

Report on
MOUNT AIRY WATERWORKS

By
Haywood M. Sparger

B —
This report is
excellent in
appearance and
organization
You should be more
careful about
the use of hyphens

I hope you will
show this to Mr.
Merritt.

Report on

MOUNT AIRY WATERWORKS

Made to

Dr. A. C. Howell

By

Haywood M. Sparger

Student in Electrical Engineering

MOUNT AIRY

1938

Mount Airy, N. C.
June 24, 1938

Dr. A. C. Howell
Professor of English
University of North Carolina
Chapel Hill, N. C.

Dear Sir:

It is with pleasure that I submit the attached examination report on the Mount Airy waterworks as an authorized part of English 59.

This report contains the complete history and development of the Mount Airy waterworks together with statistics and data showing the operating costs of the present water plant. An effort is also made in the report to show the advantages and savings to be derived from substituting Diesel power for the present electrically operated pumps.

Very truly yours,

H. M. Sparger

H. M. Sparger, E.E.

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MOUNT AIRY AND ITS WATERWORKS

Location

Mount Airy, N. C., is located at the foothills of the Blue Ridge Mountains, in the northeast corner of Surry County, only four miles from the Virginia State Line. Because of the fact that it is only one mile from the largest open-faced quarry in the world and the city is underlaid with granite, it is frequently called the Granite City.

Population

Since its founding Mount Airy has grown rapidly and now embraces a population of over 8,000. In

Industries

addition to the large quarry, there are three large furniture factories, a chair factory, mirror factory, canning plant, two hosiery mills, a knitting mill, a ladies' underwear factory, and two large tobacco warehouses; all doing an ever increasing amount of business. In addition, several of the largest apple and peach orchards in the state are situated near the town, thus giving Mount Airy the distinction of being one of the most prominent industrial and agricultural cities in this section.

Transportation

Unfortunately, Mount Airy is served by only one railroad; however, it does have the advantage of being located on highways No. 80, 89, 66, and 121. These give good direct connections by motor-car to all important points.

History

Many changes have been made in the water supply system of Mount Airy since the first installation in 1903. At that time the Rucker-Witt Tobacco Company was in business on Willow Street, just two blocks from Main Street, and for their own use they had a deep well drilled.* The town officials at that time laid a one-inch water line from uptown to this well and for some time purchased water from the tobacco company. It was soon evident that this well would not supply sufficient water for the town, so in 1904 construction was started on a "town well" which was located just outside the northeast corner of town. This well, 25 feet in depth and 40 feet in diameter, was constructed around a spring and was built of brick. At this time a small brick building was erected to house a 400 gallons per minute belt driven pump coupled to a 30 horsepower, 110 volt, ~~belt driven~~ motor. With this equipment water was pumped to an old wooden tank which was located on Lebanon Hill in the northern part of town.

By 1905 it was evident that the well, as constructed, would not supply sufficient water for the town, so a watershed of one-quarter square mile area, located on Creasey's Branch, was selected. Here a small intake dam was built and a four-inch spiral steel gravity

* Information gathered from old historical records on file at the City Hall.

pipe line was laid from the intake to carry the water into the old brick well from which it was pumped, without treatment, to the wooden tank. As an auxiliary unit to be used in case of fire or failure of the electric unit, a 26 horsepower gasoline engine was installed and coupled directly to a 300 gallons per minute, centrifugal pump. H

The above arrangement gave satisfactory operation for several years; however, by 1910 the supply was again inadequate. This time Tumbling Rock Branch with a watershed area of over one square mile and with a flow several times that of Creasey's Branch, was chosen for the location of the new dam. Here, west of Mount Airy, a small intake dam was erected across the stream. An eight-inch gravity pipe line 4,600 feet long, was laid from the intake to the old brick well, from which water was pumped without treatment.

In 1913 it was decided to build the town's first filter plant and the contract was awarded to the Tucker-Laxton Co., of Charlotte, for the designing and construction. This first plant consisted of a small brick coagulation basin, a chemical control house, two one-quarter m.g.d. reinforced concrete filter basins, and a reinforced concrete filtered water storage basin with a capacity of 150,000 gallons. Sterilization of the water was accomplished by adding a solution of sodium hypochlorite to the filtered water. The old wooden

tank on Lebanon Hill was torn down during the same year and replaced by a 150,000 gallon capacity steel elevated tank. (This tank is the smaller of the two shown in Fig. 1).

