2020 Sanitary Sewer Capacity Study

Final Report

Version 2

City of Marion, Iowa

February 5, 2021

This Technical Memorandum (TM) documents the development, calibration, results, and recommendations of a model of the sanitary sewer system for the City of Marion, IA (City). Model results are intended to provide the City with an overview of performance of the sanitary sewer system within the City and to inform the potential need for system improvements for existing and future land use conditions.

This TM is organized as follows:

Contents

Executive Summary

In 2019, an evaluation of the Indian Creek Basin sanitary sewer network was completed. Results and discussion of the 2019 Study are presented in *Technical Memorandum 5: Capacity Analysis*. The hydraulic model refinement and calibration presented in this Technical Memorandum (TM) is intended to provide a detailed and accurate evaluation of the remainder of the City's sanitary sewer system, including the Christopher & Dry Run Creek, Lower Indian Creek, and Squaw Creek Basins. An InfoWorks ICM hydraulic model was used to simulate several different existing and future development scenarios, identify sewer deficiencies for each scenario, estimate opinion of probable costs to improve the sewer network, and develop qualitative recommendations. To provide clear and concise results and recommendations to the City on the sanitary sewer system, some content from the *Technical Memorandum 5: Capacity Analysis* has been included in this TM. Locations where content is duplicated in both TMs are identified throughout the report.

A summary of the existing and future development scenarios included in the evaluation presented in this TM is shown in Table 1. The scenarios are also shown spatially in Figures 42-54.

Table 1. Modeled Scenarios for Existing and Future Development Conditions

Scenario Name	Scenario Number	What is included in each scenario
Existing Condition	1	Existing sanitary sewer service area, population, and employment. The existing estimated population is approximately 41,000 people.
Baseline Condition	2	Scenario 1 plus proposed Segment 7 sewer improvements as described in the Proposed Sewer in the Dry Run and Lower Indian Creek Basins Section[1].
Proposed Regional Trunk Sewer Condition	3	Scenario 2 plus all recommended (Segment 3 through Segment 11) Regional Trunk Sewer improvements as described in the Proposed Sewer in the Dry Run and Lower Indian Creek Basins Section[1].
Baseline Condition with I/I Reduction Condition	4	Scenario 2 plus assume a 30 percent reduction in I/I in the Old Marion area.
Proposed Regional Trunk Sewer with I/I Reduction Condition	5	Scenario 3 plus assume a 30 percent reduction in I/I in the Old Marion area
2040 Population in Existing Service Area Condition	6	Scenario 5 but with 2040 population and employment. The estimated 2040 population for the City is approximately 47,800 people.
2040 Population in Existing Service Area + Denser Uptown District Condition	7	Scenario 6 plus a denser Uptown District as shown in the City's Comprehensive Plan
2040 Population in Existing Service Area + Growth Area 1 Condition	8	Scenario 7 plus Growth Area 1
2040 Population in Existing Service Area + Growth Area 2 Condition	9	Scenario 7 plus Growth Area 2

Scenario Name	Scenario Number	What is included in each scenario
2040 Population in Existing Service Area + Growth Area 3 Condition	10	Scenario 7 plus Growth Area 3
2040 Population in Existing Service Area + Growth Area 4 Condition	11	Scenario 7 plus Growth Area 4
2040 Population in Existing Service Area + Growth Area 5 Condition	12	Scenario 7 plus Growth Area 5
Full Development Condition	13	Incorporates all elements from each of the different scenarios. The estimated full development population is approximately 82,000 people.

[1] See Appendix A and Hydraulic Model Refinements section for discussion on the 2007 Report.

Model results for each scenario evaluated are included in Appendix B. Model results indicate that the existing sanitary sewer system has sufficient capacity to convey the dry weather flows for all evaluated scenarios except Scenario 12 and Scenario 13. In Scenario 12 there is one segment of pipe in the Squaw Creek basin that does not have the capacity to convey the additional flows from Growth Area 5. In Scenario 13, the existing sanitary sewer system is capacity deficient in several locations including along the Indian Creek, Berrys Run Creek, and Dry Run Creek trunk sewers.

Model results indicate that the existing system does not have the capacity to convey sanitary flows for the 2-year and 5-year wet weather events for both existing conditions (Scenario 1) and for several future development conditions (Scenarios 8 through Scenario 10, and Scenario 12 through Scenario 13). Additionally, model results indicate that even with all recommended improvements to the regional Indian Creek/Dry Run Creek sanitary trunk sewer (Regional Trunk Sewer), there are still several capacity deficiencies within the Indian Creek Basin during existing development conditions (Scenario 1 and Scenario 2). The capacity deficiencies within the Indian Creek Basin for existing development conditions are located along the Indian Creek trunk line from 10th Street to Alburnett Road and along Alburnett Road and Larick Drive, west of Indian Creek.

These capacity deficiencies predict surcharges which could potentially result in sanitary sewer overflows (SSOs) and basement backups during the 2-year and 5-year wet weather events. Recommended improvements to address the deficiencies in the existing system are shown in Table 2. Projects 1 through 3 are improvements to the Regional Trunk Sewer and have a total estimated probable cost of $11.54 million. To address the deficiencies within the Indian Creek Basin, an estimated $1.68 million in improvements would be required (Projects 4 and 5 in Table 2). The recommended improvements described in Table 2 are shown spatially in Figure 6 of Appendix A for Projects 1 through 3, and in Figure 55 for Projects 4 and 5. The total cost to address all deficiencies identified in existing system is $13.22 million.

Table 2. Recommended Improvements to Address Current Development Deficiencies (Scenario 1 through 5)

#	Name	Description	Cost
1	Regional Trunk Sewer, Segment 7[1]	Replace existing sewer with 60-inch	$6,010,000
2	Regional Trunk Sewer, Segment 10[1]	Replace existing sewer with 48-inch	$1,810,000
3	Regional Trunk Sewer, Segment 6[1]	Replace existing sewer with 60-inch	$3,720,000
4	Indian Creek Basin, Trunk Line – 10th Street to Alburnett Road (0.5 miles of sewer pipe)	Additional 5.8 MGD sewer capacity (2x existing capacity)	$1,190,000
5	Indian Creek Basin, Main Line – Alburnett Road and Larick Drive (0.6 miles of sewer pipe)	Additional 1.2 MGD sewer capacity (2x existing capacity)	$490,000
Total Cost			In Indian Creek basin: $1,680,000 Regional Trunk Sewer[1]: $11,540,000 **Total: $ 13,220,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

The recommended improvements in Table 3, in conjunction with Table 2, address the deficiencies that occur in 2040 population and employment in the current service area conditions (Scenario 6 and Scenario 7). To address the deficiencies in these two conditions, all improvements listed in Table 2 and Table 3 are needed. The total combined cost (Table 2 and Table 3) for recommended pipe improvements to address deficiencies (Scenario 1 through Scenario 7) within the City is $4.09 million, the total cost for recommended I/I reduction improvements is $8.55 million, and the total cost for recommended improvements in the Regional Trunk Sewer is $32.23 million. Project 6, Project 7, and Project 9 are shown spatially in Figure 56 through Figure 58, respectively. Project 8 is shown in Figure 6 of Appendix A.

Table 3. Recommended Improvements to Address 2040 population and employment in Current Service Area Deficiencies (Scenario 6 and 7)

#	Name	Description	Cost
6	Christopher Creek Basin, Trunk Line – Cambridge Drive NE to Dry Run Creek Trunk, part of Segment 12 (0.58 miles of sewer pipe)	Additional 30 MGD sewer capacity (3x existing capacity)	$2,260,000

#	Name	Description	Cost
7	Squaw Creek Basin, Main Line – South of Chapelridge Circle, near Ski Lodge Road (585 LF of sewer pipe)	Replace existing with 15-inch	$150,000
8	Regional Trunk Sewer, (Segments 3, 4, 5, 8, 9, 11)[1]	Replace existing sewer with 48-inch (Segments 8, 9, 11), 54-inch (Segment 11), and 60-inch (Segments 3, 4, and 5)	$20,690,000
9	Lower Indian Creek Basin, I/I reduction in Old Marion	Reduce I/I through pipe sliplining, disconnecting illegal connections (downspouts and sump pumps), etc.	$8,550,000
Total Cost (Including Table 2 Projects)			In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional Trunk Sewer[1]: $32,230,000 **Total: $ 44,870,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

Additional sanitary flow (Growth Areas) cannot currently be added to the sanitary sewer system upstream of without increasing the risk of potential SSOs and basement backups during wet weather events. The following recommendations were identified to address the capacity deficiencies in the sewer system for the Growth Areas. These improvements would then allow for growth throughout the City without increasing the risk of the potential SSOs and basement backups.

The recommended improvement for Growth Area 1 (Scenario 8) is shown in Table 4 and in Figure 59. The total cost for the recommended improvements for Growth Area 1 (including Table 2 and Table 3) within the City is $12.74 million. Recommended improvements for Growth Area 2 (Scenario 9) are shown in Table 5 and in Figure 60 through Figure 63. The total cost for the recommended improvements in Growth Area 2 (including Table 2 and Table 3) within the City is $24.67 million. Recommended improvements for Growth Area 3 (Scenario 10) are shown in Table 6 and Figure 64. The total cost for the recommended improvements in Growth Area 3 (including Table 2 and Table 3) within the City is $28.06 million. Recommended improvements for Growth Area 4 (Scenario 11) are shown in Table 7 and Figure 65. The total cost for the recommended improvements (including Table 2 and Table 3) within the City is $14.70 million. Recommended improvements for Growth Area 5 (Scenario 12) are shown in Table 8 and Figure 66. The total cost for the recommended improvements (including Table 2 and Table 3) within the City is $14.76 million.

