ENEngineering

Comprehensive and Dependable Engineering, Consulting, and Automation Services

Natural Gas System Plan

Model Creation, Growth Analysis
and Capital Investment Plan
2021 – 2026

Project # 2020-004

Prepared for:

City of Ellensburg WASHINGTON

Prepared by:

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2021 – Final V1

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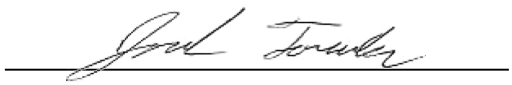

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Executive Summary

City of Ellensburg (COE) requested that EN Engineering (EN) perform an analysis to review their current natural gas system infrastructure and develop a six-year capital investment plan to include anticipated growth and infrastructure changes within their distribution system.

A gas network model based on COE's Geographic Information System (GIS) information was built for this analysis. The analysis evaluated the impact of medium and high populated growth scenarios projected to 2026 accounting for potential residential and commercial service increases. These modeling scenarios were used to evaluate system performance under current and projected demands. Planned projects as well as new system improvements were modeled and analyzed for their benefits. Additionally, EN identified and ranked single-feed branches by severity.

The analysis determined that the current gas system infrastructure is sufficient to adequality supply additional services resulting from projected medium or high population growth. Utilizing increased supply pressures, the gas system maintains service pressures above 20 PSI during the extreme weather condition of 60 HDD, and when the Central Washington University (CWU) physical plant service is disabled, service pressures are maintained during the very extreme weather condition 80 HDD conditions.

In order to maintain current system performance under medium projected population growth the following improvements are necessary:

- Increase the system supply pressure to 49 PSI

In order to maintain current system performance under high projected population growth the following improvements are necessary:

- Increase the system supply pressure to 50 PSI and
- A 3,900-foot 4-inch extension along Number 6 Road from West Willis Road to Vantage Highway and then west along Vantage Highway to join to Main ID: 898-131.

1.0 Introduction

City of Ellensburg (COE) requested that EN Engineering (EN) perform an analysis to review their current natural gas system infrastructure and develop a six-year capital investment plan to include anticipated growth and infrastructure changes within their distribution system. EN worked alongside the COE Gas Engineering team to review the current operating system and to perform analysis to identify potential performance issues and infrastructure improvements needed to account for future growth throughout the system.

The analysis was performed by utilizing the current COE GIS data and other available data sources to develop a Synergi Gas model to replicate COE's current operating system. The model was used to perform simulations of the current operating conditions to identify potential performance issues. Additionally, EN performed a future growth analysis projection to identify medium and high growth projects within their service territory. The projected growth results were applied to the model and used to assess current and potential infrastructure. As a result of the modeled projected growth analysis, EN identified potential infrastructure improvements for COE to maintain their system as the demand increases within their system. The following report outlines the analysis performed and the potential improvement within the system to meet the demands.

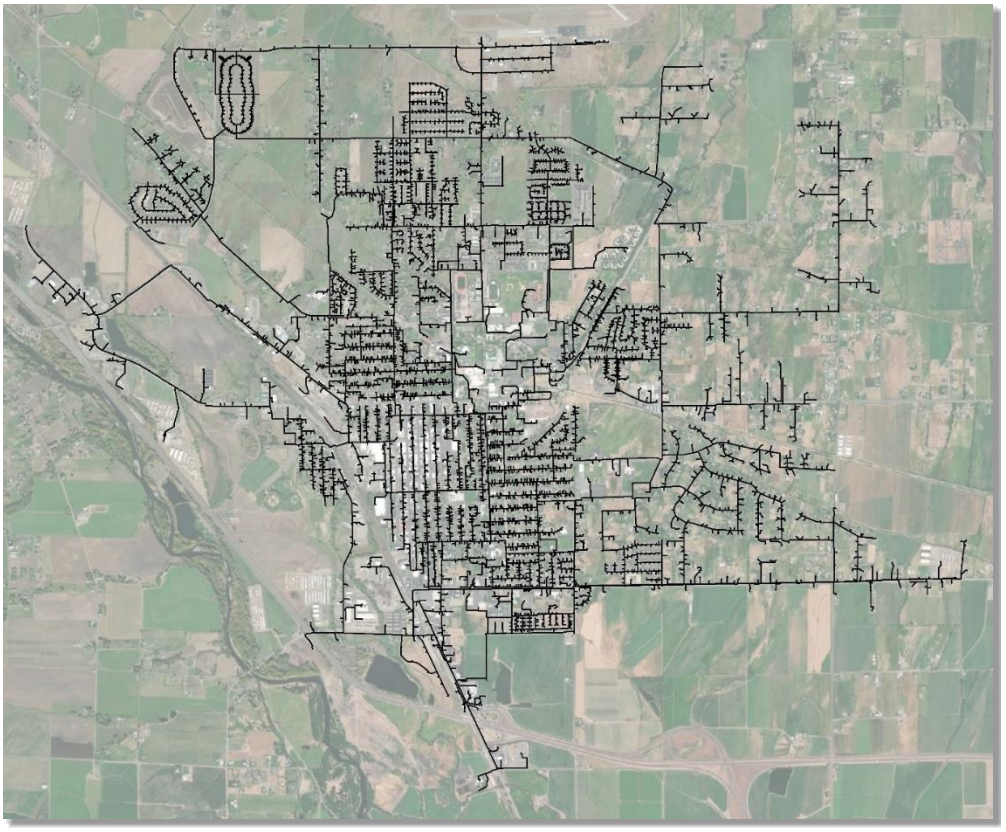

Figure 1 System Overview

2.0 COE Natural Gas System

The COE and surrounding area have an estimated population of 21,345[1] and is the county seat of Kittitas County located in central Washington. The city operates and maintains the natural gas distribution service within their allowable territory which includes the city and parts of Kittitas county residents. The first gate station to the city was constructed in late 1956 supplying gas through the Wenatchee lateral, which is currently operated by the Williams Northwest Pipeline Company.

Currently COE is supplied at the Kittitas Tap Station located at 3261 Kittitas Highway, Ellensburg, WA, which was rebuilt in 2000. Within the tap station there is the Kittitas Regulator Station and there is a second regulator station located on Seattle Avenue supplying the city. Below are the current operating conditions and the maximum capacities of the stations.

Regulator Station	Capacity (SCFH)	Inlet Pressure (PSIG)	Outlet Operating Pressure (PSIG)	Operating MAOP (PSIG)
Kittitas Highway	422,702	145	42	60
Seattle Avenue	1,026,987	145	42	60

Table 1 Regulator Stations

2.1 Distribution System Overview

Over the proceeding years, the infrastructure of the distribution system has expanded to supply new developments and growing business within the city. Currently, the system is comprised of 135.10 miles of distribution main lines and 76.03 miles of service lines. Table 2, Table 3 and Table 4 below detail the sizes, materials and installation decade.

Nominal Diameter (inch)	Mains Lengths (miles)	Services Lengths (miles)
½	0.00	24.70
¾	0.00	7.49
1	0.00	42.83
1 ½	0.07	0.00
2	76.28	1.00
4	38.46	0.01
6	20.26	0.00
8	0.02	0.00
Total	135.10	76.03

Table 2 Mains and Services Lengths[2]

[1] https://worldpopulationreview.com/us-cities/ellensburg-wa-population

Pipe Material	Mains Lengths (miles)	Services Lengths (miles)
PE	92.73	59.03
Steel	42.36	17.00
Total	135.10	76.03

Table 3 Main and Service Materials[2]

Decade Installed	Mains Lengths (miles)	Services Lengths (miles)
1950	34	0.00
1960	6	0.00
1970	4	0.00
1980	6	0.93
1990	30	6.27
2000	40.57	11.27
2010	12.55	7.90
2020	1.97	0.28
Unknown	0.00	49.38
Total	135.10	76.03

Table 4 Main and Service Install Decade[2]

According to GIS data, within the current system there are a total of 991 valves which are used for multiple functions within the system.

Valve Use	Valve Count
System Valve	21
Isolation	28
Emergency	145
Unspecified	797
Total	991

Table 5 GIS Valve Count by Use

2.2 Customer Volume Data

As of 2020, there are currently 4,885 active customers which constitutes of 4,095 residential customers and 790 commercial customers. The customers are grouped into three (3) different categories and their associated average flows per season are outlined in table 6 in units centi-cubic feet per day (CCFD).

Customer Category	Average Winter[3] Flows (CCFD)	Average Summer[4] Flows (CCFD)

[2] GIS Feature Class Tables and PHMSA 2020 Annual Report
[3] December, January, and February

Customer Category	Average Winter[3] Flows (CCFD)	Average Summer[4] Flows (CCFD)
Commercial/Industrial	454.82	282.83
Residential	9.26	1.25
Municipal	54.25	11.80
Combined Averages	518.32	295.88

Table 6 Average Flows by Customer Category[5]

Daily averaged flows hide the impacts of consumption cycle peaks. The analysis was performed using hourly flows to account for peak conditions. Customer load records were provided in the units of centi-cubic feet (CCF) per the billing cycle, which was converted into standard cubic feet per hour (SCFH) based on a 14-hour day. A 14-hour day was used within the analysis to account for normal daily use, which provided a conservative value compared to a 24-hour day.

3.0 Modeling Methodology

A hydraulic model was built of the COE natural gas system using the Synergi Gas modeling software (Synergi). The model was developed by using COE provided GIS data consisting of the distribution system piping and facility features. The provided GIS data was reviewed to ensure the connectivity and attributes reflected the current system.

Additionally, the customer load data provided by COE customer records over the last 6 years (2015 through 2020) were reviewed and the data was correlated to the geospatial location within the system. The customer load data was used to calibrate the model and develop the model parameters and load variables to reflect the current operating conditions. The developed model was used to understand the current operating performance and to generate system improvements recommendations for COE.

3.1 COE GIS Data Review

EN reviewed the provided GIS data in the table below, to ensure the connectivity and attribute information reflected the current COE distribution system. The review of the GIS data was to eliminate out-of-scope, erroneous or duplicate records. Special attention was paid to the connectivity of pipe features and the size of pipes and valves. All the validated input data used in the model went through a series of validations and standardizations before importing the data into Synergi.

Feature Type	Source	Records
Pipes	P_Pipes	2,888
Services	P_Service	7,567
Valves	P_Valves	995
Meter	P_Meter_Setting_Old	5,429

Table 7 GIS Data Summary[6]

[4] June, July, and August
[5] Gas Billing Data
[6] GIS Feature Class Tables

The GIS connectivity review consisted of combining a network dataset model to automatically identify disconnected segments and geometry errors. After the automatic review, a final manual review was performed ensuring that the system's engineering aspects were feasible and correct. Additionally, duplicate records were removed and overlapping segments were corrected.

3.1.1 Service Meter Location Review

In the analysis, the customer locations within the city were spatially placed using the provided meter feature class "P_Meter_Setting_Old". The customer billing records were related to the spatial location through two (2) different methods that include relating the Equipment ID attribute between the two data sets which accounted for relating 4,424 or 90.6% of the customers. The second method used georeferencing the address within GIS to spatially locate the reaming records.

3.2 Model Parameters

The following standard hydraulic modeling parameters were employed for this analysis:

- Friction Factor Calculation method: Colebrook-White equation
- Base Temperature: 60.0 $°F$
- Specific Gravity: 0.60

3.3 Feature Import

The evaluated and confirmed GIS data was imported into Synergi to develop the COE model. Along with the spatial information of the features, the following attributes were imported and associated to their corresponding pipe features.

- GlobalID
- Nominal diameter
- Material
- MainID
- Operating Pressure
- Connectivity
- Status

The GlobalID and MainID were associated with all features within the model to provide COE the flexibility to relate the model and GIS data. These attributes do not directly impact the model hydraulically, but they were included to facilitate updates to the model as needed in the future.

3.4 Calibration

As the preliminary model was developed using GIS data it required to be calibrated to reflect the COE operating conditions. The calibration requires known pressure and flow records to compare model performance. The known pressures and flows are applied to the model, the calibration point pressures are fine tuned to the known values using pipe efficiency and roughness values.

The known pressure points within the system were the Kittitas Tap Station, Central Washington University Physical Plant and the Twin City Foods Station using the 2015-2019 records. Two calibration periods during 2019 were selected to ensure the model was calibrated against the most current available pressure and flow conditions. The flow periods of January-February and May-June were selected as calibration periods. Winter and summer periods were used to capture and account for the seasonal nature of gas demands.

Tuning the pipe efficiency to 97% and using pipe roughness values of 1.8×10^{-3} inches for Steel and 6.0×10^{-5} inches for PE pipe brought the modeled pressures 99.26% within the current recorded operating conditions.

3.5 Variable Demand File

A variable demand file was generated using the recorded load data. Such a demand file allows the model to be loaded based on the weather conditions of the user's choosing. Heating degree days (HDD) were used as the weather variable in this analysis. HDD values are the difference between the outside temperature relative to 65ºF. As outside temperature drops below 65ºF, the HDD value increases. This demand file was used to simulate elevated HDD conditions on the system.

To create the variable demand file a linear relationship was derived between each service type and the HDD conditions experienced by customers during the given billing cycle. The weather data used to establish the relationships were recorded at the Yakima Air Terminal approximately 30 miles south of Ellensburg[7], since this location had complete records for 2020 compared to other locations within the surrounding area.

A linear relationship was determined between the load data records and the weather records on a per service type basis. The chart below illustrates the relationship between customer demand in standard cubic feet per hour (SCFH) and HDD value.

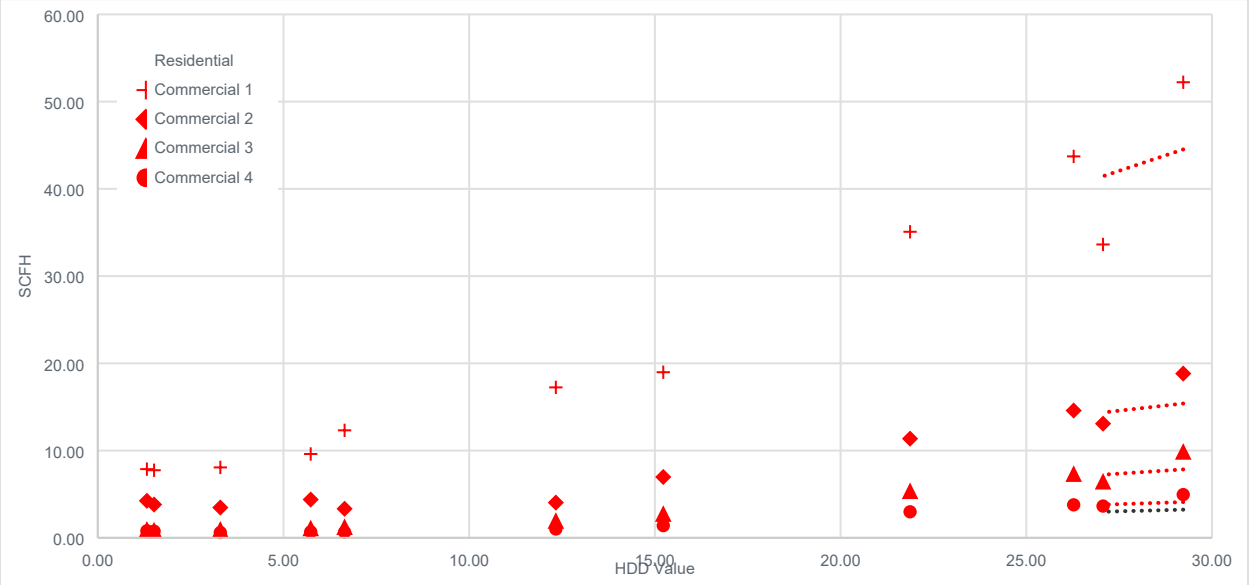

Figure 2 Customer Demand and HDD Relationship[8]

The linear relationship between the customer demands and weather was used to make a demand formula for each service type to be associated to each service in the form of a variable demand file. This variable demand file was used to load the model at arbitrary HDD values to assess the model's response to various loading conditions.

[7] www.degreedays.net
[8] Gas Billing Data

3.5.1 Central Washington University Variable Demand

The method detailed in Section 3.5 was applied to the high demand customer CWU's Physical Plant service. The chart below represents the linear relationship between the demand in SCFH and the HDD value for CWU's Physical Plant service.

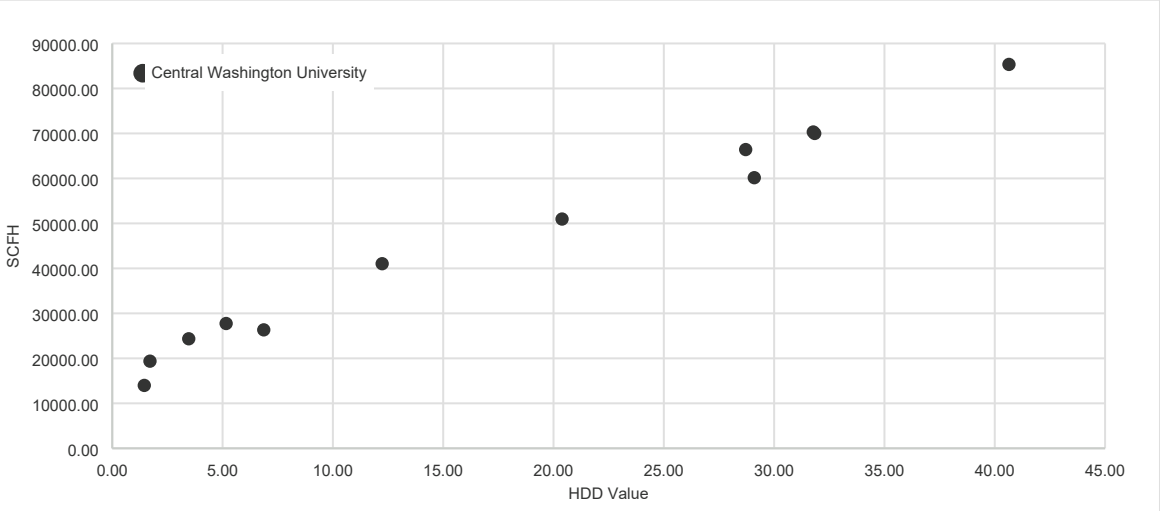

Figure 3 CWU Demand and HDD Relationship[9]

3.5.2 Twin City Foods Consideration

The Twin City Foods customer is a large customer located centrally in the City of Ellensburg. According to billing records, this customer does not follow similar demand/weather trends compared to the commercial and residential customers as detailed in Section 3.5. The peak winter demand of 1,708.33 SCFH was used as a static demand through the different seasons since it does not exhibit a normal seasonal demand response.

3.5.3 Demand Scenarios

Using the above methodology, six (6) demand scenarios were generated. The six (6) scenarios are detailed in Table 8 below. Scenarios 1 and 4 were used to model the system under the current customer demands. While scenarios 2, 3, 5 and 6 were used to model the medium and high population demands in the model.

Scenario Number	Services	HDD condition	CWU Physical Plant
1	2020 services	60	Active
2	2026 medium projected growth	60	Active
3	2026 high projected growth	60	Active
4	2020 services	80	Inactive
5	2026 medium projected growth	80	Inactive
6	2026 high projected growth	80	Inactive

Table 8 Six Demand Scenarios

[9] Gas Billing Data

4.0 Growth Projection Methodology

Medium and high growth projections were generated using publicly available demographic data. The growth projections were based on the population change trends of the City of Ellensburg. As the population expands, so to the number of gas customers is expected to increase. The relationship between the population and customer by type (Section 4.3) was used to project the expansion of gas customers.

4.1 Data Used

Historic population data was used to understand the growth trends for this analysis. Data available from the United States Census Bureau was used to establish a growth trend for the City of Ellensburg and surrounding area. The census data spans from 1990 to 2020.[10]

Year	Population	Year	Population	Year	Population
1990	12,779	2001	15,780	2012	18,460
1991	12,745	2002	16,138	2013	18,520
1992	12,579	2003	16,384	2014	18,961
1993	12,894	2004	17,062	2015	18,985
1994	13,307	2005	16,961	2016	19,763
1995	13,269	2006	17,288	2017	20,300
1996	13,481	2007	17,214	2018	20,977
1997	13,814	2008	17,344	2019	21,111
1998	14,170	2009	17,505	2020	21,345
1999	14,512	2010	18,416		
2000	15,565	2011	18,602		

Table 9 US Census Bureau City of Ellensburg Population 1990-2020[10]

4.2 Projecting Population Growth

The available population records were used to forecast the population growth out to 2026. The population records depict a positive trend best fit to a linear trendline. The fitted linear trendline has a high R-squared value of 98.16%. This indicates a well fit trendline. Figure 4 represents the population records by year. The black line represents the recorded data, while the red lines represent the projected population values. A high and low growth range has been added to the chart and is indicated by the dashed red lines above and below the solid red medium growth line. The high and low growth trend lines represent a 95% confidence range of growth.[10]

[10] Ellensburg, Washington Population 2021 (Demographics, Maps, Graphs) (worldpopulationreview.com)

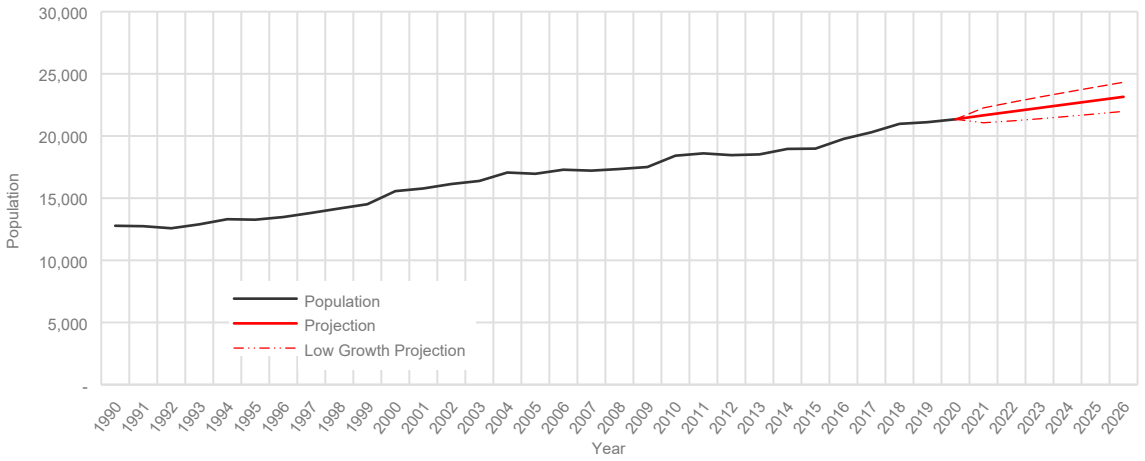

Figure 4 City of Ellensburg Historic and Projected Population[10]

The generated growth projections were used to estimate expected service increases in the gas system. This process is detailed below.

4.3 Estimating Service Growth

A linear relationship was derived between recorded service counts and recorded populations and extrapolated the relationship out to 2026 using the high and medium population growth projections. This method was performed on residential services, and the four (4) commercial category services. The results for each of the five (5) service types are provided below. See Appendix A – Population and Service Projection Tables for more information.

4.3.1 Residential Services

The methodology explained in Section 4.3 was applied to the last five (5) years of customer records provided by COE. A linear relationship was derived between recorded residential service counts and population per year. That relationship was extrapolated out to 2026 using the high and medium population growth projections. The results are in Figure 5 below.[11]

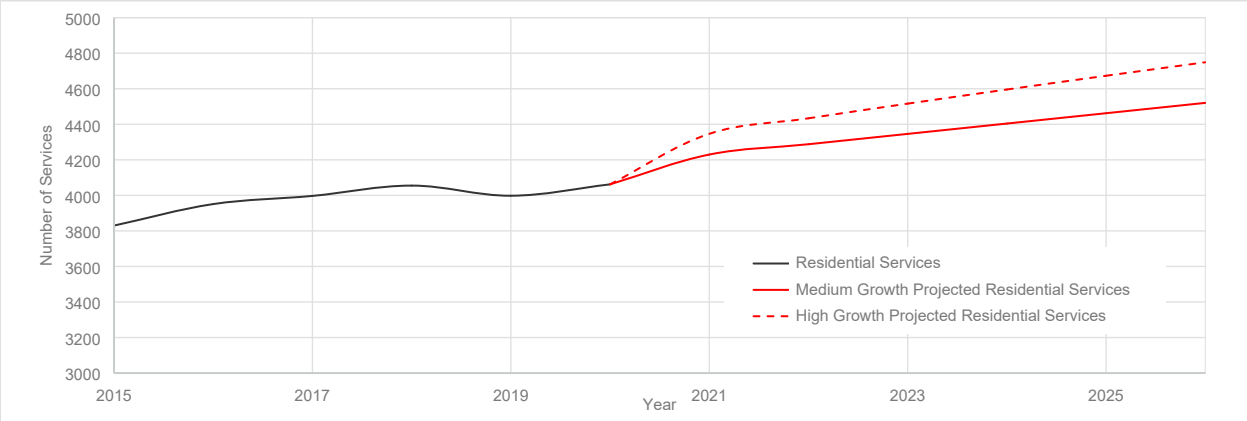

Figure 5 Residential Services Projected Growth[11]

[11] Service Projections

4.3.2 *Commercial Services*

The methodology explained in Section 4.3 was applied to the last five (5) years of customer records provided by COE. A linear relationship between recorded commercial service counts and population per year was established. That relationship was extrapolated out to 2026 using the high and medium population growth projections established in Section 4.2.[11] This was done to the four (4) commercial customer categories:

1. Category 1 – Commercial 1000 CF and greater
2. Category 2 – Commercial 750/800 CF
3. Category 3 – Commercial 415/425 CF
4. Category 4 – Commercial 275 CF and less

The results are in the four (4) charts below.

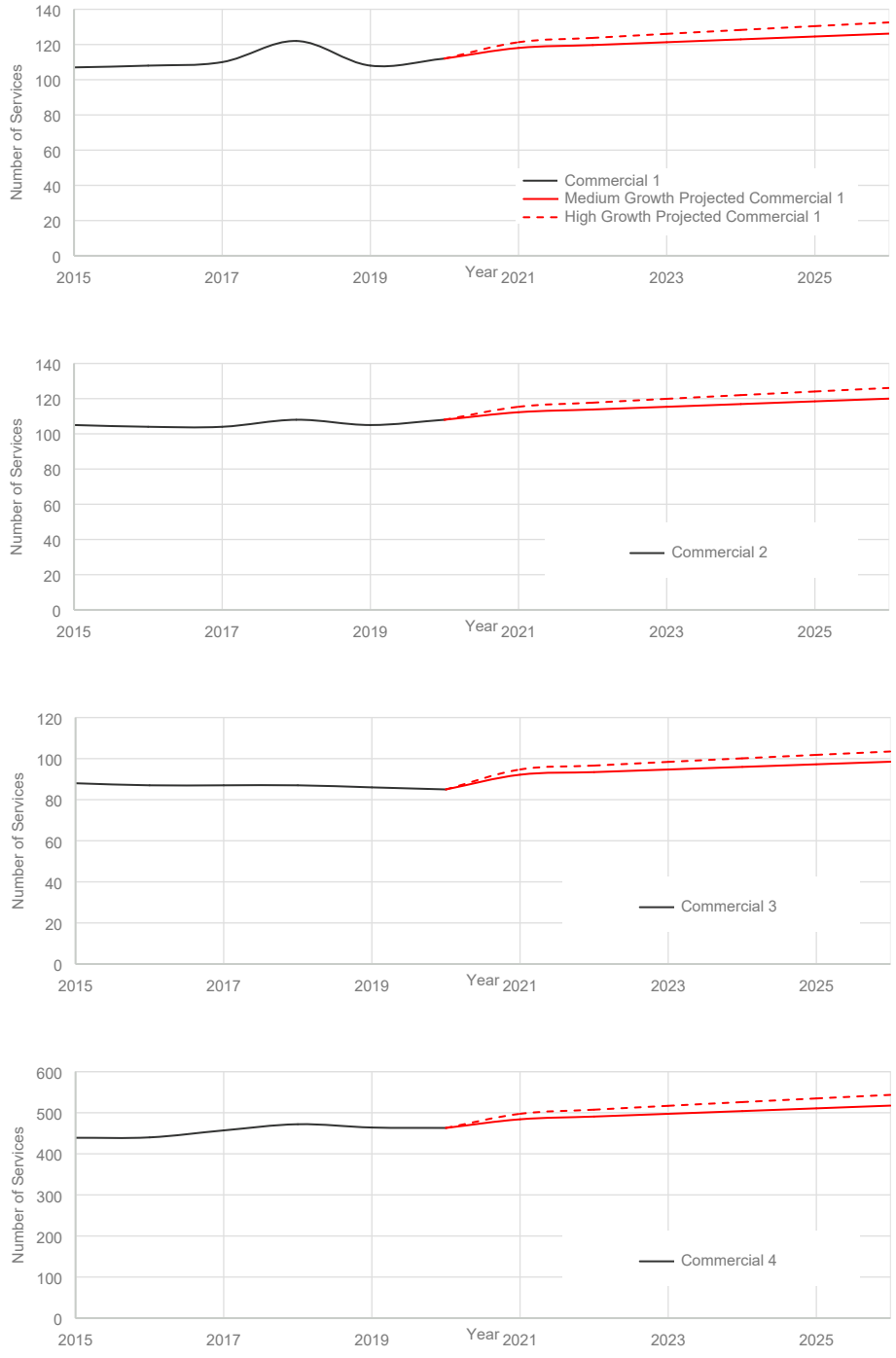

Figure 6 Commercial Category 1-4 Projected Growth[11]

5.0 Current System Performance

The performance of the current system piping was analyzed using the hydraulic model. Analysis criteria and methodology was established to assess the current system performance. Then this methodology was applied to the model under the six (6) demand scenarios (see Section 3.5.3 for demand scenario explanation). Table 10 (below) lists the maximum HDD conditions at which the modeled system can sustain customers at pressures at or greater than 20 PSI. Appendix B – Current System Limits contains the modeling result exhibits.

Scenario Number	Highest HDD that all services are supplied with ≥ 20 PSI.	Total Supply Flow (SCFH)	Supply Pressure (PSIG)
1	63	446,904	41
2	57	443,447	41
3	54	434,869	41
4	88	451,108	41
5	77	445,182	41
6	73	440,652	41

Table 10 Current System HDD Limits

5.1 Current Performance Criteria

The model results indicate that the current system piping can successfully supply all current services with at least 20 PSI of pressure during 60 HDD and slightly beyond. 60 HDD conditions was selected as the first weather condition criteria to attain adequate service pressures during. Under extreme demand cases, such as when the weather conditions exceed 60 HDD, COE can shut off service to their large customer CWU in order to meet the increased demand from other customers. This demand relief mechanism was considered for this analysis and an extreme demand scenario of 80 HDD was selected as the second weather condition criteria. The model results indicate that the current system piping can successfully supply all services except the CWU Physical Plant service with at least 20 PSI of pressure during 80 HDD and slightly beyond.

5.2 Current System Performance Under Projected Growth Scenarios

The current system piping fails to supply at least 20 PSI pressures at services at the established 60/80 HDD criteria under both six (6) year medium and high population growth scenarios. Figure 7 below illustrates the model performance under current and projected customer demands.[12]

[12] Current System Performance

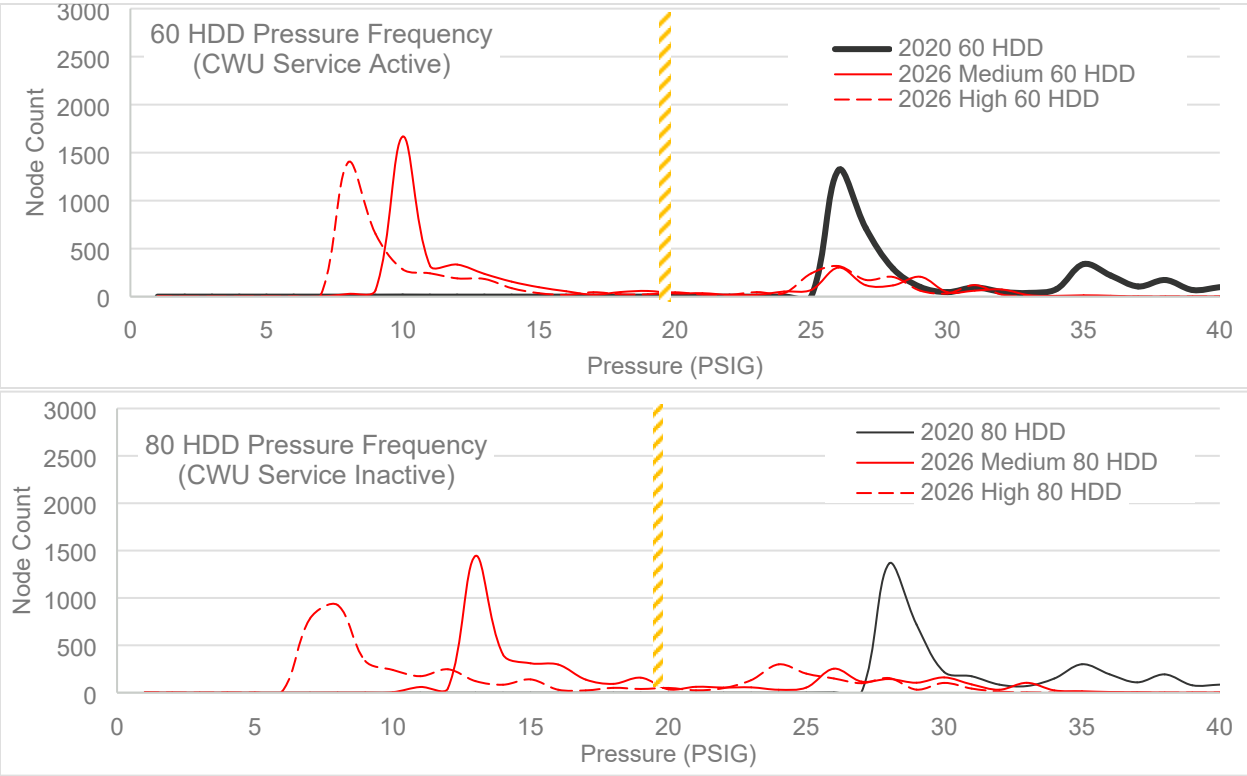

Figure 7 Current System Performance 60/80 HDD[12]

5.2.1 *2026 Medium Projected Growth*

If actual population growth matches the medium projected growth, the current system piping will only be able to maintain adequate pressures up to 57 HDD with CWU active and 77 HDD with CWU inactive.

5.2.2 *2026 High Projected Growth*

If actual population growth matches the high projected growth, the current system piping will only be able to maintain adequate pressures up to 54 HDD with CWU active and 73 HDD with CWU inactive.

6.0 COE System Improvement Analysis

EN analyzed twelve (12) system improvements using the hydraulic model. Individual improvement descriptions, results and benefits are discussed in this section. Six (6) of the twelve (12) system improvements were provided by COE. These planned improvements are renumbered in this report as improvements number one through 6. EN generated the remaining four (4) improvements using the model to identify flow bottle necks and main extension opportunities based on system performance.

The system improvements were modeled and analyzed individually using load scenarios 1, 2 and 3. These scenarios were sufficient in determining the hydraulic impact of each system improvement to the system. See Appendix C – Individual System Improvement Exhibits for the modeling results exhibits for each individual system improvement.

The project cost estimates used in this report were generated using high level estimation methodologies. The estimates include price of pipe material and tracer wire, cost of

contractor installation and cost of directional bore as well as a 20% contingency for fittings, mechanics, technicians and inspector and final restoration) which does not account for trenching, bedding, backfilling. See Table 11 below for per foot prices used for estimates.

Pipe Size (inches)	Material	Pipe Price per Foot	Tracer Wire Price per Foot	Installation Price per Foot	Boring Price per Foot	Combined Price per Foot
2	PE	$0.91	$0.09	$13.00	$12.89	$26.89
4	PE	$3.19	$0.09	$15.17	$14.75	$33.20
6	PE	$5.16	$0.09	$23.23	$18.62	$47.10
6	Steel	$10.15	N/A	$23.23	$18.62	$52.00

Table 11 Cost Estimation Table

Additional considerations were applied to the cost estimates for improvements 8 and 9 because of their small scale compared to the other improvements. Day rate cost considerations were added to these small projects which more accurately approximates the actual costs. An hourly rate of $116 per person and 8-hour workdays were used to estimate these day rates. These additional considerations for improvements 8 and 9 are detailed in their respective sections.

The cost estimates should be used for estimating purposes only and are based on historic values which are non-location specific. Further detailed analysis is required to account for regional and/or site-specific considerations.

6.1 Improvement 1 – Highway 97/10 Connection

The Highway 97/10 connection improvement includes a 3,200-foot of 6-inch main installation located in the northwest of the system. It would span east-west from the intersection of Highway 97 and Desmond Road to the intersection of Old Highway 10 and Clearview Drive at the Currier Creek Development.

