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# Planning a Central Sewer System for Rural Areas

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The Federal Water Pollution Control Act amendments of 1972 established an extensive program to improve the quality of waters in this country. In 1978, however, of the 73 percent of the population served by a central wastewater system, only 33 percent (53 million people) had adequate treatment (secondary or better). Those who must build new treatment facilities or improve existing facilities need information that will help them with their task.

Rural areas may need planning assistance more than other areas. Population increases in non-metropolitan areas in the 1970s are more than offsetting the decreases of the previous decade. As population densities increase in these rural areas, community leaders must investigate alternatives to the individual septic tank and absorption field.

The Ozarks is one such rural area. We gathered data from recently built facilities in the Ozarks and non-Ozarks regions of Oklahoma and Missouri to develop a budget analysis. This analysis will help local decision makers in planning collectors, mains for conveyance and treatment facilities. (Generally, conveyance and interceptor sewers are larger mains between household collectors and the final treatment plant.)

## Planning a wastewater system

In the initial stages of designing the system, follow these steps:

- Prepare the layout of the collection and conveyance system.
- Estimate future population and wastewater flow.
- Determine pipe sizes.
- Complete a cost analysis. These steps are outlined below.

## Laying out the collection and conveyance system

Draw up the layout according to the following suggestions:

- Obtain a topographical map of the area, preferably with a scale of 1 inch to 2,000 feet.
- Draw all possible sewer lines with due consideration that flow should be gravity-assisted.
- Plan for the installation of manholes.
- Estimate the number of present and future connections each line will serve.

The layout will be useful in estimating pipe footage and numbers of manholes and cleanouts.

## Estimating future population and wastewater flow

Accurate estimates of future population growth, potential industrial and commercial growth, groundwater infiltration into the system, and maximum daily flow of wastewater will help in determining both the size of pipe and the size of treatment facility necessary.

You can estimate future wastewater flow by two methods. With the first method, multiply the projected population 25 years in the future by the estimated flow rate per capita per day of 100 gallons. With the second method, use Table 1 along with your knowledge of community growth in both residential and commercial aspects to estimate wastewater flow. With either method, add estimated flow from major water-using industrial establishments to your total.

**Table 1**
Wastewater flow rate estimating guide

| Type of establishment | Flow rate |
|---|---|
| Apartments — per capita | 60 to 75 gallons per day |
| Churches — per seat | 5 gallons per day |
| Dwellings | |
| Single family — per capita | 75 gallons per day |
| Cottages (seasonal occupancy) — per capita | 50 gallons per day |
| Trailer Park — per space | 150 to 250 gallons per day |
| Factories (exclusive of industrial wastes) — per employee | 25 to 35 gallons per day |
| Hospitals — per bed space | 250 gallons per day |
| Hotels (private bath, 2 persons per room) — per occupant | 60 gallons per day |
| Laundromat (self-service) — per washer load | 50 gallons per day |
| Motels — per bed space | 40 gallons per day |
| Picnic parks — per capita | 5 gallons per day |
| Restaurants — per patron | |
| Toilet and kitchen wastes | 10 gallons per day |
| Addition for bars | 2 to 3gallons per day |
| Schools — per student | |
| Day, without gyms, cafeterias or showers | 15 gallons per day |
| Day, with gyms, cafeterias and showers | 25 gallons per day |
| Day, with cafeterias, but without gym or showers | 20 gallons per day |
| Service stations — per vehicle served | 10 to 12 gallons per day |
| Stores — per rest room | 400 gallons per day |
| Swimming pools — per patron | 10 gallons per day |
| Movie theaters — per auditorium seat | 5 gallons per day |
| Drive-in theaters — per car space | 5 gallons per day |

**Source: Goldstein, Steven N. and Walter J. Moberg, Jr. *Wastewater Treatment Systems for Rural Communities.* Washington, D.C.: Commission on Rural Water, 1973.**

# Determining pipe size

Pipe size depends on the flow, slope and roughness coefficient of the pipe in use. Cumulative population along a sewer line is also a key factor in determining the diameter of the pipe needed. State and federal regulations indicate that new lines should not be made from pipe smaller than 8 inches in diameter. Indeed, if no more than 1,000 residents live along a line, 8-inch diameter piping should be sufficient for the entire length of the line. As the cumulative population along the line increases to over 1,000, however, we recommend larger pipe diameters. Table 2 lists pipe diameters needed for various populations along a sewer line.

