature on water utility needs puts much emphasis on the subject of system deficiencies. A recent USPHS survey of utilities serving populations of 25,000 or more indicates that these deficiencies have reached very serious proportions. The percentages of systems showing deficiencies in the principal categories are: supply 20 per cent; transmission capacity, 40 per cent; treatment plant capacity, 40 per cent; pumping capacity, 33 per cent; distribution system, 57 per cent, including ground level storage facilities, 29 per cent, and elevated storage, 43 per cent.

Water utilities often develop deficiencies because of lack of public support. Too frequently, local authorities fail to take action in time to prevent serious shortages. The only positive solution to this dilemma is to provide professional management for water utilities. This subject is effectively discussed in a recent article by Raymond J. Faust.

Supply and Treatment Records

The records that most utilities keep on supply and treatment facilities are, when properly interpreted, usually adequate for planning purposes. In the long-range planning of supply and treatment facilities, the most useful records are those that show the historical trend in demand. The average annual day, the maximum day, and maximum hour for about 20 years should be known. Records of hourly pumpage and consumption for several maximum days each year should be studied and summarized. Sufficient record data should be studied annually to develop daily-demand curves for maximum days and maximum weeks. The weekly-demand curves should sometimes be developed for: filtration rates, low-service pumping, high-service pumping, and high-service consumption.

Other records that are useful in the long-range planning of supply and treatment facilities are those on adequacy of supply, quality of supply, demand categories (industrial, commercial, manufacturing, and domestic), population served, per capita consumption, number of services, water unaccounted for, rainfall and temperature data.

In order to anticipate what improvements will be necessary in the supply facilities of any given utility, reliable information must be available on separate plant elements. This includes information on the overall hydraulic limitations of the plant and each of its elements; the safe rated capacity of all.
basins and filter units; the delivery, under present and future head conditions, of all low- and high-service pumps, operating both individually and in various combinations (including the largest unit out of service); the capacity of all basin equipment and chemical-handling and -feeding equipment. In short, sufficient data must be available to insure that the weakest link in the plant chain can be strengthened before any break actually develops.

A special study of the abnormal increase in maximum day demands was made. This study revealed that the rapidly increasing use of nonconserving type air conditioner was causing a runaway demand simultaneously with normal summer peaks. It was concluded that the growth trend of city demand could be represented best by considering the 7 months from Oct. 1 to May 1. This 7-month average-day trend is shown graphically in Fig. 1.

In 1954 utility officials were advised that unless steps were taken to combat the loads imposed by air-conditioning equipment, the ultimate capacity of the present plant would be exceeded before a new source of supply could possibly be developed. Following the increas-

**Fig. 1. Effect of Air-Conditioning Demand Charge on Maximum-Day and 7-Month Average-Day Trends, Omaha, Neb.**

*The dashed portions of the curves represent trends predicted as a result of the imposition of the air-conditioning demand rate after 1956.*

**Air-Conditioning Demands at Omaha**

Figure 1 shows the trend of the maximum day system demand at Omaha, Neb., for the period 1939 to 1959. In 1952 an improvement program designed to increase the plant capacity from about 75 mgd to 120 mgd was begun. The abnormally high demands experienced in 1953, 1954, and 1955 resulted in an accelerated plan of improvements. It was decided that the plant should be brought up immediately to its ultimate capacity of 140 mgd. Furthermore, an engineering study was authorized for the purpose of developing a master plan of system improvements beyond a capacity of 140 mgd.
ingly high demands experienced during the summer of 1955 it was decided to place a demand charge of $36 per ton per year on all nonconserving air-conditioning installations. This demand charge became effective Jan. 1, 1956, and its immediate effect on the maximum-day demand can be seen in Fig. 1. The change in trends is partly because the dry years, 1953, 1954, and 1955, were followed by abnormally wet years. The maximum-day demand rose from 80 mgd in 1952 to 120 mgd in 3 years and then dropped back to about 94 mgd by 1958. The 1959 maximum day is on the predicted maximum-day trend line.

