City of Portage
Water System Reliability Study

Prepared For:
City of Portage
Portage, Michigan

August 29, 2019
Project No. 181560

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List of Abbreviations/Acronyms

ADD	average daily water demand
CIP	Capital Improvements Plan
City	City of Portage
EGLE	Michigan Department of Environment, Great Lakes, and Energy
GIS	Geographic Information System
gpm	gallons per minute
ISO	Insurance Services Office
MDD	maximum daily water demand
MDEQ	Michigan Department of Environmental Quality (now known as EGLE)
MG	Million Gallons
mgd	million gallons per day
psi	pounds per square inch
REU	Residential Equivalent Units
SCADA	Supervisory Control and Data Acquisition
State	State of Michigan

1.0 Executive Summary

The City of Portage (City) owns and operates a municipal water system which supplies water to the City's residents, parts of western Pavilion Township, and parts of Schoolcraft Township. The water system is supplied by 19 supply wells, 4 of which pump water through an arsenic and iron removal plant. In addition, the water system has two elevated storage tanks, the Haverhill Tank with a volume of 0.75 million gallons (MG) and the Pineview Tank with a volume of 1.5 MG. The Michigan Department of Environment, Great Lakes, and Energy (EGLE) requires that each public water supply complete a Reliability Study and update their General Plan every five years. This report was completed as part of a water system Reliability Study and General Plan to fulfill the requirements for the City.

The City's water system was analyzed using a variety of metrics as recommended by EGLE. These metrics give a general picture of the condition of the system. An overall assessment of the system was made using a calibrated hydraulic model, with respect to pressures and available fire flow.

The historical water demands of the system were analyzed for the City and were found to trend downwards from 2009 to 2018. A conservative approach of assuming no-growth was used to project future demands. Table 1 shows the current and projected water demands for the City.

Table 1 – Water System Demand Projections

Year	Average Day Demands (mgd)	Maximum Day Demands (mgd)	Peak Hour Demands (mgd)
2019	5.59	16.08	24.12
2024	5.59	16.08	24.12
2039	5.59	16.08	24.12

*mgd – million gallons per day

The percentage of unaccounted water, or unbilled water, in the system was also evaluated. An average unaccounted water percentage of 22.29% was calculated for the City. A value of 10% unaccounted water is a typical goal for municipal water systems. Recommendations to decrease unaccounted water include replacement of aged pipe, replacement of aged meters for customer services (especially the largest users), and regular calibration of key meters at the supply wells and the Garden Lane arsenic removal plant.

The production capacity of the water supply facilities was also evaluated. EGLE generally requires that communities begin planning for an expansion of their supply system when their maximum day demands exceed 80% of the firm supply capacity, which is the capacity with the largest process unit out of service. The projected maximum day demands for the City are below 80% of the firm capacity of the water supply system based on the projected demands for the next 20 years, and the supply capacity is considered to be adequate for the planning period.

The water storage available to the system was also examined. The usable storage volume was calculated to be 695,000 gallons lower than recommended to meet equalization, emergency, and fire flow storage needs. It is recommended that the City add additional well capacity or water storage to meet the system's storage deficiency.

The ability to provide adequate pressures and fire flows was evaluated for the City system, using the Ten States Standards and City guidelines for available fire flow as benchmarks. The pressures were evaluated through the system for a worst-case scenario, at a projected 2039 peak hour demand condition. Pressures throughout the system remained above 35 pounds per square inch (psi) at all locations, the minimum pressure recommended

by the Ten States Standards. The available fire flow was evaluated during a 2039 maximum day demand. A target available fire flow of 1,500 gallons per minute (gpm) was chosen based on the previous Reliability Study for the City. Areas that did not meet this available fire flow goal were typically near older and smaller mains in the system, and dead-end mains.

A Capital Improvements Plan (CIP) was created for 0- to 5-year water distribution system and water supply improvements for the City. The City's existing 5-year CIP was considered in the formation of the CIP for this report. No improvements are recommended for the 6- to 20-year period beyond regular well maintenance. The estimated costs are preliminary in nature, and any project should include an updated budgetary estimate for its total projected cost. The total costs of the recommended improvements are shown in Table 2.

Table 2 - CIP Improvement Costs

Improvement Category	Total Cost of Improvements
5-Year Distribution Improvements	$6,331,000
5-Year Facilities Improvements	$9,160,000

2.0 Introduction

The City of Portage (City) owns and operates a municipal water system which supplies water to the City's residents, parts of western Pavilion Township, and parts of Schoolcraft Township. The City water system is a groundwater supply system with a rated firm capacity (capacity with the largest supply unit out of service) of 20.34 million gallons per day (mgd).

In 2018, the City retained Fishbeck, Thompson, Carr & Huber, Inc. (Fishbeck) to complete a Reliability Study and General Plan update for the City water system. The Reliability Study and General Plan are required to comply with the Part 12 and Part 16 rules of the State of Michigan (State) Safe Drinking Water Act, P.A. 399. A Reliability Study is required every five years, focusing primarily on evaluation of firm capacity of the water system to meet present and projected future water demands. An update to the General Plan is also required every five years, focusing primarily on the hydraulic performance of the distribution system and the development of 5-year and 20-year capital improvements plans. As part of the study, Fishbeck updated the existing WaterGEMs hydraulic model of the combined system and conducted hydrant flow testing and calibration. This report is intended to meet the State requirements for a Reliability Study and General Plan for the City system.

3.0 Water Distribution System

The City water system serves the City of Portage, parts of western Pavilion Township, and parts of Schoolcraft Township. The system has 2 elevated storage tanks, the Haverhill Tank and the Pineview Tank, that provide system pressure stabilization, fire flows, and emergency flows.

3.1 Service Connections and Residential Equivalent Units

The current number of service connections in the water system by meter size are shown in Table 3.

Table 3 - Service Connections

Meter Size	Totals
Unknown	55
5/8"	10,475
3/4"	1,731
1"	4,322
1 1/2"	514
2"	438
3"	47
4"	32
6"	10
10"	2
Total	**17,626**

The current number of service connections in the water system by customer type are summarized in Table 4.

Table 4 - Service Connections by Customer Type

Customer Type	Totals
Adult Foster Care	2
Churches	60
Commercial	1,500
Governmental	41
Industrial	95
Mobile Homes	5
Residential	15,885
Schools	38
Total	**17,626**

Table 5 summarizes the estimated Residential Equivalent Units (REU) for the City system. Each REU represents the water use for a single-family dwelling. For other types of customers, the REUs are estimated based on that customer's water use in comparison to a single-family unit.

Table 5 - System REUs

Meter Size	Number of Meters	REU Meter Equivalent	REUs per Meter Size
Unknown	55	1.0	55
5/8"	10,475	1.0	10,475
3/4"	1,731	1.1	1,904
1"	4,322	1.4	6,051
1 1/2"	514	1.8	925
2"	438	2.9	1,270
3"	47	11.0	517
4"	32	14.0	448
6"	10	21.0	210
10"	2	29.0	58
		Total Estimated REUs	**21,914**

3.2 Water Main

The water distribution system General Plan Map for the City is illustrated in Figures 2 to 4. Based on modeling data, there are more than 232 miles of water main in the City water distribution system. The water mains in the water system evaluated in this report range from 4 to 20 inches. The lengths of water main are listed by diameter in Table 6.

Table 6 – Main Lengths by Pipe Diameter

Diameter (inches)	Pipe Length (feet)	Percent of Pipe by Length
4	1,628	0.13%
6	201,902	16.45%
8	560,356	45.66%
10	37,798	3.08%
12	281,784	22.96%
14	622	0.05%
16	106,211	8.65%
20	36,899	3.01%
Total	1,227,200	100.00%

The City water main lengths are indicated by pipe material in Table 7. The material proportions shown in Table 7 are based off those found in the hydraulic model.

Table 7 – Main Lengths by Pipe Material

Pipe Material	Pipe Length (feet)	Percent of Pipe by Length
Cast Iron	319,985	26.07%
Ductile Iron	906,593	73.87%
PVC	622	0.05%
Total	1,227,200	100.00%

The approximate years of installation for mains throughout the City System are listed by their corresponding length in Table 8. These years of installation were estimated from the City's Geographic Information System (GIS) database.

Table 8 – Main Lengths by Pipe Age

Approximate Year of Installation	Pipe Length (feet)	Percent of Pipe by Length
Unknown	50,581	2.25%
1950 - 1960	415,684	18.48%
1961 - 1970	152,014	6.76%
1971 - 1980	155,425	6.91%
1981 - 1990	144,052	6.40%
1991 - 2000	165,284	7.35%
2001 - 2010	138,041	6.14%
2011 - Current	6,120	0.27%
Total	1,227,200	100.00%

3.3 Water Storage

The City system has a one composite and one steel elevated storage tank. The parameters of the two tanks are shown in Table 9.

Table 9 – Elevated Tank Parameters

Tank Name	Haverhill Tank	Pineview Tank
Type	Steel	Composite
Volume (gallons)	750,000	1,500,000
Overflow Elevation (feet)	1,035.3	1,035.3
Total Head Range (feet)	30	40
Date Constructed	1962	1992

The tanks are reported to be in good physical condition. The Haverhill Tank was last inspected in 2018, the interior was painted in 2009 and the exterior was painted in 1998. The Pineview Tank was last inspected in 2015, the interior was last painted in 1992 and the exterior was painted in 2012. It is recommended that elevated tanks be inspected every 5 years.

4.0 Historical Water Use

4.1 Water Demands

Historical water pumpage data for the past 10 years, 2009 to 2018, was compiled and reviewed. The amount of water pumped to the system was assumed to be equivalent to water demand in the system for the purposes of this study. The average daily water demand (ADD) is the annual average daily water volume pumped to the system. The maximum daily water demand (MDD) is the maximum water pumped to the system in a single day for a given year. The peaking factor is the calculated ratio of the MDD to the ADD. These values are displayed in Table 10.

Table 10 - Portage Water Demands

Year	ADD (mgd)	MDD (mgd)	Peaking Factor (MDD:ADD)
2009	5.51	12.63	2.29
2010	4.90	12.46	2.54
2011	4.97	12.53	2.52
2012	5.74	17.03	2.97
2013	5.02	12.67	2.52
2014	4.95	12.65	2.56
2015	4.57	9.16	2.00
2016	4.73	9.68	2.05
2017	4.89	11.52	2.36
2018	4.70	10.12	2.15
Average	5.00	12.05	2.40
Maximum	5.74	17.03	2.97
Minimum	4.57	9.16	2.00
Standard Deviation	0.36		0.29
Average + 1 StDev	5.36		2.69
Average + 1.65 StDev	5.59		2.87

4.2 Unaccounted Water

Water distribution systems typically “lose” water due to unmetered usage, leaks, meter errors, firefighting, illegal water use, or other reasons. This lost water is referred to as unaccounted water, or non-revenue water. One metric that can help to indicate the health of a water system is the percentage of water supplied to the system that ends up unaccounted. An unaccounted water percentage of 10% or below is considered typical. Historical pumpage and billing data were examined to estimate the percentage of water lost or otherwise unaccounted.

Billing data was provided by the City for fiscal years 2015 to 2018. The City’s fiscal year begins on the 1st day of July of the preceding year and ends on the 30th of June of the year indicated as the fiscal year. For example, fiscal year 2015 would begin on July 1st, 2014 and end on June 30th, 2015. The billing data was compiled, analyzed, and compared to the pumpage totals to determine the amount of unaccounted water. The results of this analysis are shown in Table 11.

Table 11 - Total Unaccounted Water

Fiscal Year	Pumpage Total (MG)	Billing Total (MG)	Non-Revenue Water (MG)	Unaccounted for Water (%)
FY 2015	1,711	1,399	312	18.25%
FY 2016	1,730	1,312	418	24.18%
FY 2017	1,710	1,263	447	26.13%
FY 2018	1,714	1,361	353	20.61%

In general, municipal water systems strive to reduce unaccounted water to less than 10% of total water use. The City was significantly above the recommended 10% metric in each of four years analyzed. There are steps that can be taken to reduce unaccounted water for the City. The City could use a meter tracking and replacement program for larger users.

Most of the flow meters at the supply wells have been recently replaced. Continuing regular calibration of the meters at the treatment plant and the well houses will give the City an accurate picture of what is truly being pumped to the system. Reduction of unaccounted water can have a significant impact on increasing revenue and may relieve any future supply limitations.

4.3 Top Water Users

The City provided records of the demands for the top twenty water users, which were entered into the hydraulic model at their geographic locations. The remaining demands were allocated equally to the other nodes across the system. The top users and their associated average day demands are shown in Table 12.

