Fluoridation of Water Supplies in Small Rural Communities

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OF THE 20,593 communities of all sizes in the United States, 2,612, or 12.7 percent, are fluoridating their water supplies. More than half (10,677) of the 20,593 communities have less than 1,000 (or unspecified) population. According to the Division of Dental Public Health and Resources, Public Health Service, only 678, or 6.4 percent, of these small communities were fluoridating their water supplies as of December 31, 1963—half the percentage for all communities regardless of size.

Unusual problems that arise in fluoridating the water supplies of the very small communities may be causing this severe lag. First, the technical supervision of the water supply itself may be less than desirable with, perhaps, only a part-time, untrained "water superintendent" in charge. Second, for many small towns the capital outlay for equipment may present a seemingly insurmountable problem. Third, the continuing per capita cost of operation may be relatively high when compared with big-city operations, where mass production reduces per capita costs. Yet it is in many of these small rural communities, often in financially depressed areas and usually without immediately available dental services, that fluoridation is all the more important. Cognizant of this situation, the New Mexico Department of Public Health and the Public Health Service attempted to bring fluoridation to small towns.

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Background

Since World War II, strides have been made in bringing safe water supplies to small rural New Mexico communities. Over the years the sources of drinking water for many New Mexico towns have varied from potholes in dry streambeds (frequently used also for watering livestock) to irrigation ditches, dug wells, and, in some instances, water hauled in by horse and wagon. However, after the Mutual Domestic Water Consumers' Association Act was passed in 1947 by the New Mexico State Legislature, the situation began to change for the better (*1*, *2*). The act permitted the New Mexico Department of Public Health to establish a unique program (*3*)—

> . . . to assist rural, unincorporated communities to organize Mutual Domestic Water Consumers' Associations for the construction of supplies to replace unsafe sources of water. The bill has been reenacted at each legislative session with an appropriation . . . each biennium. . . .
>
> A community must meet the following requirements to receive assistance under the Act: The community must have been in existence at least twenty-five (25) years, have at least ten (10) families, have an unsafe water supply . . ., and be unincorporated, in order to qualify for State assistance. . . .
>
> Each participating community is required to contribute an amount equal to at least one-third (⅓) of the State's in cash, labor, land, use of equipment, or any combination. Each individual family pipes water from the main line into the house since the State assistance is limited to drilling the well, providing the

pump, motor, main pipeline, and tank. Labor for trenching, pipe laying, well house construction, and tank foundation is supplied by members of the Association.

In order for a community to receive State Assistance it must incorporate as a Mutual Domestic Water Consumers' and Mutual Sewage Works Association with the State Corporation Commission, and elect a President, Vice-president, Secretary-Treasurer, and two other board members. A nominal amount is charged each user on a monthly basis to cover operating costs, mostly electricity. This charge does not usually exceed $2.50 per month since these are non-profit organizations and the cost of electricity is the principal expense.

As of . . . 1963 a total of 118 water systems . . . had been completed at a cost of $996,238.49. . . . The average cost per family for water has been $207.72, while the average water project has cost $8,442.69. Safe water is now available to a minimum of 4,796 families, or an estimated total of 22,000 persons.

Most of these water systems were established in the rural mountain valleys of northern New Mexico, inhabited by Spanish-American descendants of the conquistadores of the 16th and 17th centuries (fig. 1). Annual per capita income in some of these areas is as low as $600, and median family income is as low as $2,000. As high as 16 percent of the labor force may be unemployed (*4–6*). Most of the systems have drilled and cased wells with storage tanks and pumphouses or wellhouses built along similar plans (fig. 2).

A 1957 paper by Maier (*7*) describing a system for fluoridating water supplies of individual homes sparked the idea of applying his basic concepts, that is, an inexpensive installation, centrally serviced, to these small community systems. A prospectus was developed, and local water-conditioning companies were asked to bid on installation and servicing of fluoridation systems. However, without a guarantee of an immediate market of several communities in the same vicinity, the bids from private companies were prohibitive.