In 1915 it was found necessary to add to the pumping equipment, if water was to be provided at all times regardless of break-downs or repairs to the pump. To take care of such a situation and to provide for later enlargements, an extension was added to the old brick building and within this extension was installed a 60-hp., 2200 volt, 1760-r.p.m., three-phase, 60 cycle electric motor, coupled directly to a centrifugal pump. This whole unit was capable of pumping 500 gallons per minute against a 300 foot head.

During the year of 1924 the old system of sterilizing the water with sodium hypochlorite was replaced by a manually controlled pulsating chlorinator. This unit gave greater protection than the former one and the cost of operation was considerably less.



Fig. 1 Water Tanks

Because of a severe dry spell during the year 1924, the water in Tumbling Rock Branch became insufficient to meet the needs of Mount Airy. The officials, therefore, decided to tap water from Lovell's Creek at a point where the intake line from the dam passed under the river. By placing a tee and blow-off^{valve} in the gravity line at this point, it was possible to install a small pump to supply enough creek water to the filter plant to meet the demands. The deficiency of water in the streams effected the flow to such an extent, however, that the power houses located on the streams below town were unable to operate. This placed a tremendous burden on the old gas engine, so in order to be free of electrical troubles and have an extra pumping unit during dry spells, it was decided to increase the equipment of the filter plant. Accordingly, a 225 horsepower, six cylinder, 1,200 r.p.m. gasoline engine, directly connected to a three stage, six-inch centrifugal pump, was installed. It was possible to pump 1,000 g.p.m. against a 300 foot head with this unit. Because of the inconvenience and expense of pumping raw water from the creek, the officials decided to construct an earth fill dam with concrete spillway just above the old intake on Tumbling Rock Branch. This dam impounded nearly 10,000,000 gallons of water when full. To further reduce the hazards of dry weather the town at the same time erected a 200,000 gallon standpipe on Lebanon Hill. (This standpipe is the larger of

the two shown in Fig. 1). This additional standpipe greatly increased the capacity and allowed the repair and painting of one without interruption of service.

The foregoing improvements would normally have provided an adequate capacity for several years, but 1926 was another very dry year and during the summer it was again necessary to pump water from Lovell's Creek. Because of the seriousness of the situation and the many complaints made by consumers, the town officials decided to obtain recommendations for the permanent solution of Mount Airy's water problems. Accordingly, a survey was made by the Gilbert C. White Company, of Durham, N. C., who decided that Lovell's Creek was the best source from which to obtain Mount Airy's water supply. They also drew up plans and specifications for a new raw water line and filter plant. As the Tucker and Laxton Company, of Charlotte, were the lowest bidders the contract was awarded to them. sp

The contract called for the construction of a reinforced concrete intake on Lovell's Creek (Fig. 2), three miles of fourteen-inch cast iron pipe from intake to filter plant, three 500,000 gallons per day reinforced concrete filter units (Fig. 3), an additional 500,000 gallons per day reinforced concrete coagulation unit (Fig. 4), three dry feed machines for adding soda ash and filter alum to the raw water and soda ash to the H

filtered water when needed (Fig. 5), a new reinforced concrete covered clear water storage basin with a capacity of 500,000 gallons (Fig. 6), a new and modern filter house constructed of brick and trimmed with native Mount Airy granite (Fig. 7), and a new three-phase, 60 cycle, 1740 r.p.m., 2200 volt, 100 hp. motor directly connected to a three stage, 1,000 g.p.m. centrifugal pump (Fig. 8).