Table 12 – Top Water Users

Rank	Customer Name	Average Daily Usage (gpm)
1	Edward Rose Apartments	78.53
2	Greenspire Apartments	44.08
3	Stryker Instruments	43.57
4	Zoetis	36.11
5	Freg-Harvard	30.35
6	Milham Meadows	23.36
7	Stryker Medical	20.76
8	Portage MI Investment	17.40
9	Crossroads Mall	17.31
10	Trillium Timberwood Crossing Apartment	14.15
11	Mann - Hummel	13.70
12	Medilodge of Portage	13.05
13	Colonial Acres Association LLC	11.23
14	Manatron Incorporated	7.69
15	Plazacorp Reality Advisors, Incorporated	7.61
16	Summit Polymers	7.52
17	Altera	7.22
18	Summit Polymers, Incorporated	7.15
19	Air Zoo	6.87
20	Spring Manor	4.60

5.0 Water Demand Projections

5.1 Population Projections

Historical population data and future population projections through 2030 were presented in the *City of Portage 2008 Comprehensive Plan* (City of Portage Planning Commission). Population projections for 2040 were extrapolated from the available projections through 2030. Table 13 summarizes historical population data and projections. The assumption was made that the percentage of the population served would not exceed 90%. It is recommended that the population projections made in the 2008 Comprehensive Plan updated to account for actual observed population growth over the past decade as part of the City's planning process.

Table 13 – Historical Population Data and Future Population Projections

Year	U.S. Census Data	Comprehensive Plan Projection	Annual Percentage Increase over Period	Percentage of Population Served	Population Served
1960	20,181	--	--	--	--
1970	33,590	--	6.64%	--	--
1980	38,157	--	1.36%	--	--
1990	41,042	--	0.76%	52.0%	21,342
2000	44,897	--	0.94%	75.8%	34,009
2010	46,292	--	0.31%	90.0%	41,663
2018	48,816	--	0.68%	90.0%	43,934
2020	--	51,133	2.37%	90.0%	46,020
2030	--	55,737	0.90%	90.0%	50,163
2040	--	59,834	0.74%	90.0%	53,851

5.2 Water Demand Projections

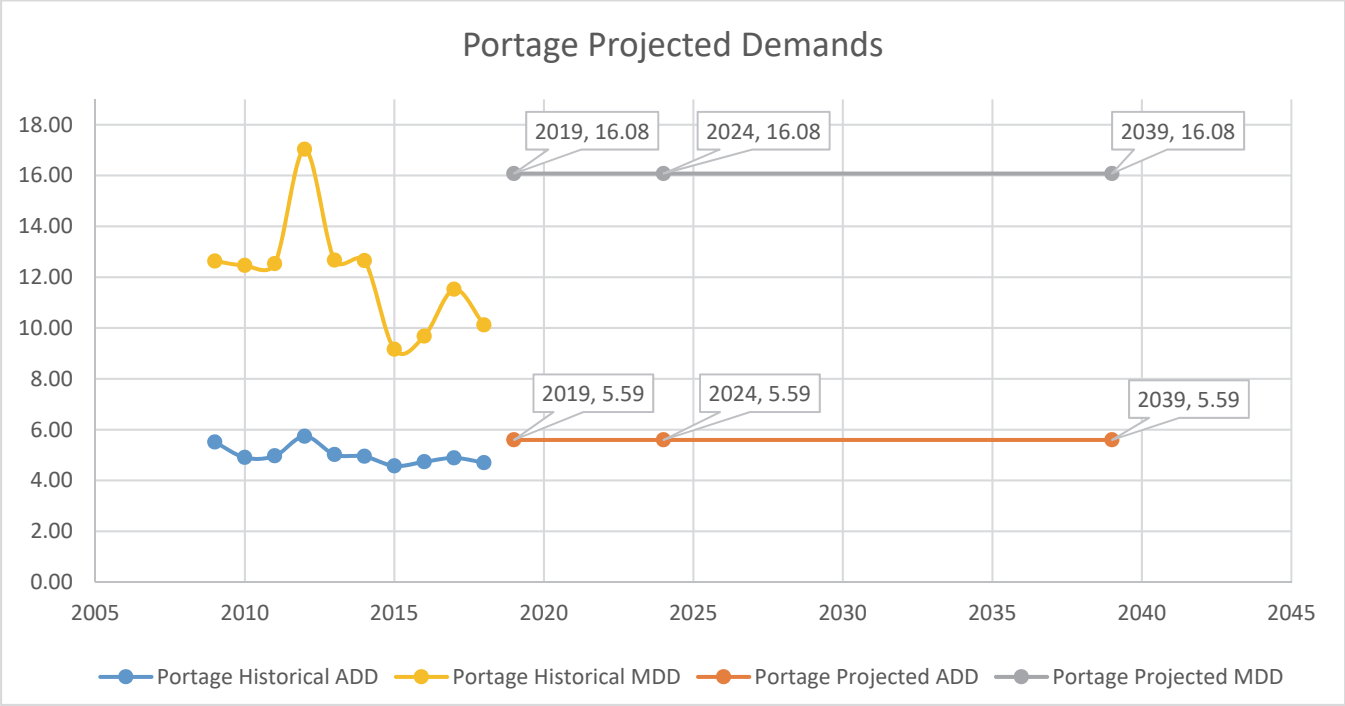
Both the ADD and MDD of the water system showed a trend of decreasing slightly over the last ten years, 2009 to 2018. The water demand trend has continued though population has increased. This is likely due the increased use of low flow fixtures required in current plumbing codes and increased awareness of water conservation practices. Increased water rates may be a contributing factor, but in general, rate increases are thought to only have short term impacts on reductions in water use.

For future projections, a no-growth assumption was used to project future demand values for the ADD. The projected ADD values are intended to most accurately reflect potential future demand values, while also remaining conservative enough to encompass future fluctuations in demand. The starting point for ADD projections was set equal to the average of the data plus 1.65 standard deviations. Statistically, this value will be greater than 95% of the predicted future values based on the observed data for the last ten years. This value is high enough to cover any spikes in demand, while remaining within the predicted future demand set. This approach assumes the data represents an approximately normal distribution.

The projected MDD values are intended to ensure the system can handle the highest water demand day that could be anticipated to occur in the projected time frame. This results in a more conservative number for the MDD values than for the ADD values. The projected MDD values were found by multiplying the projected ADD values by the average peaking factor plus 1.65 standard deviations, which will multiply the projected ADD values

by a peaking factor value that is statistically greater than 95% of the predicted future peaking factors based on observed data for the last ten years. The current and projected demands for the system using this method are illustrated in Figure 1.

Figure 1 – Projected Water Demands



Of note in Figure 1, is that the projected MDD valves are below the observed 2012 MDD of 17.03 mgd, which is an apparent outlier in the data set. The City has called this value into question due to operational practices which were prevalent at the time. In the past, operators for the City had come in early in the morning, around 6:00 AM, on weekends and holidays and taken meter readings at every well house as quickly as possible to leave the rest of the day free. On the subsequent weekday, operators would come in around 8:00 AM and take the whole day visiting each well house in turn, performing regular maintenance and taking meter readings. Due to this discrepancy in the timing of meter readings between the weekend or holiday and the subsequent weekday, the meter readings for certain wells would account for significantly more than a typical 24-hour reading, resulting in daily pumpage readings that were higher than they should have been. More recently, operational procedures have changed to more accurately reflect the actual maximum water demand observed within a 24-hour period.

The projected demands are shown in Table 14.

Table 14 – Water System Demand Projections

Year	Average Day Demands (mgd)	Maximum Day Demands (mgd)	Peak Hour Demands (mgd)
2019	5.59	16.08	24.12
2024	5.59	16.08	24.12
2039	5.59	16.08	24.12

6.0 Water Supply Evaluation

6.1 Water Source Facilities

6.1.1 Groundwater Supply Wells

The City water supply consists of 19 currently active wells throughout the distribution system. An iron and arsenic removal treatment plant treats water supplied from Garden Lane Wells 1 through 4. Well testing data was compiled and analyzed to determine the rated capacity of the wells and the actual tested capacity of the wells. Table 15 summarizes the well data for the City system.

Table 15 – Well Capacity Summary

No.	Well Name	Rated Well Pump Capacity (mgd)	2017 Well Pump Testing Capacity (mgd)	Capacity on Standby Power (mgd)
1	Amberly 1	1.44	1.44	1.44
2	Amberly 2	0.65	0.57	0.57
3	Garden Lane 1	1.15	0.93	0.89
4	Garden Lane 2	1.73	1.31	1.26
5	Garden Lane 3	1.44	1.70	1.41
6	Garden Lane 4	1.73	1.44	1.44
7	Garden Lane 5	0.92	0.94	0.94
8	Milham 1	1.15	1.22	1.22
9	Milham 2	1.30	1.44	1.44
10	Milham 3	1.30	1.28	1.28
11	Pershing 1	0.86	0.94	0.94
12	Pershing 2	0.86	0.81	0.81
13	Portage Creek	1.58	1.44	1.44
14	Rolling Hills	1.30	1.08	1.08
15	Shuman 1	1.44	1.44	1.44
16	Shuman 2	5.76	5.54	0.00
17	Wedgewood	0.58	0.66	0.66
18	Westfield 1	0.94	0.86	0.86
19	Westfield 2	0.79	0.88	0.88
	Total Capacity	26.91	25.87	19.95
	Firm Capacity	21.15	20.34	N/A

The actual tested capacity was used to determine overall well capacity for the system. Total capacity is the sum of the capacity of all wells in the system. The firm capacity the total capacity minus the capacity of the largest well. For the City, this would be the capacity with the Shuman 2 well out of service. The firm capacity of the system is calculated as 20.34 mgd based on the 2017 data. Note that the monthly production totals of each well in the system was also recorded. This data is included in Appendix 1.

In accordance with the Michigan Safe Drinking Water Act, Type 1 water systems are required to have a water supply with a firm capacity sufficient to meet maximum day demand. The City has a water supply with a firm capacity, 20.34 mgd, that exceeds its current and 20-year projected maximum day demand of 16.08 mgd.

EGLE recommends that municipalities start planning for water supply expansion when demands exceed 80% of the supply's firm capacity. The City's current and projected maximum day demands do not exceed this metric. Thus, it is not necessary that the City expand their water supply at this time.

The supply wells in the City water system are intended to provide water in the event of an emergency, and thus are outfitted with generators to provide flow with a power loss. Standby power is available to most of the supply wells in the system with the ability to provide a total 19.95 mgd to the system in the event of a power outage. Table 16 shows information on the generators and their locations. Table 15 indicates the available capacity of each well while running on standby power.

Table 16 – Generator Locations and Capacities

Location - Well	Address	Generator Make	KW-KVA	Volts-Phase	Engine Make	Fuel
Milham Well Site	822 W. Milham	Onan-Cummings	300 kw - 375 kva	480 V - 3 Ph	Cummins	Diesel
Shuman Well Site	9872 Oakland	Onan-Cummings	200 kw - 250 kva	480 V - 3 Ph	Cummins	Diesel
Garden Lane # 2	815 Garden Lane	Onan-Cummings	300 kw – 350 kva	480 V - 3 Ph	Cummins	Natural Gas
Garden Lane # 3	815 Garden Lane	Onan-Cummings	200 kw - 250 kva	480 V - 3 Ph	Cummins	Diesel
Garden Lane # 4	815 Garden Lane	Generac	150 kw - 188 kva	480 V - 3 Ph	Generac	Diesel
Garden Lane # 5	1054 E. Milham	Onan-Cummings	250 kw - 312 kva	480 V - 3 Ph	Cummins	Diesel
Portage Creek	1054 E. Milham	Onan-Cummings	300 kw - 337 kva	480 V - 3 Ph	Cummins	Diesel
Westfield	4210 W. Milham	Generac	150 kw – 188kva	480 V - 3 Ph	Generac	Natural Gas
Haverhill	6544 Marlow	Generac	35 kw – 44 kva	120/240 V - 1 Ph	Generac	Natural Gas
Pineview	9700 Pineview	Generac	35 kw – 44 kva	120/240 V - 1 Ph	Generac	Natural Gas

6.1.2 Water Treatment

There is a single arsenic/iron removal treatment plant that treats water from the Garden Lane Wells Nos. 1 to 4. The treatment plant uses four horizontal pressure filters to remove the arsenic and iron from the water. The plant has a firm capacity of 3,000 gpm. Table 17 shows the parameters of the arsenic/iron removal treatment plant.

Table 17 – Arsenic/Iron Removal Plant Parameters

Filter Type	Horizontal Pressure Filters
No. of Filters	4
Filter Dimensions - Diameter (feet)	7.0
Filter Dimensions - Length (feet)	13.4
Filtration Area, each Filter (ft^2)	100
Total Filtration Area (ft^2)	400
Normal Filtration Rate (gpm/ft^2)	10
Total Capacity	4,000
Filtration Area w/ one cell out	300
Firm Capacity	3,000

Note that there is currently no bypass around or through the plant. Thus, if the plant were to be out of service, water supply from Garden Lane Wells Nos. 1 to 4 would be unavailable as well. Note that this would not change the firm capacity of the system as the combined flow of the four wells does not exceed the capacity of the Shuman 2 well.

6.2 Water Shortage Response

The facilities have adequate resources and the ability to respond to emergency scenarios, such as power outages, water main breaks, water plant contamination/failure, storage contamination/failure, inorganic/organic contamination, bacteriological contamination, and water system depressurization.

