THE TENTATIVE WATER SYSTEM

OF HONAN SUBURB, CANTON, CHINA

THESIS FOR DEGREE OF B. S.

IN CIVIL ENGINEERING

ONN M. LIANG

1926

Carotin, Chlorin – Water-pigment

Civil engineering - Sanitary engineering

The Tentative Water System of Honan Suburb, Canton, China.

A Thesis Submitted to

The Faculty of

Civil Engineering Department

of

MICHIGAN STATE COLLEGE

By

Onn M. Liang

Candidate for the Degree of

Bachelor of Science

In Civil Engineering

June 1936.

Content.

Chapter I

INTRODUCTION.

Water is one of the necessities to the life of a community. As cleanliness and health are closely allied, and as a supply of fairly pure drinking water effectively cuts down the ravages of typhoid and other kindred diseases, hence every municipality should have a public water supply of good quality.

Like all other centers of industry in the Orient, Subburn Honan at the present, obtains her supply of water from the river, open wells as deep as 300 to 400 feet and filtred rainfall. In many cases, people of well-to-do have to purchase their water of some peripatetic vendors at necessarily high unit prices (above ten cents per 100 gallons). Consequently, the consumption is much less than the standard as in United States.

Since 1904, Canton has her own system excepting Honan Suburb. It was built by the combined interests of the City Government and the business men. In 1910 it was entirely charged, under the contract of a stock corporation with an authorized capital of $2,250,000. By 1921 it was found that the system was poorly managed; then, the Public Utilities Department of Canton took over the project.

The financial condition of Canton for the past five years, is growing day by day and year by year. Naturally a pipe built across the river at present, is no question, but from the economical and the water supply standpoint of view for the future it is more convenient to build a new plant in Honan Suburb. The reasons are as follows:

1. The filter plant of Canton water works is too small for the present population of 897,210 and the future increasing of population of 1,560,000 as estimated.
2. The size of the main pipe is too small.
3. The system of distribution is unsuitable for the large city as Canton
4. The cost of the cross river pipe would be as expensive as the filter and the pumping plant.

Much of the transportation of China is carried on by boats in the river. Nearly all streams are navigable; any plan of daming the tributaries must be postponed for at lease five years. Obtaining water from the ground source would cause serious trouble with private open wells, especially in the dry season. If water must be obtained, the only source is from the river, and the most economical is river bottom intake or open rapid sand filter plan.

General Survey

Canton is the capital city of Kwangtung Province and also an important commercial center in Southern China. It is situated in a delta where the three rivers - the East, West and North - meet. Its location is considered to be a very productive and fertile piece of land. Long ago the city had communications with other countries; namely, as near a Phillipine Island, Java and Singapore, and as far as Europe and America. The city, therefore, acquired its commercial

importance from a very far origin. As time went on, it had been browing and formalizing those efforts made to improve it. At present the increasing of population, the growing of business and the close contact with other nations, altogether, have made the city become more important that it used to be.

The Honan suburb, the Southern section of the city, is separated by a river (Canton river) from the main city. In this section most of the manufacturers and industries are located.

Population Studies

Table I.

Population of the City of Canton, is as follows:

Year	Population.
1918	821,463
1921	809,128
1922	813,646
1924	866,521
1925	897,210

Population in Honan S uburb.

Table I-a

Year	Population.
1918	77,152
1921	73,840
1922	80,165
1924	86,630
1925	88,128

In comparison between these two tables, the total average number of people living in Honan suburb is about one-tenth of the total average population of Canton.

In figure I, looking at these, we can find out how rapid the population has increased and we can easily estimate that after 30 years it may amount to 170,000.

Population of different sections is as follows:

Sections	Population
1	50,000
2	55,000
3	35,000
4	30,000
	170,000

Chapter II

WATER CONSUMPTION

The amount of water is consumed proportionate to the size of the city; even in the same city it may vary according to the weather, the citizen, commercial and industrial conditions and the use of water meters.

From the water supply standpoint, we may divide the cities into four classes: (1) Commercial center or harbor, (2) Industrial center, (3) College town and (4) Farm country. Also there are three different ways of using water in a city, as, (1) Domestic use, (2) Commercial and Industrial use and (3) Public use. To calculate the water supply, wearing out of pipe line, etc., would cause a considerable

big leakage, this is an inovitable case. In order to get an accurate calculation of its amount of water used, this point should not be neglected.

