Engineering Economics of Rural Systems: A New US Approach

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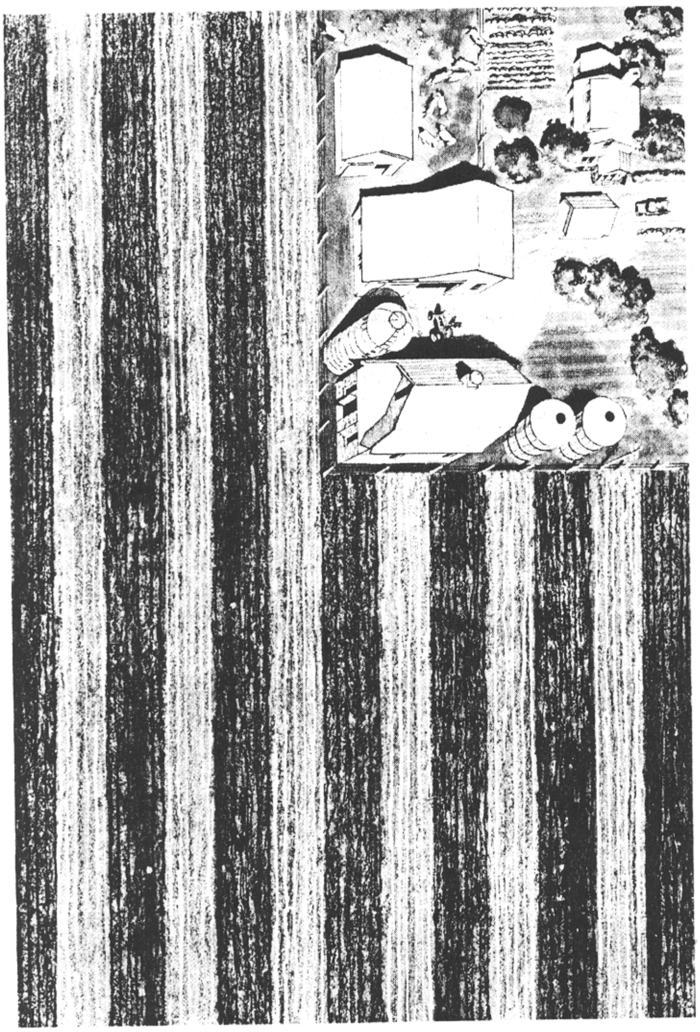


The rural areas of the US have always been plagued with the difficulty of receiving services from public or private utilities. This article presents a view of engineering principles with regard to the problem as applied by the Natl. Demonstration Wtr. Project and the Com. on Rural Wtr. Local conditions and system design are explored and defined in both quantitative and qualitative terms.

Many US citizens, especially those who live in remote, economically depressed regions and rural minority centers, do not have adequately safe drinking-water facilities. At least, this is the conclusion that emerges when existing facilities are surveyed and judged against a reasonable standard of adequacy. Documenting this assertion requires not only that existing water facilities be surveyed, but also that a concept of adequacy be developed that can be used as a standard when judging water facilities.[1]

The Meaning of Adequate Facilities

Because drinking water is essential to life, everyone has some method for obtaining it. The term "facility," however, implies some type of man-made device. In other words, drinking directly from a stream is a method, whereas a well would be considered a facility. Determining the adequacy of existing facilities requires that the concept of quality be included with that of quantity. It would be grossly misleading, for example, to list a well as an existing water facility if the water were contaminated.

Considerations of cost and convenience also must be recognized. If a family transports pure water from a distant source at a great expense, should that source be considered as an adequate water facility. Although most people are willing to recognize the need for safe water, they seem to be less willing to accept low cost and convenience as minimum standards, at least for the purpose of establishing a public responsibility.

There is no reason for this type of attitude to prevail. Cost and convenience to citizens, as well as public safety, are factors in most public policies that can also be applied to rural water facilities as well. A minimum standard of "adequate" would seem to ensure a satisfactory supply of potable water delivered to the home.