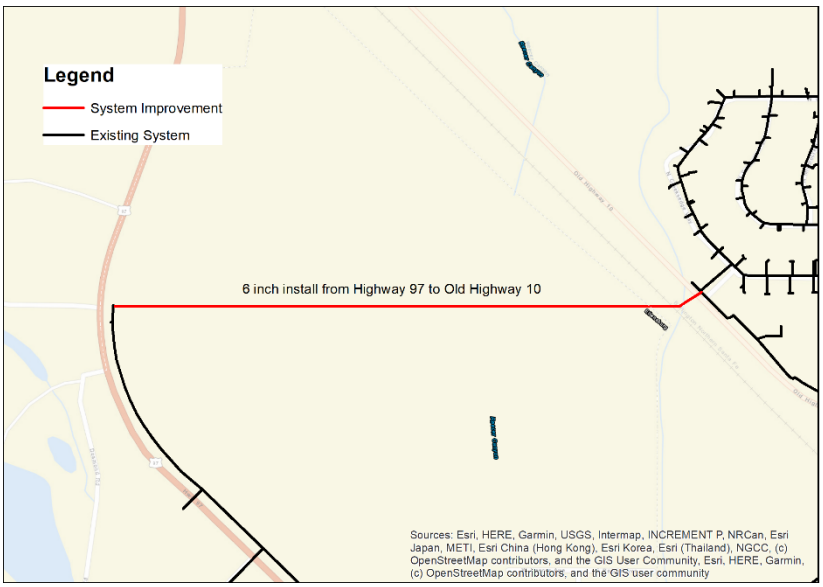

Figure 8 System Improvement 1 Overview

This installation has a looping benefit for the services along Highway 97 in the northwest. According to modeling results, this improvement will provide a slight hydraulic benefit of 0.86 PSI to local services under a medium population growth scenario. And it will provide a significant local hydraulic benefit of 2.65 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $181,000 (Calculated per unit costs in Table 11)

See Appendix C.01 – Improvement 1 Result Exhibits for modeling results.

6.2 Improvement 2 – Helena Avenue Extension

The Helena Avenue extension improvement incudes 540-foot of 4-inch main extension located in the northwest of the system. It would span east-west from the west end of Helena Avenue to the 4-inch main (ID: 05-2486) located within Cora Street.

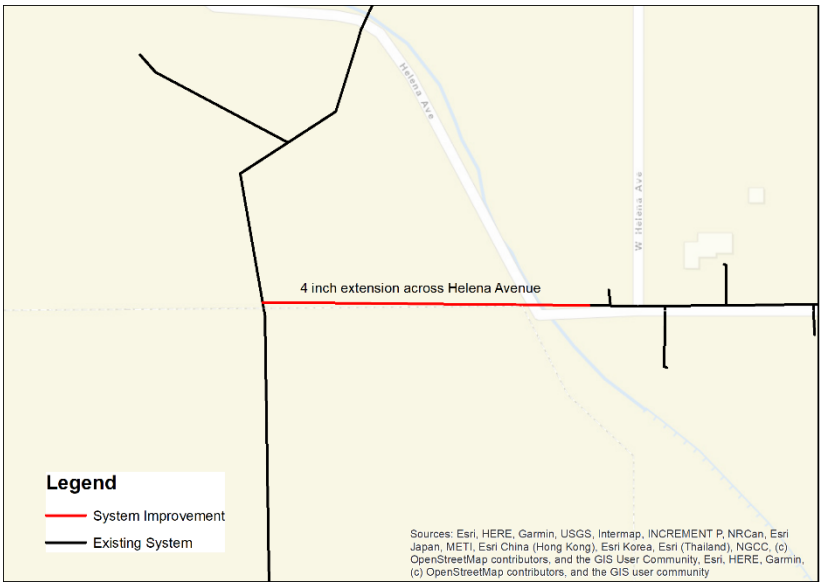

Figure 9 System Improvement 2 Overview

This installation has a looping benefit for the services along West Helena Avenue in the northwest. According to modeling results, this improvement will provide a slight hydraulic benefit of 0.21 PSI to local services under a medium population growth scenario. And it will provide a slight local hydraulic benefit of 0.42 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $22,000 (Calculated per unit costs in Table 11)

See Appendix C.02 – Improvement 2 Result Exhibits for modeling results.

6.3 Improvement 3 – Game Farm Road Extension

The Game Farm Road extension improvement includes a 3,750-foot of 6-inch main extension located in the northeast of the system. It would span east-west from the intersection of Game Farm Road and Wilson Creek Road to the 6-inch main along Game Farm Road (ID: 899-017), east of Pfenning Road.

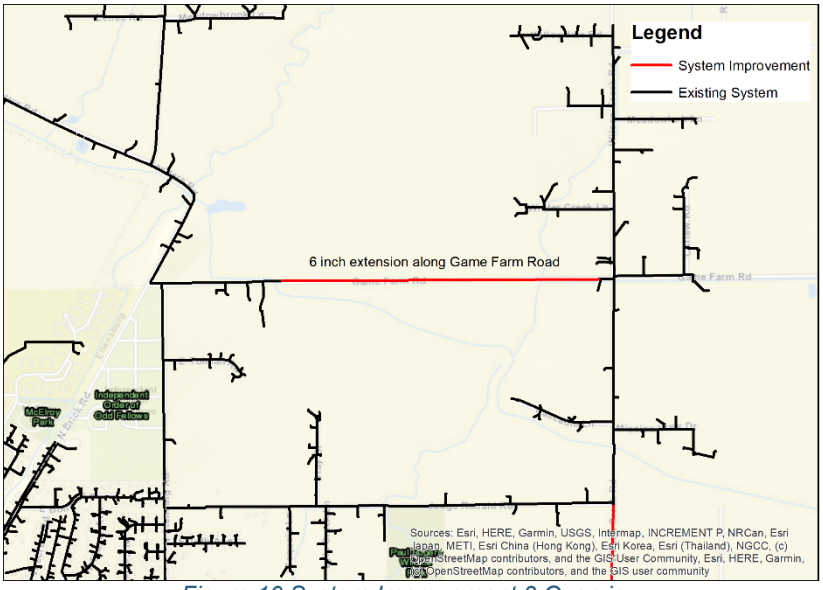

Figure 10 System Improvement 3 Overview

This installation has a major looping benefit for the services along Judge Ronald Road and Wilson Creek Road in the northeast. According to modeling results, this improvement will provide a slight hydraulic benefit of 0.03 PSI to local services under a medium population growth scenario. And it will provide a slight local hydraulic benefit of 0.06 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $212,000 (Calculated per unit costs in Table 11)

See Appendix C.03 – Improvement 3 Result Exhibits for modeling results.

6.4 Improvement 4 – Number 6 Road Extension

The Number 6 Road extension improvement includes a 3,900-foot of 4-inch main extension located in the East of the system. It would span north-south along Number 6 Road from near the intersection of West Willis Road and Number 6 Road and then east-west along Vantage Highway to a 2-inch main (ID: 898-131).

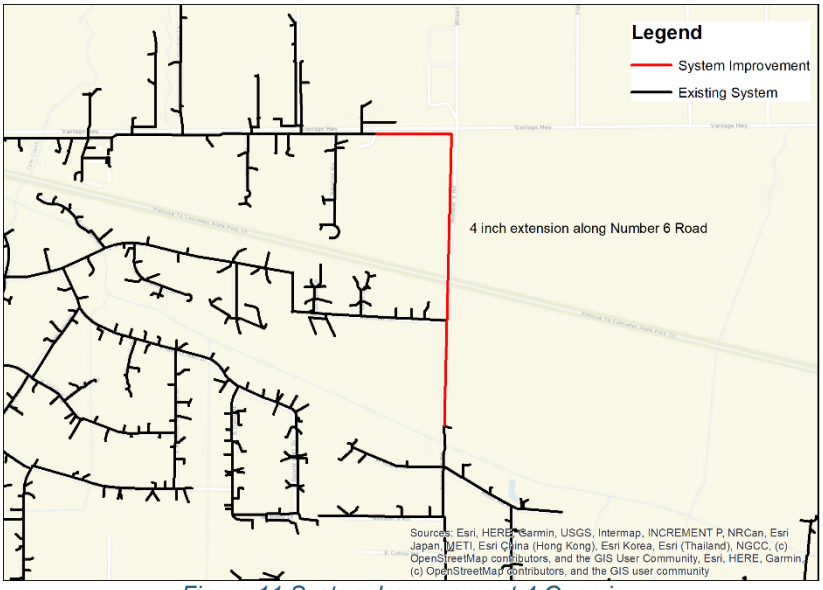

Figure 11 System Improvement 4 Overview

This installation has a major looping benefit for the services along Vantage Highway, Lone Star Lane, and East 3rd Avenue. According to modeling results, this improvement will provide a significant system-wide hydraulic benefit of 5.50 PSI and a significant hydraulic benefit of 4.94 PSI to local services under a medium population growth scenario. And it will provide a significant system-wide hydraulic benefit of 9.51 PSI and a significant local hydraulic benefit of 4.94 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $155,000 (Calculated per unit costs in Table 11)

See Appendix C.04 – Improvement 4 Result Exhibits for modeling results.

6.5 Improvement 5 – Berry Road Extension

The Berry Road extension improvement includes a 5,360-foot of 4-inch main extension located in the South of the system. It would span north-south along Bull Road from the intersection of Bull Road and East Umptanum Road to the intersection of Bull Road and Berry Road then east-west along Berry Road to the 4-inch main (ID: 897-006).

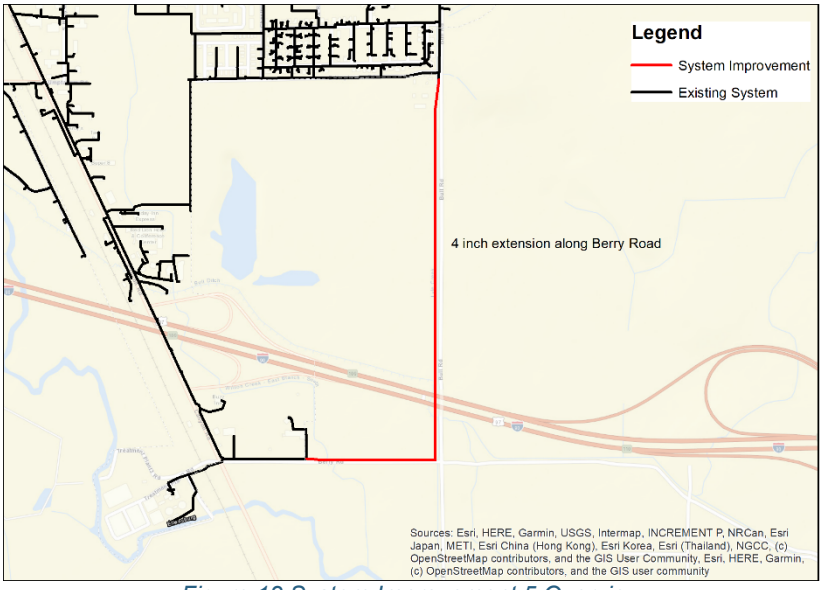

Figure 12 System Improvement 5 Overview

This improvement has a looping benefit for the services along Canyon Road. According to modeling results, this improvement will provide a slight hydraulic benefit of 0.40 PSI to local services under a medium population growth scenario. And it will provide a slight local hydraulic benefit of 0.82 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $214,000 (Calculated per unit costs in Table 11)

See Appendix C.05 – Improvement 5 Result Exhibits for modeling results.

6.6 Improvement 6 – East 11th Avenue Upgrade

The East 11th Avenue upgrade improvement includes a 1,350-foot of 2-inch main insertion located centrally in the system. It would replace the 4-inch steel main (ID: 859-004) along East 11th Avenue and North Chestnut Street.

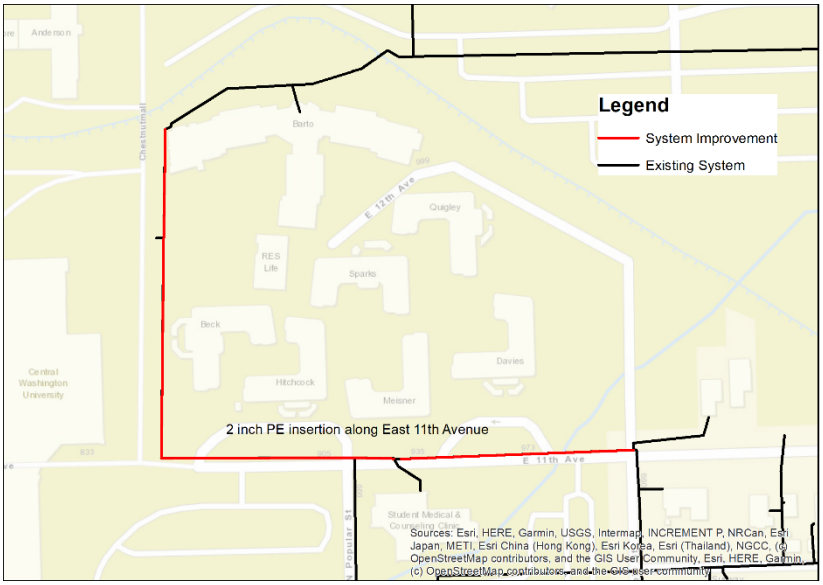

Figure 13 System Improvement 6 Overview

The smaller diameter PE pipe will be adequate to supply gas to this area. This installation would not result in a looping benefit not already seen in the system. According to modeling results, this improvement will create a hydraulic detriment or loss of 1.01 PSI to local services under a medium population growth scenario. And it will create a local hydraulic detriment of 1.88 PSI under a high population growth scenario.

Estimated Project Cost: $44,000 (Calculated per unit costs in Table 11)

See Appendix C.06 – Improvement 6 Result Exhibits for modeling results.

6.7 Improvement 7 – Northwest Regulator Station

The North West Regulator Station improvement includes a regulator station installation at Reecer Creek Road in the northwest of the system near the Currier Creek Development. This station requires a 3.84 mile 6-inch main installation branching from the 6-inch 856-001 main near the Seattle Road Station. The routing for this 3.84-mile main addition was modeled prioritizing the shortest path while following existing mains. A less invasive but longer route was not evaluated as part of this analysis.

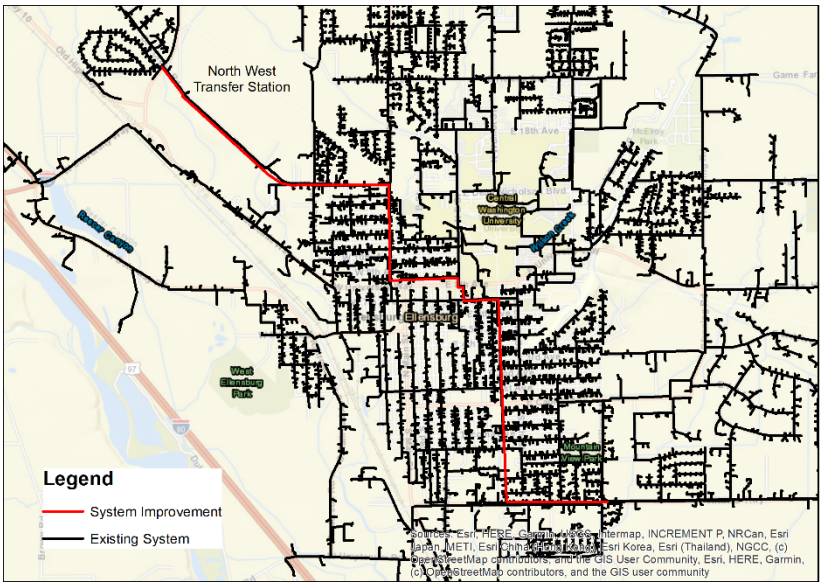

Figure 14 System Improvement 7 Overview

According to modeling results, this improvement will provide a major system-wide hydraulic benefit of 11.11 PSI under a medium population growth scenario. And it will provide a major system-wide hydraulic benefit of 15.75 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: N/A (Project cost not estimated per the request of COE)

See Appendix C.07 – Improvement 7 Result Exhibits for modeling results.

6.8 Improvement 8 – East 7th Avenue Upgrade

The East 7th Avenue upgrade improvement includes replacing 117-foot main ID: 870-001 of the current 4-inch main with a 6-inch main located at the intersection of East 7th Avenue and North Sampson Street.

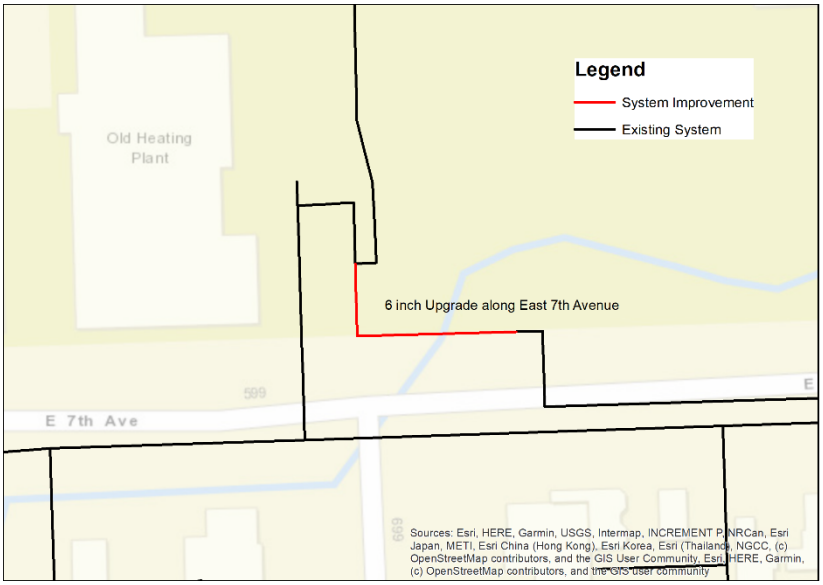

Figure 15 System Improvement 8 Overview

This improvement would not result in a looping benefit not already seen in the system. According to modeling results, this improvement will provide a slight local hydraulic benefit of 0.71 PSI under a medium population growth scenario. And it will provide a slight local hydraulic benefit of 1.29 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Additional cost estimation considerations:

1. Five-man crew with equipment for six (6) days: $27,840
2. Two-man boring crew with equipment for one (1) days: $1,856
3. Pipe cost: $1,220
4. 20% contingency

Estimated Project Cost: $37,100

See Appendix C.08 – Improvement 8 Result Exhibits for modeling results.

6.9 Improvement 9 – Radio Road Upgrade

The Radio Road upgrade improvement includes replacing 80-foot main ID: 870-001 of the current 2-inch main with a 4-inch main located at the intersection of Radio Road and Vista Road.

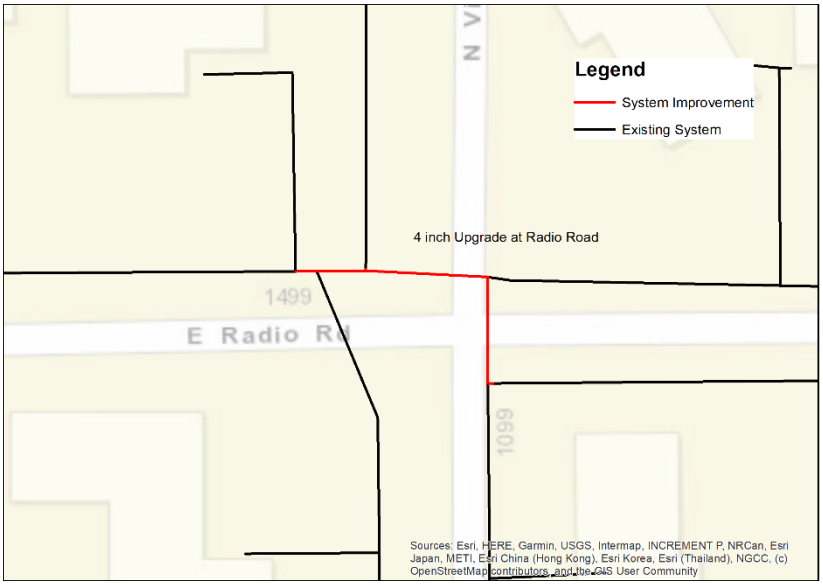

Figure 16 System Improvement 9 Overview

This improvement would not result in a looping benefit not already seen in the system. According to modeling results, this improvement will provide a slight local hydraulic benefit of 0.24 PSI under a medium population growth scenario. And it will provide a slight local hydraulic benefit of 0.38 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Additional cost estimation considerations:

5. Five-man crew with equipment for five (5) days: $23,000
6. Two-man boring crew with equipment for one (1) days: $1,856
7. Pipe cost: $263
8. 20% contingency

Estimated Project Cost: $30,400

See Appendix C.09 – Improvement 9 Result Exhibits for modeling results.

6.10 Improvement 10 – Wilson Creek Road Extension

This improvement expands upon improvement 4, named the Number 6 Road extension. The Wilson Creek Road extension improvement involves the installation of 2,700-feet of 4-inch main in addition to the 3,900-foot of 4-inch main installed for Number 6 Road extension (improvement 4). It would span north-south along Wilson Creek Road to Judge Ronald Road.

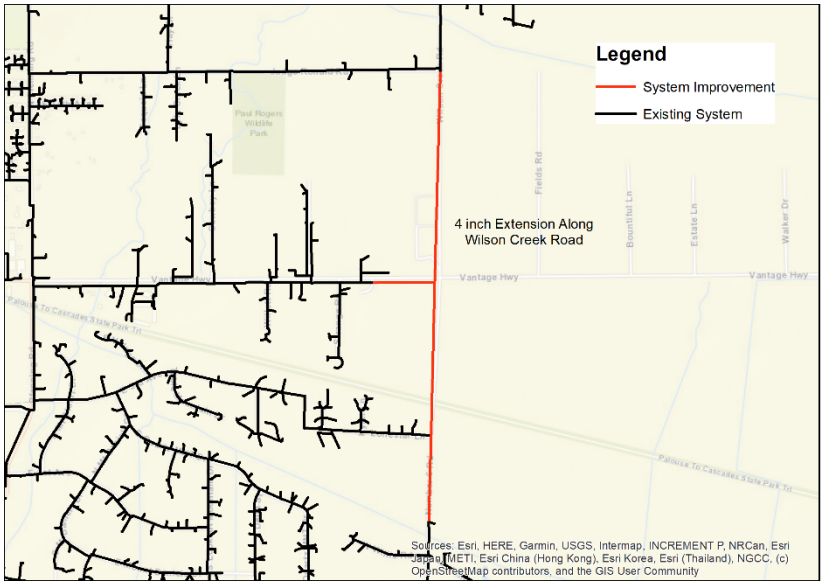

Figure 17 System Improvement 10 Overview

This improvement would result in a significant looping benefit to services along Judge Ronald Road, Vantage Highway, Lone Star Lane, and East 3rd Avenue. According to modeling results, this improvement will provide a significant system-wide hydraulic benefit of 8.18 PSI and a significant hydraulic benefit of 9.72 PSI to local services under a medium population growth scenario. And it will provide a significant system-wide hydraulic benefit of 13.22 PSI and a significant local hydraulic benefit of 14.74 PSI under a high population growth scenario. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $108,000 (Calculated per unit costs in Table 11)
Total project cost including $155,000 for Improvement 4: $263,000

See Appendix C.10 – Improvement 10 Result Exhibits

6.11 Improvement 11 – Increase Supply Pressure

Customer pressures can be improved throughout the system by increasing the system supply pressures. The minimum supply pressures recommended to maintain current performance criteria (Section 5.1) were modeled. These results are listed in Table 12 below.

Scenario Number	Services	HDD condition	CWU Physical Plant	Minimum Supply Set Pressures (PSIG)
2	2026 medium projected growth	60	Active	49
3	2026 high projected growth	60	Active	56
5	2026 medium projected growth	80	Inactive	47
6	2026 high projected growth	80	Inactive	56

Table 12 Improvement 11 Results

Under scenarios 2 and 5: 2026 medium projected growth, a supply pressure increase to at least 49 PSIG is recommended to maintain system performance without the need to implement any other system improvements.

Under scenarios 3 and 5: 2026 high projected growth, a supply pressure increase to 56 PSIG is recommended to maintain system performance without the need to implement any other system improvements. A smaller supply pressure increase less than 56 PSIG would not be sufficient alone to maintain system performance under high growth projections. Additional system improvements can be implemented in concurrence with a reduced supply pressure increase less than 56 PSIG and still maintain system performance under high growth projections.

6.12 Improvement 12 – Meadowbrook Lane to Willowdale Road Extension

The Meadowbrook Lane to Willowdale Road extension improvement includes 3,000-foot of 2-inch main extension located in the North East of the system. It would span east-west from Meadowbrook Lane to Willowdale Road.

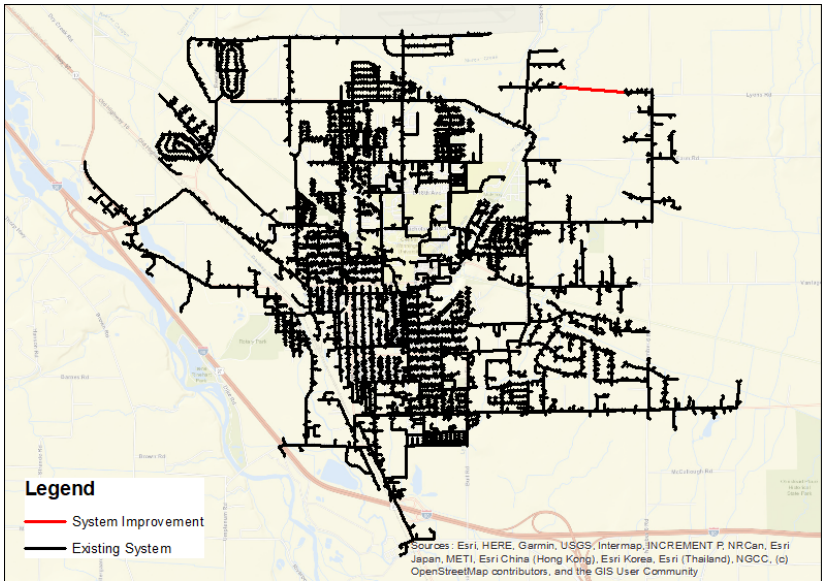

Figure 18 System Improvement 12 Overview

This improvement would result in a significant looping benefit to services branching from Main ID: 899-115 and 800-104. According to modeling results, this improvement will not provide a significant system-wide hydraulic benefit. Alone, this improvement does not enable the system to maintain current system performance under medium or high population growth scenarios.

Estimated Project Cost: $97,000 (Calculated per unit costs in Table 11)

See C.11 – Improvement 12 Result Exhibits

7.0 Minimum Improvements to Maintain System Performance

The six (6) year projected demand increase necessitates system improvements to maintain performance at current benchmarks (Section 5.1). Implementing one or more improvements are recommended to allow the system to function within the performance criteria established for this analysis. Those criteria being:

1. Supply all services with at least 20 psi up to 60 HDD conditions
2. Supply all services except CWU with at least 20 psi up to 80 HDD conditions

Through an iterative process, the minimum configuration of improvements which allow the system to maintain performance was determined. The following projected demand growth scenarios were considered:

Scenario Number	Services	HDD condition	CWU Physical Plant
2	2026 medium projected growth	60	Active
3	2026 high projected growth	60	Active
5	2026 medium projected growth	80	Inactive
6	2026 high projected growth	80	Inactive

Table 13 Projected Growth Scenarios

7.1 Maintaining System Performance Under Medium Population Growth Scenario

The following system improvement is recommended to maintain system performance under a six (6) year medium population growth scenario:

- Improvement 11 – Increase Supply Pressure to 49 PSIG

See Appendix D – Minimum Improvements Result Exhibits.

7.1.1 Six-Year Plan and Cost Estimates – Medium Population Growth

The following schedule of recommended improvements was made using the yearly population projections established in Section 4.2. This schedule reflects the recommended improvements under medium projected population growth.

Year	Does the System Meet Performance Criteria?[13]	Estimated Project Cost[14]
2021	System meets criteria with current infrastructure and supply pressures.	N/A
2022	System meets criteria with current infrastructure and supply pressures.	N/A
2023	System meets criteria with current infrastructure and supply pressures.	N/A
2024	System meets criteria with supply pressure set to 43 PSIG.	N/A
2025	System meets criteria with supply pressure set to 45 PSIG.	N/A
2026	System meets criteria with supply pressure set to 49 PSIG.	N/A

Table 14 Six-Year Improvement Schedule Medium Growth

[13] Performance criteria is established in Section 5.1
[14] Adjusted for annual inflation of 2.5%

7.2 Maintaining System Performance Under High Population Growth Scenario

The following system improvements are recommended to maintain system performance under a six (6) year high population growth scenario:

- Improvement 4 – Number 6 Road Extension
- Improvement 11 – Increase Supply Pressure to 50 PSIG

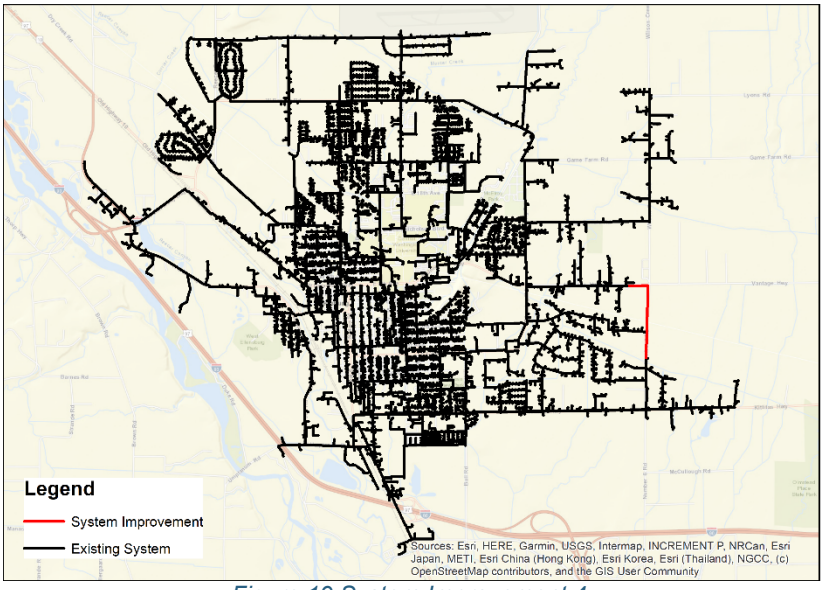

Figure 19 System Improvement 4

See Appendix D – Minimum Improvements Result Exhibits.

7.2.1 Six-Year Plan and Cost Estimates – High Population Growth

The following schedule of recommended improvements was made using the yearly population projections established in Section 4.2. This schedule reflects the recommended improvements under high projected population growth.

Year	Does the System Meet Performance Criteria?[15]	Estimated Project Cost[16]
2021	System meets criteria with current infrastructure and supply pressures.	N/A
2022	System meets criteria with supply pressure set to 44 PSIG.	N/A
2023	System meets criteria with supply pressure set to 47 PSIG.	N/A
2024	System meets criteria with supply pressure set to 49 PSIG.	N/A
2025	System meets criteria with supply pressure set to 52 PSIG.	N/A
2026	System meets criteria with improvement 4 and supply pressure set to 50 PSIG.	$175,368

Table 15 Six-Year Improvement Schedule High Growth

[15] Performance criteria is established in Section 5.1.
[16] Adjusted for annual inflation of 2.5%

8.0 Additional Analysis Results

Two (2) additional analyses were conducted during this project. For the first, single-feed branches were identified and ranked by potential impact to customers. For the second, EN was asked to prepare a telemetry system upgrade scope of work to serve as guidance on replacing and upgrading the telemetry system with considerations to see live data and remote integration of small pressure recorders.

8.1 Single-Feed Branches

As part of the current system review, EN identified the seventeen (17) single-feed branches with the greatest number of services. Single-feed branches pose an elevated service loss risk in gas networks and should be eliminated. Only branches with at least twenty (20) services were included in this analysis. Table 16 details each single-feed branch.

Single-Feed Branch Number	Feed Main ID	Current Service Count
1 A[17]	899-115	83
1 B17	899-115	34
2[18]	896-027	63
3	856-114	50
4	856-054	50
5	856-056	49
6	5-1968	43
8	895-004	35
9	856-040	34
10	899-069	33
11[19]	890-136	33
12	898-125	31
13	4-1955	29
14	856-025	29
15	856-026	24
16	856-028	24
17	856-044	24

Table 16 Single-Feed Branch Ranking

Figure 20 depicts the seventeen (17) single-feed branches locations within the COE system.

[17] Single-feed branch 1 A&B are related and are affected by system improvement number 3.
[18] Single-feed branch 2 would be eliminated by system improvement number 4.

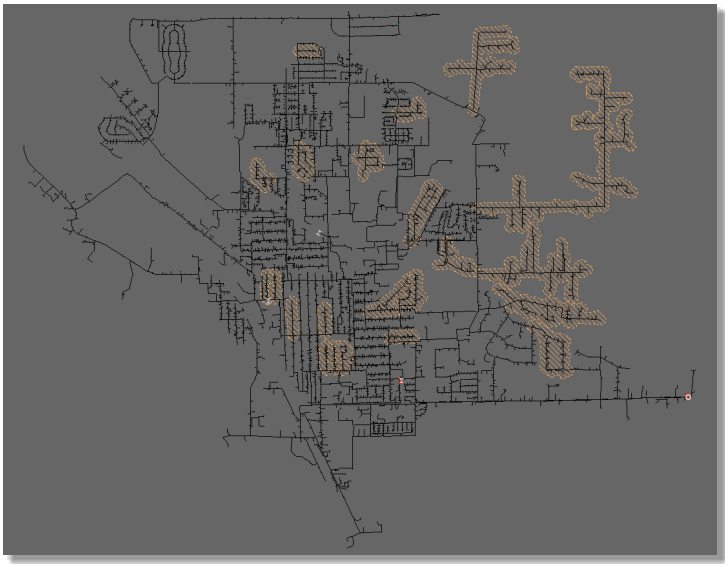

Figure 20 Single-Feed Branches Overview

See Appendix E – Single Feed Branch Model Exhibits for a plan view of each single feed branch.

9.0 Recommendations

Based on the model results, the current system piping is capable of adequately supplying service points with at least 20 PSIG under the medium growth scenarios through 2026 if supply pressures are increased. And the current system piping is capable of adequately supplying service points with at least 20 PSIG under high growth scenarios through 2025 if supply pressures are increased. Implementing system improvement 4 and increasing supply pressures are recommended to enable the system to adequately supply service points with at least 20 PSIG under high growth scenarios through 2026. The minimum system improvements for both the medium and high population six (6) year projection are as follows:

Six (6) Year Medium Projected population growth recommended improvements:

- Improvement 11 – Increase Supply Pressure to 49 PSIG

Six (6) Year High Projected population growth recommended improvements:

- Improvement 4 – Number 6 Road Extension
- Improvement 11 – Increase Supply Pressure to 50 PSIG

9.1 Other System Improvement Recommendations

In addition to the minimum recommended improvements, the other system improvements were prioritized by degree of benefit according to modeling results and looping benefit. Improvement 7 was not considered for prioritization because of the infeasibility of implementation due to its extreme cost. Improvement 2 and 5 were not considered for prioritization because it is already planned as of the writing of this report.

Priority	System Improvement Number	Hydraulic Benefit Medium Growth (PSIG)	Looping Benefit 2020 services looped	Estimated Project Cost (2021 Prices)
1	4	5.50	63	$155,000
2	10[20]	8.18	29	$108,000
3	12	-0.01	83	$97,000
4	3	0.03	32	$212,000
5	1	0.86	16	$181,000
6	8	0.50	0	$37,100[21]
7	9	0.04	0	$30,400[21]
8	6	-0.44	0	$44,000

Table 17 Project Prioritization

[20] System improvement 10 is an expansion of system improvement 4 and thus is subsequent to system improvement 4 in this prioritization list.
[21] Cost estimate based on approximate daily crew rates.