Those cities where all the consumers installed water meters in U.S.A. in 1920 showed the average consumption per capita daily, was from 60 to 99 gallons. While in other cities where the installation of meters became less than 10 per cent, the amount was from 137 to 277 gallons per capita daily. This shows why the consumption of water is different from city to city, because those not having installed meters usually waste more water than is really necessary.

As the Public Utilities Department of Canton stated, that if there are more than ten consumers of water in one house or the house is furnished with modern shower and water closet and garden fountain, it must be furnished with water meter in order to prevent the waste of water.

Various Consumption

I. Domestic Use - We may classify the users into three classes: (1) rich, (2) middle and (3) poor. The wealthy householders use more water than the middle class and the poor use less than the middle class, but some times the laborers may use a considerable amount of water.

The domestic use of water per capita per day in U.S.A. is from 16.8 gals. to 71 gals. (See table B) From the different data obtained it can be summerized that for a metered supply, the domestic use for an entire city will range ordinarily from about 20 to 50 gallons per day.

II. Commercial and Industrial Use — This includes all the commercial and industrial users of water. The greater amount of the water is used by the restaurants, stores, office buildings, hotels, dairy houses, textile mills and all others. In table (B) is given values, ranging from about 10 gallons to over 50 gallons per capita daily and is fairly representative.

III. Public Use — This includes the use of water by the public; as for street sprinkling, water-troughs and fountains; fire extinguishing, sewer flushing and the flushing of water mains, schools and other public buildings, parks and a few other occasional uses. Especially the amount used in schools and other public buildings, in which millions of gallons are often wasted daily.

In Fall River, Mass., U.S.A., the public use of water for 1914 was designated by the amount per capita per day as 12.74 gallons and in Cleveland, Ohio in 1910 the amount was 6.31 gallons per capita per day. The average public use of water in either Europe or U.S.A. is from 5 to 15 gallons per capita per day.

IV. Loss and waste — Some large city in U.S.A. gave very high consumption of water (200 to 300 gallons per capita daily) and after the installation of water meters, it was found that the greater part of the waste was due to the leakage of pip lines and the careless use of the consumer. Another important cause results from the poor quality (or getting old) of pipes, and the meters and pumps have been used for some years.

The careless use by the people can be eliminated by the installation of meters, but these are still minor wastes that we must take into account, as in general, the whole problem can be corrected and the amount of water wasted, greatly decreased.

In U.S.A. this leakage is assumed as from 15 to 40 gallons per capita per day.

Total Consumption of water per capita

Combining the above estimates for various purposes, we have the average consumption of water with suitable meter used as follows:

Table 2.

Kind of Use.	Gallons per Capita per day		
	Minimum	Maximum	Average
Domestic	20	50	35
Commercial & Industrial	10	50	30
Public	5	15	10
Loss & Waste	15	40	25
Total	50	155	100

The quantity of water consumed in certain of the large cities of Europe is stated as follows:

Paris	65	Gallons per capita per day
Hamburg	44	"
London	39	"
Liverpool	38	"
Amsterdam	37	"
Copenhagen	27	"
Dresden	26	"
Berlin	22	"
Average	37.25	"

At present there are only one-fifth of the total population in the city of Canton using water from the Kwang-tung water works. The consumption per capita daily is 20 gallons. It is less than four-fifths as compared with U.S.A. (100 gallons per capita daily), and is less than about 17.5 gallons as compared with the average of Europe. The main reason of those facts may be stated as follows;

1. Sewerage systems are not quite well laid off.
2. The housing conditions are not quite properly arranged.
3. Majority of the householders own their wells.
4. The poor class use well or river water. Some people use public water for drinking purposes and use well water for washing purposes.

The improvement of sewerage system is of vital importance in regard to the problem of the city, so the city authorities have been planning to improve it. As methods, the communication methods have been improved. The industires and commerces are growing and also the living standard is raised; it is so far as my observation is concerned; I take pleasure in saying that within the next few years the new sewerage system will be completed and then the public use of water will be increased.

As the commercial and industrial development and the population in the city is increasing so rapidly, just stated above, the consumption of 20 gallons per capita per day would not be taken as the real base of the calculation for the future. As reasonable, I shall estimate that it will be fair to take 50 gallons per capita per day, except those occasioned by fire service.

Variations in Consumption

I. Monthly Variations - During the year the high monthly rates of consumption are usually in the Summer, with more than the usual sprinkling or lawns, or Winter, with a high rate for fire protection (see Table 3). The highest rate is about 120% of the average.