In 1960 a prospectus for studying the feasibility of fluoridating water supplies in several small communities in two health districts of New Mexico, covering seven north central New Mexico counties, was submitted to the Division of Dental Public Health and Resources of the Public Health Service. Subsequently, a 3-year contract was negotiated with the Public Health Service and activated in February 1961. The contract provided that the New Mexico Department of Public Health "conduct an evaluation and feasibility study on the fluoridation of small

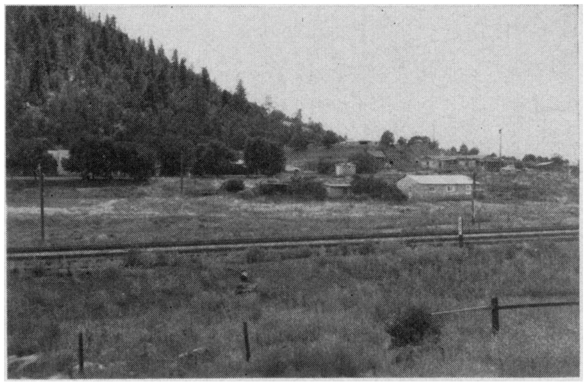


Figure 1. Typical small rural mountain community, New Mexico

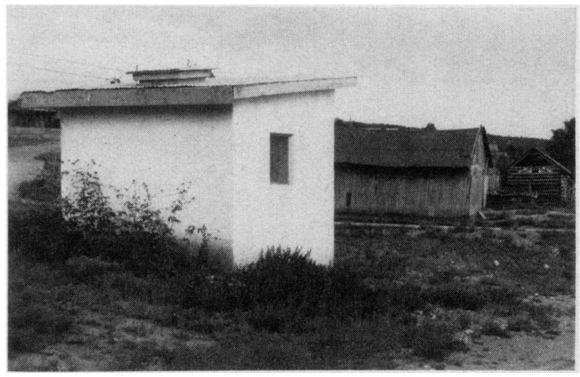


Figure 2. Type of wellhouse used in water systems of small rural communities, New Mexico

community water systems" by providing "for the installation and servicing of fluoridation equipment in 25 small communities within the State of New Mexico through the use of a centralized servicing agency." Included among the stipulations was the provision that none of the communities was to exceed a population of 2,000.

Project Activities

Technical engineering consultation was provided by both the New Mexico Department of Public Health Division of Environmental Sanitation Services and the Division of Dental Public Health and Resources of the Public Health Service. Dental consultation was provided by the Division of Dental Health, financial records were kept and analyzed by the Division of Business Management, and fluoride determinations

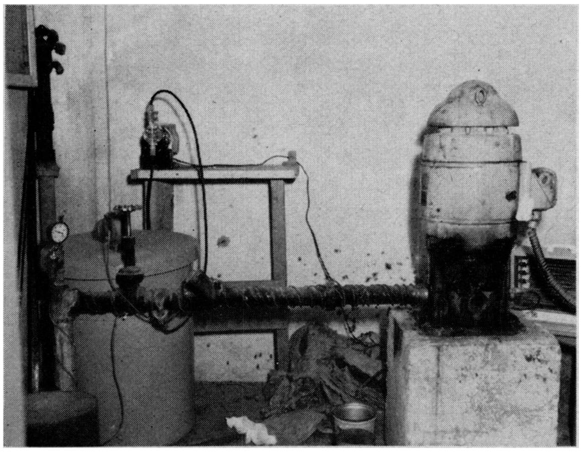


Figure 3. Typical fluoride feeding installation used in wellhouses, fluoridation project, New Mexico