Fig. 2 Concrete Intake



Fig. 3 Filter Units



Fig. 4 Coagulation Units



Fig. 5 Dry Feed Machines



Fig. 6 Storage Basin



Fig. 7 Filter House

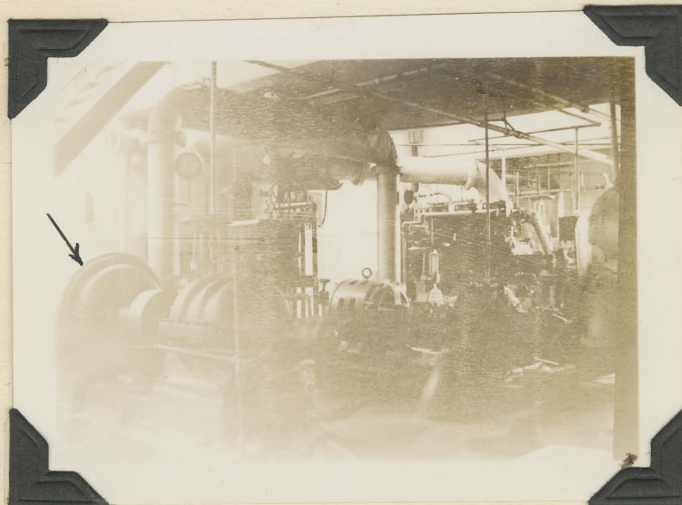


Fig. 8 Motor and Pump

Changes
in old
system

The contractors also made a number of changes in the old equipment in addition to the new construction. The old pumping and laboratory equipment was moved into the new pumping house; the old raw water basin, filter house, and part of the pumping station were torn down; and the underground pipe system revised. The actual work on the new plant was begun in January, 1927, and construction was pushed rapidly to completion in August of the same year. It so happened that the new plant was finished just in time to prevent another serious water shortage as 1927 was another very dry year. The cost of the plant, including all engineering fees and extra work, was \$144,000.

Old Dam

To eliminate the expense of pumping the water to the filter plant it was necessary to go some three miles above town in order to secure the necessary elevation. Also, there was much less contamination and pollution of the water at the site chosen. As an old wooden mill-dam was already located on the chosen site, the town officials decided to use the old dam as long as possible in order to economize. By 1930, however, the old dam was leaking so badly that it became necessary to tare it down and replace it by a more suitable structure. City Engineer, Will D. Merritt, was therefore called upon to design and supervise the construction of a new dam.

New Dam

The new dam, as constructed, consisted of eight reinforced concrete piers spaced 12.5 ft. apart with a gravity draw flume as shown in Fig. 9. The face of the dam was made of heavy 4 in. by 8 in. oak timbers, which have a remarkably long life when kept wet. In order to make it unnecessary to change the old reinforced concrete intake the dam was built with a total height of 12.5 ft. above the footing. Including the end buttresses the dam has a total span of 125 ft. and was built for the remarkably low cost of \$4,350.



Fig. 9 Green Hill Dam

Location
Plans

Figure 10 is a sketch, taken from the blue-prints made by the Gilbert C. White Co., showing the relative locations of the Green Hill dam, the gravity flow pipe line, the filter plant, and Mount Airy.