Table 4. Recommended Improvements to Address Growth Area 1 (Scenario 8)

#	Name	Description	Cost
10	Christopher Creek Basin, Growth Area 1 – New Sewer	Extend sewer in Growth Area 1 to accommodate additional flow.	$100,000
Total Cost (Including Table 2 and Table 3 Projects)			In Christopher Creek basin: $2,360,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 44,970,000**

[1] These are priority improvements that were identified in the 2007 Report regarding Regional Trunk Sewer.

Table 5. Recommended Improvements to Address Growth Area 2 (Scenario 9)

#	Name	Description	Cost
11	Indian Creek Basin, Growth Area 2 – New Sewer	Extend sewer in Growth Area 2 to accommodate additional flow.	$4,170,000
12	Indian Creek Basin, Trunk Line – Berrys Run Creek trunk to 10th Street (2.2 miles of sewer pipe)	Additional 1.0 MGD sewer capacity (1.5x existing capacity)	$4,400,000
13	Indian Creek Basin, Trunk Line – Alburnett Road to W 8th Street (0.4 miles of sewer pipe	Additional 5 MGD sewer capacity (2x existing capacity)	$910,000
14	Indian Creek Basin, Berrys Run Creek Trunk Line – Valentine Circle to Indian Creek trunk (1.4 miles of sewer pipe)	Additional 1.8-7.9 MGD (average 2.0x existing capacity)	$2,550,000
Total Cost (Including Table 2 and Table 3 Projects)			In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $13,710,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 56,900,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 6. Recommended Improvements to Address Growth Area 3 (Scenario 10)

#	Name	Description	Cost
15	Indian Creek Basin, Growth Area 3 – New Sewer	Extend sewer in Growth Area 3 to accommodate additional flow.	$7,950,000
16	Indian Creek Basin, Trunk Line – Stanley Cup Drive to Berrys Run Creek trunk (2.2 miles of sewer pipe)	Additional 4.3 MGD sewer capacity (2.5x existing capacity)	$2,160,000
Total Cost (Including Table 2, Table 3 Projects, and Project 12 and 13 from Table 5)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $17,100,000[1] In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[2]: $32,230,000 **Total: $ 60,290,000**	

[1] Also Includes Projects 12 and 13 from Table 5 because those projects are needed to address deficiencies in both Growth Areas

[2] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 7. Recommended Improvements to Address Growth Area 4 (Scenario 11)

#	Name	Description	Cost
17	Squaw Creek Basin, Growth Area 4 – New Sewer	Extend sewer in Growth Area 4 to accommodate additional flow.	$710,000
18	Squaw Creek Basin, Trunk Line – Grant Wood Trail to south of 3rd Avenue (0.6 miles of sewer pipe)	Replace existing sewer with 24-inch	$1,350,000
Total Cost (Including Table 2 and Table 3 Projects)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $2,210,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 46,930,000**	

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 8. Recommended Improvements to Address Growth Area 5 (Scenario 12)

#	Name	Description	Cost
19	Squaw Creek Basin, Growth Area 5 – New Sewer	Extend sewer in Growth Area 5 to accommodate additional flow.	$1,260,000
20	Squaw Creek Basin, Main Line along Grant Wood Trail – Partners Avenue to east of Highway 13 (0.6 miles of sewer pipe)	Replace existing sewer with 15-inch	$860,000
Total Cost (Including Table 2 and Table 3 Projects)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $2,270,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional Trunk Sewer[1]: $32,230,000 **Total: $ 46,990,000**	

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

The recommended improvements and total costs for the full development condition are shown in Table 9. Also included in Table 9 are the Figures that correspond to each project that is recommended for Full Development Conditions. The total cost for the recommended improvements within the City is $44.85 million and the total cost for recommended improvements in the Regional Trunk Sewer is $37.83 million.

The modeling included in this evaluation indicate that Regional Trunk Sewer downstream of Segment 8 has capacity to convey the additional sanitary flows for full development conditions. However, the model does not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids) that are served by the Regional Trunk Sewer. Future growth beyond the study area may actually limit the available capacity of the Regional Trunk Sewer. If future growth does limit the capacity of the Regional Trunk Sewer, then full development conditions in the study area may not be achievable. A further investigation of the complete Indian Creek/Dry Run Creek sewersheds would be required to quantify the available capacity of the recommended improvements in the Regional Trunk Sewer. This further investigation should be completed before the recommended improvements in the Indian Creek Basin identified in this TM are designed and constructed.

Table 9. Recommended Improvements to Address Full Development Conditions (Scenario 13)

#	Name	Description	Cost	Figure
1	Regional Trunk Sewer, Segment 7[1]	Replace existing sewer with 60-inch	$6,010,000	6, App. A
2	Regional Trunk Sewer, Segment 10[1]	Replace existing sewer with 48-inch	$1,810,000	6, App. A
3	Regional Trunk Sewer, Segment 6[1]	Replace existing sewer with 60-inch	$3,720,000	6, App. A
5	Indian Creek Basin, Main Line – Alburnett Road and Larick Drive (0.6 miles of sewer pipe)	Additional 1.2 MGD sewer capacity (2x existing capacity)	$490,000	55
6	Christopher Creek Basin, Trunk Line – Cambridge Drive NE to Dry Run Creek Trunk, part of Segment 12 (0.58 miles of sewer pipe)	Additional 30 MGD sewer capacity (3x existing capacity)	$2,260,000	56
7	Squaw Creek Basin, Main Line – South of Chapelridge Circle, near Ski Lodge Road (585 LF of sewer pipe)	Replace existing sewer with 15-inch	$150,000	57
8	Regional Trunk Sewer, (Segments 3, 4, 5, 8, 9, 11)[1]	Replace existing sewer with 48-inch (Segments 8, 9, 11), 54-inch (Segment 11), and 60-inch (Segments 3, 4, and 5)	$20,690,000	6, App. A
9	Lower Indian Creek Basin, I/I reduction in Old Marion	Reduce I/I through pipe sliplining, disconnecting illegal connections (downspouts and sump pumps), etc.	$8,550,000	58
10	Christopher Creek Basin, Growth Area 1 – New Sewer	Extend sewer in Growth Area 1 to accommodate additional flow.	$100,000	59
11	Indian Creek Basin, Growth Area 2 – New Sewer	Extend sewer in Growth Area 2 to accommodate additional flow.	$4,170,000	60
14	Indian Creek Basin, Berrys Run Creek Trunk Line – Valentine Circle to Indian Creek trunk (1.4 miles of sewer pipe)	Additional 1.8-7.9 MGD (average 2.0x existing capacity)	$2,550,000	63

#	Name	Description	Cost	Figure
15	Indian Creek Basin, Growth Area 3 – New Sewer	Extend sewer in Growth Area 3 to accommodate additional flow.	$7,950,000	64
17	Squaw Creek Basin, Growth Area 4 – New Sewer	Extend sewer in Growth Area 4 to accommodate additional flow.	$710,000	65
19	Squaw Creek Basin, Growth Area 5 – New Sewer	Extend sewer in Growth Area 5 to accommodate additional flow.	$420,000	66
20	Squaw Creek Basin, Main Line along Grant Wood Trail – Partners Avenue to east of Highway 13 (0.6 miles of sewer pipe)	Replace existing sewer with 15-inch	$860,000	66
21	Indian Creek Basin, Trunk Line – Stanley Cup Drive to W 8th Avenue (3.7 miles of sewer pipe)	Additional 3.5-21.1 MGD (average 3.0x existing capacity)	$12,660,000	68/69
22	Squaw Creek Basin, Trunk Line – Grant Wood Trail to south of 3rd Avenue (0.6 miles of sewer pipe)	Replace existing sewer with 27-inch	$1,520,000	67
23	Regional Trunk Sewer, Additional Segment 10 through Segment 8[2] (1.7 miles of sewer pipe)	Additional 17 MGD (average 2x more capacity than what is presented in 2007 Report)	$5,600,000	69
24	Squaw Creek Basin, Trunk Line – South of 3rd Avenue to south of Ski Lodge Road (1.1 miles of sewer pipe)	Additional 4.5 MGD (average 1.8x existing capacity)	$2,460,000	67
Total Cost		In Christopher Creek basin: $2,360,000 In Squaw Creek basin: $6,120,000 In Indian Creek basin: $27,820,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $37,830,000 **Total: $ 82,680,000**		

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

[2]This improvement is required in addition to the already planned sewer replacement as described in the 2007 Report.

Objective

Development and calibration of a hydraulic model of the City's Indian Creek Basin sanitary sewer system during the 2019 Sanitary Sewer Capacity Study (2019 Study) provided an initial assessment and overview of estimated performance of the Indian Creek Basin sewer system under existing and future conditions. Results and discussion of the 2019 Study are presented in *Technical Memorandum 5: Capacity Analysis*.

The hydraulic model refinement and calibration presented in this Technical Memorandum (TM) is intended to provide a more detailed and accurate evaluation of the remainder of the City's sanitary sewer system, including the Christopher & Dry Run Creek, Lower Indian Creek, and Squaw Creek Basins. These sanitary sewer basins are shown in Figure 1. Similar to the 2019 Study for the Indian Creek Basin, capacity of the sewers in these basins were evaluated under existing and projected future conditions. Results from this refined model inform the planning process of potential needs for major improvements to the citywide sanitary system.

The hydraulic model was used to identify the following for the entire sanitary sewer system:

- Peak flows in the sewer network during dry and wet weather conditions.
- Segments of pipe that have current and future capacity issues. The criteria for identifying capacity issues is defined in the Capacity Analysis Section.
- Approximate size of trunk extensions to service growth areas.
- Probable costs for servicing future growth areas not currently served by the collection system.