The Inadequacy of Existing Facilities

Judged by even a minimum standard, too many present water facilities are inadequate for rural areas of the US considering the following facts from completed studies:

1. Nearly 75 per cent of the US population is served by public water systems (that is, community facilities serving many households), but a recent USPHS survey of selected systems discovered that 41 per cent failed to meet USPHS drinking water standards. Only 50 per cent of the systems serving fewer than 500 people met even the minimum standards.[2]

2. A 1969 study by the US Farmers Home Admin. (FmHA) identified over 30 000 communities with populations below 5 500 that needed assistance in either building a water system for the first time or improving an inadequate one. The study did not cover communities that were considered by FmHA to be unsuitable for central systems.[3]

3. Individual water supplies can also be considered as "adequate" if they are properly constructed and maintained. However, surveys that have been done of individual water supplies suggest that they are worse than community supplies, primarily because of a wide occurrence of initially substandard facilities such as dug wells or spring-fed supplies. Recent regional field studies in three southern states found a substantial majority of the individual supplies actually sampled to be contaminated, in some cases as high as 90 per cent contamination. Further, the areas sampled were generally located in economically depressed regions and relate more toward the conditions in those areas than to other rural regions. However, since nearly one quarter of the US population, mostly in rural areas, relies on individual water supplies, an estimated 20–30 million citizens in rural areas could be drinking unsafe water.

These facts and other data can lead to the conclusion that existing water facilities in the US are inadequate and it is the rural sector that is hardest hit. The known inadequacies of water facilities in rural areas suggest that the national system for delivering these services could be performing at less than peak efficiency. This is created partly because of weaknesses in the present system itself and partly because of the nature of rural life.[4]

Pollution and geography are the key factors that have produced the rural problem. It is well known that most US streams are now polluted by human and industrial wastes. Acceptable ground water aquifers, which are the major source of water in rural areas, have also been adversely affected. The result is that an ample and convenient supply of water can only be obtained by drilling, pumping, treating, piping, and storing.

The population density in the US also is a factor. Persons who live in densely populated urban areas, large or small, can be served efficiently and economically by a central water source and treatment facility. However, the scattered rural population, especially those living outside any incorporated municipality, cannot usually be reached by central water systems. They must rely instead on individual systems.

The rural situation means that even many persons with moderate incomes cannot receive satisfactory water service. The fact that many rural residents have low incomes further complicates the problem. Affluent residents can afford wells. This does not, however, guarantee adequate facilities since there is usually no supervisory body to provide regular maintenance and inspection to prevent malfunction, contamination, and pollution. Low-income persons are often left with even worse facilities or no facilities at all. They cannot pay the cost of constructing and maintaining an adequate water system. They are faced with a dilemma of either moving to a city or enduring poor water service.

Weaknesses in the US National Delivery System

Although the delivery system for rural water has reached many residents in the past, the increased pollution of water supplies, the need for more complex and expensive facilities, and the general shift of human and financial resources away from the rural areas have made this system progressively less satisfactory in recent years. The major weaknesses in the present system are

Policy and priority. There is no coherent or adequately supported national commitment to the provision of basic sanitation service, for both water and wastewater, for rural residents or to assistance for areas most in need.

Financing. Subsidized and nonsubsidized financing is not available in many rural areas to residents who seem to need it most.

Development. The limited availability of public and private developers prevents many rural residents from assembling and managing the resources required to provide sanitation services.

User support. Users who generally want adequate domestic sanitation services are not always aware of the process involved in obtaining and sustaining this service and the role that they must play in the endeavor.

Technology. Design and construction of facilities is not sufficiently directed at meeting technical problems in rural areas, although most common problems can be resolved at a reasonable cost with existing technology.

Operation and maintenance. Inadequate attention to operation and maintenance has often meant that services that have been established could not be maintained over the loan period.[5]

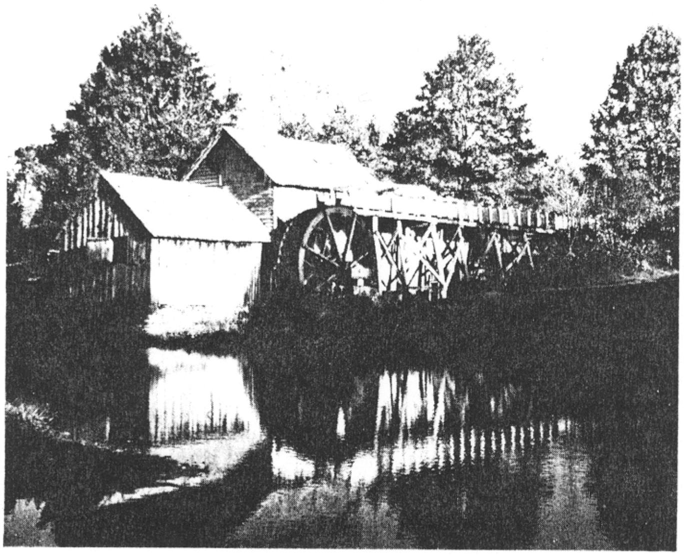
The development of a national commitment to adequate water facilities involves both the question of general responsibility for action by way of public sector or private sector and the question of the proper governmental level for any public action deemed necessary.[6]