**Table 2**
Approximate pipe diameters for various populations along sewer line

| Population | Pipe diameter |
|---|---|
| 1 to 1,000 | 8 inches |
| 1,000 to 2,500 | 10 inches |
| 2,500 to 5,000 | 12 inches |
| 5,000 to 7,500 | 14 inches |
| 7,500 to 10,000 | 16 inches |
| 10,000 to 20,000 | 18 inches |
| 20,000 to 30,000 | 20 inches |
| 30,000 to 40,000 | 24 inches |

# Selecting pipe material

The pipes of most rural sewer lines in use today are made of vitrified clay, asbestos cement, pre-cast concrete, plastic pipes, or cast-iron or ductile iron. No single material is best suited for all applications, and the choice from among these materials depends on availability, type of waste, waste transport method, design factors and capital cost per unit. For a particular project, one or two materials might give the desired performance. You will need to weigh the tradeoff between cost and engineering considerations.

# Further considerations

The state Department of Natural Resources can furnish detailed design standards and requirements. With those guidelines in mind, consider the following points when making preliminary studies:

- Design all sewer systems for the ultimate population with a design period of 25 years.
- Design new sewer lines on the basis of an average daily flow (in some cases, public agencies will allow designs for an average daily flow less than 100 gallons per person per day in small rural communities, for example, 60 to 80 gallons).
- Use pipe 8 inches or more in diameter for new sewer lines.
- If sewer lines are less than 24 inches in diameter, lay them in straight-line alignment. (If that is not possible, install manholes at every change in alignment.)

# Estimating costs

Once the layout of the wastewater collection and conveyance system is prepared, the future population of the service area and its wastewater flow estimated, and the pipe sizes determined, local decision makers should develop capital and operating cost budgets for the complete wastewater system.

For the collection and conveyance system, expenses include pipe, trenching manholes and cleanouts, crossings, lift stations and other miscellaneous items. We calculated average costs as of January 1979 for these items from bid data for 23 projects in Oklahoma and Missouri. Refer to Table 3 for these averages for the Ozarks and non-Ozarks regions of these states.

**Table 3**
Average price of items used in wastewater collection and conveyance systems, January 1979

| Description of item | Unit | Price per unit* | |
|---|---|---|---|
| | | Ozarks | Non-Ozarks |
| Pipe** | | | |
| 8-inch CIP | l.f.*** | $14.02 | $16.08 |
| 8-inch DIP | l.f. | $15.48 | $17.66 |
| 8-inch VCP | l.f. | $9.56 | $13.02 |
| 10-inch VCP | l.f. | $11.91 | $13.67 |
| 12-inch PVC | l.f. | $16.10 | $18.84 |
| Manholes | | | |
| manholes | each | $553.09 | $613.55 |
| cleanouts | each | $90.25 | $90.25 |
| Crossings | | | |
| railroad, 15 feet | l.s.**** | $1,165.35 | $1,165.35 |
| highway, 40 feet | l.s. | $3,309.60 | $3,309.60 |
| Lift station | l.s. | $35,839.66 | $35,839.66 |
| Miscellaneous | percent***** | $22.12 | $22.12 |

***Prices include labor costs.**
****Pipe prices are for installed pipe. CIP = cast iron pipe; DIP = ductile iron pipe; VCP = vitrified clay pipe; PVC = polyvinyl chloride.**
*****l.f.= linear foot.**
******l.s. = lump sum.**
*******Calculate miscellaneous expenses as given percent times total of all other costs. These expenses include non-construction cost items such as engineering fees.**

To figure the cost for your system, begin by determining total footage of pipe from the system layout. Next determine the sizes of pipe you will need according to cumulative population along a line. Then determine the number of manholes required by dividing the total footage of pipe by 400 if pipes are under 15 inches in diameter. (Divide by 500 for larger pipes.) Locate cleanouts at the end of every sewer line.

