An Essential Tool for Municipalities

Water Conservation

The definition of 'water conservation' places the emphasis upon saving water rather than developing it. By Carl A. Tinert and William B. Lord*

What is Water Conservation?

Many Texans, like other westerners, have understood water conservation to mean the impoundment and storage of runoff in reservoirs. Water saved in this way could then be used at times when normal streamflow was inadequate to meet demands. This sense of the word is preserved in the newly-enacted revisions to the Texas Water Code, but another definition is also found there. It defines conservation as, "those practices, techniques, and technologies that will reduce the consumption of water, reduce the loss or waste of water, improve the efficiency in the use of water, or increase the recycling and reuse of water so that a water supply is made available for future or alternative uses."

This second definition places the emphasis upon saving water rather than developing it. It is consistent with what we mean by "conservation" when we talk about conserving energy, land or wildlife. As we approach full development of our water supplies, this second sense of the word "conservation" will displace the older sense, because storing runoff will no longer prevent waste. Instead, it will withhold water from other users, often at the price of increased evaporative losses. This article uses the term "conservation" in this second sense of reducing the rate of water use.

Past Conservation Efforts in Texas

Individual Texans have long adapted to water shortages by conserving water. However, water conservation became a recognized and used instrument of municipal policy during the drought of the 1950s. From 1949 to 1956, many communities restricted or banned outdoor water use during summer months or rationed the amount of water customers could use. During the 1960s and 1970s, many communities expanded their water supplies in response to the 1950s drought; droughts were more localized and conservation activities were limited.

In the 1980s, water conservation has again been used as a management tool. During the summer of 1984, about 90 water utilities, public and private as well as small and large, experienced water supply problems and implemented conservation activities. For many, only educational policies and voluntary measures were required to reduce consumption. In others, most notably Austin and Corpus Christi, mandatory restrictions were required. Several communities also had to temporarily augment their water supplies, frequently at great cost and inconvenience to customers.

Again in the summer of 1985, about 90 water utilities implemented water conservation programs. Drought was a less significant factor. Population and economic growth appeared to be the major stimulus. Some communities began for the first time to encounter the high costs of system expansion in an era of high interest rates and declining federal assistance. Smaller systems, with their limited resources, were particularly hard hit.

Why Conserve Water?

Municipalities or other water providers conserve water for several reasons. The most important thing to remember is that water conservation is an alternative to expanding water supplies. Expanding supplies is an increasingly costly undertaking. Water conservation policies can be costly, too; not so much in dollars as in learning new ways to use water more efficiently. Most of us resist changing our habits unless we are convinced that the benefits of change outweigh the costs.

The first reason for adopting a water conservation policy is to cope with a long-term water supply limitation. The City of El Paso, for example, realized that it was facing critical supply problems. The city's surface water supply was fully developed and its groundwater supply

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**Water Resources Associates, Inc., Austin, Texas and WBLA, Inc., Boulder, Colorado respectively.*

was limited. Additional groundwater sources, while available, were expensive and would involve litigation. In response, the city implemented a water conservation program to increase public awareness, reduce demand, and develop reuse opportunities. Today, water conservation is a way of life for El Paso residents and the city has begun operation of a reclamation plant to treat wastewater for injection into the aquifer.

Sometimes water supply shortages are only temporary. The 1984 drought created a short-term emergency for many South Texas communities, especially in Corpus Christi and the surrounding areas. Initially, Corpus Christi sought to reduce consumption by 25 percent. As the drought worsened, rationing was implemented to reduce consumption by nearly 50 percent. The city's efforts were successful, and today many customers benefit from their conservation efforts. Total demand is down about 20 percent and industrial customers are enjoying cost savings because of reuse and recycling programs.