II. Daily Variations — The daily rate of the city of Canton does not differ much between the average. Commercial rates are quite constant, since they run their business on Sunday too, excepting that the industrial and school uses are almost nothing on Sunday. Domestic use is generally greatest on the day of the middle and the end of each month. Generally the high daily consumption of 15 gallons per capita (130%) in addition to the average, will be quite sufficient.

III. Hourly Variations — Usually the high rate of consumption in Canton is generally from 7 A.M. to 12 A.M. and from 5 P.M. to 10 P.M. Within these ten hours, the rates are about 150 percent of the average daily.

IV. Fire Consumption — The amount of water used for a fire may be several times the total consumption for a day, and the maximum water consumption per minute during the fire, may be many times the rate per minute of ordinary consumption. So the consumption for large fires must then be considered in addition to the rate stated above.

Each fire stream throws 250 gallons per minute, as required by the Fire Department of the City of Canton; also the duration of the fire consumption has been estimated at about 4 hours followed in 3 days as a mixiumm for the full number of streams.

Table 3

Report of Fires During 1922 and 1923.

Year	Month	No. of Fires: Disregardful	No. of Fires: Lighting	Loss of Houses by Fire: Whole	Loss of Houses by Fire: Half
1922	Jan.	8	0	61	6
	Feb.	4	0	3	5
	Mar.	3	1	1	1
	Apr.	4	0	19	3
	May	7	0	22	2
	June	1	1	1	1
	July	0	0	0	0
	Aug.	3	0	8	1
	Sept.	6	0	18	6
	Oct.	6	0	6	1
	Nov.	10	0	89	11
	Dec.	9	0	217	5
Total		61	2	395	41
1923	Jan.	4	4	108	2
	Feb.	6	2	37	2
	Mar.	8	2	23	5
	Apr.	6	1	8	1
	May	3	2	3	3
	June	2	1	33	1
	July	4	0	5	2
	Aug.	5	0	57	7
	Sept.	4	0	3	3
	Oct.	13	0	8	5
	Nov.	15	0	370	6
	Dec.	7	1	10	3
Total		77	13	665	40

Number of Fire Streams Required.

By the formula of the American National Board of Fire Underwriters.

$$Q = 1020\sqrt{x}\,(1 - .01\sqrt{x})$$

Where Q = fire flow in gallons per minute and x = population in thousands.

$$Q = 1020\sqrt{170}\,(1 - .01\sqrt{170})$$

$$= 11,536.2 \text{ gallons per min.}$$

$$11,536.2 \div 250 = 46 \text{ streams.}$$

In this case form 30 streams in business section and 16 streams in residential section.

Conclusion

Quantity of water needed daily, including fire protection, requirement on the basis of a four hour fire:

			M.G.D.
Average consumption	=	50 x 170,000 =	8.5
Summer & Winter "	=	8,500,000 x 1.2 =	10.2
Maximum daily "	=	8,500,000 x 1.3 =	11.05
Maximum hourly "	=	8,500,000 x 1.5 =	12.75
Fire consumption	=	250 x 46 x 4 x 60 =	2.73

(average consumption = 5903 gallons per min.)

Chapter III

SOURCE OF SUPPLY

Investigations relative to sewerage and sewerage disposal may seem somewhat foreign to the duties of the City Public Health Service, but when it is considered that the surface water supplies of the city constitute the most extensive and most valuable sources of water supply for domestic and industrial purposes, it becomes of paramount importance to examine into the conditions of surface water with reference to their pollution. This pollution is brought about primarily as a result of the discharge of large quantities of sewerage from various municipalities. The water of streams is also affected detrimentally, by the discharge into them of manufacturing wastes.

While the primary object of investigating the pollution of streams is to preserve them so far as practicable, as sources of water supply, there are also many other evils resulting from stream pollution, such as odor nuisance, the destruction of fish life and the rendering of the streams unfit for navigation and pleasure purposes.

The City Public Health Service believes that all surface water supplies should be purified by filtration or disinfection before they are used for drinking purposes. It has, therefore, promoted the installation of filtration and disinfection.

The following are the different examinations of the Canton river water, report by State Health Service.

Table 4.

Physical.	
Sediments	0.27 per sq. ft. of water.
Chemical.	
	Parts per million.
Free Ammonia	0.10
Chlorine	0.31
N. as Nitrite	0.004
Required Oxygen	2.06
Temporary Hardness	0.30
Permanent "	0.70
Bacteriological	
Colonies	185 per C.C.
B. Coli	2 per 10 C.C.