In the event of an emergency power outage, the standby power systems at the individual wells are able to pump 19.95 mgd to the system, which exceeds the maximum day demands of the system. Water can also be provided on a temporary basis from the elevated storage in the system, consisting of a 0.75 MG and a 1.5 MG elevated storage tank. The elevated storage tanks could only supply water to the system for a short time, which would give the wells time to switch over to standby power. There is also an interconnection with the City of Kalamazoo near the intersection of Helen Avenue and Portage Road. This could be used in an emergency to supply the City of Portage water system.

Any extended reduction in well supply or distribution capacity would be addressed by City emergency response notifications and procedures.

7.0 Storage Assessment

The City water system was evaluated to determine if it has adequate storage capacity. This analysis was based on emergency storage, fire protection and operational equalization volume. The existing system has two elevated tanks, the Haverhill Tank with a volume of 0.75 MG and the Pineview Tank with a volume of 1.50 MG. EGLE has historically used a guideline that a system should have storage capacity equal to 25% of the maximum day demand for that system. The projected maximum day demand of the system is estimated at 16.08 MG and 25% of this value is 4.02 MG. To meet the EGLE guideline, an additional 1.77 MG of storage volume would be required.

However, the City water system has built-in reliability due to its excess well capacity with standby power. An analysis accounting for emergency, fire protection, equalization storage and excess well capacity was completed using the following equation:

(Equalization Storage) + (Higher of Fire Storage or Emergency Storage) – Excess Well Capacity = Required Storage

Equalization storage was calculated by multiplying the MDD by 25%. An emergency storage equal to 50% of the ADD was used. Fire protection storage was calculated based on a 6,000 gpm demand and a 6-hour duration. The emergency storage requirement was used in the equation as it was higher than the fire storage requirement. The details of this analysis are included in Appendix 2. A summary of the numbers used in the calculation are shown in Table 18.

Table 18 - Recommended Storage Requirement Calculation Metrics

Storage Requirement Metric	Volume (gallons)
Emergency (50% of ADD)	2,795,000
Fire Flow (6,000 gpm for 6 hours)	2,160,000
Equalization (25% of MDD)	4,020,000
Excess Well Capacity (Standby Well Capacity exceeding MDD)	3,870,000
Recommended Storage (based on calculation)	2,945,000
Existing Storage	2,250,000
Additional Storage Needed (Recommended - Existing)	**695,000**

The City has a deficit of 695,000 gallons of storage to meet the system's needs. It is recommended that the City add additional storage to make up the deficit. Alternatively, additional well capacity could be added instead of additional storage.

8.0 Water Distribution System Evaluation

The water distribution system evaluation included calibrating the hydraulic model with hydrant flow testing data obtained in the field. The calibrated hydraulic model was used to predict system performance. The system's reliability in meeting projected water demands and fire flows at adequate pressures was assessed. Recommendations were provided for system improvements based on the hydraulic modeling analysis.

8.1 Hydrant Flow Testing

A hydrant flow test analysis was completed on the model to identify locations where the system could be significantly stressed. In choosing the hydrant flow test locations, the age, diameter, location, and material of the pipes in the system were considered. In total, eight flow tests were completed with five hydrants used in each test. For each test, one hydrant was flowed, while residual pressures were observed at the hydrants not flowing. A list of the hydrant flow test locations is included in Appendix 3.

8.2 Model Calibration Adjustments

System operational data was recorded during the flow tests, including tank levels and pumps running. This data was used to adjust settings for pumps and tanks in the hydraulic model during calibration. The Hazen-Williams pipe friction C-factors were then adjusted over several iterations, so the hydraulic model output reflected field data. After calibration, the model was able to predict static and residual pressures within 3 psi for all the flow tests. The model calibration data is included in Appendix 4.

A Hazen Williams C-factor gives an indication of the condition of the pipe interior. As a reference, a C-factor of 130 is typically used for newly installed ductile iron pipe. A high C-factor indicates a good condition of the pipe. A C-factor of 50 or below indicates a pipe with a deteriorating interior. The C-factors, by water main lengths, used in the calibrated model of the City are listed in Table 19.

Table 19 – Main Lengths by C-Factor

C-Factor	Pipe Length (feet)	Percent of Pipe by Length
90 - 99	18,875	1.54%
100 - 109	251,191	20.47%
110 - 119	382,773	31.19%
120 - 129	548,558	44.70%
130 - 139	25,181	2.05%
140 - 150	622	0.05%
Total	1,227,200	100.00%

8.3 Model Runs at Projected Peak Hour Demands

The updated model was run at a 2019 peak hour demand condition to evaluate the current performance of the distribution system in a worst-case scenario. Since water demands are projected to remain steady through the next 20 years, the model run for 2019 peak hour demand would be an identical fit to the 2024 and 2039 peak hour demands. The peak hour demands for the large water users in the system were entered at their respective locations; the rest of the demand for the City was distributed evenly across the distribution system. The results

of the 2019 peak hour demand scenario are presented in Figure 6 in the form of pressure contours. The contours are drawn based on pressures at the junctions and other locations in the system, while within the limits of the contour, may not correspond exactly to the pressure shown; the contours are meant to be used as a visual overview of system performance.

The system pressures for City ranged from approximately 41.4 to 81.8 psi during the projected peak hour demand scenario, with a mean pressure of 63.6 psi.

8.4 Model Runs at Projected Maximum Day Demands for Fire Flow

The available fire flow analysis calculates the flow rate that can be withdrawn from the system at a given node in the model while maintaining a pressure of 20 psi at all other nodes in the model. This analysis was completed for each node in the system at a 2019 maximum day demand. Since water demands are projected to remain steady through the next 20 years, the available fire flow analysis run for the 2024 and 2039 maximum day demand scenarios are the same as presented for the 2019 maximum day demands. to.

The model interpolates fire flow values across the system, including the areas between the distribution mains. As such, the model will generate contour lines that extend over areas not served by the water system. Therefore, careful examination of the contour maps is necessary to identify areas with actual deficiencies. The results for the fire flow analysis are presented in Figure 5 in the form of available fire flow contours.

One important clarification to note is that the reported fire flows represent the flow available in the pipe at the location indicated. Quite often this flow can be higher than what a single hydrant can deliver, and multiple hydrants in the vicinity would be needed to get the reported flow rates out of the pipe. Depending on the hydrant and nozzle, maximum flows per hydrant may be in the range of 1,000 to 2,000 gpm. Fire hose or fire truck capacity may also impose similar limits on the maximum flow each hydrant can withdraw from the system.

A minimum fire flow goal of 1,500 gpm was established for use in the study based on the previous Reliability Study for the City. Industrial and commercial areas will require more fire flow using the same considerations. Areas with available fire flows less than 1,500 gpm were considered deficient for the purposes of this study.

There are several areas in the City system with available fire flows below 1,500 gpm. Aging 4- and 6-in pipe, particularly when not interconnected with larger, adequately-sized pipe, was often a source of the deficient fire flows. There are several locations in the City system where the small pipes are located at dead ends. The Ten States' Standards recommends the minimum diameter pipe that a fire hydrant can be connected to at 6 inches. There are locations where hydrants have been installed on 4-inch pipe. These pipes should be replaced with minimum 6-inch pipe as part of the City's pipe replacement program. In the case of some dead ends, a hydrant installed on a smaller pipe may be left in place for flushing purposes, but the customers served at the dead end should have adequate fire flow coverage off the adjacent mains.

8.5 Existing System Pressure Deficiencies

All areas of the water system are predicted to remain above the minimum 35 psi during projected peak hour demand conditions, the most conservative demand condition for the system. The model predicts that pressures drop below 40 psi in the northwest part of the system, due to the high elevation of that area. These areas have pressures which are marginal, but which meet the minimum pressure criteria.

8.6 Existing System Fire Flow Deficiencies

There are several areas in the City with available fire flows below the 1,500 gpm target. These are mainly in the northwest part of the system but also are present at the end of dead-end water mains. Section 9.0 includes water main improvements that would alleviate most of these fire flow concerns.

9.0 Recommended Improvements

Recommended improvements to the distribution system and to water system facilities are presented in this section. Where applicable, construction cost estimates are provided. Distribution system improvements are depicted on Figures 7 and 8.

9.1 5-Year Water Distribution System Improvements

The following are recommended improvements to water mains in the distribution system with corresponding construction cost estimates to be done within the next 5 years. These improvements were chosen as 0- to 5-year improvements based on several factors, coordination with road work, age of the water main, and hydraulic impact on the system. These improvements were considered a higher priority than the projects identified for the 6- to 20-year improvement period.

The difference in unit costs for the projects depends on the size of the main being installed and what kind of restoration must be done after main installation. The location of each improvement is illustrated on Figure 7 and listed in Table 20, along with the estimated costs of each improvement.

Table 20 - 5-Year Distribution System Improvements Estimated Costs

Project No.	Project Description/Location	Replacement Diameter (inches)	Main Length (feet)	Main Unit Cost ($/foot)	Water Main Cost
1	Replace water main along Idaho Avenue from Oregon Avenue to S Westnedge Avenue	8	2,770	$205	$568,000
2	Replace water main along Romence Road from Oakland Drive to Constitution Boulevard	12	3,085	$238	$735,000
3	Install water main along Wetherbee Avenue from Portage Road to Woodlawn Drive	8	1,070	$205	$220,000
4	Install water main along Nevada Avenue from Milham Avenue and Idaho Avenue	8	1,370	$205	$281,000
5	Install water main along Dakota Avenue from Milham Avenue and Idaho Avenue	8	1,370	$205	$281,000
6	Install water main along Ohio Avenue from Milham Avenue and Idaho Avenue	8	1,370	$205	$281,000
7	Replace water main along Shaver Road from West Centre Avenue to S Westnedge Avenue	12	2,796	$238	$667,000
8	Replace water main along Shaver Road from W Osterhout Avenue to Vanderbilt Avenue	12	7,761	$238	$1,848,000
9	Replace water main along Lakeview Drive from S Shore Drive to Portage Road	8	4,805	$205	$986,000
10	Install water main along Portage Road from Helen Avenue to Byrd Drive	8	490	$205	$101,000
11	Replace water main along E Milham Avenue from S Westnedge Avenue to Concord Street	12 & 16	1,490	$238 & $272	$363,000
				Cost of 5-Year Distribution System Improvements	$6,331,000

9.2 5-Year Water Facilities Improvements

The recommended improvements for the first 5 years of the CIP planning period, their estimated cost, and project year are shown in Table 21.

Table 21 - 5-Year Water System Facilities Improvement Estimated Costs

Project No.	Project Title	Project Cost	Short Description
1	Pineview Storage Facility Renovation	$350,000	Coating interior of Pineview Storage Facility
2	SCADA System Upgrade	$60,000	Complete upgrades to City SCADA system
3	Shuman Well Rehabilitation	$350,000	Rehabilitation of the Shuman Wells
4	Wellfield Improvements	$5,000,000	Planned Improvements to the City Raw Water System (from City's existing CIP)
5	Wellfield Improvements	$1,200,000	Planned Improvements to the City Raw Water System (from City's existing CIP)
Cost of 5-Year Water System Facilities Improvements		$9,160,000	

9.3 20-Year Water Distribution System Improvements

The 6- to 20-year period of the CIP was developed with the goal of replacing any water main that had reached the end of its useful life within the planning period. It was also developed considering creating a sustainable water main replacement schedule for the water system. A typical estimate of the useful life of a water main is about 100 years which equates to replacement of 1% of the water system per year.

The goal of a pipeline replacement program is to replace water mains before they fail. This is done by scheduling replacement based on anticipating the end of their expected useful life and adjusting based on performance indicators, such as pressures, fire flow, and main break frequency. To assess the condition of the City's water system, the expected and remaining useful life of each water main was calculated based on recommendations established in the AWWA report, "Buried No Longer." It is estimated that 0.2% of the City system will reach the end of its useful life within the next 20 years. Given this is such a small percentage of the system, no improvements are recommended for the 6- to 20-year period.

It is recommended that the City set aside a portion of the budget to pay for future water main projects while replacing any water main that reaches the end of its useful life. The recommended 5-Year CIP replaces 0.26% of the system per year, while the 20-year CIP recommends none of the system is replaced. A certain part of the budget should be set aside annually for future projects with the intention of achieving and annual average replacement of 1% of the water system in the future.

9.4 20-Year Water Facilities Improvements

There are no recommended capital improvements to water system facilities to be done in years 6 to 20 of the CIP. However, the City cleans and maintains all its wells on a ten-year rotation and completes an annual drawdown test on each well to ensure they are performing well. Money is set aside for this regular well maintenance.

9.5 Summary of Cost Estimation

Estimates of cost for distribution system improvements represent total project costs, including engineering and contingencies, for replacement of the water main and restoration of the driving surface directly above the main. Costs for replacement of adjacent utilities and road reconstruction are not included in the unit costs. Improvements should be coordinated with other utility and road replacement projects wherever feasible to maximize the benefit for the investment. City budgetary constraints will dictate the actual priorities and timing of construction for projects.