The Responsibility for Action

There are several possible options when the responsibility for alleviating a social problem is to be assigned. The entire problem may be left in the hands of private, profit-making groups without any participation by the public sector of the economy. At the other end of the scale, the public sector may assume all of the responsibility to the point of constructing, owning, operating, and maintaining necessary facilities. Or there can be a partnership involving both public and private interests.

The private sector does play a major role in water development in the US, especially in the development of ground water technology. In addition, about 15 per cent of all water companies are private, profit-making enterprises. They serve approximately 15 million people, mostly in rural areas.

A major drawback to the private sector approach, however, is that profit-making interests have not been able to extend service to all rural residents in the past and may not be able to do so in the future. The primary reason for this is financial. Since most of the rural population that presently lacks adequate



In rural areas water systems are deficient.

facilities lives in scattered communities and in isolated areas where the cost of service is high, a central distribution or collection system can only be extended at prices that low-income families cannot afford. Nor can such families bear the financial burden of having segments of the private sector, such as water-well contractors, construct individual facilities. The presence of a public, municipal water system rather than a profit-making company does not automatically solve the problem. Like private companies, if municipal or other governmental water systems extend service into rural areas, the cost of such service is usually too high for many low-income families.

What seems to be required in the US is some form of public subsidy for the construction and operation of facilities. This kind of public assistance is now so common that it is no longer considered as a public subsidy. Certainly schools and roads for all citizens would have been impossible without governmental assistance. Rather than give a direct subsidy to those who could not afford to buy services themselves, the government assumed the responsibility for developing public facilities available to all, regardless of income.

Although the problem has been handled somewhat differently, the health of the US population has also long been regarded as a matter of public concern. Not only have communicable diseases been attacked through public efforts, but environmental health, including water and sanitation, has been controlled, also.[1] Local governments, in one way or another, regulate the vast majority of US water systems. State governments, through health departments and planning bodies, provide research, regulation, and sometimes financing. The federal government, long involved with research in water and sanitation through such agencies as the US Public Health Service, the US Office of Water Resources Res., the USGS, and the USEPA, has been an important source of funding and significant technical assistance for water and wastewater projects.

A striking indication that US policy makers at the federal level have accepted the importance of an adequate water supply as a factor in community development is provided by activities of the US Agency for Intl. Development. Between the early 1940s and 1968, the US contributed almost 1 billion dollars to the development of water-supply systems in foreign countries.[7] Within the US, however, there has been no public effort of a scope and cohesiveness to match those efforts made abroad.

US citizens have traditionally been inclined to rely on private initiative as much as possible and to turn toward government, especially for funds, only when private methods are inadequate. Although the private sector should continue to have an important role to play in water-system development, it is likely that it cannot do the job alone.

Weaknesses in Funding Policy

Low-income families, as defined by the US Office of Economic Opportunity guidelines, cannot pay water bills or meet loan payments much in excess of $7.00 per month. This rate is difficult to attain without benefit of public subsidy.

Although the Farmers Home Admin. (FmHA) financing has been important in advancing the quantity and quality of rural water facilities, it is not unfair to note that funds have not usually been made available to those who need them most—low-income residents. The agency's eligibility requirements under individual loan programs (No. 502 and No. 504) have been a difficult hurdle for the rural poor. They sometimes lacked clear title to their property or could not meet loan payments when the life of the loan was for only ten years. Properly concerned with the fiscal health of its operations, FmHA has avoided risky loans, thus channeling funds for water facilities to those persons in the best position to afford their own facility without any assistance.