There are other reasons for implementing a water conservation program besides coping with long-term water supply limitations or with short-term droughts. One is to adjust to water treatment or wastewater treatment capacity limitations. These limitations can be temporary, occurring when equipment fails or when other kinds of emergencies force shut-down. They can also occur through deliberate choice, when a decision is made to defer expensive investments pending a bond issue or receipt of a federal grant. Or, limitations may result from attempts to control growth, as Austin voters did in the 1970s and early 1980s. In any event, water conservation measures often can reduce demands to the point where they can be met with available capacity.

Yet another reason for invoking water conservation measures is to save money. This is not really different from the other reasons given above, because it is almost always possible to expand water supplies or treatment capacities if you are willing to pay what it may cost to do so. In many situations, however, those costs may greatly exceed the benefits which additional water supplies provide. A key question, then, is when do the benefits of supply expansion exceed their costs? Any good water conservation analysis should answer this question.

Water supply limitations may be due to institutional as well as hydrologic and financial considerations. In Arizona, for example, the 1980 Ground Water Management Act requires that ground water pumping not exceed "safe yield," which is to say the sum total of natural and artificial recharge, by the year 2025. In order to meet this requirement, the state establishes GDC (gallons per capita per day) limits for all municipal water providers; limits which will be reduced for each successive one-year planning period until the goal of 140 GCD is reached in 2025. These limits are just as real as hydrologic limitations.

Some communities have begun to encounter for the first time, the high costs of system expansion in an era of high interest rates and declining federal assistance.

In Texas, water conservation programs may be invoked because of similar institutional requirements. It is increasingly common to find wholesale water suppliers requiring their retailer customers to implement a conservation program if the wholesaler determines that conservation is necessary to reduce system demand. This is typically included in the wholesale contracts as a special condition. Also, Texas has now joined Arizona and California in adopting a state water conservation policy.

What Are the Water Conservation Provisions of Texas' Water Code?

On November 5, 1985, Texas entered a new era of water resources management with approval of the constitutional amendments for water resources project funding. This amendment activated House Bill 2, which was passed earlier by the 69th Legislature. That legislation addresses many issues, among them the establishment of a water conservation program for the state. First, the legislation broadens the definition of water conservation as previously described. It also requires the consideration of water conservation in requests for state assistance in water projects and water rights permit applications.

Responsibility for implementing the new water conservation program is vested in the Texas Water Development Board and the Texas Water Commission. The Board will adopt rules for the preparation, review, and enforcement of an applicant's water conservation program, as a requisite for receiving state funds for water resource development. It appears that the rules will require that applicants have active programs, that programs address both long and short-term elements, and that the programs include evaluation of the potential effectiveness of the conservation measures. The Board will offer technical assistance to utilities and municipalities.

The new legislation states that water conservation plans required under the Act shall meet local needs and conditions and that plans may include restrictions on discretionary water uses, plumbing code standards, retrofit programs, educational programs, metering, conservation-oriented rate structures, leak detection and repair, and drought contingency plans.

The Texas Water Commission is empowered to require the formulation and submission of a water conservation plan as part of a water rights application. The Commission may also decide whether an applicant has provided evidence that

Reasons for adopting a water conservation policy include: coping with a long-term water supply limitation, adjusting to water treatment or waste treatment capacity limitations, and saving money.

reasonable diligence will be used to avoid waste and achieve water conservation in granting an application. While the Commission's authority to set water conservation requirements is discretionary, it will probably require water conservation actions on the part of at least some water rights applicants. It also appears that the Commission will not propose specific guidelines, but will rely on guidelines of the Texas Water Development Board and will examine applications on a case-by-case basis.

Conservation Measures and How They Work

Water conservation can be achieved through two quite different approaches, both of which have their place along with supply augmentation, in any well-considered water management plan. The first of these approaches is to improve the efficiency of the existing water supply system. The second is to reduce the demands placed upon that system.

Improving System Efficiency

There are five techniques generally considered to improve the efficiency of a water system: watershed management, evaporation suppression, pressure reduction, metering and meter maintenance, and leak detection and repair.

