INVESTIGATION OF THE WATER SUPPLY SYSTEM OF ALLEGAN, MICHIGAN

Thesis for the Degree of B. S.

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Wayne Knox Ward

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Investigation of the Water Supply System of Allegan, Michigan

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By

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THESIS

Foreward

The purpose of this report is to show the difficulties encountered and the remedies that should be used to improve an existing water supply system. Allegan is a city of approximately 5500 people and yet is one of the few Michigan towns of this size without metered service. It is a very backward community as to public utilities. Seemingly, the general public is not properly informed on the subject of just what their public services have to offer. In my investigations, many local residents were interviewed as to the water supply system itself. Very few even had any knowledge as to the location of the wells. Less than half of those contacted could tell whether there was a fire hydrant located in their own residential block. When suggestions were made as to the improvement of the water supply system, many answers were to be found. Some believed improvements were necessary. Others said, "Well, we get water at our house. Why are improvements necessary?" They felt that as long as they received water the system was entirely adequate. Suggestions were even made to improve other facilities around town instead of worrying about the existing water supply. This shows lack of information and interest in the actual condition of the water supply system.

The water supply system is a public utility, municipally owned and the people should understand that it is their civic responsibility to take an interest in its functions. The complete system of furnishing water to the domestic, industrial, commercial and public services should provide sufficient earnings to cover the cost of labor and material consumed in the operation of the plant. These include adequate revenues to cover the cost of electrical energy for pumping and lighting,

heating of pumping stations, treatment of water if required or desired, depreciation of plant and equipment, and a reasonable reserve for extensions and capital improvements.

History

Allegan County is located in the third tier of counties north of the Indiana state line and on the east shore of Lake Michigan. The location has made this county a popular vacation spot with facilities available for recreation, outdoor fun and a variety of sports. Fishing and boating are popular because of the forty-five recorded lakes widely distributed over the entire area. Lake Michigan comprises the entire western border of this popular vacation land. Eighty thousand acres of forest area of which forty-five thousand are state owned offer unlimited opportunities to the ardent hunter. The Kalamazoo River is available for canoeing and the banks afford a pleasant site for picnics and hikes. Comparitively lightly populated, Allegan County might be said to resemble the county of a century ago in that the forests have been well preserved or replanted. Allegan County is famous for its fruit, celery beds, wildlife land, oil wells, and onion farms. Industrially, the county is a large producer of paper, fine furniture, canned food products and numerous other manufactories.

Early history records Allegan county as a very good trading area. The Kalamazoo River offered the means of transporting goods from inland cities to Lake Michigan. A natural harbor is found where the Kalamazoo River flows into Lake Michigan. Now the stream has many hydro-electric dams to halt all navigation by water. Due to this change, the river is now considered as a source of natural power for industry and public use.

The city of Allegan is located at the junction of state highways M-40, M-89, and M-118. It is the county seat and assumes normal municipal functions for the county as well as the city itself. Allegan is the leading industrial center of the county. Roads from the city lead to

golfing, resort and camping areas, lakes, streams, and many other numerous points of interest.

The population of Allegan has increased from 60 persons in 1835 to 4526 (1940 census). The great increase was due to the ideal situation for industries and in earlier history to its favorable location with respect to trade. The population in 1947 has been estimated at 5500.

The town is situated in a valley and is completely surrounded by hills except for the river channel area. The Kalamazoo River created a necessity for a total of five bridges to care for the transportation needs of people and vehicles. All business establishments and the greater majority of industries are located below the hills. The area above the hills is principally used for residential purposes.

Water supply history as found to be interesting as to the development of the present system. Negotiations took place between village officials and the originator of the Holly system of water works, and in March 1871 the citizens, by a vote of 225 to 130, favored the installation of the water supply system and the bonding of the village to the amount of $25,000 to carry the proposition into effect. Double turbine engines were first used for forcing the water, and mains were laid through the business district and gradually extended to the residential districts. By 1873 the water works had been proved satisfactory and the engine company of the fire department was then dispensed with, the pressure in the mains being sufficient. Before the system was complete, nearly $50,000 had been expended by the city.

The water works has been improved and extended from time to time. In March 1896 the village voted an issue of bonds not to exceed $7,000 for repairing and improvement. On September 11, 1901, at a special election, it was voted (242-67) to bond the village to the amount of $15,000

for the installation of new pumps at the water works. In April 1903 the proposition was carried by popular vote to bond the village $26,000 for the improvement of water works and water power. City records indicate that the total initial cost of the present plant and distribution system represents a capital investment of over $200,000.

INVESTIGATION OF PRESENT WATER SUPPLY SYSTEM

No permanent records were found as to the quantity of water pumped, due to lack of meters at the pumps as well as in the homes. Records on the piping system were incomplete and inadequate for any studies. No recorded information was available on the pumps as to kind, age, manufacture, type, capacity, or operating condition. These vital facts are important for the engineer if he wishes to improve the water works system.

