AN INVESTIGATION OF THE WATER SUPPLY AT CHARLESTON, ILLINOIS

BY

MARSHALL SIMEON DUTTON
GEORGE ORLANDO WITH

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

MUNICIPAL AND SANITARY ENGINEERING

IN

THE COLLEGE OF ENGINEERING

OF THE

UNIVERSITY OF ILLINOIS

1915

UNIVERSITY OF ILLINOIS

May 28 1915

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

MARSHALL SIMEON DUTTON and GEORGE ORLANDO WITH

ENTITLED AN INVESTIGATION OF THE WATER SUPPLY AT CHARLESTON, ILLINOIS

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF BACHELOR OF SCIENCE IN MUNICIPAL AND SANITARY ENGINEERING

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INVESTIGATION OF THE WATER SUPPLY AT CHARLESTON, ILLINOIS

The city of Charleston was visited on the 12th and 13th of February, 1915, for the purpose of making an examination of the public water supply with special reference to the purification works. All information and data herein contained were obtained from observation, from local officials and employees, or from reports relating to the subject matter involved.

GENERAL CONSIDERATIONS

Location

Charleston is located in the central part of Coles County, Illinois, and is two and one-quarter miles northwest of the Embarrass river from which the water supply is obtained.

Population

The present population of Charleston as taken from the 1910 United States Census Report is 5,884 and the city will have an estimated population of approximately 6,700 in 1930. It is difficult to approximate the future growth of a city such as Charleston since the city is a small, inland community and the population of cities of such a character has been known to fluctuate within very wide limits in short periods. Our estimate was based on the following considerations. Charleston is a city with but few industries bringing men in aside from the car shops of the two railroads running through the city. However, with the State Normal School located here, the population will have a tendency to undergo a slow but steady increase. For these reasons, it seems logical and sufficiently accurate to estimate the population from graphs representing the values obtained from census reports for the city. (Figure 1.) Curve (1) represents the actual population up to 1910 as obtained from the census reports and is produced with the idea that the population will have about the same rate of increase as in the period from 1900 to 1910. Curve (2) represents the increase from 1910 to 1930 as following a wave that appears in the curve for former periods. Curve (3) represents the increase for all periods as being constant and following a straight line. These curves give the population in 1930 as 6600, 6160, and 7370, respectively, with 6700 as the average value.

Sewerage Conditions

The present sewerage system is constructed on the combined plan and empties into a small creek which later empties into the Embarrass river about five miles below the water supply intake. Naturally, with such an extensive sewerage system, the water consumption is increased due to the added convenience in disposing of waste water.

INSTALLATION AND DEVELOPMENT OF WATER WORKS

In the year 1875, an election was carried and bonds were sold for a public water works which was put in operation in the year 1876. The original installation comprised the following:

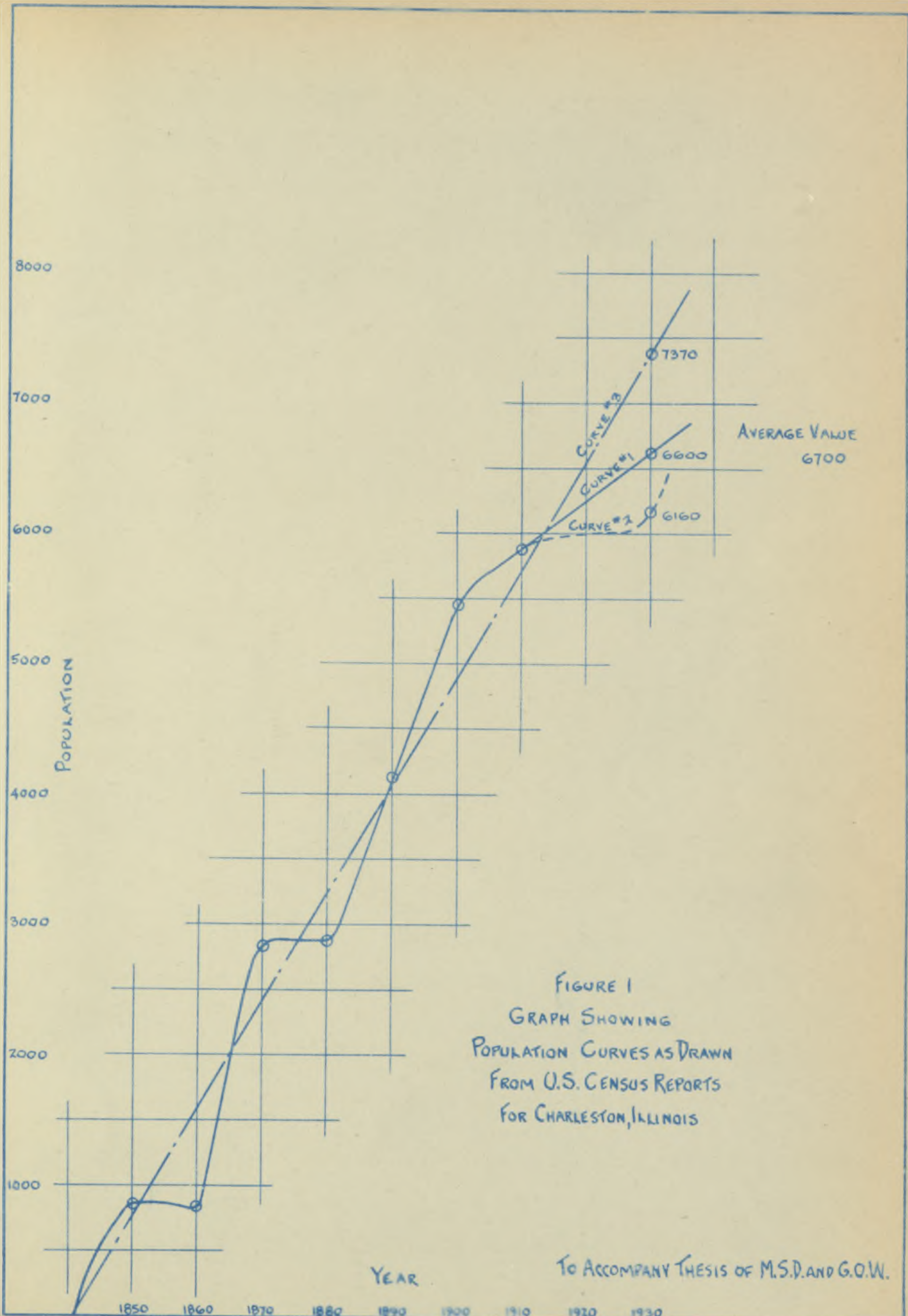


FIGURE I
GRAPH SHOWING
POPULATION CURVES AS DRAWN
FROM U.S. CENSUS REPORTS
FOR CHARLESTON, ILLINOIS

an intake on the Embarrass river about two and one-half miles from the city; a pumping station near the intake including a fire tube boiler and a compound duplex steam pump of 1,500,000 gallons per day capacity; an 8 inch cast iron supply main two miles long; and a rather extensive distribution system of cast iron pipe.

In the early 90's the pumps were set down about twelve feet lower in pits. In 1894 and 1895, during the low water periods, it was necessary to plow and scrape the stream bottom to open up springs and let down the water contained in pools above the intake. It became necessary in the year 1897, to install a new compound duplex steam pump of 1,500,000 gallons per day capacity.

Due to the trouble encountered in the early 90's because of insufficient stream flow, a masonry dam was built across the river about one and one-half miles below the intake in the year 1899.

In 1908 a Terre Haute boiler and a McGowan pump of 2,000,000 gallons per day capacity were added to the pumping station and the distribution system was extended to meet the needs of the increasing growth of the city. Since the installation of the McGowan pump the Deane pump has been out of service. In 1909 a new form of intake was constructed together with a settling basin.

In the year 1912, due to growing dissatisfaction on account of the muddiness of the water, a purification works and accessories were added. In the same year an elevated steel storage tank was constructed within the city limits.

In the year 1914, the installation of water meters throughout the city was started, the purpose being to reduce as far as possible the existing high rate of water consumption. In the same year, a centrifugal pump was put in at the elevated tank due to the inadequacy of the pumps at the station to raise the water into the tank.

At the present time, electric current is being installed at the plant for the purpose of lighting the buildings because of considerable inconvenience in the past due to poor lighting facilities.

The filter plant is in good condition being just lately installed, but the pump house is in an exceedingly dilapidated condition; the building and pumping machinery being much in need of repair.

SOURCE OF SUPPLY

The Embarrass river empties into the Wabash river and its drainage area occupies 2410 square miles in the south-eastern part of the state. The river rises in the central part of Champaign County to the southwest of Urbana, and flows thence through Douglas and Coles counties. The drainage area above the point of intake comprises 685 square miles and is long and narrow, with a length of about 100 miles and a width which varies from 15 to 30 miles. The sources of the river are at an elevation of about 730 feet and the mouth is about 400 feet above sea level. This gives the stream an average slope of a little less than two feet per mile.

The surrounding country, which is used mainly for farming purposes, is flat or slightly rolling. In the vicinity of Charleston, the river flows through a gorge about 100 feet deep which has been cut below the general level and through the glacial drift.

The chief crop on the drainage area is corn, although some wheat and other grains are raised. In the central part of the basin, to the north and west the soil is the familiar black loam. Farther south, in the vicinity of Saint Marie, along the river, the soil is sandy. To the east the soil is light colored clay which was formerly covered with a heavy growth of water oak. For a distance above and below Oakland occurs a sandy, red soil which is of interest in that it imparts peculiar color to the water in the river at Charleston.

Pollution

As there is always danger of pollution when a water supply is taken from a stream, a few of the facts relating to the sanitary conditions of the drainage area above Charleston will be given. For twenty miles above the intake, the valley has steep slopes which cannot be used for habitation, farming, or pasture land. The danger of pollution from the land immediately bordering the stream is therefore slight.

It was found on inquiry that bathers frequent the river not more than five hundred feet above the intake. This, together with other incidental pollution, constitutes the only menace until Oakland is reached twenty miles upstream.

Oakland has a population of 1200 and is contemplating the construction of a sewerage system with outlet into the Embarrass river. At the present time more or less objectionable surface drainage enters into the river at this point.

A number of analyses made by the State Water Survey indicate slight contamination such as might be anticipated from a physical examination of the drainage area. This slight contamination may be readily removed by suitable treatment.

Intake Pond

The intake pond is formed by the masonry dam one and one-half miles below the intake. It is six or eight feet high and backwater extends upstream two or three miles. The maximum variation in water level, locally observed but not actually measured, gave a depth of flow of 15 inches over the dam, the lowest level occurring when the water was 15 inch below the top of the dam. As calculated from the stream flow records for maximum flood flow from the drainage area, by using submerged weir formula, the maximum depth of flow over the dam was 4 feet. The pond is estimated to have a capacity of 55,000,000 gallons when the water is just going over the dam. At such times, the water is backed up for a distance of approximately two and one-half miles with an average width estimated to be 100 feet and an average depth of 5-1/2 feet. The longest period known when there was no water flowing over the dam is two months.

There is considerable brush and dead wood scattered along the banks which has been deposited there during periods of flood flow. Moreover, at the present time there is at least six inches of mud overlying the sandy and rocky stretches of stream and bed. The dry weather flow is largely contributed by springs which emerge from the bed of the stream and the water is therefore very clear during the periods of small stream flow.