Rainfall and Runoff

The wet season of Canton is from April to September, each year. The high rainfall month is July - its average amount is 9.54268 inches (or 242.2 millimeters), 15.7% of the total rainfalls of each year. December is the driest month - its average amount is 1.57994 inches (or 40.1 millimeters), 2.5% of the total rainfall of each year.

The maximum yearly rainfall is 80.17466 inches (or 2034.9 millimeters), the minimum is 49.931 inches (or 1115.0 millimeters), and the average is 60.62084 inches (or 1538.6 millimeters). For comparison of these, it is found that a wet year has 82% more than a dry year.

The amount of rain which falls in any given region varies in different parts of the country, and only a part passes off the surface, either directly or indirectly, the balance being disposed of partly by evaporation and partly by percolation into the ground. That portion which flows off the surface of the land in the form of visible streams, is what may be called the flood-flow.

The total flow of a stream, in general, is equal to the rainfall, less the evaporation; the flood-flow is equal to the rainfall, less the percolation and evaporation.

In investigating the influences affecting evaporation and percolation, the Board of Conservancy works of Kwangtung believes its ratio is about 60% of the total yearly rainfall. The other 40% runs off to the streams. Hence the run-off of rainfall to the streams per year is 40% of 60.62084 inches, or equals 1.78 cu. ft. per second per sq. mile.

The area of the Canton river watershed is 1771.74 square miles (or 4590 sq. K.M.). Therefore, the total run-off of rainfall per year in this watershed is 3409 cu. ft. per second.

Discharge of Canton River (Back Reach)

The discharges of Canton river are different between the periods of flood and ebb. The mean velocity is from 2.2 nautical miles per hour (or 1.13 meters per second) to 6 nautical miles per hour (or 3.1 meters per second). The discharge at the customs Buoy yard is from 141,256 to 282512 cu. ft. per second (or from 4 to 8 hundred cu. meters per second).

Table 5

Rainfall at Canton

(in Millimeters)

Month	Years. 1908	1909	1910	1911	1912	1913	1914	1915	1916	Average
Jan.	137.5	168.4	31.0	47.0	121.2	36.6	00	11.7	6.8	62.3
Feb.	79.8	121.2	55.1	3.3	96.0	66.8	65.0	21.8	36.3	60.6
Mar.	20.3	98.8	41.7	102.1	178.6	74.7	33.0	125.8	70.7	82.8
Apr.	15.5	128.0	124.8	206.5	90.9	75.0	238.5	131.8	108.2	124.4
May	78.0	259.3	71.6	456.2	235.2	251.0	312.2	329.0	164.1	239.6
June	226.9	215.7	213.1	72.1	365.5	251.0	249.9	256.0	232.1	231.4
July	329.2	144.3	291.6	176.6	219.5	123.2	537.2	275.3	84.3	242.2
Aug.	213.4	125.0	183.1	239.8	358.9	305.8	111.8	247.9	232.4	224.2
Sept.	102.1	65.3	123.7	28.2	24.2	321.8	245.1	21.6	115.1	118.6
Oct.	109.0	218.7	0.0	75.2	00	21.1	69.4	47.2	61.2	66.8
Nov.	0.0	10.7	63.3	109.0	1.8	15.7	125.8	82.6	00	45.4
Dec.	94.5	0.0	30.7	20.8	77.2	65.3	47.0	21.6	3.8	40.1
Total	1406.2	1575.4	1229.7	1537.0	1769.0	1608.0	2034.9	1572.3	1115.0	1536.6

Table 6

Maximum High water level and Minimum Lower Water Level at the Customs Buoy Yard, Canton.

Figers in feet above the gage, (= 103.659 meters)