As mentioned before, this can be classed as a typical report on the difficulties to be encountered by an engineer in an attempt to remodel and improve an existing system. He must resort to the basic principles of designing a new system and find out if the present system will fit in with the pumps, pipes, and equipment of a basically new plan.

To do this accurately and from an engineering standpoint, the system has been broken down into studies of source of supply, pumps, pipes, population, consumption, and other necessary analyses needed to design an adequate and modern system of water supply.

Wells & Pump House
1 - 750 gpm pump
1 - 14" well
42' deep

Well & Pump House
1 - 1200 gpm pump
1 - 750 gpm pump
1 - 26" well
42' deep

Well & Pump House
2 - 500 gpm pumps
6 - 5" wells
42' deep

Population Studies

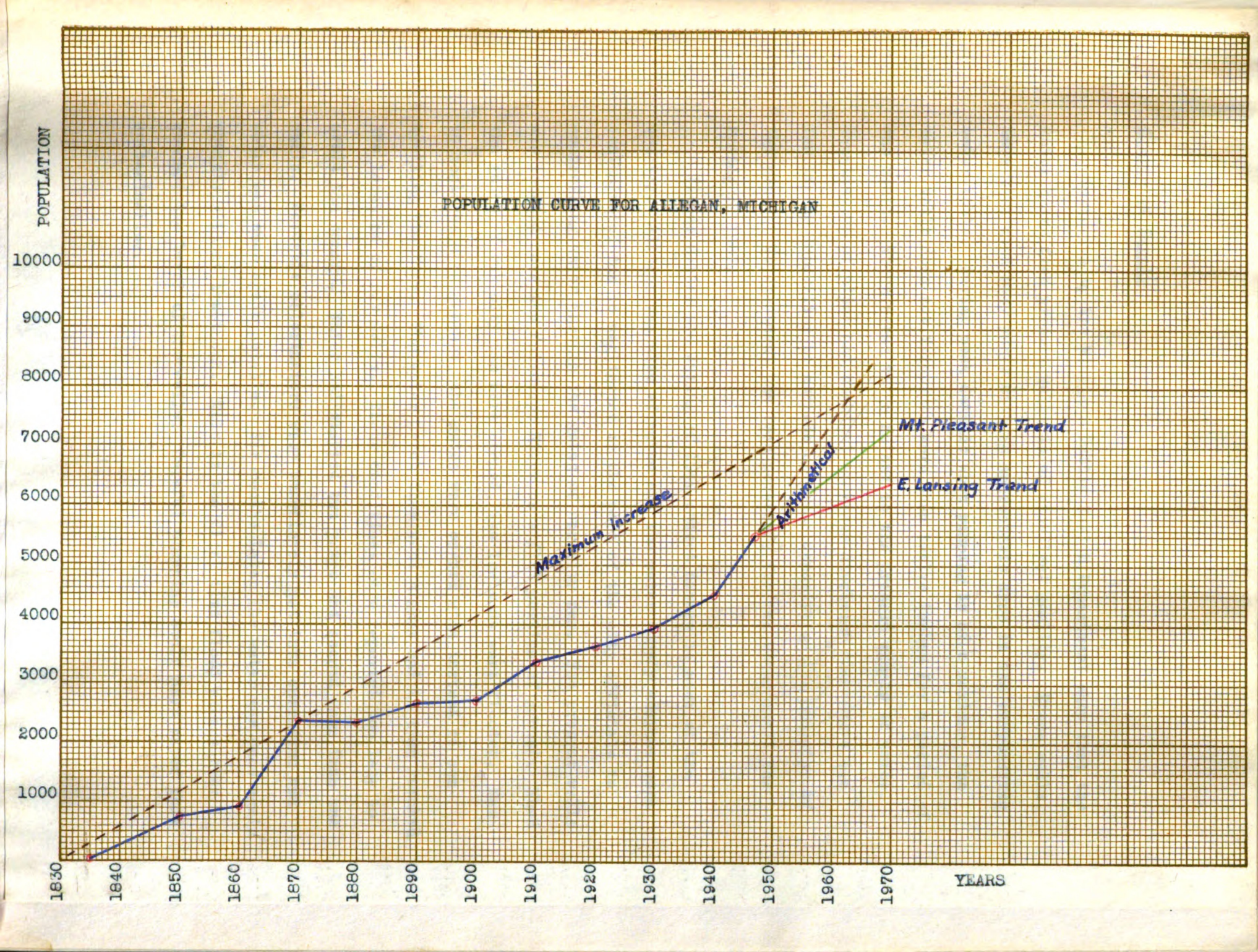
Wide variations are found in the average domestic use of water which is usually about 35 gallons per capita per day. The economic status of the customers will affect this greatly. In high-value residential districts the consumption will be high due to their ability to pay for greater services such as added bathrooms, sprinkling systems, air conditioning, steam heat, and showers. Apartment houses will show the highest consumption because of the higher density of population over a small area. The consumption rate of slum areas can be assumed as 20 gallons per capita per day while apartment buildings will show as high as 60. The lowest figures will be expected where there are no sewage facilities and only one faucet to serve one or several homes. Density of population has a definite effect on consumption. High densities will create large consumption rates while the smaller concentration of population will have very little effect.