More importantly, perhaps, grant and loan funds for community systems have by and large been extended only to central systems with one water source of water and one treatment facility, determined mostly on the basis that efficiency and continuity of operation are best assured by such systems. Rural communities or clusters of houses not meeting FmHA criteria for central systems have thus been excluded.

Even where eligibility standards have not been a problem, a persistent shortage of grant funds has limited the agency's ability to respond to low-income residents. This shortage has developed into an outright end of grant funding. Loan funds are presumably in plentiful supply, but this does not solve the problem.

Future Policy

Whether funds are provided for water projects through a federal agency or through states, there are certain basic features that are government-incorporated into any funding program. Most basic of all is the need for public subsidies—grant funds. If low-income citizens are forced to rely on their own meager resources entirely, then it will be a long time before they have adequate facilities. Money will not solve all the problems of developing water systems, but the other program efforts are irrelevant if grant funds for construction are not available.

Public assistance to those who need help and are willing to help themselves has been traditional in US society. There should not be any misunderstanding about the extent to which low-income residents will help themselves. Under the previous FmHA water-association plan (where systems were financed by a combination of 50 per cent grant and 50 per cent loan funds), users would pay about 79 per cent of the total cost of the system (initial capital plus operating expenses) or 62 per cent of the present value of the total system cost.

An additional criterion that future policy should meet is the lessening of eligibility requirements for assistance so that low-income households can qualify. Since there will probably always be some rural people who are so isolated that they will be excluded from any central system, their needs will have to be met on an individual basis. Lower interest rates and longer repayment periods would probably alleviate much of this problem.

In any case, future funding agencies should be less restrictive about the types of water systems that they will finance. The difficulties involved in reaching low-income rural residents by traditional central systems have led to attempts in recent years to devise a new approach based on the experience of rural electric cooperatives for delivering electricity to rural homes.[8] This approach also makes possible the kind of effort that is broadly endorsed in the US ethic—a combined public-private effort.

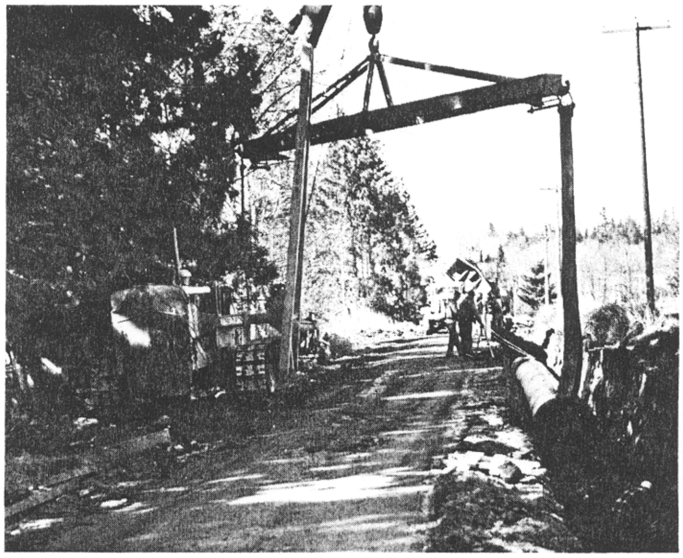
The public-private approach is being tested in various parts of the US by the Natl. Demonstration Water Project (NDWP) and the Com. on Rural Water (CRW). Beginning in the late 1960s as a single project in Virginia, NDWP has since developed a number of model projects in other states, all designed to demonstrate the effectiveness of using local organizations to solve the problems involved in obtaining water and sanitation facilities for rural residents.

The original NDWP project emerged from the efforts of low-incomes residents in a five-county area around Roanoke, Virginia, to obtain adequate water supplies.[9,10] With funding from the US Office of Economic Opportunity, NDWP established a series of separately incorporated water companies and then trained residents to operate the companies as nonprofit associations. After a considerable struggle, the necessary approvals were obtained and financing was secured from the Farmers Home Admin. for the construction of facilities. Several companies are presently in full operation, and others are in various stages of development. Water is now being supplied to residents who never before had an adequate supply.