As has been stated, the intake is one and one-half miles above the dam and takes the water at the edge of the stream. Since the first installation several different types of intake have been tried. The first intake was a cast iron pipe which extended a short distance into the stream. In 1911, an 8 inch pipe was laid and connected to a small detritus tank which was constructed at the edge of the stream. This tank was so constructed that it allowed the water to enter along its downstream face but was not effective in keeping out debris since sand was continually deposited at the opening thus shutting out the water. In the year 1912, the present intake was built which is a concrete conduit 25 feet long, 3 feet 6 inches wide, and 8 feet 6 inches high, with sides, top, and bottom 6 inches thick. This shape intake is for the purpose of allowing the heavy particles of suspended matter to settle before the water is drawn into the suction pipe. At this point it might be well to state that the top of the dam is 44 inches above the top of the intake. Two hundred feet of 10 inch pipe carries the water from the intake to the low lift pump. The suction lift is 4-1/2 feet when the water in the pool is at such a level that it is just going over the dam.

The only noticeable objection at the intake is the fact that the waste water pipe from the filters empties into the pond only 25 feet below the intake, and the water has a tendency to form eddies that carry this waste back to the intake. The intake is protected with two inch wire mesh screen to prevent large matters such as branches and sticks from being drawn into the suction pipe.

Dam

The dam is built of masonry, is 150 feet long and 6 or 8 feet high extending to steep slopes on each side of the stream. It is 5 feet wide on top, 12 feet wide at the bottom, and was built at an approximate cost of $5,000. The dam is founded on rock and has a clay filling on the upstream side. The spillway extends practically the full length of the dam and the water reaches a height of about 4 feet above the dam during the periods of heavy flood,as previously stated.

TABLE I

STREAM FLOW DATA - EMBARRASS RIVER AT CHARLESTON, ILL.

RECORDS AVAILABLE FROM REPORT OF RIVERS AND LAKES COMMISSION, ILLINOIS, 1914

Embarrass River near Oakland - Drainage Area 535 sq. mi.
Embarrass River near St.Marie- Drainage Area 1540 sq. mi.
Embarrass River near Charleston-Drainage Area 685 sq. mi.

Results for Charleston a mean value as interpolated from records for Oakland and St. Marie

1909 — DAILY DISCHARGE IN SECOND-FEET

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	44	177
2	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	46	162
3	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	52	158
4	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	50	143
5	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	48	139
6	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	46	154
7	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	45	147
8	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	49	130
9	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	51	130
10	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	48	130
11	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	47	130
12	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	47	285
13	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	46	1252
14	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	47	1823
15	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	50	1796
16	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	60	1496
17	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	202	1067
18	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	309	778
19	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	218	645
20	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	156	490
21	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	220	- -
22	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	259	- -
23	- -	- -	- -	- -	- -	- -	- -	- -	- -	61	614	- -
24	- -	- -	- -	- -	- -	- -	- -	- -	- -	94	939	- -
25	- -	- -	- -	- -	- -	- -	- -	- -	- -	109	668	- -
26	- -	- -	- -	- -	- -	- -	- -	- -	- -	84	524	- -
27	- -	- -	- -	- -	- -	- -	- -	- -	- -	68	386	- -
28	- -	- -	- -	- -	- -	- -	- -	- -	- -	55	263	- -
29	- -	- -	- -	- -	- -	- -	- -	- -	- -	55	202	- -
30	- -	- -	- -	- -	- -	- -	- -	- -	- -	49	185	- -
31	- -	- -	- -	- -	- -	- -	- -	- -	- -	42	- -	- -

Sample calculation:-

From Oakland $\frac{52}{535} = \frac{x}{685}$ $x = 67$

Oct. 23, 1909. Interpolated:-

From St. Marie $\frac{126}{1540} = \frac{x}{685}$ $x = 55$

Mean = 61

TABLE I. (continued)

1910

DAILY DISCHARGE IN SECOND-FEET

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	281	356	3045	134	278	362	268	674	37	77	72	468
2	281	350	2865	145	304	348	165	562	35	67	72	427
3	281	413	2330	130	432	300	306	282	36	65	71	267
4	303	460	2175	127	1172	282	461	187	39	270	67	247
5	303	401	1890	130	808	264	791	137	67	1236	67	218
6	303	367	1590	121	539	246	825	112	133	1635	63	190
7	303	318	1255	114	439	218	599	115	177	1728	63	180
8	239	289	1027	118	508	202	406	88	299	1687	68	153
9	217	274	799	113	911	185	383	82	347	1471	65	138
10	217	268	694	108	806	170	221	76	311	1084	67	121
11	217	228	592	105	755	162	140	71	242	699	67	107
12	419	204	533	107	1205	131	146	66	199	562	65	93
13	1353	195	477	108	1230	118	269	60	179	460	65	94
14	2825	261	437	112	982	118	215	60	195	393	61	84
15	3280	225	394	115	862	115	202	56	129	350	61	76
16	2870	220	361	265	638	97	2000	61	98	279	55	73
17	2255	172	338	637	540	92	2050	66	77	214	51	70
18	2595	182	301	547	418	134	2090	62	72	188	51	67
19	2820	150	269	341	379	76	1900	80	63	160	48	67
20	2745	144	258	312	336	71	1465	70	55	135	45	61
21	2220	172	248	243	284	66	982	53	55	124	43	70
22	1805	336	238	248	252	59	584	47	52	113	43	63
23	1355	406	223	215	908	61	407	45	65	103	44	67
24	873	364	209	210	1520	56	282	46	69	103	41	63
25	744	335	199	199	860	51	222	44	67	98	43	49
26	644	282	199	213	1151	54	177	49	82	89	41	53
27	588	1245	186	237	861	143	164	202	92	89	51	55
28	545	2015	179	242	792	267	163	118	96	81	659	73
29	480	- -	169	243	601	473	675	53	86	78	1051	203
30	434	- -	151	249	567	374	924	43	79	66	1304	490
31	382	- -	138	- -	456	- -	881	39	--	66	- -	446

TABLE I. (continued)

1911

DAILY DISCHARGE IN SECOND-FEET

Day	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1	520	2105	544	355	877	77	71	26	- -	3510	636	564
2	578	1940	462	325	925	71	45	25	- -	3355	470	534
3	530	1685	400	396	853	69	44	26	- -	3015	399	480
4	483	1541	351	1045	725	184	42	26	- -	2690	354	439
5	450	1318	327	1542	575	475	38	27	- -	2460	340	400
6	400	1302	321	1895	365	429	37	27	- -	2240	387	367
7	364	1435	644	2155	296	438	34	37	39	2355	482	354
8	331	1240	1245	1840	283	279	34	31	53	2770	520	451
9	296	1063	1340	1335	264	255	34	27	60	1785	499	484
10	263	881	1212	1010	249	171	34	26	60	1495	470	701
11	227	635	1018	885	214	196	32	26	79	1300	517	932
12	233	468	726	819	189	97	32	23	97	1090	827	842
13	268	507	682	1670	172	91	31	23	169	920	1570	813
14	652	553	584	2965	156	85	30	23	674	789	1320	513
15	1090	695	500	3050	137	71	30	23	767	653	1131	512
16	1035	712	466	2995	129	71	30	24	1269	494	1081	505
17	1303	1167	407	2765	129	64	30	23	1444	474	1068	827
18	786	1435	387	2505	121	74	30	23	1362	619	1770	714
19	717	1485	400	1870	120	65	30	--	727	679	1850	599
20	665	1515	358	1845	116	59	29	---	581	992	1620	637
21	564	1415	312	1685	147	58	29	--	551	1222	1380	827
22	661	1165	282	1240	148	56	27	--	514	1337	1540	1105
23	648	886	265	1107	135	55	27	--	454	1665	1320	891
24	749	796	248	889	133	57	27	--	352	1845	1112	767
25	946	842	229	793	123	85	27	--	448	1625	886	718
26	1023	984	258	685	106	71	26	--	1775	1445	643	665
27	1342	960	589	613	96	76	25	--	2175	1103	581	752
28	2100	669	599	593	91	81	25	--	2535	951	590	643
29	2390	- -	470	599	89	85	26	--	3240	865	714	555
30	2385	- -	420	776	82	77	26	--	3575	832	617	651
31	2280	- -	280	- -	79	--	26	--	- -	775	- -	553

TABLE II.

MONTHLY SUMMARY OF DAILY DISCHARGE OF EMBARRASS RIVER NEAR CHARLESTON, ILL.
Drainage Area 685 sq. mi.

Month	MAXIMUM.		MINIMUM.		MEAN	
	Gals. per day	Gals per day per sq. mi.	Gals. per day	Gals per day per sq. mi.	Gals. per day	Gals. per day per sq. mi.
1909						
Oct 23-31	70,500,000	103,000	26,400,000	39,600	43,800,000	64,000
Nov	607,000,000	887,000	28,500,000	41,600	127,000,000	185,000
Dec 1 -20	1,180,000,000	1,720,000	- -	- -	366,000,000	535,000
Jan 1910	2,125,000,000	3,110,000	141,000,000	205,000	712,000,000	1,040,000
Feb	1,310,000,000	1,910,000	- -	136,000	245,000,000	358,000
Mar	1,970,000,000	2,880,000	- -	130,000	496,000,000	725,000
Apr	413,000,000	603,000	67,800,000	99,000	137,000,000	201,000
May	984,000,000	1,440,000	163,000,000	238,000	466,000,000	680,000
June	306,000,000	447,000	33,000,000	48,200	114,000,000	166,000
July	1,350,000,000	1,970,000	- -	132,000	425,000,000	621,000
Aug	436,000,000	636,000	25,200,000	36,800	77,400,000	113,000
Sept	224,000,000	327,000	22,700,000	33,100	73,000,000	106,500
Oct	1,120,000,000	1,640,000	42,000,000	61,400	297,000,000	434,000
Nov	844,000,000	1,230,000	26,500,000	38,700	98,000,000	143,000
Dec	317,000,000	463,000	31,700,000	46,300	101,000,000	147,000
the year	2,125,000,000	3,110,000	22,700,000	33,100	270,000,000	394,500
Jan 1911	1,550,000,000	2,250,000	146,000,000	214,000	549,000,000	802,000
Feb	1,360,000,000	1,990,000	304,000,000	443,000	725,000,000	1,060,000
Mar	865,000,000	1,265,000	148,000,000	216,000	346,000,000	505,000
Apr	1,970,000,000	2,880,000	210,000,000	307,000	912,000,000	1,330,000
May	589,000,000	874,000	51,100,000	74,600	169,000, 0	247,000
June	307,000,000	448,000	36,500,000	51,800	870,000,000	127,000
July	46,900,000	67,000	16,200,000	23,600	21,900,000	32,000
Aug	23,900,000	34,900	- -	- -	16,800,000	24,600
Sept	2,310,000,000	3,370,000	- -	- -	620,000,000	905,000
Oct	2,200,000,000	3,310,000	31,700,000	46,600	964,000,000	1,405,000
Nov	1,195,000,000	1,745,000	22,000,000	32,100	580,000,000	847,000
Dec	713,000,000	1,042,000	22,900,000	33,400	413,000,000	603,000
the year	2,310,000,000	3,370,000	- -	- -	453,000,000	661,000

WATER CONSUMPTION

It is impossible to get any close estimate as to the daily water consumption, but by estimating according to the times the clear water reservoir and elevated tank are filled during the day, the consumption ranges from 600,000 to 1,000,000 gallons, averaging 700,000 gallons per day. According to the latest census, this would give a per capita consumption of from 102 to 170 gallons per day. This high rate may be due to several causes. Firstly, to the fact that no services were metered until the middle of last year and the complete metering has not yet been accomplished. Secondly, the State Normal School, which has an attendance of about four hundred, is supplied with free water although at the present time the city of Charleston is trying to force the school to pay for the water used. Thirdly, the car shops of the Cloverleaf railroad and also the Toledo, St. Louis, and Western railroad use a large amount of water of which no record is kept.

