ENVIRONMENTAL AND ECONOMIC FACTORS IN SELECTING A SEWAGE TREATMENT SYSTEM

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Oklahoma communities of all sizes are plagued with problems concerning the disposal of treated sewage in compliance with Public Law 92-500, the Federal Water Pollution Control Act Amendments of 1972. As applied to civic treatments (as point sources), this legislation requires the discharge of zero pollutants into navigable waters by 1985. This study analyzes a rural town's cost-effective investigations in attempting to comply with the law. Emphasis is on the economic and environmental efficiencies of alternatives to the presently used system.

INTRODUCTION

The rapid population increases of certain small towns convey the advantages and disadvantages associated with urbanization. Income redistribution, enlarged tax revenues, and increased property values can best benefit a community when that society's newly accumulated traffic, power, water, and waste demands are kept to a minimum. The acquisition of metropolitan lifestyles usually means abandonment of the resourcefulness associated with rural agricultural communities. Wastes of all types tend to increase especially in cases where water is readily available (1).

Water is easily converted from its natural state by the addition of various dissolved and suspended, organic and inorganic pollutants. Virtually all industrial production uses water to some extent somewhere along the raw-to-finished-product line. Domestic water, regarded as an always present and constant commodity, is used as a produce and laundry cleaner, a carrier for garbage disposal grist, and a necessity for human metabolic functions. Each process excretes the utilized water with its own type of pollutant yet all converge at the same location, the local sewage treatment plant. Too often the municipal treatment plant designed for a particular capacity and type of sewage cannot keep up with demand and allows the outflow of non-treated or only partially treated wastewaters. The eutrophic problem of receiving waters caused by the release of municipal wastewater effluents was one of the prime reasons for implementation of Public Law 92-500.

The law seeks to sequentially outline the standards and scheduling of water pollution abatement procedures. The law applies to "point source" discharges and the appicable guidelines issued by the Environmental Protection Agency. By 1977, "secondary treatment", based on aerobic bacterial decomposition, must be used by all municipal sewage treatment facilities. By 1983, these plants must furnish the "best practicable waste treatment technology" which will produce "reasonable progress" toward zero discharge of pollutants, the 1985 goal (2).

As rural populations around metropolitan areas grow, they often outgrow their vital services' capacities. Not only is the sewage treatment facility itself not able to handle the influx due to new homes and businesses but the sewage pipelines which transport the wastes also reach capacity limits. Enlargement of or supplements to the whole system are sometimes needed. This requires the acquisition of additional easements and extension properties to meet current and future needs and regulations.

METHODS

Assignment of water quality standards are based on the potential health problems of the use of the water downstream. Water pollution problems were identified long ago so that a pollution discharge permit system was required by the Refuse Act of 1899. The Federal Water Pollution Control Act of 1948 and its subsequent amendments (1961, 1965, 1966, and 1970) allowed discharges based on a receiving water's assimilative capacity. Although the 1972 amendment calls for a permit system (the National Pollution Discharge Elimination

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System - NPDES), it also requires the use of actual technologies to remedy the given situation. The National Environmental Policy Act of 1969 requires the assessment of environmental, economic, and social impacts, when and where federal monies are utilized in construction projects (5).

A community which needs to update its wastewater system must first evaluate its current status. Step I, the Planning and Preliminary Design, requires determination to what extent the current wastewater treatment facility can provide compliance with future scheduled regulations. Step I must diagnose what water quality standards can and cannot be met. Areas needing rejuvenation must be identified and their flaws corrected. This commonly means that large amounts of money for capital improvement must be spent, which small towns do not have readily available. Applications for Federal cost-sharing allocations are appropriate after submission and approval of the Step I planning procedures. Once Step I plans are authorized, Step II Plans, Specifications, and Estimates are drawn. After approval of the design, Step III — Construction — may begin with invitation of bids. The completed facility must meet applicable NPDES water quality standards.