The Omaha experience shows that the load imposed by nonconserving air-conditioners is probably the most difficult type of load to be dealt with in a water system, for, as soon as rates are adjusted to be consistent with the cost of providing service, the load may disappear almost completely, owing to the installation of water-conserving equipment. The net result of this experience at Omaha was that extra system capacity was provided several years before it would otherwise have been necessary. The 1952 plan of increasing the plant capacity to 120 mgd would have been adequate until about 1967, had it not been for the temporarily high air-conditioning load.

Figure 2 has been included to show hourly system demand at Omaha during the 1955 maximum day. It should be noted that the peak-hour rate was 157.3 mgd, whereas the total consumption for the day was 119.3 mil gal. Because of adequate storage at the plant and on the distribution system, plant capacity is determined by maximum-day demands. High-service pumping capacity is set 10 per cent higher than maximum-day demands. The 1940 maximum-day curve is included to show the change in the shape of the maximum-day load curves representing the effect of the nonconserving air-conditioning loads experienced in 1955.

System Analysis

The development of the Hardy Cross system 20 years ago has gradually brought distribution system analysis from the rule-of-thumb category into the realm of sound engineering principles. Recently the McIlroy analyzer and the electronic computer have replaced older, tedious methods of analysis. Basic data must, however, still be compiled before any method of
analysis can be applied. It is therefore essential that complete and reliable records be available.

**Input Data**

The maximum-day conditions that are usually analyzed are maximum-hour demand and replenishing storage. It is necessary, in the study of maximum days, to have hourly data on all sources of supply to the distribution system, including high-service pumps, gravity supply, booster stations, and ground and elevated storage. Data on the source of supply are usually available in the form of 24-hr flowmeter charts. Storage inflow and outflow rates may be determined from flowmeter records or level records. The level records may be either on charts or tabulated from data on storage capacity at any water level. Hourly records of discharge rates, hours operated, suction pressure, and discharge pressure should be available for all high-service pumps and booster pumps. The current head-capacity curves, of course, should be available.

Figure 3 is an example of a distribution system network condensed to simple form. The only sources of input during the maximum hour are the supply works and storage. The rates from these sources are obtained, of course, by analyzing maximum-day load curves. At the source, hourly pumpage rates are required. Hourly water level records for distribution storage reservoirs or elevated tanks are essential if backflow rates during peak hours are to be known. Although these are the most fundamental records needed for a distribution system, it often happens that no information is available on storage operation. This means that the shape of the maximum-day demand curve can only be guessed, no actual record being available on maximum-hour demands.

**Pipe Records**

Before the distribution of flow in the network can be computed, other basic data are necessary. The size, age, and length of each pipe section in the skeleton network must be known. These data are usually, but not always, obtainable from records. Complete records should be kept on the installation of all new distribution piping and should include the date of installation, size and type of pipe, type of pipe lin-
ing, if any, and length of pipe laid. Records should be kept of cleaning and relining of old mains. Details of connections to existing distribution piping and of valve locations are also essential.

**Water Use Data**

In addition to data on network piping, it is necessary to know the pattern of water use throughout the system. Except for special surveys, the only sources of information available on the distribution of water usage throughout the system are meter reading records. Usually, this information is used only by the commercial department for computing water bills. When the Hardy Cross system of analysis was first used, maps of meter reader routes often were not available. Maps could be developed only by the laborious process of referring to individual meter books for routing locations. Because of this situation, the author suggested, as early as 1944, that the distribution of water usage throughout the system should be checked annually. The meter book district usually is the most convenient unit of area for this purpose. If meter reader routes are made to conform to the boundaries of established census tracts, it is possible to follow the trend of population, water usage and per capita consumption in each of the population subdivisions of the city. The use of this principle is very ably described by Graeser, in connection with the use of the Hardy Cross analysis in Dallas:

> It is planned to use the meter reading data according to read districts and census tracts as time goes along, and to use the same load centers as those of the 1980 master plan to determine whether or not pressures will be low in a certain area and what areas should be given priority in construction as growth continues.

The punch card records now in use at Dallas provide a wide variety of information very useful in long-range planning of system improvements as well as in making rate studies. Many other valuable records are also available in addition to the primary functions of billing and accounting operations. Before discussing further the basic data needed for distribution system analysis, certain information relating to census tracts and political wards as population subdivisions will be presented.