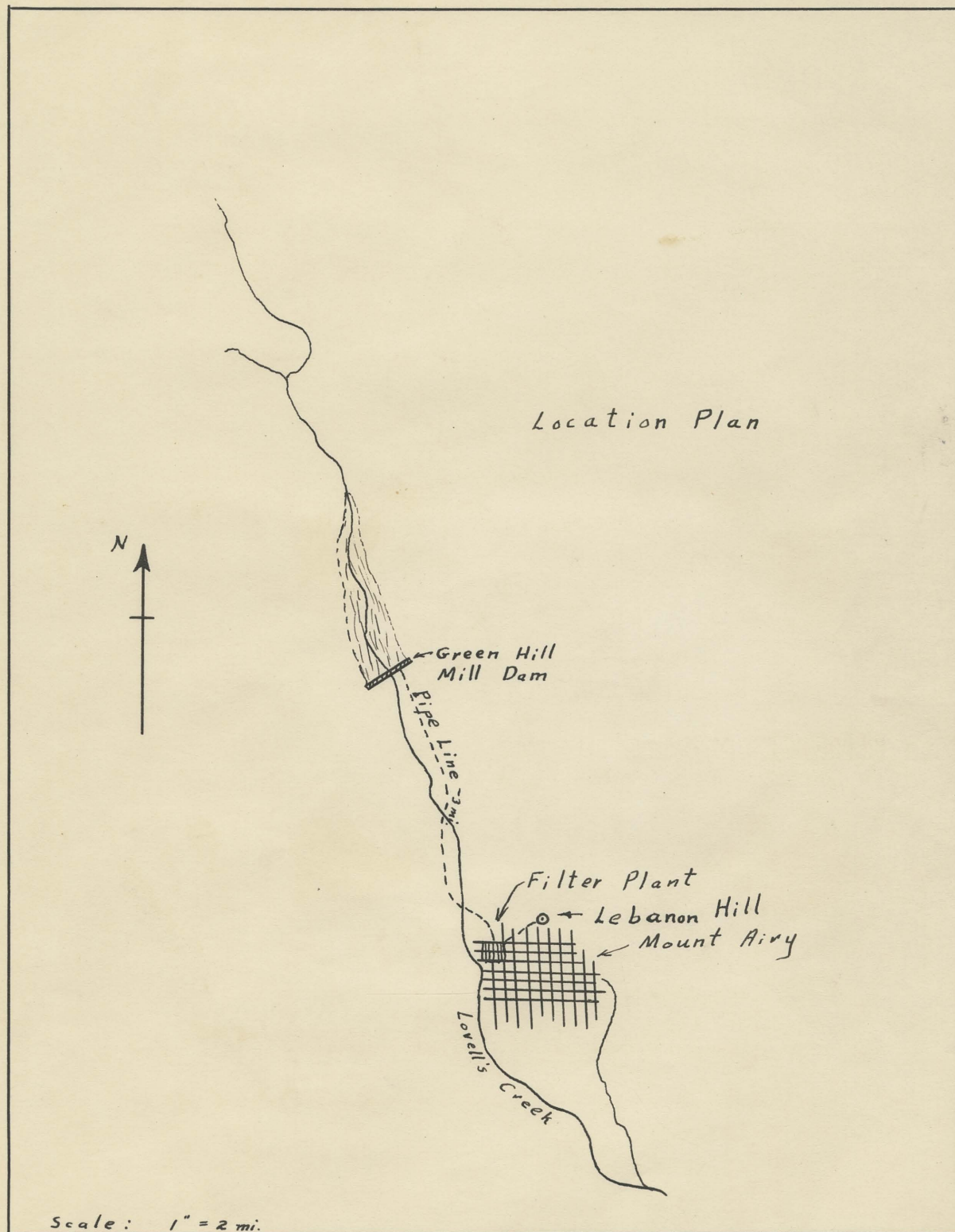


Fig. 10 Location Plan of Water System

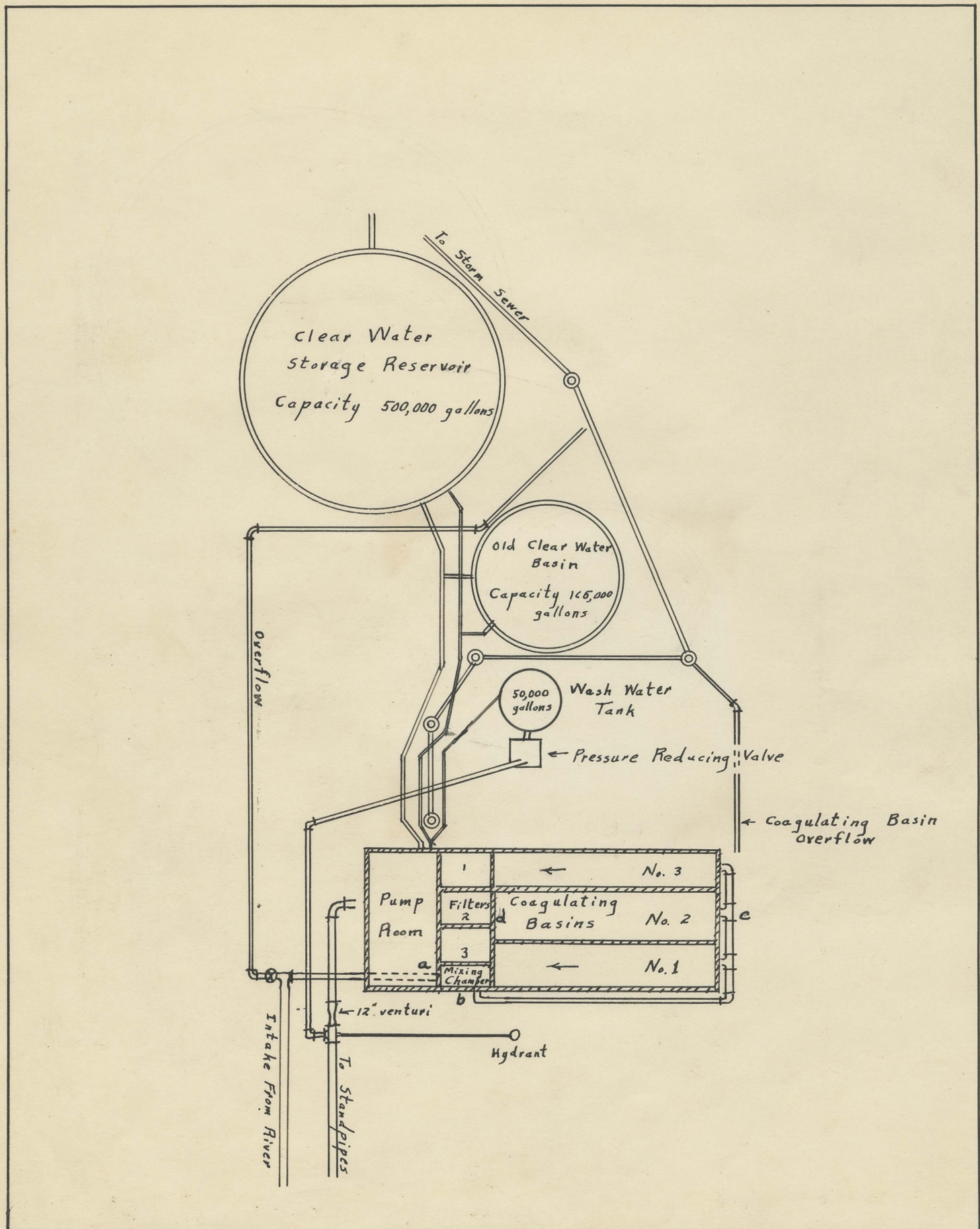


Fig. 11 General Layout of Filter Plant

Filtration

Figure 11 is the general layout plan of the filter plant. From the plan it is seen that the raw water from the river first enters the mixing chamber at point (a) where it passes alternately over and under a series of 10 ft. baffles until it reaches the opposite end of the mixing basin. As the water entered the mixing chamber filter alum and lime were added by the dry feed machines to precipitate the flock. Figure 12 is a snapshot taken of the mixing chamber.



Fig. 12 Mixing Chamber

After the water leaves the mixing basin at (b) it is carried through a 16 in. cast iron pipe to the opposite ends of the coagulation or settling basins at (c). The water, during the normal operation of the plant, requires about five hours to pass through the settling basins, during which time the flock, precipitated by the alum, gradually settles to the bottom. After passing through the settling basins to

point (d), Fig. 11, ^{the water} and enters the filter beds within the filter house (Fig. 3). The three filter beds each have a capacity of 500,000 gallons per day and are made up in the ordinary manner, i.e., with fine sand on top, gradually getting coarser toward the bottom. It is necessary to wash these filter beds periodically to remove the flock which collects on the top. This is accomplished by passing water from the wash-water tank (Fig. 13) back up through the filter beds and out through the wash-water troughs to the storm sewer.



Fig. 13 Wash-Water Tank

As the covered clear water wells are located below the elevation of the filter beds the water flows into them by gravity from the filter beds. Here chlorine is added to further purify the water and kill any harmful bacteria which might be present.

The water again flows by gravity from the clear water wells to the pumps located in the basement of the filter plant. These pumps force the water through two parallel 12-in. pipes to the standpipes on Lebanon Hill. The standpipes are a half-mile from the filter plant and have an elevation of 196 feet above the pumps at the filter plant. A 12-in. venturi meter is placed in the pipe line and measures the quantity of water pumped and records this on a sheet of polar coordinate paper which ^{is} ~~are~~ kept for future reference. Mount Airy's present water distribution system has pressures varying from 40 to 100 pounds per square inch, depending upon the altitude in the city.