Year	1911		1912		1913		1914		1915		1916		Avera
Month	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Min. W.L.	Max. H.W.L.	Mi W
Jan.	8.2	0.1	8.4	0.3	8.3	0.3	7.9	-0.1	8.2	0.3	8.4	8.3	8.23	0
Feb.	8.0	8.0	8.3	0.2	8.0	0.0	7.9	-0.9	8.4	-0.6	8.2	-1.15	8.13	-0
Mar.	8.0	0.2	8.3	0.6	8.2	-0.3	7.9	-0.2	7.9	0.1	7.6	0.0	7.98	0
Apr.	8.1	0.1	8.3	0.3	8.4	-0.5	8.4	0.1	8.2	1.3	7.8	0.1	8.20	0
May	9.2	0.7	9.0	0.8	8.9	0.7	8.6	1.2	9.3	1.4	8.8	0.7	8.97	0
June	9.4	2.0	9.7	3.0	8.9	1.1	9.9	1.5	9.0	1.6	8.9	1.6	9.20	0
July	9.6	3.3	9.3	1.6	9.0	1.2	9.5	3.0	13.7	3.6	8.5	0.4	10.27	2
Aug.	9.3	2.4	8.4	1.2	11.0	3.5	8.9	1.8	10.1	2.0	7.9	0.2	9.27	1
Sept.	8.7	0.2	8.1	0.8	8.9	0.6	8.4	0.5	8.4	0.4	8.2	0.3	8.45	0
Oct.	8.4	0.1	8.7	0.7	8.4	1.2	8.4	0.3	8.7	0.9	8.2	0.7	8.47	0
Nov.	8.4	0.2	8.7	0.2	8.2	0.4	8.6	0.3	8.5	0.3	8.2	0.8	8.43	0
Dec.	8.4	0.2	8.9	0.6	7.9	0.3	8.2	0.2	8.6	0.3	8.4	0.5	8.40	0
Average of 12 Mo.	8.64	0.79	8.68	0.68	8.68	0.6	8.55	0.58	9.25	0.95	8.26	0.37	8.68	0
Average of 8 Mo.	8.27	0.14	8.46	0.50	8.41	0.15	8.21	0.02	8.36	0.35	8.12	0.19	8.28	0

Table 7

Meterlogy of Canton, 1921.

Month	Barometer inches	Temperature, F. Maximum	Minimum	Mean	Rainfall Inches
Jan.	30.27	63.0	48.0	54.0	0.54
Feb.	30.16	68.0	52.0	59.0	1.56
Mar.	30.05	70.2	57.9	63.3	2.39
Apr.	30.01	78.7	66.7	71.3	1.45
May	30.21	86.2	76.3	77.5	16.42
June	29.63	88.2	75.0	81.3	9.28
July	29.79	90.7	77.2	83.1	11.19
Aug.	29.69	89.3	78.4	84.2	7.81
Sept.	29.91	87.4	73.6	77.2	12.67
Oct.	30.03	85.7	67.6	75.6	0.20
Nov.	30.16	78.4	58.8	66.9	0.54
Dec.	30.20	71.4	55.6	62.3	0.39

Chapter IV.

DISTRIBUTING SYSTEM

Distributing Reservoirs

In this case the direct-indirect system is to be used. The capacity of the pumps should be provided 10. m.g.d., a reservoir of sufficient capacity is provided and being a suitable location in the central part of the suburbs. (see map.).

The function of the reservoir is to take water when it comes and to make it available when it is needed or during fires. The sufficient capacity of the intervening main should be 10. m.g.d. or 6931 gallons per minute.

This reservoir is built with reinforcement, and covered with a light roof.

Required capacity of the reservoir, assuming a four hours fire followed in 3 days of maximum consumption = 8.28 m.g. or 40994.28 cu.yd.

The elevation of the bottom should not be less than 100 feet above the mean level of the ground.

Pumping Plant & Filtration.

The location of the pumping plant is located at the river side, Southwestern section of the city. (see map). The rapid sand filter plant is provided. The area of the entire plant should not be less than 45,000 square feet.

The capacity of coagulation basis is required three of 10 million gallons capacity, the size of the basins is about 50' x 100' each. The time required for satisfactory sedimentation and coagulation should be at least 24 hours.

The filters are built with concrete, rectangular in form. Required 5 of 20' x 25' in size.

Arrangement of Pipe Line

Consumption of different sections as follows:

Section	Average Gal./ Min.	Max. hourly rate (Gal.)
1	1736	3120
2	1910	3440
3	1215	2187
4	1041	1874

Size of pipes and location of fire hydrants and arrangement of valves (see Map.).

River intake should be reached at a suitable location at low water.

Chapter V.

ESTIMATE COST.

The cost of the different purpose assumed in American currency are as follows:

Land = $100 per 100 sq. ft.

Miscellaneous expenses, including materials, = $0.30 per liner ft. average.

Filter Plant = $10,000 per million gallons.