Existing sewer flows are based on flow metering data that was collected in Spring 2019 (for the 2019 Study) and Summer 2020. Future flows are forecast based on projected population estimated by the United States Census and Zoning Densities (U.S. Census) established by the Iowa Department of Natural Resources. Results from this refined model inform the planning process of potential needs for major improvements.

Background

Portions of the sewer system in the City are at or approaching hydraulic capacity and certain areas have been prone to basement flooding and manhole surcharging during heavy rainfall events. Continued growth in the service area has the potential for additional sewer backups during wet weather events. This, coupled with increasing regulatory attention and pressure to eliminate SSOs and basement backups, creates the need for planning and providing additional capacity.

In 2018, the City initiated the 2018 Sanitary Sewer Capacity Study for the Indian Creek Basin. The goals of this overall study include documentation of cultural resources, potential environmental impacts, and existing and future peak flows and capacity issues. Preliminary estimation of peak flows and capacity issues was completed in 2018 using an uncalibrated hydraulic model. A more detailed and accurate evaluation of the peak flow and capacity of the sewers through calibration and refinement of the hydraulic model was completed as part of the 2019 Study. Results and discussion of the 2019 Study are presented in *Technical Memorandum 5: Capacity Analysis*. To provide clear and concise results and recommendations to the City on the sanitary sewer system, some content from the *Technical Memorandum 5: Capacity Analysis* has been included in this TM. Locations where content is duplicated in both TMs are identified throughout the report.

Hydraulic Model Development

The citywide sanitary sewer hydraulic model was developed using InfoWorks ICM software. InfoWorks ICM, from Innovyze, provides a comprehensive, GIS-based, computational engine to model sewer system collection system hydraulics that is both stable and efficient. The capabilities and HDR's experience locally and nationally with this software make this selection a good and fitting platform to model the City's sanitary collection systems.

The Indian Creek Basin model developed for the 2019 Study was used as a start-off point for the development of the complete citywide hydraulic model, which now includes the Christopher Creek & Dry Run Creek, Lower Indian Creek, and Squaw Creek Basins.

Model Methodology

The InfoWorks ICM hydraulic model of the City's sanitary sewer collection system is composed of public sanitary gravity sewer with diameters of 8 inches or larger. Private sewers and laterals were not incorporated in the hydraulic model. The methodologies for model development used in this study are consistent with the methodologies that were used in the 2019 Study.

The City modeled pipe network (including the Indian Creek Basin from the 2019 Study) is loaded at 712 locations, each representing the sewershed area that adds flow to a key location of the interceptor and major trunk network. Loading from each sewershed is composed of base sanitary, dry weather, and wet weather loadings as follows:

- Base Sanitary Flow (BSF) is composed of residential, commercial, and industrial wastewater calculated on per-person residential and employment (commercial) loading, and metered loadings for major industrial sources.
- Base Flow loading is composed of the BSF plus groundwater infiltration (GWI).
- Wet weather loading consists of BSF plus GWI plus infiltration and inflow (I/I) related to rainfall also known as rainfall dependent infiltration and inflow (RDII).

U.S. Census data and parcel data were used to develop approximations for BSF, and calibration to flow meters was used to develop approximations for GWI and RDII. The 2-year and 5-year nested storm events were then evaluated to determine which segments of the sanitary sewer collection system are providing adequate conveyance or are capacity deficient.

Model Source Data

Source data for the hydraulic model includes data provided by the City from its GIS database, population and land use planning data, and U.S. Census GIS polygons. The sanitary sewer and sanitary manhole shapefiles provided by the City contained minimal data gaps. However, where data gaps occurred, missing information was inferred from available information using engineering judgement and the assumptions that pipes always have a positive slope and move from smaller diameter sewers to larger diameter sewers.

Model Network and Sewersheds

The citywide modeled existing sanitary sewer network and sewersheds are shown in Figure 2. The detailed model one-dimensional (1D) sewer network includes pipes that are 8 inches in diameter and larger. A total of 2,489 pipe segments were modeled in the City, accounting for 123 miles of sewer or 67 percent of the total system. Industry standard Manning's n values were used for all modeled pipe materials to represent pipe roughness for open channel flow.

The model loading is conveyed from the sewersheds to the 1D sewer network as time-varying flows and is routed dynamically through the system accounting for attenuation until it outfalls at the Cedar Rapids Water Pollution Control Facility (CRWPCF). InfoWorks ICM applies the Saint-Venant's equations to conserve mass and momentum through the collection system. This results in precise flow routing across the system and a smooth transition between free surface and surcharged flow conditions. Where pipe is capacity limited due to a segment or downstream bottleneck, they will pressurize and the model will eventually indicate a sanitary sewer overflow (SSO) occurrence if the hydraulic grade line rises high enough.

For current conditions, the City was divided into 335 unique sewersheds to allocate dry and wet weather loading to the existing interceptors and trunk sewers in more detail. Some sewersheds are loaded at more than one location depending on the locations of the sewer pipe relative to the sewershed boundary. The number of sewersheds in the Squaw Creek, Christopher & Dry Run Creek, Lower Indian Creek, and Indian Creek Basins are 123, 43, 68, and 101 sewersheds, respectively. The average size of all the sewersheds is 30.5 acres. An example of the sewersheds are shown in Figure 3.

Proposed Sewer in the Dry Run and Lower Indian Creek Basins

In 2007, HDR completed an evaluation of the Indian Creek and Dry Run Creek Trunk Sanitary Sewer Capacity. The 2007 evaluation identified a number of priority sewer improvement projects in the Indian Creek and Dry Run Creek Basins. The recommended improvements are described in a TM to the Linn County Regional Planning Commission dated December 11, 2007 which is included in Appendix A. Since the 2007 Report, the highest priority project (Segment 2) has been constructed.

The recommended improvements described in the 2007 Report are located near the downstream end of this study area. However, the status (designed/constructed/no change) of the 2007 recommended improvements directly influences the peak flows and surcharging effect for the sewer system included in this study area. Because of the direct influence on this study area, the model was updated to include the already constructed Segment 2 improvements. Additionally, several of the modeled scenarios evaluated in this TM include future priority improvements between Segment 3 and Segment 11. These improvements are referred to as the Regional Trunk Sewer improvements throughout this report.

Future priority Segment 6 through Segment 11 improvements identified in the 2007 Report reduce the potential surcharging into the City's Indian Creek Basin sewer, with Segment 6, Segment 7, Segment 10, and Segment 11 being the highest priority. Segment 7 and Segment 11, which are currently being designed, are located between Collins Road SE and 40th Street Drive SE and from north of Alpine Road to the confluence of Indian Creek and Dry Run Creek, respectively. Segment 6 is located downstream of Segment 7, between 40th Street Drive SE and 30th Street Drive SE. Segment 10 is located immediately downstream of the Indian Creek Basin, between 8th Avenue and 3rd Avenue. Segment 3 through Segment 5 are lower priority and would be required to address deficiencies in the growth area scenarios. Segment 3 through Segment 11 are shown spatially in Figure 6 of Appendix A and are described in greater detail on page A-6 of Appendix A.

Base Flow Allocation

BASE SANITARY FLOW

Base flow was allocated to the modeled sanitary sewer network using residential and commercial data specific to each of the 335 sewersheds. It was assumed that the commercial diurnal pattern developed by HDR in 2015 for the Cedar Rapids Metropolitan Area is sufficient for the City of Marion model. The commercial flow diurnal pattern is shown in Figure 4.

The 2019 Study for the Indian Creek Basin included diurnal patterns for residential flow using the flow meter data that was collected in Spring 2019. The residential diurnal patterns developed for the 2019 Study were not modified as part of this 2020 Study and are shown in Figure 5 through Figure 7[1].

New diurnal patterns for the Squaw Creek, Christopher & Dry Run Creek, Lower Indian Creek Basins were developed using flow meter data that was collected in Summer 2020. The diurnal patterns include separate weekday and weekend patterns. The additional diurnal patterns developed from the 2020 flow meter data are shown in Figure 8 through Figure 15.

RDII FLOW ALLOCATION

The wet weather flow was allocated based on land use within each sewershed. Land use was split into three groups (Residential, Commercial/Industrial, and Open Space) and established as runoff surfaces within InfoWorks ICM. Each runoff surface is treated separately within the model and runoff parameters can be adjusted for each surface independent of the other surfaces. The Open Space land use were set to have zero contribution to the wet weather flow allocation for areas where the collection system is not in the vicinity (more than 150 feet away from a sewer pipe) and would not affect the system's RDII.

The future wet weather flow was allocated based on the future land uses as identified by City staff. Figure 16 shows the future land use plan used in this analysis, City staff provided this plan to HDR via email on November 3rd, 2020. The same runoff parameters for the three runoff groups used in current conditions were used for the future land use plan as well.

ENERGY LOSSES

Major losses in gravity sewers were represented using Manning's n values and a roughness coefficient value unique to each pipe material. Major losses in force mains were represented using Hazen-Williams roughness coefficients. Energy losses at manholes are calculated using the InfoWorks ICM built-in normal head loss relationship. This method calculates energy losses based on the velocity and depth in the pipes upstream or downstream of the manhole. The method used does not account for losses due to pipe entry or exit angles. This method was

[1] Figures duplicated from *TM5: Capacity Study*

developed assuming that manholes are well-constructed and was selected for this analysis for its applicability to the variety of manhole junction types present in the City's GIS database.

DOWNSTREAM BOUNDARY CONDITION

The downstream boundary condition for the model was set as a free outfall at the end of the Anaerobic Conveyance Sewer at the Indian Creek Lift Station and the outfall of the Main Interceptor at the Main Lift Station at CRWPCF. Hydraulics within the CRWPCF were not modeled.