With the Roanoke experiment considered a success, NDWP is testing its model in various areas that have different problems. A project now underway in Logan, West Virginia, includes wastewater facilities as well as water facilities. Another model project in Beaufort and Jasper counties in South Carolina is attempting to produce a cooperative arrangement with a local municipality in one area and a water system that includes fire protection in another. Other development efforts sponsored by NDWP are presently under way in Lee County, Arkansas, and in New Mexico. NDWP is also developing a field demonstration project at the national level in conjunction with the Natl. Rural Electric Cooperative Assn.[11]

The NDWP program is a solid combination of public and private efforts. Developmental work has been funded by the US Office of Economic Opportunity. Money for construction of water facilities has in the past depended largely on the US Dept. of Agriculture's Farmers Home Admin., and presently grants for the construction of wastewater systems are sought from the USEPA. Development activities themselves, including the research and technical assistance associated with these activities, have been undertaken by private, social, and technical research organizations representing the ground-water industry and various community organizations. Several government agencies at all levels have shown an interest in improving rural-water and waste-disposal facilities. A national clearinghouse for rural water information has also been established. As a result of the activities undertaken by this group of public and private organizations, NDWP is attempting to develop a method of rural water development that can be effective in all parts of the US.

The precise choice of implementing organization—the funding agency itself, another governmental agency, or a public-private organization such as NDWP—is not the crucial issue; any of the three or a combination of the three might be



Pipe-laying cost is but one rural water-system factor.

successful. What is important is that the present lack of an organization within the US to implement a program of rural water development is a serious weakness in the present national delivery system.

The NDWP Approach

To help remedy the weakness in the national delivery system, NDWP adopted certain concepts in the development of its field projects.[11-13] The term "water system," for example, normally implies centralized operation in the tapping of a water source, treatment of water (if necessary), and the distribution of it, but it need not mean centralized *physical* facilities. The centrality of a water system may lie in (1) its water source and treatment configurations, (2) its type of management, or (3) both.

A water system may have central management, one water source, and one treatment facility for all households included in the system. This is probably what the term "system" means to most people. It suggests perhaps an incorporated town in which a city water authority supervises the water facilities for all households and commercial establishments within the city's limits. It might also describe an unincorporated area, perhaps part of a county, in which similar centralized services are provided by a privately owned, profit-making company.

There seems to have been a general feeling in the US that only a central water source or a central treatment facility could provide satisfactory service and quality water.[14] This preference for central systems is based on the fact that such systems have had central management, which has been a crucial factor in the production of reliable service and quality. However, central management need not be bonded to central systems in the physical sense.

Another type of system employs central management but several different systems. Several low-capacity wells and small treatment plants could serve a varying number of people—one house, several houses, several dozen houses—all as part of the "system" in the sense of management. With central management, the actual configuration of the facilities need only meet realistic engineering criteria that are based on a detailed economic analysis of system alternatives for the specific project.

Local conditions. The designer of water systems for any community with essentially rural, low-income residents must consider the ultimate cost to the user. In the NDWP experience, the local conditions and their respective impact on the specific project area play a critical role in assessing the ultimate configuration of the system's design. The local conditions or field parameters fall into three broad categories as follows:

1. Geographic (topography, population density, surface reservoir proximity, and suitability)
2. Hydrologic (surface water quality and availability, and ground water quality and availability)
3. Political (state and federal regulatory agency attitude)

Each of the previously mentioned categories is interrelated with another in any one project.

Early in the preliminary design, NDWP project personnel defined the "field parameters." In one project area the economic impact of certain geographic factors were significant to project design because frequent bedrock exposure and a clustered population density in isolated areas were common features. Bedrock exposures combined with isolated clusters of homes are factors that place design emphasis on reducing the extent of distribution-line construction between each isolated group of homes as much as possible. In other project areas the geographic factor has far less of an impact. This would be in such areas as low relief having unconsolidated sediments at the surface, thereby inherently requiring less capital for distribution-line construction.

The hydrologic parameter is the second factor that is carefully delineated before a particular water system can be selected. Local water availability and quality are reviewed with regard to either a surface-water or ground-water source. Because a ground-water source is usually, although not exclusively, favored on an economic basis, its quality is a significant factor.[12,15,16]

If, for example, previous test drilling and production analyses of the ground water in the project area indicate that significant treatment will be required to remove iron and manganese, then the economic impact of this factor may make a surface-water source more favorable economically.