8 St.

PUMPAGE

On the average, Mount Airy consumes some 500,000 gallons of water per day; however, this may vary from 380,000 gallons in winter to 600,000 gallons in the summer. To maintain maximum pressure in the mains and to provide for any unforeseen emergency drainage on the system, the pumps are usually run for five periods each day; ~~usually~~ twice in the morning and twice in the afternoon, with one pumping at night. It requires a

total of between eleven and twelve hours for the smaller electrically driven pump to supply the demands on the system. As we shall later see, the overall pumping efficiency using the 60 horsepower unit is greater than for the other units and therefore this unit is used most of the time. When there is an unusually heavy drain on the water system or when the small pump is being repaired the large 100 horsepower electrically driven pump is put into operation; however, the small pump meets all normal requirements satisfactorily. Only on rare occasions such as fire or interruption of electrical power is the old six-cylinder, 225 horsepower, gasoline engine used. This is because the pump is getting old and is rather expensive to operate and maintain.

Consumption Rates

With an average daily water consumption of 500,000 gallons, per day we find that the rate of consumption is equal to 20,800 gallons per hour. The tabulated data below shows approximately how the rate of consumption for the town varies throughout the day. (Table 1) From the curve drawn, Fig. 14, we see that the rate of water consumption increases very rapidly ^{in the early part of the day} because factories are starting and housewives are preparing meals, etc. The rates of consumption between 9:00 A.M. and 1:00 P.M. are fairly constant; however, the rate

TABLE 1 Consumption Rates

TIME OF DAY	RATE OF CONSUMPTION IN GALLONS PER HOUR
6:00 A.M.	8,600
7:00 "	12,700
8:00 "	21,600
9:00 "	31,500
10:00 "	33,900
11:00 "	33,800
12:00 NOON	33,000
1:00 P.M.	31,500
2:00 "	26,000
3:00 "	26,200
4:00 "	27,000
5:00 "	28,300
6:00 "	28,000
7:00 "	27,000
8:00 "	26,600
9:00 "	23,600
10:00 "	18,700
11:00 "	15,000
12:00 "	9,000
1:00 A.M.	6,800
2:00 "	5,000
3:00 "	4,600
4:00 "	4,400
5:00 "	5,500