AN EXAMPLE OF COMPLIANCE

The population of Warner, Oklahoma, has grown since a 1960 census of 650 to a 1977 estimated population of 1,270 with a predicted population in the year 2000 A.D. of 2,000 individuals. This southern Muskogee County community has received an immigration of new businesses, retirees, and Muskogee commuters, which favor the relaxed atmosphere of the rural area close to the more metropolitan center. Warner's close proximity to several eastern Oklahoma lakes and recreation areas, its location at the Interstate 40 and U.S. Highway 64 junction, and the presence of Connors State College make it a choice site for growth. It has increased from 26 businesses in 1965-66 to 66 in 1976-77.

By increasing so rapidly, Warner has also incurred its share of growing pains. Currently, its major problems are acquisition of more water supply and effective elimination of wastes. The two issues are interrelated yet only the wastewater problem is being considered here.

Warner's current wastewater collection and treatment facility is a 6.5 acre two-cell sewage lagoon built in 1964 to service fewer than 250 homes. (The lagoon design flow was for 125,000 gallons per day with a yearly average of 72,000 gallons per day. The water consumption rate averages 98 gallons per capita per day.) In fiscal 1968, there were 273 sewer connections while in fiscal 1976 there were 400 sewer connections with 17 new homes under construction (6).

A survey of the Warner treatment facility was undertaken after NPDES regulations established discharge standards which sewage lagoons cannot meet. Problems of surcharging (manholes overflowing and sink backups) were becoming increasingly more prevalent. It was determined that "the existing treatment facilities at Warner cannot meet secondary treatment requirements without installation of new facilities" and that inaction or partial action would put Warner in violation of the Federal NPDES requirements. The town of Warner wished to comply so it could enhance environmental quality and so that it might grow in population and attract business to its proposed industrial park (4). (All the following values are supplied from this same source).

Parameter	30 consecutive day period	7 consecutive days
BOD (mg/*l*)	20	30
TSS (mg/*l*)	30	40
Fecal coliforms (no/100 m*l*)	200	400

Two problems were shown by the study: an alternative to the current sewage lagoon had to be found and the collection system had numerous repairs to be made. Repairs needed to relieve surcharging were found to be:

1) general leak and connection patches, and cleaning out of the largest (ten-inch) outfall pipe and its interceptors.
2) the installation of a supplemental eight-inch pipe to parallel existing pipes in order to carry design flow.
3) implementation of a new pump station.

These three processes were needed regardless of which secondary treatment alternative would be selected. The combined costs for these projects was estimated to be $115,000 (1 $5,000; 2 $75,000; 3 $35,000). Such high repair costs did not make the decision-making process any easier for selection of a secondary treatment system.

A cost-effective (or least-cost) analysis was done to determine the most efficient process for the least amount of initial cost (3). Certain secondary treatments such as complete primary-secondary reactors (i.e., trickling filters) and rotating bio-discs were eliminated from consideration because of excessive costs for the predicted capacity. Inaction could not be an alternative because the present lagoons exceed the NPDES Total Suspended Solids standards for discharge.

RESULTS

Four alternatives were selected for consideration as the best practicable waste treatment technology to accompany the collection system repairs. They were evaluated and ranked on the basis of financial cost, environmental effects, and efficiency. The four options are:

1) Spray irrigation with effluent
2) Complete lagoon retention
3) Oxidation ditch track
4) Treatment and reuse.

Alternative 1: spray irrigation with effluent.

The estimated costs for storage in lagoons and land application are indicated in Table 1.

The land application option would require the retention of up to nine months' sewage in a 40-acre storage lagoon. Spray irrigation would normally be during summer months at the rate of 2-3 inch/acre/week. Spray would be over 80 additional acres surrounded by a buffer zone.