When designing NDWP projects, concern for the system over a long-term period (over 40 years) is one of the guiding philosophies. As explored previously, proper management is another guiding philosophy. To design on this basis, however, requires a slight departure from previous practices. Detailed data on water quality and availability are imperative to proper design and are normally unavailable. Many projects are designed on the basis of gross data that can lead to early failure, malfunction, or severe loss of efficiency. NDWP projects recognize the need for the detailed evaluation of local conditions and allocate development funds for defining such parameters.

The third field parameter that affects the design of a system is the political factor. This factor is not as easily defined quantitatively as the first two, but it can be assessed qualitatively. For example, in NDWP experience, problems have developed when a specific design is presented to the regulatory agency for approval. One state agency historically prohibits the use of PVC pipe; another may require specific well sizes.

A strong tendency exists for regulatory agencies to favor systems that are overly designed and economically unsuited to the project's local conditions. This tendency most likely stems from the agencies' concern for the system's longevity and operational simplicity. Therefore, the regulatory institution must be considered early in the system's design.

System costs are affected, especially if preference is expressed by an agency for one type of water-supply system over another. One example of this is the common preference for a central high-capacity well system, a preference that is based more on operational control considerations than on an engineering basis. On an economic basis (including due consideration for operation and maintenance) several decentralized installations of lower capacity may often be the superior design.

Local parameter translation. Once the approach to assessing the degree of impact of the local conditions on the ultimate design of a system has been briefly explored, the next stage of the NDWP evaluation consists of translating the relative impact of the conditions into the system's design. There are four accepted system types, or alternatives, for obtaining a community water supply in a rural area:

1. Tap and treat raw surface water; for example, small surface reservoirs and rivers.
2. Purchase treated surface or ground water; for example, extending existing water lines.
3. Construct a single high-capacity well system; for example, one well, a central treatment plant, and an extensive distribution system.
4. Construct a multiple or "cluster" well system; for example, more than one well, additional treatment plants, and less extensive distribution systems.

NDWP field affilitate projects have so far employed all but the first alternative. According to the NDWP approach, each of the system types is reviewed with regard to its possible use in the project area. Given the local parameters, an economic comparison of the systems' total cost is made as follows:

$$S_R = P_W + T_{CR} + D_{CR} + O_{CR} + M_{CR} = \text{raw-surface-water system}$$

$$S_T = P_P + D_{CE} + M_{CE} = \text{purchased water system}$$

$$S_C = W_{CC} + T_{CC} + D_{CC} + O_{CC} + M_{CC} = \text{high-capacity well system}$$

$$S_M = \sum_{i=1}^{n} W_{CM_i} + T_{CM_i} + D_{CM_i} + O_{CM_i} + M_{CM_i} = \text{medium–low capacity well systems}$$

where:

S_R, S_T, S_C, S_M = total cost of system over project life
P_W = pumping plant construction cost
P_P = purchased-water cost estimation over project life
T_{CR}, T_{CC}, T_{CM} = treatment-plant construction cost
$D_{CE}, D_{CR}, D_{CC}, D_{CM}$ = distribution-system construction cost
W_{CC}, W_{CM} = well-system(s) construction cost
O_{CR}, O_{CC}, O_{CM} = system-operation cost over project life
$M_{CE}, M_{CR}, M_{CC}, M_{CM}$ = system-maintenance cost over project life

Each factor on the right side of the previous equations can be evaluated in terms of the effect of every significant local parameter on total systems costs over project life, that is, the term of the loan. Also, comparisons of equivalent factors, that is, maintenance costs for a central well system and a multiple well system, can be made and their relative impact on total cost assessed.[12,17]

When the total system costs among the four alternatives are compared, the local parameters dictate which system is to be selected. This selection is based on economically sound engineering, which ensures the lowest possible monthly per-user rate and consequently the most efficient use of funds. Although the examples provided are for water systems, the same approach is also taken with wastewater systems design.[18]

Central Well Systems vs Cluster Well Systems

NDWP-sponsored rural water projects usually include some variation of a well system, and hence the need arose to develop an approach that would more accurately compare the total costs of a central well system with a multiple well system.

