Feasibility Study

Reduction of Water System Entry Points

Prepared for
City of Kalamazoo

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2210003

Prein&Newhof

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1 INTRODUCTION

The City of Kalamazoo has entered into an Administrative Consent Order (ACO) with the Michigan Department of Environment, Great Lakes, and Energy (EGLE) that is intended to address issues with the City's drinking water supply system as identified by EGLE.

The intent of this report is to review the feasibility of reducing the number of entry points to the City of Kalamazoo drinking water distribution system with a goal of achieving a more consistent source water quality in the system. Specifically, this report is intended to address the requirements of item 2.2 in the ACO.

2 POTENTIAL SYSTEM MODIFICATIONS AND IMPROVEMENTS

The Kalamazoo water system is currently supplied by 88 active wells in 13 active well fields. Water quality varies over these multiple sources. This study reviews several options for improving the quality and the consistency of the source water quality provided to the distribution system. A map showing an overview of the City of Kalamazoo Water System is provided as Figure 1.

Options considered to improve the source water include combinations of the following:

2.1 Abandon Selected Wells or Wellfields

When considering well water quality for the City of Kalamazoo system, it is important to consider water quality parameters that could directly exceed aesthetic or health-based drinking water limits as well as parameters like pH that might not cause any issues directly, but if variations occur over time due to source changes, could cause problems in the piping network through interactions with scale or sediment in the distribution system.

The water quality and capacity of existing wells has been reviewed in order to identify potential abandonment and/or replacement of individual wells or well fields that may be contributing to a lower quality water in the distribution system and/or creating significant shifts in the water quality in the distribution system over time. Implementation of this option may require additional capacity be located and developed to replace lost capacity in order to adequately meet City demands.

Water quality data provided by the City was reviewed to identify candidates for wells that could be disconnected from the system to improve water quality. A map showing some of the water quality parameters and their relative concentrations is provided in Figure 2 and Figure 3.

The following potential issues with water quality identified during review of historical sample results from each well field:

– Station 1 wells have manganese exceeding the aesthetic criterion. Stronger oxidants such as permanganate are typically required to effectively oxidize manganese to allow it to be removed by filtration. Since permanganate is not routinely used at the Central Treatment Plant, this is likely not being removed.

– Well 1-4 has had up to 0.2 mg/L ammonia and a higher hardness, it also has a higher pH of 8.2 vs. approximately 7.2 in other nearby wells. This well should be considered for some additional sampling. If these differences in quality are confirmed, this well should be used less or potentially abandoned.

– Station 1 wells and Station 2 well have higher sodium than most other City wells.

– Well 2-1 has iron and manganese above the aesthetic criteria.

– Wells at Station 3 have around 0.1 mg/L ammonia, wells 3-2 and 3-5 have elevated iron.

– Wells at Station 4 have lower pH of <7 and elevated iron and manganese. Aeration and filtration could address the iron and pH issues.

– Well 4-9 had arsenic detected above the MCL in 2014. This well should be resampled to confirm arsenic values below the MCL.

– Wells at Station 5 have ammonia concentrations of 0.1 to 0.3 mg/L and iron and manganese significantly exceed the aesthetic criteria. Recently, PFAS has been detected and treatment is being implemented.

– Wells at Station 8 have ammonia levels of 0.1 to 0.2 mg/L, and iron and manganese above aesthetic criteria.

– Wells at Station 12 have ammonia near the detection limit of 0.1, and iron and manganese exceed the aesthetic limit.

– Some of the wells at Station 14 exceed the aesthetic criteria for iron and manganese. Nitrate is present from 0.5 to 3 mg/L

– The well at 17 has ammonia at 0.13 mg/l, and exceeds the aesthetic criteria for iron and manganese. PFAS has also been detected and this well is being considered for abandonment.

– At Station 18, iron and manganese exceed aesthetic criteria. PFAS has also been detected and this well is being considered for abandonment.

– Two of the wells at Station 22 have iron above aesthetic criteria, and all of the wells have manganese above aesthetic criteria.

– Wells at 25 have iron, manganes, or both above aesthetic criteria.

– At Station 39, one well has elevated ammonia (0.59 mg/l) and iron above aesthetic critera, the other has elevated manganese.

In general, the most prevalent water quality issues are elevated iron and manganese with several wells also have ammonia concentrations detected. In most cases, these wells are still available for production of high quality drinking water as long as attention is paid to dealing with ammonia where present and removing iron and manganese when above aesthetic criteria if possible.

Where ammonia is present in the water, it can be handled by making sure the correct dose of chlorine is applied to convert ammonia to nitrogen gas and provide free chlorine in the water. This requires a chlorine dose of roughly 9 times the concentration of ammonia. If chlorine is underdosed, chloramines will be left in the system. Variation between free chlorine and chloramines as the dominant form of chlorine in a system can cause significant quality issues due to lead, iron, and other parameters dissolving as the chemistry and biology in the system changes, so this is critical. That said, the ammonia can be handled easily without significant treatment if the dosing is correct.

Iron and manganese are present at varying concentrations that could cause aesthetic water quality issues and contribute to low chlorine residual, potential microbiological growth and associated chemistry changes that could impact lead/copper concentrations. Treatment is already provided for several wells, but not all, so the quality of the water in distribution varies depending on which well fields are running and what percentage of the water supplied is treated.

Ideally, this issue would be addressed by providing treatment for all wells with detectable iron and manganese. A secondary option would be to operationally make the ratio of water supplied from wells with and without treatment consistent so that the water quality in distribution remains relatively consistent. There are not wells with iron and manganese concentrations that indicate a need to remove the wells from the system.