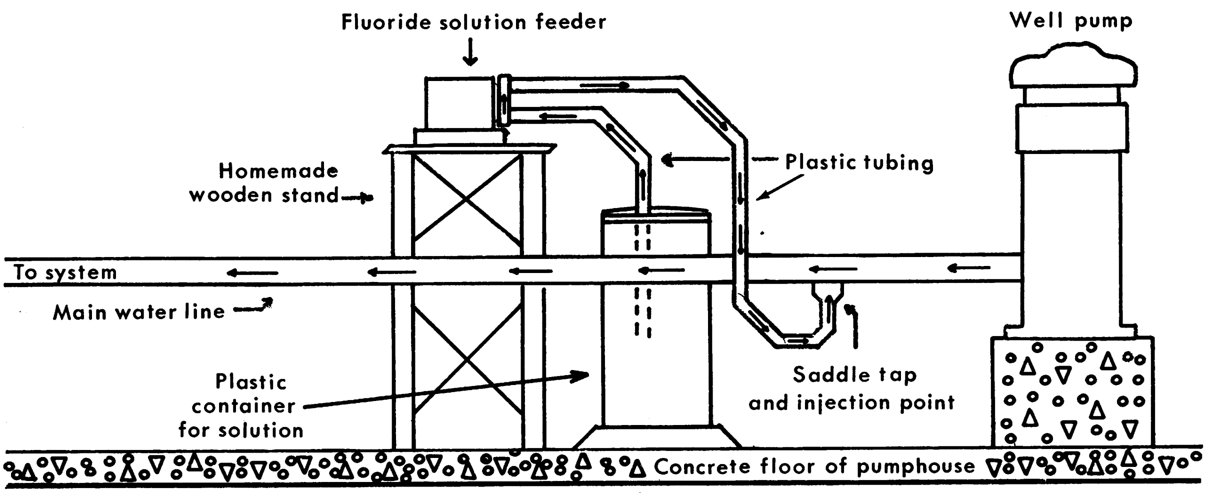
on split water samples were provided by the Division of Public Health Laboratories, all of the New Mexico Department of Public Health.

A young Spanish-speaking sanitarian with a baccalaureate degree in biology and 2 years of experience with a local health department was transferred to the State health department headquarters to serve as sanitarian for the project. Considerable time was spent by the dental, engineering, and laboratory staff in orienting the project sanitarian to the respective technical aspects of fluoridation. He also attended a short course at New Mexico State University in the operation of waterworks.

The project sanitarian worked closely with local health department personnel, particularly sanitarians, in approaching the officials of the local mutual domestic water consumers' associations about the possibility of fluoridating their local water supplies. He did not limit his activities to fluoridation per se but worked on other water and environmental health problems when visiting these communities. Communities were selected on the basis of the following criteria: (*a*) location in health district 1 or 5, (*b*) fluoride content of water supply less than 0.5 ppm, (*c*) probable cooperative attitude of community water association officials, and (*d*), of less importance, geographic proximity to headquarters at Santa Fe.

Formal written requests from each of the communities in the program for the installation of fluoridation systems were obtained rather easily. Two factors were responsible: first, excellent rapport had been established over the years between the officials of the water associations and health department workers as the water associations were organized and the water supplies developed and maintained; second, there was no need for the community to make an initial capital outlay. Each community, however, did provide (*a*) housing for the fluoridation equipment, (*b*) the stand for the fluoridator, and (*c*) electricity to operate the fluoride feeder. In addition, in the one incorporated community in the program, the fluoride salt and the fluoride-testing equipment were provided by the community. Since that

Figure 4. Feeding system used in fluoridation project, New Mexico



community has a full-time, qualified water superintendent, the fluoridation equipment also is now being operated and serviced by him.

In the meantime, considerable exploratory work was done to determine the most feasible and economical fluoride feeding and testing equipment. Finally, a chemical solution feeder was selected from competitive bidders at a cost of $110 per single unit and $75 each in dozen lots. (Specifications and further details may be obtained from the New Mexico Department of Public Health, Santa Fe.) The fluoride solution was fed from a 20- or 30-gallon plastic container with a locking cover, usually a plastic garbage can, which at that time ranged in cost from $8 to $13. The feeder, wired to the same circuit as the well pump, injected fluoride into the main waterline through a saddle tap or, where convenient, a tee was installed (figs. 3 and 4).

The feeder will deliver from 0.17 to 0.7 gallon of fluoride solution per hour. With a fluoride concentration of zero and a 1 percent fluoride-ion solution, this feeder provides 1.0 mg. per liter in fluoridating a maximum flow of 7,000 gallons of water per hour. The feed rate of solution can be adjusted by changing the length of the delivery stroke. The feeder can be used without special proportioning equipment when a constant waterflow is to be treated. For varying rates of flow, it must be equipped with a device such as a water meter to control fluoride content. It can be used effectively for populations up to 1,600, with water utilization not exceeding 100 gallons per day per person. The average per capita utilization was estimated at 25 gallons a day—a safe operating margin. At this rate maintenance costs are reduced materially, and the life of the feeder may be extended.