Construction of a single high-capacity, or central, well system for a rural community is a method that has many advantages. The single water source and treatment facility makes possible economies of scale. Central management of the water system promotes efficiency and continuity in system operation, particularly if the central management is a governmental body. As mentioned previously, federal agencies with authority to finance rural water projects have shown a decided preference for this type of central system. The principal drawback to this approach is that many rural residents cannot be reached from a central water source, or extensions thereof, except at a price they cannot pay. If individual households and small communities are scattered over a large area, as they often are in rural regions, residents who cannot afford individual wells face a choice between expensive water from a distant source or no water of acceptable quality at all.

The limitation of the traditional central well system approach to water system development has led NDWP to the development of the "cluster well" alternative. Several wells of medium-to-low capacity are constructed, each serving a small cluster of homes, but the multiple system of wells and low-capacity treatment plants is centrally managed. In this way, the objectives of both low construction cost and efficient operation may be achieved. Although the "cluster well" alternative is not always applicable since one or more of the local field parameters may preclude its employment, this alternative does find widespread application in the US and elsewhere.

A key consideration when comparing the design economics of the central well system and the cluster well system is the distance between the homes to be served. There is a point beyond which it becomes more economical to construct a second well than to lay pipe to connect a distant house to an existing well. Another equation that has been developed by NDWP as a criterion for comparing costs is

$$\frac{S_C}{S_M} = C_R$$

or

$$\frac{W_{CC} + T_{CC} + D_{CC} + O_{CC} + M_{CC}}{\sum_{l=1}^{n} W_{CM_l} + T_{CM_l} + D_{CM_l} + O_{CM_l} + M_{CM_l}} = C_R$$

where:
C_R = total system cost ratio
S_C = total system cost of high capacity or central well system
S_M = total system cost of medium-low-capacity or multiple well system

When the effects of the local field parameters have been translated into estimated dollars in terms of their effect on construction, operation, and maintenance costs, estimated cost components are entered into the respective expressions and the equations solved for total system cost; for example, S_C for the central system, and S_M for a multiple well system. Ideally, if the total system costs ratio is unity (one) or less, the central well system would be the superior design for the particular project area.

Central Well Extensions

As is often the case, one well system is constructed to serve a cluster of homes and then additional wells are added according to the economics of laying additional pipe to outlying consumers.

The following is another useful relationship that has been developed to assess the feasibility of constructing facilities that are distant from an existing system. A key consideration when comparing the economics of extending existing systems and developing a potential, separate system is the distance between homes. There is a point beyond which it becomes economical to construct a second system rather than to lay pipe to connect distant houses to an existing system. If the following equation is valid, then one or more outlying wells is justified:

$$P_C > (W_{CM} + T_{CM} + D_{CM} + O_{CM} + M_{CM})$$

or

$$P_C > S_M$$

where: P_C = total interconnecting distribution cost (in place) plus costs related to increased production of existing system
W_{CM} = well construction costs for medium-low capacity systems
T_{CM} = treatment costs for medium-low capacity systems
D_{CM} = distribution line costs for medium-low capacity systems
O_{CM} = operation costs for medium-low capacity systems
M_{CM} = maintenance costs for medium-low capacity systems
S_M = total system cost of medium-low capacity or multiple well systems

Therefore, if P_C is less than S_M, an extension of the existing system is merited. If P_C is greater than S_M, then a cluster system would be merited.

An example of this comprehensive design approach can be found in the NDWP-supported project in Arkansas. Two regions within the project area have specific local conditions that affect system design. In one region the project will obtain water from a newly constructed extension of an existing line and another will obtain water via a multiple or cluster well system. This is typical of adjusting the system design to the local parameters. A similar variety of approaches is being taken in NDWP's South Carolina project.