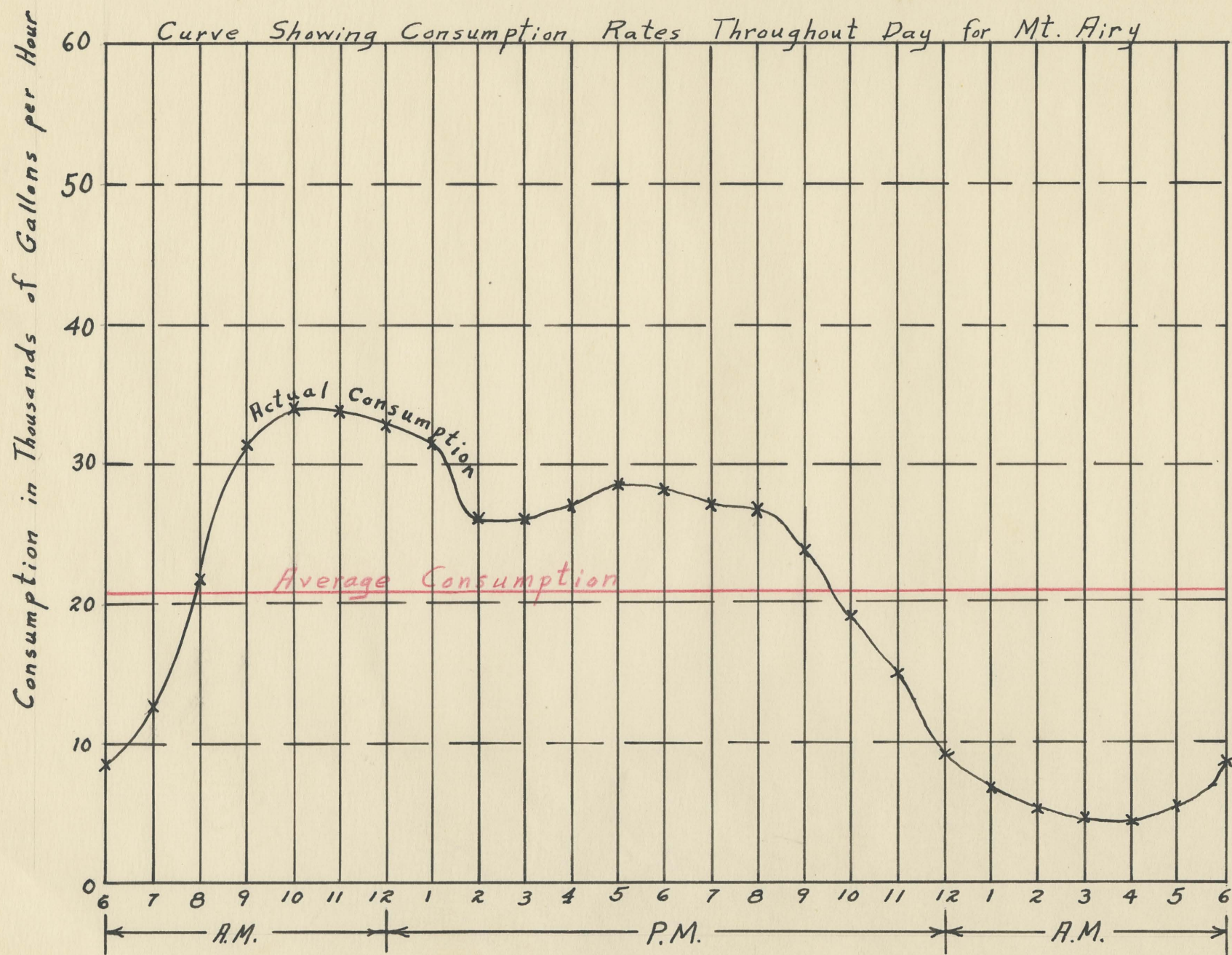


Fig. 14

drops off in the early afternoon and then builds up again until around 5:00 P.M. After 5:00 P.M. the rate of consumption begins to slowly decline until around 9:00 P.M. where it rapidly drops off and reaches a minimum at 3:33 A.M. The reasons for the changes in the demand rates are quite obvious when one considers the nature of the demands. (see Industries). The average per capita consumption runs around 62.5 gallons, which is rather high when one considers that not all of the homes are serviced by the city water mains. Of course the hosiery mills with their dyeing processes account in part for the high rate of consumption.

Tests on Pumps

On December 22, 1937, the following tests were run on the electrical pumping units to determine the efficiencies.

For the small 60 horsepower electric pump the following data was obtained, using the Duke Power meter. In order to get a good average several readings were made.

No. of Turns	Time in Seconds
10	79.24
10	79.40
10	80.00
10	80.00
Ave. 10	79.66

The following formula was used with the meter to determine the actual power taken by the motor.

$$\text{Watts} = \frac{(\text{No. of turns})(2400)}{\text{Time in Seconds}} 200$$

thus,

$$\text{Watts} = \frac{(10)(2400)(200)}{79.66} = \underline{60,250}$$

Since 746 watts are equivalent to one horsepower, we have:

$$\text{Horsepower consumption} = \frac{60,250}{746} = \underline{80.9}\text{-hp.}$$

A venturi meter reading showed that the unit was pumping 740 gallons per minute or 6,165 pounds of water per minute. Due to the pipe friction the pressure increased from 85 lb.per sq. in. to 90 pounds per square inch after the pump was started. This is equivalent to pumping against a total head of 207.8 feet. We thus find that the horsepower output of the unit is:

$$\begin{aligned} \text{Horsepower output} &= \frac{(6,165)(207.8)}{33,000} \\ &= \underline{38.82} \end{aligned}$$

The overall efficiency of the unit is equal to the ratio of power output to power input, thus:

$$\% \text{ Efficiency} = \frac{38.82}{80.90} = \underline{48.0} \%$$

Using the same power meter the following data was taken on the large 100 horsepower electric pump. H

No. of Turns	Time in Seconds
10	51.5
10	51.9
10	52.4
10	51.9
Ave. 10	51.97

Using the same formula as in the previous test, we find ~~that~~ the power taken by ^{the} motor to be:

$$\text{Watts} = \frac{(10)(2400)(200)}{51.97} = \underline{92,480}$$

$$\text{Horsepower consumption} = \frac{92,480}{746} = \underline{124} \text{ hp.}$$