After review of all of the available quality data, it appears that the wells in the following table are candidates to be abandoned:

Table 1: Candidates for Well Abandonment

Well(s)	Capacity (gpm)	Reason
PS 39 (2 wells)	2,500	Elevated ammonia and iron, adjacent to historic chemical release
Well 4-9	500	Arsenic exceeds MCL
Rest of PS 4	4,600	pH lower than rest of system
PS-17	500	PFAS Detected
PS-18 (2 wells)	1,250	PFAS Detected

PS-39 is still currently used by the City, and the City has expressed interest in keeping the station online. Treatment options outlined below are outlined assuming that PS-39 is kept online. Assuming the low pH at PS 4 is dealt with by chemical addition or operation to minimize shifts in distribution and PS-39 remains in service, abandoning the rest of the above list would result in a reduction in total well capacity of 1.8MGD (2,250 gpm). This would require development of additional well capacity to maintain the current system capacity.

The cost to abandon the Well 4-9, the PS-17 well and the PS-18 wells is estimated to be approximately $65,000. This does not include demolition of the associated pumping stations.

2.2 New Wellfields

If wells are removed per the above section, it is likely that additional capacity will have to be developed to provide sufficient supply to the City. The City has identified 2 areas for potential future well fields in previous reviews as outlined in the 2017 Wellhead Protection Plan. These two sites are estimated to provide up to a total of 5.5 MGD (3,840 gpm) as follows:

Ross Township Site – 3 MGD (2,100 gpm)

Oshtemo Township Site – 2.5 MGD (1,740 gpm)

With an estimated four wells per well field, it is estimated that development of these two wellfields would cost approximately $3,000,000. This does not include treatment, or watermain to connect to these wellfields.

The concept of one large wellfield to serve all/most of the City demands was also reviewed, but was not considered feasible or advisable. First, it is very unlikely that one well field could supply the City's current Firm Pumping Capacity of 54 MGD (38,000 gpm) as even productive aquifers would have very significant interference impacts at that total capacity. In addition, having all of the source water capacity in one location amplifies the risk of contamination or long-term loss of production capacity for the entire City supply.

2.3 Expand Treatment Facilities

Currently, the City provides treatment at the Central Treatment Plant and the Kendall Iron Removal Plant. The Central treatment plant includes air stripping of VOCs, iron removal via gravity sand filtration, and disinfection. The Kendall Iron Removal Plant (IRP) removes iron and vinyl chloride and provides disinfection. The Central Treatment Plant is served by its own wellfield, while the Kendall IRP is served by Pump Station No. 11 and its wellfield. This amounts to about 17.5% of the total limiting capacity of the system.

A potential way to reduce the fluctuations in water quality would be to increase the fraction of the water that is treated to the same standard at treatment facilities. This could be done in several ways, three of which are outlined in the following sections.

2.3.1 Expand Central Treatment Plant

Currently, the Central Treatment Plant has a firm capacity of 7,500 gallons per minute (GPM), which is equivalent to about 10.8 MGD. The plant is served by the adjacent wellfield, which also has a firm capacity of 7,500 GPM. One potential way to increase the fraction of the water that is treated to the same standard is to expand the Central Treatment Plant and route more nearby pump stations to the plant for treatment. This was explored in an April 2020 expansion feasibility report prepared by Prein&Newhof.

The 2020 report noted that nearly doubling the treatment capacity of the Central Treatment Plant is feasible on the current site. Air strippers, chemical feed systems, gravity filters, and high service pumps would all need to be expanded or upgraded. New building additions would likely be required for the new air strippers, blowers, and filters, but could be contained on the current treatment plant site. These upgrades could bring the total treatment capacity of the plant to 13,500 GPM (or roughly 19.4 MGD). Further increasing the capacity of the capacity of the plant on the current site to meet the full raw water firm pumping capacity of 19,900 GPM (28.7 MGD) does not appear to be feasible without purchasing additional property to construct additional water treatment plant buildings. It is important to note that the nearby transmission main piping would need to be upgraded as part of the plant expansion in order to handle the flow coming from the plant.

As the Central Treatment Plant's wellfield can only supply 9,000 GPM with all wellfield pumps running, upgrading the treatment capacity of the plant would also require getting more raw water into the plant. This could feasibly be done by additionally routing Pump Stations 2 through 4 (and their wellfields) to the plant. Pump Station No. 2 (Born Court) is located approximately 0.3 miles from the treatment plant, No. 3 (Balch) is located across Balch Street from the plant, and No. 4 (Maple) is located approximately 0.5 miles by road from the plant. Routing all of these pump stations to only supply water to the Central Treatment Plant would increase the firm raw water pumping capacity to 19,900 GPM (28.7 MGD) with one of the 1,500 GPM wellfield pumps at the Central Treatment Plant wellfield out of service. As with the treatment upgrades, the wellfield and pump station upgrades would require significant raw water transmission main piping to connect the outlying 3 stations to the Central Treatment Plant.

Note that cost estimates for treatment (in this section and all other treatment estimates) are preliminary based primarily on the total proposed water treatment capacity. Actual costs for treatment expansion or construction may vary significantly based on further information on treatment goals, treatment technology selected property available, current material costs and many other factors. More accurate cost estimates can be developed during preliminary design.

Preliminary estimates for raw water transmission main construction and treatment plant expansion costs are approximately $23,000,000 as shown in Appendix A. This cost takes into account increasing the capacity of the plant to 13,500 GPM, not the full firm capacity of the wellfields (19,900 GPM). Additional costs to purchase land, construct additional treatment buildings, and coordinate the pumping and piping of water between the buildings has not been considered in the scope of this report. This cost estimate is based on preliminary sizing of raw water transmission main piping, and preliminary modeling results indicating where treated water transmission is needed. Exact sizing and lengths of pipes have not been calculated as part of this study. Preliminary hydraulic modeling of this configuration determined that a relatively small amount of medium (roughly 16"-30" diameter) and large (>30" diameter) piping would be needed to convey treated water to many of the City's storage tanks and reservoirs. Additionally, modeling of this scenario used existing maximum day demands. It is possible that future demands could increase the required length of transmission upgrades, making the cost for this option more significant.