The following facts on population were found in the census reports or in the historical records of the city:

Year	Population
1835	60
1850	752
1860	922
1870	2374
1880	2305
1890	2669
1900	2667
1910	3419
1920	3637

Year	Population	
1930	3941	
1940	4526	
1947	5500	(Approximately)

The approximate population for 1947 was determined from Post Office records. This information has been entered in graphic form on the following page. Future prediction for population and the general population trend information is available from the graph mentioned above.


POPULATION CURVE FOR ALLEGAN, MICHIGAN
POPULATION
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
YEARS
Maximum Increase
Arithmetical
Mt. Pleasant Trend
E. Lansing Trend

Source of Supply

Tests run by the Michigan Public Health Department show that the water taken from present wells is of excellent quality. These wells have been used many years with no appreciable drop in the surrounding water table. During peak demands when pumping is at a maximum, the water table does not fluctuate more than twelve inches for a period of one month. There seems to be no end to the present supply of water. Examination of pipes and chemical analyses discloses that there are few if any impurities to corrode or cause deposits on the interior of the pipes. No treatment has been necessary for the water until the Spring of 1947.

Floods during the Spring of 1947 caused damage to most of the country. Allegan was also affected and the water supply sources were contaminated due to negligence on the part of the city officials in controlling water through the gates of our city dam. The present wells are located near the Kalamazoo River on a flat portion of ground. When the gates of our city dam were opened, the lowlands were flooded. Due to negligence of workmen, the gates were opened wide instead of controlling the flow. The water level then went higher and in time reached the location of our wells. These conditions were reported too late to avoid the damage. Water had stopped two pumps and seeped down into the wells. Portable chlorinators were immediately put into operation and water was once again potable. Six months later the water was once again potable without treatment. This is the first time flood waters ever reached the level of the wells. Careful planning could have saved this contamination.

Pumps

By personal investigation of the wells in Allegan it was possible to check the pumps and get the following information:

No.	Capacity Head	RPM	Depth of Well	Manufacturer
1	1200 gpm. 162'	1750	42'	Gould
1	750 gpm. 162'	1750	42'	Fairbanks-Moorse
1	750 gpm. 150'	1750	42'	Gould
2	500 gpm. 150'	1750	42'	Rees-Ro-Turbo

All pumps are old and seem to be in generally poor condition as to regular and adequate maintenance in former years. However, verbal information was available from the repairman that the pumps had been overhauled within the last two years. Some had been repaired within the last six months but no written record of these important facts was made. It seems that all repair work was done by employees of the water supply system. Parts were ordered from the factories. At the time of my investigation, all pumps were running. This was necessary because of the heavy seasonal demand for sprinkling and water used for cooling purposes. If a pump had broken down, it would have been impossible to maintain proper pressures in the mains. The officials are entirely dependant upon adequate repairs of the pumps, made before the peak demand of water comes about, to hold the system through the season of highest demand. This is a crude and inefficient solution to the problem but seems to have worked after a fashion. Pressures during this peak demand are very low especially in the homes on the hills. Rigid sprinkling regulations are always a necessity to give adequate pressure for fire demand and homes on the hill.

Pipe System

The pipe system is adequate for the demand at present and, if proper changes are made as requested, will be adequate for future demands. Pipes that have been in the ground for as much as thirty years still show no signs of corrosion or deposits causing high frictional losses. Investigation of the older records disclosed that there are several wood mains still in service. These have been inspected and found to be in excellent condition.

Metering

There are no meters existing in the entire water system. On two 500 gpm. pumps there are pressure gages. The operator of these pumps merely sees to it that a pressure of from 68-70 pounds per square inch is maintained.

Equipment

The Department of Public Works has available all the necessary equipment to do any repair work needed on pipes, pumps, valves, hydrants, or service to homes. Storage space is available for spare pipes, valves, hydrants, and parts for equipment. A good stock of these necessities is kept on hand.

Consumption Studies

Consumption rates vary from about 35 to 530 gallons per capita per day. This wide variation can be caused by one or various combinations of the following important factors: size of city, presence of industries, quality of the water, its cost, its pressure, climate, characteristics of population, whether supply is metered, and the efficiency of the water works administration.