For municipal wastewater, federal legislation requires secondary treatment. Treatment facilities that may be economically feasible for small rural communities include:

- Stabilization ponds or lagoons — aerated or facultative;
- Oxidation ditches; and
- Factory-built package treatment plants.

Aerated lagoons use a mechanical device to supply oxygen to the lagoon. Facultative lagoons operate with both oxygen- and non-oxygen-requiring bacteria. An oxidation ditch is generally an oval concrete-lined ditch with a mechanical aerator-mixer and facilities for sludge removal.

We have listed capital costs for lagoons and oxidation ditches in Table 4. Table 5 shows costs for package treatment plants.

**Table 4**
Minimum land required and capital costs for lagoons and oxidation ditches, January 1979 (table is split into two parts)

| Population | 2-cell aerated lagoon | | | 3-cell facultative lagoon | | |
|---|---|---|---|---|---|---|
| | Minimum land required | Capital costs* | | Minimum land required | Capital costs* | |
| | | Ozarks | Non-Ozarks | | Ozarks | Non-Ozarks |
| 150 | 1.0 acre | $30,100 | $21,200 | 3.0 acres | $15,800 | $8,900 |
| 200 | 1.0 acre | $32,100 | $23.000 | 3.0 acres | $26.900 | $14.100 |
| 300 | 1.5 acres | $34,500 | $25.100 | 3.5 acres | $33.700 | $16.300 |
| 400 | 1.5 acres | $45,000 | $35.000 | 4.0 acres | $40.200 | $20.600 |
| 500 | 2.0 acres | $47,000 | $38.600 | 5.0 acres | $48.500 | $24.300 |
| 600 | 2.5 acres | $50,100 | $41.800 | 6.0 acres | $58.400 | $28.600 |
| 700 | 3.0 acres | $55,200 | $46.300 | 6.5 acres | $69.500 | $32.700 |
| 800 | 3.0 acres | $66,200 | $55.800 | | | |
| 900 | 3.5 acres | $71,100 | $58.800 | | | |
| 1000 | 3.5 acres | $75,000 | $61.000 | | | |
| 1200 | 3.5 acres | $86,000 | $72.400 | | | |
| 1400 | 4.0 acres | $90,000 | $76.500 | | | |
| 1600 | 4.0 acres | $95,000 | $80.800 | | | |
| 1800 | 5.0 acres | $102,000 | $88.100 | | | |
| 2000 | 5.0 acres | $105,000 | $92.300 | | | |

***Includes clearing site, excavation, and fencing. Land costs are not included.**

**Table 4**
Minimum land required and capital costs for lagoons and oxidation ditches, January 1979 (continued)

| Population | Oxidation ditch | | |
|---|---|---|---|
| | Land required | Capital costs** | |
| | | Ozarks | Non-Ozarks |
| 100 | 0.5 acres | $62,300 | $46,500 |
| 200 | 0.5 acres | $73,400 | $53,200 |
| 300 | 0.5 acres | $91,800 | $64,400 |
| 400 | 0.5 acres | $107,000 | $72,500 |
| 500 | 0.5 acres | $124,000 | $82,200 |
| 600 | 1.0 acres | $142,300 | $92,500 |
| 700 | 1.0 acres | $157,500 | $99,000 |
| 800 | 1.0 acres | $167,500 | $105,000 |
| 900 | 1.0 acres | $186,300 | $115,000 |
| 1000 | 1.0 acres | $201,000 | $122,000 |
| 1200 | 1.0 acres | $230,700 | $137,000 |
| 1400 | 1.5 acres | $269,300 | $157,000 |
| 1600 | 1.5 acres | $299,300 | $173,000 |
| 1800 | 1.5 acres | $331,900 | $189,500 |
| 2000 | 1.5 acres | $362,000 | $205,000 |