The construction cost estimates presented in this report reflect June 2019 costs. These opinions of cost were prepared to determine approximate project costs. There are a number of factors that could cause the actual project costs to deviate from these estimates. These include the competitive bidding climate at the time the construction bids are received, inflation, and additions to or changes in the scope of the project that may occur during the design process. The City should update estimated costs prior to proceeding with any future work and make necessary adjustments to determine the bidding climate in the year the work is proposed to be completed.

10.0 Discussion

This report has identified several areas of the City water system recommended for improvement. The following summarizes these recommendations.

10.1 Water Distribution System Improvements

Water main improvements were identified for the next 20 years based on coordination with planned road projects, hydraulic concerns, the age of water main and forming a sustainable water main replacement schedule. The water main improvements were arranged in order of approximate priority, but it is understood that this order may be changed for a variety of reasons. Thus, the CIP is mainly intended to set budgets for the next 20 years rather than provide a comprehensive plan of replacement.

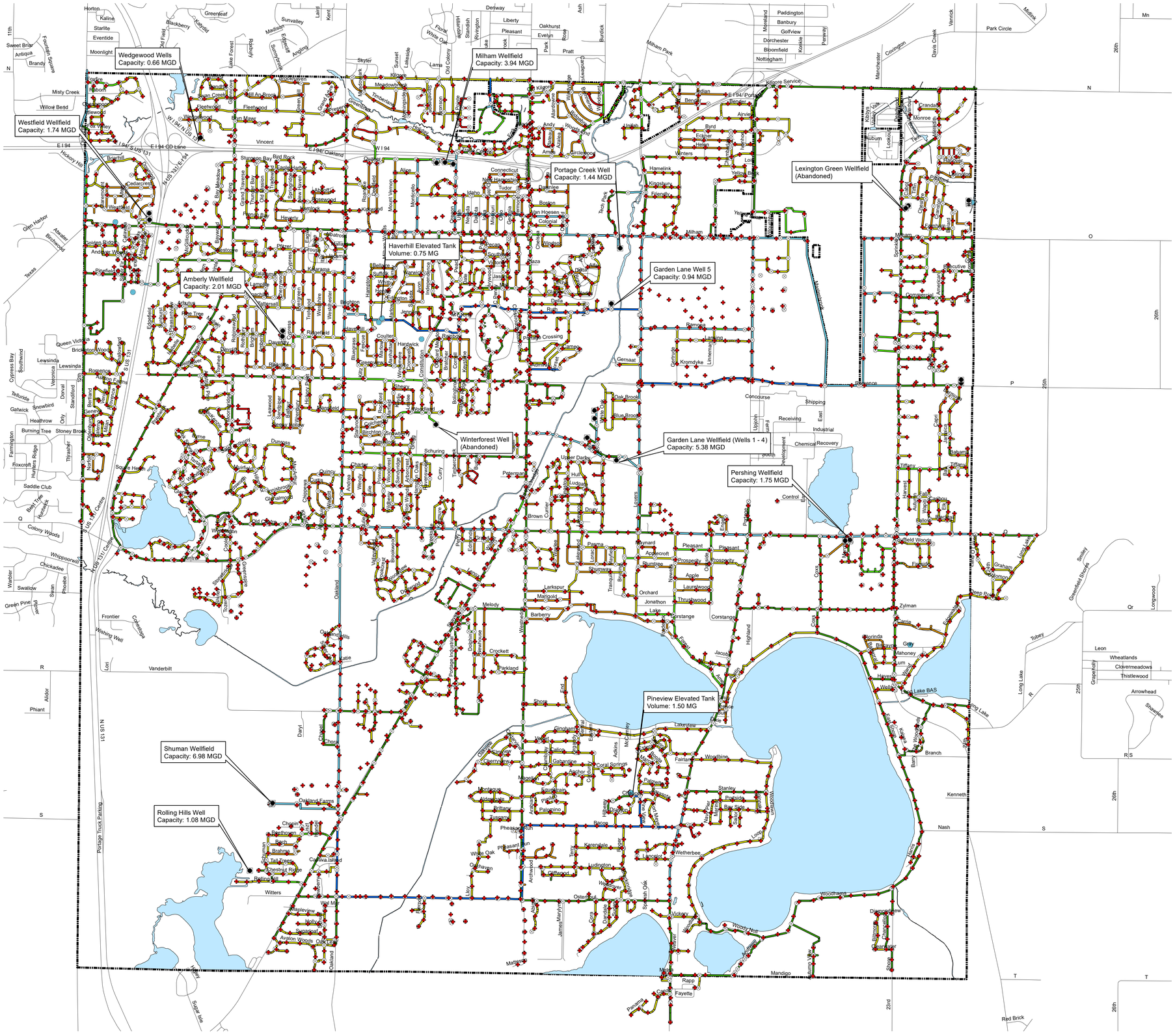
Some discussion of achieving a sustainable water main replacement schedule of 1.0% of the system annually is included in Section 9.0. The 5 and 20-Year CIPs do not currently meet the target replacement number of 1.0% because the system is fairly new. It does not make sense to replace water main before it is approaching the end of its useful life. Thus, the recommended 5-Year CIP replaces 0.26% of the system per year, while the recommended 20-Year CIP replaces none of the system. However, rates should be set to establish a replacement fund to allow an expanded pipeline replacement program in the future.

In general, the city plans replacement of cast iron water main located under paved surfaces with the reconstruction of a street. Cast iron water main located in the curb lawn on local streets are not as prone to breakage because the frost in not driven down by vehicular traffic. Water main breaks on major streets are prioritized because they pose a safety threat to workers.

10.2 Water System Facilities Improvements

General maintenance is needed for the well system. Future water storage improvements are recommended to make up the storage deficit of 695,000 gallons identified in Section 7.0.

Figures



LEGEND

- Pump
- Elevated Tank
- wHydrant
- wSystemValve

DIAMETER

- <= 4-inch
- 6-inch
- 8-inch
- 10-inch
- 12-inch
- 16-inch
- 20-inch
- 24-inch
- Roads
- city_boundary

GENERAL PLAN WATER MAIN DIAMETERS

NORTH

0 1,000 2,000 4,000 FEET

DATA SOURCES:

fhc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

City of Portage

Kalamazoo County, Michigan

Portage Reliability Study

Drawn By:

Designer:

Reviewer:

Manager:

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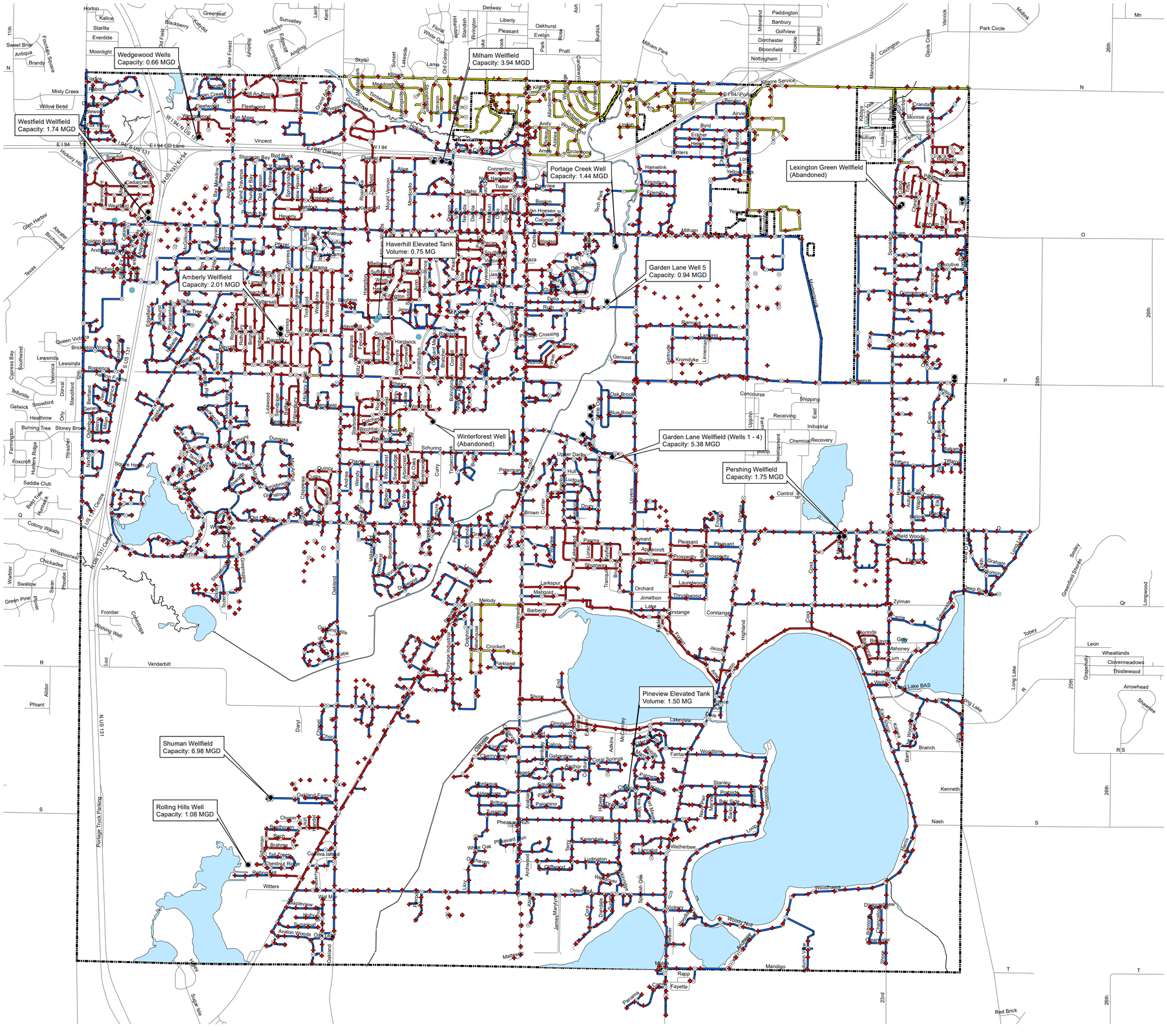

LEGEND

- Pump
- Elevated Tank
- city_boundary
- Roads
- wHydrant
- wSystemValve
- Unknown

MATERIAL

- Cast Iron
- Ductile Iron
- PVC

GENERAL PLAN
WATER MAIN MATERIALS

NORTH

0 1,000 2,000 4,000 FEET

DATA SOURCES:

fitc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

City of Portage
Kalamazoo County, Michigan

Portage Reliability Study

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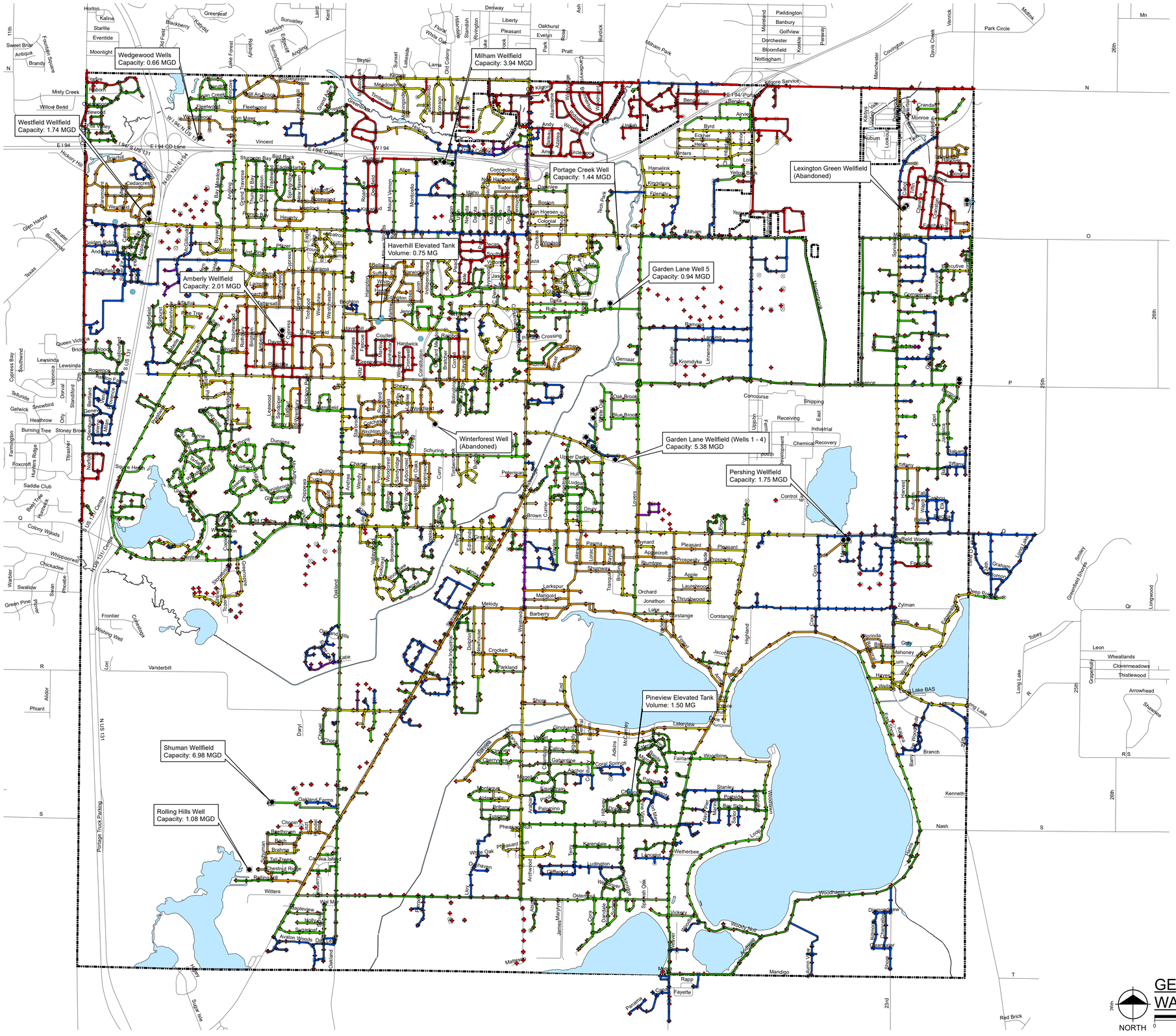