Operation & Maintenance. = $ 4.00 per million gallons

Pumping = $100 per million gallons

Pumping Plant 10 m.g. = $40,000

Reservoir = $17,730

River intake = $1,500

Pipes = $50 per ton (Class B)

Size of Pipe	Length in feet	Cost per liner foot	Total
30	7,800	$ 8.2500	$ 64,350.00
24	12,950	5.8340	75,550.30
20	8,250	4.3760	36,102.00
14	31,750	2.5620	80,343.50
10	19,050	1.5620	29,756.10
8	65,200	1.1619	75,755.88
6	23,500	.8139	19,126.65
Total	168,500		$ 380,984.43

No.	Items	Average unit price	Total
204	Hydrants	$ 60.00	$ 12,240.00
450	Valves	150.00	67,500.00
324	Curves & Branches	15.00	4,860.00
Total			$ 84,600.00

The First Cost of Construction.

Cost of pipes, branches, hydrants, etc.	=	$ 465,584.43
Cost of miscellaneous	=	50,550.00
" " reservoir	=	17,730.00
" " river intake	=	1,500.00
" " pumping plant	=	40,000.00
" " filter plant	=	85,000.00
" " Land	=	45,000.00
Total	=	$ 705,364.43

Cost of Operation, Maintenance and Pumping per year.

Operation and Maintenance	=	$ 12,410.00
Pumping	=	310,250.00
Total	=	$ 322,660.00

The capital necessary to provide for depreciation may be determined as follows:

Let P = Sum required;

C = Cost of renewed, assumed equal to the first cost;

R = Rate of interest; (5)

N = Years of life of the structure (30 years);

O = Annual cost of operation and maintenance;

S = Total capitalized sum

Whence $$P = \frac{C}{(1+r)^n - 1}$$

$$S = C + \frac{O}{r} + P$$

$$S = 705864.43 - \frac{322560}{0.05} \div \frac{705864.43}{(1.05)^{30} - 1}$$

$$= 705864.43 - 650,000 \div 211,800$$

$$= \$1,567,165.00$$

The end.

Books for Reference.

In English.

American Civil Engineers' Handbook, Merriman, 1920.

Public Water-supplies, F. H. Turneaure, Dr. Eng., and
H. L. Russell, Ph. D., 1924.

Water its purification and use in the Industries,
W. W. Christe.

Modern City Planning and Maintenance, F. Koester.

Illinois State Water Survey No. 11 and 13

Water Supply Engineering, A.P. Folwell.

Report on Additional Water Supply, Flint, Mich., 1924.

Water Filtration, Engineering Bulletin No. 9.
Mich. Dept. of Health, 1925.

American Pipe Manual, American Cast Iron Pipe Co., 1924.

In Chinese:

Report of Conservancy Works, Kwangtung,
1913, 1916, 1920.

The China Year Book, No. 1., Shanghai, Commercial Press, 1922.

Geography of China, Shanghai Commercial Press, 1915.

History of Chinese Industry, Shanghai Commercial Press, 1916.

One year of age of Canton, Shanghai Commercial Press, 1920.

Municipal Government Report, Canton, 1921, 1925.