2.3.2 Single Central Treatment Plant

Another option for regulating the quality of water served to the Kalamazoo distribution system would be to create one central treatment plant and pipe all wellfields to the treatment plant via the use of the existing pumping stations, which would be converted to convey raw water directly to the treatment plant. The existing iron removal plant at Kendall would be abandoned in order to send raw, untreated water only to the expanded central plant.

The current location of the Central Treatment Plant is a centralized location to choose for a proposed system-wide treatment plant. In order to convey raw water from the pumping stations to the plant, significant transmission main construction would need to be undertaken, with an estimated length of transmission main piping of nearly 170,000 feet, varying in size from 14-inch to 72-inch diameter. A proposed treatment plant would need to have a treatment capacity of 47,050 gallons per minute (approximately 68 MGD) in order to treat the full rated raw water pumping capacity of the current stations. This is approximately 7 times the current rated capacity of the Central Treatment Plant, so significant treatment upgrades and new building construction would be necessary to provide the required capacity. It is expected that adjacent or nearby property would need to be purchased in order to house the full size of the treatment facilities. A layout of this proposed Central Treatment Plant location and associated raw water transmission piping is found in Figure 4.

After the water is treated, a combination of new and upgraded transmission main piping would be required to distribute the water to the City's various elevated storage facilities. This option is estimated to cost approximately $290,000,000 as shown in Appendix A. This cost estimate is based on preliminary sizing of raw water transmission main piping, and preliminary modeling results indicating where treated water transmission is needed. Exact sizing and lengths of pipes have not been calculated as part of this study. Additionally, modeling of this scenario used existing maximum day demands. It is possible that future demands could increase the required length of transmission upgrades, making the cost for this option more significant. Preliminary hydraulic modeling of this configuration determined that dedicated transmission mains to and from many of the City's elevated storage tanks and reservoirs would result in a monumental effort required to reroute much of the City's piping. More detailed modeling and design calculations would need to be undertaken in order to determine the exact required lengths and sizes of treated water transmission mains. Due to the immense amount of raw water and transmission piping upgrades that would be required, the reconstruction of roadways required to be removed for these upgrades, and the significant required upgrades of the Central Treatment Plant within its constrained site, it does not appear feasible to treat 100% of the City's raw water at one centralized treatment plant.

2.3.3 Grouped Wellfields with Multiple Smaller Treatment Plants

While a centralized treatment plant would be able to maintain a more consistent water quality system-wide, it may be more feasible to split the Kalamazoo system into parts, each with their own treatment plant. These split systems would each operate their own treatment plant but would still be connected to the other groups. This way, although the system is sharing water from several different wellfields, all the water is treated to a consistent quality. Two potential options for this are outlined in the following sections.

2.3.3.1 Three-Group Split

The Kalamazoo system could also be feasibly split into three groups. In this scenario Group 1 consists of the Super High, Ultra High, Northwest High, West Side High, and West Side Low pressure districts. Group 2 consists of the East Side High and Intermediate pressure districts. Group 3 consists of the Low and High pressure districts.

Group 1 would be served by Pumping Stations 11, 12, 22, and 24. Group 2 would be served by Pumping Stations 5, 14, and 25. Group 3 would be served by Pumping Stations 1, 2, 3, 4, 8, 9, and 39. Again, stations 17 and 18 would be abandoned. A layout of this split can be found in Figure 5.

As with the two-group split, this option would require three treatment plants centrally located within their respective group. For Group 1, the iron removal plant at Kendall would be expanded and retrofitted to be a full treatment plant with capacity of 18,000 GPM (25.9 MGD). For Group 2, a treatment plant at Schippers Lane (Pumping Station No. 5) with capacity 7,300 GPM (10.5 MGD) would be constructed. For Group 3, the Central Treatment Plant would be expanded to a capacity to 26,950 GPM (39 MGD). This would result in surplus capacity for projected 2037 average day flows. At 2037 projected max day flows, Group 1 would experience a deficit of approximately 7.5 MGD due to limitations in the wellfields and pumping stations. It is recommended that if this option is pursued further, considerations for expanding the wellfield capacity and pumping capacity at Stations 11, 12, 22, and 24 be explored in order to ensure that the treatment plant is supplied and can treat an adequate flow of water to serve its group on a max day event. Other than emergency interconnects installed at the borders of the groups, the three systems would function largely as independent systems.

This three-group split would require approximately 45,000 feet of raw water transmission main construction in Group 1 to bring raw water to the plant at Kendall, 28,000 feet of raw water transmission main construction in Group 2 to bring raw water to the Plant built at Schippers Lane, and 65,000 feet of raw water transmission main construction in Group 3 to bring raw water to the plant built at E. Kilgore.

Preliminary estimates for raw water transmission main construction and treatment plant construction or expansion costs are approximately $170,000,000, as shown in Appendix

A. This cost estimate is based on preliminary sizing of raw water transmission main piping, and preliminary modeling results indicating where treated water transmission is needed. Exact sizing and lengths of pipes have not been calculated as part of this study. Preliminary hydraulic modeling of this configuration determined that a large amount of medium-sized (roughly 16"-30" diameter) piping would be needed to convey treated water to many of the City's storage tanks and reservoirs. Additionally, modeling of this scenario used existing maximum day demands. It is possible that future demands could increase the required length of transmission upgrades, making the cost for this option more significant. Compared to the single central plant option, this option involves a similar length of treated water transmission main piping required, but the diameter of the piping may be able to be smaller.

2.3.3.2 Seven-Group Split

A final option for splitting the wellfields and pumping stations into groups serving smaller treatment plants is to split the system into seven small groups, each with its own small treatment plant. While the capital costs of constructing seven small plants are quite large, this option works with the City of Kalamazoo's current plans to build treatment plants at several locations. This option also minimizes the amount of raw water piping necessary to bring wellfield water to a treatment plant, since the plants are closer to their grouped wellfields.

As part of this split, PS 18 (Emerald) and PS 17 (Konkle) would be abandoned. This was already part of the City's water system improvements plan, and raw water piping will not be constructed from either PS 18 or PS 17. A layout of this split can be found in Figure 6.