Simple, relatively accurate, portable field equipment for determining the fluoride content of water supplies was necessary. Several types were investigated, and finally a small, battery-powered, direct-reading colorimeter (filter photometer) using the SPADNS method (*8*) was selected. [SPADNS=zirconium+sodium 2-(*p*-sulfophenylazo)-1, 8-dihydroxy-3, 6-naphthalene disulfonate.] The complete field kit cost about $170 including colorimeter, graduates, pipettes, sample bottles, and filter. A standard fluoride solution was prepared at the headquarters of the New Mexico Department of Public Health before each trip to the field. The colorimeter was calibrated against the standard solution before each analysis. The water was sampled at each installation, and all samples were "split" in two. One half of each sample was analyzed on the spot, and the other half was usually sent to the New Mexico Department of Public Health laboratories for control analysis by the Scott-Sanchis method (*8*), with the SPADNS technique used occasionally as a double check. Table 1 gives the analytic findings on the split samples by field and laboratory methods.

Table 1. Comparison of fluoride analyses of 489 split water samples by laboratory and field methods, fluoridation project in 25 small rural communities, New Mexico

F–ion concentration (mg./l.)	Laboratory result [1]	Field result [2]
0.55	4	0
.60	5	1
.65	16	1
.70	33	3
.75	28	3
.80	46	38
.85	40	17
.90	67	91
.95	65	31
1.00	70	134
1.05	33	34
1.10	45	106
1.15	14	17
1.20	18	13
1.25	0	0
1.30	4	0
1.35	0	0
1.40	1	0

[1] Scott-Sanchis method: mean, 0.91 mg./l.; median, 0.94 mg./l.; standard deviation, 0.15 mg./l.; mode, 1.0 mg./l.

[2] SPADNS method: mean, 0.99 mg./l.; median, 0.96 mg./l.; standard deviation, 0.10 mg./l.; mode, 1.0 mg./l.

Table 2 lists the 25 communities in which water supplies were fluoridated in this project by county, date fluoridation was started, population served, number of samples of finished water, initial fluoride levels, optimum fluoride levels, and fluoride levels since fluoridation.

In four of these communities, chlorination and fluoridation were combined. In three of the four communities (Cundiyo, El Rito, and

Wagon Mound), solution feeders that were part of existing chlorinating installations were used to feed fluorides simultaneously. The same solution containers were used for both sodium hypochlorite and sodium fluoride. It was important that sodium hypochlorite rather than calcium hypochlorite be used as the source of Cl ion to avoid the loss of F ion through combination with calcium as CaF_2, which is relatively insoluble.

The combination solution was prepared with 1.0 pound of 98 percent sodium fluoride and 0.75 gallon of 5.25 percent sodium hypochlorite to each 10.0 gallons of water. The percentage of F ion was 0.5 and of Cl ion, 0.4. There was no appreciable interference of Cl ion with F-ion analyses at Cl-ion levels below 0.6 mg. per liter. It is recommended that Cl ion be completely neutralized through the use of arsenite before analyzing for F ion (*8*).

In the fourth community, Abiquiu, the fluoridation project actually facilitated the initiation of chlorination of the town's spring-fed supply. No problems were encountered in these combined programs, and the capital outlay was reduced considerably.

Twenty-four of the installations, with constant well-pump outputs, could use constant-rate feeders. Only one installation, with a spring-fed gravity system, required a variable-rate solution feeder.