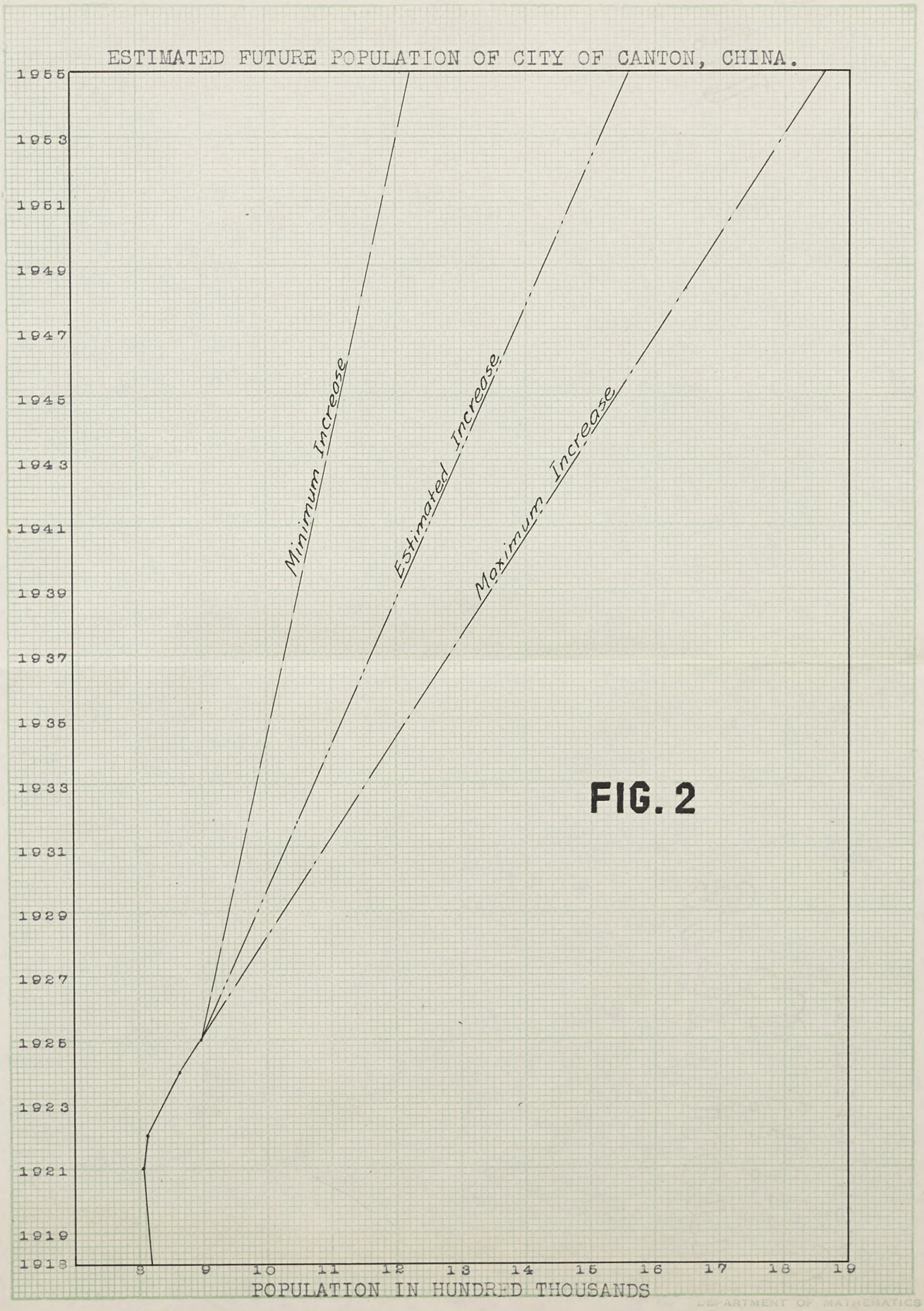

FIG. 2

ESTIMATED FUTURE POPULATION OF HONAN SUBURB, CANTON, CHINA.