Alternative 2: complete lagoon retention

The estimated cost for a complete retention lagoon is shown on Table 2. On the basis of a loss to seepage and pan evaporation of 29 inch/yr, a predicted flow of

TABLE 1. *Alternative 1 - spray irrigation with effluent: capital costs and salvage values (4).*

Item	Cost ($)	Life (years)	Salvage value ($)
Sewer line repair	5,000	50	3,000
5,000-ft. 8-inch sewer	75,000	50	45,000
Pumping station	35,000	20	0
Standby motor generator	5,000	20	0
Force main, 3000 ft. (8-inch)	24,000	50	14,400
Storage lagoon (40 surface acres)	190,000	50	114,000
Irrigation pump station	20,000	20	0
Spray irrigation system	30,000	20	0
Land for spray irrigation (80 acres) buffer zone	160,000	Perm.	160,000
Total construction cost	544,000		
Salvage value at year 20			336,400
Sites and easements	80,000		80,000
Contingencies and engineering	136,000		
Total capital cost	760,000		
Annual operating and maintenance costs	5,000		

TABLE 2. *Alternative 2 - complete lagoon retention: capital costs and salvage values (4).*

Item	Costs ($)	Life (years)	Salvage value ($)
Sewer line repair	5,000	50	3,000
5,000-ft. 8-inch sewer	75,000	50	45,000
Pump station	35,000	20	0
Standby motor generator	5,000	20	0
Force main, 3,000 ft. (8-inch)	24,000	50	14,400
Lagoon (93 surface acres)	350,000	50	200,000
Total construction cost	494,000		
Salvage value at year 20			252,400
Sites and easements (120 acres for sites)	240,000		240,000
Contingencies and engineering	124,000		
Total capital cost	858,000		
Annual operating and maintenance costs	4,000		

TABLE 3. *Alternative 3 - oxidation ditch treatment plant: capital costs and salvage values (4).*

Item	Costs ($)	Life) (years)	Salvage value ($)
Sewer line repair	5,000	50	3,000
5,000-ft. 8-inch sewer	75,000	50	45,000
Pumping station	35,000	20	0
Oxidation ditch	250,000	20	0
Total construction cost	365,000		
Salvage value at year 20			48,000
Contingencies and engineering	91,000		
Total capital cost	456,000		
Annual operating and maintenance costs	6,000		

200,000 gal/day, and zero discharge, an area of 116 acres would be needed to retain all effluent.

Alternative 3: oxidation ditch track

The cost estimate for an oxidation ditch track is shown in Table 3.

An oxidation ditch track provides a type of extended aeration of activated sludge. It can guarantee meeting or exceeding the NPDES standards. It requires careful operation and would require a State-certified operator to keep it in functional, adequate order. It has a retention time of 24 hr.

TABLE 5. *Ranking of alternative projects (4).*

Criterion	Alternative 1	Alternative 2	Alternative 3
Least environmental effects	3	2	1
Lowest monetary costs	2	3	1
Implementation capacity	3	2	1
Accomplishment of goals	1	1	1
Energy and resources use	2	1	3
Reliability	3	1	2
Public acceptability composite	3	2	1

Alternative 4: treatment and reuse

Treatment and reuse is not a viable option since no large industries exist. There are no other opportunities (i.e., road medians, golf courses) to reuse nonpotable water.

CONCLUSIONS

The differences between alternative costs are quite pronounced, as illustrated in Table 4, as regards both original capital costs and the annual equivalent cost. The differences between environmental effects are not as clearly defined,

1) the spray irrigation system actually requires more land than the complete-retention lagoon, uses much energy for spraying during the peak summer load months, uses additional energy to pump the sewage out to a suitable location, requires a buffer zone to contain aerosols, and needs close operational control.

2) the complete retention lagoon requires the most land to be taken out of production, causes the greatest loss of wildlife habitat, uses energy to pump the sewage out to a suitable location, but otherwise has very low operation and maintenance costs and no discharge.

3) the oxidation ditch track requires a continuous source of energy because of its mechanical equipment.