Calibration

2019 Study Model Calibration[2]

The flow meters (Table 10 and Figure 17) were installed on April 2-3, 2019 and remained in place until May 22, 2019 (49-50 days). While the flow meters were installed, the average dry weather flow (DWF) in each meter was 0.23 MGD (meter 1), 0.88 MGD (meter 2), and 0.11 MGD (meter 3).

The average DWF (MGD) for each meter equates to an average gpcd of 89 gpcd at Meter 1, 94 gpcd at Meter 2, and 34 gpcd at Meter 3. The design assumption (100 gpcd for population) is a close approximation, within 11 percent, to the measured gpcd at Meter 1 and Meter 2. These meters are located in the older, more densely populated areas of the study area. However, the design assumption (100 gpcd for population) is nearly three times higher than the measured gpcd for Meter 3. The significant difference in average gpcd between Meter 1 and Meter 2 sewersheds and Meter 3 sewershed is attributed to the higher proportion of newer development with newly constructed sanitary sewer and open space in Meter 3 sewershed.

Table 10. Flow Metering Sites

Meter Number	Pipe Diameter (inches)	Manhole ID	Average DWF (MGD)	Average Gallons per Capita per Day (GPCD)
1	15	SNMH-362-013	0.23	89
2	33	SNMH-014-019	0.88	94
3	22	SNMH-303-022	0.11	34

Model results were generated and calibrated by modifying dry weather and wet weather loading parameters. Figures showing the RDII wet weather flow data and model results are outlined in the following sections.

BASE FLOW CALIBRATION

The refined model was validated to meter flows during an extended period without precipitation to determine ground water infiltration (GWI) and base sanitary flow. The following period was selected for the base flow calibration: April 19-22, 2019. This period was selected to represent a flow condition during an extended period with no rainfall, but prior to a rainfall event (rainfall event occurred on April 22, 2019). This flow condition in mid-April is representative of a

[2] Calibration discussion for 2019 Study duplicated from *TM5: Capacity Study*

condition with higher GWI than likely present during the winter when flows GWI in the system would typically be at a minimum.

The objective of this base flow calibration was to replicate the diurnal patterns and peak flow at the meter locations within the study area that had accurate data collected during the calibration period chosen. The model was run for the calibration period, April 19-22, 2019, and was compared to the flow meters. A comparison of model results with measured flow at the meters is summarized in Table 11 and shown in Figure 18 through Figure 20. Overall, the base flow parameters were reduced by 28 percent from the uncalibrated model to calibrate the model with the meter data.

Meters within the study area validated well to flow volumes and fairly well to peak flows. Additionally, diurnal patterns matched for each of the meters. Generally, volume differences less than 10 percent and peak flow differences less than 20 percent are indicative of a calibrated model for base flow. The peak flow difference at Meter 3 is 26 percent; however, there is a significant amount of 'noise' in the Meter 3 data which suggests that the meter peak flow is not accurate.

Table 11: Base Flow Calibration Summary

	Meter Volume (MG)	Model Volume (MG)	% Difference	Meter Peak Flow (MGD)	Model Peak Flow (MGD)	% Difference
Meter 1	1.62	1.61	-1%	0.69	0.62	-10%
Meter 2	5.93	5.75	-3%	2.71	2.47	-9%
Meter 3	0.67	0.66	-1%	0.39	0.29	-26%[1]

[1] Potential erroneous meter peak flow

RDII CALIBRATION

The refined model's RDII response was validated to the April 7, 2019 rainfall event. This rainfall event was chosen because (1) there were no rainfall events for two days prior to the April 7th event (additional rainfall events prior to the selected event could skew the response in the meter data) and (2) all meters showed a visible response to the April 7th rainfall event. The model calibration involved adjusting the percentage of rainfall on each runoff surface contributing to the sewersheds and adjusting parameters that determine the shape of the runoff response and RDII volume entering the sanitary sewer network. The age of the neighborhood is accounted for in the parameters that determine RDII volume entering the sanitary sewer network.

A comparison of model results with measured flow at the meters is summarized in Table 12 and shown in Figure 21 through Figure 23. Overall, the RDII parameters were reduced by 75 percent from the uncalibrated model to calibrate the model with the meter data. Meters within the study area calibrated well to peak flows and fairly well to flow volumes. Generally, volume differences less than 20 percent and peak flow differences less than 10 percent are indicative of a calibrated model for RDII flow.

Table 12: RDII Flow Calibration Summary

	Meter Volume (MG)	Model Volume (MG)	% Difference	Meter Peak Flow (MGD)	Model Peak Flow (MGD)	% Difference
Meter 1	1.64	1.78	8%	0.81	0.80	-1%
Meter 2	6.19	6.48	5%	2.89	2.92	1%
Meter 3	0.69	0.81	17%	0.42	0.38	-9%

2020 Study Model Calibration

The flow meters (Table 13 and Figure 24) were installed on May 13-15, 2020 and remained in place until July 9-10, 2020 (55-58 days). While the flow meters were installed, the approximate average dry weather flow (DWF) in each meter was 0.15 MGD (meter 4), 6.06 MGD (meter 5), 0.90 MGD (meter 6), 0.48 MGD (meter 7), 0.24 MGD (meter 8), 0.44 MGD (meter 9), 0.24 MGD (meter 10), and 0.87 MGD (meter 11).

The average DWF (MGD) for each meter equates to an average residential gpcd of 35 gpcd at Meter 4, 37 gpcd at Meter 5, 138 gpcd at Meter 6, 83 gpcd at Meter 7, 84 gpcd at Meter 8, 52 gpcd at Meter 9, 66 gpcd at Meter 10, and 77 gpcd at Meter 11. The standard Iowa design assumption for sanitary sewers is 100 gpcd for population. This design assumption is a close approximation, to the measured gpcd at Meter 6, Meter 7, and Meter 8. These meters are located in the older, more densely populated areas of the City. However, the design assumption is nearly three times higher than the measured gpcd for Meter 4 and Meter 5. The significant difference in average gpcd between the meters is attributed to the higher proportion of newer development with newly constructed sanitary sewer and open space.

Table 13. Flow Metering Sites

Meter Number	Pipe Diameter (inches)	Manhole ID	Average DWF (MGD)	Average Gallons per Capita per Day (GPCD)
4	18	SNMH-261-007	0.13	34
5	33	SNMH-014-023	6.00	37
6	21	SNMH-012-014	0.80	138
7	18	SNMH-063-062	0.46	83
8	21	SNMH-322-061	0.25	84
9	24	SNMH-051-003	0.49	52
10	18	SNMH-333-014	0.23	66
11	30	SNMH-081-007	0.82	77

Model results were generated and calibrated by modifying dry weather and wet weather loading parameters. Figures showing the RDII wet weather flow data and model results are outlined in the following sections.

BASE FLOW CALIBRATION

The refined model was validated to meter flows during an extended period without precipitation to determine ground water infiltration (GWI) and base sanitary flow. The following period was selected for the base flow calibration, June 16-18, 2020. This period was selected to represent a flow condition during an extended period with no rainfall, but prior to a rainfall event (rainfall event occurred on June 19, 2020). This flow condition in mid-June is representative of a condition with higher GWI than likely present during the winter when GWI in the system would typically be at a minimum.

The objective of this base flow calibration was to replicate the diurnal patterns and peak flow at the meter locations within the study area that had accurate data collected during the calibration period chosen. The model was run for the calibration period between June 16-19, 2020 and was compared to the flow meters. A comparison of model results with measured flow at the meters is summarized in Table 14 and shown in Figure 25 through Figure 32.

Meters within the study area validated well to both flow volumes and peak flows. Additionally, diurnal patterns matched for each of the meters. Generally, volume differences less than 10 percent and peak flow differences less than 20 percent are indicative of a calibrated model for base flow.

Table 14: Base Flow Calibration Summary

	Meter Volume (MG)	Model Volume (MG)	% Difference	Meter Peak Flow (MGD)	Model Peak Flow (MGD)	% Difference
Meter 4	0.43	0.42	-2.4%	0.19	0.19	-4.3%
Meter 5	17.47	17.38	-0.5%	7.43	6.83	-8.8%
Meter 6	2.45	2.53	3.2%	0.97	0.90	-7.4%
Meter 7	1.19	1.14	-4.6%	0.49	0.47	-4.9%
Meter 8	0.70	0.77	8.9%	0.32	0.32	0.0%
Meter 9	1.27	1.50	15.3%	0.60	0.66	9.6%
Meter 10	0.68	0.72	5.3%	0.31	0.30	-2.3%
Meter 11	2.46	2.70	9.0%	1.08	1.11	3.0%

RDII CALIBRATION

The refined model's RDII response was validated using rain gauge data for a gauge that was installed at Indian Creek Elementary School for the same duration as the flow metering. During the duration of the flow metering and rain gauge installation, four significant rainfall events occurred prompting a flow response in all of the meters. The significant rainfall events occurred on May 23rd, May 25th, June 9-10th, and June 22nd, 2020. There were several additional smaller events that occurred, but those smaller events did not always result in a flow response.

The model calibration involved adjusting the percentage of rainfall on each runoff surface contributing to the sewersheds and adjusting parameters that determine the shape of the runoff response and RDII volume entering the sanitary sewer network. The age of the neighborhood is accounted for in the parameters that determine RDII volume entering the sanitary sewer network. A comparison of model results with measured flow at the meters for the duration between May 23rd and June 23rd, 2020, is summarized in Table 15 and shown in Figure 33 through Figure 40. Meters within the study area calibrated fairly well to peak flows and very well to flow volumes. Generally, volume differences less than 20 percent and peak flow differences less than 10 percent are indicative of a calibrated model for RDII flow.