Climatic conditions are always present in design work. In regions where it is hot and dry, much water will be used for sprinkling. Bathing

is increased, air conditioning units are heavy users, street sprinkling has some effect and even ornamental fountains should be taken into consideration. In cold climates water is wasted by running water at faucets to prevent freezing of pipes.

Metering will always cause a drop in the consumption compared to the unmetered system. Customers are billed for water used and become economical with its use. Less water is wasted by consumers because they realize the added cost of waste. Unaccounted for water is easily traced when meters are used so this can be kept at a minimum.

Industries and commerce are usually dependant upon large quantities of water. They always tend to raise the consumption rates. Paper and steel industries use the highest amount of water.

High densities of population will cause high consumption rates. This does not necessarily hold true in slum districts. Low concentrations of population bring about lower consumption. Apartment houses will show the greatest density value and consumption rates. Slums will be the lowest.

The size of a city has an indirect effect. Area covered, density of population, whether or not a sewer system is in use and large industries all must be investigated before the size of the city can be allowed to effect the consumption rates.

The following paragraphs will be devoted to definitions of domestic, commercial, and industrial, and public uses of water. Loss and waste must also be included. These definitions must be studied before any further facts can be presented.

Domestic consumption includes water furnished to houses, hotels, business establishments, etc. for sanitary use, drinking, washing,

bathing, cullinary, and other purposes such as irrigation and sprinkling of privately owned gardens and lawns.

Commercial and Industrial water includes all water furnished to commercial and industrial plants. It is dependent upon the type of industry, whether large or small, period of operation, and whether or not they patronize the public water works. It is entirely possible for a large industry to use over 50% of the total output of water from the supply.

Loss and Waste can be attributed to leaks in mains, unauthorized connections, pump slippage, leaks in plumbing fixtures, or just careless and willful waste. This loss can be kept at a minimum with a properly engineered water system. If meters are installed 100%, leaks can be easily traced.

Public use of water includes use of water in public buildings such as city halls, court houses, jails, schools, and other public institutions. Fire demand is included in public use. This can cause high consumption rates over short periods of time. Over long periods it has little effect.

Audit Report

BOARD OF PUBLIC WORKS

City of Allegan, Michigan

Water & Sewer Department

November 15, 1946

Board of Public Works,
City of Allegan, Michigan

Gentlemen:

I have examined the books of account of the Electric Department, Water Department and Sewer Department of the Board of Public Works of the City of Allegan, Michigan for the period from July 1, 1945 to June 30, 1946 and submit herewith my report covering the period examined.

I tested or examined the accounting records and supporting evidence and reviewed the accounting methods of these departments, but I did not examine the details of all transactions.

Respectfully,

C. E. Cooper, C.P.A.

Water Department Comments

Cash on deposit in bank 3,771.36

A comparison with June 30, 1945 shows a decrease amounting to $5,643.22

Accounts Receivable 4,109.53

A comparison with june 30, 1945 shows a decrease amounting to $113.42 which is accounted for as follows:

	June 30, 1946	June 30, 1945	Decrease June 30, 1946
Customers Accounts	4,340.03	4,453.45	113.42
Less: Reserve for Bad Debts	230.50	230.50	
Net Customers Accounts	4,109.53	4,222.95	113.42

I did not verify these accounts by direct correspondence with the customers or examine them in detail, or determine the adequacy of the Reserve for Bad Debts.

Inventories 3,829.97

Consist of Material and Supplies and when compared with June 30, 1945 Increased $851.26. I accepted the Inventories without verification.

Payables 348.37

A comparison with June 30, 1945 shows a decrease amounting to $1,819.84 which is accounted for as follows:

	June 30, 1946	June 30, 1945	Decrease June 30, 1946
Payable to Electric Department	348.37	1,819.89	1,471.52
Other Accounts Payable		348.32	348.32
Total	348.37	2,168.21	1,819.84
Bonds			1,000.00

Are General Obligation Water Bonds dated May 1, 1906 payable July 15, 1946 with interest at 4 percent. The City of Allegan pays the principal and the Water Department pays the interest. A comparison with June 30, 1945 shows a decrease amounting to $1,000.00

Operations

A condensed comparative statement of operating Income and Expenses shows the following:

	July 1, 1945 to June 30, 1946	Jan. 1, 1945 to June 30, 1945	Jan. 1, 1944 to Dec. 31, 1944
Total Income	13,525.43	9,612.17	12,634.70
Total Expenses	11,841.26	5,871.62	10,964.95
Net Income	1,684.17	3,740.55	1,669.75