Appendix A – Population and Service Projection Tables

Appendix A – Population and Service Projection Tables

Medium Growth Projection													
Year	Population	Population Forecast	Percent Change	Residential Services	R/P Ratio	Commercial 1	C/P 1 Ratio	Commercial 2	C/P 2 Ratio	Commercial 3	C/P 3 Ratio	Commercial 4	C/P 4 Ratio
1990	12,779	-	-	-	-	-	-	-	-	-	-	-	-
1991	12,745	-	-	-	-	-	-	-	-	-	-	-	-
1992	12,579	-	-	-	-	-	-	-	-	-	-	-	-
1993	12,894	-	-	-	-	-	-	-	-	-	-	-	-
1994	13,307	-	-	-	-	-	-	-	-	-	-	-	-
1995	13,269	-	-	-	-	-	-	-	-	-	-	-	-
1996	13,481	-	-	-	-	-	-	-	-	-	-	-	-
1997	13,814	-	-	-	-	-	-	-	-	-	-	-	-
1998	14,170	-	-	-	-	-	-	-	-	-	-	-	-
1999	14,512	-	-	-	-	-	-	-	-	-	-	-	-
2000	15,565	-	-	-	-	-	-	-	-	-	-	-	-
2001	15,780	-	-	-	-	-	-	-	-	-	-	-	-
2002	16,138	-	-	-	-	-	-	-	-	-	-	-	-
2003	16,384	-	-	-	-	-	-	-	-	-	-	-	-
2004	17,062	-	-	-	-	-	-	-	-	-	-	-	-
2005	16,961	-	-	-	-	-	-	-	-	-	-	-	-
2006	17,288	-	-	-	-	-	-	-	-	-	-	-	-
2007	17,214	-	-	-	-	-	-	-	-	-	-	-	-
2008	17,344	-	-	-	-	-	-	-	-	-	-	-	-
2009	17,505	-	-	-	-	-	-	-	-	-	-	-	-
2010	18,416	-	-	-	-	-	-	-	-	-	-	-	-
2011	18,602	-	-	-	-	-	-	-	-	-	-	-	-
2012	18,460	-	-	-	-	-	-	-	-	-	-	-	-
2013	18,520	-	-	-	-	-	-	-	-	-	-	-	-
2014	18,961	-	-	-	-	-	-	-	-	-	-	-	-
2015	18,985	-	-	3,830	0.202	107	0.006	105	0.006	88	0.005	439	0.023
2016	19,763	-	-	3,951	0.200	108	0.005	104	0.005	87	0.004	440	0.022
2017	20,300	-	-	3,997	0.197	110	0.005	104	0.005	87	0.004	457	0.023
2018	20,977	-	-	4,055	0.193	122	0.006	108	0.005	87	0.004	472	0.023
2019	21,111	-	-	3,998	0.189	108	0.005	105	0.005	86	0.004	464	0.022
2020	21,345	-	-	4,062	0.190	112	0.005	108	0.005	85	0.004	463	0.022
2021	-	21,662	1.48%	4,230	0.195	118	0.005	112	0.005	92	0.004	484	0.022
2022	-	21,960	1.38%	4,288	0.195	120	0.005	114	0.005	93	0.004	491	0.022
2023	-	22,258	1.36%	4,346	0.195	121	0.005	115	0.005	95	0.004	497	0.022
2024	-	22,556	1.34%	4,404	0.195	123	0.005	117	0.005	96	0.004	504	0.022
2025	-	22,854	1.32%	4,462	0.195	125	0.005	118	0.005	97	0.004	511	0.022
2026	-	23,152	1.30%	4,521	0.195	126	0.005	120	0.005	98	0.004	517	0.022

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Appendix A – Population and Service Projection Tables

High Growth Projection													
Year	Population	Population Forecast	Percent Change	Residential Services	R/P Ratio	Commercial 1	C/P 1 Ratio	Commercial 2	C/P 2 Ratio	Commercial 3	C/P 3 Ratio	Commercial 4	C/P 4 Ratio
1990	12,779	-	-	-	-	-	-	-	-	-	-	-	-
1991	12,745	-	-	-	-	-	-	-	-	-	-	-	-
1992	12,579	-	-	-	-	-	-	-	-	-	-	-	-
1993	12,894	-	-	-	-	-	-	-	-	-	-	-	-
1994	13,307	-	-	-	-	-	-	-	-	-	-	-	-
1995	13,269	-	-	-	-	-	-	-	-	-	-	-	-
1996	13,481	-	-	-	-	-	-	-	-	-	-	-	-
1997	13,814	-	-	-	-	-	-	-	-	-	-	-	-
1998	14,170	-	-	-	-	-	-	-	-	-	-	-	-
1999	14,512	-	-	-	-	-	-	-	-	-	-	-	-
2000	15,565	-	-	-	-	-	-	-	-	-	-	-	-
2001	15,780	-	-	-	-	-	-	-	-	-	-	-	-
2002	16,138	-	-	-	-	-	-	-	-	-	-	-	-
2003	16,384	-	-	-	-	-	-	-	-	-	-	-	-
2004	17,062	-	-	-	-	-	-	-	-	-	-	-	-
2005	16,961	-	-	-	-	-	-	-	-	-	-	-	-
2006	17,288	-	-	-	-	-	-	-	-	-	-	-	-
2007	17,214	-	-	-	-	-	-	-	-	-	-	-	-
2008	17,344	-	-	-	-	-	-	-	-	-	-	-	-
2009	17,505	-	-	-	-	-	-	-	-	-	-	-	-
2010	18,416	-	-	-	-	-	-	-	-	-	-	-	-
2011	18,602	-	-	-	-	-	-	-	-	-	-	-	-
2012	18,460	-	-	-	-	-	-	-	-	-	-	-	-
2013	18,520	-	-	-	-	-	-	-	-	-	-	-	-
2014	18,961	-	-	-	-	-	-	-	-	-	-	-	-
2015	18,985	-	-	3,830	0.202	107	0.006	105	0.006	88	0.005	439	0.023
2016	19,763	-	-	3,951	0.200	108	0.005	104	0.005	87	0.004	440	0.022
2017	20,300	-	-	3,997	0.197	110	0.005	104	0.005	87	0.004	457	0.023
2018	20,977	-	-	4,055	0.193	122	0.006	108	0.005	87	0.004	472	0.023
2019	21,111	-	-	3,998	0.189	108	0.005	105	0.005	86	0.004	464	0.022
2020	21,345	-	-	4,062	0.190	112	0.005	108	0.005	85	0.004	463	0.022
2021	-	22,260	4.28%	4,346	0.195	121	0.005	115	0.005	95	0.004	497	0.022
2022	-	22,707	2.01%	4,434	0.195	124	0.005	118	0.005	97	0.004	507	0.022
2023	-	23,130	1.86%	4,516	0.195	126	0.005	120	0.005	98	0.004	517	0.022
2024	-	23,537	1.76%	4,596	0.195	128	0.005	122	0.005	100	0.004	526	0.022
2025	-	23,934	1.68%	4,673	0.195	130	0.005	124	0.005	102	0.004	535	0.022
2026	-	24,322	1.62%	4,749	0.195	133	0.005	126	0.005	103	0.004	543	0.022

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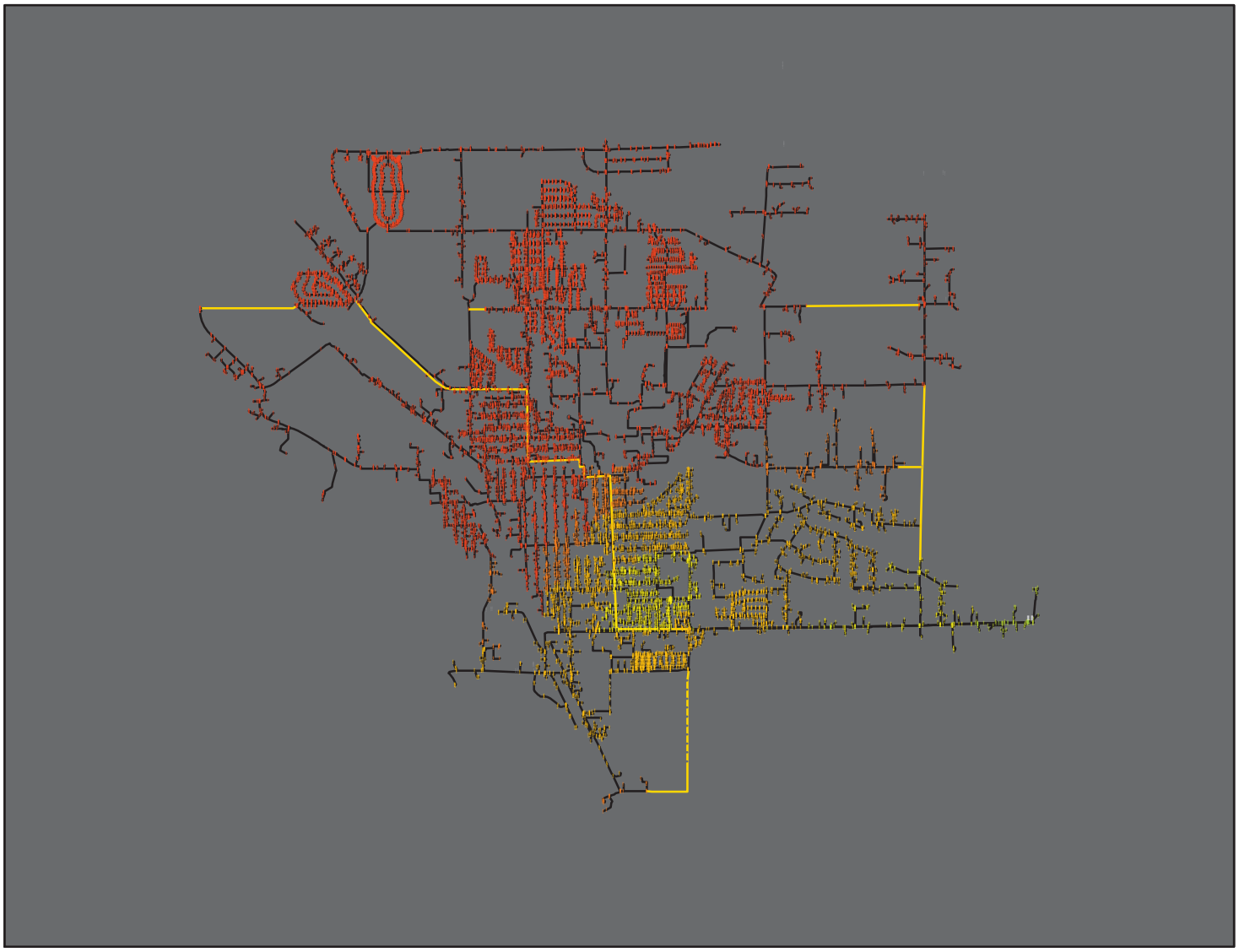
Appendix B – Current System Limits

Current System Limit
2020 Current | CWU Active



0 2,900 5,800 8,700 11,600 Feet

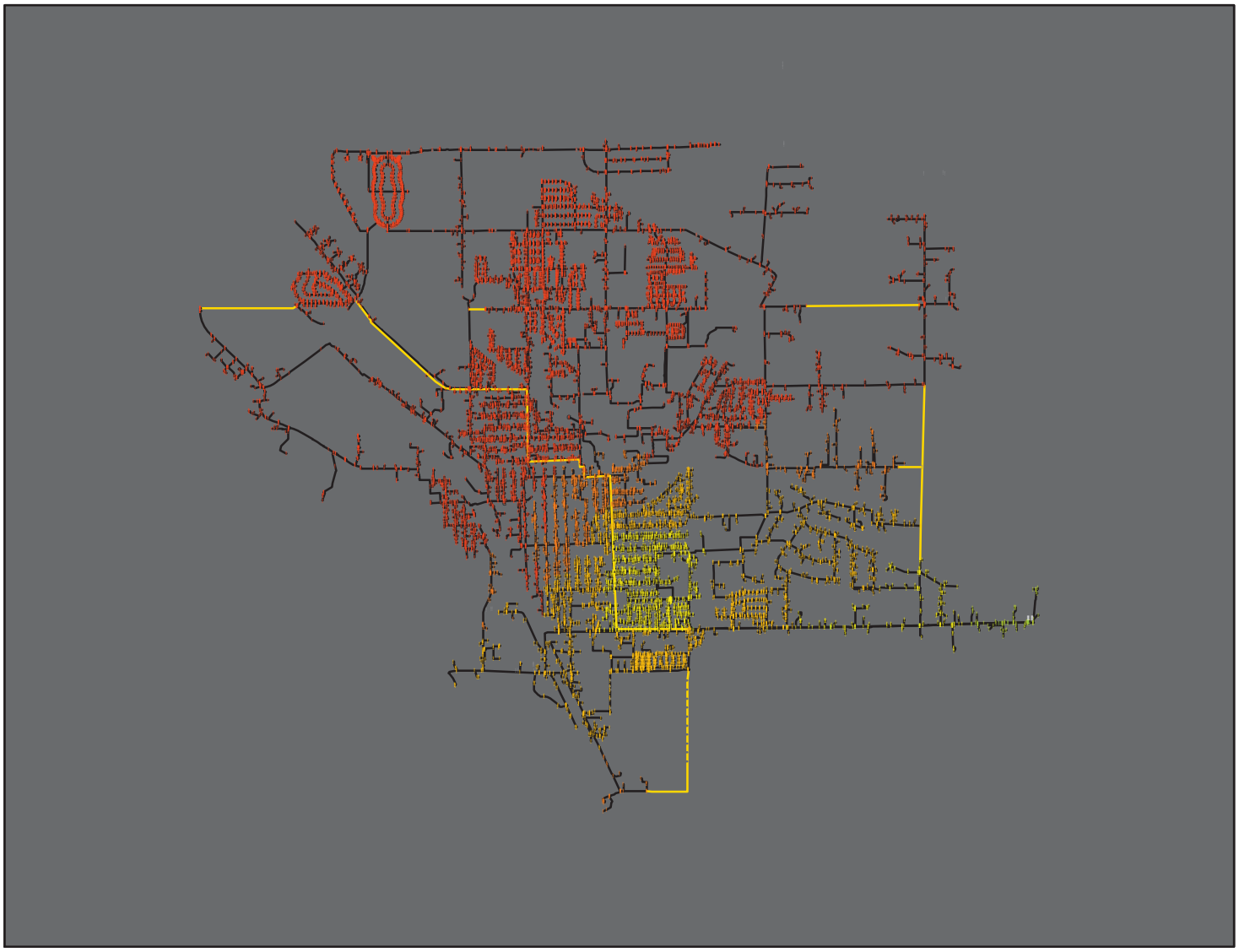
Scale: 1 = 64,830

Current System Limit Information

Services: 2020 Current
HDD: 63
CWU Service: Active
Total Supply Flow: 446,904.36 SCFH
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (11781)
Proposed (21)	25.00 - 30.00 (975)
Retired (0)	30.00 - 35.00 (3492)
	35.00 - 40.00 (1116)
	40.00 - 45.00 (69)
	> 45.00 (33)

Current System Limit
2026 Medium Growth | CWU Active



0 2,900 5,800 8,700 11,600 Feet

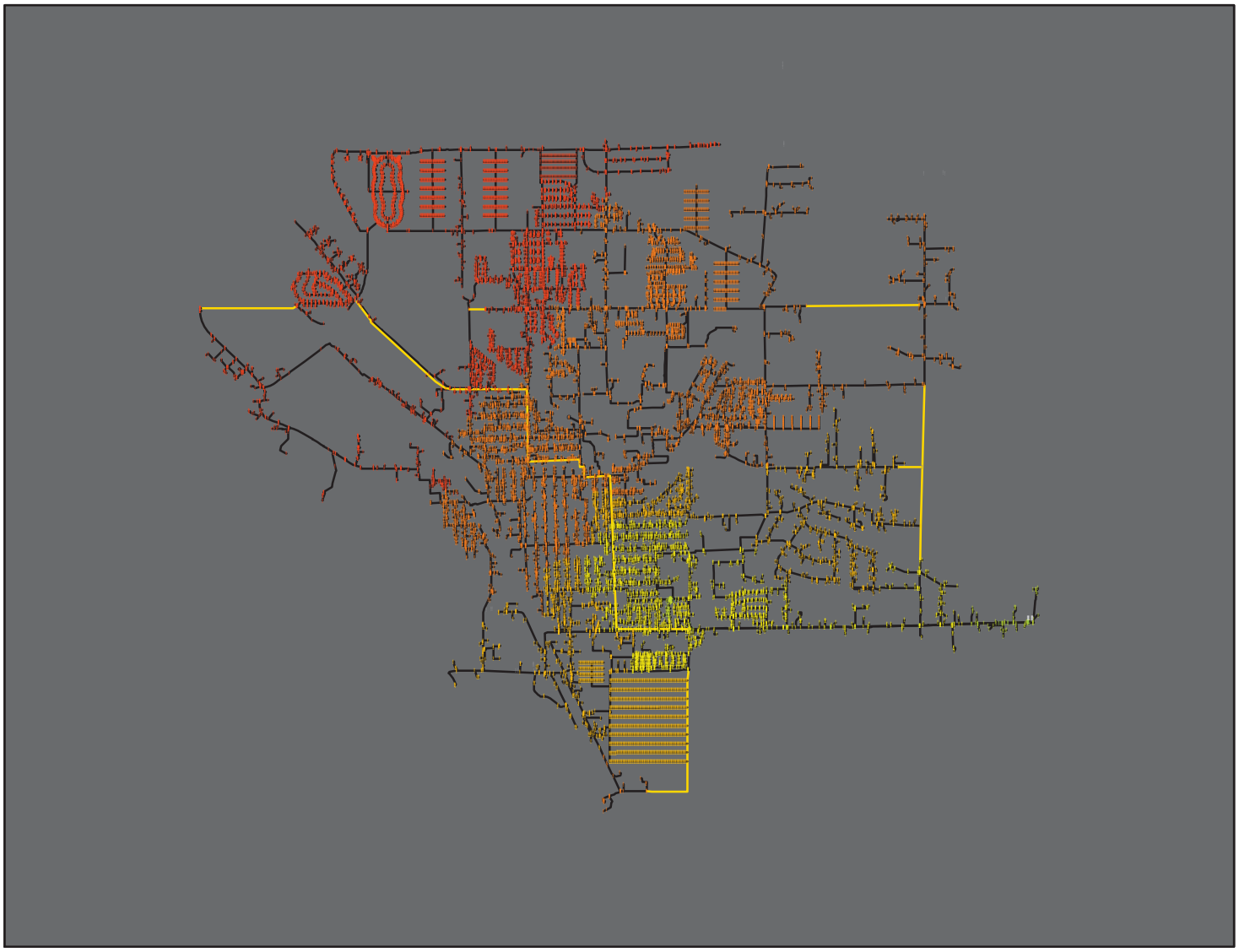
Scale: 1 = 64,830

Current System Limit Information

Services: 2026 Medium
HDD: 57
CWU Service: Active
Total Supply Flow: 443,447.16 SCFH
Suply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2565)
.	Enabled (17640)	!	< 20.00 (2)
.	Disabled (2563)	!	20.00 - 25.00 (11270)
.	Proposed (21)	!	25.00 - 30.00 (1414)
.	Retired (0)	!	30.00 - 35.00 (3141)
		!	35.00 - 40.00 (1535)
		!	40.00 - 45.00 (73)
		!	> 45.00 (33)

Current System Limit
2026 High Growth | CWU Active



0 2,900 5,800 8,700 11,600 Feet

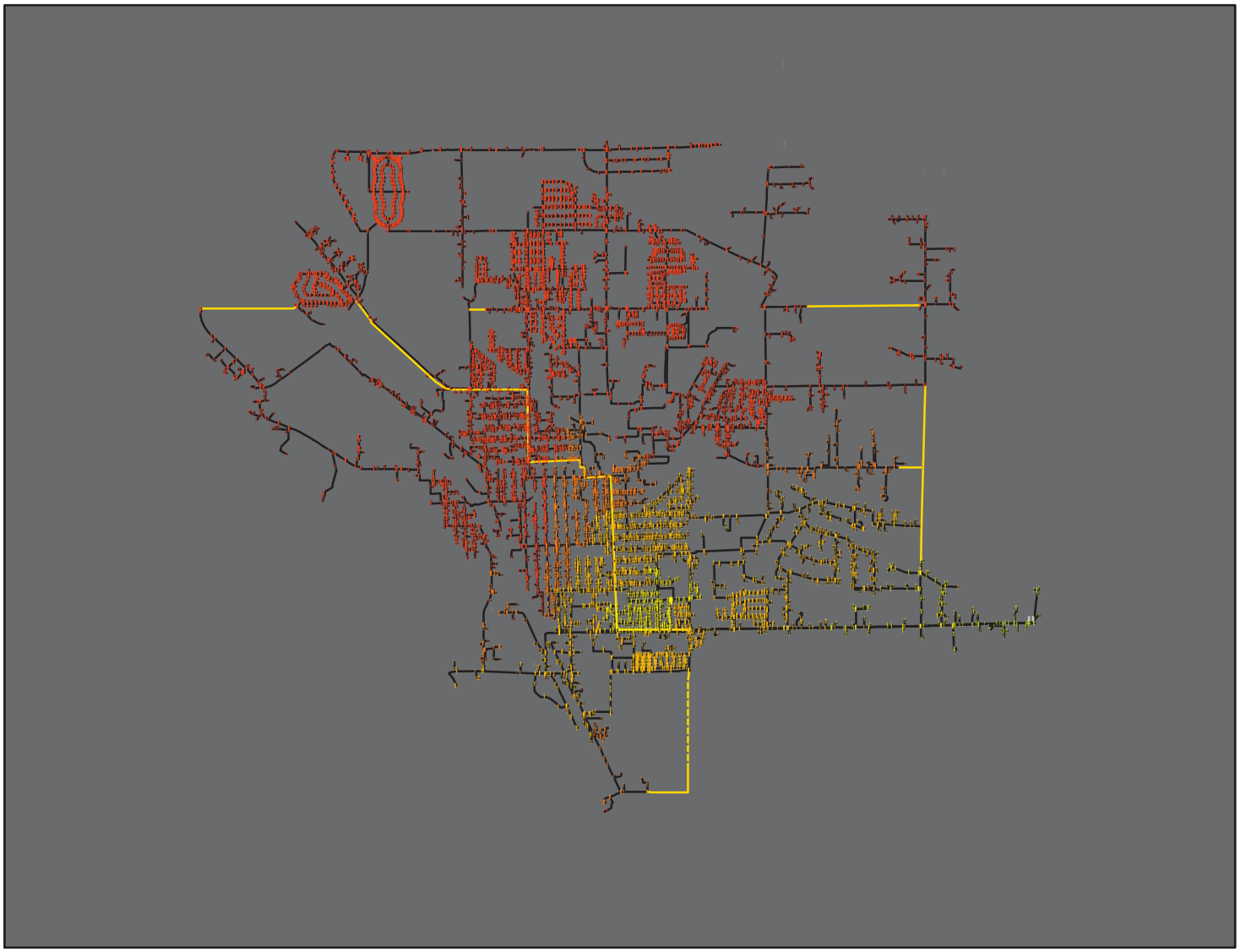
Scale: 1 = 64,830

Current System Limit Information

Services: 2026 High
HDD: 54
CWU Service: Active
Total Supply Flow: 434,868.95 SCFH
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (35)
.	Enabled (20179)	!	< 20.00 (2)
.	Disabled (24)	!	20.00 - 25.00 (6352)
.	Proposed (21)	!	25.00 - 30.00 (7276)
.	Retired (0)	!	30.00 - 35.00 (3373)
		!	35.00 - 40.00 (2801)
		!	40.00 - 45.00 (157)
		!	> 45.00 (37)

Current System Limit
2020 Current | CWU Inactive



0 2,900 5,800 8,700 11,600 Feet

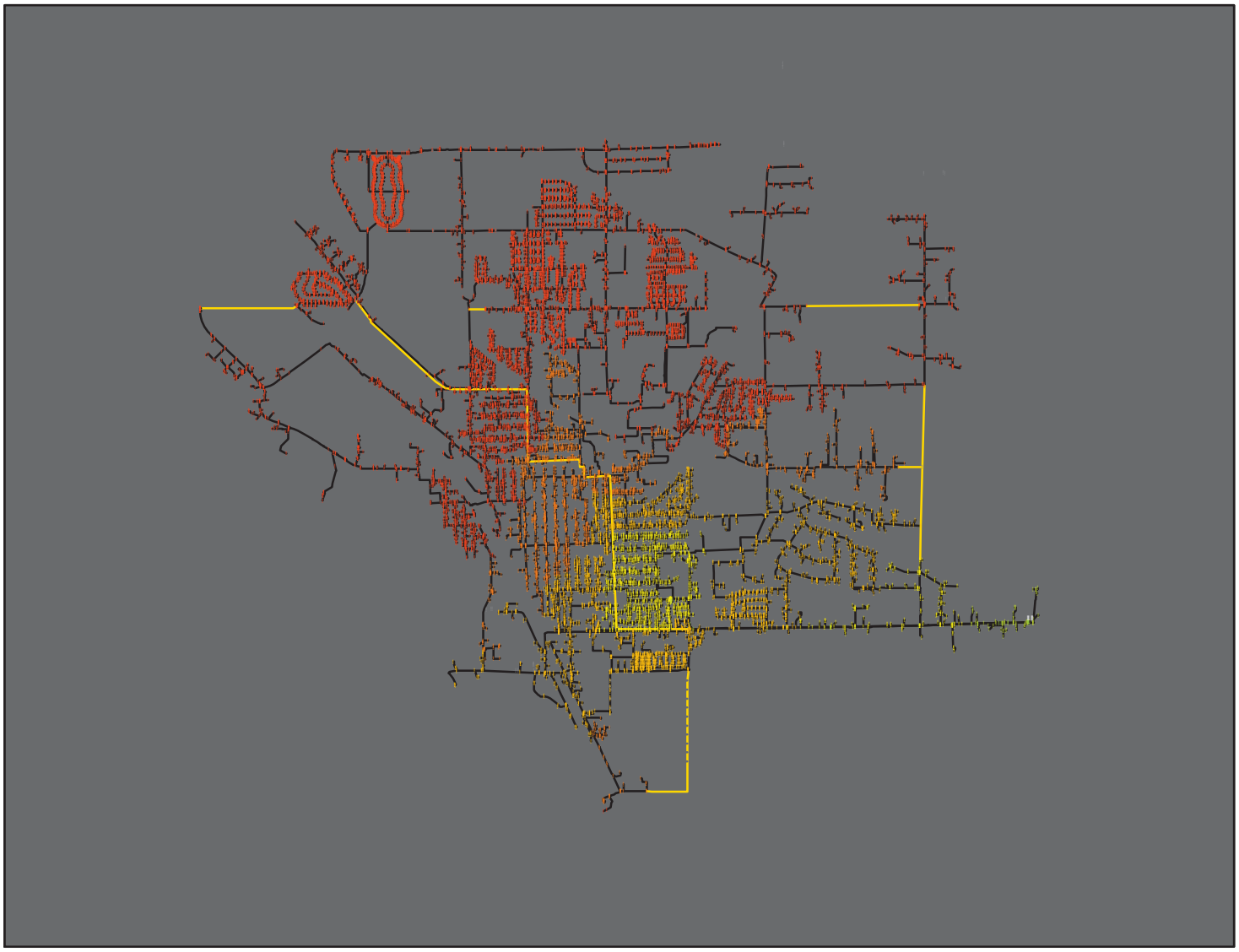
Scale: 1 = 64,830

Current System Limit Information

Services: 2020 Current
HDD: 88
CWU Service: Inactive
Total Supply Flow: 451,107.93 SCFH
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 1*
*TCF is supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2566)
Enabled (17639)	< 20.00 (1)
Disabled (2564)	20.00 - 25.00 (11224)
Proposed (21)	25.00 - 30.00 (1670)
Retired (0)	30.00 - 35.00 (3675)
	35.00 - 40.00 (796)
	40.00 - 45.00 (68)
	> 45.00 (33)

Current System Limit
2026 Medium Growth | CWU Inactive



0 2,900 5,800 8,700 11,600 Feet

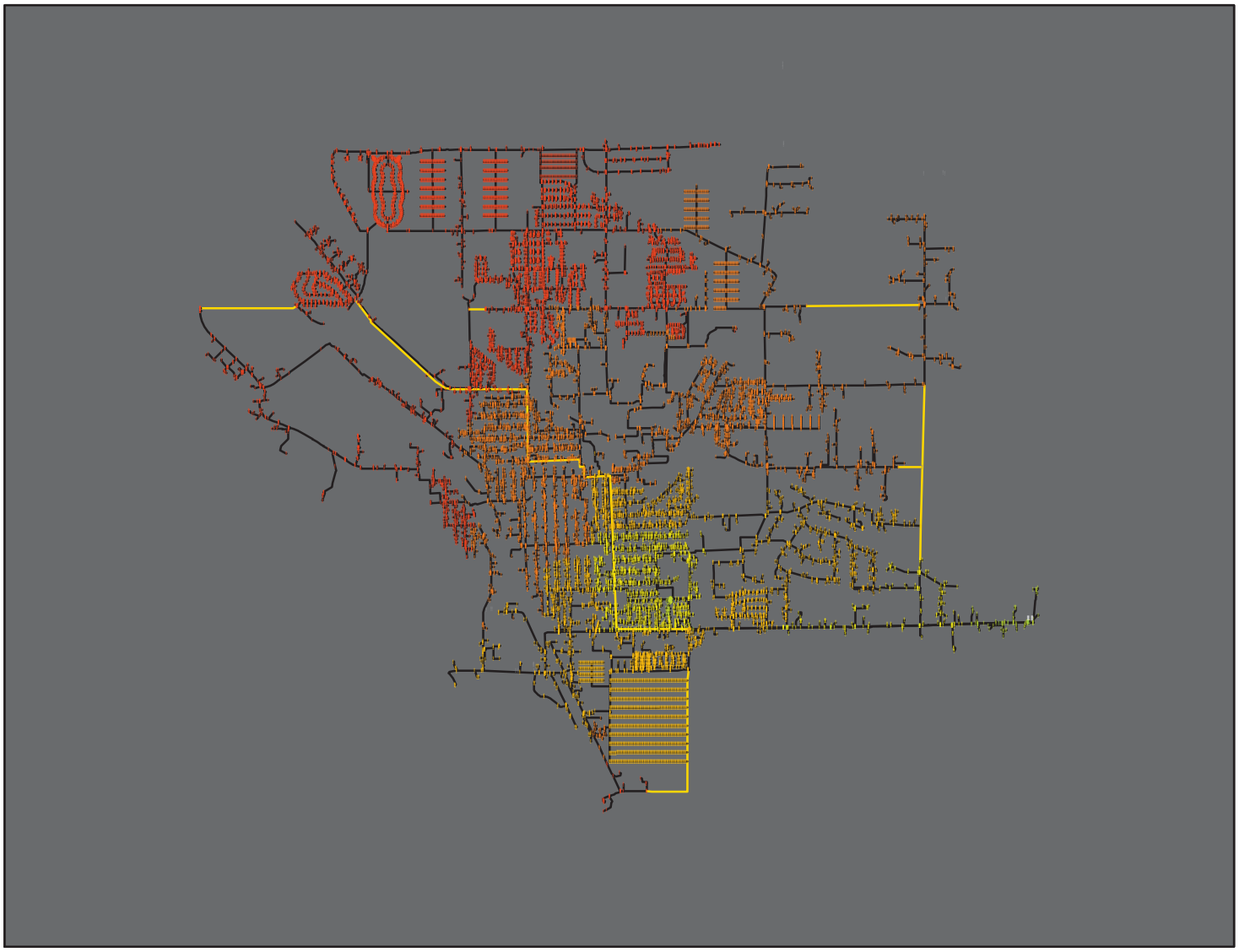
Scale: 1 = 64,830

Current System Limit Information

Services: 2026 Medium
HDD: 77
CWU Service: Inactive
Total Supply Flow: 445,182.33 SCFH
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*TCF is supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2566)
Enabled (17639)	< 20.00 (1)
Disabled (2564)	20.00 - 25.00 (10193)
Proposed (21)	25.00 - 30.00 (2423)
Retired (0)	30.00 - 35.00 (3252)
	35.00 - 40.00 (1476)
	40.00 - 45.00 (89)
	> 45.00 (33)

Current System Limit
2026 High Growth | CWU Inactive



0 2,900 5,800 8,700 11,600 Feet

Scale: 1 = 64,830

Current System Limit Information

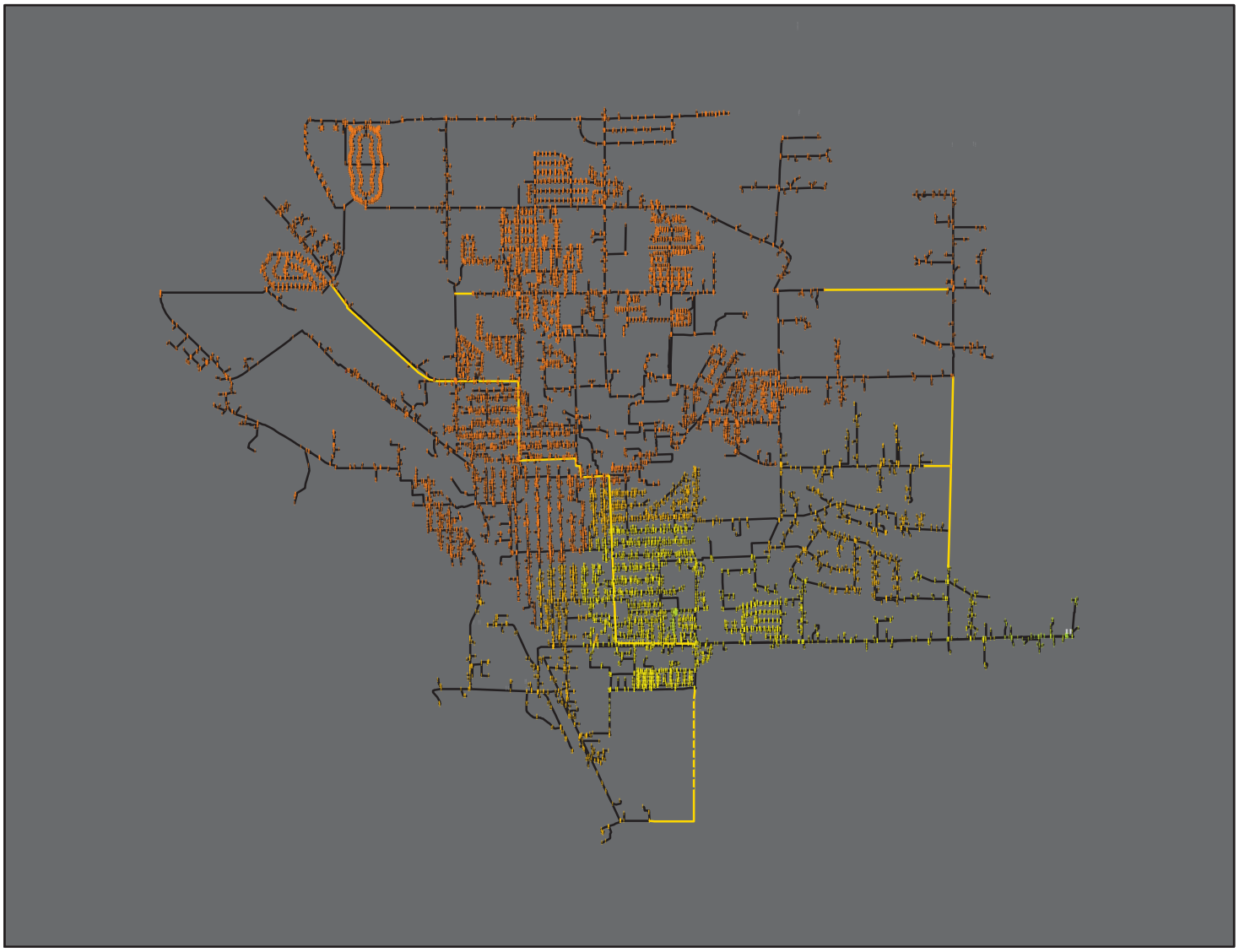
Services: 2026 High
HDD: 73
CWU Service: Inactive
Total Supply Flow: 440,652.26 SCFH
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*TCF is supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (36)
.	Enabled (20178)	!	< 20.00 (1)
.	Disabled (25)	!	20.00 - 25.00 (8045)
.	Proposed (21)	!	25.00 - 30.00 (5682)
.	Retired (0)	!	30.00 - 35.00 (4465)
		!	35.00 - 40.00 (1617)
		!	40.00 - 45.00 (154)
		!	> 45.00 (33)

Appendix C – Individual System Improvement Exhibits

Appendix C.01 – Improvement 1 Result Exhibits

Improvement 1 - Highway 97/10 Connection
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

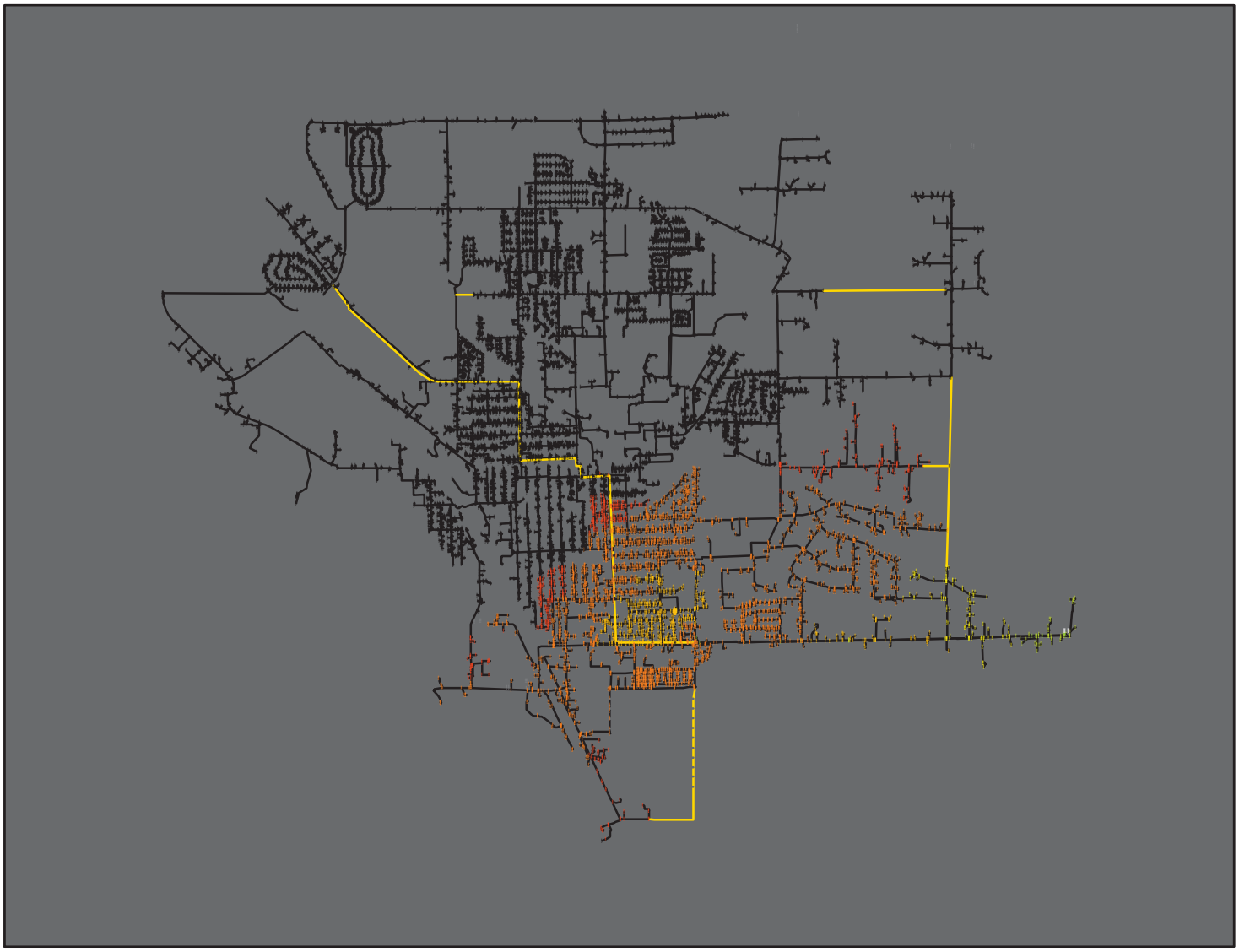
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17641)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (1)
Proposed (20)	25.00 - 30.00 (12108)
Retired (0)	30.00 - 35.00 (2188)
	35.00 - 40.00 (2974)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 1 - Highway 97/10 Connection
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