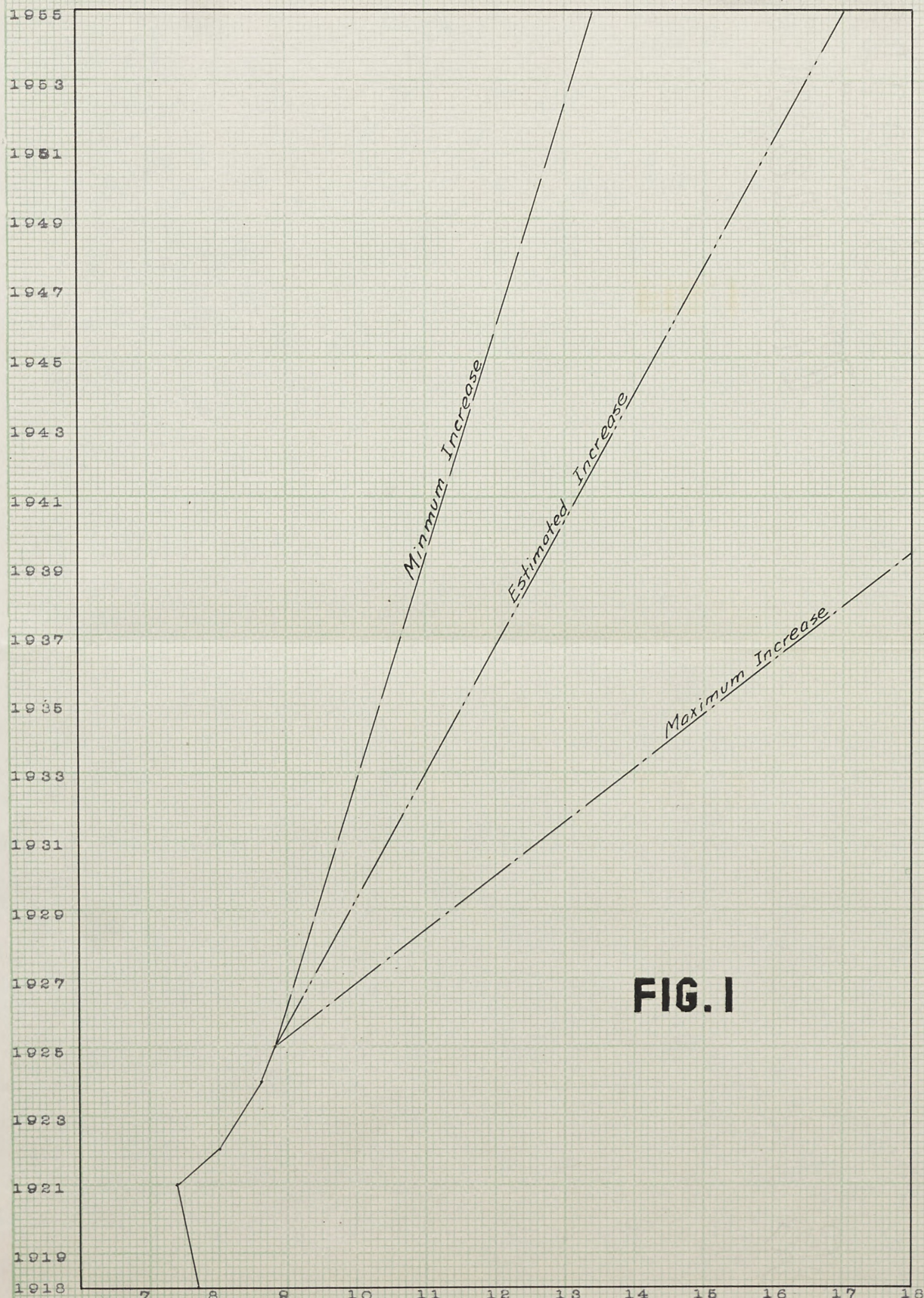

FIG. I

Main City of Canton.

Canton River (Front Reach)

Canton bridge

Honan Park.

Customs Club

Riverside Road

Honan Theatre

Looncai Fire

Mechanic Building

Chu-Kong Motor Boat Manufactary

To Dock Yards & Kwangtung Cement works

Park Ave.

Public Market

Hung Shing Fire Ave.

Nanwu High S.

Fire Dept.

Haitang Ave.

Kaihao

Paradise Ave.

Chofang Ave.

Ningaick Ave.

Nanwu Ave.

Field

Yen-chai Hospital

Dean Ave.

Fuyen Ave.

Back Reach

Pumping Plant

1 2 3 4

N

SIGNS

X = Business section
o = Fire hydrant
# = Valve
--- = Pipe line

MAP OF WATER WORKS SYSTEM

HONAN SUBURB, CANTON, CHINA.

Designed by O.M. Liang

Scale 1" = 500'

May 29, 1926

TABLE B.

Consumption per Capita for Various Purposes[1].

City.	Population	Number Taps.	% Taps Met.	Consumption per Capita in Gal. per day.						
				Domestic		Ind.	Com.	Pub.	Loss	Total
				(a)	(b)					
Milwaukee, Wis.	430,000	59,603	99.4	[D]33.0	..	43.0	....	5.8	29.2	111.4
New Orleans, La.	360,000	40,200	99.7	16.8	19	12.8		3.2	24.4	57.2
SanDiego, Cal.	85,000	14,153	100.0	36.0	..	7.2	12.0	10.0	15.4	80.6
Lexington, Ky.	40,000	5,206	100.0	16.9	..	17.9	16.0	8.4	2.9	62.1
Madison, Wis.	27,000	5,775	99.2	35.0	..	5.8	6.2	3.3	28.7	79.0
Oak Park, Ill.	26,000	5,750	100.0	52.5	..	8.5	1.6	2.5	3.9	69.0
Fort Dodge, Iowa.	20,000	2,600	96.0	19.6	30	7.8	...	...	...	50.0
Elyria, Ohio.	16,000	3,650	100.0	39.0	36	47.0	7.2	5.6	22.3	121.1
Corning, N. Y.	14,900	2,753	99.0	58.0	71	17.0	7.3	1.5	....	83.3

Domestic consumption (a) is equal to total metered domestic consumption divided by population; (b) is equal to consumption per family divided by 5.

[D] Includes commercial use.

[1] See the Public Water-Supplies, by F. F. Turneaure & H. L. Russell, page 15.