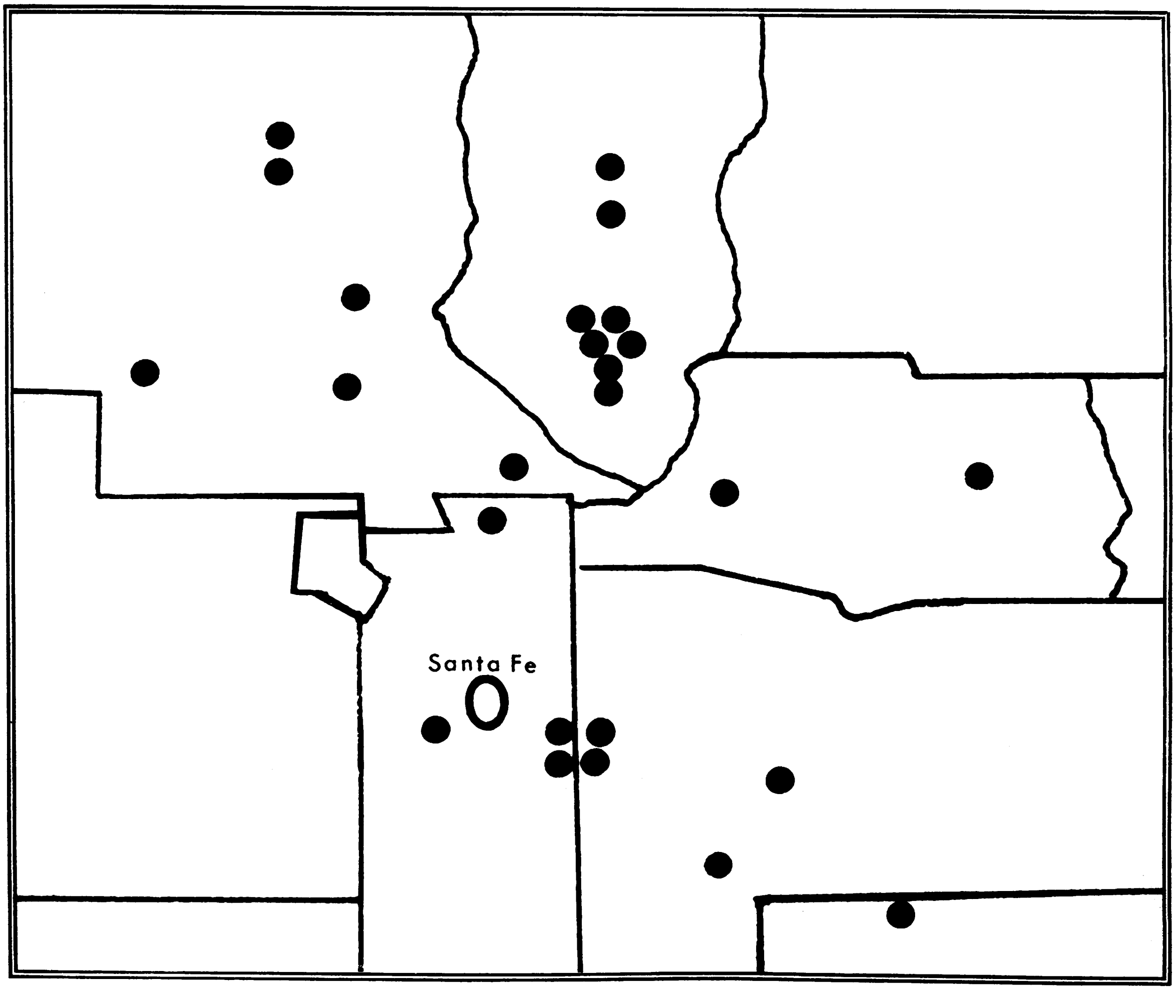
The project sanitarian arranged for installation of the fluoridation system after a community applied formally in writing. He serviced

Table 2. Fluoride level maintained during fluoridation of water supplies in 25 small rural communities in New Mexico

County and community	Date fluoridation was started	Estimated population served	Natural fluorides (mg./l.)	Number samples of finished water	Average F level of laboratory analyses (mg./l.)	Average F level of field analyses (mg./l.)	Optimum F level (mg./l.)[1]
Guadalupe County:							
Anton Chico	Apr. 2, 1962	600	0. 2	18	1. 03	1. 08	0. 95
Mora County:							
Cleveland	Feb. 1, 1962	295	. 3	20	. 94	1. 01	1. 00
Wagon Mound [2]	June 6, 1962	760	. 3	36	. 81	(2)	. 95
Rio Arriba County:							
Abiquiu	May 27, 1962	500	. 4	22	. 94	1. 00	. 95
Capulin	May 21, 1962	150	. 2	17	1. 00	1. 01	1. 00
Cordova	June 29, 1962	300	. 3	26	. 92	. 96	1. 00
El Rito	June 26, 1962	500	. 1	14	1. 06	1. 00	1. 00
Ensenada	June 4, 1962	200	. 1	14	1. 05	1. 08	1. 00
Tierra Amarilla	June 28, 1962	800	. 3	13	. 94	. 98	1. 00
Santa Fe County:							
Agua Fria	June 22, 1961	450	. 2	22	. 95	1. 00	. 95
Cundiyo	Dec. 29, 1961	75	. 2	21	. 86	. 93	. 95
Glorieta	June 23, 1961	80	. 3	29	. 90	1. 02	. 95
Glorieta, East	do	70	. 4	27	. 97	. 98	. 95
San Miguel County:							
Pecos, East	June 27, 1961	475	. 1	27	. 88	. 98	. 95
Sena	Dec. 26, 1961	150	. 2	20	. 87	. 95	. 90
Tecolote	do	150	. 2	17	. 85	. 96	. 90
Valley Ranch	June 27, 1961	225	. 3	27	. 86	. 84	. 95
Taos County:							
Cañon	Apr. 9, 1962	500	. 1	14	. 88	. 96	. 95
La Placita	Dec. 8, 1961	80	. 2	21	. 82	. 93	1. 00
Llano San Juan	Apr. 6, 1962	250	. 3	16	. 89	. 94	1. 00
Peñasco	Dec. 8, 1961	750	. 2	21	. 92	1. 01	1. 00
Rio Lucio	Sept. 8, 1961	295	. 1	22	. 88	. 97	1. 00
Rodarte	Dec. 8, 1961	330	. 1	18	. 83	. 90	1. 00
Vadito	July 26, 1961	275	. 1	28	1. 01	1. 00	1. 00
Valdez	Dec. 28, 1961	100	. 0	14	1. 05	1. 02	1. 00