No records whatever are available to show the amount of water used for domestic or industrial purposes or the amount wasted through leakage and other causes.

PUMPING STATION, PURIFICATION WORKS AND SURROUNDINGS

General

The pumping station and purification works are located at the bottom of a high bluff and are within 50 feet of the stream. At the present time, the plant is in a dilapidated condition, that is as regards the pump house. The filters and sedimentation basin have been but recently constructed. Still no care is taken of the general appearance of the plant. The road leading down the bluff is almost impassable in bad weather and debris and rubbish are scattered all over the ground. Old pipe fittings, discarded pump casings, and other rubbish offer a poor appearance to the most casual observer.

The general layout of the water works is shown in plan on the following page, (Figure 4). This shows the method of handling the water from the time it enters the intake to the time it is forced through the rising main to the city. A profile of this pipe line is plotted in Figure 5.

The water is drawn through a 10 inch pipe through a 4-1/2 foot suction lift by a centrifugal pump and is delivered to the purification works. From the purification works the water flows by gravity to the clear water reservoirs and is then pumped by the high lift pump into the city supply main. The supply pipe from this pump is 10 inches in diameter and is laid on the top of the ground from the pumping station to the top of the bluff. It has a vertical rise of 140 feet in approximately 300 feet. The water is pumped at a pressure of 90 pounds per square inch and this gives about 30 to 45 pounds pressure in the city. This pressure goes up to about 50 pounds during the day when the elevated tank is in use.

PUMPING STATION AND MACHINERY

The pump house and the machinery it contains is in an extremely run down condition. No information is available to ascertain the duty of the plant since no operation records are kept. The only gages in the building are a pressure gage on the

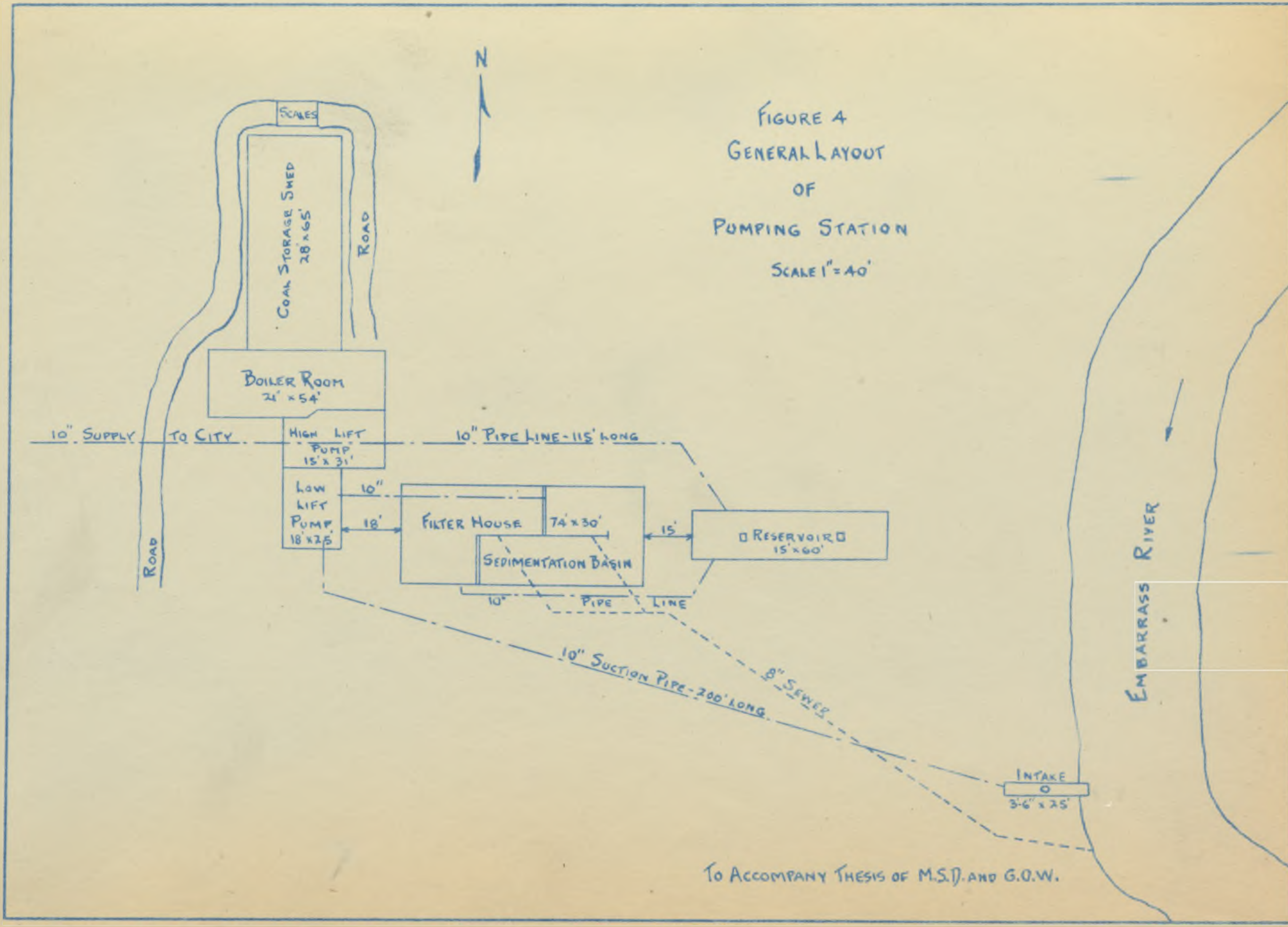


Figure 4
General Layout
of
Pumping Station
Scale 1" = 40'

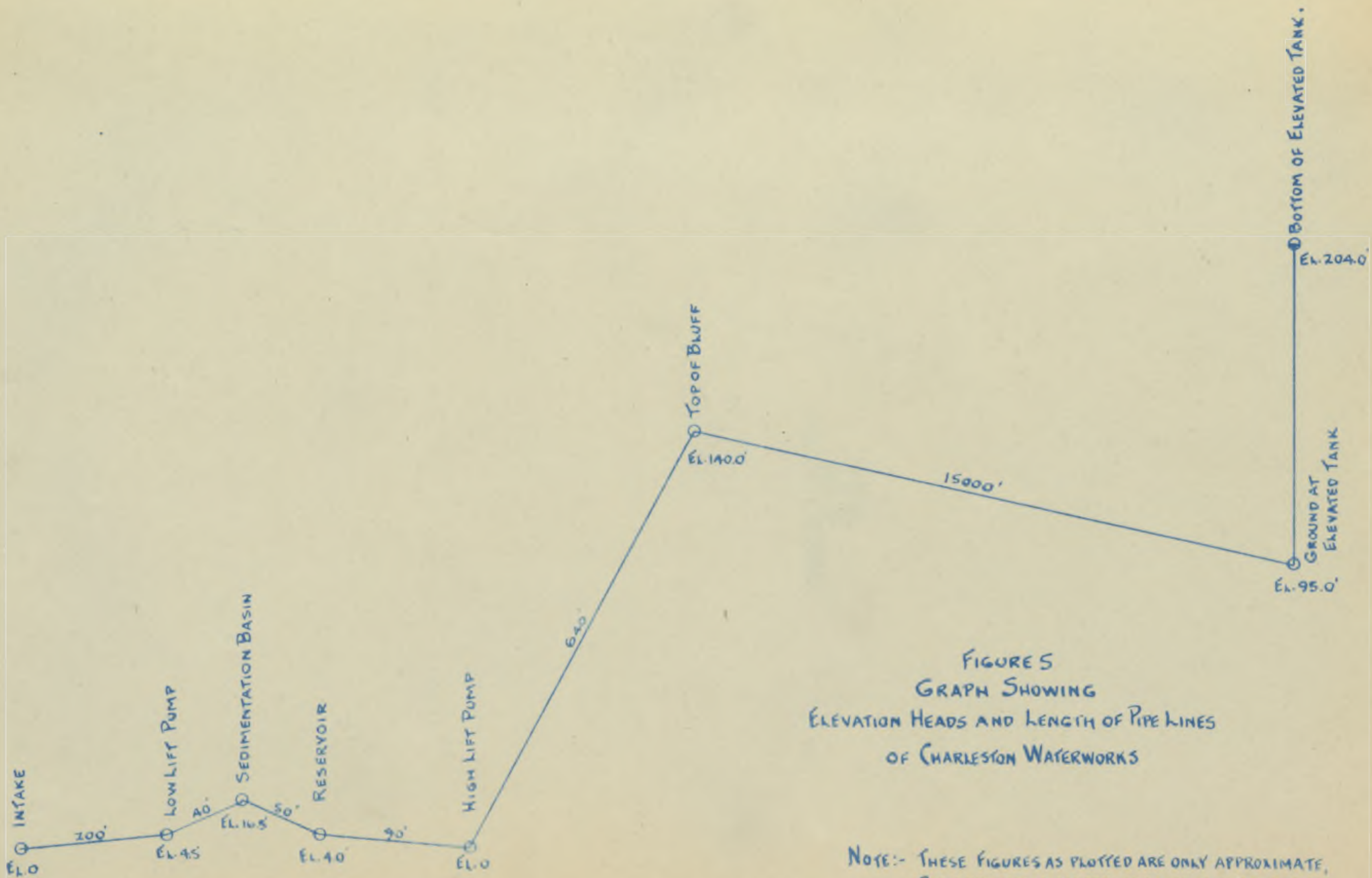


Figure 5
Graph Showing
Elevation Heads and Length of Pipe Lines
of Charleston Waterworks

Note:- These figures as plotted are only approximate, but give one a general idea of the conditions.
All pipe lines are 10" in diameter.
To accompany Thesis of M.S.D. and G.O.W.

boiler and one on the high lift pump. A brief description, together with the accompanying plan (Figure 6), will show the general layout of the pump house.

The building is divided into two parts by a wooden partition; one part contains the boilers with a large coal shed adjacent to them, while the other part contains the pumping machinery. The coal shed is 65 feet by 28 feet with a 6 foot passage down the center opening directly into the bins for storing the coal. The coal is hauled from town by wagon and shovelled directly into the bins. All coal and ashes are handled in wheel-barrows at the plant.

The coal shed opens directly onto a 21 foot by 15 foot operating floor in front of the boilers and adjacent to this is a 21 foot by 21 foot space which is used for a work shop and a place to store oil, pipe fittings and other appurtenances.

There are two boiler units, one double, horizontal, return tubular Frost boiler rated at 230 horse power, and one horizontal, return tubular Erie City Iron Works boiler rated at 80 horse power. There is a steel smoke stack 18 inches in diameter and 35 feet high for each unit.

The building is brick for 5 feet above the ground and frame the rest of the way. At present it is not equipped with lighting facilities. This is inconvenient to the operators since much of the pumping is done at night when the elevated tank is being filled.