- Watershed management is used primarily to protect supplies against contamination or to improve flows to a supply source. This may be accomplished by thinning vegetation in the watershed to increase water runoff or by purchasing the watershed and thereby maintain land under direct control. Communities may also use their zoning authority to limit or prohibit inappropriate land uses in the watershed area and subdivision regulations to require that development proceed in a way that does not harm the watershed and/or recharge zone.
- Evaporation supression can be a useful technique in more arid regions where evaporation accounts for losses of 10 percent or more of the water supply. While most, if not all, treated water reservoirs in Texas are covered, there are water systems which have uncovered raw water storage facilities. Evaporation can sometimes be significant, ranging up to 20 percent. Covering these facilities may be cost-effective. Some utilities have also experimented with evaportation suppression techniques on major supply reservoirs. These techniques are expensive and not always successful because of reservoir hydrology and other conditions.
- Pressure reduction is used in areas where water pressure is high, generally considered above 80 pounds per square inch. Pressure-reducing valves installed in mains or individual services reduce waste by reducing the amount of water passing through the line.
- Metering itself is not a conservation technique because it neither reduces water loss nor encourages use reduction. It does, however, provide an accurate accounting of water used in the system which is needed for other programs such as

leak detection and repair and economic incentives. Metering is, therefore, one of the two basic building blocks of a water conservation plan for an unmetered system (the other is an effective public information program). Since meters deteriorate with use and begin to underregister water usage, utilities should consider regular meter maintenance or replacement programs.

- Leak detection and repair requires the analysis of unaccounted-for water within a system.

Unaccounted-for water may be due to defective hydrants, abandoned services, unmetered water (municipal uses such as fire fighting and landscape watering), illegal hookups, unauthorized use of fire hydrants, and leaks in mains and services. If a utility has a high unaccounted-for loss caused by leaks, a scan of the system or localized areas utilizing electronic listening devices is appropriate. If the unaccounted-for water is not caused by leaks, a water audit is appropriate. A water audit is an accounting of the quantity of water from the point at which it enters the system to the points at which it leaves the system. The feasibility of repairing leaks discovered will vary from system to system depending on the cost of water and the cost of repair.

Managing System Demand

All measures for managing water system demand rely on one of three general approaches. The first approach is to use information as the means of changing water use behaviors in order to save water. The second approach is to use monetary incentives to accomplish that same end. The third approach is to use regulations which prescribe what water users may not do or what they must do.

- Providing information to water users is easy and inexpensive. Water bill stuffers, press releases, and similar techniques cost little and reach many people. The information conveyed may be simply educational, such as telling people how to determine when their lawns really need more water, and how much. It may also be persuasive, such as attempts to portray water conservation as socially responsible or morally good. In either case, providing information alone has limited effectiveness. Information measures are best regarded as supplementary to incentives or regulations if appreciable reductions in water demand are required. They can be almost indispensable supplements, however. Furthermore, people do not object to information measures.

- Monetary incentives reward people or penalize them for specific actions. Allowing tax credits for investments in energy conservation or solar energy home improvements are familiar examples. The same principle can be applied to investments in water conserving plumbing fixtures, in low water demand landscaping, and in efficient lawn irrigation systems. Positive incentives such as these can be very effective and are highly acceptable. They are also very costly.

A penalty for wasting water is an example of a negative incentive. Negative incentives are also very effective, and they are not costly. In fact, they can produce additional revenues, although the better they work, the less revenue they produce. Their big drawback is that people resent being penalized in this way, except in extreme drought situations.

Water conservation can be achieved through two quite different approaches: improve the efficiency of the existing water supply system and reduce the demands placed upon that system.