[1] Estimates are based on Galagan, D. J., and Vermillion, J. R.: Determining optimum fluoride concentrations. Public Health Rep 72: 491–493, June 1957.

[2] Fluoride analyses from Wagon Mound were not always submitted on a split sample basis and therefore were not included in table 1.



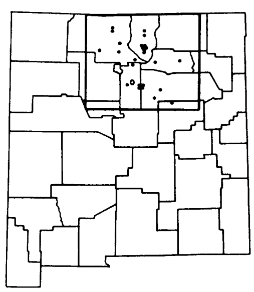


Figure 5. Location of rural communities serviced in relation to Santa Fe, fluoridation project, New Mexico

each installation at least monthly by checking F-ion content of raw and finished water, replenishing the fluoride solution, and checking, lubricating, and servicing the feeding equipment on the few occasions when trouble occurred. For example, occasional cleaning of the injection nozzle and replacement of check valves were necessary. Also, some feeders had a tendency to air-lock and required frequent checking.

Three other technical problems were encountered early in the program. First, the reagent head on a few of the feeders failed, apparently because of inherent weakness in the design of the feeder, and had to be replaced. There has been no further trouble in this regard. Second, sand particles occasionally caused check valves in the injection nozzle to jam. Jamming has been minimized by extending the injection nozzle into the waterflow. Third, freezing temperatures have been troublesome at several installations. Thermostatically controlled electrical heating tapes were installed to protect tubing and piping, and heat lamps were used to protect the feeders. During the 3-year program the feeders themselves have been essentially trouble free.

The project sanitarian prepared the NaF solution at each site from NaF prepackaged (0.25–2.5 pounds per package) at headquarters and a measured volume of water. A typical amount would be 1.0 pound of NaF to 10.0 gallons of water. Usually, the sanitarian visited new installations more frequently than once a month until a pattern of servicing could be worked out. In winter months when demand for water was low, once-a-month visits generally were sufficient. In summer, more frequent trips were necessary; however, the more frequent summer visits could be obviated by using larger containers or a second container of solution, or stronger solutions.

Centralized servicing from the State health department headquarters apparently has worked out well. The map (fig. 5) indicates the location of the communities in relation to Santa Fe. During the project 240 trips, consisting of 747 service calls (3.1 service calls per trip), were made. Approximately 35,410 miles were covered with an average of 148 miles per trip. At 7 cents per mile, the travel expense amounted to $2,478.70. Personal services (salary and fringe benefits for the project sanitarian) amounted to $16,113. Maintenance and supplies (electrician's services, small tools, reagents, and fluoride compound) were $689. Equipment (colorimeter, feeders, and solution containers) totaled $2,555. Per diem amounted to $109 for travel of the project sanitarian to the waterworks short course, and telephone bills were $18. Thus total cost of the project, resulting in the fluoridation of water supplies in 25 small communities and the concomitant chlorination of one water supply, plus routine service calls, amounted to $21,962.70, an annual per capita expense of $1.22. Typical installation in a small rural community cost about $100 (table 3).