The rest of the building contains the pumps which are set in a pit about 12 feet below the operating floor of the boilers. This pit always has water standing in it and has no way to drain

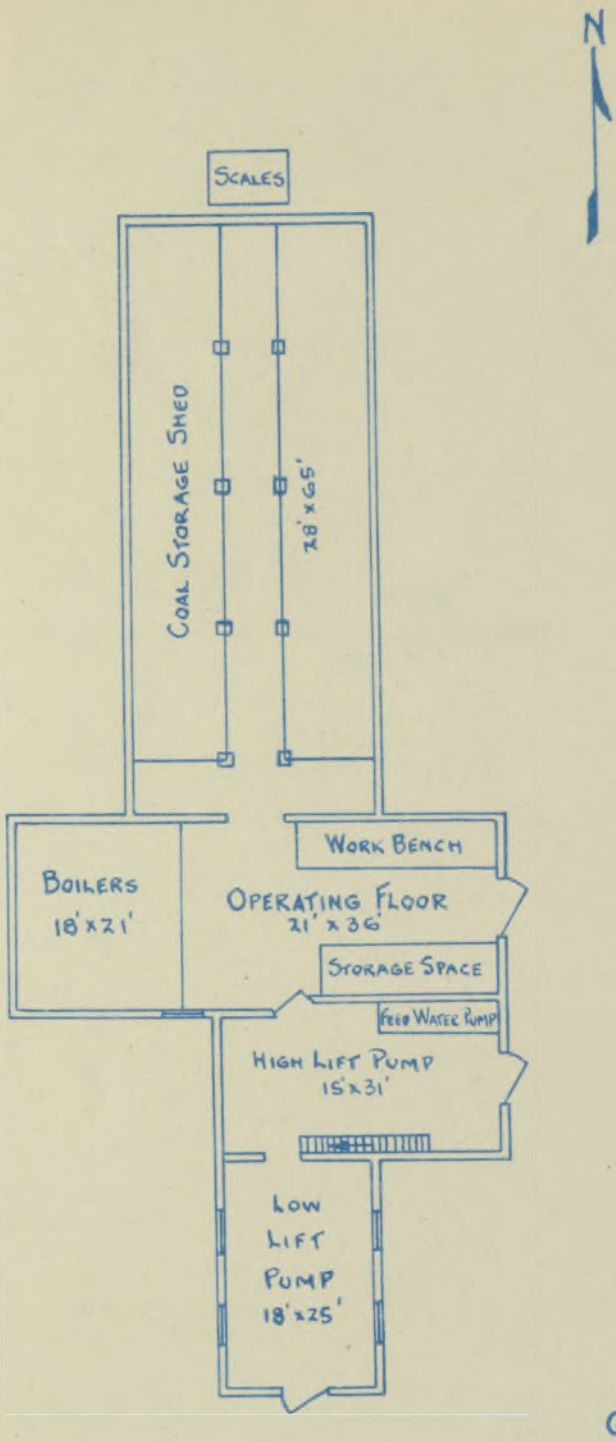


FIGURE 6
GENERAL LAYOUT
OF
PUMP HOUSE
SCALE 1" = 20'

TO ACCOMPANY THESIS OF M.S.D AND G.O.W.

except through cracks in the floor. The pumps are old, rusty, and covered with dirt. Moreover, due to the absence of light the operator must carry a lantern while working in the pit.

One half of the pit contains the 8 inch low lift centrifugal pump directly connected to a small vertical, slide valve steam engine. Also, an old Deane Brothers compound, duplex pump of 1,500,000 gallons per day capacity which has been disconnected and in disuse since the purification works were installed. At the present time, a Chuse single valve engine, 6 inches by 6 inches cylinder, 315 revolutions per minute, is being installed on the floor above to operate, by belt, an 8 inch, 1800 revolutions per minute, centrifugal pump. This pump will be used for pumping from the river to purification works. The one now in use will be availed of as a wash water pump, supplying water directly from the clear water reservoir. The air blower is located on the operating floor of the filter house.

The high lift McGowan compound, duplex steam pump is rated at 2,000,000 gallons per day capacity and occupies the other half of the pit by itself. Conditions are decidedly unfavorable for efficient operation of this pump and it requires nearly continuous attention, although practically new.

It might be of interest at this point to tell when this pump is operated. It is operated at night with a pressure of 90 pounds per square inch at the pump, giving a pressure of about 45 pounds in town and supplies enough water to allow the centrifugal pump at the elevated tank to operate and fill the tank. In the morning, when the valve admitting water from the tank to the distribution system is opened the pressure supplied by the tank checks the McGowan pump and it ceases to operate until the tank is empty.

A small, centrifugal pump of 250 gallons per minute capacity on an 8 inch pipe line lifts the water directly from the city mains into the elevated tank. This naturally causes some inconvenience in the immediate vicinity because of the reduction in pressure. The tank is filled at night and supplies water from seven in the morning until about two o'clock in the afternoon.

PURIFICATION WORKS

General Features

As the water comes from the low lift pump, it is delivered to a mixing chamber, thence it passes through a sedimentation basin to two filters, and through the filters to a clear water reservoir below. The sedimentation basin may be by-passed but if repairs are necessary in the mixing chamber or if both filter units are out of commission, the whole plant must be shut down.

The purification works were designed to operate at a rate of 1,000,000 gallons per day, but this rate is exceeded in that the plant is made to yield 700,000 gallons in fifteen hours which gives a rate of 1,120,000 gallons per day. The nominal rate of filtration is 125,000,000 gallons per acre per day. Figure 7 shows the general features and the layout of the purification works.

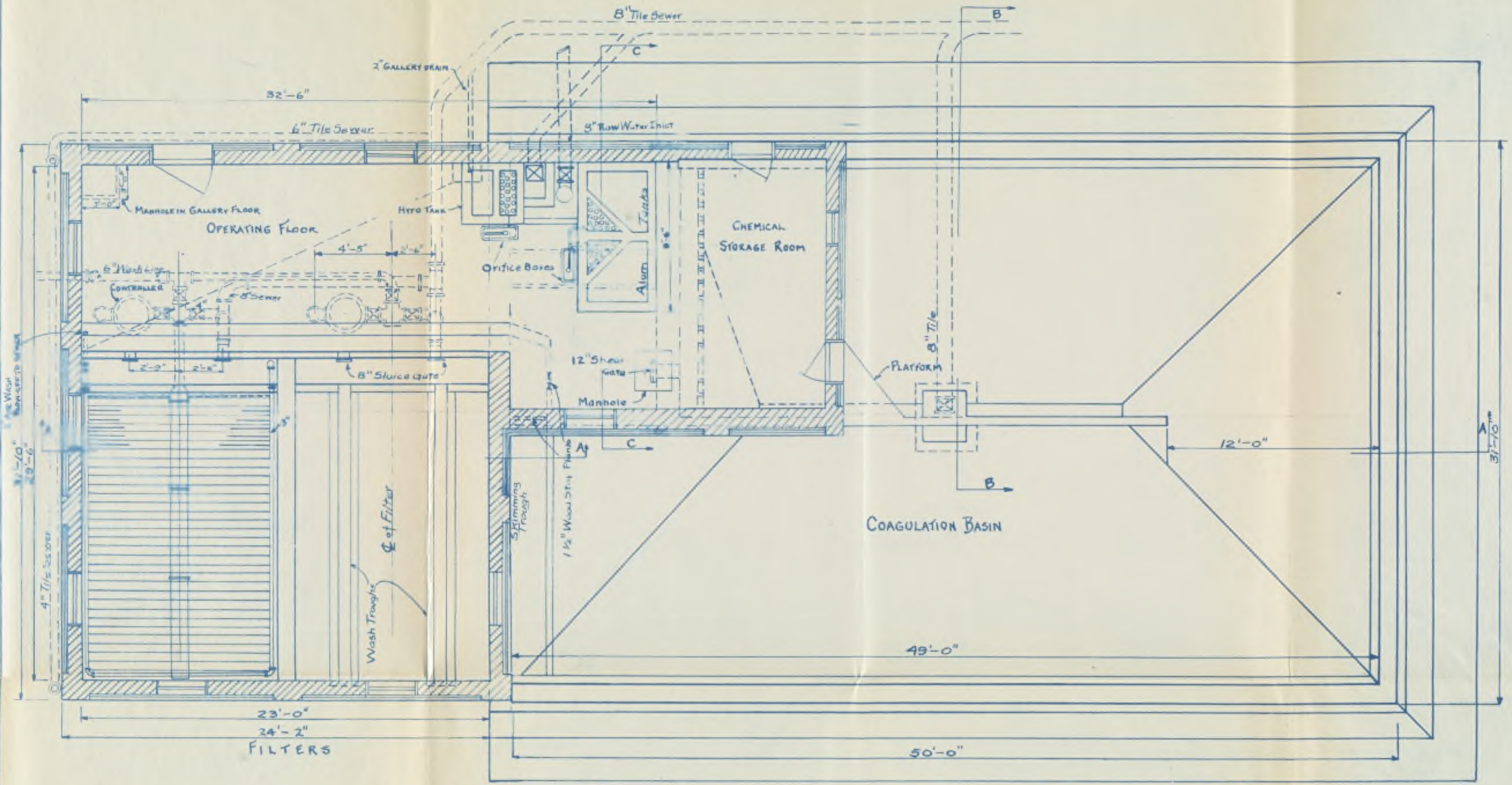


Figure 7
Plan
of
Purification Works
At Charleston Filter Plant
Scale ⅛" = 1'

To Accompany Thesis of M.S.D. and G.O.W.

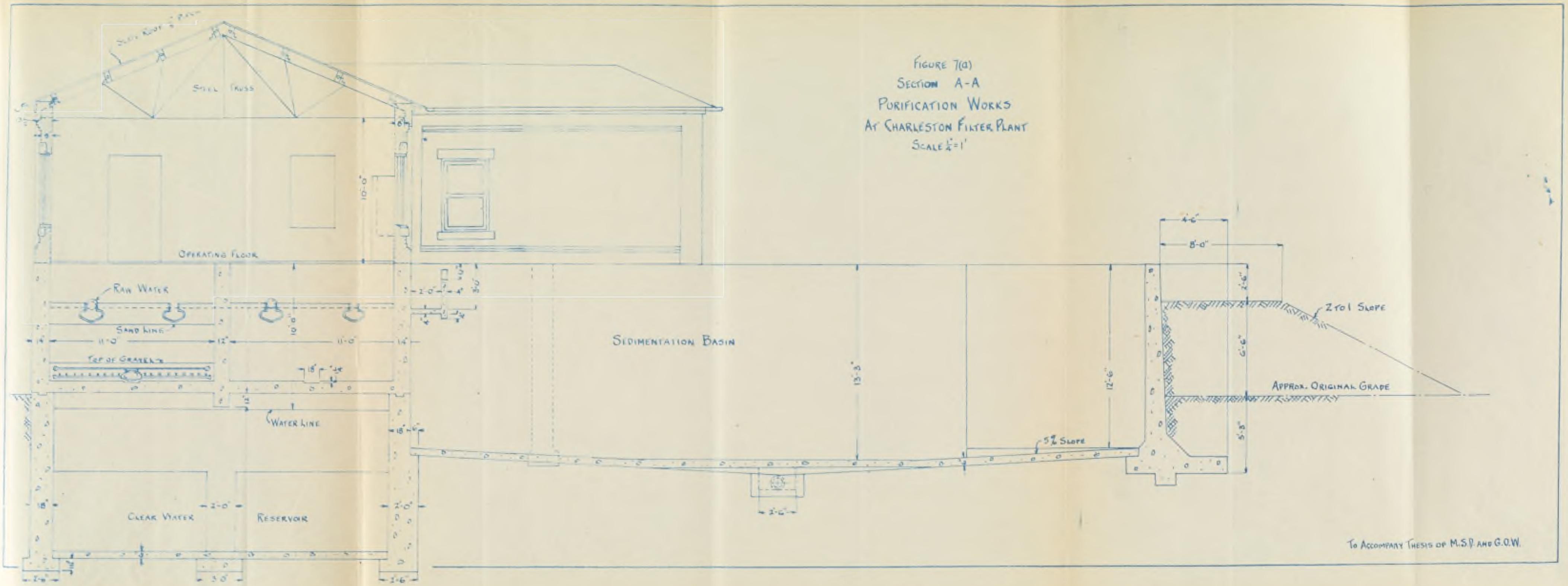


Figure 7(a)
Section A-A
Purification Works
At Charleston Filter Plant
Scale 1/4" = 1'

Mixing Chamber

The mixing chamber is located in one corner of the sedimentation basin as shown in Figure 7. The period of retention for the present rate of 1,120,000 gallons per day is 13 minutes. The water enters the bottom of the chamber at the north wall, through an 8 inch cast iron pipe from the low lift pump. The rate of flow into the chamber is regulated by a copper float which rises and gradually closes the valve on the influent pipe when the chamber is full. Baffles as shown in Figure 8 produce a velocity of about 5.22 feet per minute which effectively mixes the chemical with the water.