• Perhaps the most useful form of incentive-based water conservation measure is the water conservation rate structure. People do respond to price increases by decreasing consumption, thus limiting the effect of the rate change upon their household budgets. Furthermore, the longer the increased rate persists the greater will be the reduction in use, provided that an adequate information campaign is employed to explain the change and suggest ways of adapting to it. Such a campaign is also necessary to explain the reasons for the rate increase and thus to reduce what is otherwise a moderately high degree of public opposition to rate increases. But conservation rate structures can be very effective and are very flexible. Also, they increase revenues (but sophisticated rate structures can be designed to achieve any desired revenue goal and to place the burden on specific user classes, while still meeting water conservation objectives and conforming to the principle of cost-of-service pricing).

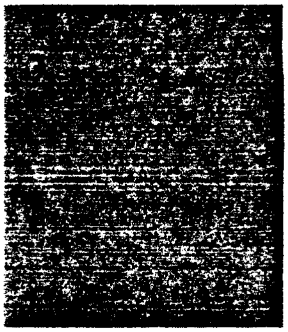
Regulatory measures, such as lawn watering restrictions, building code requirements, and water rationing are inexpensive to adopt, although sometimes expensive to enforce. They can be highly effective, although some, such as lawn watering restrictions, are rather ineffective. Regulations, like penalties, often raise the ire of the public, except in times of drought emergencies. A supplementary public information campaign is desirable to reduce unacceptability and to explain the regulations.

Lessons From Past Conservation Efforts

Past conservation efforts in Texas and California, where effects have been studied more, have taught us several important lessons. The first is that public acceptance of drought-accommodation water conservation measures is very high and that these measures can be very effective if the perception of crisis is widely shared. At the same time, the best measures to use for emergency demand reduction are short-lived; their effectiveness declines sharply with time. Long-run demand reduction measures retain their effectiveness, but they are apt to encounter more opposition.

The second lesson is that water conservation measures differ widely in their effects. Regulatory measures, such as those which were widely used in the California drought, tend to reduce revenues in proportion to their effectiveness. Price-based measures, in contrast, tend to raise revenues.

The third lesson is that a water conservation program should be carefully planned if it is to achieve its objectives without creating new problems in the process. Short-run measures do not solve long-term problems, and vice versa. A combination of revenue reducing and revenue increasing measures will ordinarily be needed to retain a revenue-expenditure balance. Finally, public acceptability is an important consideration, but one which can be influenced with a good information program. ■



The Second and Concluding Article

Designing an Effective and Acceptable Water Conservation Plan

To be effective, your plan must understand your utility's future water demand and water supply in order to identify problems and bring each into balance. To work, your plan must be acceptable to city council members and consumers. ■ By Carl A. Teinert and William B. Lord*

In the first article of this series, we provided a general overview of water conservation and the new emphasis conservation will have in Texas. No longer will conservation mean only the building of a reservoir to capture surface water flows, but it will also include efforts to reduce consumption of water, reduce the waste of water, increase the reuse and recycling of water and improve the efficiency in the use of water. These efforts will now need to be considered by municipalities as they make application for state assistance in building water projects and for water rights permits.

We also discussed various conservation measures and how they work. Water conservation can be achieved by two approaches. The first approach is to improve system efficiency and the second is to reduce the demands placed upon the system. Techniques to improve system efficiency include: watershed management, evaporation suppression, pressure reduction, metering and meter maintenance, and leak detection and repair. Techniques to reduce system demand include using: information to change the water use habits of consumers, monetary incentives to encourage use reduction, and regulations which prescribe what consumers may or may not do.

With this general information, you are now ready to design an effective and acceptable water conservation plan. Your plan must be effective in the sense that it be capable of achieving the desired results. This requires an understanding of your utility's future water demand and water supply in order to identify problems and bring each into balance. Your plan must be acceptable in the sense that it receives approval from the city council and from the consumers. Consumer acceptability is measured not only by their support during city council consideration, but more importantly by their implementation of water conservation techniques as required by the plan.