Table 2 below outlines the proposed split of the Kalamazoo system.

Table 2 - Seven-Group Split of Kalamazoo Water System

Grouped Stations	Treatment Plant Location	Treatment Plant Capacity (MGD)
PS 22 (Colony Farm) PS 24 (Atwater)	PS 22 (Colony Farm)	15
PS 8 (E. Kilgore) PS 9 (W. Kilgore)	PS 8 (E. Kilgore)	7.5

PS 39 (Morrow Lake)	PS 39 (Morrow Lake)	3.75
PS 11 (Kendall) PS 12 (DeHann)	PS 11 (Kendall)	4.5
PS 1 (Central) PS 2 (Born) PS 3 (Balch) PS 4 (Maple)	PS 1 (Central)	28
PS 5 (Schippers Lane) PS 14 (Spring Valley)	PS 5 (Schippers Lane)	4
PS 25 (Campbell)	PS 25 (Campbell)	6.5

This option would require the construction of five new water treatment plants, and the upgrade of two plants (Kendall and Central). However, the City has previously expressed interest and put plans into place to construct plants at Schippers Lane and E. Kilgore. All treatment plants would be designed to remove iron and manganese to levels below the aesthetic criteria, but plants other than Central may need treatment for VOCs. Ammonia is proposed to be removed through chlorination at each plant. It is estimated that upgrading Central and Kendall plants and constructing the five additional plants would come at a cost of approximately $86,000,000.

This seven-group split would require a total of approximately 48,000 feet of raw water transmission main construction to bring raw water from each wellfield to their respective treatment plants.

Preliminary estimates for raw water and treated water transmission main construction amount to a total cost of approximately $21,000,000. Including engineering, legal, administrative, and acquisition fee estimates, the total cost for this seven-group split amounts to approximately $140,000,000, as shown in Appendix A. This cost estimate is based on preliminary sizing of raw water transmission main piping, and preliminary modeling results indicating where treated water transmission is needed. Exact sizing and lengths of pipes have not been calculated as part of this study. Preliminary hydraulic modeling of this configuration determined that a relatively low amount of medium-sized (roughly 16"-30" diameter) piping would be needed to convey treated water to many of the City’s storage tanks and reservoirs. Additionally, modeling of this scenario used existing maximum day demands. It is possible that future demands could increase the required length of transmission upgrades, making the cost for this option more significant. Compared to the single central plant option and the three-plant option, this option involves a significantly shorter length of treated water transmission main piping required, and the diameter of the piping may be able to be smaller. However, the construction of seven independent water treatment plants drives the overall cost of this option up significantly compared to the options with fewer plants.

2.4 Grouping and Separating Pressure Districts

The City may be able to improve the consistency of water quality in distribution by grouping certain pressure districts together and supplying them with water from selected wellfields. The goal would be to supply each defined sub-area of the system with a consistent mix of water from selected wellfields/wells, except for during emergency scenarios. Although the water being served to the City would not be 100% treated at a conventional treatment plant, this could result in much more consistent water quality within defined areas of the system.

To begin looking at this possibility, data from the City's most recent water reliability study was gathered. In order to determine necessary design flows, the 2037 projected average and max day flows for each pressure district were compiled in the table below:

Table 3 - 2037 Projected Average and Max Day Demands by Pressure District

Pressure District	2037 Average Day (MGD)	2037 Max Day (MGD)
Low	4.0	8.9
Intermediate	1.4	2.8
High	6.3	13.4
East Side High	2.7	6.1
Super High	4.8	14.7
Ultra High	2.1	4.3
Northwest High	3.3	6.9

Note that the West Side High and West Side Low pressure districts were not included above. These districts are small, and their demand is assumed to be grouped within the Super High district, which supplies the only water that gets to the West Side pressure districts.

In addition to the demands, the supply capacities of the wellfields and pumping stations in each pressure district were compiled in the following table:

Table 4 - Supply Capacities by Pressure District

Pressure District	Well Capacity (MGD)	Pumping Station Capacity (MGD)	Pumping Station Firm Capacity (MGD)	Limiting Firm Capacity (MGD)
Low	27.6	31.6	13.5	12.5[a]
Intermediate	4.0	4.0	0.0	0.0[b]
High	25.1	33.1	15.7	11.7[c]
East Side High	6.5	8.1	4.8	4.8[d]
Super High	14.1	29.4	19.3	14.1[e]
Ultra High	0.0	0.0	0.0	0.0
Northwest High	0.0	0.0	0.0	0.0
West Side High	0.0	0.0	0.0	0.0
West Side Low	0.0	0.0	0.0	0.0

[a] Low district firm capacity limited by well capacity at PS 1, pumping capacity at PS 2, 3, and 4.
[b] Intermediate district firm capacity limited by pumping capacity.
[c] High district firm capacity limited by well capacity at PS 9, pumping capacity at PS 4, 8, 11, 12, and 39.
[d] East Side High district firm capacity limited by pumping capacity.
[e] Super High district firm capacity limited by well capacity at PS 24, and by well and pumping capacity at PS 22

Comparing the two tables, it is concluded that the Intermediate and East Side High districts can supply their own water on projected average and max days, provided that the firm pumping capacity at the pumping stations is increased in both districts. The existing wellfields that supply the pumping stations have enough capacity to supply water at projected 2037 average and max day flows. It is also recommended that Booster/Bleeder stations 10, 23, and 27 as well as Bleeder station 23B be closed off and opened only in emergency situations. This would lead to the intermediate and east side high districts being served only by their respective wellfields and pumping stations, with no interconnect between districts.

The High pressure district also has the capacity to supply itself with water at projected 2037 average and max day flows, provided that the limiting firm capacity is raised from 11.7 MGD to the required 13.4 MGD. This can be done by combining some of the improvements noted in footnote c of the table above (increasing well capacity at PS 9, and pumping capacity at PS 4, 8, 11, 12, and 39). As with the previous districts, several booster and bleeder stations should be valved off to isolate the pressure district from others. Specifically, Stations 6, 11A, 21, 30, 31, 33, and 35 should be closed. It is important to note here that PS 4 (Maple) would continue to supply about two thirds of its capacity to the High pressure district, and one third to the Low pressure district.