****Includes clearing site, excavation, lining ditch, seeding grounds, fencing, and one gate. Land costs are not included.**

**Table 5**
Costs for package treatment plants, January 1979

| Plant capacity* | Total capital costs** |
|---|---|
| 25,000 gallons per day | $41,059.20 |
| 50,000 gallons per day | $63,531.98 |
| 100,000 gallons per day | $98,294.33 |
| 200,000 gallons per day | $152,101.95 |
| 500,000 gallons per day | $270,856.12 |
| 750,000 gallons per day | $349,645.04 |
| 1,000,000 gallons per day | $419,091.03 |

***For approximate population equivalent, divide plant capacity by 100.**
****Cost of basic plant including only necessary blowers, motors, control panels and internal piping. (January 1979)**

Data for the systems analyzed in 1978 indicate that total operating and maintenance costs were $32 per hookup per year for systems with lagoons or oxidation ditches and $57 for systems with activated sludge treatment plants built on site. Operating costs for systems with package treatment plants should approximate $57 per hookup per year.

Once you have developed a budget, you must examine the financial situation of the district. Compare annual costs and annual revenue in the early planning stages; consider different financing options. Numerous methods of financing are available.

# Funding sources

Several federal agencies can provide funding to rural communities interested in constructing and operating wastewater facilities:

- Farmers Home Administration (FmHA).
- Economic Development Administration (EDA).
- Department of Housing and Urban Development (HUD).
  Environmental Protection Agency (EPA).

# Farmers Home Administration

The FmHA can grant up to 75 percent of total eligible project development costs to communities under 10,000 in population. They give priority to towns under 5,500 in population.

# Economic Development Administration

To receive funding from the EDA, an area must be an EDA-designated area, an economic development district or an economic development center. The major criteria for such designation include high unemployment and low family income. Direct grants of up to 50 percent of total eligible project costs are available.

# Department of Housing and Urban Development

Through the Small Cities Program, HUD is authorized to make grants to communities less than 50,000 in population having the greatest needs as evidenced by poverty and substandard housing. Sewage treatment works and interceptor sewers are not eligible for assistance under this program.

# Environmental Protection Agency

The Clean Water Act (P.L. 92-500 and P.L. 95-217) is the legal basis for the largest public works grant program in this country. Section 201 of that act established a construction grants program for wastewater treatment facilities. Through the EPA, grant awards are available for 75 percent of eligible costs of a project. (Up to 85 percent for projects incorporating innovative or alternative technology.)

For specific information on these sources of funding, consult state or regional offices. These offices can provide funds currently available, specific criteria concerning a community's eligibility, and grant and/or loan application procedures.

# Summary

Local decision makers should find this guide helpful in the initial planning stages of developing central wastewater collection, conveyance, and treatment facilities or in expanding or improving existing facilities. Initial design approximations and cost information will help you make important budgetary and rate structure decisions.

If the decision process goes beyond these preliminary stages, hire a consulting engineer to conduct the actual design of the system. By consulting with the appropriate state agency throughout the process, you should be able to build a centralized wastewater collection, conveyance and treatment facility that will meet federal and state regulations and provide adequate service to the community.

In cases of low population density, central sewage systems may not be economically feasible. An alternative may be the installation of small aerobic treatment plants for individual households. Local governments could support perpetual maintenance of these individual plants.

# Reference


- Nelson, Marlys Knutson and Michael Fessehaye. *Wastewater Collection, Conveyance, and Treatment in the Rural Ozarks: A Handbook for Local Decisionmakers.*



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## Related MU Extension publications

- EQ401, Septic Tank/Absorption Field Systems: A Homeowner's Guide to Installation and Maintenance http://extension.missouri.edu/p/EQ401
- WQ402, Residential Sewage Lagoon Systems: A Homeowner's Guide to Installation and Maintenance http://extension.missouri.edu/p/WQ402
- WQ403, Sewage Treatment Plants for Rural Homes http://extension.missouri.edu/p/WQ403

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