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Establishing Water Conservation Objectives

Texas law now encourages municipalities to prepare water conservation plans, plans which enable you to suppress long-term water demand and to be prepared for drought or other short-term water supply reductions. These are sensible goals. But each municipality will want to be more specific about the objectives of its own water conservation plan. How much and what kind of water conservation makes sense for your system? The answer to this question will provide you with essential guidance as you decide which conservation measures to include in your plan.

The first step in establishing your water conservation objectives is to project future demands for water.

Demand will grow as population and economic activity increase. Projections of future population and economic activity are likely to have been developed for other municipal or regional planning purposes. They can be used for water conservation planning as well.

Water utilities, or their consultants, have frequently projected future water demands by determining current water consumption per capita and then simply multiplying projected population by current per capita consumption. This "constant GCD" method is no longer adequate, if it ever was. Too many other factors also shape water demand. Better projections can be developed by including the prospective influence of land use and housing changes, and changes in the composition of the industrial base.

Such factors determine not only how much water will be consumed but also the daily and seasonal patterns of water use. Daily peak demand dictates the amount of water treatment capacity required, while seasonality influences both daily peak demand and the amount of seasonal storage needed. Treatment capacity and seasonal storage can be two of the most costly components of a water system. Controlling these costs can be a major goal of a water conservation program.

Water demand also varies with the weather, primarily due to the relationship between natural precipitation and lawn watering. Reliable weather forecasts do not extend into the future. Instead, it is necessary to treat the influence of weather statistically, as a source of uncertainty. Thus the actual demand for water may exceed or fall short of the projected demand by a small margin (likely) or a larger margin (less likely). Contingency planning for drought or other short-term emergency requires that this uncertainty be quantified and considered.

An important factor in determining future demand for water is the price which consumers will have to pay. Rate increases may be needed to pay for developing new water supplies, for additional seasonal storage, for water treatment and distribution facilities, or for other purposes. These rate increases will affect how much water is demanded, by whom, and when. It is exactly for this reason that pricing is one of the most effective water conservation measures. However, it is best to project water demands initially without considering the potential effects of rate changes. This important factor can receive full consideration in the program development phase of planning.

Future water supplies must be projected next. The yield of the system as it now exists is the base upon which future supplies are projected. That yield may be expected to change, as aquifers are depleted or system enhancements currently under construction are completed, for example. Projections of total annual water supply, and maximum daily deliveries should be prepared.

The "constant GCD" method of projecting future water demands is no longer adequate.

Optional increments in total water supply, seasonal storage, and treatment capacity should be tabulated, along with the earliest dates on which they can be added to the system and their prospective costs. The result should be a stair step-like function which shows potentially increasing values of each of the three main water supply components throughout the planning period.

Water supply, no less than water demand, is subject to uncertainties due to weather variability and other unforeseeable factors. The potential effects of these uncertainties must be quantified, preferably with estimated probabilities of occurrence. The often-used concept of "safe-yield", which establishes a planning target based upon an arbitrarily selected level of system reliability, should be avoided. Its use prejudges the critical question of how much insurance (in the sense of costly excess capacity) you can afford to carry to protect you against emergencies. This question deserves to be analyzed carefully, not assumed away. The risk of water shortage, like other risks in life, cannot be totally eliminated. Rather, an explicit decision must be made about how much risk to accept, balancing the costs of running short of water against the costs of building in excess capacity.

Now, by comparing projected future water demands with projected future supplies, it will become apparent where and when problems of inadequate supply are likely to arise. Again, these are as likely to be problems of seasonal distribution of supplies or of treatment capacity inadequacies as they are overall water shortages. And, each will include the dimension of uncertainty, and the costs necessary to reduce that uncertainty. Addressing these revealed problems to bring supply and demand into balance at reasonable cost provides the specific objectives for your water conservation plan. Those objectives will specify what reductions in total water use, peak seasonal use, and peak daily use you hope to achieve and when.