Table 15: RDII Flow Calibration Summary

	Meter Volume (MG)	Model Volume (MG)	% Difference	Meter Peak Flow (MGD)	Model Peak Flow (MGD)	% Difference
Meter 4	6.19	6.00	-3.2%	0.27	0.28	3.9%
Meter 5	269.05	280.71	4.2%	13.37	14.72	9.1%
Meter 6	40.34	38.96	-3.5%	3.03	3.35	9.7%
Meter 7	22.07	20.14	-9.6%	2.38	1.53	-55.0%
Meter 8	10.64	11.05	3.7%	0.54	0.59	9.1%
Meter 9	19.35	22.09	12.4%	1.17	1.14	-2.9%
Meter 10	10.40	10.44	0.4%	1.15	1.04	-11.1%
Meter 11	39.62	39.30	-0.8%	3.17	2.71	-16.8%

Review of the meter data during the wet weather periods shows significant Inflow and Infiltration (I/I) at meters 6, 7, 10, and 11. Flow in these meters more than doubles during wet weather events. Many factors could be contributing to the significant I/I in these areas, including leaky pipes (at joints or cracks), leaky manholes, and illegal connections to the sewer (sump pumps and downspouts). The City should consider further investigating the cause of I/I in the areas highlighted in Figure 41, and if possible, address the issues to reduce the wet weather influence. Further discussion on the benefits of reducing I/I is included in the Model Results section.

Capacity Analysis

Model Scenarios

The calibrated hydraulic model was used to simulate several different current and future development scenarios. The modeled scenarios are summarized in Table 16 and described in greater detail below.

Table 16. Modeled Scenarios for Existing and Future Development Conditions

Scenario Name	Scenario Number	What is included in each scenario
Existing Condition	1	Existing sanitary sewer service area, population, and employment. The existing estimated population is approximately 41,000 people.
Baseline Condition	2	Scenario 1 plus proposed Segment 7 sewer improvements as described in the Proposed Sewer in the Dry Run and Lower Indian Creek Basins Section[1].
Proposed Regional Trunk Sewer Condition	3	Scenario 2 plus all recommended (Segment 3 through Segment 11) Regional Trunk Sewer improvements as described in the Proposed Sewer in the Dry Run and Lower Indian Creek Basins Section[1].
Baseline Condition with I/I Reduction Condition	4	Scenario 2 plus assume a 30 percent reduction in I/I in the Old Marion area.

Scenario Name	Scenario Number	What is included in each scenario
Proposed Regional Trunk Sewer with I/I Reduction Condition	5	Scenario 3 plus assume a 30 percent reduction in I/I in the Old Marion area
2040 Population in Existing Service Area Condition	6	Scenario 5 but with 2040 population and employment. The estimated 2040 population for the City is approximately 47,800 people.
2040 Population in Existing Service Area + Denser Uptown District Condition	7	Scenario 6 plus a denser Uptown District as shown in the City's Comprehensive Plan
2040 Population in Existing Service Area + Growth Area 1 Condition	8	Scenario 7 plus Growth Area 1
2040 Population in Existing Service Area + Growth Area 2 Condition	9	Scenario 7 plus Growth Area 2
2040 Population in Existing Service Area + Growth Area 3 Condition	10	Scenario 7 plus Growth Area 3
2040 Population in Existing Service Area + Growth Area 4 Condition	11	Scenario 7 plus Growth Area 4
2040 Population in Existing Service Area + Growth Area 5 Condition	12	Scenario 7 plus Growth Area 5
Full Development Condition	13	Incorporates all elements from each of the different scenarios. The estimated full development population is approximately 82,000 people.

[1] See Appendix A and Hydraulic Model Refinements section for discussion on the 2007 Report.

Scenario Number 1: The existing condition is the sanitary sewer network, population, and employment within the current service area. The sewersheds included in the existing condition are shown spatially in Figure 42.

Scenario Number 2: The baseline condition includes all aspects of existing condition, plus the Regional Trunk Sewer, Segment 7 sewer improvement that is currently being designed. For the evaluation presented in this TM, it is assumed that the Segment 7 sewer improvement includes replacing the existing 36-inch pipe with a 60-inch pipe at the same grade as the existing pipe. The sewersheds included in the baseline condition are shown spatially in Figure 43.

Scenario Number 3: The proposed Regional Trunk Sewer condition includes all of the aspects of the baseline condition plus, all of the recommended improvements (Segment 3 through Segment 11) for the Regional Trunk Sewer as described in the 2007 Report (See Appendix A, page A-6 for recommended improvements). This scenario was evaluated in order to quantify the impacts in the City from downstream capacity deficiencies. This condition is also used to identify potential improvements needed in the study area. The sewersheds included in the proposed Regional Trunk Sewer condition are shown spatially in Figure 44.

Scenario Number 4: The baseline I/I reduction condition includes all aspects of baseline condition, plus assuming a 30% reduction in I/I in sewersehd located in Old Marion in the Lower Indian Creek Basin. I/I reduction can be achieved through pipe sliplining, disconnecting downspouts and sump pumps, and fixing leaky manholes. This scenario was evaluated to determine if I/I reduction efforts can reduce or prevent the need for future sewer improvements. The sewersheds included in the baseline I/I reduction condition is shown spatially in Figure 45.

Scenario Number 5: The proposed Regional Trunk Sewer improvements with I/I reduction condition includes all aspects of the proposed Regional Trunk Sewer condition, plus assuming a 30% reduction in I/I in sewershed located in Old Marion in the Lower Indian Creek Basin. I/I reduction can be achieved through pipe sliplining, disconnecting downspouts and sump pumps, and fixing leaky manholes. This scenario was evaluated to determine if I/I reduction efforts can reduce or prevent the need for future sewer improvements. The sewersheds included in the proposed Regional Trunk Sewer with I/I reduction condition is shown spatially in Figure 46.

Scenario Number 6: The 2040 population in existing service area condition includes all aspects of the proposed Regional Trunk Sewer with I/I reduction condition, but uses projected 2040 population and employment for the entire service area. It includes all the recommended improvements (Segment 3 through Segment 11) for the Regional Trunk Sewer as described in the 2007 Report (See Appendix A, page A-6 for recommended improvements). The sewershed included in the 2040 population in existing service area condition is shown spatially in Figure 47.

Scenario Number 7: The 2040 population with a denser Uptown District condition includes all aspects of the 2040 population in existing service area condition plus a denser Uptown District as shown in the City's Comprehensive Plan (Land Use UTR-2, U-1, U-2, and UC-1 in the Comprehensive Plan). The projected 2040 population and employment was used for the entire sanitary sewer service area in this condition. The sewershed included in the 2040 population with a denser Uptown District condition is shown spatially in Figure 48.

Scenario Number 8: The 2040 population with Growth Area 1 condition includes all aspects of the 2040 population with a denser Uptown District condition plus additional population and employment in the northwestern portion of the City. The sewer expansion for the additional service area is assumed to be a 12-inch diameter pipe. The sewersheds included in this condition are shown spatially in Figure 49. Note that further expansion of the service area beyond what is shown in Figure 49 might be possible topographically but was not considered herein.

Scenario Number 9: The 2040 population with Growth Area 2 condition includes all aspects of the 2040 population with a denser Uptown District condition plus additional population and employment in the northern portion of the City. The sewer expansion for the additional service area ranges from 8-inch to 18-inch diameter pipe. The sewersheds included in this condition are shown spatially in Figure 50. Note that further expansion of the service area beyond what is shown in Figure 50 might be possible topographically but was not considered herein.

Scenario Number 10: The 2040 population with Growth Area 3 condition includes all aspects of the 2040 population with a denser Uptown District condition plus additional population and employment in the northeastern portion of the City. The sewer expansion for the additional service area ranges from 8-inch to 24-inch diameter pipe. The sewersheds included in this condition are shown spatially in Figure 51. Note that further expansion of the service area beyond what is shown in Figure 51 might be possible topographically but was not considered herein.

Scenario Number 11: The 2040 population with Growth Area 4 condition includes all aspects of the 2040 population with a denser Uptown District condition plus additional population and employment in the eastern portion of the City. The sewer expansion for the additional service area ranges from 8-inch to 15-inch diameter pipe. The sewersheds included in this condition are shown spatially in Figure 52. Note that further expansion of the service area beyond what is shown in Figure 52 might be possible topographically but was not considered herein.

Scenario Number 12: The 2040 population with Growth Area 5 condition includes all aspects of the 2040 population with a denser Uptown District condition plus additional population and employment in the southern portion of the City. The sewer expansion for the additional service area ranges from 8-inch to 12-inch diameter pipe. The sewersheds included in this condition are shown spatially in Figure 53. Note that further expansion of the service area beyond what is shown in Figure 53 might be possible topographically but was not considered herein.

Scenario Number 13: The full development condition includes all aspects of 2040 population with a denser Uptown District condition plus all five growth areas. The sewer expansion for the additional service areas range from 8-inch to 24-inch diameter pipe. The sewersheds included in the full development condition are shown spatially in Figure 54. Note that further expansion of the service area beyond what is shown in Figure 54 might be possible topographically but was not considered herein.

SUMMARY OF MODEL SCENARIOS

A total of 13 scenarios were evaluated as part of this study. The first five scenarios, existing condition (Scenario 1), baseline condition (Scenario 2), proposed Regional Trunk Sewer condition (Scenario 3), baseline with I/I reduction condition (Scenario 4), and proposed Regional Trunk Sewer with I/I reduction condition (Scenario 5) all represent the current development (population and employment) within the current sanitary sewer service area. The differences between these five current development scenarios is the size and capacity of the Regional Trunk Sewer and whether I/I reduction efforts are included.

Eight scenarios were evaluated to identify capacity deficiencies for growth and future development conditions. The future growth and development scenarios are 2040 population in existing service area condition, 2040 population with a denser Uptown District condition, 2040 population with Growth Area 1 condition, 2040 population with Growth Area 2 condition, 2040 population with Growth Area 3 condition, 2040 population with Growth Area 4 condition, 2040 population with Growth Area 5 condition, and the full development condition (Scenario Numbers 6 through 13, respectively).