The venturi meter reading showed that the unit was pumping 1,030 gallons per minute or 8,590 pounds of water per minute. Because of the pipe friction the back pressure increased from 85 pounds per square inch to 95 pounds per square inch after the pump was started. This was equivalent to pumping against a total head of 219.3 feet. We thus find that the horsepower output of the unit is:

$$\begin{aligned}\text{Horsepower output} &= \frac{(8,590)(219.3)}{33,000} \\ &= \underline{57.10}\end{aligned}$$

Dividing the power input by the power output, we find the efficiency of this unit to be:

$$\% \text{ Efficiency} = \frac{57.10}{124.0} = \underline{46.0} \%$$

Because of the smaller friction head of the water in the pipes, we thus see that the smaller pump is the more efficient.

Electric
Power
Costs

Pumping costs for the motors are fixed at the rate of 1.35 ¢ per kilowatt hour by a contract with the Duke Power Company. This amounts to a monthly power bill of about \$235.00, or an average annual power bill for the motors of \$2,820.00.

DIESEL PUMP

Costs

The water requirements of the city of Mount Airy could be adequately met by a 100 horsepower Diesel pumping unit, operating a total of $8\frac{1}{2}$ hours per day. A 100 horsepower Diesel engine coupled to a three-stage, 1,000 gallons per minute pump, would cost Mount Airy roughly \$ 5,000.00, installed, and would have an operating life of twenty years or more. In order to show the operating expenses of such a unit, the following cost estimates have been made:

I. Interest on Investment.

The interest on the \$ 5,000.00 investment could be paid through the sale of City Bonds at the customary interest rate of 4.5 %. This would amount to a total of \$ 225.00 per year.

II. Fuel Costs.

The fuel oil consumption of a good 100 horsepower Diesel engine is rated at 0.48 pounds of oil per horsepower hour. For the 100 horsepower unit running $8\frac{1}{2}$ hours per day, this would mean 408 pounds or 55.8 gallons of fuel oil per day. This oil may be bought on the local market at a cost of 6.5 ¢ per gallon. Thus, the fuel costs for the engine would be around \$ 3.63 per day or \$ 1,324.00 per year.

III Lubrication Costs.

The lubrication requirements for a 100 horsepower Diesel engine is rated at one gallon per 3,000 horsepower hours. This would mean a consumption of 0.283 gallons per day or 103 gallons per year. ~~As~~ A very

good grade of lubrication oil may be purchased by the town for \$ 0.80 per gallon. This is equivalent to an annual lubrication cost of \$ 82.50 for the pumping unit.

IV. Maintenance and Labor Costs.

For Diesel engines the maintenance costs are usually estimated at the rate of \$ 1.00 per horsepower per year. The maintenance expense for the 100 horsepower engine would, therefore, be in the neighborhood of \$ 100.00 per year. Since the labor required to operate the Diesel pumping unit would be essentially the same as for the electrically driven pumping unit, this item need not be considered here.

Adding the separate expense items, we find the annual cost of operation as:

Interest on Investment	\$ 225.00
Fuel Costs	\$ 1,324.00
Lubrication Costs	\$ 82.50
Maintenance Costs	\$ 100.00
Total Expense	\$ 1,731.50

CONCLUSIONS

From the foregoing evidence it is obvious that great savings could be effected by a change in the pumping equipment. The installation of a 100-hp. Diesel pumping unit would net the town of Mount Airy an annual savings of around \$ 1,100.00. This amount would be enough to pay for the unit within a five year period, after which time the town would receive the entire benefit of the reduced pumping costs; amounting to a total of \$ 1,325.00 per year.

As there is adequate room in the basement of the filter plant, it would be unnecessary to make any major changes in the present piping system. No other changes in the filter plant are necessary at present, ^{as} the plant has more than adequate capacity for supplying the water requirements of Mount Airy.

RECOMMENDATIONS

It is therefore recommended that a 100-hp. Diesel powered pump be purchased by the town of Mount Airy as soon as possible and plans made for its early installation in the basement of the present filter plant.