Defining Water Conservation Options

There are literally scores of optional water conservation measures available from which you may choose. You can, and should, narrow that broad field of choice substantially before you undertake a detailed evaluation of your options. That can be done easily and quickly by classifying conservation measures according to whether they:

- effectively reduce total water demand
- effectively reduce seasonal water demand
- effectively reduce peak daily water demand
- increase or decrease system revenues
- are costly to employ

Approval of the conservation plan will depend upon community support. It is necessary, therefore, that a public participation program be a part of the planning effort.

- are relatively acceptable to water users
- are short-term or long-term measures

Now, you can compare the objectives which you have established with the characteristics of the available conservation options, eliminating all of those which do not match well. Be careful, however, that you do not eliminate options too readily, for it is likely that it will take an integrated combination of measures to accomplish your objectives most effectively. It is easy to discard options too soon, when it appears that they cannot achieve your objectives when examined one by one.

Lists of water conservation measures exist in several places. Perhaps the best single source is the state of California, which for several years has had a program somewhat similar to our new Texas law. The state has attempted to assist water suppliers in the preparation of their water conservation plans in many ways, including provision of lists of conservation measures and their characteristics. Research over the past ten years has documented the effects of conservation measures in many places. There is particularly rich and sophisticated literature on the effects of rate changes on water use. Any good consultant in this field should be able to prepare a list of options and their characteristics for you at a very reasonable cost.

Developing the Water Conservation Program

When your water conservation objectives have been established and the options to be considered for attaining those objectives have been defined, it is then possible to put together a program of conservation measures which should meet your objectives with minimum cost. Basically, the process of designing such a program amounts to discovering that combination of measures which is mutually complementary and responsive to identified needs.

Technically, the task is an exercise in operations research, quite similar to that which is performed to optimize production processes in industry or agriculture. Fortunately, water supply system planning seldom requires that the mathematically sophisticated tools of operations research be employed. It is usually sufficient to proceed in a step-wise fashion, bringing in one or a very few conservation measures at a time to satisfy one objective at a time. A computer program is a handy and efficient way of doing this. Some consulting firms have developed such programs, or one who is adept at using spreadsheet programs can do a good job without such help.

In developing your water conservation plan you must also prepare codes and ordinances, prepare an enforcement strategy and provide funding. Codes and ordinances establish the municipality's authority to implement and enforce a water conservation plan. One or more codes, code amendments and ordinances may be required, depending upon the plan. The city attorney should be consulted for this effort. Enforcement will require the cooperation of several municipal departments including police, fire, public works, building, legal and health. This effort must be coordinated and attention given to the other health and safety concerns of the municipality. It is recommended that funding for the conservation program be included in the water utility's budget and be covered by water revenues.

Approving A Conservation Plan

Approval of the conservation plan will depend upon community support. It is necessary, therefore, that a public participation program be a part of the planning effort. You should initiate discussions with special water user groups and with community groups. You should also have an advisory group to review the plan, hold public meetings and forward its recommendation to the city council. An existing group, such as the planning commission, could serve in this role or you may want to appoint an ad hoc committee.

Following preparation of the plan and with the support of the community, the plan should be approved by the city council. This is necessary because the plan will be setting public policy for future water utility activities. In instances where the plan was prepared because your municipality is seeking state financial assistance or making application for a water rights permit, the plan must also be approved by the appropriate state agency. State approval will be more likely if the state is consulted and advised throughout the planning process.

In closing, water conservation will soon become a new tool in the water management program of municipalities. Designing a conservation program for your community requires the establishment of objectives which seek to balance the utility's future demand and water supply. It also requires classifying the various conservation measures according to what they will accomplish. You then seek that combination of conservation measures to meet your conservation needs. The planning activities should also include the preparation of codes and ordinances, an enforcement strategy and program funding.

By considering these elements, you can develop a plan which is effective and acceptable to the community, and one which will be a useful part of your water management program. ■