Currently, the Super High district has enough firm pumping capacity to serve itself at projected 2037 average day demands without taking water from another district. However, the wellfields at PS 22 and 24 are limited in their capacity. If wellfield capacity is expanded at PS 22 and 24 to a total of greater than 14.7 MGD (an increase of 0.6 MGD), then the district can serve itself at projected 2037 max day demands without connection to another district. If both West Side pressure districts are also taken into account, it is recommended that the total wellfield capacity be increased to 15 MGD to cover for demands in the West Side districts. In this pressure district, the booster and bleeder stations shared with the High pressure district (30 and 35) and the one shared with the Ultra High district (29) would be valved off and used as an emergency interconnect only.

At their current capacity, the wells and pumping stations serving the Low pressure district can serve the entire district plus the Northwest High and Ultra High districts at projected 2037 average and max day demands. However, to ensure that these demands are met under conservative circumstances, the wellfields and pumping stations would need to be upgraded to bring the total limiting firm capacity to at least 20.1 MGD. This can be done by combining improvements noted in footnote a of the table above (increasing well capacity at PS 1, pumping capacity at 2, 3, and 4). As outlined in the previous paragraphs, booster/bleeder stations between the Low-Northwest High-Ultra High group and others should be valved off and used in emergencies only. Booster/bleeder 26 and booster 28 would need to be left operational to connect the three pressure districts in this group.

The groups, the wellfields and pumping stations that supply them, and the necessary improvements to ensure that each group can meet its own projected max day demand under firm capacity are outlined in the summary table below. Figure 7 shows the below configuration of grouped wellfields. This solution would not provide a finished water throughout the City as consistent as other options reviewed, but would improve consistency of water supplied to each individual subsection of the distributions system at a much lower cost. It would reduce operational flexibility in allowing various source waters to provide various portions of the system, but its very low cost makes it worth considering at least as a temporary measure.

Table 5 - Summary of Grouped Systems and Necessary Improvements

Group	Pressure Districts Served	Supplying Wellfields/Pumping Stations[a]	Necessary Improvements
1	Intermediate	5, 14	Upgrade firm pumping capacity at PS 5 and 14.
2	East Side High	25	Upgrade firm pumping capacity at PS 25.
3	High	4 (67%), 8, 9, 11, 12, 39	Upgrade wellfield capacity at PS 9, pumping firm capacity at PS 4, 8, 11, 12, 39.
4	Super High, West Side High, West Side Low	22, 24	Upgrade wellfield capacity at PS 22 and 24, pumping firm capacity at PS 22
5	Low, Northwest High, Ultra High	1, 2, 3, 4 (33%)	Upgrade wellfield capacity at PS 1, pumping firm capacity at PS 2, 3, and 4.

[a] Stations 17 and 18 were not counted as supplying any water since both are proposed to be abandoned. This also assumes that Station 39 is not abandoned

At current rated capacities of wellfields and pumping stations, the breakdown of supply and projected 2037 demands is outlined in the following table. Note that the available supply outlined in the table is taken as the total available supply with wellfields and stations operating at full capacity. If the demands are desired to be met under firm capacity at each station, upgrades noted above in Table 5 would need to be pursued.

Table 6 – Summary of Grouped System Operation at Various Demands

Group	Avaiable Supply (MGD)	2037 Projected Avg Day Demand (MGD)	2037 Projected Max Day Demand (MGD)
1	4.0	1.4	2.8
2	6.5	2.7	6.1
3	24.4	6.3	13.4
4	14.1	4.8[a]	14.7
5	21.3	4.0 (Low), 3.3 (NW High), 2.1 (Ultra High) – Total 9.4	8.9 (Low), 6.9 (NW High), 4.3 (Ultra High) – Total 20.1

[a]Not including demands in the West Side High and West Side Low pressure districts, which are assumed to be negligible compared to the Super High district demands

As discussed previously and shown in the table above, the grouped wellfield operation could supply water exclusively from wellfields within each group under all demand scenarios except for Group 4 on the maximum day projected demands. Upgrades noted in Table 5 above can be explored to prevent the need for interconnection between groups.

3 Other Water Quality Issues

There following are items identified during this review that do not reduce the number of entry points to the system but could provide an opportunity to increase the quality of water in the system.

3.1 Storage Tank Overflows

Correspondence from EGLE has identified overflows at the Blakeslee Reservoir and the Dartmouth Reservoir having overflow connections that are unscreened or that drain directly to storm sewer without an air gap. Each of these conditions can create risk of bacterial contamination. Generally, EGLE has also noted that 24-mesh screens on vents and overflows are required at several tanks and all air release valves. These issues can be corrected relatively easily with some minor plumbing changes and retrofitting with new screens.

3.2 Size of Blakeslee Reservoir

Model simulations and observations of City staff suggest the residence time in the Blakeslee reservoir contributes to high-age water, which can result in higher concentrations of disinfection byproducts and other water quality concerns. This tank has the ability to isolate each half, so a possible improvement would be to operate this tank at on half its current volume. The City is currently considering permanent modifications to this reservoir to reduce its operating volume.