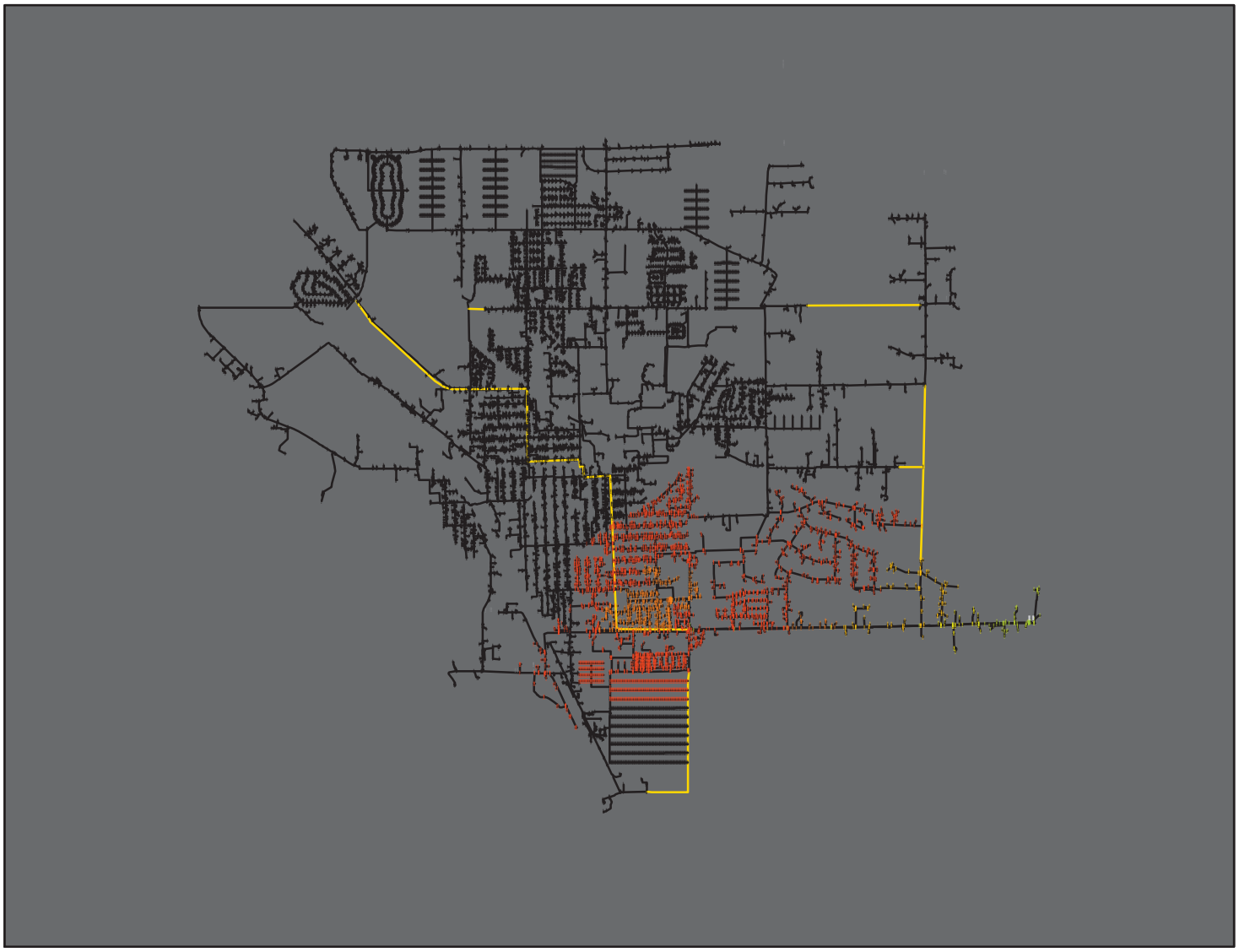
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,076

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2564)
.	Enabled (17641)	!	< 20.00 (12251)
.	Disabled (2563)	!	20.00 - 25.00 (722)
.	Proposed (20)	!	25.00 - 30.00 (3498)
.	Retired (0)	!	30.00 - 35.00 (775)
		!	35.00 - 40.00 (136)
		!	40.00 - 45.00 (55)
		!	> 45.00 (32)

Improvement 1 - Highway 97/10 Connection
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

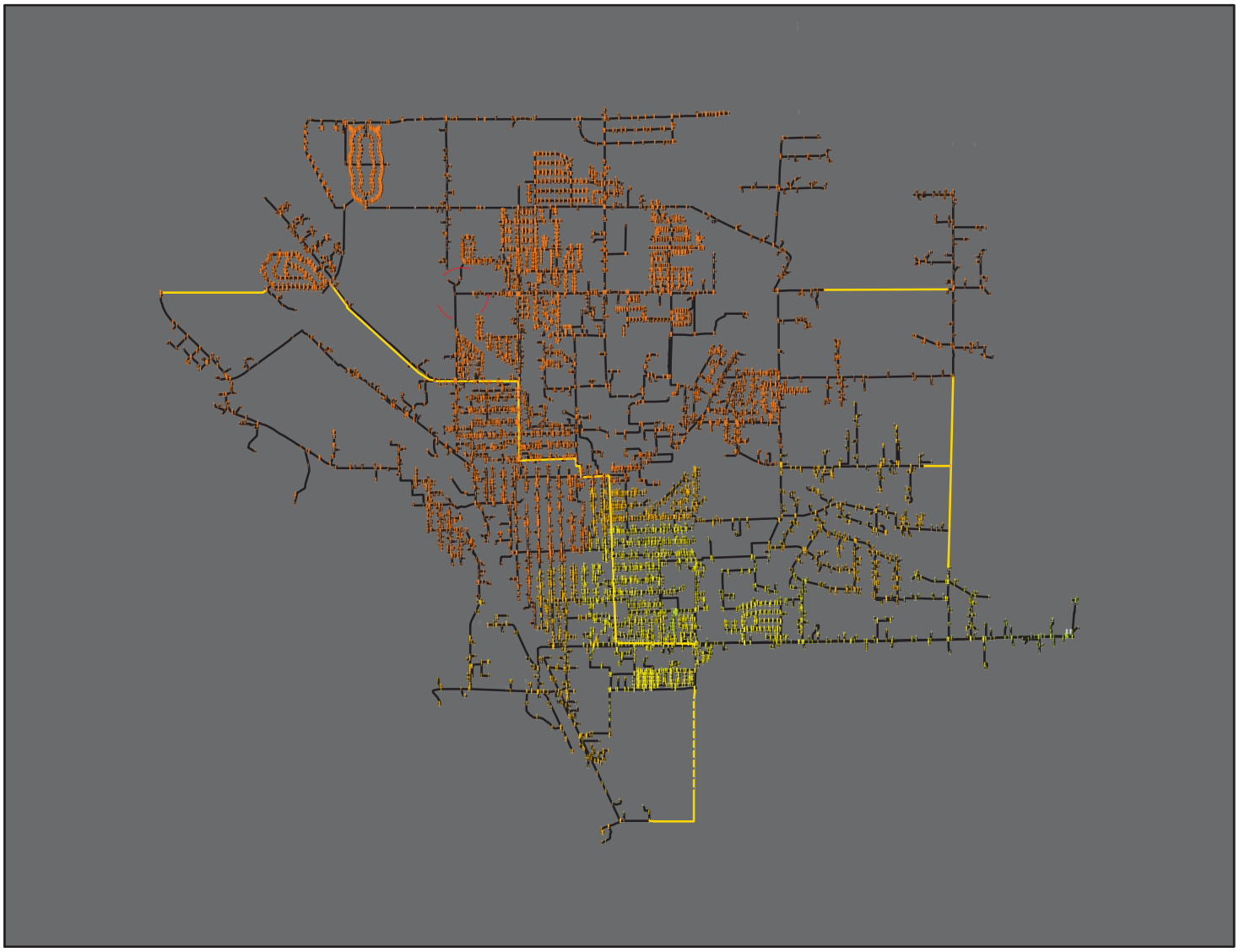
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,605

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (34)
Enabled (20180)	< 20.00 (15403)
Disabled (24)	20.00 - 25.00 (3646)
Proposed (20)	25.00 - 30.00 (680)
Retired (0)	30.00 - 35.00 (141)
	35.00 - 40.00 (42)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.02 – Improvement 2 Result Exhibits

Improvement 2 - Helena Avenue
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

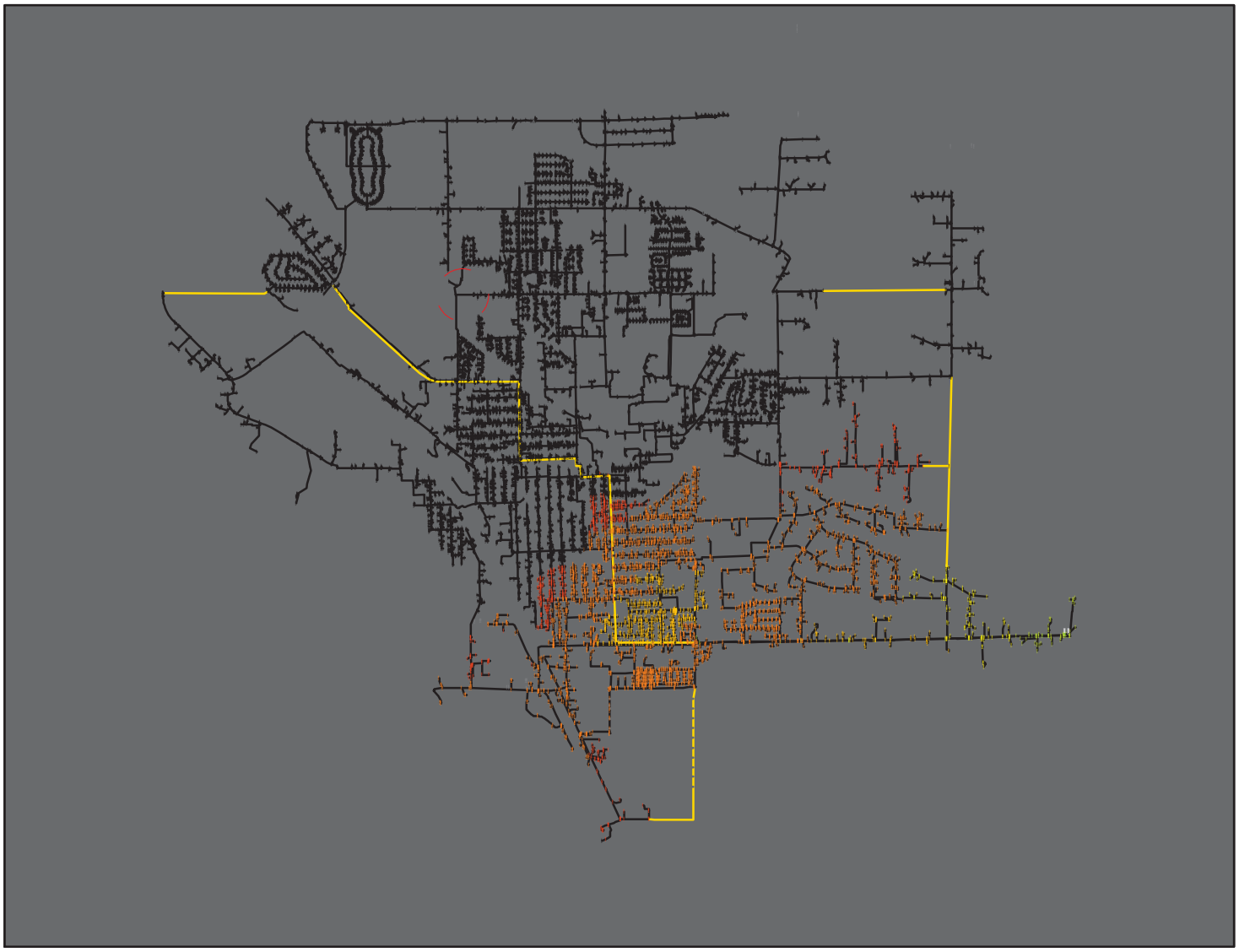
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17641)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (1)
Proposed (20)	25.00 - 30.00 (12108)
Retired (0)	30.00 - 35.00 (2188)
	35.00 - 40.00 (2974)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 2 - Helena Avenue
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

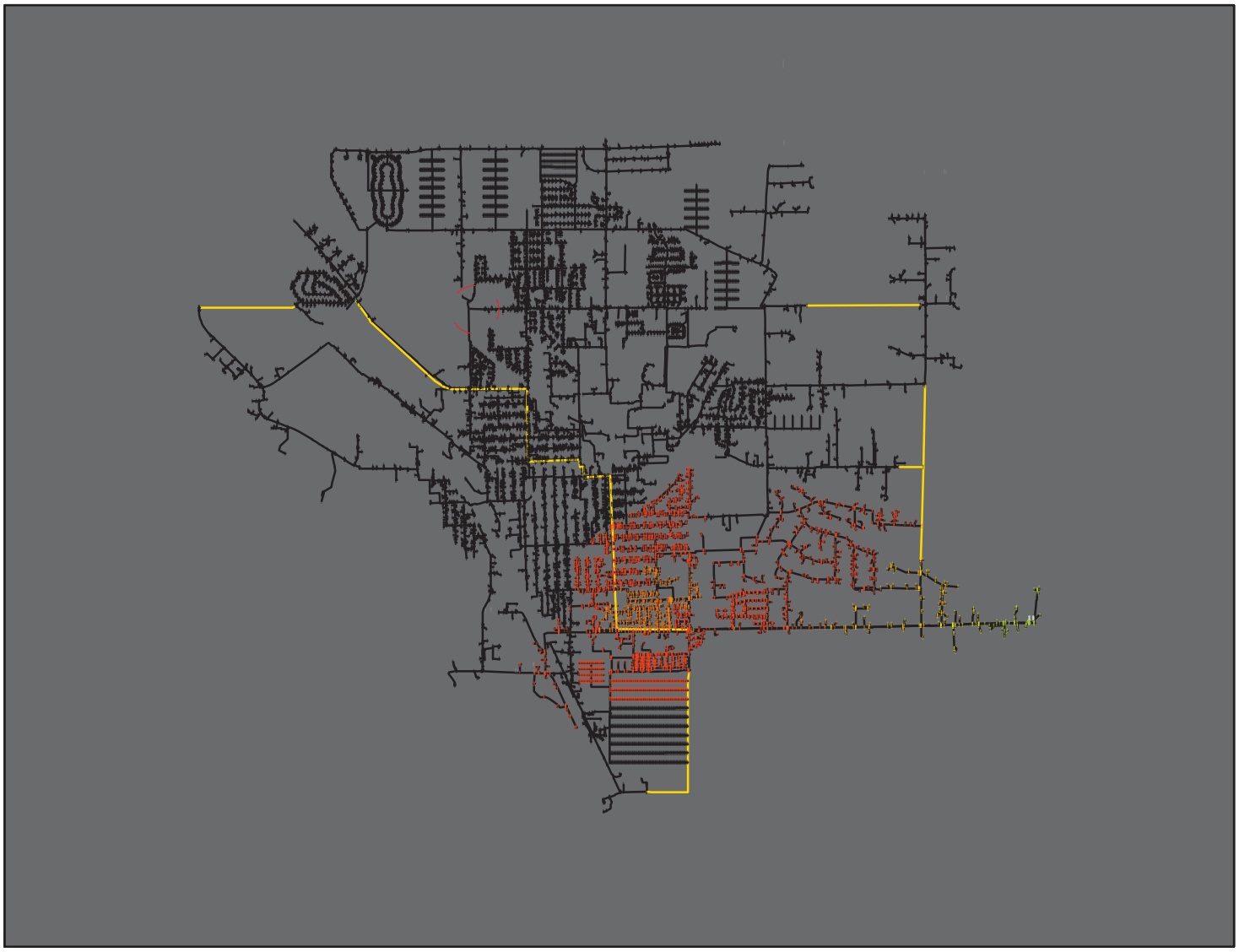
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,076

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17641)	< 20.00 (12251)
Disabled (2563)	20.00 - 25.00 (724)
Proposed (20)	25.00 - 30.00 (3496)
Retired (0)	30.00 - 35.00 (775)
	35.00 - 40.00 (136)
	40.00 - 45.00 (55)
	> 45.00 (32)

Improvement 2 - Helena Avenue
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

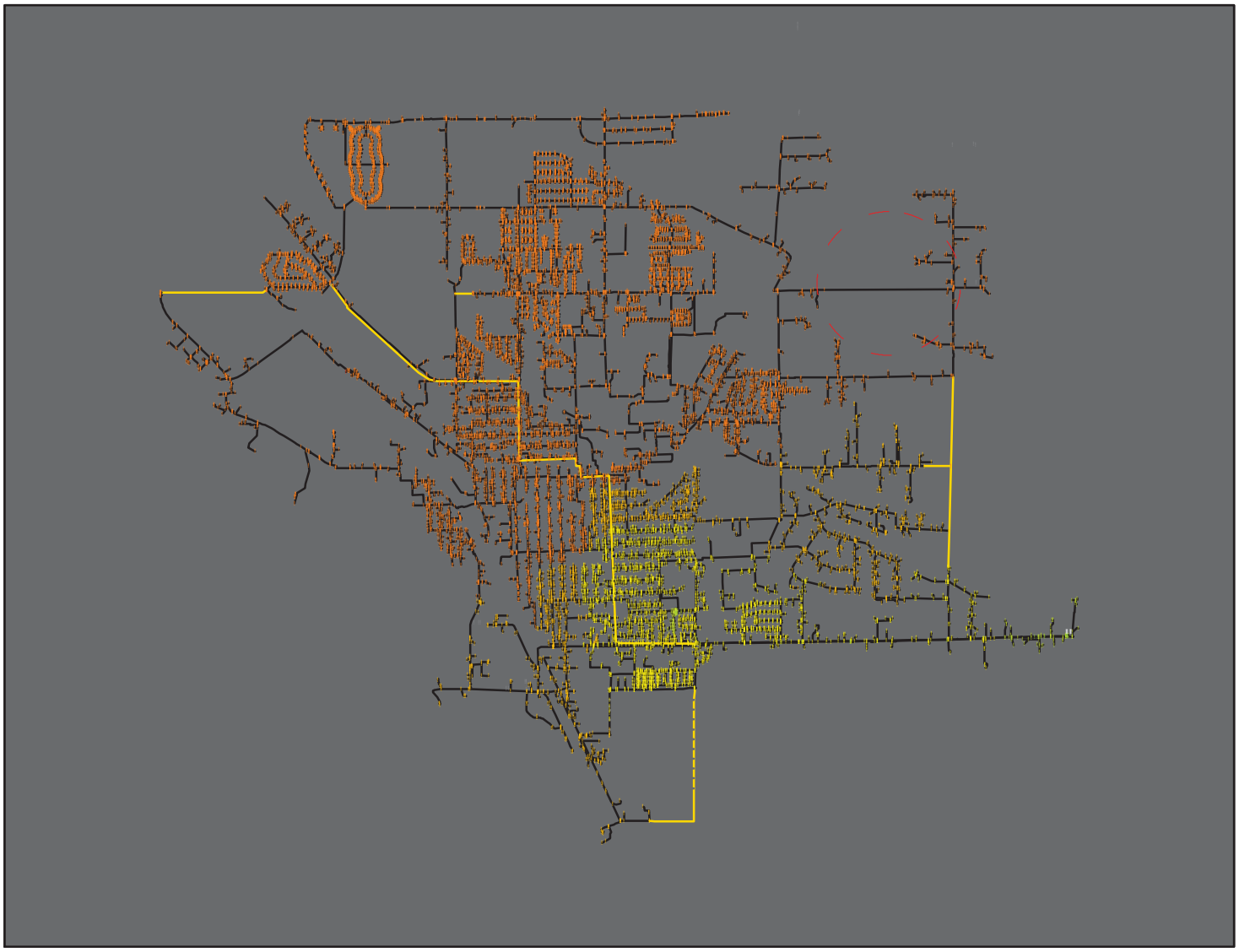
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,606

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (34)
.	Enabled (20180)	!	< 20.00 (15400)
.	Disabled (24)	!	20.00 - 25.00 (3649)
.	Proposed (20)	!	25.00 - 30.00 (680)
.	Retired (0)	!	30.00 - 35.00 (141)
		!	35.00 - 40.00 (42)
		!	40.00 - 45.00 (55)
		!	> 45.00 (32)

Appendix C.03 – Improvement 3 Result Exhibits

Improvement 3 - Game Farm Road Extension
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

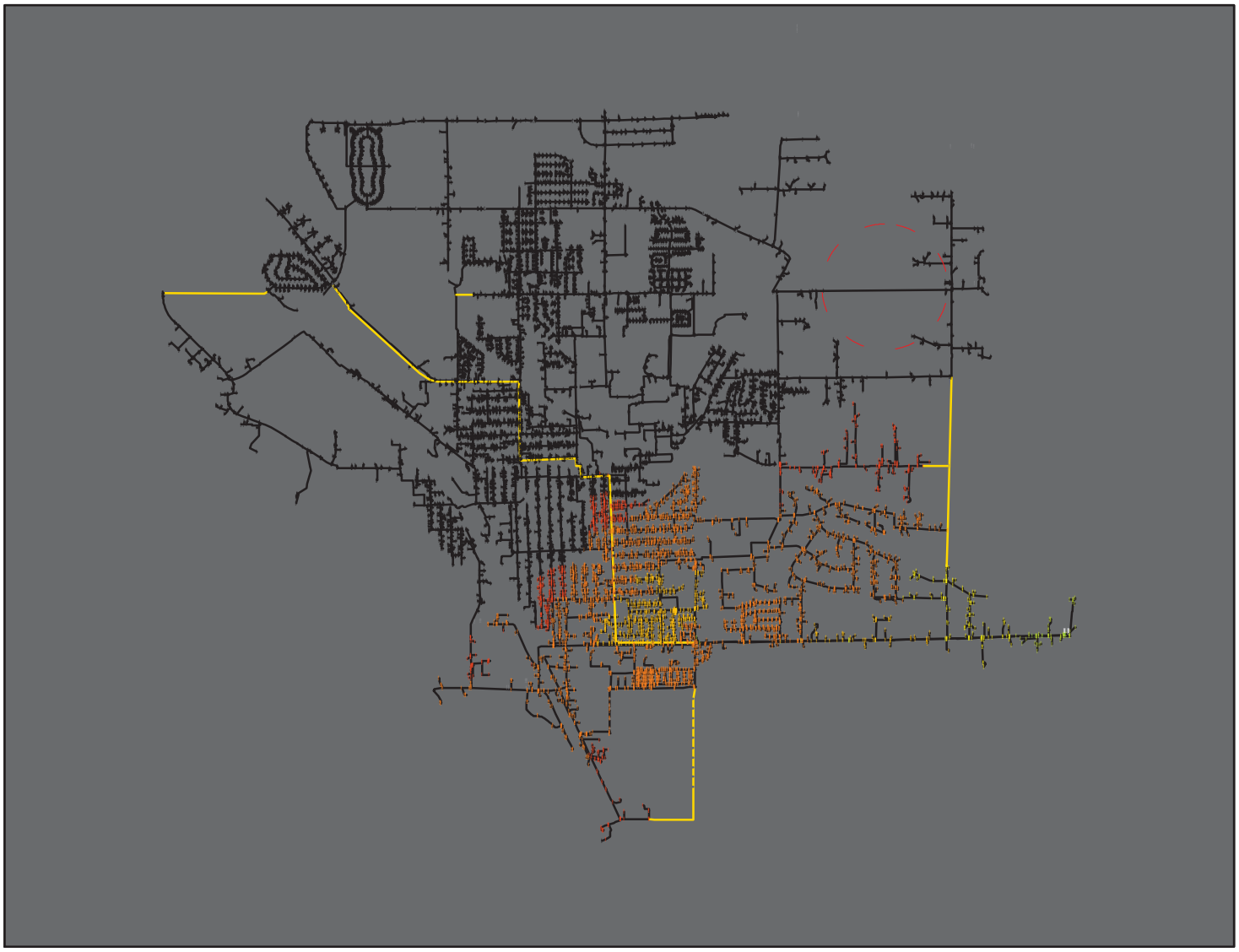
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17641)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (1)
Proposed (20)	25.00 - 30.00 (12108)
Retired (0)	30.00 - 35.00 (2190)
	35.00 - 40.00 (2972)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 3 - Game Farm Road Extension
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

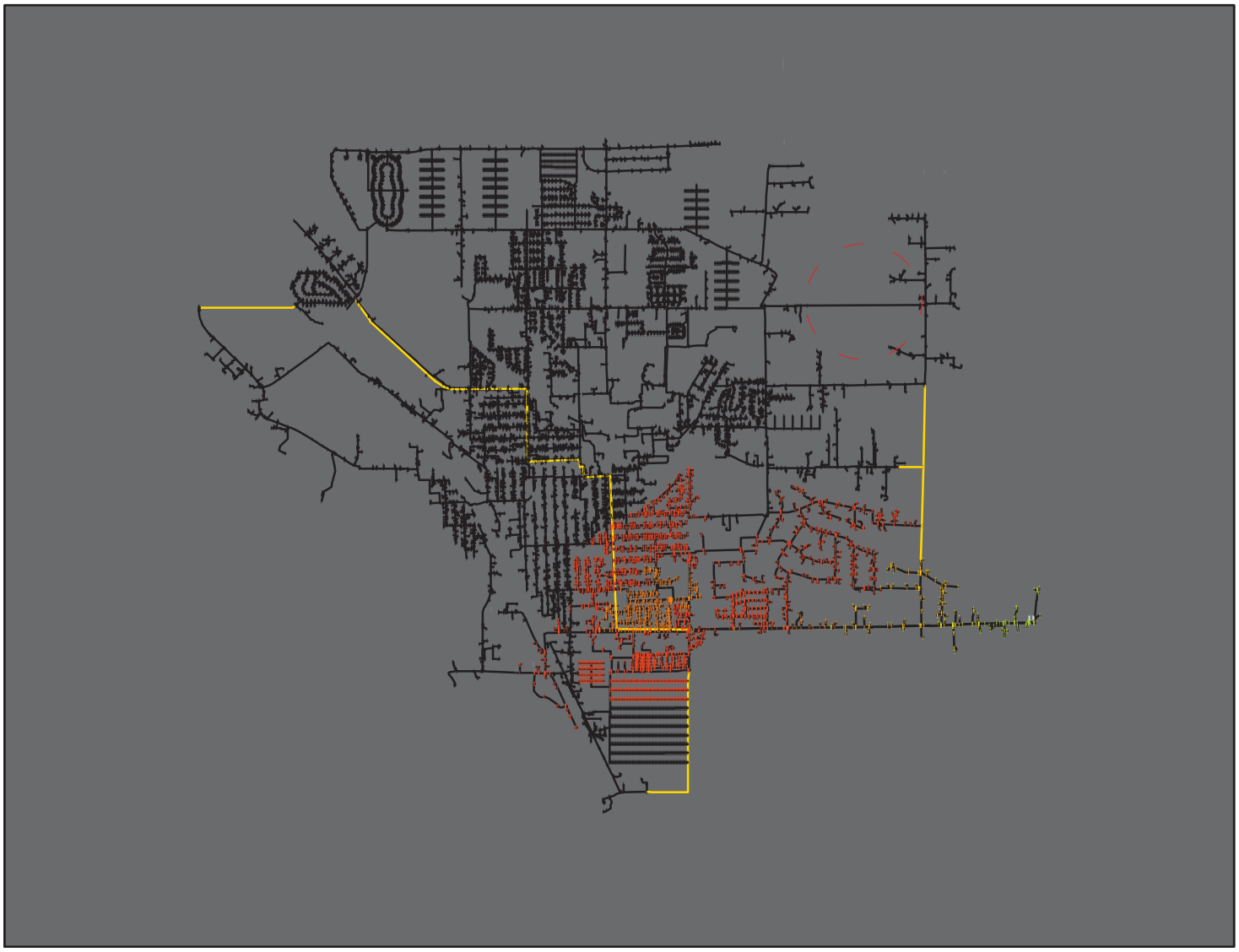
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,074

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2565)
.	Enabled (17641)	!	< 20.00 (12246)
.	Disabled (2563)	!	20.00 - 25.00 (728)
.	Proposed (20)	!	25.00 - 30.00 (3496)
.	Retired (0)	!	30.00 - 35.00 (775)
		!	35.00 - 40.00 (136)
		!	40.00 - 45.00 (55)
		!	> 45.00 (32)

Improvement 3 - Game Farm Road Extension
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

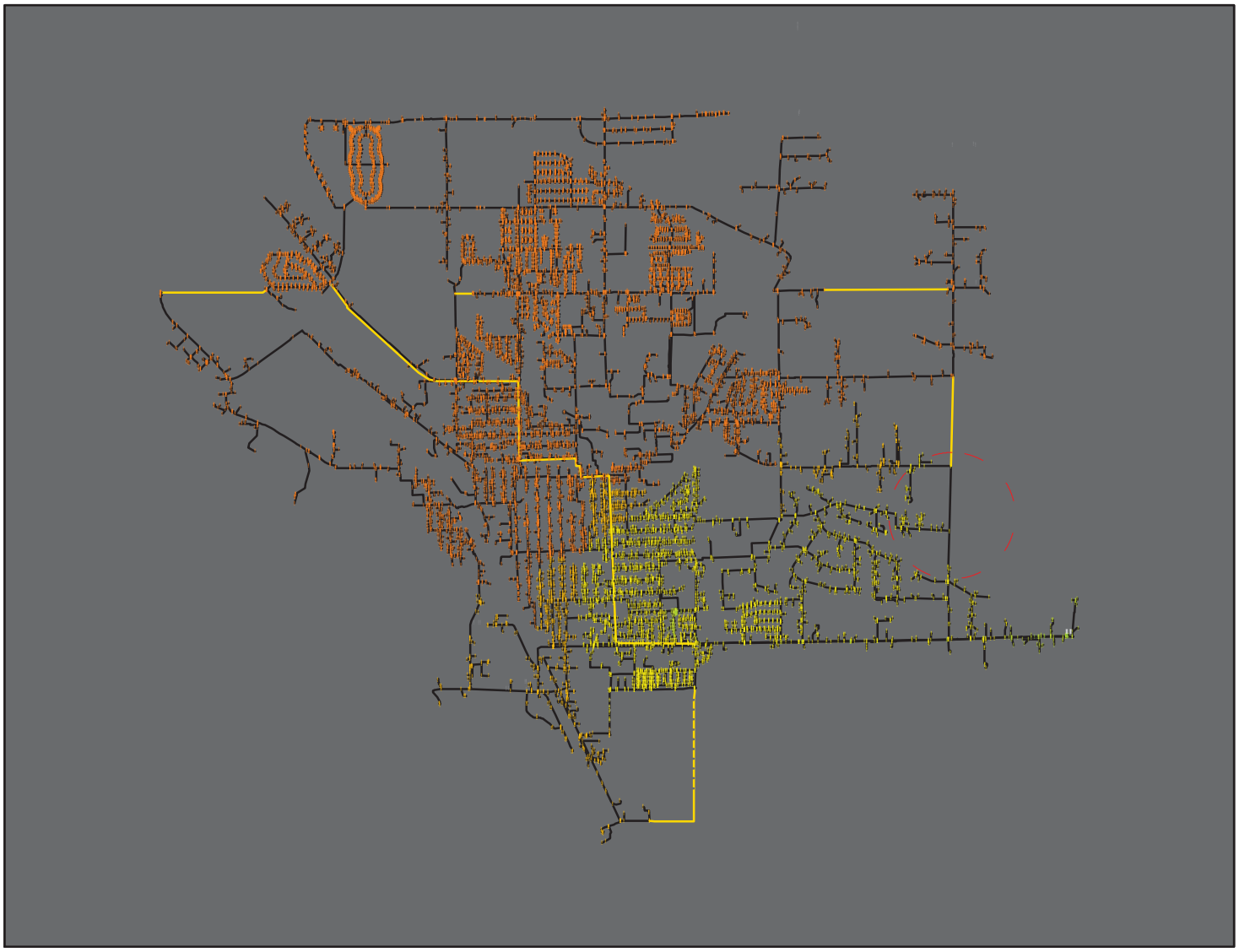
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,606

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (35)
Enabled (20181)	< 20.00 (15399)
Disabled (24)	20.00 - 25.00 (3649)
Proposed (19)	25.00 - 30.00 (680)
Retired (0)	30.00 - 35.00 (141)
	35.00 - 40.00 (42)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.04 – Improvement 4 Result Exhibits

Improvement 4 - Number 6 Road Extension
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

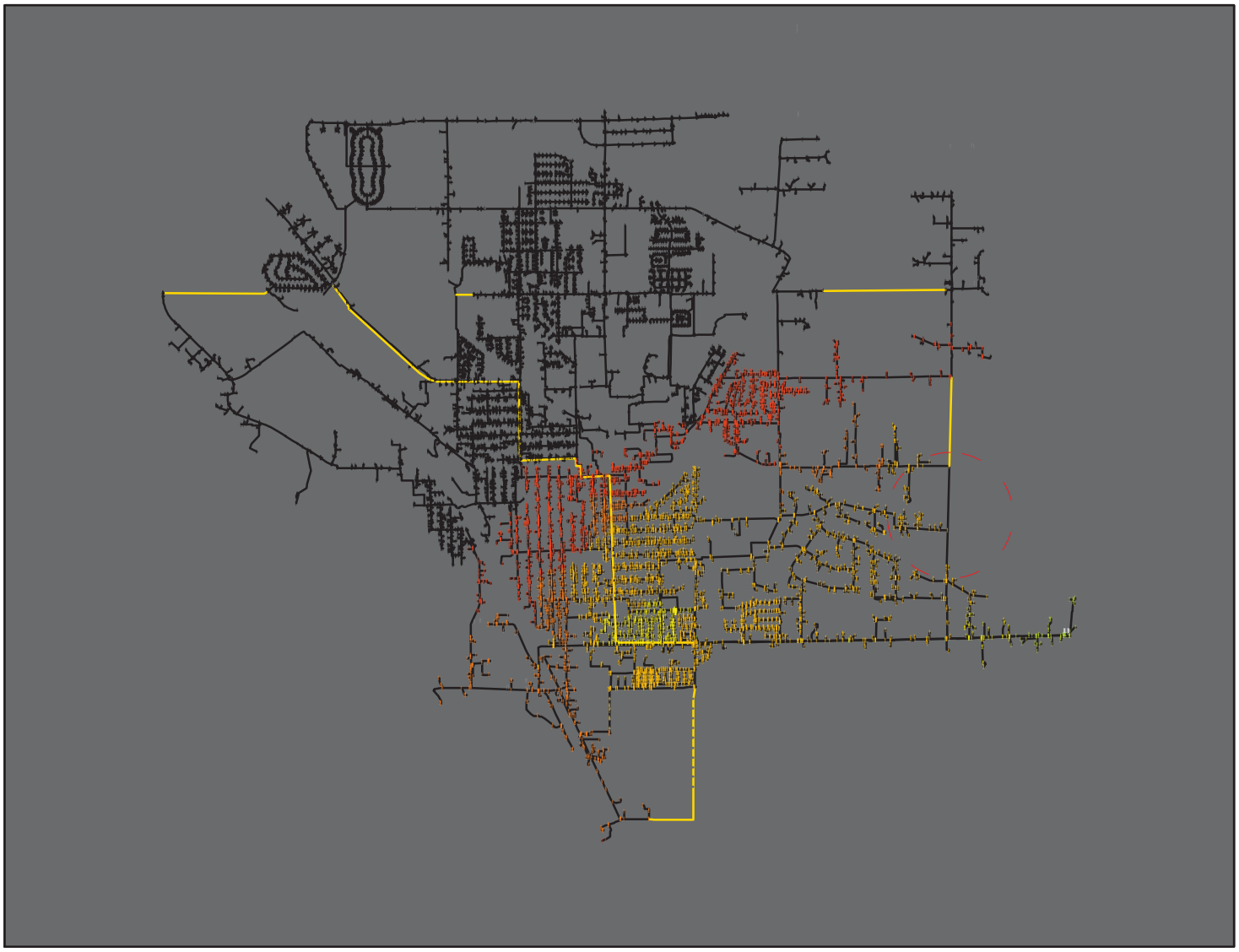
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17643)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (0)
Proposed (18)	25.00 - 30.00 (12064)
Retired (0)	30.00 - 35.00 (1352)
	35.00 - 40.00 (3851)
	40.00 - 45.00 (150)
	> 45.00 (50)

Improvement 4 - Number 6 Road Extension
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