For further details of the Operations see Schedule H

Schedule G

Balance sheet as of June 30, 1946

ASSETS		
Cash		3,771.36
Allegan State Bank		3,771.36
Receivables		
Customers Accounts	4,340.03	
Less: Reserve for Bad Debts	230.50	
Total		4,109.53
Inventory		
Material and Supplies		3,829.97
Capital Assets		
Plant Investment (Temporary Account)	1,000.00	
Structures and Improvements	772.97	
Mains and Accessories	11,433.95	
Meters	175.80	
Tools and Work Equipment	1,646.94	
Office Equipment	93.64	
Wells and Pumping Equipment	2,268.58	
Total		17,391.88
Deferred Assets		
Unexpired Insurance		9.44
TOTAL ASSETS		29,112.18
LIABILITIES AND CAPITAL		
Payables		
Accounts Payable to Electric Department	348.37	
Accounts Payable	None	
Total		348.37
Bonded Indebtedness		1,000.00
Accrued Interest		38.33
Capital Surplus		8,000.00
Surplus		19,725.48
TOTAL LIABILITIES AND CAPITAL		29,112.18

Schedule H
Comparative Statement of Operating Income
and Expenses

	July 1, 1945 to June 30, 1946	Jan. 1, 1945 to June 30, 1945	Jan. 1, 1944 to Dec. 31, 1944
INCOME			
Flat Rate Sales to Customers	11,801.78	8,915.08	11,510.93
Public Fire Protection	850.48	637.86	850.48
Forfeited Discounts	97.08	22.25	111.98
Miscellaneous Water Revenues	776.09	36.98	161.31
Total	13,525.43	9,612.17	12,634.70
EXPENSES			
Interest on Long Term Debt	41.66	38.69	100.02
Labor Supervision	2,271.18	1,003.04	1,749.63
Supplies	162.75	296.95	44.68
Maintenance Pumping	264.24		143.13
Fuel and Electric Power	4,525.16	2,043.98	4,059.60
Labor	800.03	791.38	1,240.77
Maintenance	976.66	306.95	1,100.49
Administrative Salaries	606.95	329.28	584.22
Legal, Etc.	209.00		85.13
Office Salaries	1,042.42	531.00	981.19
Office Supplies and Expenses	532.05	287.38	357.96
Insurance	190.12	136.23	294.40
Misc. General Expense	219.04	108.74	223.73
Total Expenses	11,841.26	5,871.62	10,964.95
NET INCOME	1,684.17	3,740.55	1,669.75

Note: The Flat Sales to Customers and Public Fire Protection shown above for the period from January 1, 1945 to June 30, 1945 are for three quarters of a year.

Financial

In the financial report for 1947 which is not complete at this time, the following information was available for this report. Revenue is collected on a flat rate basis. Necessary information as to the number of residences, industrial and commercial firms are included in this report.

Water Department Reserves (1947)

11	Industrial firms	$ 526.00
1325	Residences	9000.00
188	Commercial firms	2300.00
1	Fire department	240.00
	Total Revenue	$12966.00

Computations

Pump Capacities

1200 gpm
750 "
750 "
500 "
500 "
3700 gpm = Total capacity

Maximum output

3700 (60) 24 = 5,330,000 gal./day

Assume pumps are operating at 60% efficiency

5,330,000 (0.60) = 3,193,000 gal./day

Domestic use (average)	3,193,000	(31%)	=	985,000 gal./day
Industrial use "	"	(38%)	=	1,216,000 gal./day
Public use "	"	(11%)	=	352,000 gal./day
Loss and Waste "	"	(20%)	=	640,000 gal./day
Total				3,193,000 gal./day

Maximum Consumption rate

$$\frac{3,193,000}{5500} = 580.5 \text{ gal./cap./day}$$

Domestic Consumption rate (Maximum)

Population 5500

Domestic Water 985,000 gal./day

$$\frac{985,000}{5500} = 179 \text{ gal./cap./day}$$

Maximum daily output equals 175% of the average day

$$\text{average day} = \frac{\text{maximum daily output}}{175\%} = \frac{580.5}{1.75} = 332 \text{ gal./cap./day}$$

The average daily consumption rate of water is extremely high but can be expected where water is common and a lot of it is available at a low price. This is one value that must be lowered.

RECOMMENDATIONS FOR FUTURE IMPROVEMENTS

The following suggestions are to be made for a design period of twenty years or until 1967. Improvements should be made as soon as possible to make the present system adequate as well as financially independent. Improvements cost money and must be paid for by bond issues or taxes until adequate reserves can be built up. These costs must be repaid, therefore finances and defined planning are definitely necessary. The difficulties encountered will be discussed in the following pages with detailed recommendations to implement these improvements and changes.