LEGEND

- Pump
- Elevated Tank
- Roads
- city_boundary
- wHydrant
- wSystemValve

Year

- 1958 - 1960
- 1961 - 1970
- 1971 - 1980
- 1981 - 1990
- 1991 - 2000
- 2001 - 2010
- 2011 - 2019

GENERAL PLAN
WATER MAIN INSTALLATION YEARS

NORTH

0 1,000 2,000 4,000 FEET

DATA SOURCES:

fitc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

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LEGEND

- Pump
- Elevated Tank
- Water Main
- Roads
- city_boundary

Available Fire Flow Contours

- <1500 gpm
- 1500 - 2000 gpm
- 2000 - 3000 gpm
- 3000 - 4000 gpm
- 4000 - 5000 gpm
- 5000 - 6000 gpm
- 6000 - 7000 gpm
- 7000 - 8000 gpm

NORTH

0 1,000 2,000 4,000 FEET

2019 MAXIMUM DAY DEMANDS AVAILABLE FIRE FLOW CONTOURS

DATA SOURCES:

fbc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

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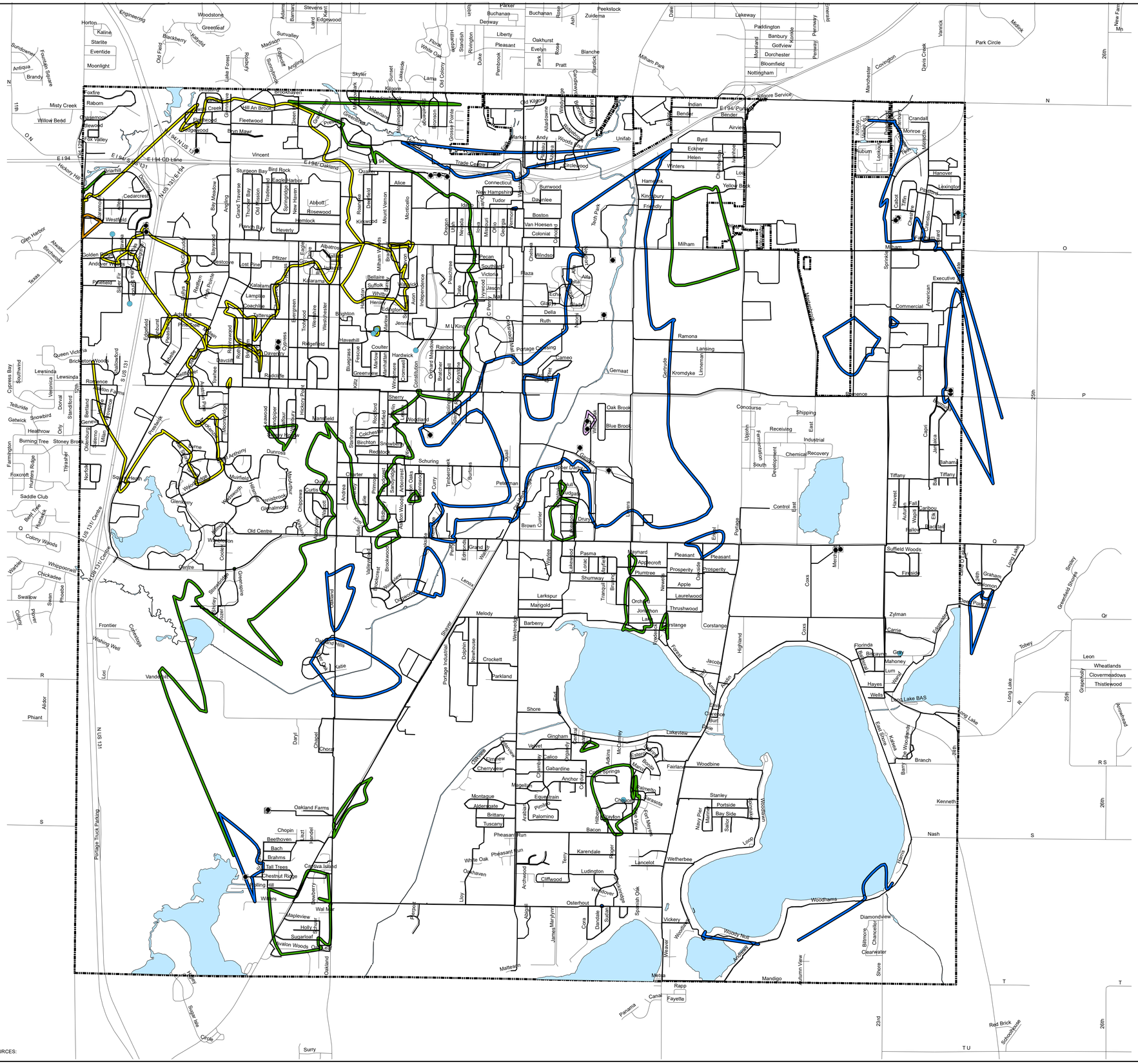

LEGEND

- Pump
- Elevated Tank
- Water Main
- Roads
- city_boundary

PKHR_PressureContours

- <35 psi
- 36 - 45 psi
- 46 - 55 psi
- 56 - 65 psi
- 66 - 75 psi
- 76 - 85 psi
- 86 - 95 psi

NORTH

0 1,000 2,000 4,000 FEET

2019 PEAK HOUR DEMANDS PRESSURE CONTOURS

DATA SOURCES:

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fhc&h

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Kalamazoo County, Michigan

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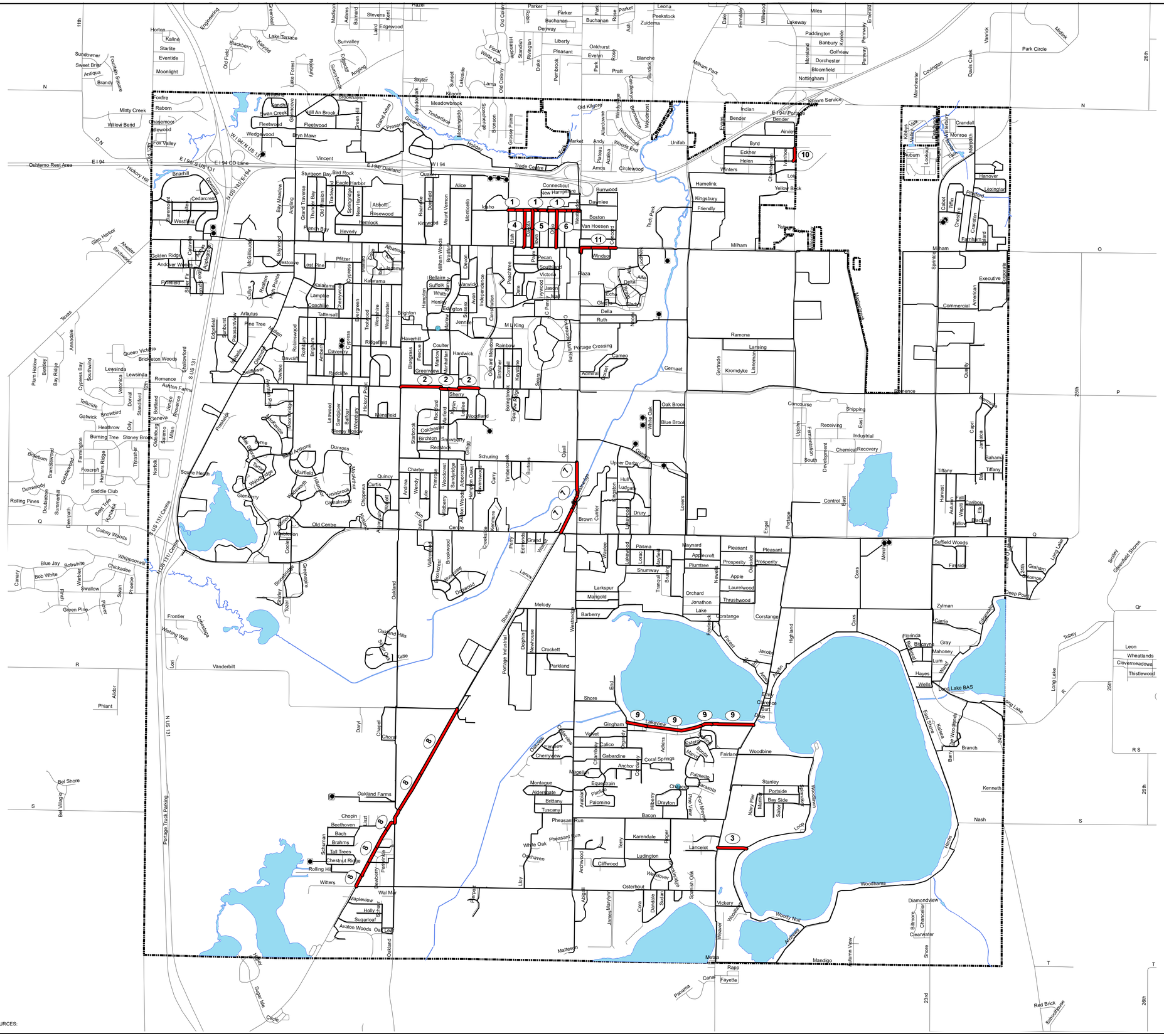

LEGEND

- Pump
- Elevated Tank

Water Main

Installation_Year

- 1958 - 2018
- 2019 - 2024
- 2025 - 2039
- Roads

5-YEAR IMPROVEMENTS

NORTH

0 1,000 2,000 4,000 FEET

DATA SOURCES:

fr|c&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

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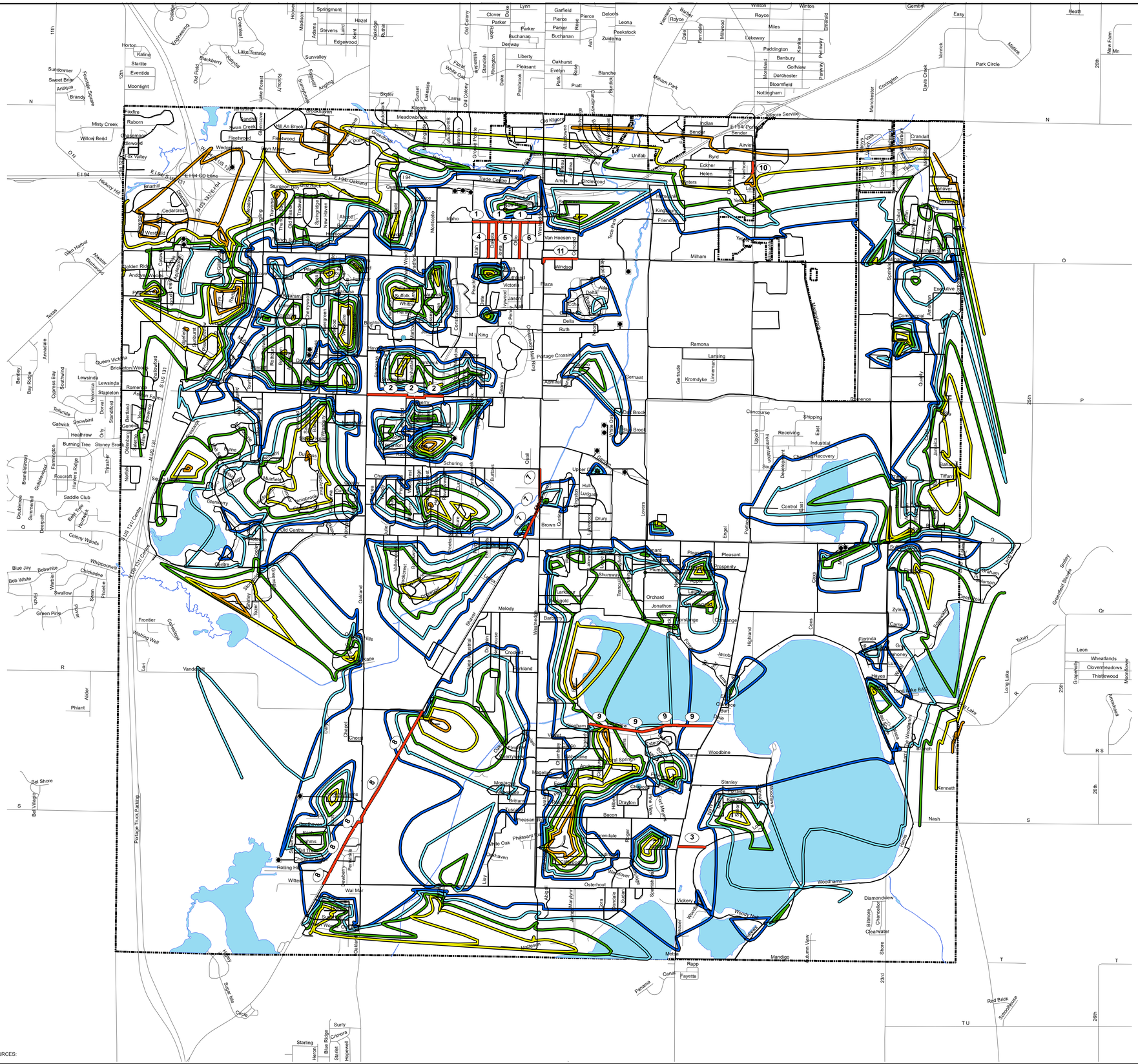