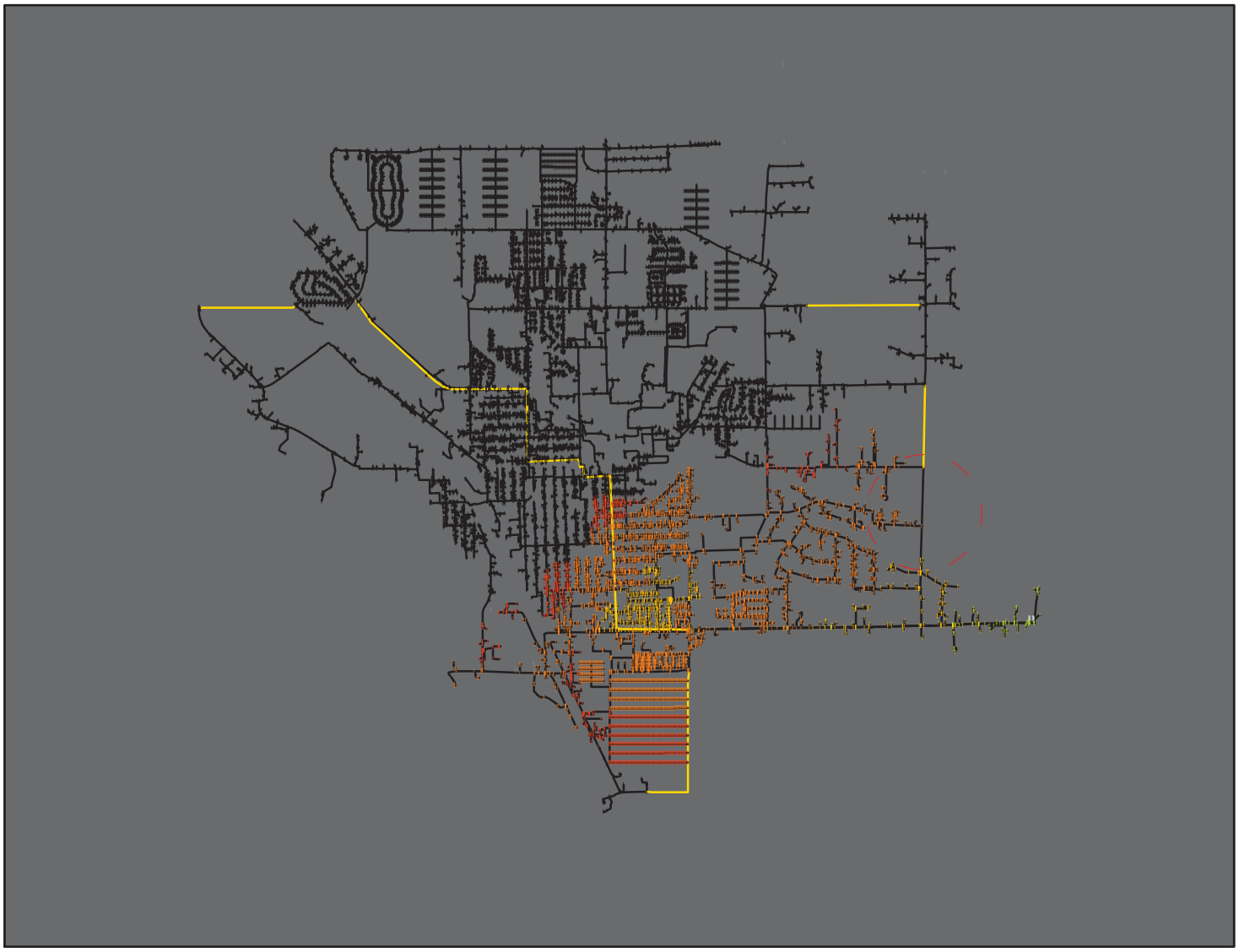
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2,366

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2564)
.	Enabled (17643)	!	< 20.00 (9905)
.	Disabled (2563)	!	20.00 - 25.00 (2358)
.	Proposed (18)	!	25.00 - 30.00 (1029)
.	Retired (0)	!	30.00 - 35.00 (3539)
		!	35.00 - 40.00 (551)
		!	40.00 - 45.00 (54)
		!	> 45.00 (33)

Improvement 4 - Number 6 Road Extension
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

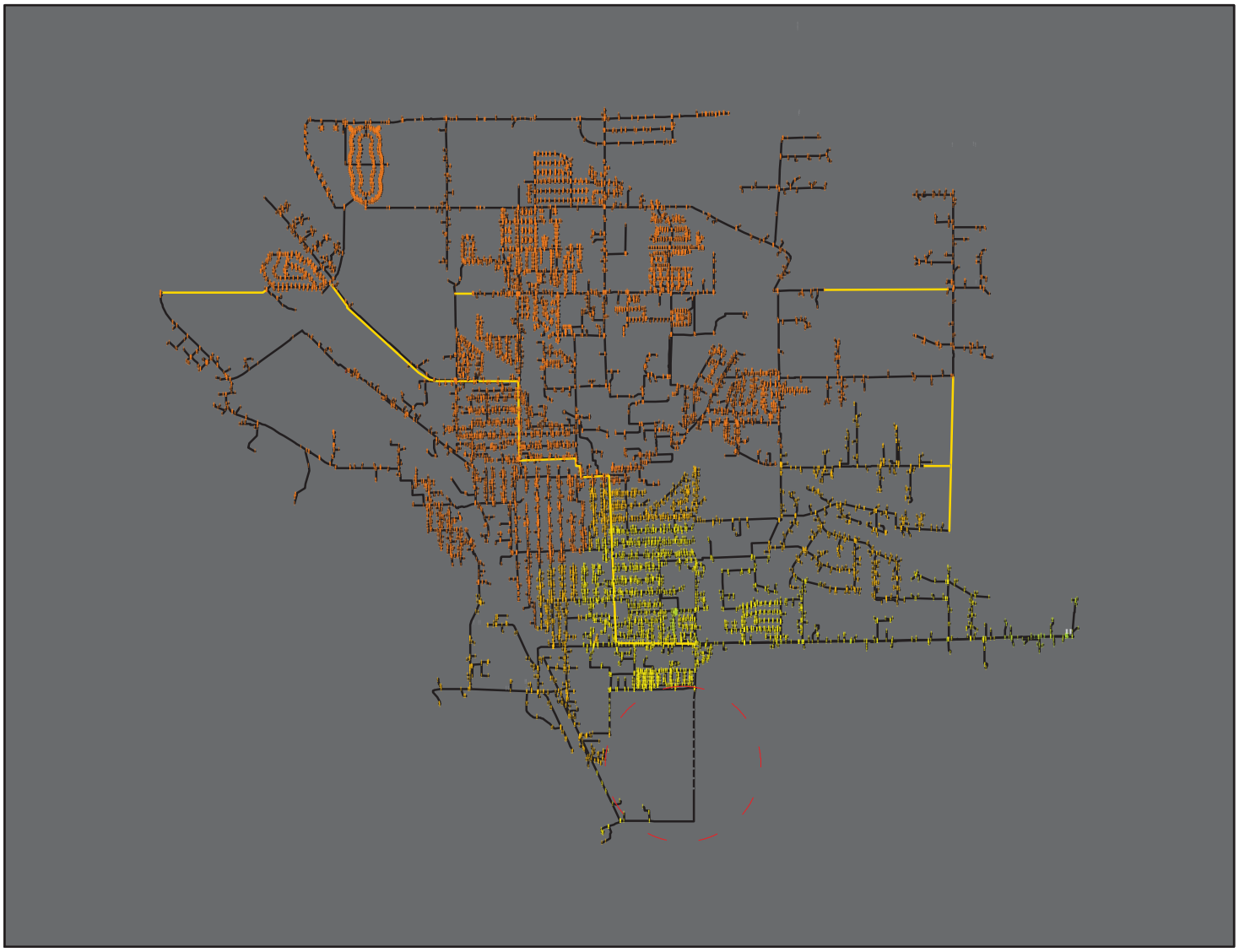
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,230

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (34)
Enabled (20183)	< 20.00 (13659)
Disabled (24)	20.00 - 25.00 (1360)
Proposed (17)	25.00 - 30.00 (4061)
Retired (0)	30.00 - 35.00 (793)
	35.00 - 40.00 (39)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.05 – Improvement 5 Result Exhibits

Improvement 5 - Berry Road Extension
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

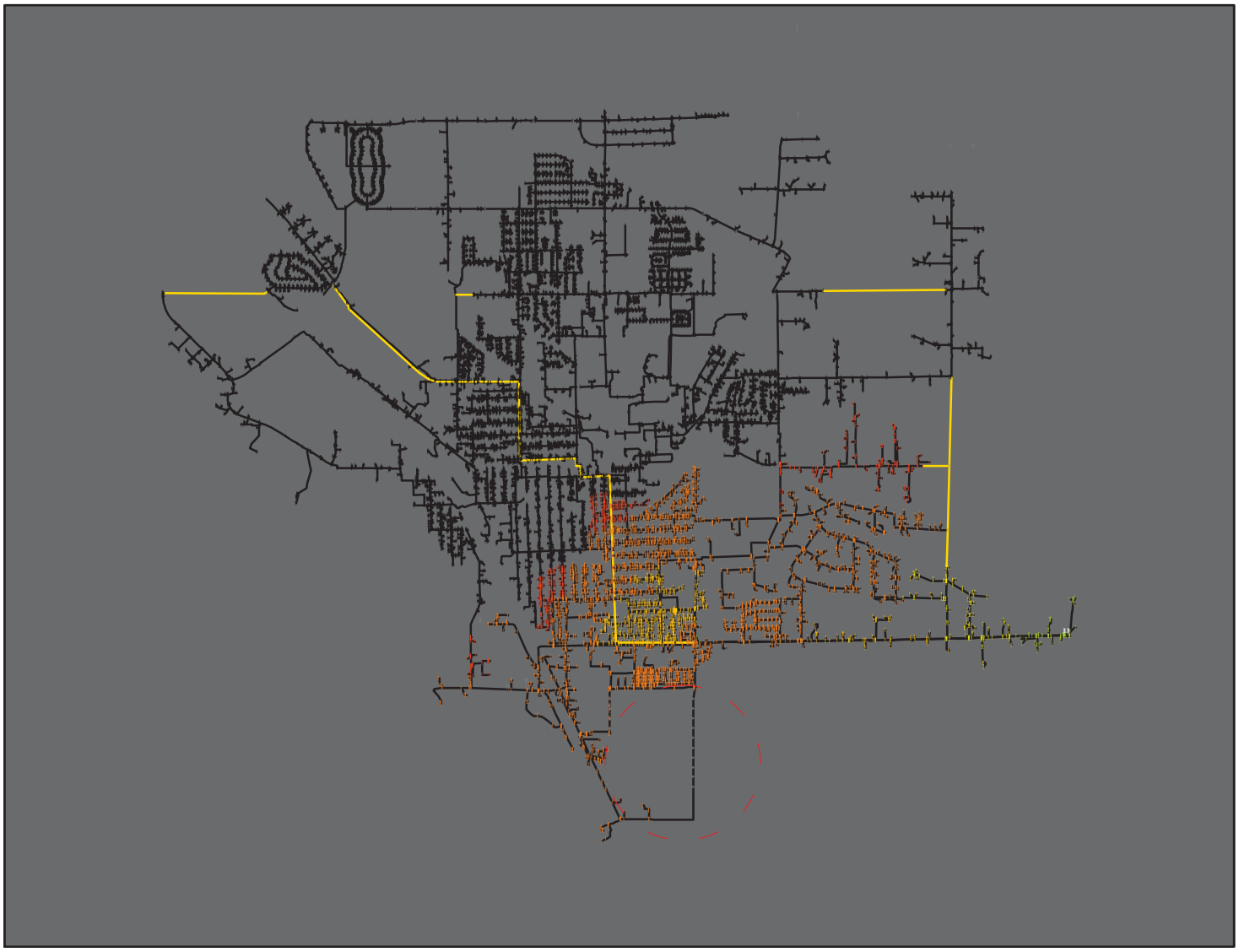
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2555)
Enabled (17651)	< 20.00 (2)
Disabled (2564)	20.00 - 25.00 (1)
Proposed (9)	25.00 - 30.00 (12103)
Retired (0)	30.00 - 35.00 (2146)
	35.00 - 40.00 (3030)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 5 - Berry Road Extension
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

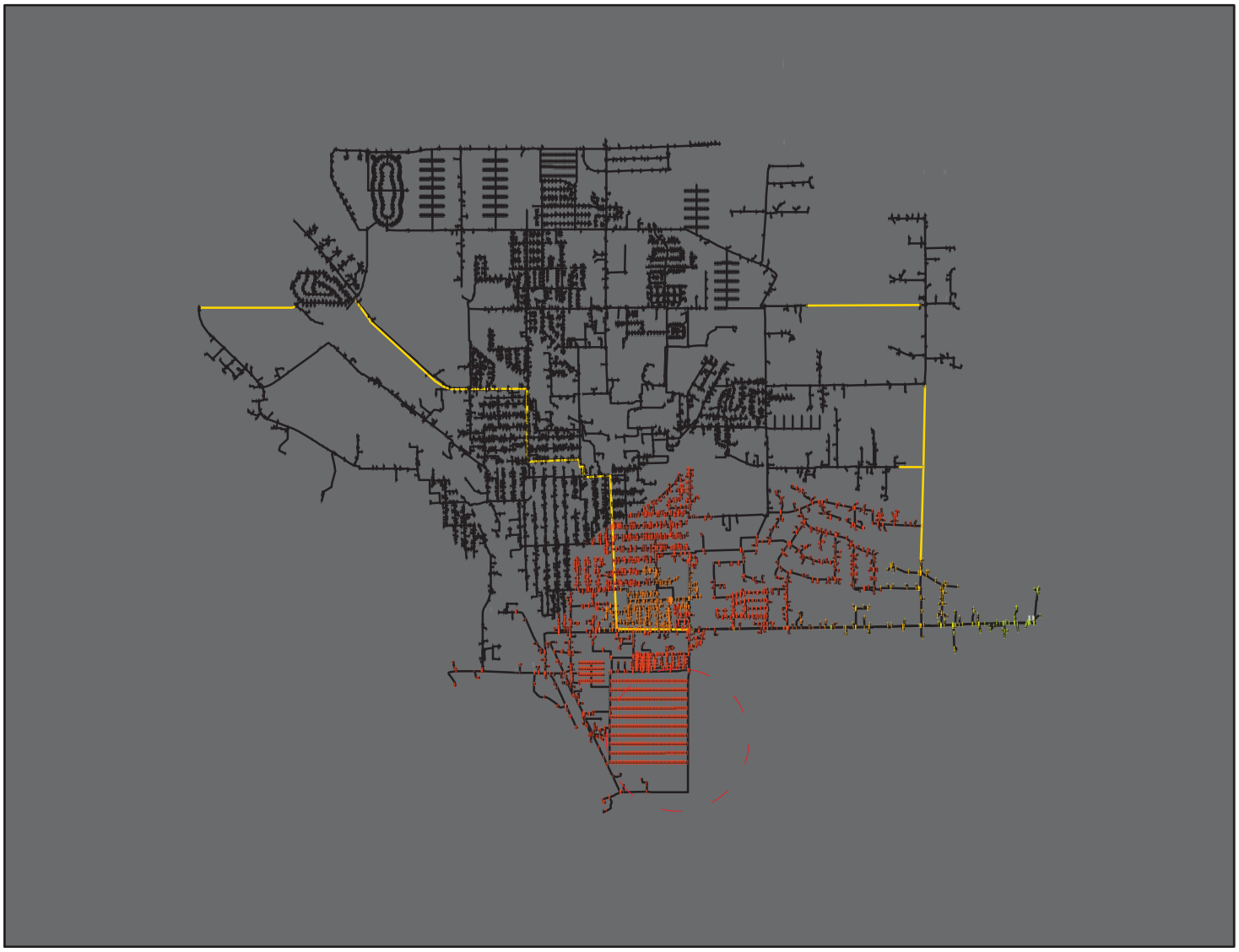
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,071

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2555)
.	Enabled (17651)	!	< 20.00 (12242)
.	Disabled (2563)	!	20.00 - 25.00 (662)
.	Proposed (10)	!	25.00 - 30.00 (3569)
.	Retired (0)	!	30.00 - 35.00 (782)
		!	35.00 - 40.00 (136)
		!	40.00 - 45.00 (55)
		!	> 45.00 (32)

Improvement 5 - Berry Road Extension
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

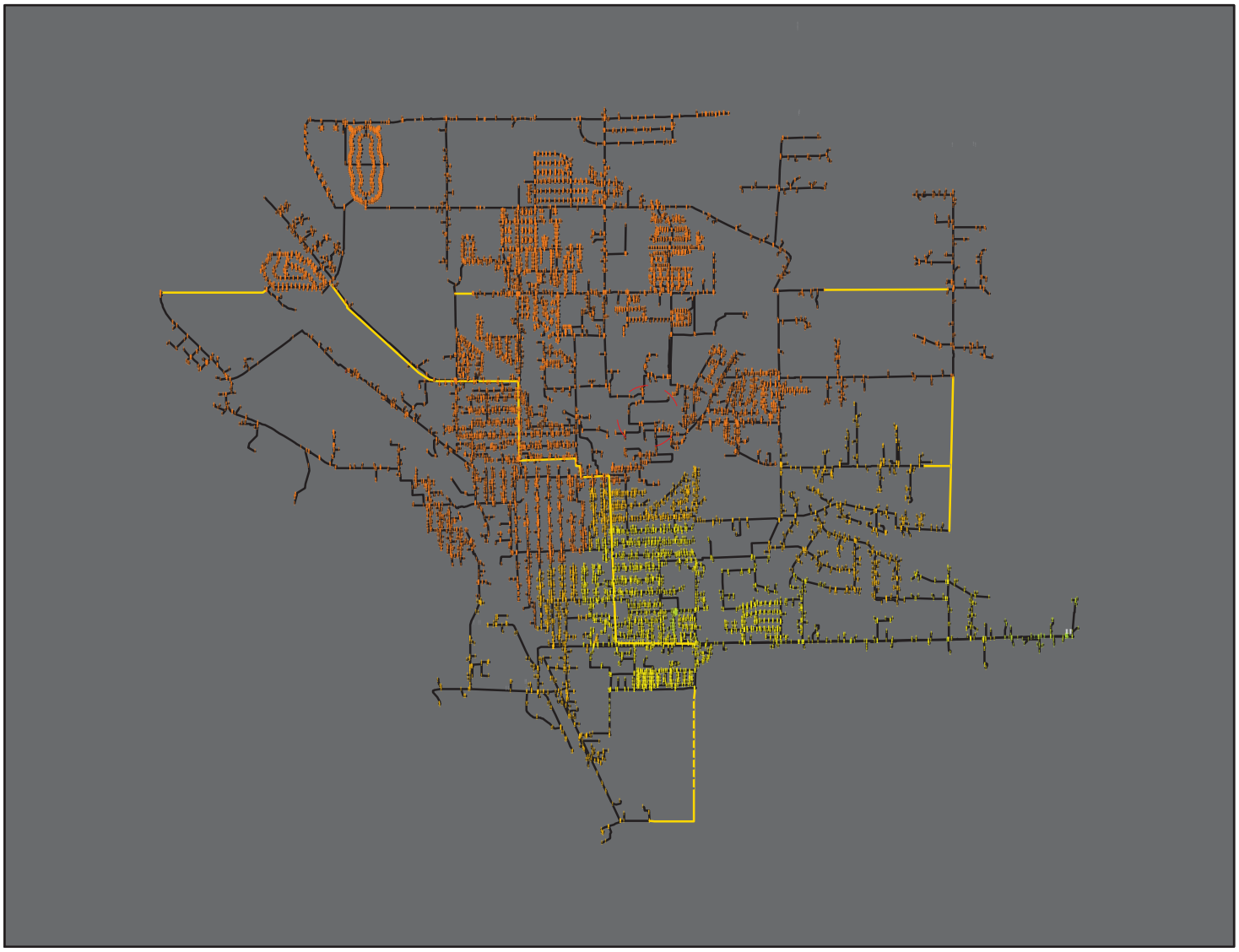
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,428

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (35)
Enabled (20191)	< 20.00 (14378)
Disabled (24)	20.00 - 25.00 (4669)
Proposed (9)	25.00 - 30.00 (681)
Retired (0)	30.00 - 35.00 (141)
	35.00 - 40.00 (42)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.06 – Improvement 6 Result Exhibits

Improvement 6 - East 11th Avenue Upgrade
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

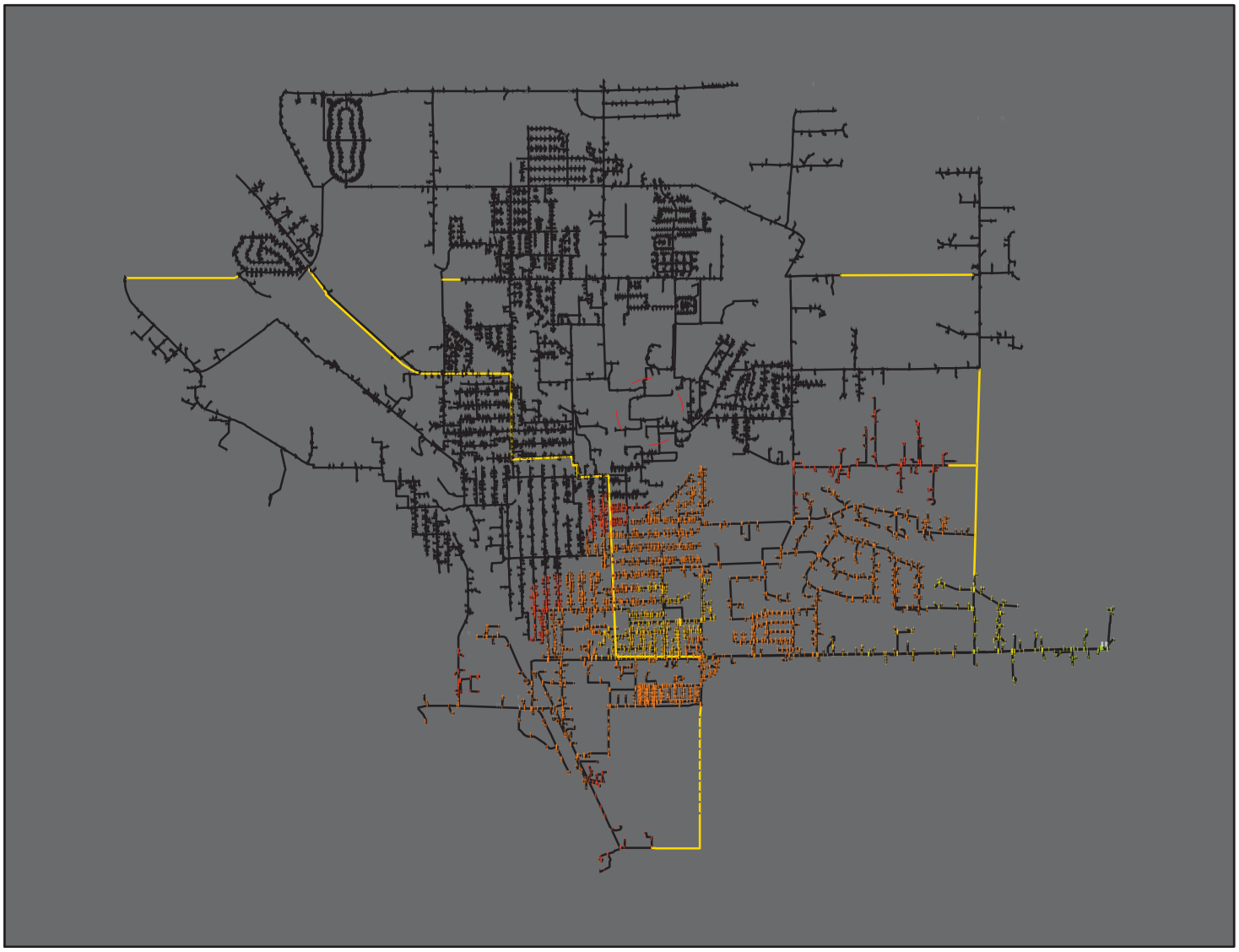
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (2)
Disabled (2564)	20.00 - 25.00 (1)
Proposed (20)	25.00 - 30.00 (12109)
Retired (0)	30.00 - 35.00 (2183)
	35.00 - 40.00 (2977)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 6 - East 11th Avenue Upgrade
Scenario 2



0 2,250 4,500 6,750 9,000 Feet

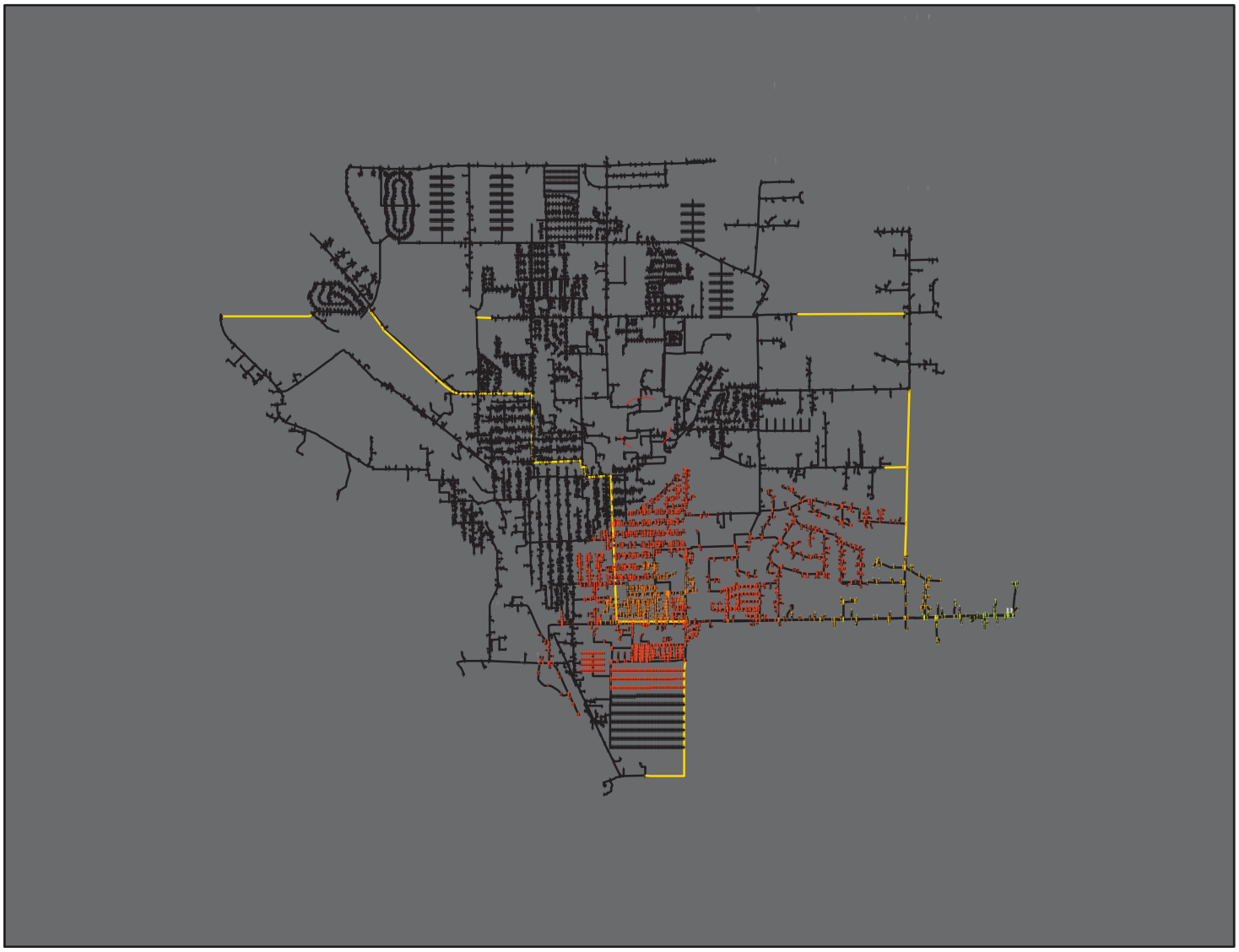
Scale: 1 = 54,950

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,075

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2565)
.	Enabled (17640)	!	< 20.00 (12249)
.	Disabled (2563)	!	20.00 - 25.00 (725)
.	Proposed (21)	!	25.00 - 30.00 (3499)
.	Retired (0)	!	30.00 - 35.00 (772)
		!	35.00 - 40.00 (136)
		!	40.00 - 45.00 (55)
		!	> 45.00 (32)

Improvement 6 - East 11th Avenue Upgrade
Scenario 3



0 2,750 5,500 8,250 11,000 Feet

Scale: 1 = 68,190

Improved Piping Information

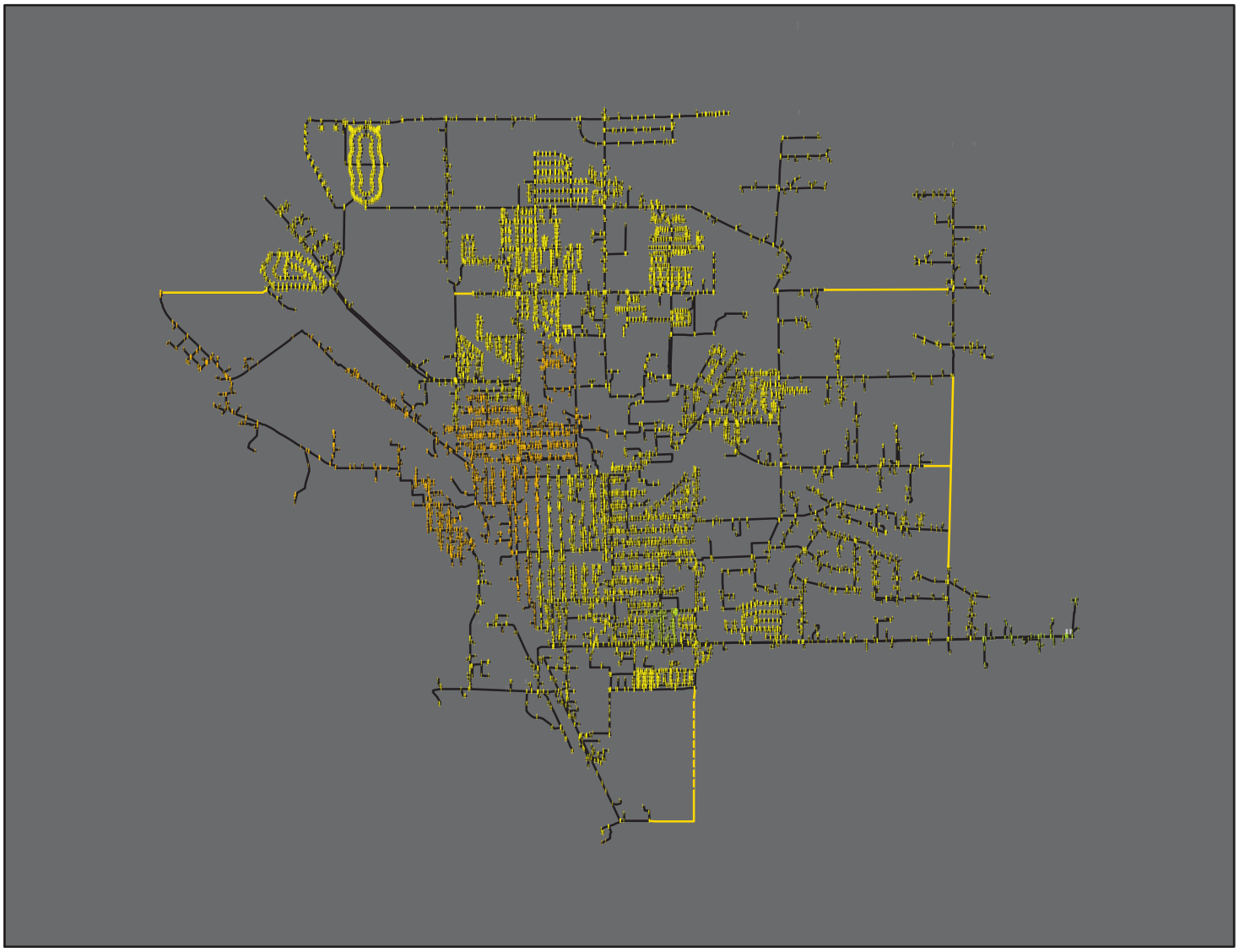
Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,606

Facilities Color By
Service State
- Not Applicable (0)
- Enabled (20179)
- Disabled (24)
- Proposed (21)
- Retired (0)

Nodes Color By
Pressure (psig)
- Not Applicable (35)
- < 20.00 (15402)
- 20.00 - 25.00 (3647)
- 25.00 - 30.00 (679)
- 30.00 - 35.00 (141)
- 35.00 - 40.00 (42)
- 40.00 - 45.00 (55)
- > 45.00 (32)

Appendix C.07 – Improvement 7 Result Exhibits

Improvement 7 - Northwest Regulator Station
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

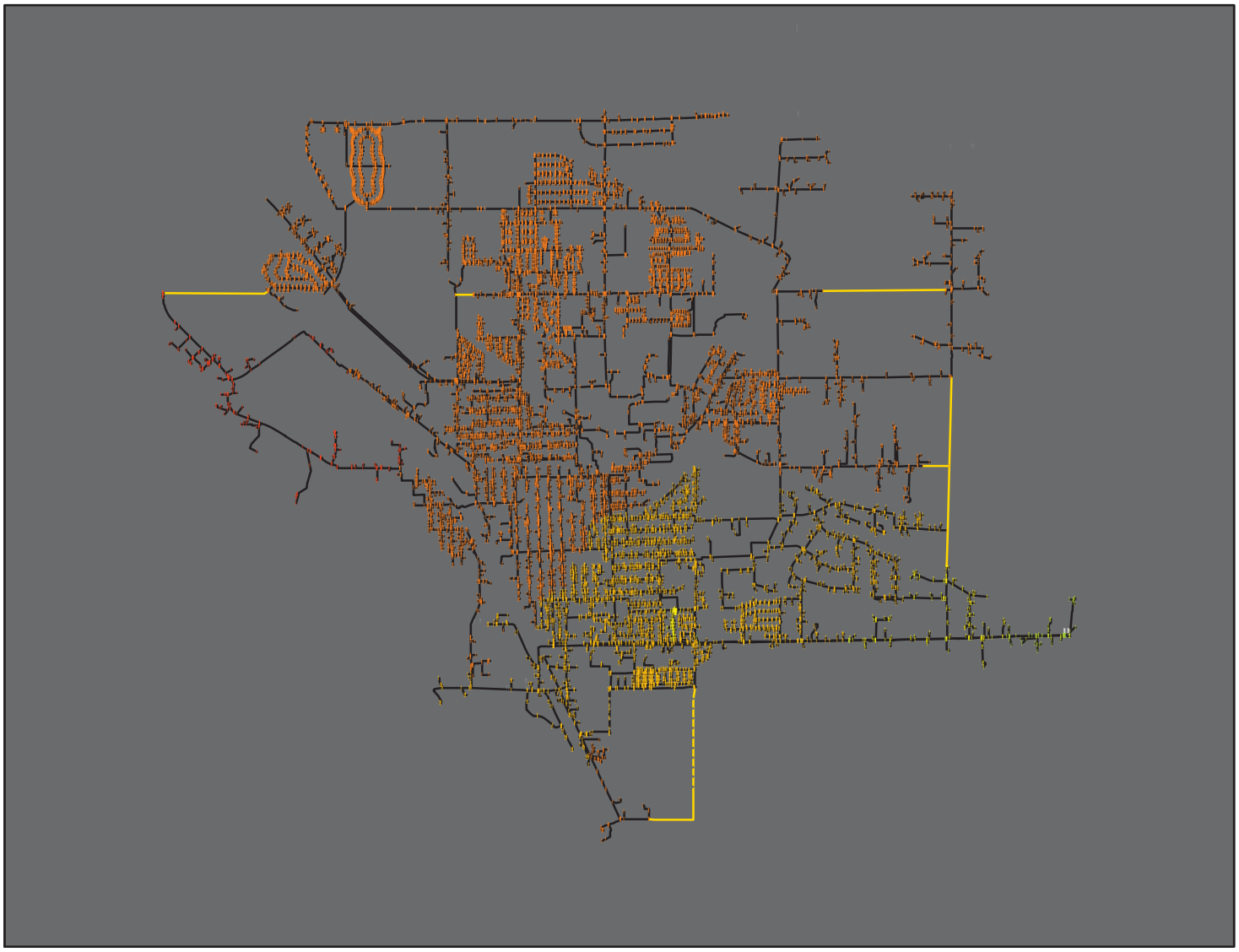
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2562)
Enabled (17643)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (0)
Proposed (18)	25.00 - 30.00 (0)
Retired (0)	30.00 - 35.00 (2590)
	35.00 - 40.00 (14512)
	40.00 - 45.00 (317)
	> 45.00 (50)