Source of Supply

The same source of water should be continued. Water tests show it low in mineral contents, clear, good taste, and no treatment necessary. The definition of potable water is: Potable water is one that is safe to drink, pleasant to the taste, and usable for domestic purposes. The present water supply has all these requirements without necessity of treatment. The supply presents no indications of being limited in quantity either in the past or during present times. Treatment of the water has been unnecessary up to the spring flood of 1947. By investigation it was possible to see why this happened. It is very unlikely that there will be a re-occurance of this difficulty. Portable chlorinators should be part of the necessary equipment to provide for unforeseen emergencies. The buildings that house the pumps could also be waterproofed and small pumps installed to carry away any seepage that might occur during floods. This would prevent seepage, into the wells, of contaminated water and allow all pumps, motors, and equipment to remain dry..

Pumps

All pumps used at the present time should be rebuilt and put into good condition. The pumps now used will be sufficient for any demand after meters have been installed at the pumps as well as in the residences. It will be possible to transfer one of the 750 gpm. pumps to the storage tank to help in any emergency. Any combination of pumps to produce 2000 gpm will prove adequate to serve all users of water. The present pumps are rated 3700 gpm. Therefore, this will allow a plan of rotation to be set up on the use of the pumps. Additional pumps will be available to use for peak loads such as fire demands or

sprinkling during the summer months. The storage tank will equalize pressures in the system and allow more even use of the pumps. Repairs can be easily made by utilizing a pump that is available. In my survey no suggestions are made for additional pumps because they will not be needed in the proposed system.

Pipe System

This has proved itself satisfactory and in a good state of preservation. It has been accepting high consumptions of 3,500,000 gallons per day without difficulty or failing. With the new system installed, the maximum daily output should be 1,800,000 gallons per day. The present system is certainly adequate to allow this flow. Valves and hydrants are very well located and there is no need for any more except in the outward expansion of the city. These facts will come to the attention of the administration as the city expands.

Metering

Meters should be installed at each and every pump to accurately measure the water supplied to the mains from the wells. This will lead to valuable information regarding maximum hourly rates of consumption. Consumption rate curves can be made for the maximum, average and minimum days. These will show the maximum and minimum consumption needed on each of these successive days. This information will lead to better planning on the part of the water works commission. It will also allow a rotational plan to be considered on the use of the pumps.

Installation of meters for all consumers is an important and essential corrective measure. If all consumption is metered, the difference between the water pumped and the total amount utilized by the

consumers will show the un-accounted-for waste. This information is of great use to the engineer. Leaks can be traced more easily and unaccounted-for water kept at a minimum to insure lower rates to the users of water. Water consumption was found to be extremely high for a town of 5500 people. The easiest way to make people realize their waste of water is to meter each home. Metering is a fair way to cover the cost of water by distributing the cost to all customers in exact ratio to their use of the said utility. If an unmetered system is used, the economical and careful person must help bear the burden imposed by careless and wasteful people plus industrial uses of water which are very high. A good system of water charges cannot be constructed unless they are based on the actual individual consumption of water. Meters affect the consumption greatly when installed. Sometimes the consumption is cut as much as 50% of the unmetered consumption. This reduces the necessity of providing more water, pumps, larger pipes and added equipment. Meters cause people to become more economical and resourceful in their use of water. It is one important way to completely organize an efficient water system. The cost of meters can be borne by the sale of bonds. With proper planning, the meters will pay for themselves in a very short time, and thus make full use of present plant capacity to provide adequately for present and future needs.

Storage Tank

Storage of water is necessary for several purposes: to equalize pumping rates over the day; to equalize supply and demand over a long period of high consumption; to furnish water for such emergencies as fire fighting or accidental breakdown. Storage should be elevated to give the necessary pressures by gravity instead of additional pumps.

During times of low consumption of water, the additional water will be fed into the tank. When a high consumption period is present, the tank will help raise the hydraulic grade line in the vicinity. For a city of 5500 persons a 200,000 gallon tank will prove satisfactory if located so that the high consumption area lies between supply pumps and storage. To do this, the location determined in this survey is shown on the map enclosed in the pocket of the back cover of this thesis. This location is opposite the majority of residences and all of the public and business districts. It is also located on a hill which gives greater area in which this tank will affect the hydraulic grade line variations.

Fire Demand

The National Board of Fire Underwriters uses the following formula for computing the necessary demand for fire extinguishing:

$G = 1020\sqrt{P}\ (1 - 0.01\sqrt{P})$

G = necessary demand in gallons per minute

P = population in thousands

Population = 5500

$G = 1020\sqrt{5.5}\ (1 - 0.01\sqrt{5.5})$

$= 1020\ (2.34)\left[1 - 0.01\ (2.34)\right]$

$= 2495\ (1 - .0234) = 2495 - 56.2$

$= 2438.8$

G = 2438.8 gallons per minute

Consumption Study and Commutations

This is a report on the improved system and is merely a theoretical answer but should prove to hold true within 10%.

The average consumption of water is 120 gal/cap./day.

Estimated population in 20 years 8,000

Due to high consumption of water in Allegan, 200 gal/cap/day sounds entirely reasonable and well above the average to allow a margin of safety.