LEGEND

- Pump
- Elevated Tank
- Roads

Water Main

Installation_Year

- 1958 - 2018
- 2019 - 2024

Available Fire Flow Contours

- <1500 gpm
- 1500 - 2000 gpm
- 2000 - 3000 gpm
- 3000 - 4000 gpm
- 4000 - 5000 gpm
- 5000 - 6000 gpm
- 6000 - 7000 gpm
- 7000 - 8000 gpm

NORTH

0 1,000 2,000 4,000 FEET

5-YEAR IMPROVEMENTS
MAXIMUM DAY DEMANDS
AVAILABLE FIRE FLOW CONTOURS

DATA SOURCES:

fhc&h

engineers
scientists
architects
constructors

fishbeck, thompson, carr & huber, inc.

City of Portage

Kalamazoo County, Michigan

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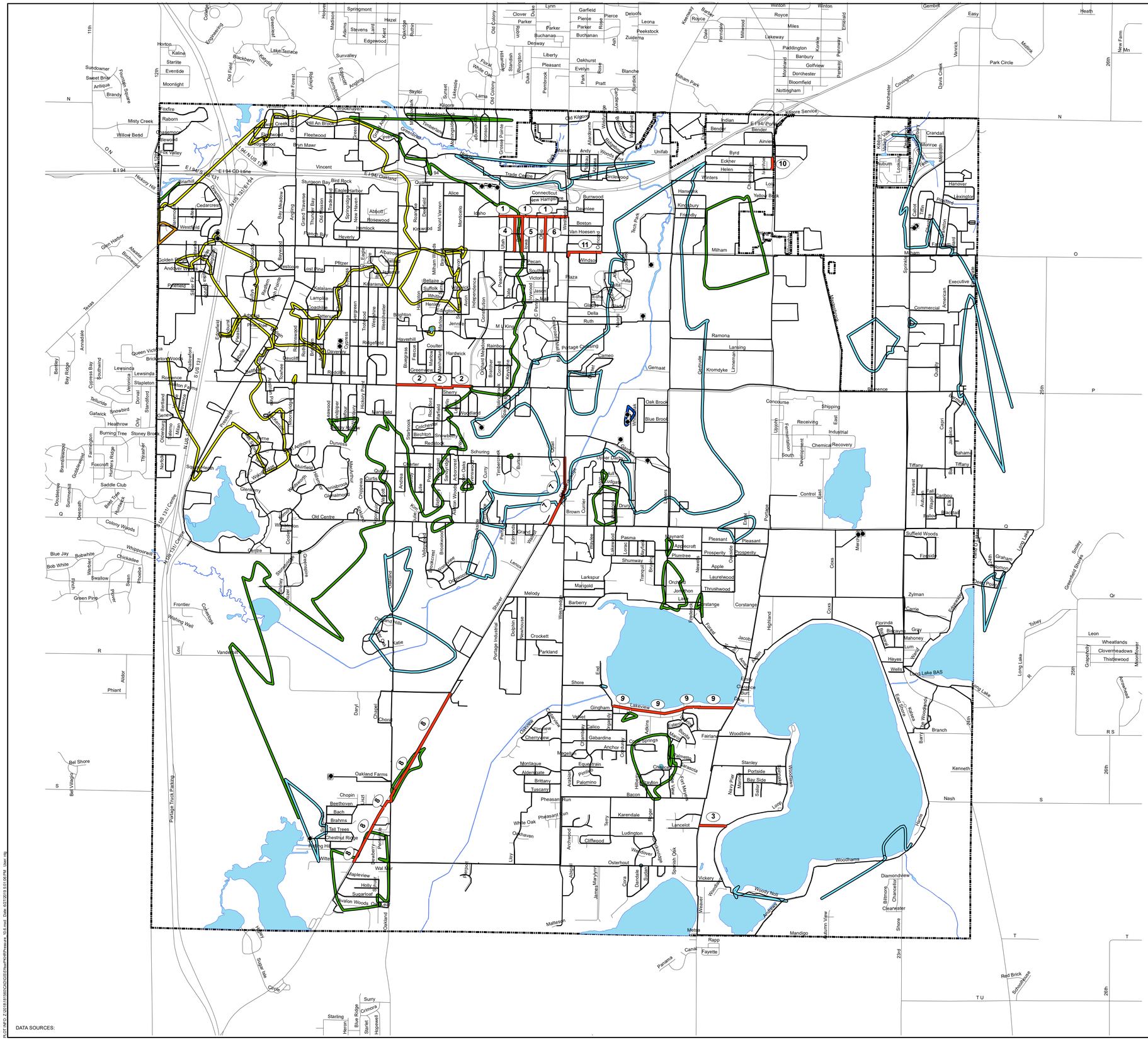

LEGEND

- Pump
- Elevated Tank
- Roads

Water Main

Installation_Year

- 1958 - 2018
- 2019 - 2024

Pressure Contours

- <35 psi
- 36 - 45 psi
- 46 - 55 psi
- 56 - 65 psi
- 66 - 75 psi
- 76 - 85 psi
- 86 - 95 psi

NORTH

5-YEAR IMPROVEMENTS PEAK HOUR DEMANDS PRESSURE CONTOURS

0 1,000 2,000 4,000 FEET

DATA SOURCES:

fitc&h

engineers
scientists
architects
constructors

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Appendix 1

Appendix 1 - Monthly Well Production

Year	Month	Amberly Well #1	Amberly Well #2	Garden Lane Well #5	Milham Well #1	Milham Well #2	Milham Well #3	Pershing Well #1	Pershing Well #2	Portage Creek Well	Rolling Hill Well	Shuman Well #1	Shuman Well #2	Wedgewood Well #1	Westfield Well #1	Westfield Well #2	Winter Forest Well	Garden Lane #1	Garden Lane #2	Garden Lane #3	Garden Lane #4	Reclaim Water	Total (MG)
2014	January	0.00	0.00	9.88	7.55	15.21	7.70	9.21	9.89	0.00	14.65	14.29	0.00	6.63	11.77	12.33	0.00	0.00	0.00	0.00	0.00	0.00	119.11
	February	0.00	0.00	11.25	3.67	7.46	3.87	10.56	11.39	0.00	15.61	14.53	0.00	7.40	12.95	13.88	0.00	0.00	0.00	0.00	0.00	0.00	112.57
	March	0.00	0.00	12.32	4.53	9.31	4.78	12.25	13.26	0.00	16.25	15.34	0.00	8.59	13.22	14.35	0.00	0.00	0.00	0.00	0.00	0.00	124.20
	April	0.00	0.00	11.25	5.11	10.26	5.08	8.98	9.68	0.00	16.68	6.95	0.00	6.20	13.01	14.04	0.00	0.00	2.68	1.40	3.93	0.20	115.45
	May	0.00	0.00	17.83	11.01	22.59	11.61	14.06	15.39	0.00	14.24	24.76	0.00	10.21	13.85	14.70	0.00	0.00	5.21	2.94	6.89	0.34	185.63
	June	0.44	0.19	16.13	13.54	28.47	14.82	14.33	15.80	0.00	13.93	22.12	0.00	9.93	15.45	16.66	0.00	0.00	0.27	0.14	0.00	0.00	182.22
	July	6.35	2.98	16.79	13.38	28.28	14.97	13.86	14.95	0.00	21.62	25.23	0.00	13.35	15.11	16.90	0.00	0.00	0.00	0.00	0.00	0.00	203.77
	August	18.57	8.35	17.47	14.12	29.98	15.71	14.37	15.37	0.00	19.68	24.58	0.00	10.63	27.50	32.10	0.00	0.00	0.00	0.00	0.00	0.00	248.43
	September	0.00	0.00	14.98	11.57	24.44	12.65	11.80	12.48	0.00	10.54	16.18	0.00	15.26	12.11	13.68	0.00	0.00	0.00	0.00	0.00	0.00	155.69
	October	12.71	5.65	12.38	2.86	6.02	3.45	13.31	10.29	0.00	13.57	15.40	0.00	5.62	10.54	11.90	0.00	0.00	7.63	0.00	13.88	4.09	149.30
	November	9.91	4.22	8.39	8.20	18.44	9.96	7.15	7.44	0.00	12.26	2.11	0.00	3.08	8.26	9.03	0.00	0.00	0.00	0.00	0.00	0.00	108.45
	December	0.00	0.00	6.76	9.56	22.71	10.30	9.79	10.35	0.00	7.66	10.40	0.00	0.63	7.59	8.64	0.00	0.00	0.00	0.00	0.00	0.00	104.39
2015	January	0.00	0.00	7.31	10.17	25.76	9.39	9.73	10.62	0.00	9.97	12.07	0.00	0.62	6.21	6.40	0.00	0.00	0.00	0.00	0.00	0.00	108.25
	February	0.00	0.00	7.25	8.95	21.89	11.07	6.19	5.95	0.00	3.02	15.99	0.00	4.15	14.28	9.57	0.00	0.00	0.00	0.00	0.00	0.00	108.31
	March	3.27	1.42	1.27	10.48	26.45	13.00	0.00	0.00	0.00	10.11	18.57	0.00	7.17	15.12	12.53	0.00	0.00	0.00	0.00	0.00	0.00	119.39
	April	8.01	3.54	0.00	9.72	20.58	11.46	7.20	7.55	0.00	14.98	14.41	0.00	6.71	10.20	10.85	0.00	0.00	0.00	4.50	0.45	0.43	130.59
	May	0.00	0.00	0.00	12.12	25.05	9.21	13.44	14.17	0.00	19.79	2.71	0.00	8.55	13.03	14.24	0.00	0.00	0.00	0.00	0.00	0.00	132.31
	June	11.41	4.71	0.00	11.87	24.62	8.17	13.46	14.16	0.00	19.76	0.21	0.00	8.52	13.52	14.70	0.00	0.00	0.57	0.00	0.00	0.07	145.75
	July	19.71	8.67	5.84	13.30	27.59	11.94	14.45	15.17	0.00	21.16	3.64	0.00	8.97	16.64	18.25	0.00	0.00	0.00	0.00	0.00	0.00	185.33
	August	22.47	9.91	12.26	10.93	22.85	13.06	21.61	22.68	0.00	17.09	18.50	0.00	17.56	13.52	15.27	0.00	0.00	0.00	0.00	0.00	0.00	217.71
	September	21.54	9.46	4.11	7.68	16.15	9.16	16.75	17.38	0.00	11.25	12.05	0.00	14.57	11.88	13.97	0.00	0.00	0.00	0.00	0.00	0.00	165.95
	October	18.48	7.99	9.22	8.12	17.06	9.67	14.57	15.05	0.00	13.22	5.87	0.00	6.70	8.88	9.73	0.00	0.00	0.00	8.25	0.00	0.25	153.06
	November	0.00	0.00	5.26	7.71	16.02	9.14	8.42	8.71	0.00	10.04	4.13	0.00	14.08	8.36	9.37	0.00	0.00	0.00	0.00	0.00	0.00	101.24
	December	3.20	1.34	2.82	8.08	16.77	9.60	9.75	10.12	0.00	7.98	11.30	0.00	8.33	6.21	7.05	0.00	0.00	0.00	0.00	0.00	0.00	102.55
2016	January	8.92	3.81	0.11	5.67	11.12	6.35	12.05	12.37	0.00	5.61	7.36	0.00	6.80	12.46	13.87	0.00	0.00	0.00	0.00	0.00	0.00	106.50
	February	12.82	5.58	3.53	3.79	7.71	4.39	11.33	12.02	0.00	1.37	1.34	0.00	7.83	11.03	11.97	0.00	0.00	0.00	1.29	0.00	0.08	96.08
	March	16.39	7.20	7.40	10.68	21.71	12.54	1.74	1.79	0.00	4.20	4.78	0.00	7.32	0.81	0.88	0.00	0.00	0.00	6.02	0.00	0.26	103.72
	April	18.28	8.04	10.31	9.76	19.52	11.09	8.17	8.46	0.00	5.57	6.38	0.00	7.89	7.06	7.68	0.00	0.00	0.00	10.16	0.00	0.34	138.71
	May	22.35	9.67	12.05	0.00	0.00	0.00	15.85	16.45	0.00	0.00	7.61	0.00	9.54	15.77	16.76	0.00	0.00	0.00	5.39	4.44	0.39	136.27
	June	21.40	9.25	12.55	20.26	23.38	13.38	15.77	16.21	0.00	0.00	2.94	0.00	10.48	12.97	13.60	0.00	0.00	0.00	1.50	52.89	1.68	228.26
	July	37.39	16.14	7.90	16.08	20.53	11.32	10.01	10.21	0.00	0.00	3.54	0.00	10.75	10.50	20.63	0.00	0.00	0.00	0.00	56.17	1.16	232.33
	August	15.50	6.69	9.84	16.58	22.34	11.48	8.07	8.31	0.00	0.00	5.72	0.00	13.75	11.00	10.61	0.00	0.00	0.00	0.00	52.54	1.31	193.74
	September	12.49	5.39	5.72	12.41	16.64	8.64	0.00	0.00	0.00	0.00	0.00	0.00	17.82	8.77	8.48	0.00	0.00	0.00	6.13	47.94	1.58	152.01
	October	11.82	5.08	6.03	12.31	15.33	8.63	0.00	0.00	0.00	0.00	0.00	0.00	19.28	8.24	7.72	0.00	0.00	0.00	39.87	4.94	1.20	140.45
	November	12.89	5.57	8.97	13.94	17.16	9.72	0.00	0.00	0.00	0.00	0.00	0.00	18.88	6.84	6.18	0.00	0.00	0.00	0.00	0.00	0.00	100.15
	December	0.00	0.00	5.77	10.61	23.70	13.48	1.04	1.07	0.00	0.00	0.00	0.00	19.37	13.98	13.18	0.00	0.00	0.00	2.20	0.00	0.09	104.49
2017	January	0.00	0.00	0.00	10.18	22.18	12.57	10.61	10.44	0.00	0.00	0.00	0.00	17.69	7.78	7.39	0.00	0.00	0.00	3.29	0.00	0.12	102.25
	February	0.00	0.00	0.00	8.18	11.59	6.55	4.48	4.59	0.00	0.00	0.00	0.00	3.35	3.42	3.25	0.00	0.00	0.00	45.60	0.00	1.47	92.48
	March	6.19	2.47	3.53	6.08	8.54	4.82	5.21	8.32	0.00	0.00	0.00	0.00	4.72	2.48	2.35	0.00	0.00	0.00	50.04	0.00	1.59	106.34
	April	0.51	0.20	4.72	8.22	11.26	6.52	7.55	7.93	0.00	0.00	0.00	0.00	5.98	6.88	6.52	0.00	0.00	0.00	43.77	5.23	1.41	116.70
	May	11.87	4.54	7.02	16.61	19.69	13.26	0.00	0.00	0.00	0.00	0.00	0.00	15.19	11.49	10.77	0.00	0.00	0.00	23.87	0.00	1.08	135.39
	June	31.20	12.48	12.87	21.58	25.23	17.45	16.24	14.47	0.00	0.00	0.00	0.00	16.53	16.65	15.71	0.00	33.00	0.00	0.00	0.00	2.33	235.74
	July	38.24	15.21	14.61	23.95	27.94	19.20	19.93	17.32	0.00	0.00	0.00	0.00	17.04	18.15	17.50	0.00	0.00	0.00	11.32	0.00	0.00	240.41
	August	38.26	15.12	6.44	17.76	21.60	14.76	15.41	13.35	0.00	0.00	0.00	0.00	16.91	14.55	27.48	0.00	0.00	0.00	45.73	0.00	0.00	247.37
	September	30.74	12.15	8.42	13.51	15.86	5.19	11.08	9.60	0.00	0.00	0.00	0.00	16.43	10.17	9.20	0.00	0.00	0.00	44.13	0.00	0.00	186.48
	October	28.28	11.13	3.54	9.20	10.77	7.15	6.01	5.19	0.00	0.00	0.00	0.00	12.76	6.83	6.20	0.00	0.00	0.00	23.56	0.00	0.24	130.86
	November	23.26	9.22	2.67	1.94	13.23	9.08	8.55	7.51	0.00	0.00	0.00	0.00	12.40	2.95	2.38	0.00	0.00	0.00	0.00	0.00	0.00	93.19
	December	9.23	3.63	1.76	0.00	9.14	6.31	6.06	5.30	0.00	0.00	0.00	0.00	13.94	0.00	0.00	0.00	0.00	0.00	41.32	0.00	2.50	99.19
2018	January	13.19	5.28	2.27	0.00	13.47	9.30	9.01	7.87	0.00	0.00	0.00	0.00	6.69	0.00	0.00	0.00	0.00	0.00	38.15	0.00	2.57	107.80
	February	10.68	4.29	2.73	0.04	10.63	7.03	7.23	6.33	0.00	0.00	0.00	0.00	6.78	0.00	0.00	0.00	0.00	0.00	36.09	0.00	2.46	94.29
	March	10.26	4.09	4.01	0.20	8.27	3.06	7.34	6.44	0.00	0.00	0.00	0.00	6.38	0.97	0.94	0.00	0.00	0.00	45.65	0.00	3.11	100.72
	April	15.52	6.20	2.78	7.41	11.68	6.72	9.81	8.58	0.00	0.00	0.00	0.00	7.00	9.31	8.81	0.00	0.00	0.00	15.01	0.00	1.03	109.86
	May	17.29	6.94	7.03	6.82	10.60	6.63	7.10	6.23	0.00	0.00	0.00	0.00	13.57	8.31	7.80	0.00	0.00	0.00	9.67	25.14	3.50	136.63
	June	33.82	13.65	6.77	5.76	8.22	5.64	8.40	7.39	0.00	0.00	0.00	0.00	4.45	8.04	7.54	0.00	0.00	0.00	35.28	23.20	2.93	171.09
	July	24.30	9.83	10.78	11.12	4.17	10.18	11.09	9.82	0.00	0.00	0.00	0.00	20.67	13.16	12.36	0.00	0.00	0.00	42.94	54.85	2.88	238.15
	August	0.00	0.00	0.00	8.65	14.53	6.53	11.59	10.06	0.00	0.00	0.00	0.00	22.13	10.79	10.04	0.00	0.00	0.86	39.10	54.23	2.97	191.48
	September	0.00	0.00	0.00	5.42	9.09	5.18	6.03	5.26	0.00	0.00	0.00	0.00	20.03	6.08	5.64	0.00	0.00	0.00	35.59	52.67	2.89	153.88
	October	0.00	0.00	0.00	8.73	14.66	8.45	8.63	7.55	0.00	0.00	0.00	0.00	20.65	9.59	9.07	0.00	0.00	0.00	7.22	31.67	1.62	127.84
	November	No Data																					0.00
	December	No Data																					0.00

Appendix 2

Appendix 2: City of Portage Water System Storage Volume Analysis
City of Portage, Michigan
Portage Reliability Study
Project G181560
5/2/2019

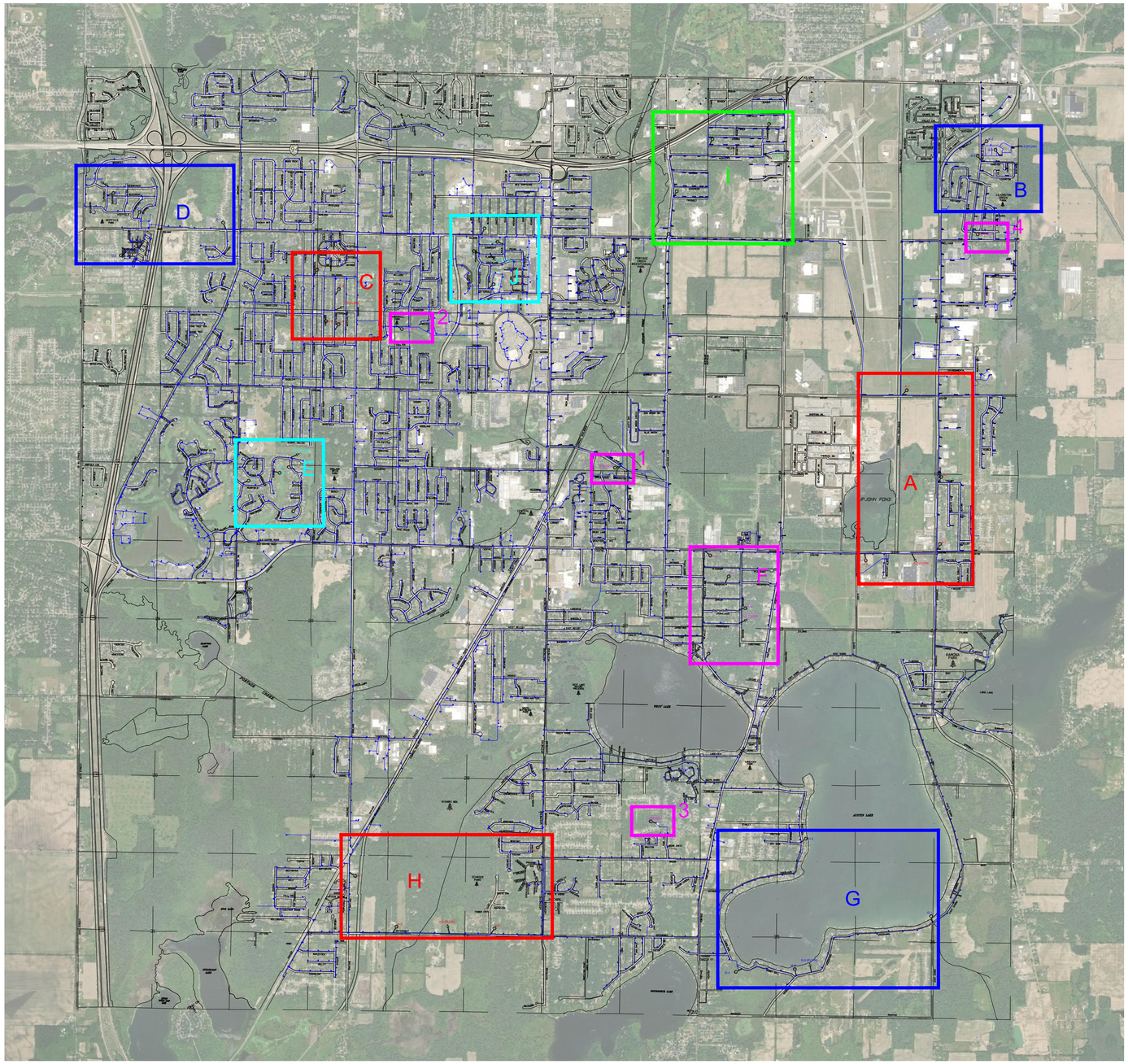
Year	Average Day Demand (mgd)	Maximum Day Demand (mgd)	Peak Hour Demand (mgd)	Suggested Fire-Flow[1] (gpm)	Duration[1] (hours)	Average Day Demand per 10 States[2] (gallons)	25% of Maximum Day Demand[2,3] (gallons)	Lowest of Two EQ Calculations (gallons)	Fire Demand[4] (gallons)	Emergency Storage - 50% of ADD (gallons)	Total Storage Needed (gallons)	Well Capacity with Standby Power (mgd)	Volume Supplied by Excess Well Supply (gallons)	Recommended Storage Volume (gallons)	Existing Storage Volume (gallons)	Recommended Additional Storage Vol. (gallons)
2019	5.59	16.08	24.12	1,000	2	5,590,000	4,020,000	4,020,000	120,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2019	5.59	16.08	24.12	2,500	2	5,590,000	4,020,000	4,020,000	300,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2019	5.59	16.08	24.12	3,500	3	5,590,000	4,020,000	4,020,000	630,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2019	5.59	16.08	24.12	6,000	6	5,590,000	4,020,000	4,020,000	2,160,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2039	5.59	16.08	24.12	1,000	2	5,590,000	4,020,000	4,020,000	120,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2039	5.59	16.08	24.12	2,500	2	5,590,000	4,020,000	4,020,000	300,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2039	5.59	16.08	24.12	3,500	3	5,590,000	4,020,000	4,020,000	630,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000
2039	5.59	16.08	24.12	6,000	6	5,590,000	4,020,000	4,020,000	2,160,000	2,795,000	6,815,000	19.95	3,870,000	2,945,000	2,250,000	695,000