**Census Tracts**

Census tracts as established by the US Bureau of Census are small areas having a population of 3,000–6,000. Certain large cities and sometimes their adjacent areas have been subdivided into tracts. These tracts are intended to remain unchanged from census to census.

There are 12,633 tracts in 69 tracted areas for which 1950 census data are available. Eight tracted areas were originally formed in 1910 and have increased in number since that time to 69.

Tracts are created for statistical and local administrative purposes. They are established with approximate uniformity in population, and some consideration is given to uniformity of size, with due regard for natural features. Tracts may form subdivisions of wards in areas where ward lines are infrequently changed, but they are usually laid out without regard to ward boundaries.

Kansas City and St. Louis were the only Missouri cities subdivided into census tracts for the 1950 census. The
number of tracts in these cities in 1950 were: Kansas City, 99 (adjacent areas, 9); and St. Louis, 128 (adjacent areas, 119).

Other cities are now in the process of being divided into census tracts for the 1960 census. For example, Springfield, Mo., is now divided into 25 tracts.

In Kansas City, many of the tract boundaries conform to section lines. Tracts may, for example, be ¼, ½, or 1 sq mi in area, depending upon their locations and populations.

Census data on population by political wards are available in all cities. Where census tracts have not been established, wards may be adopted as subdivisions of the water distribution system, but ward boundaries do change frequently, and it is therefore advisable to establish more permanent subdivisions.

### Suggested Subdivision

An effective analysis method is to subdivide a city of a given population into tracts of suitable size and population for distribution system records. In this example, the map of a city of 100,000 has been divided into 24 tracts. The principal records and information desired for each of these tracts are indicated in Table 1. Other data are also important, such as fire flow requirements and classification of consumption as to domestic, commercial, manufacturing, and industrial use. These records should be kept current, especially for rapidly expanding areas. Distribution system analysis becomes quite simple if such data are available. As more and more analyses of assumed future conditions are made and compared with actual conditions, the degree of accuracy of the analysis improves. The distribution system becomes a combination of unit areas of suitable size in which reliable water use data are available. Growth trends can be detected readily and the missing links in a master plan can be filled in in proper sequence. An orderly development of transmission and feeder mains is thus accomplished.

### Other Useful Records

In addition to the records previously discussed, several other types of distribution information are desirable. Recording pressure gages should be installed on principal feeder mains throughout the system, and particular attention should be given to critical pressure points on high ground. Permanent metering stations or pitot meter taps should be established on all principal feeder mains. Flow tests should be conducted on maximum days. Information on fire flow requirements throughout the system should always be up to date.

Aerial maps and topographic maps should be available as well as information on the elevations of all pump stations and storage facilities. Information should be readily available on possible sites for future reservoirs, ele-

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### Table 1

<table>
<thead>
<tr>
<th>Item</th>
<th>Tract</th>
<th>Entire City</th>
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</thead>
<tbody>
<tr>
<td>Population—gpcd</td>
<td>125</td>
<td>120</td>
</tr>
<tr>
<td>Average day—mgd</td>
<td>0.50</td>
<td>12.00</td>
</tr>
<tr>
<td>Maximum day—mgd</td>
<td>0.80</td>
<td>20.00</td>
</tr>
<tr>
<td>Maximum hour—mgd</td>
<td>1.50</td>
<td>36.00</td>
</tr>
<tr>
<td>Fire flow—mgd</td>
<td>1.00</td>
<td>12.96</td>
</tr>
<tr>
<td>Maximum day plus fire flow—mgd</td>
<td>32.96</td>
<td></td>
</tr>
</tbody>
</table>
vated tanks, booster stations, and other improvements.

A list of largest consumers showing location and water consumption trends should be kept current. The probable location of new industries should be studied. Records should be kept on the extent and location of building permits.

Central Control

The establishment of a point of central control of distribution system operations is highly desirable. In such a control center, information can be made constantly available on:

1. Pressure and pumping rate indications at all stations and at critical points throughout the system
2. Reservoir levels and elevated-tank levels (Altitude valves on elevated tanks may also be remotely controlled.)

Conclusion

The orderly development of any water system depends upon effective long-range planning. A planned pattern in which the various stages of improvement fit into a master plan is essential. This, in turn, is possible only when there are adequate records, particularly distribution system records, for system planning.

References