Scenarios 6 and 7 represent variations of future growth within the current service area. Scenarios 8 through 12 represent growth in the current service area plus growth beyond current City limits. All of these future growth scenarios assume that all the recommended improvements

(Segment 3 through Segment 11) have been completed in the Regional Trunk Sewer and include I/I reduction in the Old Marion area.

The full development condition (Scenario 13) represents long-term and potential maximum development conditions. This scenario assumes all of the recommended improvements (Segment 3 through Segment 11) have been completed in the Regional Trunk Sewer. It also assumes the projected 2040 population and employment for all existing and potential sewersheds (service area).

The 13 scenarios are shown spatially in Figures 42-54. All scenarios were simulated under peak dry weather, 2-year wet weather, and 5-year wet weather conditions. The scenarios considered are as follows:

- Existing Conditions, Dry Weather
- Existing Conditions, 2-Year Wet Weather
- Existing Conditions, 5-Year Wet Weather
- Baseline Conditions, Dry Weather
- Baseline Conditions, 2-Year Wet Weather
- Baseline Conditions, 5-Year Wet Weather
- Proposed Regional Trunk Sewer Condition, Dry Weather
- Proposed Regional Trunk Sewer Condition, 2-Year Wet Weather
- Proposed Regional Trunk Sewer Condition, 5-Year Wet Weather
- Baseline Condition with I/I Reduction Conditions, Dry Weather
- Baseline Condition with I/I Reduction Conditions, 2-Year Wet Weather
- Baseline Condition with I/I Reduction Conditions, 5-Year Wet Weather
- Proposed Regional Trunk Sewer with I/I Reduction Conditions, Dry Weather
- Proposed Regional Trunk Sewer with I/I Reduction Conditions, 2-Year Wet Weather
- Proposed Regional Trunk Sewer with I/I Reduction Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area Conditions, Dry Weather
- 2040 Population in Existing Service Area Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 1 Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 1 Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 1 Conditions, 5-Year Wet Weather

- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 2 Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 2 Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 2 Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 3 Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 3 Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 3 Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 4 Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 4 Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 4 Conditions, 5-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 5 Conditions, Dry Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 5 Conditions, 2-Year Wet Weather
- 2040 Population in Existing Service Area with a Denser Uptown District and Growth Area 5 Conditions, 5-Year Wet Weather
- Full Development Conditions, Dry Weather
- Full Development Conditions, 2-Year Wet Weather
- Full Development Conditions, 5-Year Wet Weather

Capacity Criteria

The capacity deficiencies discussed as part of this analysis are defined to be sewers functioning as a bottleneck due to inadequate capacity and causing potential upstream sanitary sewer backups or SSOs. This criterion is informed by the surcharge state of pipes within the model network and the freeboard flow in manholes as identified by model results.

SURCHARGE STATE

The surcharge state refers to how full a pipe is flowing. For this analysis, the surcharge state is measured as the ratio between the flow depth and the pipe diameter (d/D). A pipe with flow that is less than full will have a surcharge state value (d/D) less than 1. A pipe that is full will be characterized by the model in two ways. If that pipe is restricting flow, it will be characterized as a bottleneck. If a pipe is full, but is not restricting flow, it will be characterized as being full due to a downstream bottleneck.

FREEBOARD

The freeboard within a manhole is as the distance between the water surface elevation of flow and the manhole rim. Freeboard less than three feet indicate that the manhole is at risk of causing potential basement backups to nearby homes, assuming those homes have basements. A freeboard of zero indicates risk of a potential sanitary sewer overflow and basement backups.

These two criteria, surcharge state and freeboard less than 3 feet, are highlighted in the results figures shown in Appendix B of this TM. In the following sections, capacity deficiencies are defined to be sewers that are in a bottleneck surcharge state and are causing manholes to have less than 3 feet of freeboard. In some instances, a pipe may be identified as in a bottleneck surcharge state but not causing manholes to have less than 3 feet of freeboard. These instances can occur depending on the depth of pipe, extent of surcharge, or adjacent pipe elevations. These instances are identified as a capacity deficiency for the evaluation presented in this TM; however, no potential improvements are recommended for these locations. Due to the model assuming ideal pipe conditions, any capacity deficiencies caused by grease buildup, root intrusions, or other maintenance issues will not be identified by the model.

Model Results

Result figures for each modeled scenario are included in Appendix B. A summary of the model results is shown in Table 17. The results are discussed in detail following Table 17.

Table 17. Summary of Results for each Modeled Scenario

Scenario		Bottleneck Pipe in City	Bottleneck Pipe in Regional Trunk Sewer	Potential Backup in City	Potential Overflow in City	Recommend Improvement (yes/no)
Existing Condition (Scenario 1)	Dry Weather					No
	2-Yr Wet Weather	X	X	X	X	No[1]
	5-Yr Wet Weather	X	X	X	X	No[1]
Baseline Condition (Scenario 2)	Dry Weather					No
	2-Yr Wet Weather	X	X	X	X	No[1]
	5-Yr Wet Weather	X	X	X	X	No[1]
Proposed Regional Trunk Sewer Condition (Scenario 3)	Dry Weather					No
	2-Yr Wet Weather	X				No[1]
	5-Yr Wet Weather	X		X	X	Yes
Baseline Condition with I/I Reduction (Scenario 4)	Dry Weather					No
	2-Yr Wet Weather	X	X	X	X	No[1]
	5-Yr Wet Weather	X	X	X	X	Yes

Scenario		Bottleneck Pipe in City	Bottleneck Pipe in Regional Trunk Sewer	Potential Backup in City	Potential Overflow in City	Recommend Improvement (yes/no)
Proposed Regional Trunk Sewer with I/I Reduction (Scenario 5)	Dry Weather					No
	2-Yr Wet Weather	X				No[1]
	5-Yr Wet Weather	X		X	X	Yes
2040 Population in Existing Service Area Condition (Scenario 6)	Dry Weather					No
	2-Yr Wet Weather	X				No[1]
	5-Yr Wet Weather	X		X	X	Yes
2040 Population in Existing Service Area Condition + Denser Uptown District (Scenario 7)	Dry Weather					No
	2-Yr Wet Weather	X				No[1]
	5-Yr Wet Weather	X		X	X	No[2]
2040 Population in Existing Service Area Condition + Growth Area 1 (Scenario 8)	Dry Weather					No
	2-Yr Wet Weather	X		X	X	No[2]
	5-Yr Wet Weather	X		X	X	No[2]
2040 Population in Existing Service Area Condition + Growth Area 2 (Scenario 9)	Dry Weather	X				No
	2-Yr Wet Weather	X		X	X	Yes
	5-Yr Wet Weather	X		X	X	Yes
2040 Population in Existing Service Area Condition + Growth Area 3 (Scenario 10)	Dry Weather	X				No
	2-Yr Wet Weather	X		X	X	Yes
	5-Yr Wet Weather	X		X	X	Yes
2040 Population in Existing Service Area Condition + Growth Area 4 (Scenario 11)	Dry Weather					No
	2-Yr Wet Weather	X				No[1]
	5-Yr Wet Weather	X		X	X	Yes

Scenario		Bottleneck Pipe in City	Bottleneck Pipe in Regional Trunk Sewer	Potential Backup in City	Potential Overflow in City	Recommend Improvement (yes/no)
2040 Population in Existing Service Area Condition + Growth Area 5 (Scenario 12)	Dry Weather	X			X	Yes
	2-Yr Wet Weather	X			X	Yes
	5-Yr Wet Weather	X		X	X	Yes
Full Development Condition (Scenario 8)	Dry Weather	X		X	X	Yes
	2-Yr Wet Weather	X		X	X	Yes
	5-Yr Wet Weather	X	X	X	X	Yes

[1]The recommended improvement for Regional Trunk Sewer condition addresses the potential SSOs and basement backups identified in these conditions. Therefore, no additional projects are recommended.
[2] Improvements recommended in Scenarios 1 through 6 address deficiencies identified in this scenario, therefore no additional projects are recommended

DRY WEATHER

Scenarios 1 – 5 (Existing Conditions, Baseline Conditions, Proposed Regional Trunk Sewer Conditions, Baseline with I/I Reduction Conditions, and Proposed Regional Trunk Sewer Creek with I/I Reduction Conditions)

Model results for Scenarios 1-5 during dry weather are shown in Figure B1 through Figure B5 of Appendix B. The sanitary system has sufficient capacity to convey flow under dry weather for all of these scenarios. Some sections of pipe show flow greater than 80% full during dry weather conditions. However, this flow ratio is due to the elevation at which they connect to the trunk sewer, this causes the downstream opening of the pipe to be submerged, or nearly submerged, but the upstream end of the pipe is less than half full. Additionally, there are five manholes that indicate a potential backup in these Scenarios. The sewer invert at these manholes are less than three feet below the modeled ground elevation; therefore, any flow in the pipe will show a potential backup. No proposed improvements for the existing sanitary sewer system are recommended for dry weather for Scenarios 1 through 5.

Scenarios 6 – 7 (2040 Population in Existing Service Area Conditions and 2040 Population in Existing Service Area with a Denser Uptown District Conditions)

Model results for these scenarios during dry weather are shown in Figure B6 and B7 of Appendix B. The model results indicate the sanitary system has sufficient capacity to convey flow under dry weather for both of these future population and employment scenarios. These results show that the City can continue to grow within the existing service area without impacting capacity in the existing sewer system for dry weather conditions. In both scenarios the sewer downstream of this study area has sufficient capacity and there are no tailwater impacts for the sewer network located within this study area. No proposed improvements for the existing sanitary sewer system are recommended for these scenarios.