Figures

LEGEND

Water Main Diameter
6" and Smaller
8"
10"
12"
16"
20"
24"
30"
Bleeder Station
Booster Station
Booster/Bleeder Station
Pressure Reducing Station
Storage Tank/Reservoir
Pump Station
Production Well
Pressure District Boundary

0.5 0.25 0 0.5 1 Miles

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KALAMAZOO COUNTY, MI

FIGURE 1: EXISTING WATER SYSTEM

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Miles: 0, 0.5, 1, 2

LEGEND

Iron (ug/L)	Manganese (ug/L)	Water Main Diameter
No Data	No Data	24" - 30"
< 200	< 50	16" - 20"
200 - 300	50 - 100	10" - 12"
300 - 1,000	> 100	8" and Smaller
>= 1,000		

- Water Tower
- Kalamazoo Production Well
- Pumping Station

Booster/Bleeder Station

- BB Booster/Bleeder
- BL Bleeder
- BO Booster
- PR Pressure Reducing

Pressure District Boundary

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KALAMAZOO COUNTY, MI

FIGURE 2: IRON AND MANGANESE CONCENTRATION AT WELLS

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0 0.5 1 2 Miles

LEGEND

Ammonia (mg/L)	Water Main Diameter
No Data	24" - 30"
< 0.1	16" - 20"
0.1 - 0.2	10" - 12"
>= 0.2	8" and Smaller

Water Tower
Kalamazoo Production Well
Pumping Station

Booster/Bleeder Station
- BB Booster/Bleeder
- BL Bleeder
- BO Booster
- PR Pressure Reducing

Pressure District Boundary

CITY OF KALAMAZOO
KALAMAZOO COUNTY, MI

FIGURE 3: AMMONIA CONCENTRATION AT WELLS

Prein&Newhof
2210003

LEGEND

- Raw Water Transmission Main
- Treated Water Transmission Main
- Note: Treated water transmission main layouts are conceptual and would require further hydraulic modeling, analysis, and design.
- Bleeder Station
- Booster Station
- Booster/Bleeder Station
- Pressure Reducing Station
- Storage Tank/Reservoir
- Pump Station
- Production Well
- Pressure District Boundary

0.5 0.25 0 0.5 1 Miles

CITY OF KALAMAZOO
KALAMAZOO COUNTY, MI

FIGURE 4: SINGLE CENTRAL TREATMENT PLANT OPTION

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2210003

LEGEND

- Raw Water Transmission Main
- Treated Water Transmission Main
- Group 1
- Group 2
- Group 3
- Bleeder Station
- Booster Station
- Booster/Bleeder Station
- Pressure Reducing Station
- Storage Tank/Reservoir
- Pump Station
- Production Well
- Pressure District Boundary

Note: Treated water transmission main layouts are conceptual and would require further hydraulic modeling, analysis, and design.

0.5 0.25 0 0.5 1 Miles

CITY OF KALAMAZOO
KALAMAZOO COUNTY, MI

FIGURE 5: THREE-GROUP SPLIT WITH TREATMENT PLANT OPTION

Prein&Newhof
2210003

LEGEND

- Raw Water Transmission Main
- Treated Water Transmission Main
- Bleeder Station
- Booster Station
- Booster/Bleeder Station
- Pressure Reducing Station
- Storage Tank/Reservoir
- Pump Station
- Production Well
- Pressure District Boundary

Note: Treated water transmission main layouts are conceptual and would require further hydraulic modeling, analysis, and design.

0.5 0.25 0 0.5 1 Miles

CITY OF KALAMAZOO
KALAMAZOO COUNTY, MI

FIGURE 6: SEVEN-GROUP SPLIT WITH TREATMENT PLANTS OPTION

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2210003

LEGEND

Group Boundary	Water Main Diameter	Bleeder Station	Storage Tank/Reservoir	Pressure District Boundary
	6" and Smaller	Booster Station	Pump Station	
	8"	Booster/Bleeder Station	Production Well	
	10"	Pressure Reducing Station		
	12"			
	16"			
	20"			
	24"			
	30"			

0.5 0.25 0 0.5 1 Miles

CITY OF KALAMAZOO
KALAMAZOO COUNTY, MI

FIGURE 7: GROUPED WELLFIELD OPERATION

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Appendix A

Estimates of Probable Cost

Prein&Newhof
Engineers•Surveyors•Environmental•Laboratory

Estimate of Probable Cost - Expand Central Treatment Plant to 13,500gpm Firm

Owner:
City of Kalamazoo

Project Title:
Water System Master Planning - Reduction of Entry Points

Date:
March 30, 2022

Project #:
2210003

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
	Central Treatment Plant Upgrades				
1	Upgrade Raw Water Pumping Firm Capacity & Piping	1	Lsum	$500,000	$500,000
2	Air Stripping Tower - 2 Additional + Piping	2	Each	$500,000	$1,000,000
3	Detention Reservoir - 1 Additional Under Air Strippers	1	Lsum	$320,000	$320,000
4	Blowers (3) and Ductwork	3	Each	$150,000	$450,000
5	Blower Room Building Addition	1,400	sft	$500	$700,000
6	Pipe Chase Enclosed Building Addition	750	sft	$350	$262,500
7	New Gravity Filters (2), Associated Piping, Controls, Valves, Etc.	2	Each	$3,500,000	$7,000,000
8	Gravity Filter Building Expansion	5,300	sft	$500	$2,650,000
9	Clearwell/Weir Wall Construction	1	Lsum	$1,000,000	$1,000,000
10	High Service Pumping Upgrades (2 New Pumps)	2	Each	$350,000	$700,000
11	Misc. Electrical, Controls, Instrumentation	1	Lsum	$500,000	$500,000
	Raw Water Transmission Upgrades				
1	24" Ductile Iron Raw Water Piping - Tie Maple PS into Central PS	2,200	LF	$165	$363,000
2	24" Ductile Iron Raw Water Piping - Tie Born PS into Central PS	1,250	LF	$165	$206,250
3	24" Ductile Iron Raw Water Piping - Tie Balch PS into Central PS	860	LF	$165	$141,900
4	24" Raw Water Piping - Into Plant from Combined Stations	1,200	LF	$165	$198,000
	Restoration and Reconstruction Costs				
1	HMA Road - Remove (Assumes 1 lane, 10' width)	8,900	SY	$10	$89,000
2	Replaced Roadway - Sand Subbase (assumes 10' width, 8" thick, 1.1 tons/cyd)	2,177	Tons	$5	$10,883
3	Replaced Roadway - Aggregate Base (assumes 10' width, 6" thick, 1.35 tons/cyd)	2,003	Tons	$12	$24,030
4	Replaced Roadway - HMA (assumes 10' width, 4" thick, 110lbs/syd/in)	1,958	Tons	$90	$176,220
5	General restoration/seeding/erosion control	80	Sta.	$750	$60,075
6	Storm sewer replacement (Assumes 100ft of 12" storm sewer for every 500ft transmission main)	1,602	LF	$55	$88,110
	Treated Water Transmision Main Piping Upgrades				
1	Medium (16"-30") Transmission Main Piping	2,000	LF	$160	$320,000
2	Large (> 30") Transmission Main Piping	3,000	LF	$275	$825,000