The floor of the chamber slopes toward the northwest corner with a drop of 6 inches. In this corner there is a sump 2 feet square in plan and 2 feet 9 inches deep, which has an 8 inch cast iron nipple that connects to a tile sewer.

Sedimentation Basin

From the mixing chamber the water flows into the sedimentation basin which operates on the continuous flow basis. The basin has a total area of 1305 square feet, and it is divided into two parts by a baffle wall, giving the water an around-the-end flow. The average depth of the basin is 13 feet, which gives it a capacity of 127,000 gallons or 3.0 hours retention at the consumption rate of 1,000,000 gallons per day, but at the present rate of consumption it is sufficient for only 2.72 hours retention.

As will be observed from the foregoing plan (Figure 7) the sedimentation basin occupies a space 30 by 49 feet, one corner

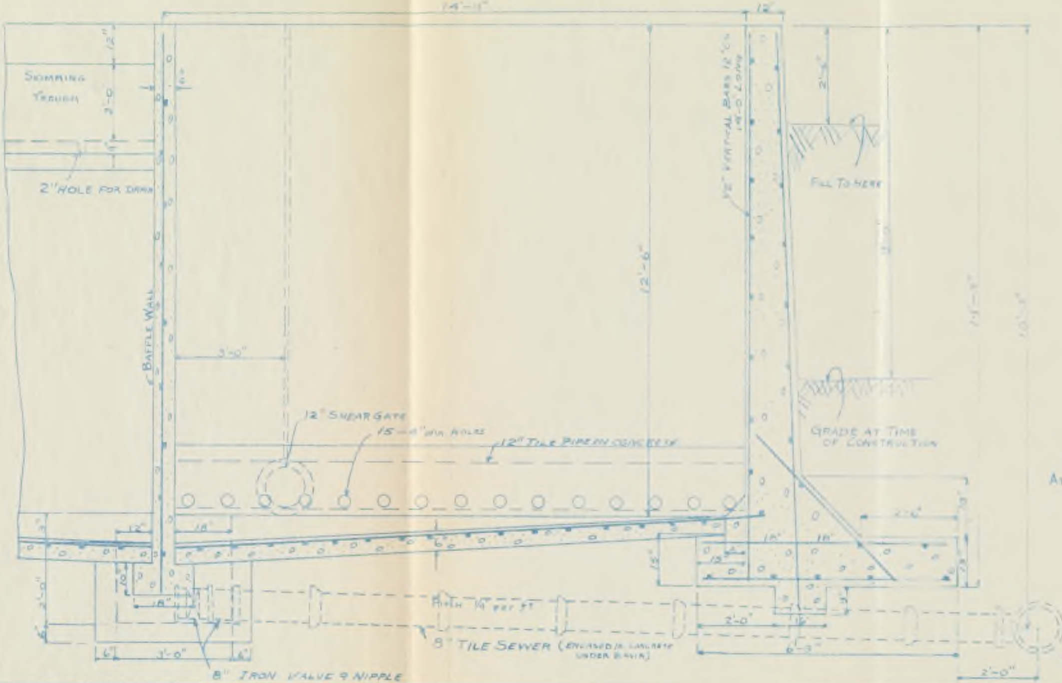


Figure 6
Section B-B
Coagulation Basin
At Charleston Filter Plant
Scale 5/8"=1'

To Accompany Thesis
of M.S.D. and G.O.N.

of which is cut out by the mixing chamber. A longitudinal center baffle wall divides the basin into two channels 49 feet and 38 feet 2 inches long respectively.

The water enters the basin at the end of the shorter channel adjacent to the mixing chamber and near the bottom. An approximately even distribution of water across the width of the channel is effected by admitting the water into a transverse conduit which has fifteen 4 inch outlets equidistantly spaced. The outlets direct the water horizontally along the bottom of the basin with an initial velocity of 2.9 feet per second thus providing a scouring action for some distance beyond the inlet end, thereby rendering ineffectual a material proportion of the sedimentation capacity. This defect may be readily corrected by a submerged baffle placed just beyond the inlet and rising to approximately mid-depth of the basin. The velocity of flow in the basin is approximately .5 of a foot per minute.

Water after passing the end of the center baffle returns in the longer channel at the end of which is placed a transverse weir or skimming trough designed to draw off the partially clarified water evenly across the width of the channel. Due to the defective operation, water in the basin is not maintained at a suitable elevation to allow it to pass over the weir and frequently water enters through two 4 inch holes in the bottom intended for draining the trough. It is found in practice that the water entering through these holes is materially more turbid than that going over the weir. This defect may be overcome by merely plugging the holes while not in use for drainage purpose.

For the purpose of cleaning, the floor of the basin slopes to a sump located in the center of the basin. This sump is 3 feet square and 2 feet deep, with 6 inch concrete floor and sides. In the sump there is a valve that connects to an 8 inch tile drain, incased in concrete, which connects to the main sewer. The valve in the sump is operated by a wheel-stand on the top of the baffle wall.

The time required for draining the basin is two to three hours. After the basin has been drained, the sludge is washed out by a fire stream from the pump house.

The sedimentation basin may be by-passed by merely closing the inlet pipe and diverting the water directly into the channel leading to the filters.

The details of the outside walls, baffle wall, and floor are shown in Figure 9. The outside walls of the basin extend 9 feet above the original ground level, but a clay embankment was made to within 2 feet 6 inches of the top. This embankment, however, has been partially washed away by flood waters.

Chemical Preparation and Feed Devices

The purification works are equipped with both hypochlorite and alum tanks. At the present time only the alum tanks are used.

There are two alum tanks, each 3 feet 6 inches by 3 feet 9 inches in plan, and 4 feet deep inside dimensions. They are constructed of reinforced concrete of 1 : 2 : 4 mixture. The tanks are built as a monolith, divided by a 4 inch wall.

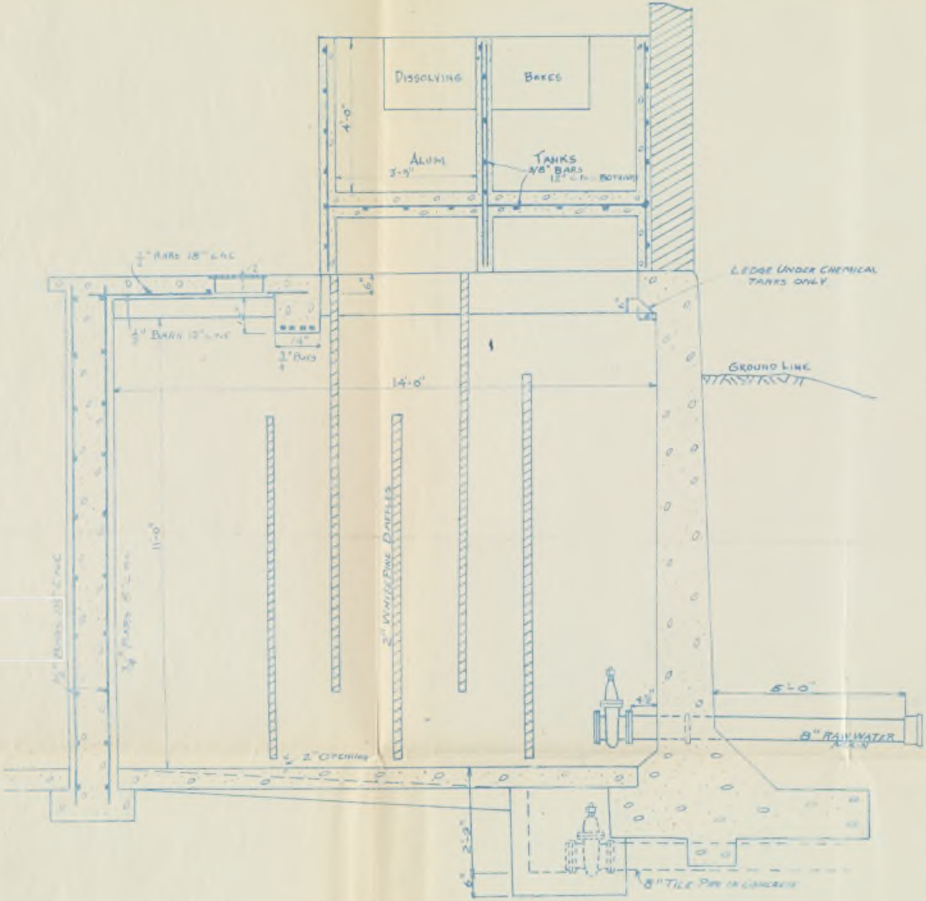


Figure 9
Section C-C
Mixing Chamber
At Charleston Filter Plant
Scale ½"=1'

To Accompany Thesis of M.S.D. and D.O.W.

The outside walls of the tanks are also 4 inches thick. The crystallized alum is dissolved in a triangular box in one corner at the top of each tank.

From the bottom of each tank a 1 inch wrought iron pipe runs out to a constant level orifice tank and a valve on each pipe allows one tank to be used at a time. The regulating tank is made of cast iron, and is 23 inches by 7 inches and 7-1/2 inches deep. A float controlled valve maintains a constant level in the tank. The amount of solution flowing out is controlled by an adjustable orifice. The solution passes through the orifice into a funnel shaped tube which discharges into the mixing chamber near the point of entrance of raw water. Since the chemical pipe is short and gives a vertical drop from the tank, no trouble results from clogging.

The chemical tanks leak at the places where the pipes enter; this causes the floor to be dirty and unsanitary. The glass indicator gages on the sides of the tanks indicating the height of the solutions are out of order and should be repaired.

The amount of alum used is determined by the operator's visual estimate of turbidity in the raw water. Standard turbidity measurements would be preferable as a guide to the application of coagulant.

At the time of our visit to the plant, a two percent solution of alum was being used as determined by a hydrometer calibrated for the purpose.