Notes:

1. Fire demand and duration based on AWWA M-31 Manual recommendations. A six-hour 6,000 gpm fire flow is goal of City of Portage
2. Equalization volume was calculated using two different methods (the minimum determined EQ volume was used): 1 - Equal to ADD, 2 - Equal to 25% of MDD
3. Equalization volume = 25% of Maximum Day Demand
4. Fire demand is based on the suggested fire flow over the duration
5. Example calculation: (Year 2037 with a 6-hour 6,000 gpm desired fire flow)

Maximum Day Demand = 16.08 mgd = 11,167 gpm (2039 projected maximum day demand)
Peak Hour Demand = 24.12 mgd = 16,750 gpm (2039 projected peak hour demand)
Equalization Volume = 25% * maximum day demand = 25% * 16.08 mgd = 4,020,000 gallons (lowest of 2 methods used to calculate equalization volume)
Fire Demand = Suggested Fire-Flow * Duration = 6,000 gpm * 6 hr * 60min/hr = 2,160,000 gallons
Emergency Storage = 50% of ADD = 0.5 * 5,590,000 = 2,795,000 gallons
Total Storage Needed = Emergency Storage + Equalization Volume = 2,795,000 + 4,020,000 = 6,815,000 gallons
Firm Well Capacity based on current well capacity with largest well (Shuman-2) offline
Excess Well Supply Volume = Firm Well Capacity - MDD = (20.34 mgd - 16.08 mgd) * 1,000,000 = 4,260,000 gallons
Recommended Storage Volume = Equalization Volume + Emergency Storage - Excess Well Supply Volume = 4,020,000 + 2,795,000 - 4,260,000 = 2,555,000 gallons
Storage Volume Provided = total of two existing storage tanks = 2,250,000 gallons
Recommended Additional Storage Volume = Recommended Storage Volume - Existing Storage Volume = 2,555,000 - 2,250,000 = 305,000 gallons

Appendix 3



NORTH

HYDRANT FLOW TEST LOCATIONS

NO SCALE

PLOT INFO: \\FTCHVALL\PROJECTS\2018\181560\CAD\REF\MODEL FLOW TEST LOCATIONS 2018.DWG LAYOUT: OVERALL DATE: 6/4/2019 TIME: 10:58:02 AM USER: CGM

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City of Portage
Kalamazoo County, Michigan

Portage Reliability Study

REVISIONS

NOT FOR CONSTRUCTION

Drawn By
Designer
Reviewer
Manager DJB

Hard copy is intended to be 24"x36" when plotted. Scale(s) indicated and graphic quality may not be accurate for any other size.

PROJECT NO.
181560

SHEET NO.

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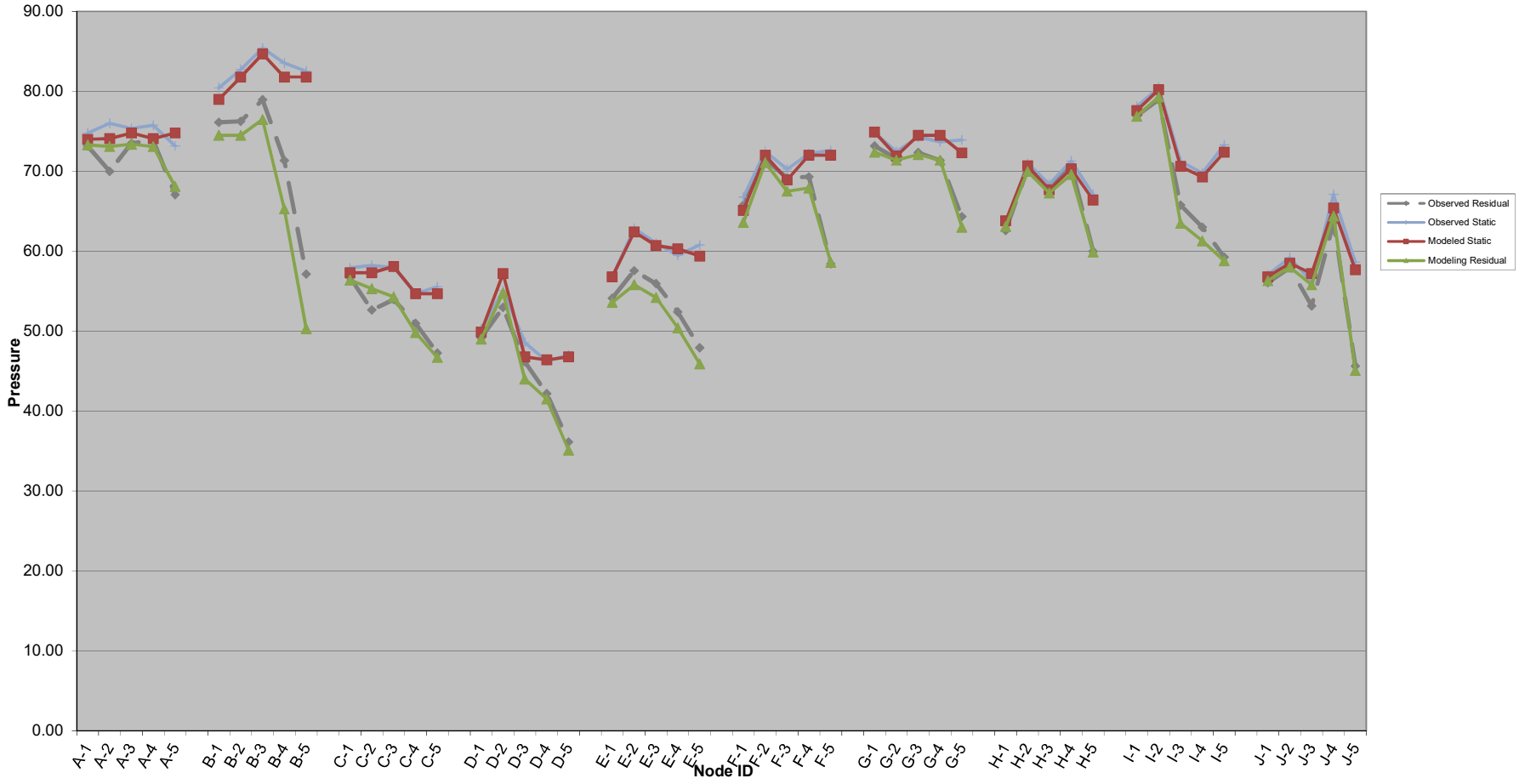
Appendix 4

model as is

City of Portage Hydraulic Model
Calibration Spreadsheet
Project No. 181560

NEW 2018 Node ID	Field Observed Static Hyd Pressure (psi)	Field Observed Hyd Flow (gpm)	Field Observed Residual Hyd Pressure (psi)	Trial 1 Model Staticl Pressure (PSI)	Trial 1 Static Pressure difference (PSI)	Trial 1 Model Residual Pressure (PSI)	Trial 1 Residual Pressure difference (PSI)	Trial 2 Model Static Pressure (PSI)	Trial 2 Static Pressure difference (PSI)	Trial 2 Model Residual Pressure (PSI)	Trial 2 Residual Pressure difference (PSI)
A-1	74.78		73.17	74	0.8	73.3	-0.1	74	0.8	73.3	-0.1
A-2	76.00		70.00	74.1	1.9	73.1	-3.1	74.1	1.9	73.1	-3.1
A-3	75.36		73.53	74.8	0.6	73.4	0.1	74.8	0.6	73.4	0.1
A-4	75.76		73.81	74.1	1.7	73.1	0.7	74.1	1.7	73.1	0.7
A-5	73.18	1250.0	67.07	74.8	-1.6	68.1	-1.0	74.8	-1.6	68.1	-1.0
B-1	80.44		76.14	79.7	0.7	73.5	2.6	79	1.4	74.5	1.6
B-2	82.74		76.26	80.1	2.6	72.4	3.9	81.8	0.9	74.5	1.8
B-3	85.44		78.96	81.4	4.0	73.3	5.7	84.7	0.7	76.5	2.5
B-4	83.55		71.36	79.2	4.4	63.6	7.8	81.8	1.8	65.3	6.1
B-5	82.52	1240.0	57.13	78	4.5	48.2	8.9	81.8	0.7	50.3	6.8
C-1	57.93		56.71	57.3	0.6	56.4	0.3	57.3	0.6	56.4	0.3
C-2	58.23		52.65	57.3	0.9	55.3	-2.6	57.3	0.9	55.3	-2.6
C-3	57.94		53.96	58.1	-0.2	54.2	-0.2	58.1	-0.2	54.3	-0.3
C-4	54.69		50.98	54.7	0.0	49.8	1.2	54.7	0.0	49.8	1.2
C-5	55.55	1130.0	47.27	54.7	0.8	42.8	4.5	54.7	0.8	46.7	0.6
D-1	50.27		49.15	49.9	0.4	49.0	0.1	49.9	0.4	49.0	0.1
D-2	55.07		52.97	57.2	-2.1	54.8	-1.8	57.2	-2.1	54.8	-1.8
D-3	48.57		46.14	46.8	1.8	44.0	2.1	46.8	1.8	44.0	2.1
D-4	46.24		42.18	46.4	-0.2	41.5	0.7	46.4	-0.2	41.5	0.7
D-5	47.00	920.0	36.12	46.8	0.2	33.4	2.7	46.8	0.2	35.1	1.0
E-1	56.76		54.13	56.8	0.0	53.60	0.5	56.8	0.0	53.6	0.5
E-2	62.85		57.57	62.4	0.4	55.80	1.8	62.4	0.4	55.8	1.8
E-3	61.02		55.94	60.7	0.3	54.20	1.7	60.7	0.3	54.2	1.7
E-4	59.47		52.39	60.3	-0.8	50.40	2.0	60.3	-0.8	50.4	2.0
E-5	60.79	1060.0	47.91	59.4	1.4	42.00	5.9	59.4	1.4	45.9	2.0
F-1	66.76		65.78	65.1	1.7	63.30	2.5	65.1	1.7	63.6	2.2
F-2	72.47		71.44	72	0.5	71.10	0.3	72	0.5	71.1	0.3
F-3	70.26		69.18	68.9	1.4	67.50	1.7	68.9	1.4	67.5	1.7
F-4	72.22		69.31	70.2	2.0	66.20	3.1	72	0.2	67.9	1.4
F-5	72.62	1200.0	58.40	70.2	2.4	51.90	6.5	72	0.6	58.6	-0.2
G-1	74.82		73.18	74.9	-0.1	72.40	0.8	74.9	-0.1	72.4	0.8
G-2	72.47		71.61	71.9	0.6	71.40	0.2	71.9	0.6	71.4	0.2
G-3	74.31		72.34	74.5	-0.2	72.10	0.2	74.5	-0.2	72.1	0.2
G-4	73.69		71.37	74.5	-0.8	71.40	0.0	74.5	-0.8	71.4	0.0
G-5	73.93	1250.0	64.33	72.3	1.6	58.90	5.4	72.3	1.6	63.0	1.3
H-1	63.24		62.59	63.8	-0.6	63.10	-0.5	63.8	-0.6	63.1	-0.5
H-2	71.00		70.30	70.7	0.3	70.00	0.3	70.7	0.3	70.0	0.3
H-3	68.40		67.94	67.7	0.7	67.30	0.6	67.7	0.7	67.3	0.6
H-4	71.29		70.67	70.3	1.0	69.60	1.1	70.3	1.0	69.6	1.1
H-5	67.10	1200.0	59.99	66.4	0.7	56.10	3.9	66.4	0.7	59.9	0.1
I-1	78.11		76.93	77.6	0.5	76.90	0.0	77.6	0.5	76.9	0.0
I-2	80.49		78.98	80.2	0.3	79.30	-0.3	80.2	0.3	79.3	-0.3
I-3	71.25		65.77	70.6	0.7	63.50	2.3	70.6	0.7	63.5	2.3
I-4	69.80		63.00	69.3	0.5	61.30	1.7	69.3	0.5	61.3	1.7
I-5	73.31	1130.0	59.25	72.4	0.9	58.80	0.5	72.4	0.9	58.8	0.5
J-1	57.04		56.07	56.8	0.2	56.30	-0.2	56.8	0.2	56.3	-0.2
J-2	59.21		57.95	58.5	0.7	58.00	0.0	58.5	0.7	58.0	0.0
J-3	56.15		53.17	57.2	-1.0	55.80	-2.6	57.2	-1.0	55.8	-2.6
J-4	67.09		63.62	65.4	1.7	64.40	-0.8	65.4	1.7	64.4	-0.8
J-5	58.62	1080.0	45.62	57.7	0.9	45.10	0.5	57.7	0.9	45.1	0.5

Portage Water System Reliability Study
Calibration Summary - Static and Residual Pressure