Scenario 8 (2040 population with Growth Area 1 Conditions)

Model results for the 2040 population with Growth Area 1 condition during dry weather are shown in Figure B8 in Appendix B. The model results indicate the Christopher Creek trunk sewer has sufficient capacity to convey flow under dry weather for this future growth scenario. The results show that the City could expand into the growth area without impacting the capacity in the existing sewer system for dry weather conditions. In this scenario the sewer downstream of this study area has sufficient capacity and there are no tailwater impacts for the sewer network located within this study area. There are no proposed improvements for the existing sanitary sewer system recommended for this scenario.

Scenario 9 (2040 population with Growth Area 2 Conditions)

Model results for 2040 population with Growth Area 2 Conditions during dry weather are shown in Figure B9 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks along the entire length of the Berrys Run Creek trunk sewer. Although the trunk line is bottlenecked, the model does not indicate and potential sanitary backups or SSOs sewer system. Because no potential backups or SSOs were identified for this scenario, no improvements for the existing sanitary sewer system are recommended. However, as stated previously, the model assumes ideal pipe conditions and this assumption may not be fully reflective of the actual system. Therefore, careful consideration and inspection of the Berrys Run Creek trunk sewer should be completed prior to growth and expansion in Area 2.

Scenario 10 (2040 population with Growth Area 3 Conditions)

Model results for 2040 population with Growth Area 3 Conditions during dry weather are shown in Figure B10 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks throughout the Indian Creek trunk sewer. Although the trunk line is bottlenecked, the model does not indicate and potential sanitary backups or SSOs sewer system. Because no potential backups or SSOs were identified for this scenario, no improvements for the existing sanitary sewer system are recommended. However, as stated previously, the model assumes ideal pipe conditions and this assumption may not be fully reflective of the actual system. Therefore, careful consideration and inspection of the Indian Creek trunk sewer should be completed prior to growth and expansion in Area 3.

Scenario 11 (2040 population with Growth Area 4 Conditions)

Model results for this scenario during dry weather is shown in Figure B11 in Appendix B. The model results indicate the Squaw Creek trunk sewer has sufficient capacity to convey flow under dry weather for this future growth scenario. The results show that the City could expand into the growth area without impacting the capacity in the existing sewer system for dry weather conditions. In this scenario the sewer downstream of this study area has sufficient capacity and there are no tailwater impacts for the sewer network located within this study area. There are no proposed improvements for the existing sanitary sewer system recommended for this scenario.

Scenario 12 (2040 population with Growth Area 5 Conditions)

Model results for this scenario during dry weather is shown in Figure B12 in Appendix B. The model results indicate the Squaw Creek and Lower Indian Creek trunk sewers have sufficient capacity to convey flow under dry weather for this future growth scenario. However, the planned growth near the Marion Airport (AirCom Park) and south of Grant Wood bike trail would cause potential SSOs in the 12-in sewer located east of Highway 13 along Grant Wood trail. This capacity issue should be addressed prior to growth around the Marion Airport. A proposed improvement for the existing sanitary sewer system is recommended for this scenario; this recommended improvement is described in greater detail in the following Recommended Improvements Section.

Scenario 13 (Full Development Conditions)

Model results for full development conditions during dry weather are shown in Figure B13 in Appendix B. The potential development and future population included in this scenario would cause several bottlenecks with the potential for widespread SSOs and potential basement backups throughout the Indian Creek Basin and along the Grant Wood trail in the Squaw Creek basin as described in the Scenario 12 dry weather flow results. Significant capacity improvements along the entire Indian Creek trunk sewer and the Berrys Run Creek trunk sewer would be required to provide adequate infrastructure to service the full development condition development potential. The recommended improvements along the Indian Creek trunk sewer and the Berrys Run Creek trunk sewer are described in greater detail in the following Recommended Improvements Section.

Model results indicate that the sanitary sewer downstream of the study area has capacity to convey additional flows from the Indian Creek Basin. However, the model does not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids) that are served by the Regional Trunk Sewer. Future growth beyond the study area may limit the available capacity of the Regional Trunk Sewer. A further investigation of the overall Indian Creek/Dry Run Creek sewersheds would be required before the proposed improvements are designed and constructed.

2-YEAR WET WEATHER

Scenario 1 (Existing Conditions)

Model results for existing conditions during 2-year wet weather are shown in Figure B14 of Appendix B. Overall, the sanitary sewer network is flowing at less than 80 percent full. However, the main trunk line along Indian Creek shows as flowing full, resulting in the potential for several SSOs and basement backups. Model results indicate that the potential SSOs and basement backups are caused by downstream capacity deficiencies; these capacity deficiencies restrict flows in the Indian Creek trunk sewer that located upstream of Alburnett Road. The deficiencies identified in this scenario are addressed through recommended improvements described in the proposed Regional Trunk Sewer condition (Scenario 3). No additional projects beyond was is described for the proposed Regional Trunk Sewer condition are recommended for existing conditions.

Scenario 2 (Baseline Conditions)

Model results for baseline conditions during 2-year wet weather are shown in Figure B15 of Appendix B. Overall, the sanitary sewer network is generally flowing at less than 80 percent full. However, the main trunk line along Indian Creek shows as flowing full resulting in the potential for basement backups. When compared to existing conditions (which does not include the Segment 7 improvement), the Segment 7 improvements in baseline conditions result in a 32 percent reduction in potential SSOs and a 38 percent reduction in potential basement backups.

Segment 7 improves conditions for the 2-year wet weather event; however, there are several additional downstream capacity deficiencies that are restricting the flows in the Indian Creek trunk sewer that located upstream of Alburnett Road. The deficiencies identified in this scenario are addressed through recommended improvements described in the proposed Regional Trunk Sewer condition (Scenario 3). No additional projects beyond was is described for the proposed Regional Trunk Sewer condition are recommended for baseline conditions.

Scenario 3 (Proposed Regional Trunk Sewer Conditions)
Model results for the proposed Regional Trunk Sewer conditions during 2-year wet weather are shown in Figure B16 of Appendix B. This scenario was evaluated to determine if the downstream capacity deficiencies are the cause of the potential backups in the Indian Creek and Dry Run Creek trunk sewers. Model results show that if all the recommended improvements (Segment 3 through Segment 11) are completed for the Regional Trunk Sewers, then the existing sewer within the City has capacity to convey the 2-year wet weather flows. No additional project improvements beyond the Indian Creek and Dry Run Creek trunk sewer improvements are recommended for this scenario for the 2-year wet weather event.

Scenario 4 – 5 (Baseline with I/I Reduction Conditions and Proposed Regional Trunk Sewer with I/I Reduction Conditions)
Model results for these two scenarios during 2-year wet weather are shown in Figure B17 and Figure B18 of Appendix B. These scenarios were evaluated to determine if I/I reduction efforts in the Old Marion area would reduce potential basement backups and SSOs. Model results indicate that no potential basement backups or SSOs occur during the 2-year wet weather event; however, there are several pipe segments in the area that are bottlenecked and flowing full in both scenarios. The inclusion of I/I efforts in this area would reduce the flow in several pipe segments from bottlenecked to flowing less than 80-percent full. No additional project improvements are recommended for these scenarios for the 2-year wet weather event.

Scenarios 6 – 7 (2040 Population in Existing Service Area Conditions and 2040 Population in Existing Service Area with a Denser Uptown District Conditions)
Model results for these scenarios during dry weather are shown in Figure B19 and B20 of Appendix B. Model results show that if all the recommended improvements (Segment 3 through Segment 11) are completed for the Regional Trunk Sewer, then the existing sewer within the City has capacity to convey the 2-year wet weather flows without potential for basement backups or SSOs. These results show that the City can continue to grow within the existing service area without impacting capacity in the existing sewer system for 2-year wet weather conditions. In both scenarios the sewer downstream of this study area has sufficient capacity and there are no tailwater impacts for the sewer network located within this study area. No additional project improvements beyond the Regional Trunk Sewer improvements and I/I reduction effort as described in Scenario 4 and Scenario 5 are recommended for these scenarios for the 2-year wet weather event.

Scenario 8 (2040 population with Growth Area 1 Conditions)
Model results for the 2040 population with Growth Area 1 condition during 2-year wet weather are shown in Figure B21 in Appendix B. The model results indicate that growth in area 1 would result in several bottleneck pipes and three potential basement backup locations in the Christopher Creek trunk sewer near Cambridge Drive NE. Capacity improvements along the

Christopher Creek trunk sewer would be required to provide adequate capacity for the potential growth in area 1. The capacity improvements would be required between Boyson Road NE and Cambridge Drive NE. The recommended improvements for this scenario are described in greater detail in the following Recommended Improvements Section.

Scenario 9 (2040 population with Growth Area 2 Conditions)

Model results for 2040 population with Growth Area 2 Conditions during 2-year wet weather are shown in Figure B22 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks, potential basements backups, and potential SSOs along the entire length of the Berrys Run Creek trunk sewer and along the Indian Creek trunk sewer from Alburnett Road to Silver Oak Trail. Significant capacity improvements along the entire Indian Creek trunk sewer and the Berrys Run Creek trunk sewer would be required to provide adequate infrastructure to service this condition’s growth development potential. The recommended improvements along the Indian Creek trunk sewer and the Berrys Run Creek trunk sewer are described in greater detail in the following Recommended Improvements Section.

Scenario 10 (2040 population with Growth Area 3 Conditions)

Model results for 2040 population with Growth Area 3 Conditions during 2-year wet weather are shown in Figure B23 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks, potential basements backups, and potential SSOs along the length of the Indian Creek trunk sewer upstream of Alburnett Road. The Indian Creek trunk sewer bottlenecks would cause potential backups and SSOs along the Berrys Run Creek trunk as well. Significant capacity improvements along the entire Indian Creek trunk sewer would be required to provide adequate infrastructure to service this condition’s development potential. The recommended improvements along the Indian Creek trunk sewer trunk sewer are described in greater detail in the following Recommended Improvements Section.