Estimated maximum consumption in 1967

8000 (200) = 1,600,000 gal/day

Domestic use	(average)	1,600,000	(31%) =	496,000 gal/day
Industrial use	"	"	(38%) =	608,000 "
Public use	"	"	(11%) =	176,000 "
Loss and waste	"	"	(20%) =	320,000 "
		Total		1,600,000 gal/day

Domestic consumption rate (maximum)

population 8000

domestic water 496,000 gal/day

$$\frac{496,000}{8000} = 62 \text{ gal/cap/day}$$

Maximum daily output equals 175% of the average day

$$\text{average day} = \frac{\text{maximum daily output}}{175\%} = \frac{200}{1.75} = 143 \text{ gal/cap/day}$$

143 gallons per capita per day is nearer to the average consumption of 120. The present rate of 332 is well out of reason. If the recommendations presented herein are adopted, it is a certainty that the per capita consumption will quickly level off to a reasonable figure more in line with the requirements of other cities of equal size and facilities.

Estimated Cost of Improvements

Water tower	200,000 gallon storage	$35,000.00
Footings and foundation	100 cu. yd. concrete @ $30.00	3,000.00
Water meters and register	5@ $700.00	3,500.00
House meters (5/8" x 3/4")	1500 @ $12.00	18,000.00
Industrial & Commercial meters	230 @ $25.00	5,750.00
	Total Cost	$ 65,250.00

The $35,000 necessary for the storage tank is the price for the tower installed and in place. The footings and foundation should be put in by labor employed through the water works. Only the cost of material need be considered under these circumstances. Labor expenses would be entered in the annual books as usual. The same situation holds true with the meters except each consumer pays a fee for installation of the meter and rental after installation has taken place. This defrays all labor expenses and pays for the meters in a short period of time.

The overflow level of the tank should be above 80 feet but doesn't need to exceed 100 feet. This will insure a pressure of at least 30 pounds per square inch in the vicinity when the tank is at its lowest level.

The total cost of improvements suggested is small compared to the total value of the present system. Results will be almost fantastic. The return from this investment will be large enough to allow the water works to be financially independent.

The bonds should be issued for the design period of twenty years. Finances can be adjusted so this investment can be paid off in small sums each year or in a lump sum at the end of twenty years. Payment

of this debt will be dependent upon the rate charged for the use of water and rental on the pumps.

Conclusions

This is a summary of all the improvements that have been deemed necessary to improve the Allegan water supply system. From the report it is possible to realize that the present system is taking care of water that could be furnished to a city four times larger in population. A system such as this can never continue to be financially sound. The following changes must be made and are here discussed in brief form.

1. No change is suggested in the present source of supply.

2. Pumps, now present, will be adequate for the future demand if the following changes are made: One 750 gpm pump will be transferred to the site of the new storage tank.

3. Pipes have proven their efficiency for the heavy consumption rates that are now present. Valves and hydrants are well located and no changes need to take place. Future expansion of the city will cause a demand for expansion of the pipe system and additional fire hydrants. These facts will be considered by the administration as these changes occur.

4. Meters are a definite necessity. All pumps must have individual meters installed to measure the water supplied to the mains from the wells. Meters should be installed in every home, industry, and public building. Metering of 100% should be required to insure a water works system to operate at maximum efficiency. Meters allow complete and accurate records to be compiled. From this data, present and future planning is possible without extensive investigations.

5. The need for the storage tank was apparent by results obtained from the investigation. Pumping rates are not steady, no emergency storage of water for fires or breakdowns and low pressures during high

consumption are factors to be improved by the installation of a storage tank.

6. New administrative duties should include keeping permanent and accurate records on water pumped, consumed, and unaccounted-for. This will allow repairs to be made to maintain unaccounted-for water at a minimum. A small laboratory should be set up to allow chemical and physical tests to be made on the water pumped into the mains. Records will show daily tests on the water and lessen the chance of contamination taking place in the water supply. The water supply commission is liable for any contamination or spread of disease caused by negligence on their part. A competent engineer will be able to plan future needs, expansion, and repairs with adequate records. When the metered consumption follows a definite curve or trend, rates can be determined by the administration. Special rates should be allowed for industries and other heavy users of water.