There is only one hypochlorite tank. This is 28 inches by 30-1/2 inches in plan and 4 feet deep. The tank is made of reinforced concrete similar to the alum tanks and it has a 4 inch dividing wall extending 2 feet down from the top. The regulating tank and accessories are identical to those for the alum tanks, and the solution is discharged into the water main as it enters the mixing chamber.

Filters

There are two filters located as shown in Figure 7. Each unit is 11 feet by 16 feet 6 inches in plan and 8 feet deep. The total sand area is 363 square feet which gives a capacity of 1,045,000 gallons per day.

The water comes from the skimming trough through a conduit 10 inches wide and 3 feet deep, adjacent to and extending along the operating ends of the two filters. The height of water in the conduit and on the filters is controlled by the height of water in the mixing chamber which in turn is controlled by the float valve on the inlet pipe. The water enters each filter into the wash water troughs through an 8 inch valve, with a velocity of 3.1 feet per second when the filters are running at the rate of 1,120,000 gallons per day.

There is no means of by-passing the filters, therefore a shut down of both filters would necessitate the suspension of operation of the whole plant.

The main collector of the underdrain system in each filter unit is a 10 inch cast iron elliptical pipe which lays in a depression in the 10 inch concrete floor, 18 inches wide and 1-1/2 inches deep, at the center of the bed and running the length of the unit. This pipe is reduced at the front end of the filter to an 8 inch circular pipe.

The laterals are 2 inch wrought iron pipes screwed into the elliptical manifold and extending to within 6 inches of the edge of the filter. The end laterals are 6 inches from end walls and all laterals are spaced 6 inches apart.

The strainers used are those manufactured by the Pittsburg Filter Manufacturing Company, 1-3/4 inches in diameter and are screwed into the laterals at 6 inch intervals. The strainer holes are 1/16 inch in diameter giving a total area of .94 square feet which is .26 percent of the total sand area. A special feature of this type strainer is that it is made in two parts so that the cap can be removed for cleaning purposes without disturbing the base which is encased in the concrete floor.

The wash water is pumped from the clear water reservoir into the underdrain system through a 6 inch cast iron pipe which connects to the manifold through a cross in the pipe gallery. The time for washing is very indefinite because washing is continued as long as the operator thinks that the water is becoming clearer.

There are two wash water troughs per filter which extend the length of the unit. They are 5 feet 6 inches center to center and 2 feet 9 inches from the sides of the filter. These troughs are made of wrought iron, being tied every 4 feet 6 inches by 1/2 inch steel rods. The flat edges of the top of the sides are 12 inches above the sand bed. The two troughs empty into a space 18 inches wide, 5 feet deep, adjacent to the end of the unit.

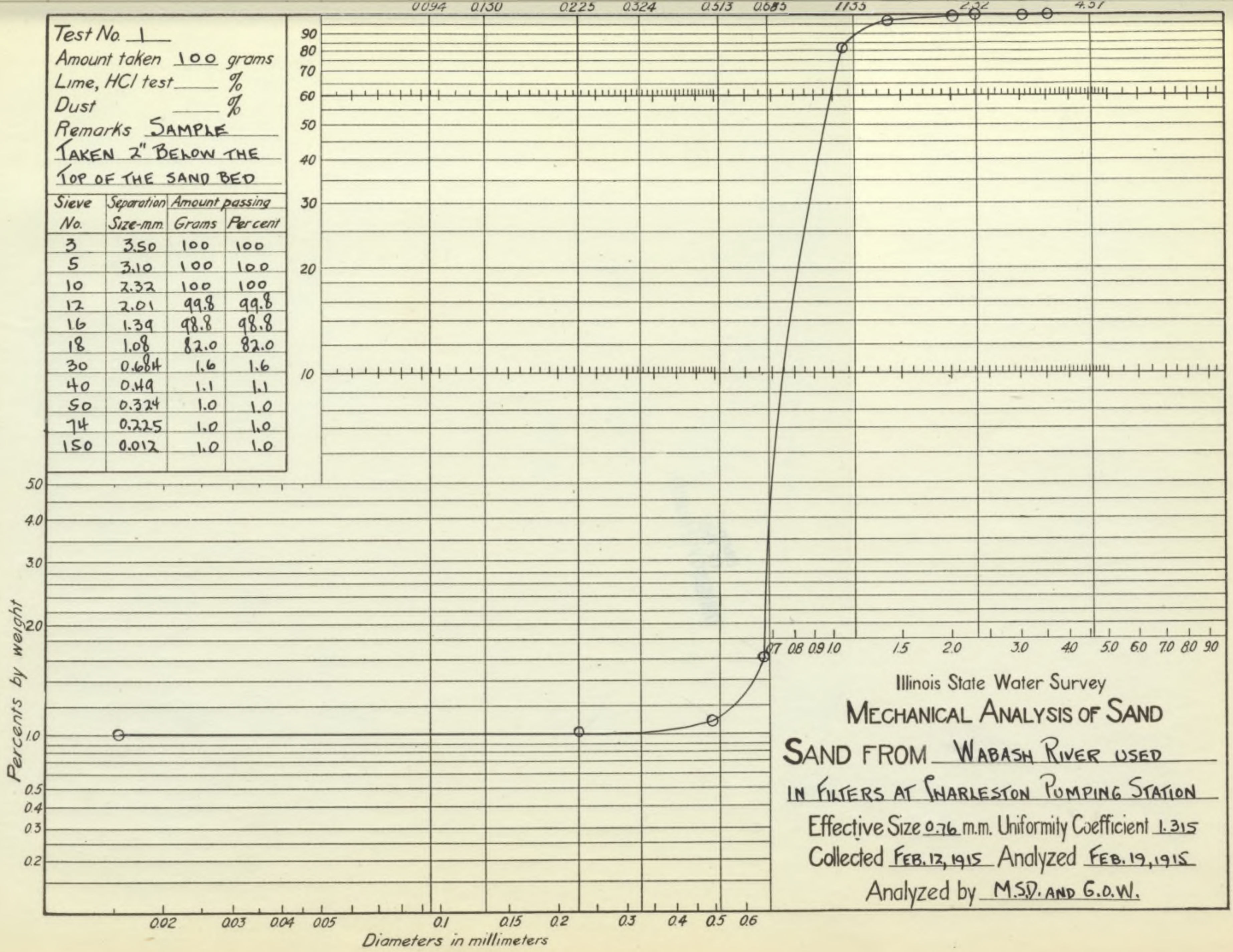
The air is supplied through a 4 inch wrought iron main by a Root blower directly connected to a Wachs steam engine. This blower is placed at the north side of the filter house opposite the filter beds, and the 4 inch main runs overhead to in front of the filters where it branches off into two 3 inch mains, one for each unit. Connecting to each main there is a 1-1/2 inch wrought iron pipe from the wash water main, which is used to wash out the air pipes whenever they get clogged. The air pressure is sufficient to force air through the filter with a few inches of water over the sand, probably in the neighborhood of 3 pounds per square inch at the blower. These 3 inch mains run along the two sides and the back of the filter units on the top of the gravel bed. The laterals, which are 1/2 inch brass pipes, are placed every six inches apart. These pipes have 1/16 inch holes spaced every 3 inches apart making the air holes about .17 percent of the total filter area.

The filters are washed after runs varying from six to twelve hours, depending upon the turbidity of the water. The method of washing is to allow the water to drain to within three inches of the sand when the effluent valve is closed and the air turned on. The air is allowed to stir up the sand and dirt for about ten minutes after which the wash water is turned on and allowed to wash the bed for about twenty minutes. Finally the water is turned off, the sewer pipe is closed, and the normal filter operation is resumed.

The filter material consists of gravel and sand. The gravel is graded from 1/2 inch down to 1/8 inch with the larger sizes on the bottom of the bed. A 12 inch layer of gravel

Test No. 1
Amount taken 100 grams
Lime, HCl test ____ %
Dust ____ %
Remarks SAMPLE TAKEN 2" BELOW THE TOP OF THE SAND BED

Sieve No.	Separation Size-mm.	Amount passing Grams	Amount passing Percent
3	3.50	100	100
5	3.10	100	100
10	2.32	100	100
12	2.01	99.8	99.8
16	1.39	98.8	98.8
18	1.08	82.0	82.0
30	0.684	1.6	1.6
40	0.49	1.1	1.1
50	0.324	1.0	1.0
74	0.225	1.0	1.0
150	0.012	1.0	1.0



Illinois State Water Survey

MECHANICAL ANALYSIS OF SAND

SAND FROM WABASH RIVER USED IN FILTERS AT CHARLESTON PUMPING STATION

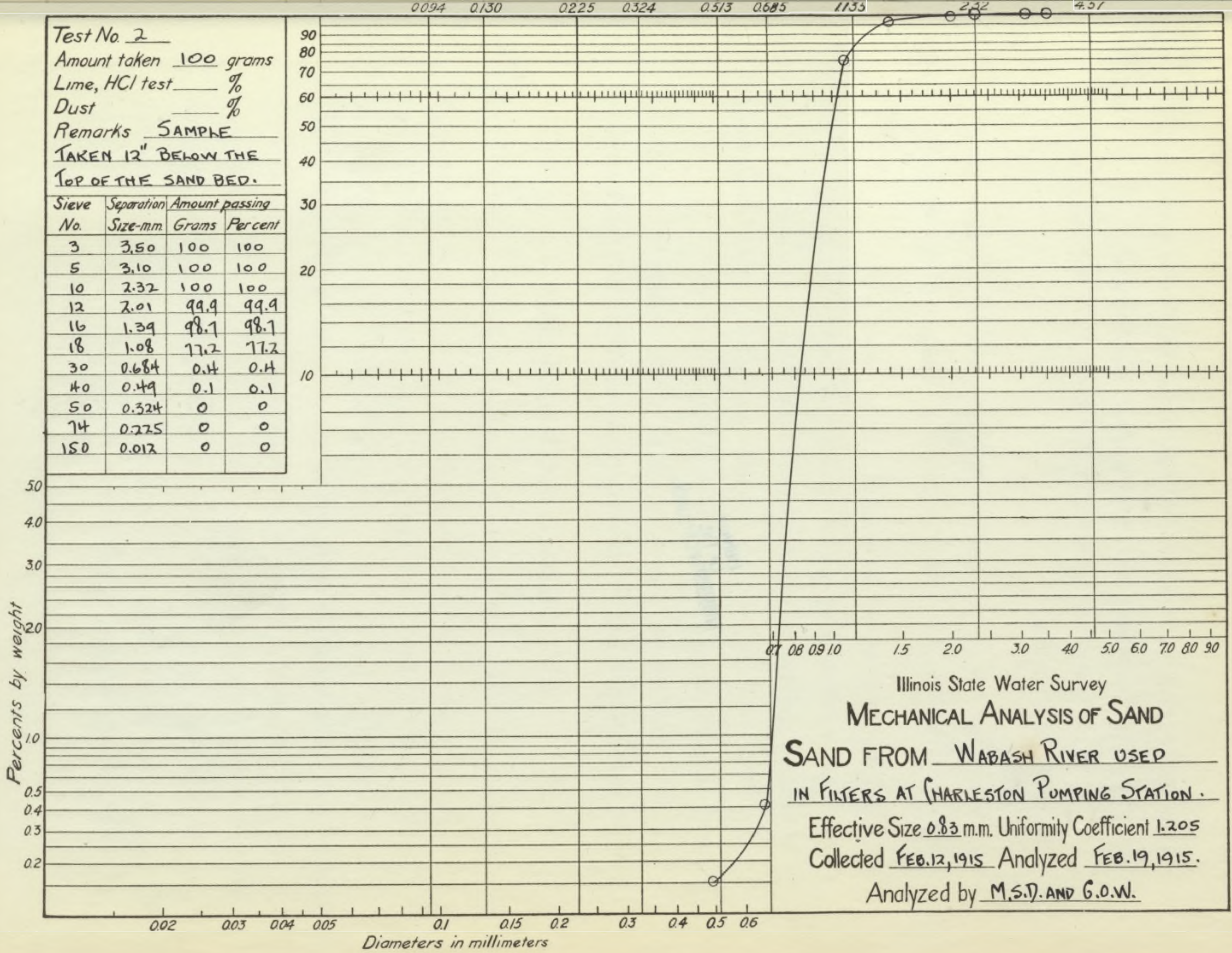
Effective Size 0.76 m.m. Uniformity Coefficient 1.315

Collected FEB. 12, 1915 Analyzed FEB. 19, 1915

Analyzed by M.S.D. AND G.O.W.