Judged on the basis of the cost-effective comparisons, operational and environmental considerations, and public sentiments (Table 5), the oxidation ditch track was selected by the town of Warner for implementation as their Best Practicable Waste Treatment Technology for secondary treatment.

Both primary and secondary adverse effects could be summarized as being negligible. An environmental impact assessment

TABLE 4. *Economic evaluation of alternatives*[a]

Item	Interest[b] factor	Land application of effluent ($)	Complete retention in lagoon ($)	Oxidation ditch ($)
Capital cost	1.00000	760,000	858,000	456,000
Salvage value as fraction of total present worth[b]	0.30454	126,810	149,956	14,620
		633,190	708,044	441,380
Average annual equivalent cost	0.09907	62,730	70,146	43,730
Annual operation and maintenance cost		5,000	4,000	6,000
Annual net return from sale of crops[c]		4,000		
Total average annual equivalent cost		63,730	74,146	49,730

Source: (4).

[a]Reference: E. L. Grant and W. G. Ireson, *Engineering Economy,* Ronald Press, New York, 1970.
[b]Interest (discount) rate = 6 1/8%. Effective 1 July 1975. Published annually in the *Federal Register,* 40 CFR 3200, by the U.S. Water Resources Council.
[c]Assuming net return from sale of crops at $50 per acre.

was prepared and filed with the State of Oklahoma concerning:

1) primary users
2) area description
3) air quality
4) water quality
5) solid waste management
6) transportation
7) noise
8) historical/ archeological properties
9) wildlife and endangered species
10) energy
11) construction
12) public relations
13) alternatives to the proposal

The impact assessment predicted:

1) no relocation of people
2) no polluted ground water
3) no change in adjacent property values
4) no adverse effect on recreational potential
5) only temporary effects from construction (noise, dust)
6) minimum inconveniences for repairs of system and new pipeline
7) some odors when switching from anaerobic to aerobic decomposition
8) need for further abatements when practical and/or economically feasible
9) improved water quality without additional environmental impacts
10) need for additional land for expansion
11) minimum use of fuels during construction
12) minimum slope would prevent erosion
13) need for seeding of the site back to native grasses.

After recognizing its problems and newly selected avenue of reform, the town of Warner applied for economic aid under the Local Public Works Capital Development and Investment Act of 1976. A federal grant authorized through the EPA allows for 75%-25% federal-municipal cost-sharing which also permits the town to seek help from state agencies or other federal sources in raising its 25% share. It must prove it has the necessary legal, financial, institutional, and managerial resources in order to apply.

Of the total $456,000 necessary, according to the proposal, the EPA will supply $342,000, leaving $114,000 to be raised by Warner. Only $16,000 per year in revenue-sharing money is received, which is not enough to cover the cost. The rest will come from taxes, the Farmers Home Administration, and/or other federal sources. This money is currently being sought as a grant from the Economic Development Administration. The Step III construction completion date of the oxidation ditch track is set for late 1979.

CONCLUSIONS

The need for adequate residential service coupled to vital environmental protection has brought about drastic changes in the manner municipalities may deal with their sewage. No longer can they dump raw or partially treated sewage into a receiving water and thus cause eutrophication and render downstream water useless for human ingestion, recreation, wildlife development, or aesthetics. The sequential water quality law is implemented to insure that *all* municipalities will have the best economically feasible secondary wastewater treatment plant possible.

Better technologies are continually being developed and implemented, such as the oxidation ditch track, in order to comply with Federal water quality standards and to attempt to meet the 1985 deadline of zero discharge. The term itself has been questioned since it may mean either total retention of treated effluent *or* the total elimination of pollutants in effluent which may be placed into a receiving stream. The ramifications therein could produce another paper. The applications of environmental laws to small rural towns have developed at a let's-wait-and-see pace. By describing the decision-making processes here, it may be possible to hasten the improvement of quality of life for towns which do not have large revenue sources. The processes described should aid in the planning and managerial decisions necessary to develop long-term plans for any given community.

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