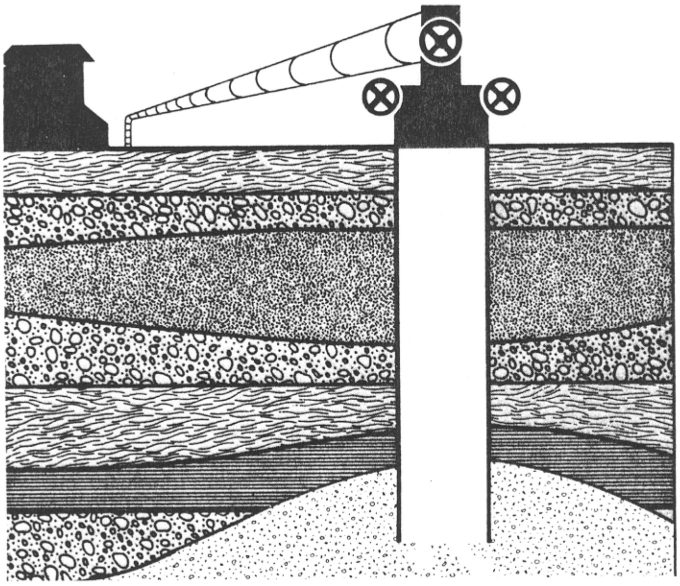
Operation and Maintenance

The cost of laying pipe is not the only critical factor of a system. The effect of operation and maintenance (O&M) must also be carefully estimated, but this is a most difficult task since the basic data are generally unavailable to the consulting engineer. O&M is usually referred to as an "undefinable variable." Although it is true that O&M costs are difficult to calculate, they can be approximated with far greater accuracy than presently attempted by many consulting engineers who often resort to convenient but often inappropriate "rules of thumb."[17] Estimating operation and maintenance costs begins in the design stages of a system's development. Proper system design and material selection appropriate to the local geographic, hydrologic, and geologic conditions are of critical importance in maintaining the proper balance between initial construction costs and future maintenance expenses.[19]

Local field parameters dictate the scope of operation and maintenance required for the system. In one area, for example, well incrustation or corrosion may be a problem. The water supply may or may not require an iron-treatment plant, which will affect operation and maintenance costs accordingly. Some systems even require additional treatment to remove other dissolved minerals. As treatment needs increase, and with them both initial construction costs and operation and maintenance costs, the suitability of treatment plant consolidation also increases, dictated solely by the local field parameter of water quality.

NDWP Focus on Operation and Maintenance

No matter how well and how inexpensively water systems are constructed, the rural problem cannot be solved unless these facilities are adequately operated and maintained. Probably the biggest mistake made in financing water development



One large centrally located well offers many advantages.

in the US and foreign countries is the failure to take this into account. After facilities were constructed, the developers simply went away and left the residents to shift for themselves. Without any real local maintenance capability, the systems deteriorated, wells failed, treatment plants malfunctioned, and distribution lines broke. The lesson was not that development will not work in rural areas but rather that development must include a strong awareness of operation and maintenance.

In whatever manner rural water systems are administered in the US in the future—by municipalities, public service districts, or nonprofit corporations—the administering authority must have enough funds and expertise to keep the system operating effectively and efficiently. Wells and treatment plants must be inspected and repaired, meters must be read, bills must be collected, records must be kept, and loan payments must be made. A public subsidy for a water system would be wasted unless funds are to be included to accomplish a realistic operation and maintenance program.[17]

In particular, maintenance capability must be built into any user-owned and user-operated facility. This capability extends beyond the system's design and incorporates the broad question of management. The officers of a rural utility service company must be able to conduct all of its functions. This would include checking to see that wells operate at peak efficiency and that they do not become contaminated and making sure that taxes are paid. These will not be easy tasks for systems where users' incomes are low and where reliable public services have not been a part of the history of the area.

This problem can be attacked either by training the members of each company to perform the necessary work or by developing a separate service company to manage operations for all companies in a project area. Many well contractors in the US are becoming more involved with this type of approach to ensure proper operation and maintenance of rural water systems.

At the present time, however, maintenance provisions for rural water systems in the US are generally inadequate. Community water systems are inadequately inspected, and individual facilities are rarely checked at all. System designers usually underestimate the maintenance requirements during the life of a loan made for the construction of a facility. Reports and other devices for evaluating the performance of water systems are not in abundance. It is not surprising to the authors that small, rural water companies have obtained a reputation for poor performance.

The authors have made no attempt to discuss all of the technical problems that relate to water-systems development. The major weaknesses in the delivery system for rural areas in the US are not solely technical in nature. There should be no technical problem that cannot be solved with the proper application of political, economic, and financial influence.

The major needs—those of commitments and funding—can only be served on the state and federal levels of the political scene. System development, centralized management, economically sound engineering, and operation and maintenance programs are all features that the Natl. Demonstration Water Project and the Com. on Rural Water are attempting to implement in their field projects. As the present NDWP projects mature, their performance will test the effectiveness of the approach.[20]

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