SUMMARY OF DATA OBTAINED FROM QUESTIONNAIRE

Municipality	Pop.	Water Treatment: Source	Softened	Chlor.	Filtered	Smetered	Daily Consumption: Maximum	Minimum	Per Cap.	% of Services: Res.	Com.	Ind.	Meter Rates: Max.	Min.	No. Hydrants	Annual Rental	Ave. Pressure
East Lansing	6000	Wells	Yes	No	No	50	1200000	600000	90	x	x	x	$1.50	.15	x	None	45#
Charlotte	6000	"	No	Yes	No	95	1300000	850000	95	x	x	x	.12	.075	114	$1330	60
Escanaba	14830	"	No	No	No	98	2861850	958250	97	x	x	x	(A).18	.075	304	$ 12000	60
Cheboygan	5763	"	No	No	No	95	275000	100000	x	x	x	x	.25	.20	43	None	40
Coldwater	7500	"	No	No	No	7	2585000	589000	114	x	x	x	.10	.06	198	"	45
Grand Haven	10000	"	No	Yes	Yes	80	1800000	600000	60.110	85	12	3	.15	.15	177	"	90
Ludington	8701	Lake	No	Yes	No	99	1500000	800000	100	89.6	8.8	1.6	.125	.06½	284	12.00Ea.	60
Manistique	6000	River	No	Yes	No	98	1000000	450000	135	x	x	x	.30	.08	185	None	48
Marshall	5019	Wells	No	No	No	None	x	x	x	80	20	0	Flat Rate		153	"	x
Midland	16000	River	Yes	Yes	No	100	5000000	2400000	200	x	x	x	(B).18	.12	200	$ 9000	45
Mt. Pleasant	8413	Wells	No	No	No	98	3000000	1300000	160	90	6	4	.375	.075	130	None	55
Niles	13000	"	No	No	No	100	2770600	591600	106	89.6	9.8	0.6	.38	.05	399	"	60.65
Petoskey	6019	"	No	Yes	No	100	2254000	525000	150	x	x	x	.18½	.075	140	"	50.120
Plymouth	6800	"	No	Yes	No	99	1200000	600000	97	94	5	1	(C).25	.10	150	$25.00Ea.	50
St. Louis	3500	"	No	No	No	80	700000	x	x	x	x	x	.43	.05	85	None	60
Sturgis	7200	"	No	No	No	x	Ave.	451700	x	82	16	2	.12	.085	190	"	68
Trenton	6000	(Detroit)	No	Yes	Yes	100	1102000	915000	x	x	x	x	.28	.20	204	$35.00Ea.	44
Ypsilanti	11000	Wells	No	Yes	No	98	2715000	1300000	100	x	x	x	(D).12½	.12½	275	$43.00Ea.	95
St. Joseph	8963	Lake	No	Yes	Yes	100	2687000	700000	125	41	6	53	(E).275	.075	211	None	40
St. Ignace	2600	"	No	Yes	No	94	506000	214000	138	75	20	5	(F).25	.10	52	$2199.96	65
Alma	7203	Wells	No	No	No	98	2759000	1742000	294	92	5	3	.35	.04	196	None	78

Municipality	Rates Effective	Change Contemplated	Proposed Rates: Max.	Min.	Pumping Energy	Power Co.	Rate-KWH	Is Revenue Satisfactory
East Lansing	1940	No			Electric	Lansing	x	Yes
Charlotte	1945	"			Steam	City		"
Escanaba	1943	"			Electric	" (G)	.01	"
Cheboygan	x	"			"	M.P.S. Co.	.015	"
Coldwater	1945	"			"	City	.014	"
Grand Haven	1941	"			"	"	.015	"
Ludington	1920	Yes			Diesel	"		No
Manistique	1936	No			Electric	M.L. & P. Co.	x	Yes
Marshall	x	"			"	City	.02	"
Midland	1936	"			Diesel	"	.0115	"
Mt. Pleasant	1935	Yes 4/1/48	.50	.125	Electric	C.P. Co.	.012	No
Niles	1936	"	.183/4.10		"	City	.013/4	"
Petoskey	1933	"			"	"	No Charge	"
Plymouth	1928	No			"	Det. Ed. Co.	.01	Yes
St. Louis	1937	"			"	City	.0133	"
Sturgis	1930	"			"	"	No Charge	"
Trenton	1943	"			"	Det. Ed. Co.	x	"
Ypsilanti	1942	"			"	" " " "	.0108	"
St. Joseph	1938	"			"	Ind. Mich.	.01	"
St. Ignace	1931	"			"	Ed. Soo Elec.	.004	"
Alma	1937	Yes			"	C. P. Co.	.0111	No

REMARKS

X Indicates that this information was not furnished.

(A) Indicates additional meter or service charge made ranging from .50 to $25.00 per month depending on size.

(B) Indicates additional service charge of .40 per month.

(C) Indicates additional service charge of .30 to $4.50 per month.

(D) First 7500 gallons or less is $3.00 per quarter.

(E) Additional service charge of .30 to $4.00 per month.

(F) Additional service charge of .60 to $20.00 per month.

* Minimum monthly bill is $2.40.

St. Ignace is the only city reporting that has a water works that is privately owned, being operated by the Edison Sault Electric Co. At Cadillac the Consumer's Power Company own and operate the water works but they did not make any response to my questionnaire.