Improvement 7 - Northwest Regulator Station
Scenario 2



0 2,400 4,800 7,200 9,600 Feet

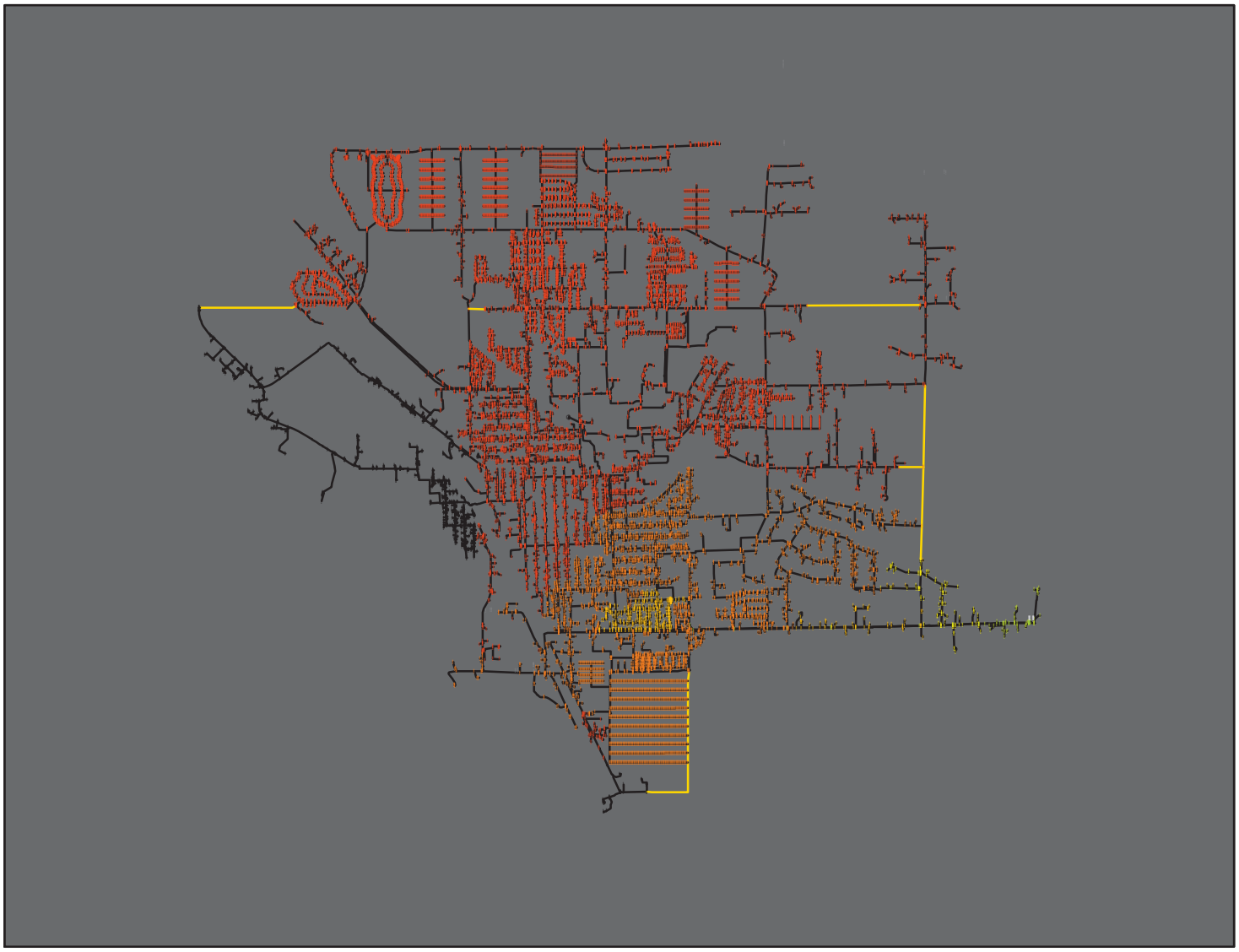
Scale: 1 = 59,550

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2562)
.	Enabled (17643)	!	< 20.00 (2)
.	Disabled (2563)	!	20.00 - 25.00 (267)
.	Proposed (18)	!	25.00 - 30.00 (12532)
.	Retired (0)	!	30.00 - 35.00 (4288)
		!	35.00 - 40.00 (286)
		!	40.00 - 45.00 (64)
		!	> 45.00 (32)

Improvement 7 - Northwest Regulator Station
Scenario 3



0 2,600 5,200 7,800 10,400 Feet

Scale: 1 = 64,660

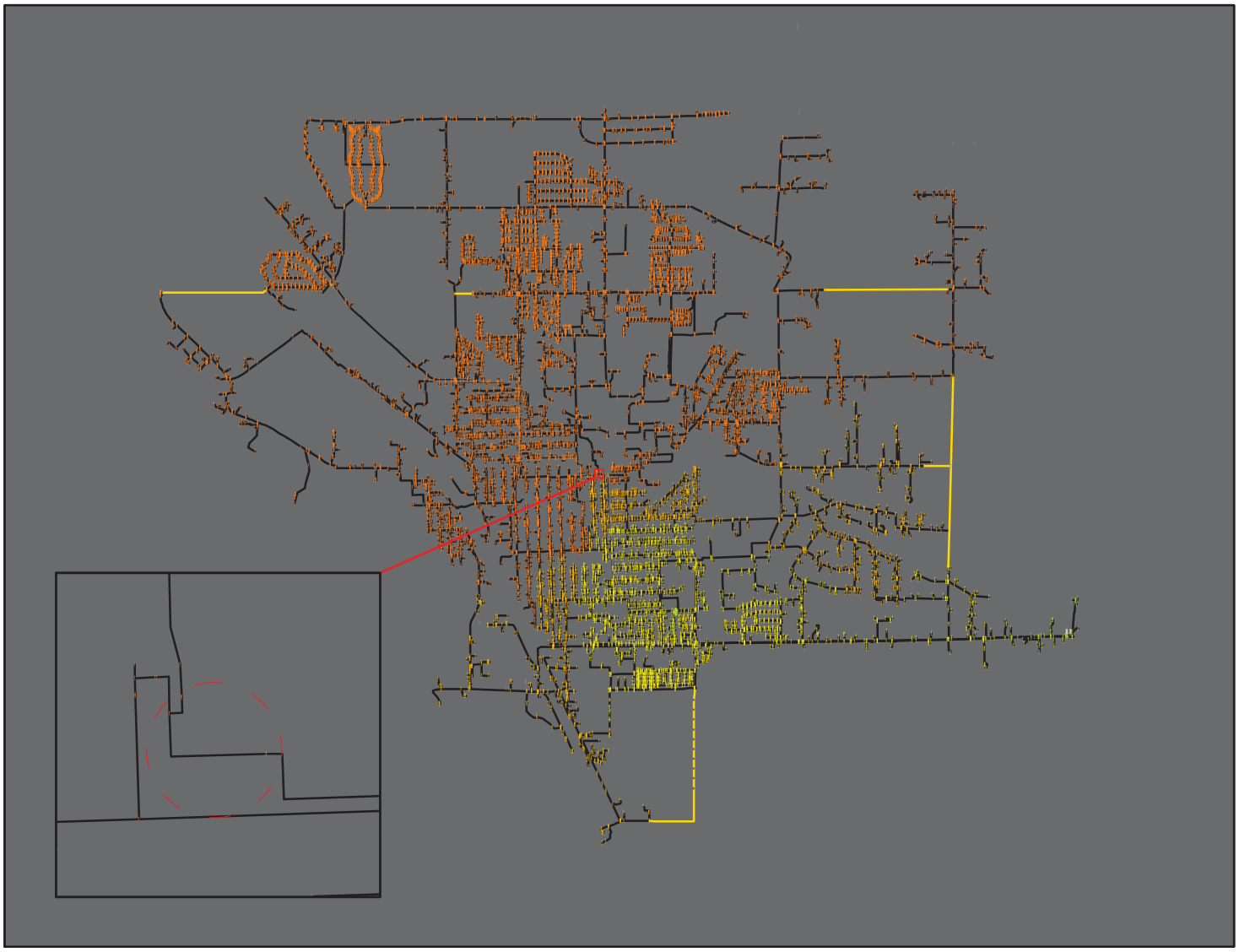
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 250

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (32)
Enabled (20182)	< 20.00 (755)
Disabled (24)	20.00 - 25.00 (13410)
Proposed (18)	25.00 - 30.00 (5059)
Retired (0)	30.00 - 35.00 (567)
	35.00 - 40.00 (124)
	40.00 - 45.00 (54)
	> 45.00 (32)

Appendix C.08 – Improvement 8 Result Exhibits

Improvement 8 - East 7th Avenue Upgrade
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

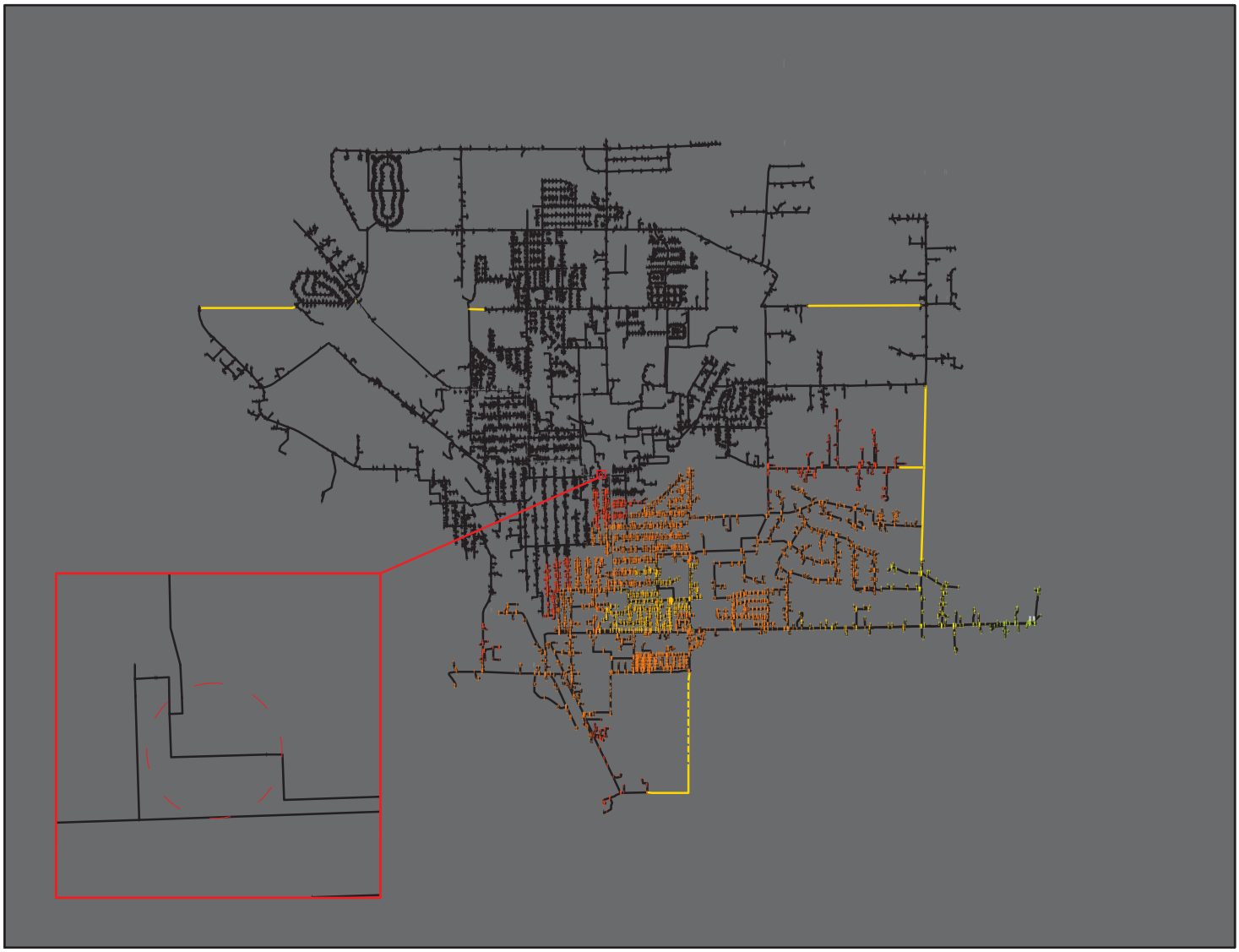
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (2)
Disabled (2564)	20.00 - 25.00 (0)
Proposed (20)	25.00 - 30.00 (12070)
Retired (0)	30.00 - 35.00 (2173)
	35.00 - 40.00 (3023)
	40.00 - 45.00 (150)
	> 45.00 (50)

Improvement 8 - East 7th Avenue Upgrade
Scenario 2



0 2,900 5,800 8,700 11,600 Feet

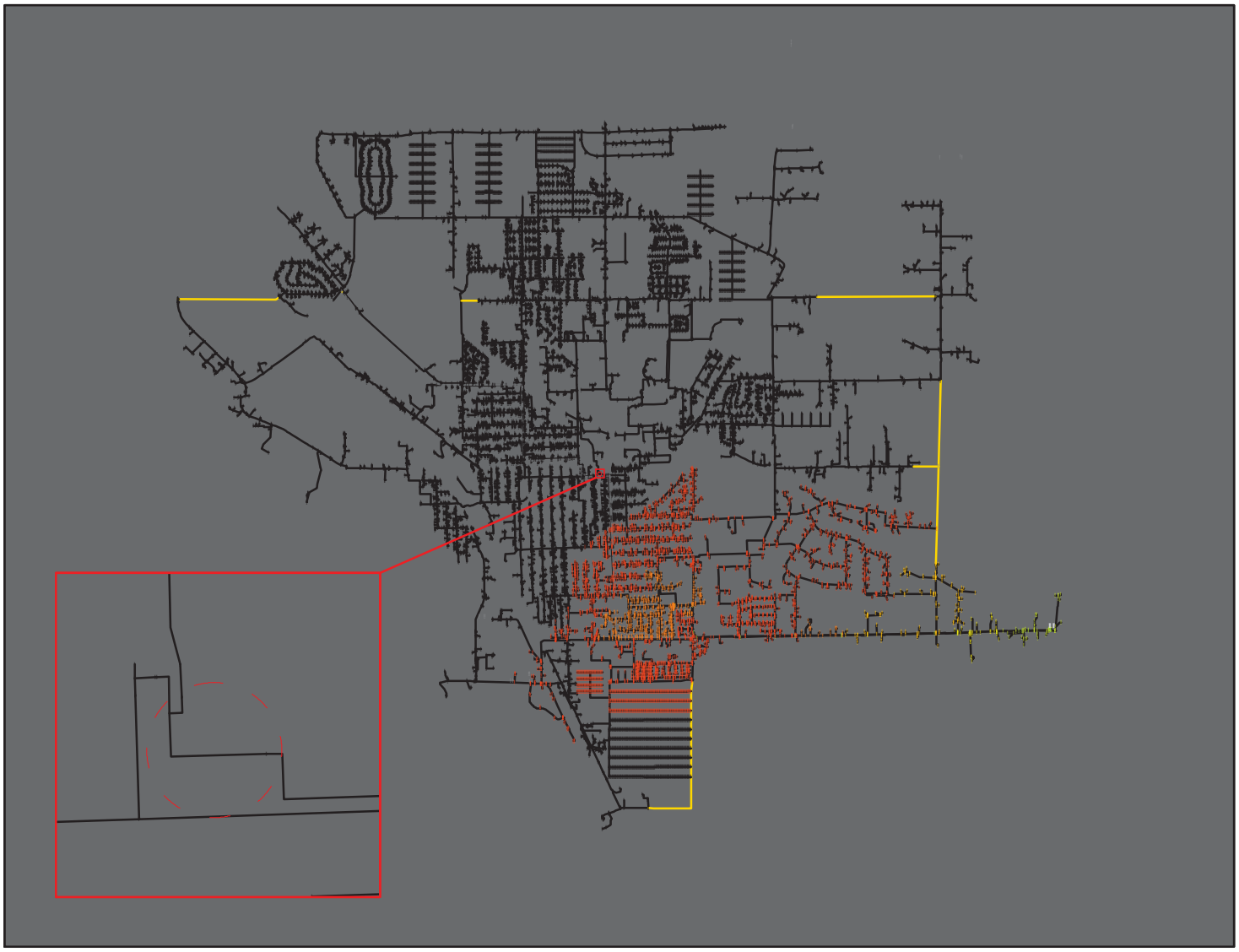
Scale: 1 = 64,660

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,065

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (12209)
Disabled (2564)	20.00 - 25.00 (754)
Proposed (20)	25.00 - 30.00 (3510)
Retired (0)	30.00 - 35.00 (770)
	35.00 - 40.00 (138)
	40.00 - 45.00 (55)
	> 45.00 (32)

Improvement 8 - East 7th Avenue Upgrade
Scenario 3



0 2,400 4,800 7,200 9,600 Feet

Scale: 1 = 61,550

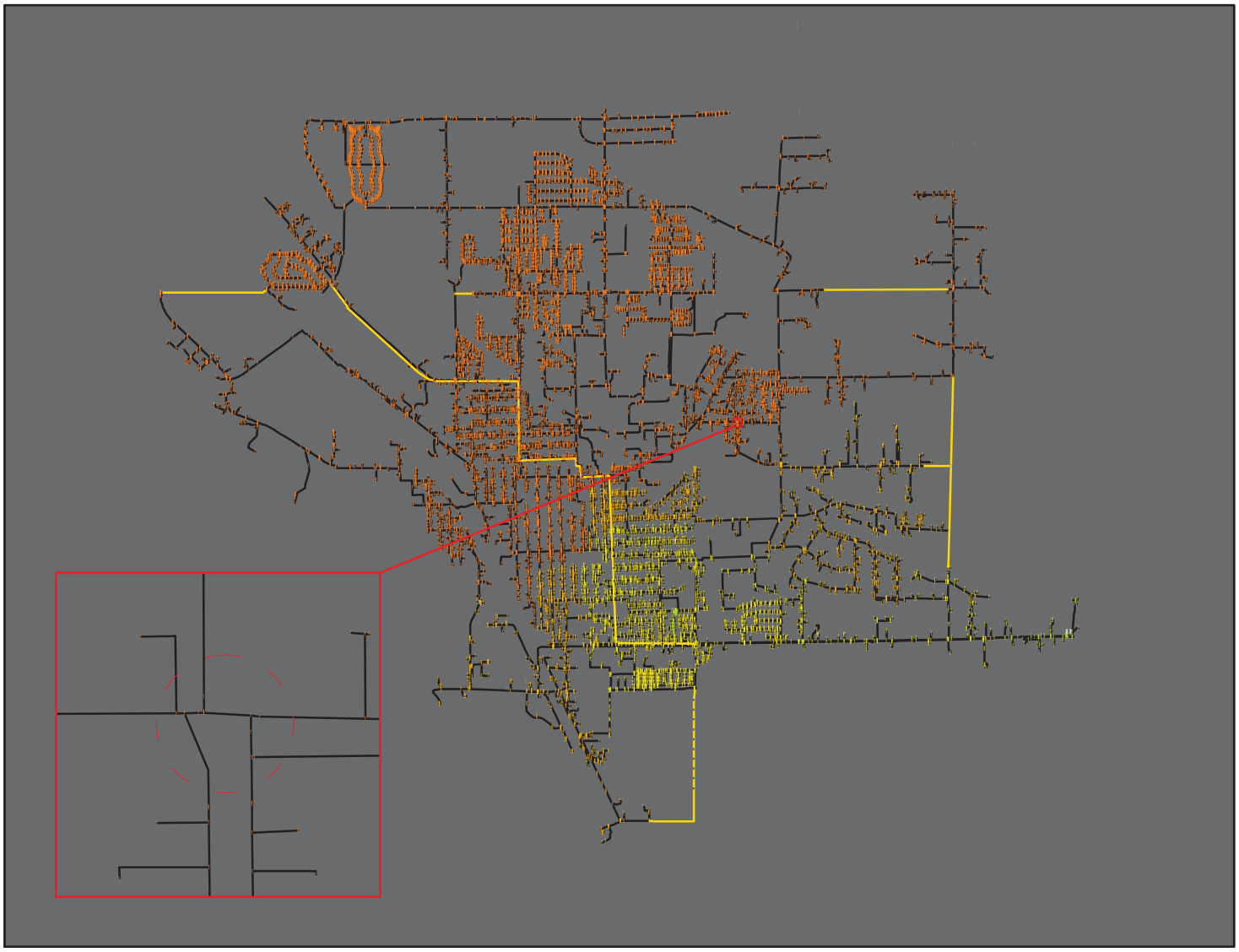
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,591

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (35)
Enabled (20179)	< 20.00 (15339)
Disabled (25)	20.00 - 25.00 (3711)
Proposed (20)	25.00 - 30.00 (676)
Retired (0)	30.00 - 35.00 (143)
	35.00 - 40.00 (42)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.09 – Improvement 9 Result Exhibits

Improvement 9 - Radio Road Upgrade
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

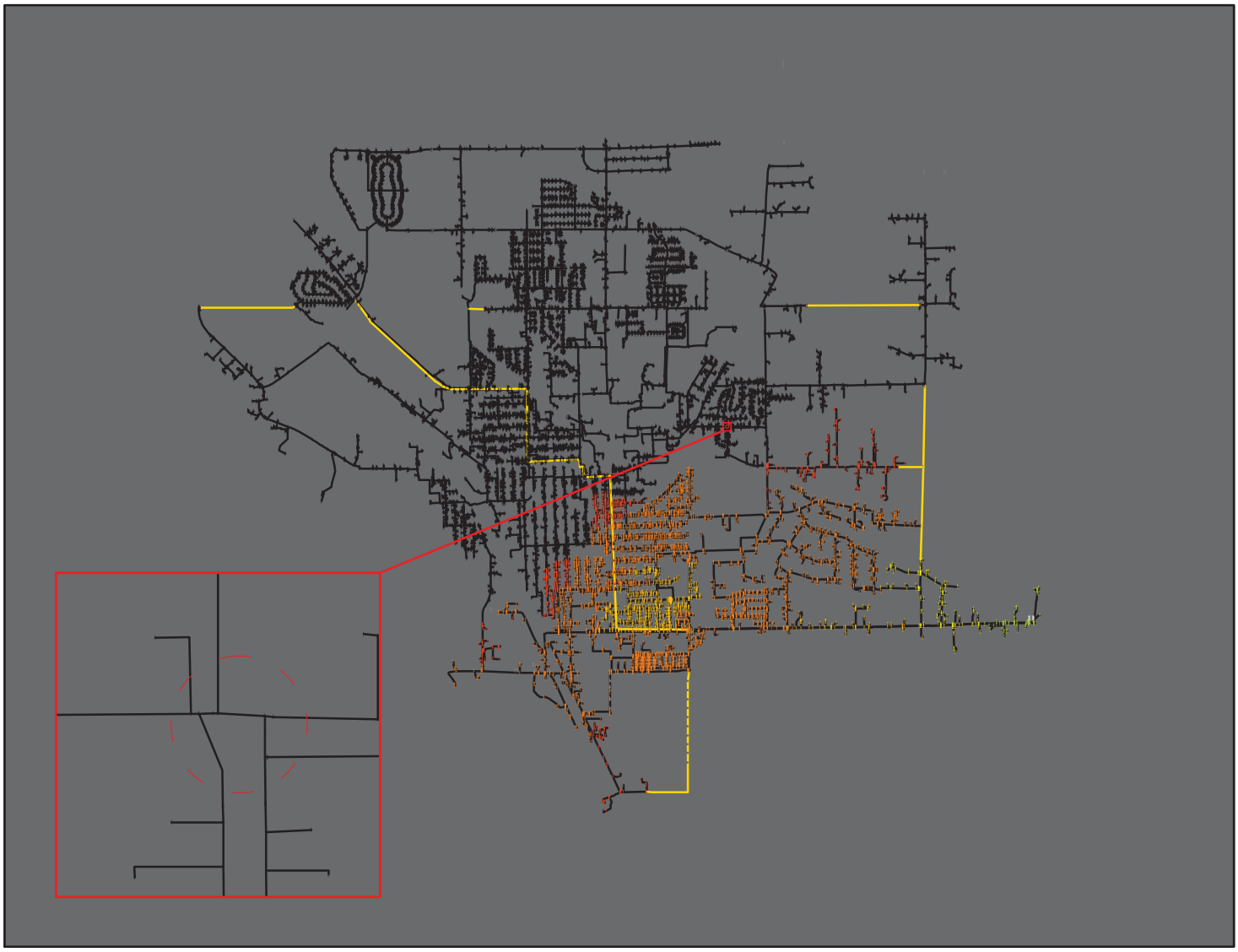
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (1)
Proposed (21)	25.00 - 30.00 (12105)
Retired (0)	30.00 - 35.00 (2197)
	35.00 - 40.00 (2967)
	40.00 - 45.00 (146)
	> 45.00 (50)

Improvement 9 - Radio Road Upgrade
Scenario 2



0 2,900 5,800 8,700 11,600 Feet

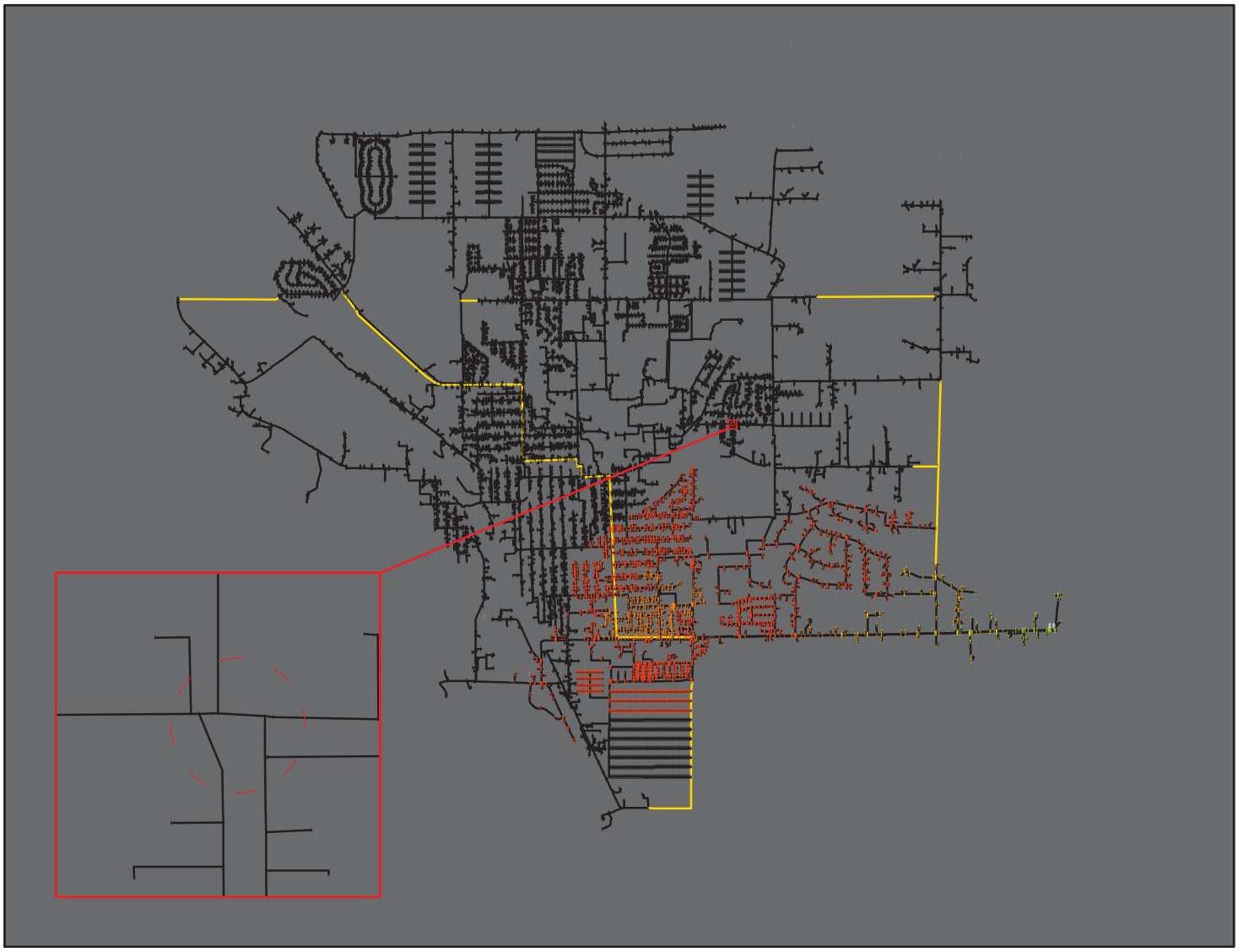
Scale: 1 = 64,660

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,076

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (12246)
Disabled (2563)	20.00 - 25.00 (724)
Proposed (21)	25.00 - 30.00 (3498)
Retired (0)	30.00 - 35.00 (777)
	35.00 - 40.00 (136)
	40.00 - 45.00 (55)
	> 45.00 (32)

Improvement 9 - Radio Road Upgrade
Scenario 3



0 2,400 4,800 7,200 9,600 Feet

Scale: 1 = 61,550

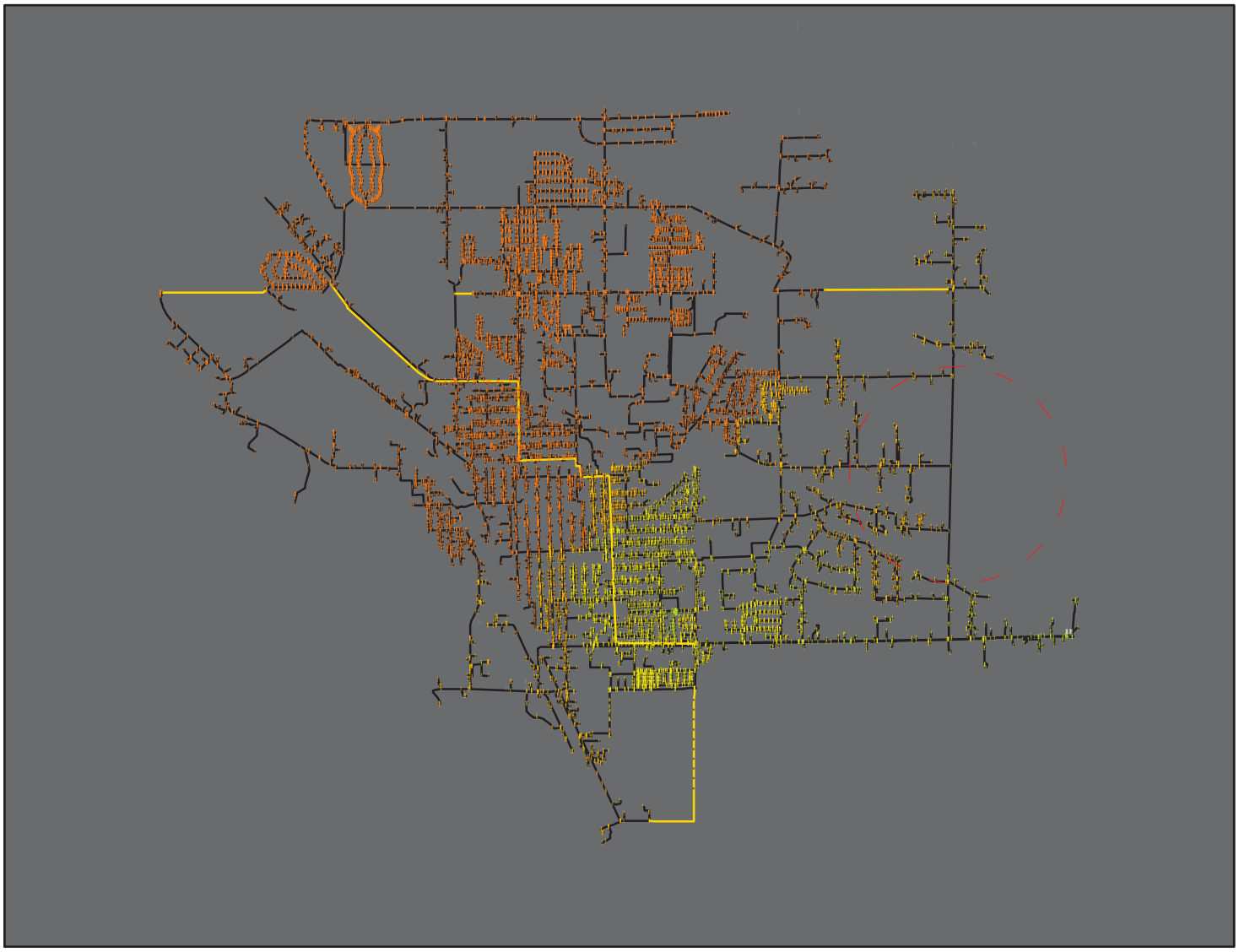
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 3,608

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (35)
Enabled (20179)	< 20.00 (15419)
Disabled (24)	20.00 - 25.00 (3628)
Proposed (21)	25.00 - 30.00 (681)
Retired (0)	30.00 - 35.00 (141)
	35.00 - 40.00 (42)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.10 – Improvement 10 Result Exhibits

Improvement 10 - Wilson Creek Road Extension
Scenario 1



0 2,400 4,800 7,200 9,600 Feet

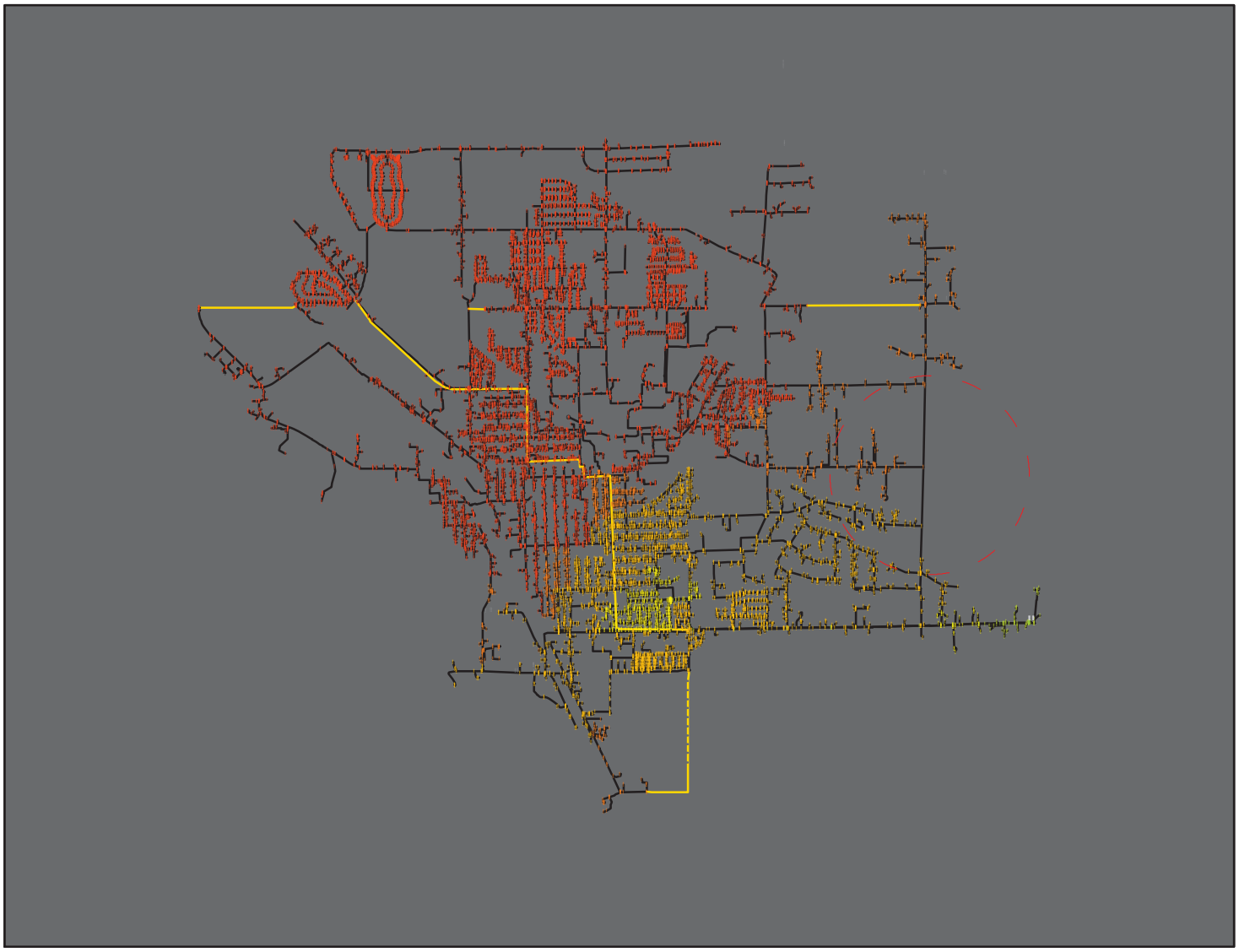
Scale: 1 = 59,250

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2564)
Enabled (17644)	< 20.00 (2)
Disabled (2563)	20.00 - 25.00 (0)
Proposed (17)	25.00 - 30.00 (11133)
Retired (0)	30.00 - 35.00 (2670)
	35.00 - 40.00 (3464)
	40.00 - 45.00 (150)
	> 45.00 (50)

Improvement 10 - Wilson Creek Road Extension
Scenario 2



0 2,500 5,000 7,500 10,000 Feet

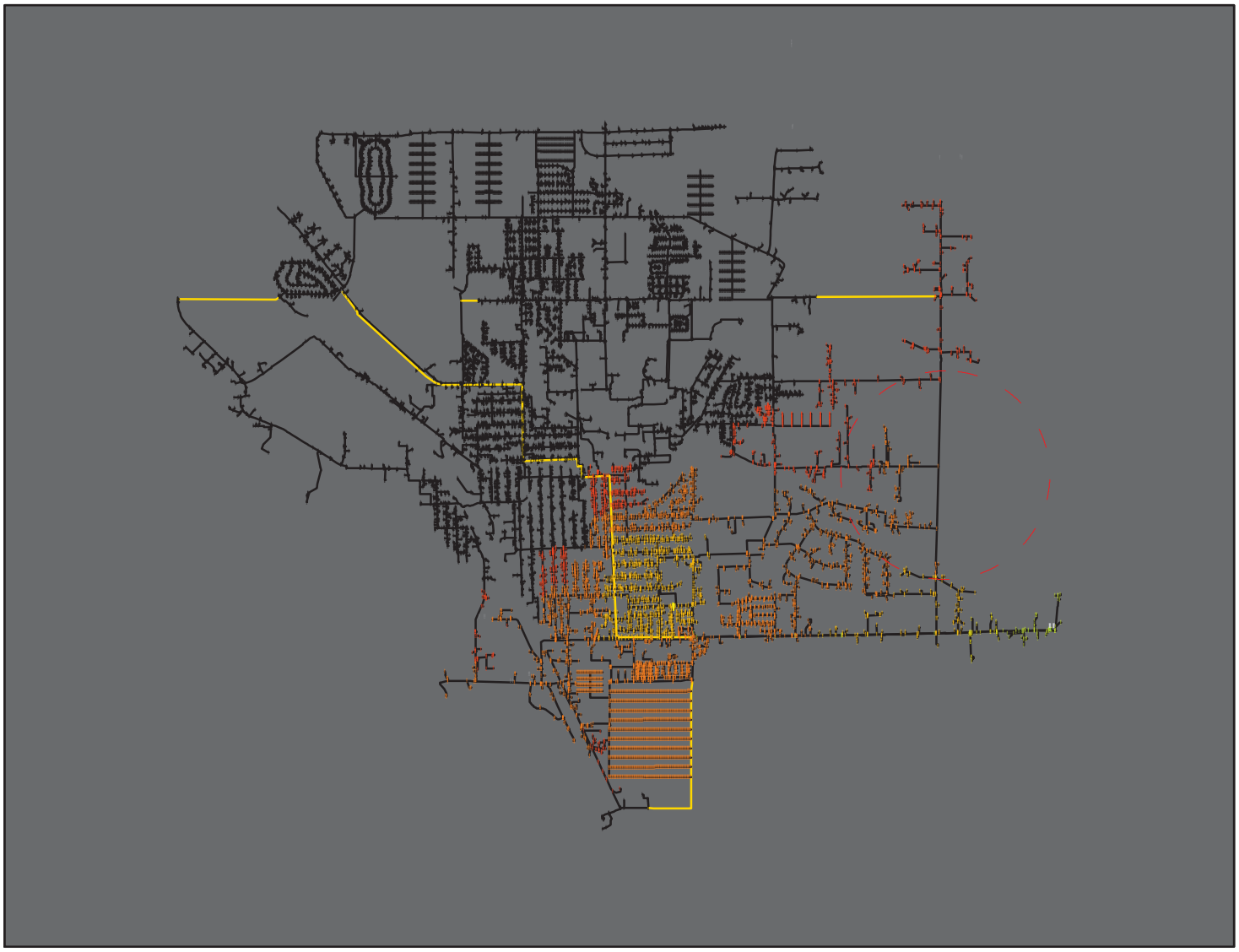
Scale: 1 = 64,660

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 10

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2564)
.	Enabled (17644)	!	< 20.00 (10)
.	Disabled (2563)	!	20.00 - 25.00 (11550)
.	Proposed (17)	!	25.00 - 30.00 (1358)
.	Retired (0)	!	30.00 - 35.00 (3786)
		!	35.00 - 40.00 (673)
		!	40.00 - 45.00 (59)
		!	> 45.00 (33)