Table 3. Cost of a typical installation for fluoridating water supply in a small rural community in New Mexico

Equipment and services	Range of cost	Average cost
Solution feeder	$70–75	$70. 14
Plastic container, 20 to 30 gallons	8–13	11. 32
Electrician's services	10–20	15. 22
Tapping saddle (for injection-nozzle connections)	4–5	4. 50
Total	92–113	101. 18

Discussion

Our fluoridation project has shown that for relatively little capital investment the benefits of fluoridation can be brought to small rural communities where such programs hitherto have been considered impractical. A centralized system of servicing proved to be rather simple to establish and to maintain. A relatively inexperienced sanitarian was oriented and prepared rather easily for the installation and servicing tasks. The project sanitarian did not restrict himself narrowly to fluoridation but provided consultation in other areas of environmental health as needed and concerned himself with the maintenance and improvement of the total water system.

Graduate sanitary engineers, although they were consulted frequently and reviewed plans, were not needed to perform the routine tasks; hence they were free to pursue more specialized assignments. The program has implications for other rural areas where there are similar water systems.

Maintaining the fluoridation program after termination of the Federal contract can be accomplished in several ways. (Costs are negligible: in a typical installation a small amount of money is needed for electricity and about $12 per year for NaF compound.) In a few communities, the water superintendents have been trained to maintain the fluoridation system, with periodic checks by local, district, or State sanitarians and engineers. The routine submission of water samples to the State health department laboratory for analysis of the fluoride content also serves as a further check. In some areas local health department sanitarians with on-the-job orientation can assume the duties of the project sanitarian.

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Private water-conditioning companies again could be asked to bid on the maintenance and servicing of fluoridation systems which are in geographic areas coinciding with their established water-softener routes. Perhaps these companies could promote the installation of fluoridation systems for water supplies not only of small communities but also of individual homes and schools.

Summary and Conclusions

A 29-month project, financially supported by the Public Health Service and the New Mexico Department of Public Health, tested and proved the feasibility and economy of installation and centralized monthly maintenance of fluoridated water systems for small rural communities. Twenty-five rural water systems, serving populations ranging from 70 to 760 persons (total population served, 8,310), were fluoridated successfully with a minimum of technical difficulty. Initial outlay for a typical installation cost about $100, and the annual per capita cost was $1.22. A relatively inexperienced sanitarian was oriented and trained to install and maintain the systems with but minimal supervision by engineering and dental specialists. Inexpensive equipment for feeding and testing fluorides was tried in the field and found to be practical and relatively accurate.

A side benefit of the project was the demonstration that a single solution feeder could serve simultaneously as both fluoridator and chlorinator.

REFERENCES

(1) Caldwell, C. G.: Safe water supplies for rural New Mexico. Public Works 91: 98–100, 179, 182, February 1960.

(2) Caldwell, C. G.: The mutual domestic water consumers' association projects. New Mexico Health Officer 17: 3–24, April 1949.

(3) New Mexico Department of Public Health: The mutual domestic water consumers' association projects. Communicable Disease Summary 10: May 18, 1963.

(4) University of New Mexico: New Mexico's changing economy. New Mexico Bus 14: 3–19, April 1961.

(5) University of New Mexico: Family incomes in New Mexico in 1959. New Mexico Bus 15: sec. 1, February 1962.

(6) Sandoval, A. D.: New Mexico county industrial composition and levels of living. New Mexico Bus 16: 3–10, May 1963.

(7) Maier, F. J.: A system for fluoridating individual water supplies. Amer J Public Health 48: 717–723, June 1958.

(8) American Public Health Association: Standard methods for the examination of water and wastewater including bottom sediments and sludges. Ed. 11. New York, 1960, pp. 128–130.

Survey of Inactive Registered Nurses

The Public Health Service conducted a 12-State survey to determine reasons why an estimated 230,000 graduate nurses are not employed at nursing.

About 10,000 nurses, or four-fifths of those who received questionnaires, responded. The reason most often given for inactive status was the belief that a mother should be in the home while her children are young. Inability to make suitable arrangements for care of immediate family, low salaries of nurses, and difficulty in arranging working hours compatible with home responsibilities were other major reasons.

The results of the survey, which was conducted by the Division of Nursing, suggest that working schedules should be developed in accordance with part-time availability of nurses and that day centers should be established for the care of their preschool and school-age children.