Note: Treated water transmission main piping lengths are order-of-magnitude estimates generated using preliminary modeling results. Exact sizing and lengths would need to be explored further in design. Estimated restoration and reconstruction cost assumes 50% of roadway replacement for treated water transmission main upgrades is done concurrently with the raw water transmission upgrades.

Rounded Construction Total	$17,600,000
Engineering, Contingency, Legal, Acquisition (30%)	$5,400,000
Project Total Estimate:	**$23,000,000**

Prein&Newhof
Engineers•Surveyors•Environmental•Laboratory

Estimate of Probable Cost - One Single Central Treatment Plant

Owner:
City of Kalamazoo

Project Title:
Water System Master Planning - Reduction of Entry Points

Date:
March 30, 2022

Project #:
2210003

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
	Plant Upgrades/Abandonment				
1	Upgraded Central Treatment Plant to 47,050 gpm capacity	1	Lsum	$150,000,000	$150,000,000
2	Abandon Kendall Iron Removal Plant	1	Lsum	$250,000	$250,000
	Raw Water Piping Upgrades ***(Note That Sizing of Pipes is Based on Conveyance of Total Wellfield Capacity at Each Station with Velocity Near 3 fps)***				
1	14" Ductile Iron Watermain	6,600	LF	$115	$759,000
2	16" Ductile Iron Watermain	10,500	LF	$130	$1,365,000
3	18" Ductile Iron Watermain	2,050	LF	$135	$276,750
4	20" Ductile Iron Watermain	53,200	LF	$145	$7,714,000
5	24" Ductile Iron Watermain	400	LF	$165	$66,000
6	26" Ductile Iron Watermain	23,000	LF	$175	$4,025,000
7	30" Ductile Iron Watermain	8,450	LF	$195	$1,647,750
8	32" Ductile Iron Watermain	22,900	LF	$205	$4,694,500
9	36" Ductile Iron Watermain	5,700	LF	$225	$1,282,500
10	42" Ductile Iron Watermain	20,460	LF	$255	$5,217,300
11	48" Ductile Iron Watermain	1,500	LF	$285	$427,500
12	54" Ductile Iron Watermain	9,800	LF	$315	$3,087,000
13	60" Ductile Iron Watermain	3,000	LF	$345	$1,035,000
14	72" Ductile Iron Watermain	1,000	LF	$405	$405,000
	Restoration and Reconstruction Costs				
1	HMA Road - Remove (Assumes 1 lane, 10' width)	258,956	SY	$10	$2,589,556
2	Replaced Roadway - Sand Subbase (assumes 10' width, 8" thick, 1.1 tons/cyd)	63,332	Tons	$5	$316,659
3	Replaced Roadway - Aggregate Base (assumes 10' width, 6" thick, 1.35 tons/cyd)	58,265	Tons	$12	$699,180
4	Replaced Roadway - HMA (assumes 10' width, 4" thick, 110lbs/syd/in)	56,970	Tons	$90	$5,127,320
5	General restoration/seeding/erosion control	2,331	Sta.	$750	$1,747,950
6	Storm sewer replacement (Assumes 100ft of 12" storm sewer for every 500ft transmission main)	46,612	LF	$55	$2,563,660
	Treated Water Transmision Main Piping Upgrades				
1	Medium (16"-30") Transmission Main Piping	52,000	LF	$160	$8,320,000
2	Large (> 30") Transmission Main Piping	77,000	LF	$275	$21,175,000

Note: Treated water transmission main piping lengths are order-of-magnitude estimates generated using preliminary modeling results. Exact sizing and lengths would need to be explored further in design. Estimated restoration and reconstruction cost assumes 50% of roadway replacement for treated water transmission main upgrades is done concurrently with the raw water transmission upgrades.

Rounded Construction Total	$224,800,000
Engineering, Contingency, Legal, Acquisition (~30%)	$68,200,000
Project Total Estimate:	**$293,000,000**