Improvement 10 - Wilson Creek Road Extension
Scenario 3



0 2,400 4,800 7,200 9,600 Feet

Scale: 1 = 61,550

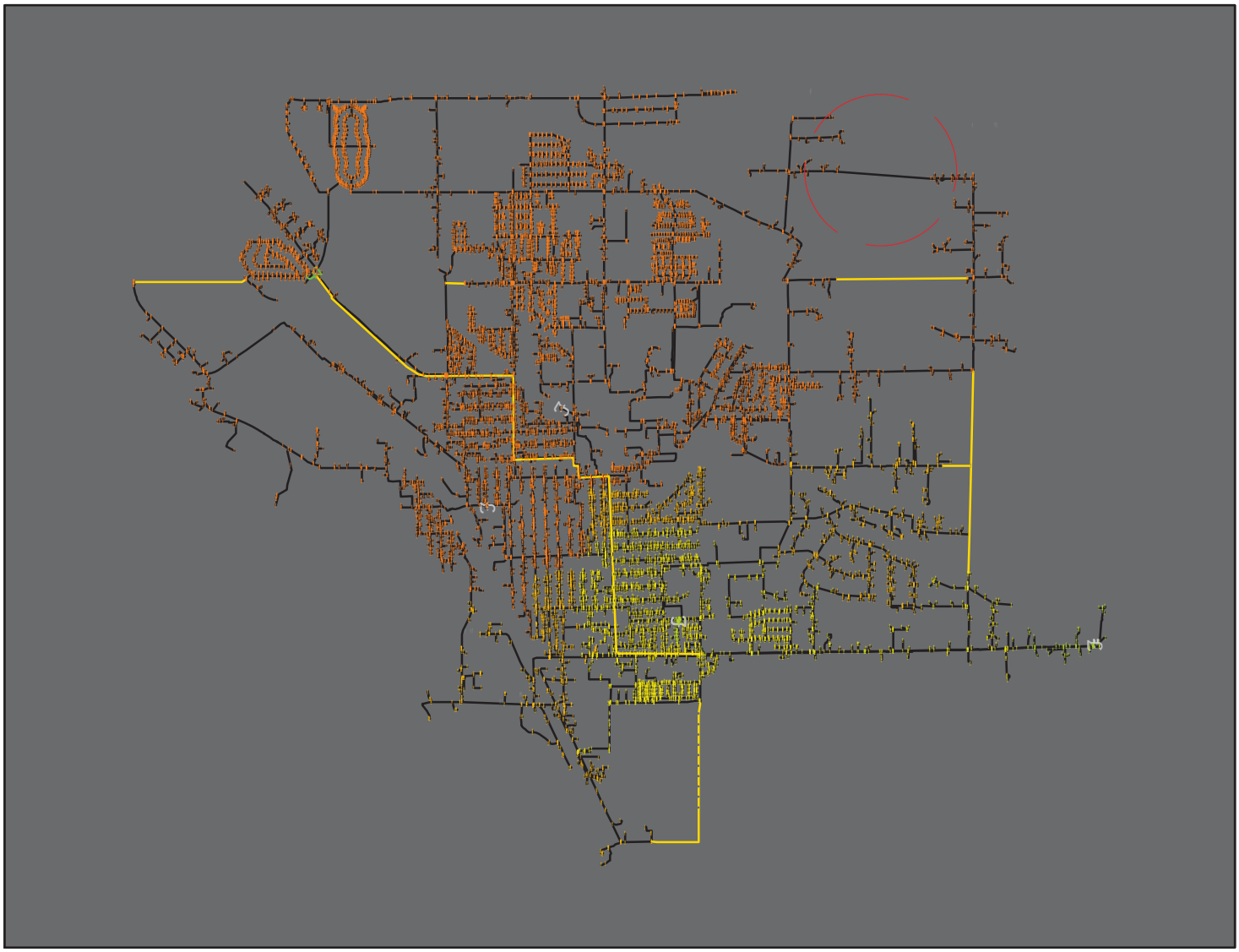
Improved Piping Information

Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2,997

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (34)
Enabled (20183)	< 20.00 (12722)
Disabled (24)	20.00 - 25.00 (1350)
Proposed (17)	25.00 - 30.00 (4341)
Retired (0)	30.00 - 35.00 (1417)
	35.00 - 40.00 (82)
	40.00 - 45.00 (55)
	> 45.00 (32)

Appendix C.11 – Improvement 12 Result Exhibits

Improvement 12 - Meadowbrook Lane to Willowdale Road Extension Scenario 1



0 3,250 6,500 9,750 13,000 Feet

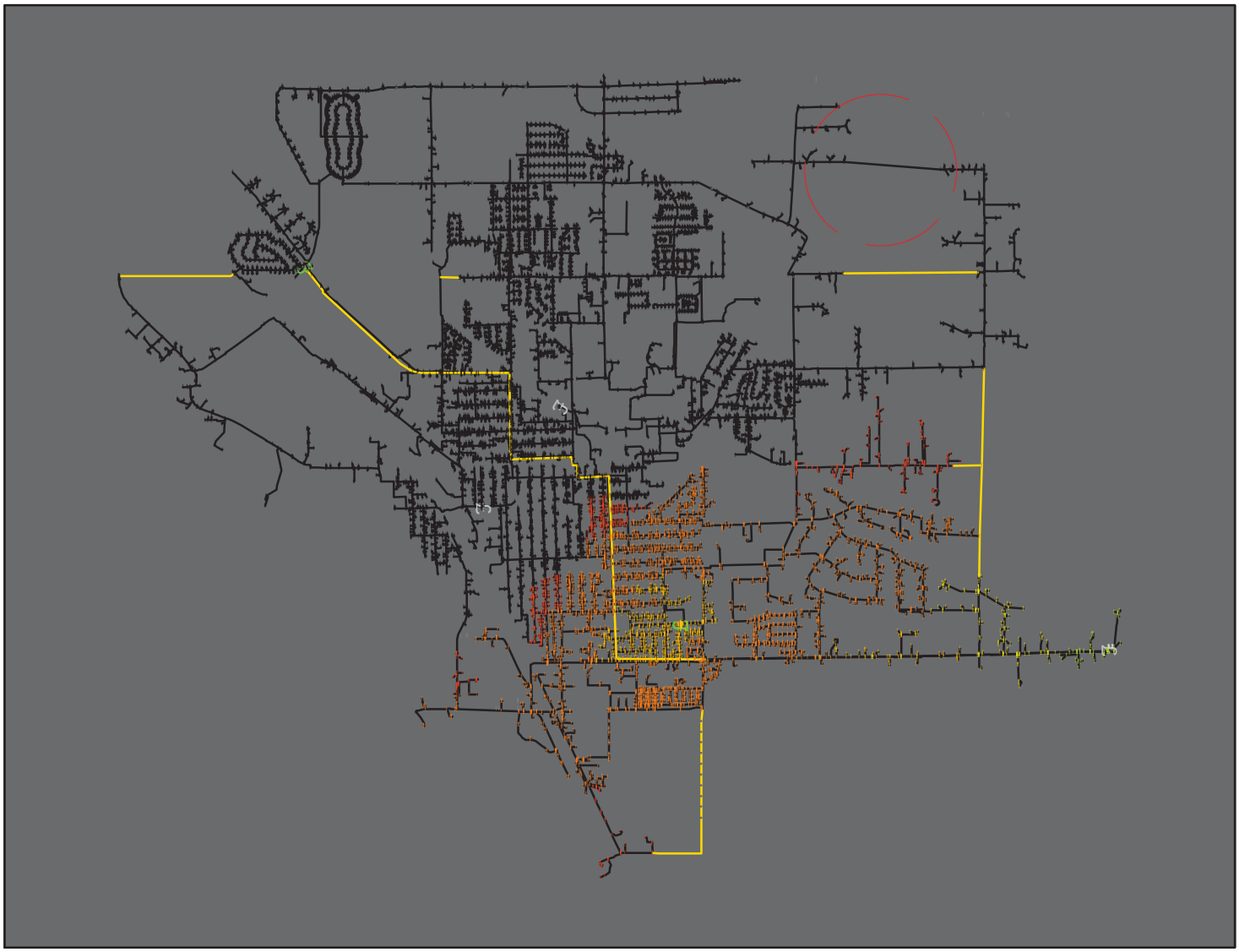
Scale: 1 = 55,980

Improved Piping Information

Services: 2020 Current
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (2565)
.	Enabled (17641)	!	< 20.00 (2)
.	Disabled (2564)	!	20.00 - 25.00 (0)
.	Proposed (20)	!	25.00 - 30.00 (12104)
.	Retired (0)	!	30.00 - 35.00 (2161)
		!	35.00 - 40.00 (3005)
		!	40.00 - 45.00 (146)
		!	> 45.00 (50)

Improvement 12 - Meadowbrook Lane to Willowdale Road Extension Scenario 2



0 3,200 6,400 9,600 12,800 Feet

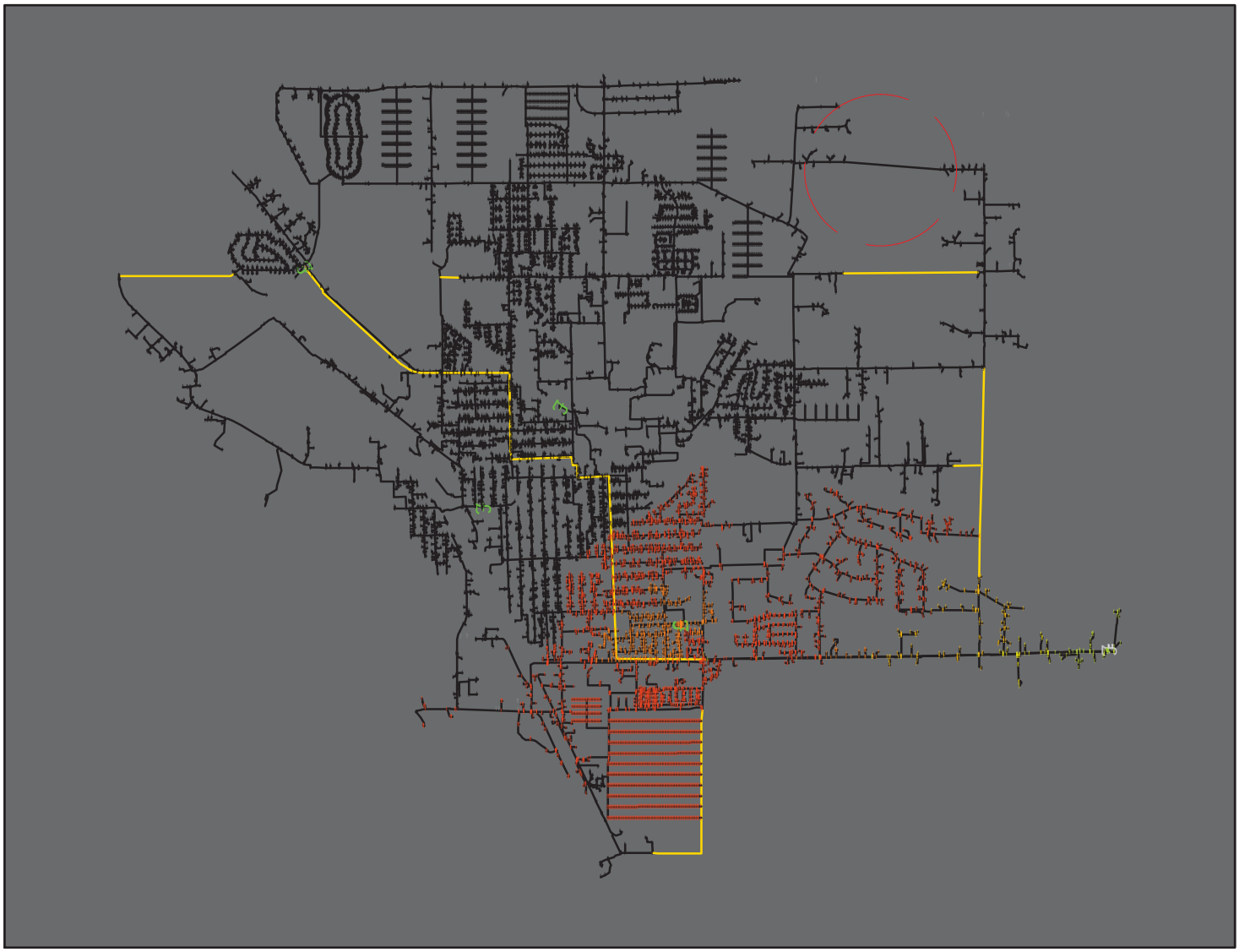
Scale: 1 = 54,310

Improved Piping Information

Services: 2026 Medium
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 4,338

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17641)	< 20.00 (12243)
Disabled (2564)	20.00 - 25.00 (703)
Proposed (20)	25.00 - 30.00 (3517)
Retired (0)	30.00 - 35.00 (782)
	35.00 - 40.00 (136)
	40.00 - 45.00 (55)
	> 45.00 (32)

Improvement 12 - Meadowbrook Lane to Willowdale Road Extension Scenario 3



0 3,200 6,400 9,600 12,800 Feet

Scale: 1 = 54,310

Improved Piping Information

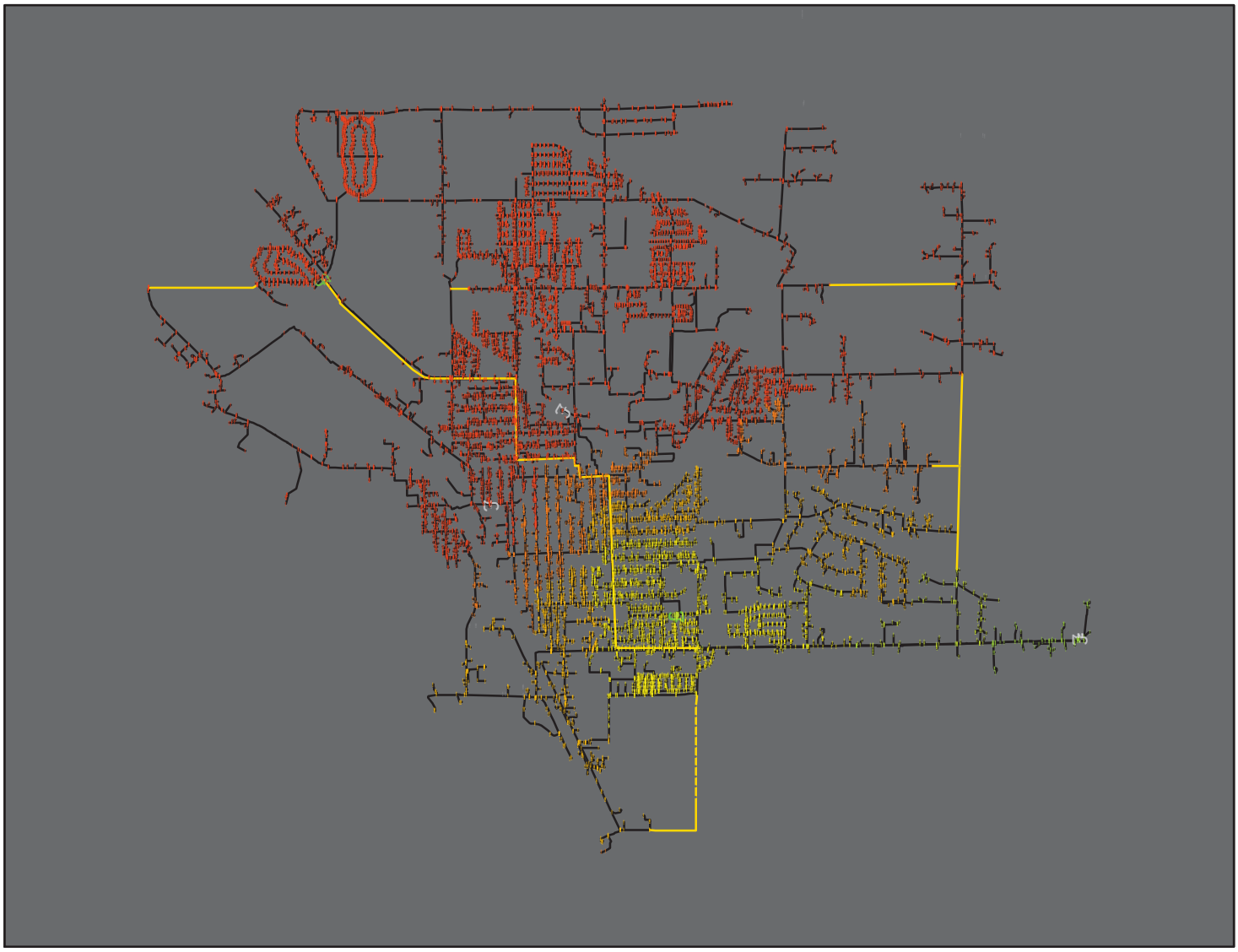
Services: 2026 High
HDD: 60
CWU Service: Active
Supply Pressure: 41 PSIG
Services Below 20 PSIG: 1,408

Facilities Color By
Service State
- Not Applicable (0)
- Enabled (20180)
- Disabled (25)
- Proposed (20)
- Retired (0)

Nodes Color By
Pressure (psig)
- Not Applicable (35)
- < 20.00 (14454)
- 20.00 - 25.00 (4593)
- 25.00 - 30.00 (681)
- 30.00 - 35.00 (141)
- 35.00 - 40.00 (42)
- 40.00 - 45.00 (55)
- > 45.00 (32)

Appendix D – Minimum Improvements Result Exhibits

Minimum Improvements to Maintain Performance
2026 Medium Growth | CWU Active



0 2,500 5,000 7,500 10,000 Feet

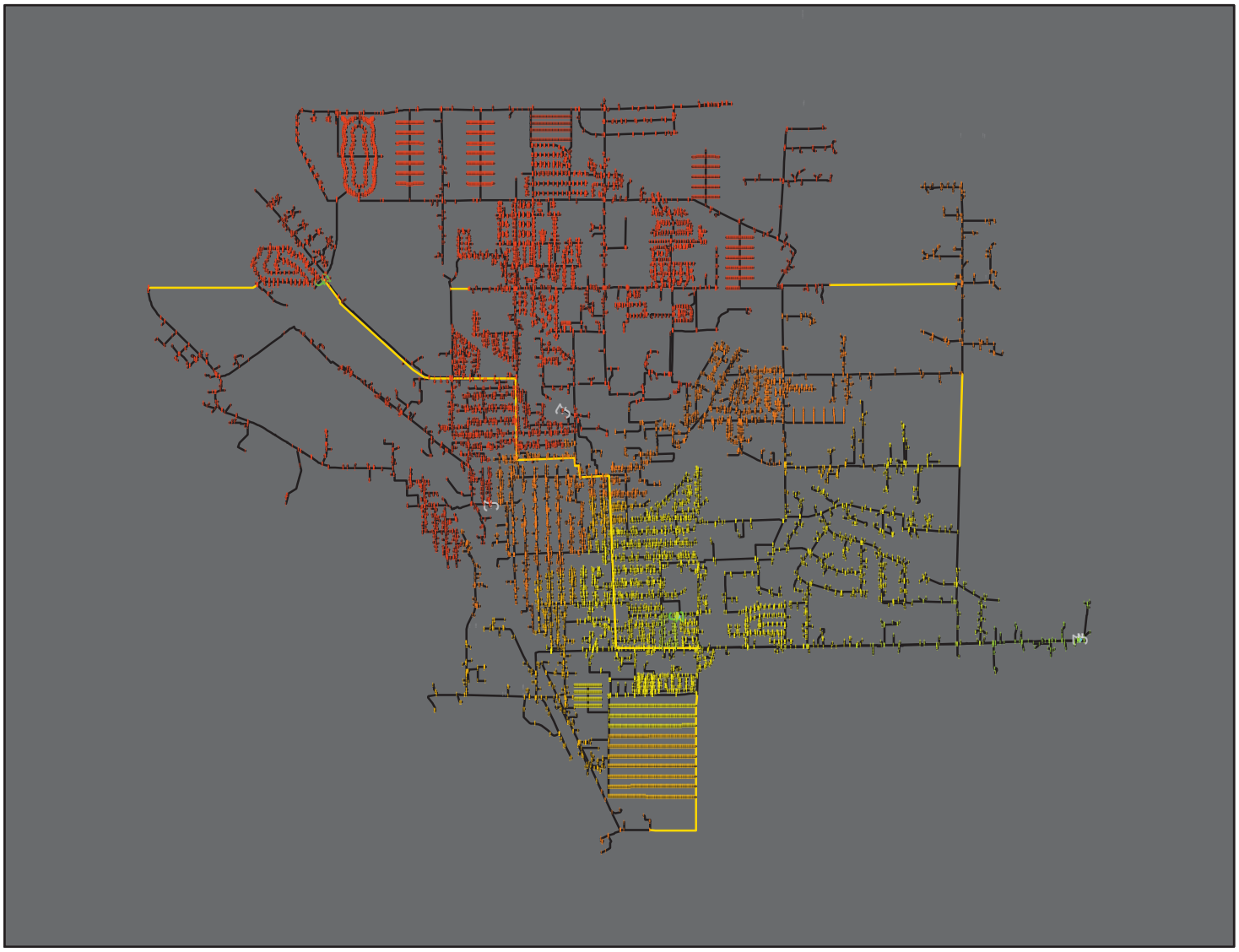
Scale: 1 = 57,720

Minimum Improvements Information

Improvements Active: 11
Services: 2026 Medium
HDD: 60
CWU Service: Active
Total Supply Flow: 462,262.60 SCFH
Supply Pressure: 49 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2565)
Enabled (17640)	< 20.00 (2)
Disabled (2564)	20.00 - 25.00 (11016)
Proposed (20)	25.00 - 30.00 (1526)
Retired (0)	30.00 - 35.00 (2043)
	35.00 - 40.00 (2547)
	40.00 - 45.00 (213)
	> 45.00 (121)

Minimum Improvements to Maintain Performance
2026 High Growth | CWU Active

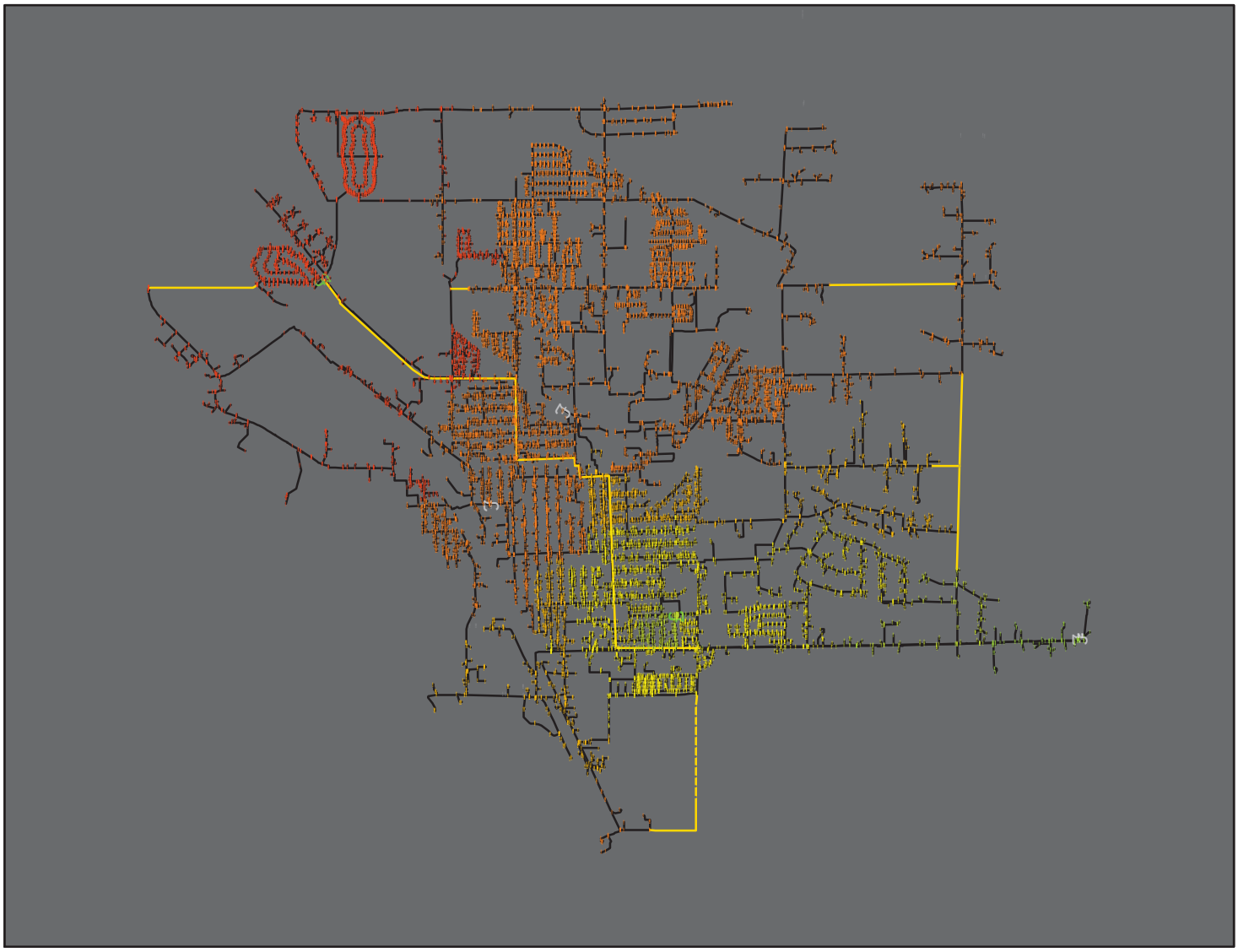


Minimum Improvements Information

Improvements Active: 4 and 11
Services: 2026 High
HDD: 60
CWU Service: Active
Total Supply Flow: 480,582.02 SCFH
Supply Pressure: 50 PSIG
Services Below 20 PSIG: 2*
*CWU & TCF are supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State		Nodes Color By Pressure (psig)	
.	Not Applicable (0)	!	Not Applicable (34)
.	Enabled (20182)	!	< 20.00 (2)
.	Disabled (25)	!	20.00 - 25.00 (10491)
.	Proposed (17)	!	25.00 - 30.00 (3152)
.	Retired (0)	!	30.00 - 35.00 (1783)
		!	35.00 - 40.00 (4140)
		!	40.00 - 45.00 (312)
		!	> 45.00 (119)

Minimum Improvements to Maintain Performance
2026 Medium Growth | CWU Inactive



0 2,500 5,000 7,500 10,000 Feet

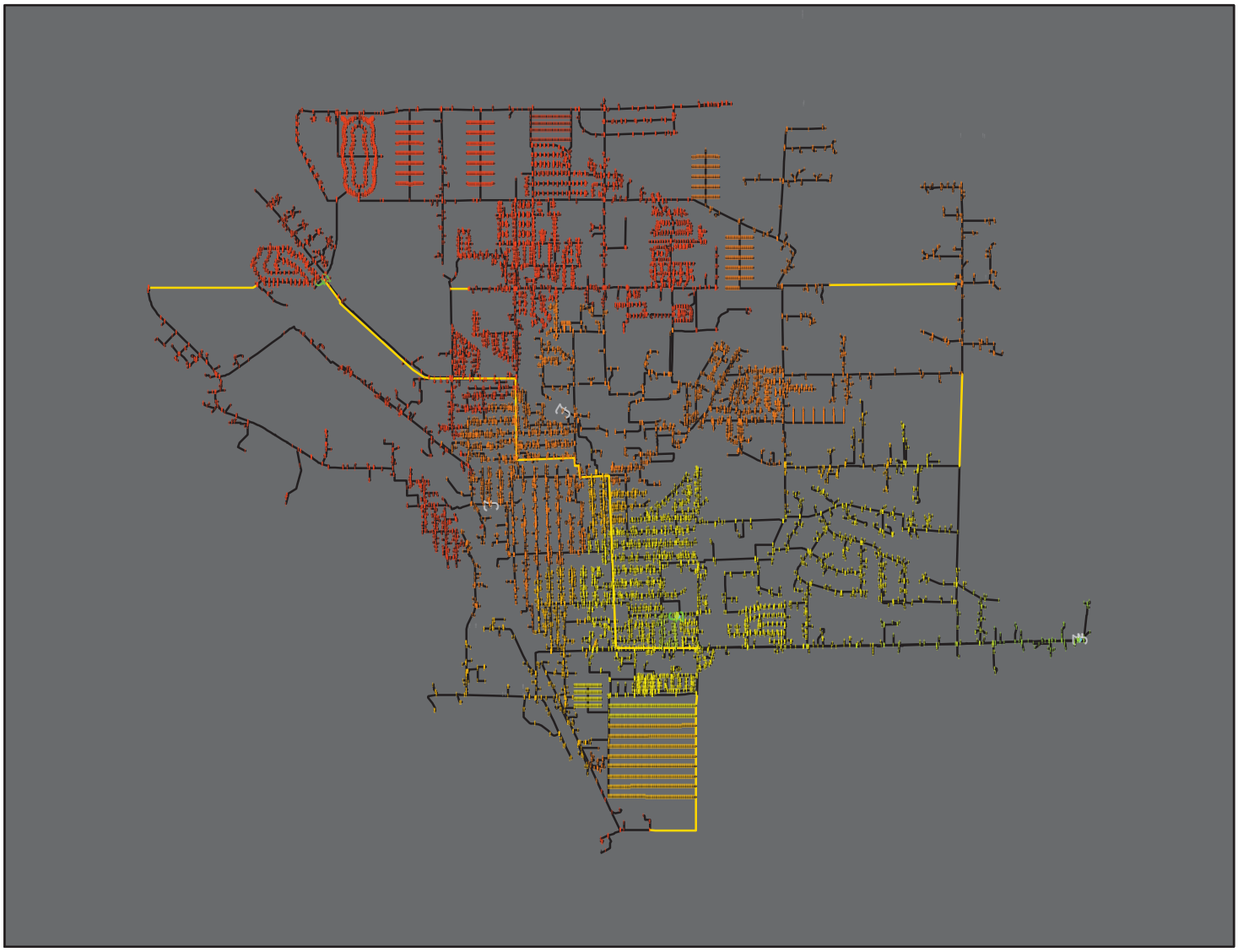
Scale: 1 = 57,720

Minimum Improvements Information

Improvements Active: 11
Services: 2026 Medium
HDD: 80
CWU Service: Inactive
Total Supply Flow: 462,262.60 SCFH
Supply Pressure: 49 PSIG
Services Below 20 PSIG: 1*
*TCF is supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (2566)
Enabled (17639)	< 20.00 (1)
Disabled (2565)	20.00 - 25.00 (2635)
Proposed (20)	25.00 - 30.00 (9415)
Retired (0)	30.00 - 35.00 (1779)
	35.00 - 40.00 (3025)
	40.00 - 45.00 (491)
	> 45.00 (121)

Minimum Improvements to Maintain Performance
2026 High Growth | CWU Inactive



0 2,500 5,000 7,500 10,000 Feet

Scale: 1 = 57,720

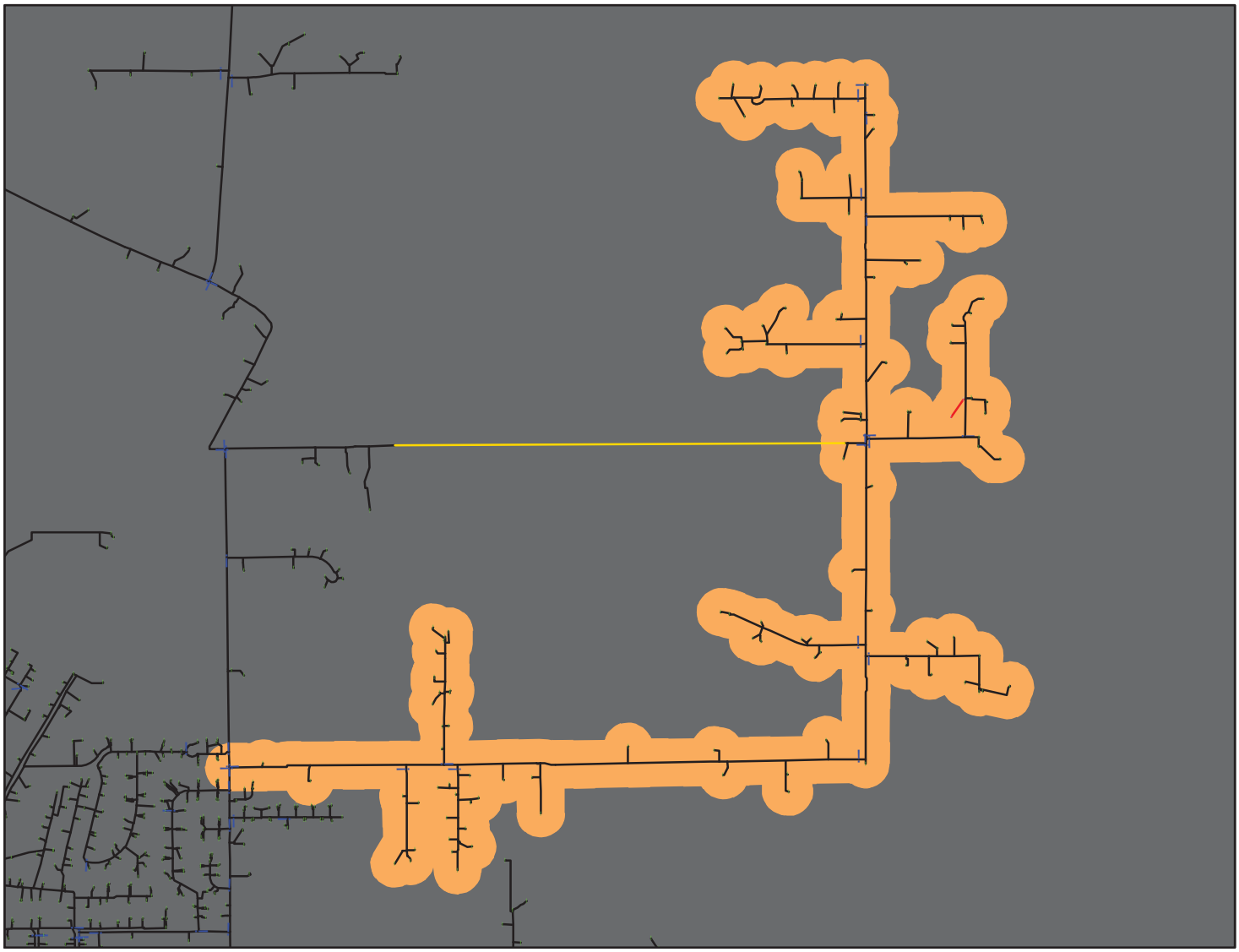
Minimum Improvements Information

Improvements Active: 4 and 11
Services: 2026 High
HDD: 80
CWU Service: Inactive
Total Supply Flow: 482,241.02 SCFH
Supply Pressure: 50 PSIG
Services Below 20 PSIG: 1*
*TCF is supplied by >20 PSIG and is regulated to 10 PSIG

Facilities Color By Service State	Nodes Color By Pressure (psig)
Not Applicable (0)	Not Applicable (35)
Enabled (20181)	< 20.00 (2)
Disabled (26)	20.00 - 25.00 (8587)
Proposed (17)	25.00 - 30.00 (4919)
Retired (0)	30.00 - 35.00 (2087)
	35.00 - 40.00 (3992)
	40.00 - 45.00 (303)
	> 45.00 (108)