Test No. 2
Amount taken 100 grams
Lime, HCl test ____ %
Dust ____ %
Remarks SAMPLE TAKEN 12" BELOW THE TOP OF THE SAND BED.

Sieve No.	Separation Size-mm.	Amount passing Grams	Amount passing Percent
3	3.50	100	100
5	3.10	100	100
10	2.32	100	100
12	2.01	99.9	99.9
16	1.39	98.7	98.7
18	1.08	77.2	77.2
30	0.684	0.4	0.4
40	0.49	0.1	0.1
50	0.324	0	0
74	0.225	0	0
150	0.012	0	0



Illinois State Water Survey

MECHANICAL ANALYSIS OF SAND

SAND FROM WABASH RIVER USED IN FILTERS AT CHARLESTON PUMPING STATION.

Effective Size 0.83 m.m. Uniformity Coefficient 1.205

Collected FEB. 12, 1915 Analyzed FEB. 19, 1915.

Analyzed by M.S.D. AND G.O.W.

is laid over the underdrain system, with a 30 inch layer of sand above it. The sand used comes from the Wabash river. A sieve analysis of the sand gave the following results:

	Effective Size	Uniformity Coefficient
Sand about 2 inches from top of bed	.81 mm	1.36 mm
Sand about 12 inches from top of bed	.87 mm	1.26 mm

The rate of filtration as determined at the time of our visit was 3 inches per minute which gave a velocity of 3.8 feet per second in the main collector and a maximum velocity of .6 feet per second in the laterals.

The vertical rise of wash water was found to be 3 inches per minute which is considerably lower than that observed during previous examinations by the State Water Survey.

Pipe Gallery and Operating Floor

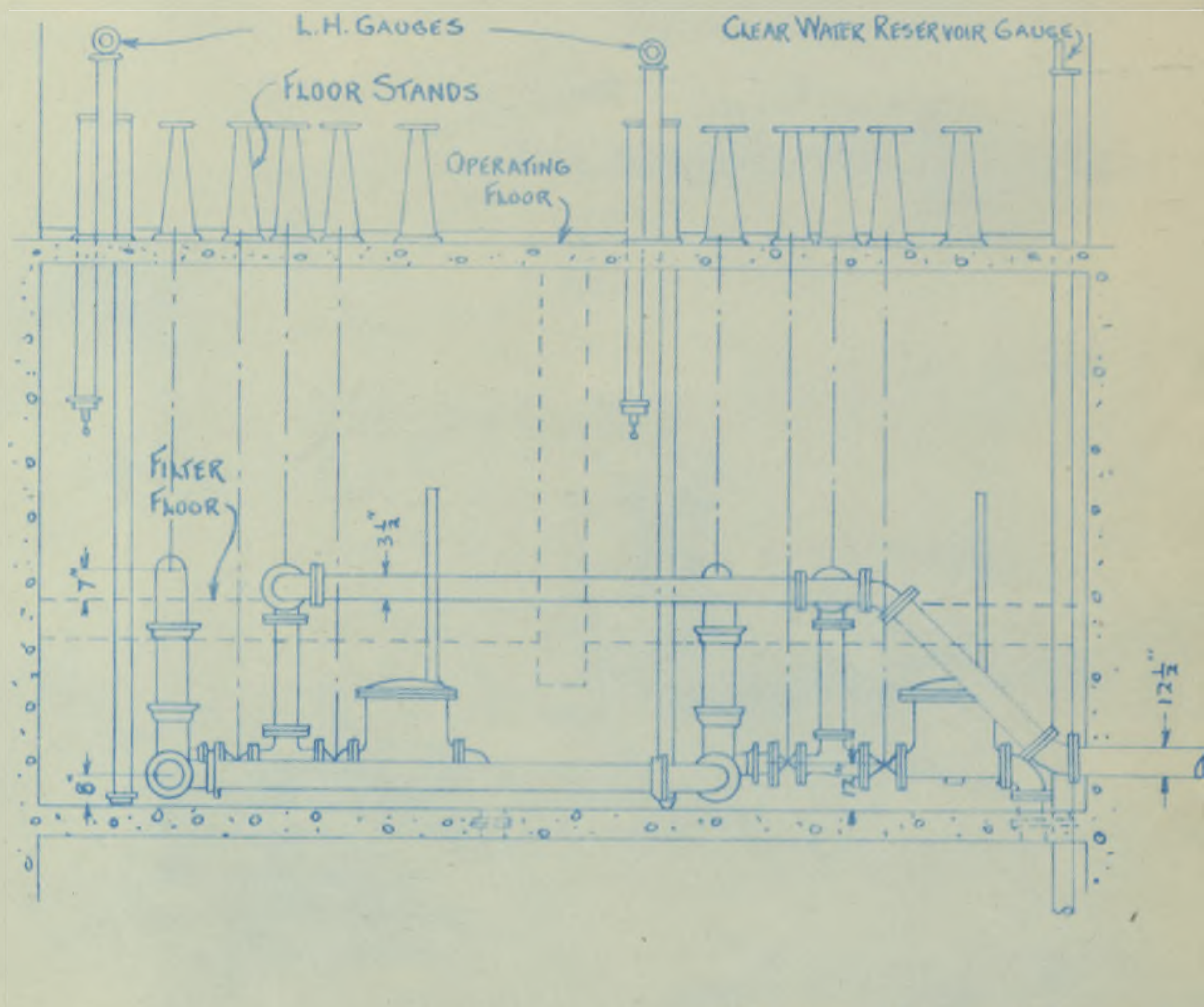
The pipe gallery occupies the space in front of the filters and contains all pipe connections with the filter. The gallery is 10 feet wide, 22 feet long, and 12 feet high. The effluent pipe, wash water pipe, and filter to waste pipe, all connect to a cross in front of each filter unit. The remaining opening of the cross is connected with the underdrain system. By the proper operation on the valves on each of the first three connections, the filtered water may be admitted to the clear water reservoir, through the rate controller, wash water may be admitted to the underdrain system, or the effluent may be run to waste through the sewer.

FIGURE 10

LONGITUDINAL SECTION

PIPE GALLERY

SCALE $\frac{1}{4}$" = 1'



TO ACCOMPANY THESIS OF M.S.D. AND G.O.W

All gages and wheel-stands for manipulating valves are on the operating floor. There are five wheel-stands at each filter for controlling the following connections:- influent; effluent; wash water; waste effluent; and soiled waste water to sewer. There is a loss of head gage for each filter unit. Both are out of order. At the west wall of the building in front of the filters there is a gage showing the depth of the water in the clear water reservoir.

In the northwest corner of the operating floor there is a 3 foot square manhole with a steel ladder leading to the pipe gallery.

The air blower, as before stated, is also on the operating floor.

A 6 inch tile sewer is placed at one end of the pipe gallery but is usually clogged so that it does not serve its purpose. This clogging could be easily prevented by a little attention, thereby preventing an unsightly condition in the pipe gallery.

Superstructure

The filter building is a red brick building with a slate roof presenting a neat appearance. The building rests on the walls of the filters, sedimentation basin, and pipe gallery. The general dimensions of the filter building are shown in Figure 7.

The building houses the filters and all their operating parts, the blower and its engine, the chemical preparation and feed devices, and there is available a limited storage space for chemicals.

Clear Water Reservoirs

There are two clear water reservoirs, an old one and a new one that was built with the filter plant. The old clear water reservoir is what formerly was used as a settling basin when water was pumped direct from the river. The basin is 15 feet wide, 11 feet deep, and 60 feet long with an arch roof on a 7.5 foot radius and 6 inches thick. The walls of the basin are 10 inches thick of plain concrete. The capacity of this reservoir is about 80,000 gallons.

The top of this reservoir is at the ground level which is about one foot above the banks of the river and each spring, when the water in the river is high, the water rises about 4 feet above the top of the reservoir. To prevent any water from flowing into the reservoir through the two manholes which are placed at the ends of the reservoir, there is a concrete box 4 feet square, 5 feet high with 6 inch walls, built up around each of the manholes. No floor nor foundation are required for this structure as it rests on solid rock. This reservoir is connected to the new one by a 4 foot square concrete conduit which enters the end of the former.

The new reservoir runs the length of the filters which is 22 feet. Under the filters it is 10 feet high and 17.5 feet wide, and under the pipe gallery it is 9.5 feet wide and 6.5 feet high which gives a total capacity for this reservoir of 40,000 gallons. The walls are of concrete 18 inches thick except the east wall which is 2 feet thick since it must withstand the pressure of the water in the sedimentation basin.

The water enters the new clear water reservoir through 8 inch cast iron pipes which come from the rate controllers, passing down through the floor of the pipe gallery into the reservoir. In the northwest corner of the old reservoir there is a 10 inch suction main which connects to the McGowan high pressure pump. Just inside the wall, this main turns downward and extends to within one foot of the floor. In the southwest corner of this reservoir there is a 10 inch main from the Deane pump which enters straight in, about 3 feet from the floor. The length of each main is about 90 feet. When the depth of water in the reservoir is 7 feet there is a positive head on the suction pipe of about 5 feet.

The old reservoir is not in the best condition as it leaks considerably. Some means of waterproofing it should be taken to eliminate the possibilities of pollution due to seepage and also to prevent any loss of water from the reservoir.

DISTRIBUTION SYSTEM

The extent of the distribution system could not be definitely ascertained, as no records of the pipe lines and accessories have ever been kept. However, it is known that the pipes range in size from 10 inches to 4 inches. The 10 inch pipe carries the water from the pumping station to the town, then it divides into 8 inch pipes, and then later into 6 and 4 inch pipes. No minimum depth of covering over the mains has been adopted. It is interesting to note that the pipe from the pumping station in places is 3 feet above the ground, but has never given any trouble due to freezing.

Air relief valves are placed on the 10 inch main at the summits of the hills near the pumping station. Such a valve consists of a 2 inch wrought iron pipe screwed into the main, with a floating ball in it which rises to shut an opening if the water tends to rush out. They also let the air in, in case the pumping stops and the water drops down on the both sides of the points of high elevation. Ninety degree bends on the ends of the riser pipes prevent stones, sticks, or other matter that would interfere with the movement of the floats from getting into them.