Prein&Newhof
Engineers•Surveyors•Environmental•Laboratory

Estimate of Probable Cost - 3 Splits

Owner:
City of Kalamazoo

Project Title:
Water System Master Planning - Reduction of Entry Points

Date: March 30, 2022

Project #: 2210003

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
	Plant Upgrades				
1	Central Treatment Plant Upgrades (6,750gpm → 26,950gpm)	1	Lsum	$50,000,000	$50,000,000
2	Construct Treatment Plant at Schippers Lane Station - 7,300gpm	1	Lsum	$15,000,000	$15,000,000
3	Expand/Retrofit Treatment Plant at Kendall Station - 12,800gpm	1	Lsum	$5,000,000	$5,000,000
	Raw Water Transmission Main Piping				
1	14" Ductile Iron Watermain	7,100	LF	$115.00	$816,500
2	16" Ductile Iron Watermain	1,200	LF	$130.00	$156,000
3	18" Ductile Iron Watermain	2,800	LF	$135.00	$378,000
4	20" Ductile Iron Watermain	44,750	LF	$145.00	$6,488,750
5	24" Ductile Iron Watermain	400	LF	$165.00	$66,000
6	26" Ductile Iron Watermain	22,800	LF	$175.00	$3,990,000
7	30" Ductile Iron Watermain	7,725	LF	$195.00	$1,506,375
8	32" Ductile Iron Watermain	26,000	LF	$205.00	$5,330,000
9	36" Ductile Iron Watermain	8,400	LF	$225.00	$1,890,000
10	42" Ductile Iron Watermain	14,750	LF	$255.00	$3,761,250
11	54" Ductile Iron Watermain	900	LF	$315.00	$283,500
	Restoration and Reconstruction Costs				
1	HMA Road - Remove (Assumes 1 lane, 10' width)	222,030	SY	$10.00	$2,220,300
2	Replaced Roadway - Sand Subbase (assumes 10' width, 8" thick, 1.1 tons/cyd)	54,301	Tons	$5.00	$271,506
3	Replaced Roadway - Aggregate Base (assumes 10' width, 6" thick, 1.35 tons/cyd)	49,957	Tons	$12.00	$599,481
4	Replaced Roadway - HMA (assumes 10' width, 4" thick, 110lbs/syd/in)	48,847	Tons	$90.00	$4,396,194
5	General restoration/seeding/erosion control	1,998	Sta.	$750.00	$1,498,703
6	Storm sewer replacement (Assumes 100ft of 12" storm sewer for every 500ft transmission main)	39,965	LF	$55.00	$2,198,097
	Treated Water Transmision Main Piping Upgrades				
1	Medium (16"-30") Transmission Main Piping	110,000	LF	$160.00	$17,600,000
2	Large (> 30") Transmission Main Piping	16,000	LF	$275.00	$4,400,000

Note: Treated water transmission main piping lengths are order-of-magnitude estimates generated using preliminary modeling results. Exact sizing and lengths would need to be explored further in design. Estimated restoration and reconstruction cost assumes 50% of roadway replacement for treated water transmission main upgrades is done concurrently with the raw water transmission upgrades.

Rounded Construction Total	$127,900,000
Engineering, Contingency, Legal, Acquisition (30%)	$39,100,000
Project Total Estimate:	**$167,000,000**

S:\2021\2210003 City of Kalamazoo\REP\Report - 2022-03-01\Estimate of Probable Cost - Raw Water Piping + Station Upgrades.xlsx

Prein&Newhof
Engineers•Surveyors•Environmental•Laboratory

Estimate of Probable Cost - Several Small WTPs Serving Wellfields

Owner:
City of Kalamazoo

Project Title:
Water System Master Planning - Reduction of Entry Points

Date: March 30, 2022

Project #: 2210003

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
	Treatment Upgrades				
1	15 MGD Plant at PS 22 - Serving PS 24 & PS 22	1	Lsum	$22,500,000.00	$22,500,000
2	7.5 MGD Plant at PS 8 - Serving PS 8 & PS 9	1	Lsum	$11,000,000.00	$11,000,000
3	3.75 MGD Plant at PS 39 - Serving PS 39	1	Lsum	$5,600,000.00	$5,600,000
4	Upgrade Central WTP to 28 MGD Capacity (~3x Expansion) - Serving PS 1, PS 2, PS 3, and PS 4	1	Lsum	$30,000,000.00	$30,000,000
5	Upgrade Kendall WTP to Full Treatment, 4.5 MGD - Serving PS 11 & PS 12	1	Lsum	$1,000,000.00	$1,000,000
6	4 MGD Plant at PS 5 - Serving PS 14 & PS 5 - Already Under Design	1	Lsum	$6,000,000.00	$6,000,000
7	6.5 MGD Plant at PS 25 - Serving PS 25	1	Lsum	$9,750,000.00	$9,750,000
	Raw Water Transmission Upgrades				
1	36" Ductile Iron Pipe - Tie PS 24 into WTP at PS 22	17,800	LF	$225.00	$4,005,000
2	20" Ductile Iron Pipe - Tie PS 9 into WTP at PS 8	5,500	LF	$145.00	$797,500
3	14" Ductile Iron Pipe - Tie PS 12 into WTP at PS 11	8,600	LF	$115.00	$989,000
4	16" Ductile Iron Pipe - Tie PS 14 into WTP at PS 5	8,900	LF	$130.00	$1,157,000
5	42" Ductile Iron Pipe - Tie PS 4 and PS 3 into WTP influent piping at PS 1 + 400ft of 42" Ductile Iron influent piping to WTP	6,200	LF	$255.00	$1,581,000
6	18" Ductile Iron Pipe - Tie PS 2 into WTP influent piping at PS 1	1,000	LF	$135.00	$135,000
	Restoration and Reconstruction Costs				
1	HMA Road - Remove (Assumes 1 lane, 10' width)	81,119	SY	$10.00	$811,189
2	Replaced Roadway - Sand Subbase (assumes 10' width, 8" thick, 1.1 tons/cyd)	19,839	Tons	$5.00	$99,195
3	Replaced Roadway - Aggregate Base (assumes 10' width, 6" thick, 1.35 tons/cyd)	18,252	Tons	$12.00	$219,021
4	Replaced Roadway - HMA (assumes 10' width, 4" thick, 110lbs/syd/in)	17,846	Tons	$90.00	$1,606,154
5	General restoration/seeding/erosion control	730	Sta.	$750.00	$547,553
6	Storm sewer replacement (Assumes 100ft of 12" storm sewer for every 500ft transmission main)	14,601	LF	$55.00	$803,077
	Treated Water Transmision Main Piping Upgrades				
1	Medium (16"-30") Transmission Main Piping	50,000	LF	$160.00	$8,000,000
2	Large (> 30") Transmission Main Piping	0	LF	$275.00	$0

Note: Treated water transmission main piping lengths are order-of-magnitude estimates generated using preliminary modeling results. Exact sizing and lengths would need to be explored further in design. Estimated restoration and reconstruction cost assumes 50% of roadway replacement for treated water transmission main upgrades is done concurrently with the raw water transmission upgrades.

Rounded Construction Total	$106,610,000
Engineering, Contingency, Legal, Acquisition (30%)	$32,390,000
Project Total Estimate:	**$139,000,000**