Appendix E – Single-Feed Branch Model Exhibits

Single Feed 1A



0 405 810 1,620 2,430 3,240 Feet

Scale: 1 = 16,220

Single Feed Information

Feed Main ID: 899-115

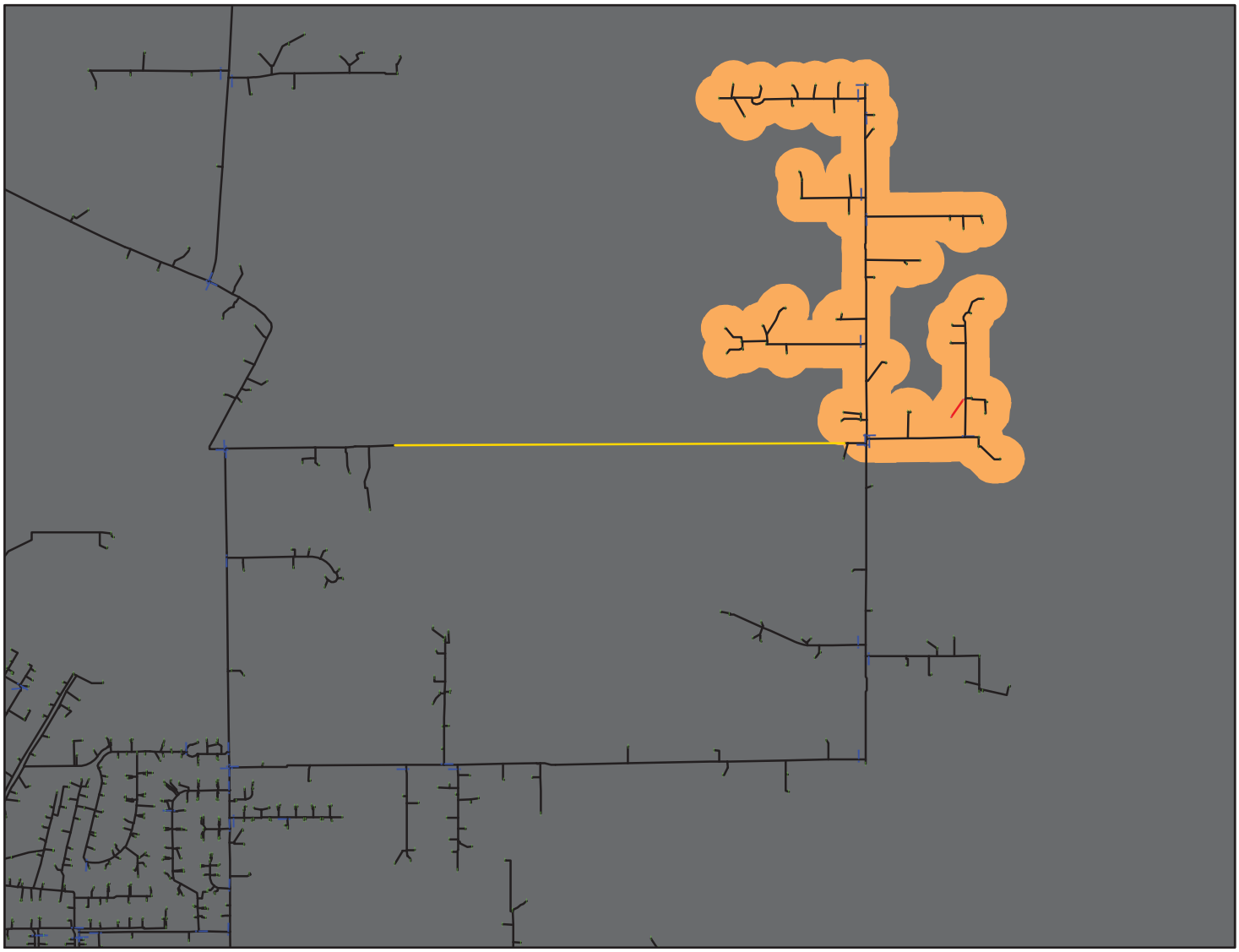
Active Service Count: 83

Polygons Symbols
- Single Feed

Facilities Symbols
- Pipe
- Regulator
- Valve

Facilities Color By Service State
- Not Applicable (0)
- Enabled (17630)
- Disabled (29)
- Proposed (16)
- Retired (0)

Single Feed 1B



Single Feed Information

Feed Main ID: 899-115

Active Service Count: 34

Note: Planned project will result in this configuration

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
£ Regulator
¡ Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 2

Single Feed Information

Feed Main ID: 896-027

Active Service Count: 63

Note: Planned project will eliminate this single feed

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 3

Single Feed Information

Feed Main ID: 856-114

Active Service Count: 50

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 4

Single Feed Information

Feed Main ID: 856-054

Active Service Count: 50

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 5

Single Feed Information

Feed Main ID: 856-056

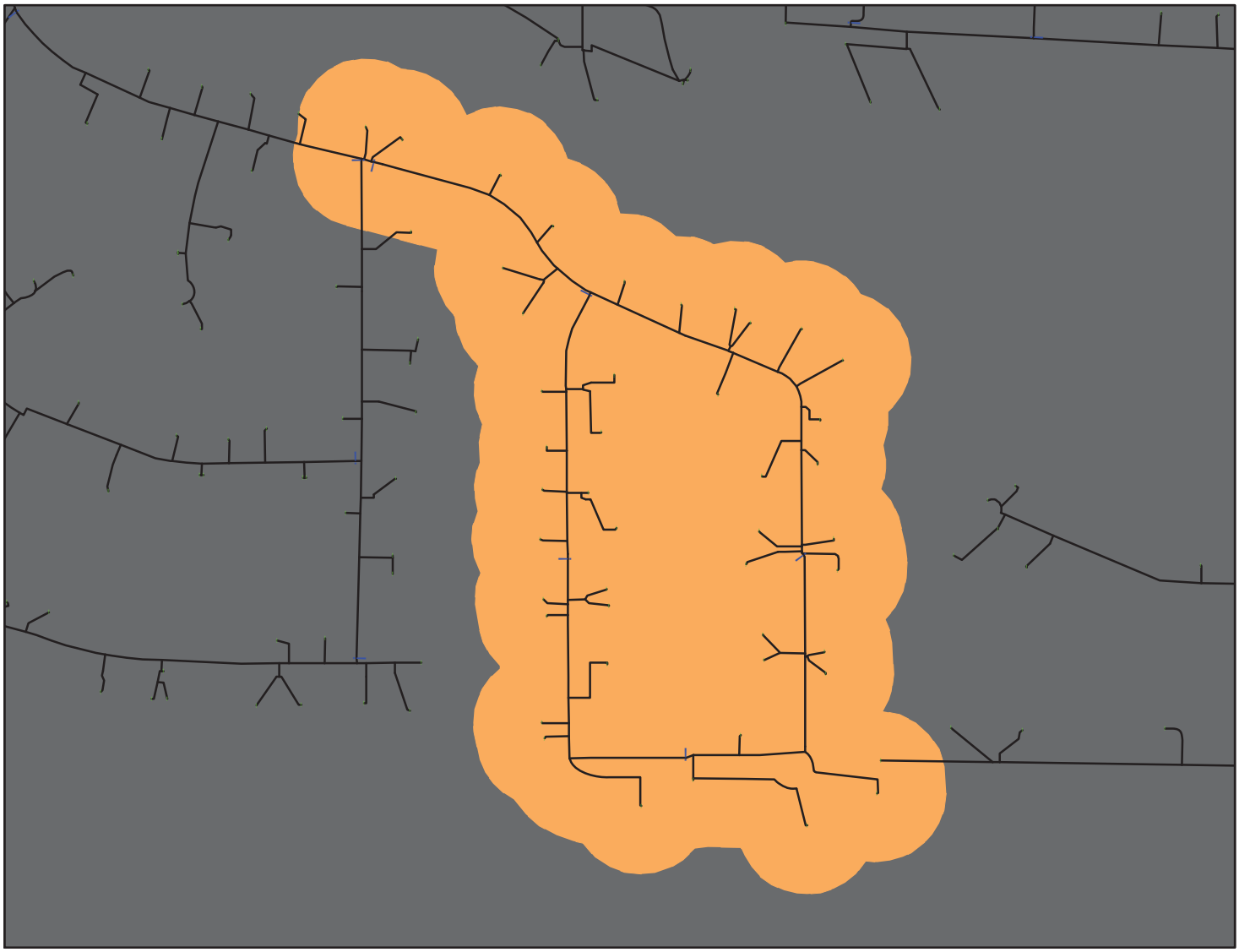
Active Service Count: 49

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 6



Single Feed Information

Feed Main ID: 5-1968

Active Service Count: 43

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 7

Single Feed Information

Feed Main ID: 895-004

Active Service Count: 35

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 8

Single Feed Information

Feed Main ID: 856-040

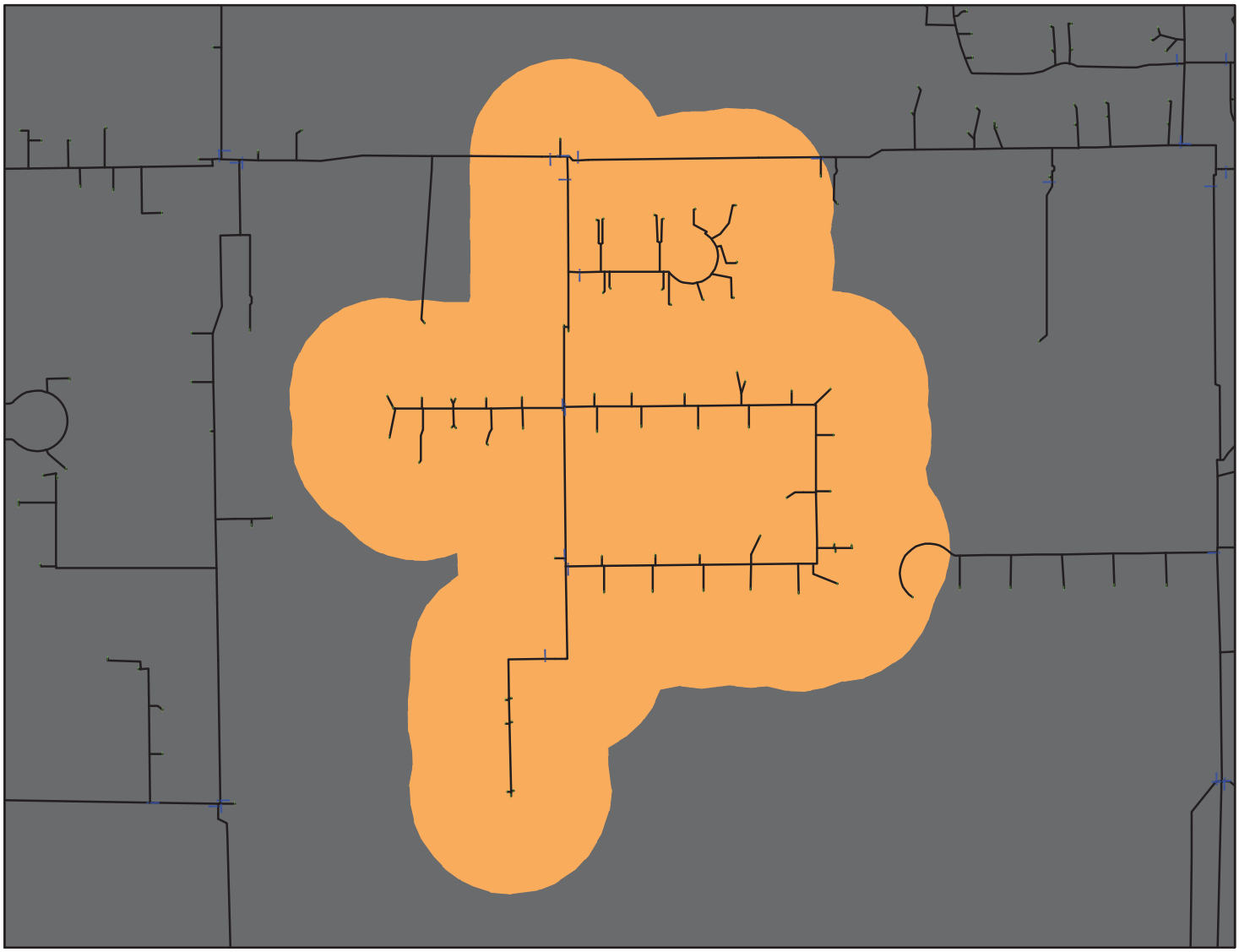
Active Service Count: 34

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 09



Single Feed Information

Feed Main ID: 899-069

Active Service Count: 33

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 10

Single Feed Information

Feed Main ID: 890-136

Active Service Count: 33

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 11

Single Feed Information

Feed Main ID: 898-125

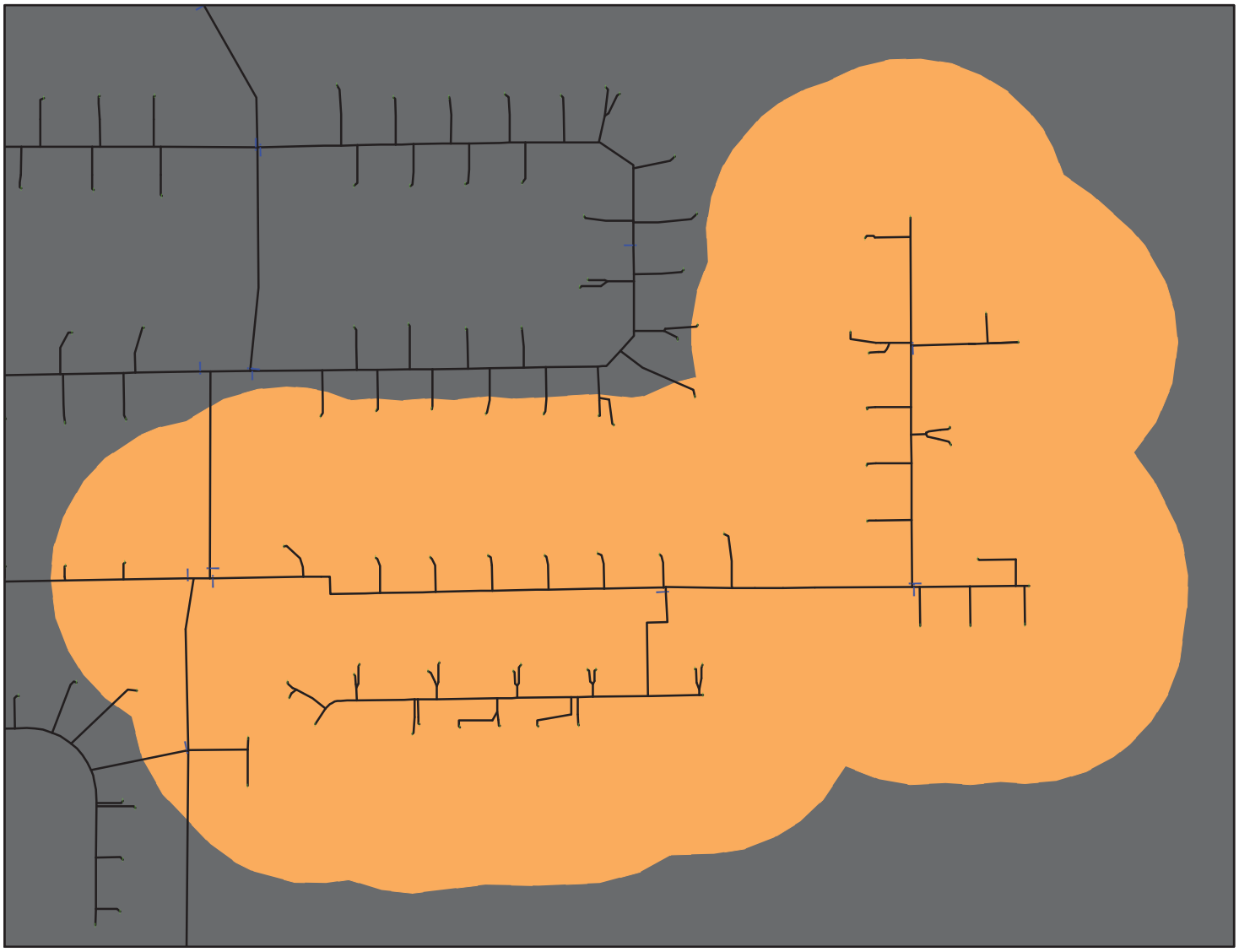
Active Service Count: 31

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17639)
Disabled (3)
Proposed (0)
Retired (0)

Single Feed 12



0 62 125 250 375 500 Feet

Scale: 1 = 2,442

Single Feed Information

Feed Main ID: 4-1955

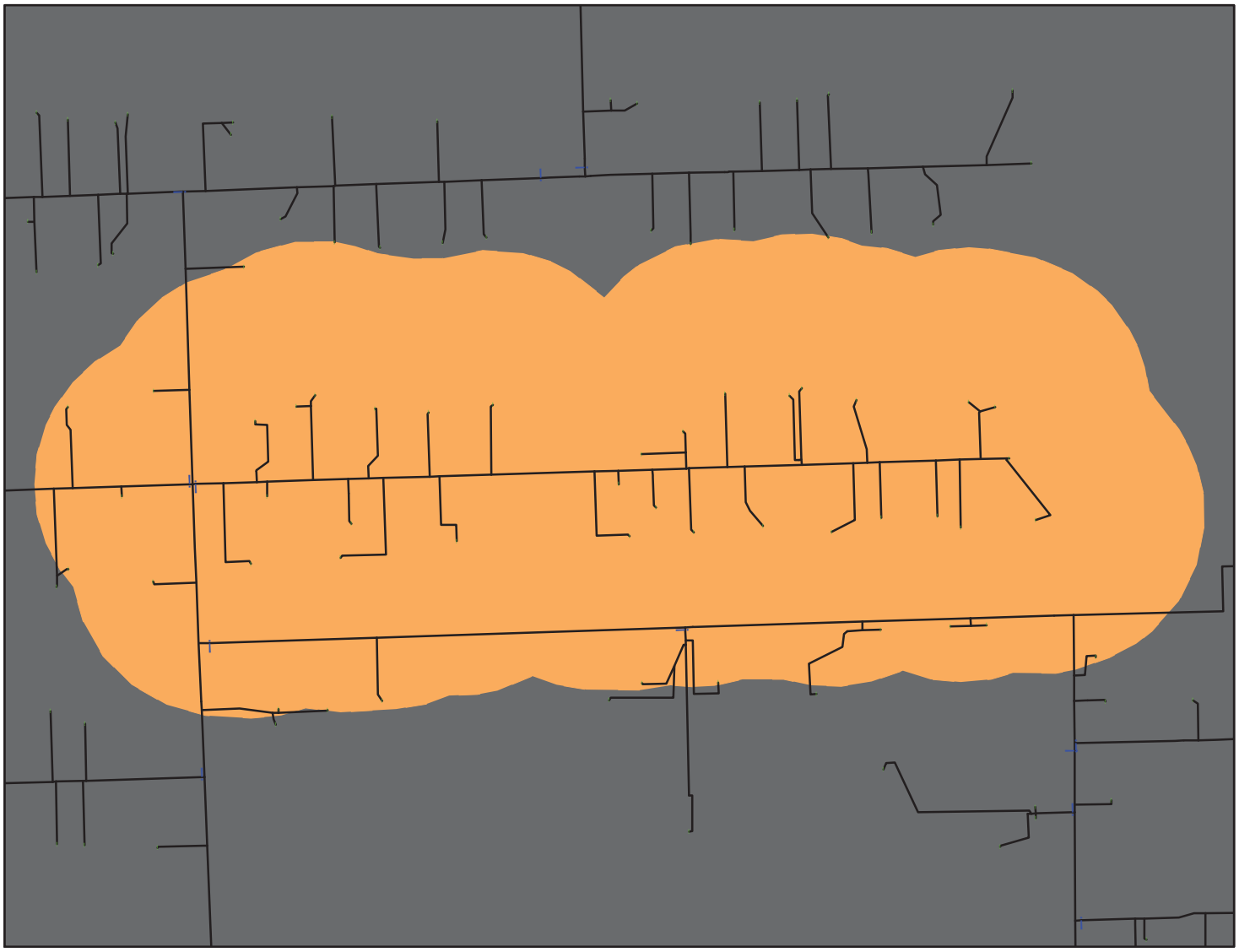
Active Service Count: 29

Polygons Symbols
- Single Feed

Facilities Symbols
- Pipe
- £ Regulator
- ¡ Valve

Facilities Color By Service State
- Not Applicable (0)
- Enabled (17630)
- Disabled (29)
- Proposed (16)
- Retired (0)

Single Feed 13



Single Feed Information

Feed Main ID: 856-025

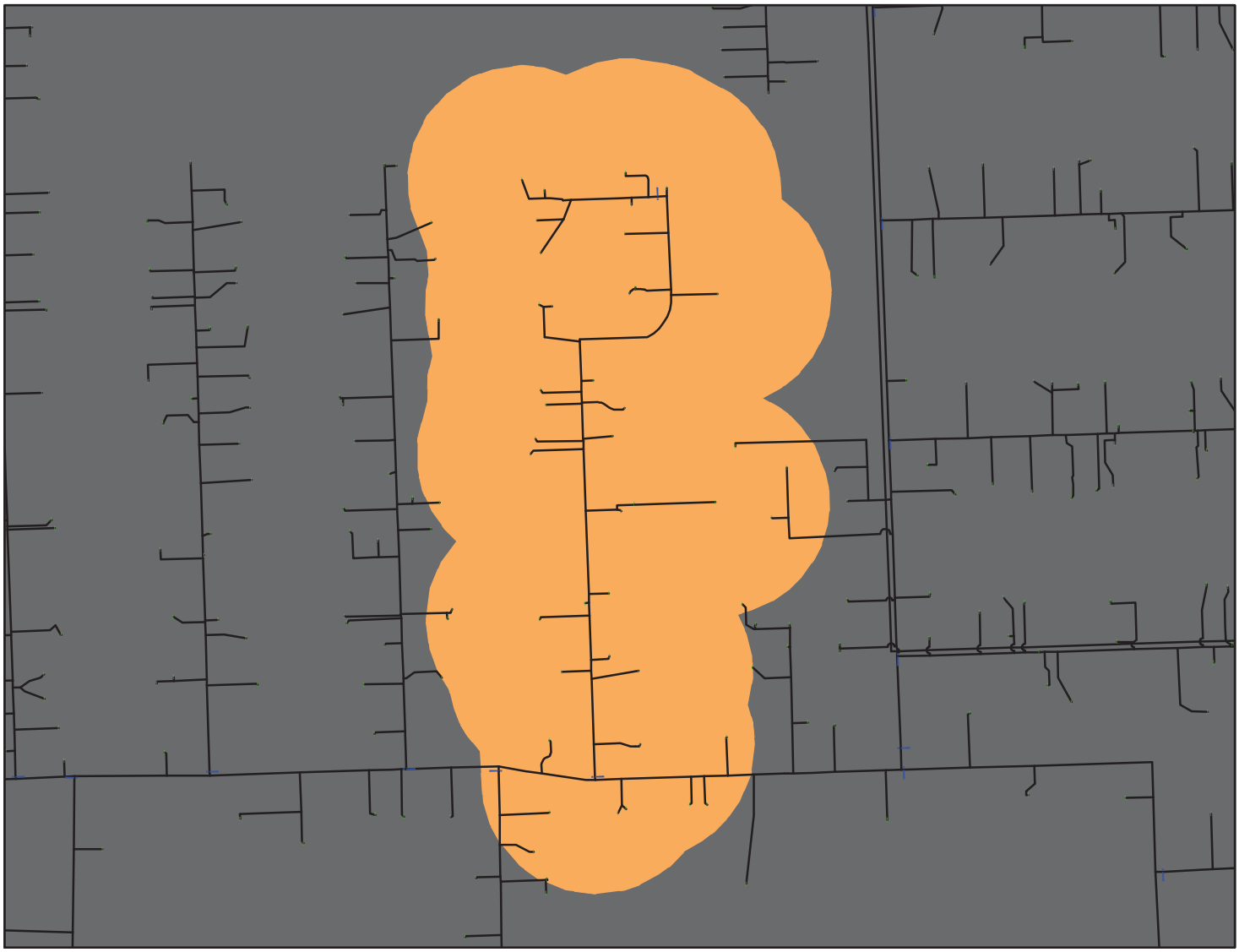
Active Service Count: 29

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 14



Single Feed Information

Feed Main ID: 856-026

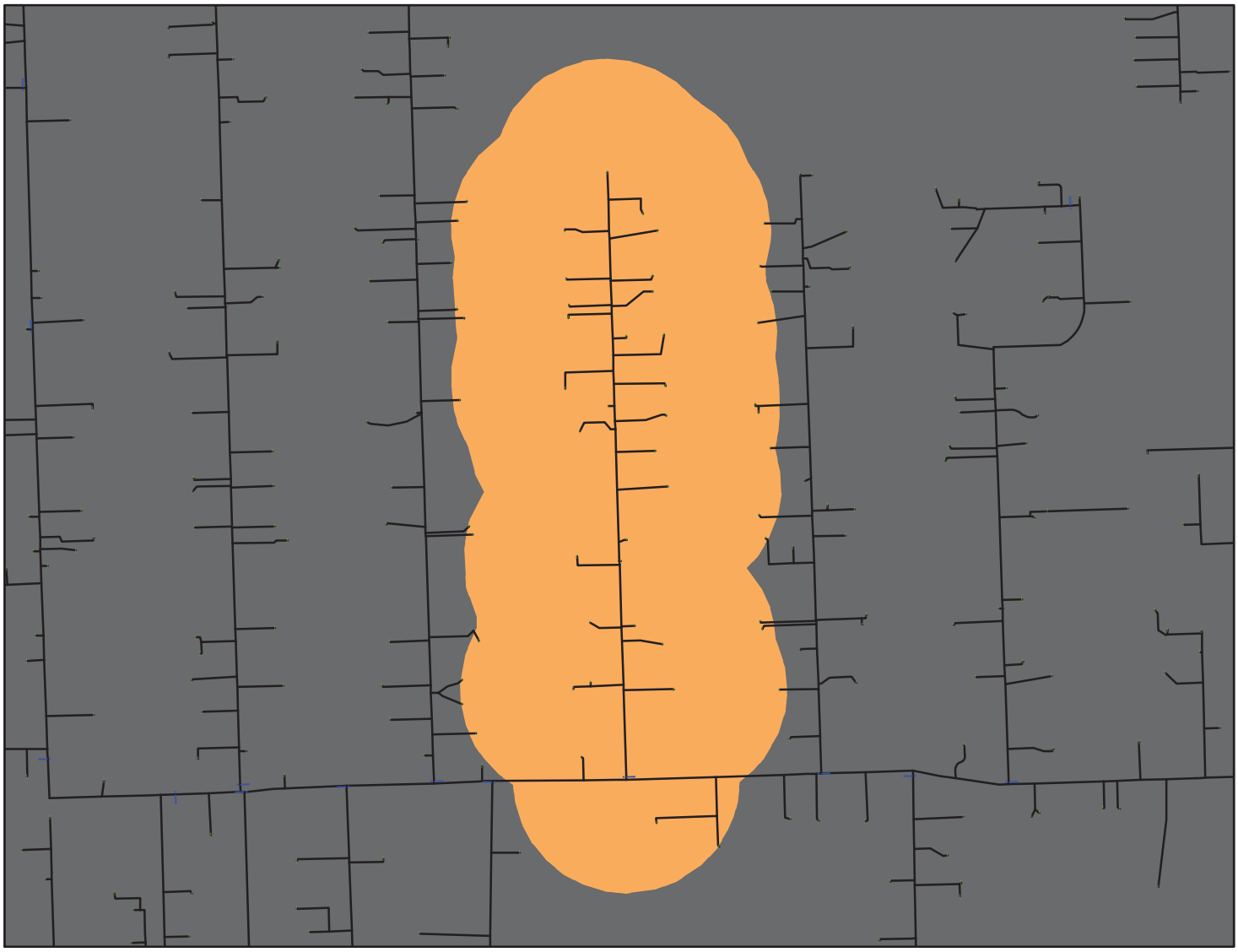
Active Service Count: 24

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 15



Single Feed Information

Feed Main ID: 856-028

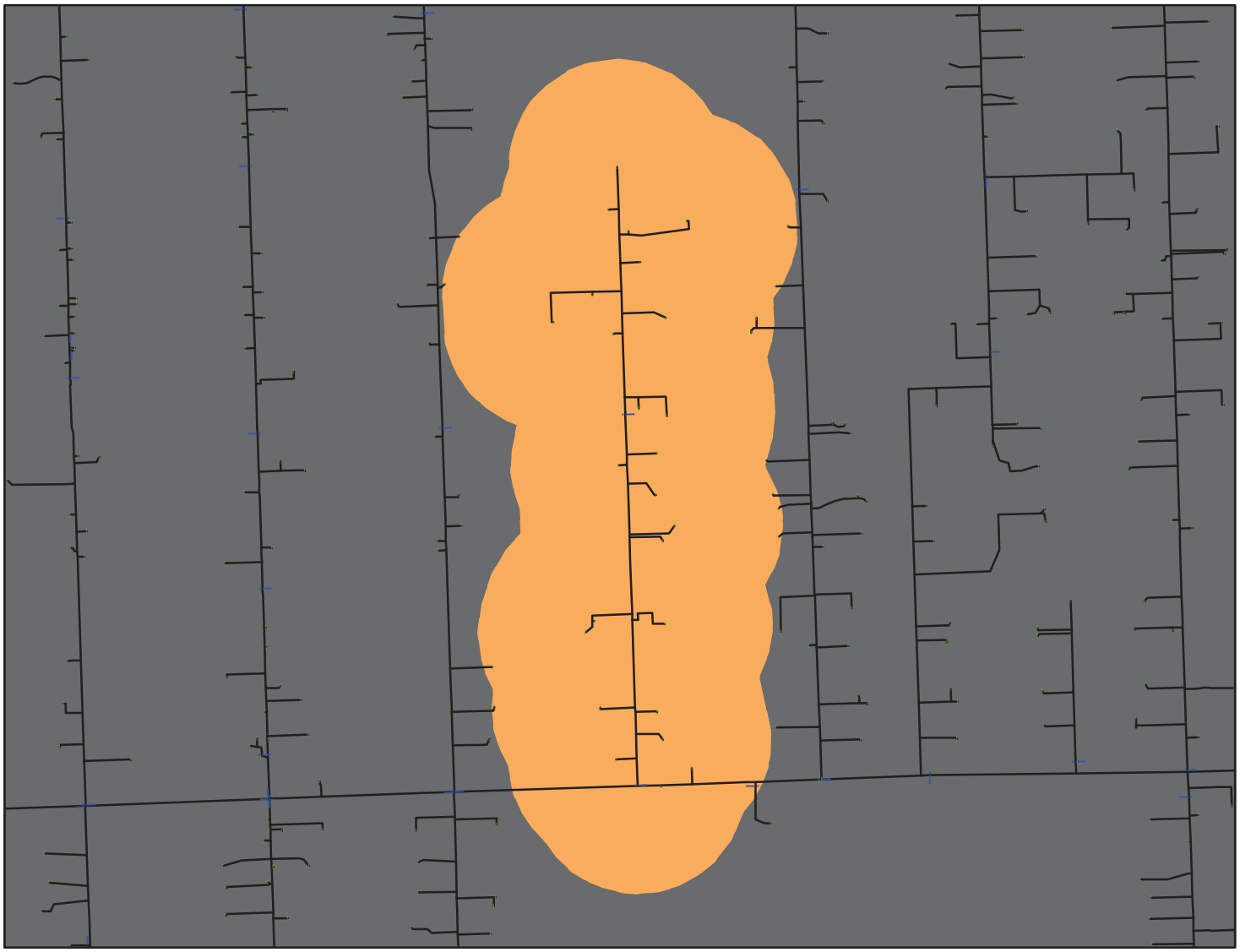
Active Service Count: 24

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 16



Single Feed Information

Feed Main ID: 856-044

Active Service Count: 24

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Single Feed 17

Single Feed Information

Feed Main ID: 856-079

Active Service Count: 23

Polygons Symbols
Single Feed

Facilities Symbols
Pipe
Regulator
Valve

Facilities Color By
Service State
Not Applicable (0)
Enabled (17630)
Disabled (29)
Proposed (16)
Retired (0)

Appendix F – Telemetry System Upgrade Scope of Work

ENautomation
a division of EN Engineering, LLC

Telemetry System Upgrade Scope of Work

City of Ellensburg, WA

Telemetry System Analysis

Project 2008119.00

Revision Number	Release Date	Remarks
00	12-Feb-2021	Initial Preliminary Release

Document No. 2008119.00-SOW-001

1 Executive Summary

An analysis of the City of Ellensburg (COE) telemetry system related to the tap station, regulator station(s) and pressure recorders was performed by EN Engineering (EN). This document serves as guidance on replacing and upgrading the telemetry system with considerations to see live data and remote integration of small pressure recorders.

2 Existing System Functionality

The stations reviewed in the assessment and their associated instrumentation are listed in Table 1. Currently, the City uses Dial-Up messenger modems to remotely monitor data from Mercury Mini-AT Volume Correctors located at three (3) Regulator stations. Pressure recorder data from the Seattle Regulator Station is monitored via cellular connection. Pressure recorder data from University Auto and WWTP sites are not remotely monitored.

Table 1 - COE Stations and Existing Equipment

Station Name	Equipment
City Hall Headquarters (HQ)	Desktop interface
Central Washington University (CWU) Regulator Station	Mercury Mini-AT Volume Corrector connected to Dial-Up service
Seattle Regulator Station	Heath Data Recorder (HDR) connected to RV-50 wireless transmitter
Kittitas Regulator and Tap Station	NJEX 7300G Odorizer System, Pressure Chart Recorder, Mercury Mini-AT Volume Corrector connected to Dial-Up service
Twin City Foods (TCF) Regulator Station	Mercury Mini-AT Volume Corrector connected to Dial-Up service
University Auto Pressure Recorder	Heath Data Recorder (HDR)
Wastewater Treatment Plant (WWTP) Pressure Recorder	Heath Data Recorder (HDR)

3 Functional Requirements

The proposed project scope of services consists of replacing and upgrading the telemetry system for the City of Ellensburg, WA. The upgraded telemetry system shall use radio or cellular routers at each remote terminal unit (RTU) to transmit data to a master telemetry unit (MTU) located at HQ. The line-of-sight and distance between the RTU and the MCU should be assessed at each site for appropriate wireless transmission method.

In addition to supplying power to the wireless radio equipment, an external source must be provided to the measurement device when connecting to an external modem. If appropriate power is not available at the device location, an alternative power source shall be installed on a permanent outdoor structure.

The system shall provide secure web-based view of live and historical data. The system must be designed in an extensible architecture for expansion into additional stations.

3.1 System Description

This section is intended to specify the main components of the instrumentation and control system and the general requirements for the construction and arrangement of the associated equipment and field instrumentation.

- HQ
    - Provide Master Telemetry Unit (MTU)
    - To the extent possible, the process monitoring network shall be physically isolated from all other networks including administration networks.
    - Provide dedicated historian workstation running compatible historian software.
    - Configure web-based monitoring interface.
    - Appropriate training shall be provided to the City for all hardware and software.
- Remote sites
    - Integrator shall provide radio or cellular communication to the four (4) Regulator Stations and two (2) City pressure monitoring sites including University Auto and WWTP.
    - An initial software radio analysis to determine the feasibility and reliability of the proposed radio system.
        - These results shall be verified with a physical radio coverage analysis.
    - Antennas, cable, and height adjustment(s) shall be furnished and installed according to the radio system study. Line of sight shall be reviewed during proposal stage to include the cost of any antenna height adjustments.

4 Regulatory Considerations for System Upgrade

The proposed system must conform to all rules, regulations, ordinances, laws, or directives set forth by the City of Ellensburg and/or the State of Washington. The Integrator who is awarded this project is required to obtain all necessary permits, licenses, approvals, and other arrangements to perform work within the City of Ellensburg.

The following minimum regulatory considerations must be followed:

- The proposed system must be compliant with all FCC regulations for over the air data transmission. Only FCC approved antennas may be used.
- Electrical work shall be executed in accordance with the latest edition of the National Electric Code (NEC) and local ordinances and regulations.
- All materials and equipment shall, within the scope of UL Examination Services, be approved by the Underwriter's Laboratories for the purpose for which they are used and shall bear the UL label.

5 Upgrade Project List of Deliverables

The scope of the project shall include:

- System Requirements Workshop – Project team members will be assembled to review and discuss the project goals, approach, budget, and schedule. The accuracy of the documentation previously provided by the City will be discussed so that the project team understands any related limitations.
- Site Visits/Field Investigation – Before planning for any changes to the existing facilities, a complete understanding of the facilities and existing conditions must be investigated. The Integrator shall perform site visits, interviews, and review pertinent existing documents. The purpose of the site visits will be to develop familiarity with each individual site and its unique characteristics. The project team will develop an inventory of existing hardware and software at each site.
- Pre-Design Report - A Pre-Design Report (PDR) shall be submitted to provide a recommendation for a reliable and secure system for system-wide process monitoring.
- Detailed Design - Detailed design shall commence following City approval of the Final PDR. There are three deliverables associated with this task.
- Integration and Installation Services - Equipment and services shall be provided for installation of a complete, fully functioning monitoring system.
- Project Close-out - A final walk-through will be required by the City to provide feedback in the form of a punch list identifying any incomplete work. The Integrator shall submit the following documentation to the City for the project to be considered substantially complete.
    - Final O&Ms including equipment BOM, wiring diagrams and panel layouts based upon as-built conditions.

6 Recommended Integrator Qualifications

The City of Ellensburg may make such investigations as deemed necessary to determine the ability of the integrator to perform the work. The integrator shall furnish all requested information and data for this purpose. The integrator should meet the following minimum criteria to be considered qualified:

- All companies shall be licensed, insured, and bonded and shall furnish satisfactory evidence to the City that they have previously performed/provided the types of services specified.
- Minimum of five years recent experience in the design, construction, installation, and successful startup of SCADA systems of comparable size, type, and complexity to the proposed projects.
- The System Integrator shall also exhibit experience in integrating and installing Wireless Telemetry Systems.