The number of service pipes is about 1100, of which 875 are now metered. The meters have been installed within the last two years. The consumers purchase the meters at a cost of fifteen dollars including the initial cost of the meters and the placing of the same. Most of the meters have been placed in Clark meter boxes outside of the houses and have caused no trouble from freezing. On installation of a meter the consumer is given a book containing twelve coupons each worth $1.25. One coupon may be used as payment on each current bill for water consumption, and when all coupons are used the meters become the property of the city.

For equalizing the pressure on the mains and to provide reserve storage in case of a breakdown at the pumping station, an elevated tank was installed. This tank was completed early in November, 1912, by the Chicago Bridge & Iron Works. It is rated at a capacity of 200,000 gallons; it is 30 feet in diameter, 17 feet high, with an elliptical bottom 9 feet deep, and a cone shaped roof. The bottom of the elliptical portion is 109 feet above the ground level. For over two years, the tank stood empty because no water could be pumped into it due to the fact that the pumps at the plant were not capable of raising the water to such an elevation. In the fall of 1914, the Public Service Company of Central Illinois installed a 7.5 horse power motor and a 3 inch centrifugal pump, to lift the water from an 8 inch main into the tank. This equipment was built in a small wooden building under the tank and now this pump is used for about 13 hours each day or the time required to fill the tank. This storage is generally enough to supply the city from seven o'clock in the morning until about two o'clock in the afternoon, at which time the pumps at the station are started. According to the present method of operation, the plant supplies water all night and a few hours during the afternoon only.

The pressure maintained during the day when the elevated tank furnishes all the water averages from 47 to 58.5 pounds per square inch. Whenever there is a fire and the elevated tank is nearly empty, the pressure is so low that it is inadequate for fire protection. This was exemplified during the first week in February of this year, when a three-story building burned to the ground due to the insufficient fire pressure.

The following table gives the water rates that are used at the present time:

5000 gallons or less per month		25 cents per 1,000
5000	to 20000 gallons per month	20 " " "
20000	to 50000 " " "	15 " " "
50000	to 100000 " " "	12-1/2 " " "
100000	to 150000 " " "	12 " " "
150000	to 200000 " " "	11 " " "
200000	to 500000 " " "	10 " " "
500000	to 1000000 " " "	9 " " "
1000000	to 4000000 " " "	6-1/2 " " "
4000000	or more " " "	5 " " "

COST DATA

The net cost of the plant is approximately $10,000. for the pumping equipment, $4,000. for the boiler plant, and $15,800. for the purification works.

The expenditures of the plant for the last five years are approximately as follows:

	1910	1911	1912	1913	1914
Tons of coal	1800	1980	2010	2490	2500
at	$2.55	$2.74	$2.64	$3.00	$2.62
Cost of coal	$4580.	$5440	$5320	$7480	$6550
Labor (engineer and two helpers)	$1680	$1680	$1680	$1680	$1680
Fixed Charges including oil, packing, insurance, repairs and miscellaneous	$750	$750	$750	$750	$750
Total. . .	$7010	$7870	$8750	$9910	$8980
Head pumped against	198 ft	198 ft	198 ft	247 ft	247 ft

The cost is high due to the low efficiency of the pumps and boilers and to the cost of hauling coal. To compare the present cost of operation with that estimated if electric power were installed, we have obtained from the Public Service Company of Central Illinois, the cost of power which was quoted at $.02125 per thousand gallons pumped. The expenses of operation would then be approximately as follows:

Labor	$1,680.
Packing	10.
Repairs	75.
Oil	25.
Miscellaneous	50.
Electric service assuming a consumption of 700,000 gallons per day	5,470.
Total. . .	$ 7,210.

This shows a saving from $1,090. to $2,090. per year when coal costs from $2.62 to $3.00 per ton.

With present methods of pumping and assuming 700,000 gallons are pumped per day, the cost per million gallons is $35.10, or in other terms 51.2 gallons per pound of coal used.

TESTS

Chemical and Bacteriological

Physical and chemical tests were made on the water supply at four different points in the process of purification. The following table gives the results of the tests as made on the raw water at the intake, on the treated water as it entered the sedimentation basin, on the settled water as it went onto the filters, and on the filtered water taken from a faucet in the pump house.

February 12, 1915

No. of sample	Where taken	Time	Turbidity	Color	Odor Hot	Odor Cold	Alkalinity	Strength of Alum Sol.
1	At intake	1 P.M.	45	26	e-1	e-2	200	
2	Entrance sedimentation basin	1 P.M.	14	0	0	0	186	2%
3	Entrance of filters	2 P.M.	14	0	0	0	186	
4	At faucet	2 P.M.	0	0	0	0	180	
5	At intake	4 P.M.	40	20	e-1	e-1	196	
6	Entrance sedimentationbasin	4 P.M.	20	0	0	0	194	2%
7	Entrance of filters	4 P.M.	20	0	0	0	190	
8	At faucet	4 P.M.	5	0	0	0	180	

February 13, 1915

No. of sample	Where taken	Time	Turbidity	Color	Odor Hot	Odor Cold	Alkalinity	Strength of Alum Sol.
9	At intake	10 A.M.	55	26	e-1	e-1	220	
10	Entrance sedimentation basin	10 A.M.	30	0	0	0	216	2%
11	Entrance of filters	10 A.M.	20	0	0	0	202	
12	At faucet	10 A.M.	5	0	0	0	194	
13	At intake	1 P.M.	50	21	e-1	e-1	202	
14	Entrance sedimentation basin	1 P.M.	20	0	0	0	202	2%
15	Entrance of filters	1 P.M.	20	0	0	0	200	
16	At faucet	1 P.M.	10	0	0	0	178	

Samples of the water were plated on agar and the following bacterial counts made after incubation at the State Water Survey laboratory in Urbana, Illinois.

February 13, 1915

No. of Sample	Where taken	Count Dilution 0.1	Dilution 0.01	Number of bacteria per cc.
1	At intake	* 380	40	3800
2	Entrance sedimentation basin	* 171	14	1710
3	Entrance of filters	40	*15	1500
4	At faucet	* 80	15	800

* These plates contained the better growths and were considered as being representative.

TESTS BY STATE WATER SURVEY

Chemical and bacteriological tests were made on the water by the State Water Survey. The samples sent in were, one gallon of raw water taken at intake, one gallon of filtered water taken at faucet; also a bacterial bottle of the water taken at both the places named above.

Results

	Raw Water	Filtered Water.
Turbidity	30	10
Color	10	3
Odor	2 v	0
Residue on evaporation	330	319
Chlorine in chlorides	6	6
Oxygen consumed	3.4	1.6
Nitrogen as:		
Free Ammonia	0.082	0.050
Albuminoid Ammonia	0.144	0.096
Nitrites	0.025	0.00
Nitrates	4.40	4.40
Alkalinity	194.	176.
Bacteria per cc.		
Gelatine	5000	3750
Agar	2500	2700
Gas Formers		
10 cc.	1+	1+
1.0 cc.	2+	2-
0.1 cc.	2-	1-1+

Note:- Raw water should be treated before being used for drinking purposes.

Note:- Treatment has reduced turbidity and color. Since the bacterial samples were uniced an accurate opinion with regard to the bacterial analysis cannot be given. The number of bacteria is quite high, but since gas formers are negative in the lower dilutions the water is safe for drinking.

H. P. Corson
Chemist and Bacteriologist

SUMMARY AND CONCLUSIONS

On the basis of the foregoing detailed descriptions and discussions, we conclude that the water purification works at Charleston will render much better service if changes and improvements are carried out as follows:

(1) Alum as a coagulant and hypochlorite as a sterilizing agent should be used at all times. The former for the purpose of insuring under all conditions a clear, limpid water and to prevent penetration of fine material into the sand of the filter beds; the latter to insure under all conditions, a water free from disease germs.

(2) Daily tests for turbidity, color, and alkalinity should be made at the filter plant by the filter attendant so that a reliable measure of the coagulant required to effectively clarify the water may be substituted for the present haphazard practice of using the appearance of the water in the coagulation basin as a criterion. In addition to tests made at the plant, more complete analyses including daily determinations of total bacteria and the presence of the colon bacillus should be made under suitable arrangements by the instructors in chemistry at the State Normal School.

(3) The employment of at least one filter attendant is highly essential to the successful operation of the filter plant. At the present time this duty is relegated to pumping station attendants whose ordinary duties demand all of their time.

(4) Wash water should be used at a rate to produce

a vertical rise of nine inches per minute as a minimum. During earlier inspections by the State Water Survey, it appeared that this rate of rise was being attained, but during the recent examination made by us, the vertical rise was but three inches per minute.

(5) The soiled wash water from the filters should be discharged at a more remote point in a downstream direction from the intake. Eddy currents near the present point of discharge, which is but 25 feet below the intake, causes the dirty water to enter the intake, thus placing an unnecessary burden on the purification works.

(6) The filter loss of head gages which have fallen into neglect and disuse should be placed in good repair so that the condition of the filters may be observed at all times, a necessary prerequisite to correct and economical washing.

(7) The apparently minor defect of drainage openings placed in the bottom of the skimming trough at the outlet to the sedimentation basins, very materially reduces the quality of the settled effluent. The defect may be readily remedied by placing plugs in the openings which plugs may easily be removed whenever it becomes necessary to drain the trough.

(8) Much inconvenience to the operators is caused by the imperfect drainage and absence of light in the pipe gallery. Though not directly responsible for the quality of the water produced by the works, it is important that adequate drainage be provided and that more light be admitted, preferably by means of basement windows or in any event by electric lighting, using at least three 40 candle power bulbs.

(9) The heating apparatus in the filter building should be placed in good repair and the temperature throughout the winter season should be kept at not less than sixty degrees so that the filter attendant may be constantly on duty without unnecessary personal discomfort.

While the purpose of our investigation was primarily to examine the purification works, our observations brought forth a number of defects relating to other water works equipment and our conclusions with reference to these are presented in the following:

(1) The pumping station building is a poorly built structure , in a very dilapidated condition and constitutes a serious fire risk. This building should be replaced with a more substantial structure, preferably fire proof throughout. If for financial reasons, this is impracticable, the existing structure should be overhauled, and made more habitable and presentable.

(2) Pumping machinery because of its rather inaccessible location in the pump pits is seriously neglected. The pump pits should be cleaned, properly drained and made easily accessible. The pumps should be overhauled and kept in good condition and to this end it would be highly desirable to provide more pumping station assistants.

(3) It appears from the limited cost data available that the cost of pumping water at Charleston is excessive. No doubt this is in part due to the poor condition of the pumping machinery and boilers and in part due to the cost of coal which must be hauled two and one-half miles by wagons over poor roads. This latter fact suggests the advisability of investigating carefully the use of

electrically driven pumping machinery, possibly maintaining the existing steam equipment for emergency use.

(4) Hitherto there have been no adequate means of ascertaining the economy and efficiency with which the water works are being operated. To eliminate this defect, a meter with automatic recording device should be installed on the main discharge from the pumping station and systematic records should be maintained of all water works operations.

(5) The grounds about the pumping station and filter plant should be neatly parked and laid out with lawns, shrubbery and trees, all of which may be accomplished at relatively small expense. While this may appear to be purely an esthetic consideration, it nevertheless has its practical value, in that it stimulates the interest of the public in the municipal water works and also stimulates the pumping station and filter attendants to better care of the equipment in their charge.

View showing pond and concrete
Intake

View showing layout of water
works

View showing sedimentation basin and filter

house