Scenario 11 (2040 population with Growth Area 4 Conditions)

Model results for this scenario during 2-year wet weather is shown in Figure B24 in Appendix B. The model results indicate some segments of full and bottlenecked pipe; however, these bottlenecks do not cause any potential basement backups or SSOs. Therefore, the Squaw Creek trunk sewer has enough capacity to convey flow under 2-year wet weather for this future growth scenario. The results show that the City could expand into the growth area without impacting the capacity in the existing sewer system for 2-year weather conditions. There are no proposed improvements for the existing sanitary sewer system recommended for this scenario.

Scenario 12 (2040 population with Growth Area 5 Conditions)

Model results for this scenario during 2-year wer weather is shown in Figure B25 in Appendix B. Similar to the results described in the dry weather results for this scenario, the model results indicate the planned growth near the Marion Airport (AirCom Park) and south of Grant Wood bike trail would cause potential SSOs in the 12-inch sewer located east of Highway 13 along Grant Wood trail. This capacity issue should be addressed prior to growth around the Marion Airport. The recommended improvement is described in greater detail in the following Recommended Improvements Section.

Scenario 13 (Full Development Conditions)

Model results for full development conditions during 2-year wet weather are shown in Figure B26 in Appendix B. The potential development and future population included in this scenario would cause several bottlenecks with the potential for widespread sanitary SSOs and potential basement backups throughout the Indian Creek Basin, along the Grant Wood trail and south of 8th Avenue in the Squaw Creek Basin, and south of Cambridge Drive SE in the Christopher Creek Basin. Significant capacity improvements along the entire Indian Creek trunk sewer and the Berrys Run Creek trunk sewer would be required to provide adequate infrastructure to service the full development condition development potential. Additional improvements in the other capacity issue areas would also be required. The recommended improvements for this full development condition scenario are described in greater detail in the following Recommended Improvements Section.

Model results indicate that the sanitary sewer downstream of the study area has capacity to convey the additional flows from the Full development condition. However, the model does not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids). Future growth beyond the study area may limit the available capacity of the Regional Trunk Sewer. A further investigation of the overall Indian Creek/Dry Run Creek sewersheds would be required before the proposed improvements are designed and constructed.

5-YEAR WET WEATHER

Scenario 1 (Existing Conditions)

Model results for existing conditions during 5-year wet weather are shown in Figure B27 of Appendix B. Model results indicate the main trunk line along Indian Creek and Dry Run Creek has capacity deficiencies, resulting in the potential for several SSOs and basement backups throughout the Indian Creek, Lower Indian Creek, and Christopher Creek Basins. Additional capacity deficiencies in the sewer near Grand Avenue and South 8th Street also cause potential basement backups and SSOs. Most deficiencies identified in this scenario are addressed through recommended improvements described in the Regional Trunk Sewer condition (Scenario 3). However, the deficiencies identified near Grand Avenue and South 8th Street require additional improvements. The deficiencies identified near Grand Avenue and South 8th Street are addressed through I/I reduction efforts as described in Scenario 4 and Scenario 5.

Scenario 2 (Baseline Conditions)

Model results for baseline conditions during 5-year wet weather are shown in Figure B28 of Appendix B. Overall, the sanitary sewer network is generally flowing at less than 80 percent full. However, the main trunk line along Indian Creek shows as flowing full resulting in the potential for basement backups. When compared to existing conditions (which does not include the Segment 7 improvement), the Segment 7 improvements in baseline conditions result in a 19 percent reduction in potential SSOs and a 10 percent reduction in potential basement backups.

Segment 7 improves conditions for the 5-year wet weather event; however, there are several additional downstream capacity deficiencies that are restricting the flows in the Indian Creek trunk sewer that located upstream of Alburnett Road. The deficiencies identified in this scenario are addressed through recommended improvements described in the proposed Regional Trunk

Sewer condition (Scenario 3) and I/I reduction improvements described in Scenario 4 and Scenario 5. No additional projects are recommended for baseline conditions.

Scenario 3 (Proposed Regional Trunk Sewer Conditions)

Model results for the proposed Regional Trunk Sewer conditions during 5-year wet weather are shown in Figure B29 of Appendix B. This scenario was evaluated to determine if the downstream capacity deficiencies are the cause of the potential backups in the Regional Trunk Sewer. Model results show that even if all the recommended improvements (Segment 3 through Segment 11) are completed for the Regional Trunk Sewer, there are still capacity deficiencies in the Indian Creek basin as well as near Grand Avenue and South 8th Street. The capacities deficiencies near Grand Avenue and South 8th Street are addressed through I/I reduction efforts as described in Scenario 4 and Scenario 5. However, additional improvements in the Indian Creek Basin are required to provide adequate capacity for the existing sewer for the 5-year wet weather event. The additional improvements recommended for this scenario are described in greater detail in the Recommended Improvements Section.

Scenario 4 – 5 (Baseline with I/I Reduction Conditions and Proposed Regional Trunk Sewer with I/I Reduction Conditions)

Model results for these two scenarios during 5-year wet weather are shown in Figure B30 and Figure B31 of Appendix B. These scenarios were evaluated to determine if I/I reduction efforts in the Old Marion area would reduce potential basement backups and SSOs. As described in Scenario 3, model results indicate several bottleneck pipes and potential basement backups and SSOs occur during the 5-year wet weather event. However, these deficiencies can be addressed through I/I reduction efforts in the area. Model results show that if a 30-percent I/I reduction is achieved in the (1) Grand Avenue and South 8th Street and (2) South 11th Street and A Avenue areas, then there are no longer and potential basement backups and SSOs in the areas. No additional project improvements beyond the beyond the Regional Trunk Sewer improvements and the I/I reduction are recommended for these scenarios for the 5-year wet weather event.

Scenarios 6 (2040 Population in Existing Service Area Conditions)

Model results for this scenario during 5-year wet weather are shown in Figure B32 of Appendix B. Model results indicate several bottleneck pipes, and potential basement backups and SSOs for this scenario. Capacity deficiencies include the Indian Creek trunk line north of Alburnett Road, the Christopher Creek trunk line south of Cambridge Drive NE, and the sewer line south of Chapelridge Circle in the Squaw Creek Basin. The deficiencies in the Indian Creek trunk line can be addressed through improvements as described in 5-year wet weather results for Scenario 3. The deficiencies in the Christopher Creek trunk line can be addressed through improvements described in the 2-year wet weather results or Scenario 8. The deficiencies south of Chapelridge Circle in the Squaw Creek Basin occurs where a 10-inch sewer is located downstream from a 15-inch sewer. Increasing the size of the 10-inch sewer would address the capacity deficiency in this area. The recommended improvements to provide adequate sewer capacity for this scenario are described in greater detail in the Recommended Improvements Section.

Scenarios 7 (2040 Population in Existing Service Area with a Denser Uptown District Conditions)
Model results for this scenarios during 5-year wet weather is shown in Figure B33 of Appendix B. Model results show that if all the recommended improvements (Segment 3 through Segment 11) are completed for the Regional Trunk Sewer and I/I reduction in the Old Marion area is completed, then the existing sewer near the Uptown District has capacity to convey the 5-year wet weather flows without potential for basement backups or SSOs. However, if I/I reduction efforts are not completed, then a denser Uptown District would result in capacity deficiencies in the area. I/I reduction efforts should be completed prior to additional construction in the Uptown District. No additional project improvements beyond the Regional Trunk Sewer improvements and I/I reduction effort as described in Scenario 4 and Scenario 5 are recommended for this scenario for the 5-year wet weather event.

Scenario 8 (2040 population with Growth Area 1 Conditions)
Model results for the 2040 population with Growth Area 1 condition during 5-year wet weather are shown in Figure B34 in Appendix B. As described in the model results for the 2-year wet weather event for this scenario, the model results indicate that growth in area 1 would result in several bottleneck pipes and potential basement backups in the Christopher Creek trunk sewer near Cambridge Drive NE. Capacity improvements along the Christopher Creek trunk sewer are recommended to provide adequate capacity for the potential growth in area 1. The capacity improvements recommended are located between Boyson Road NE and Cambridge Drive NE. The recommended improvements for this scenario are described in greater detail in the following Recommended Improvements Section.

Scenario 9 (2040 population with Growth Area 2 Conditions)
Model results for 2040 population with Growth Area 2 Conditions during 5-year wet weather are shown in Figure B35 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks, potential basements backups, and potential SSOs along the entire length of the Berrys Run Creek trunk sewer and along the Indian Creek trunk sewer from Alburnett Road to Silver Oak Trail. As described in the model results for the 2-year wet weather event for this scenario, significant capacity improvements along the entire Indian Creek trunk sewer and the Berrys Run Creek trunk sewer would be required to provide adequate infrastructure to service this condition's growth development potential. The recommended improvements along the Indian Creek trunk sewer and the Berrys Run Creek trunk sewer are described in greater detail in the following Recommended Improvements Section.

Scenario 10 (2040 population with Growth Area 3 Conditions)
Model results for 2040 population with Growth Area 3 Conditions during 5-year wet weather are shown in Figure B36 in Appendix B. The potential growth development areas included in this scenario would cause bottlenecks, potential basements backups, and potential SSOs along the length of the Indian Creek trunk sewer from upstream of Alburnett Road. The Indian Creek trunk sewer bottlenecks would cause potential backups and SSOs along the Berrys Run Creek trunk as well. As described in the model results for the 2-year wet weather event for this scenario, significant capacity improvements along the entire Indian Creek trunk sewer would be required to provide adequate infrastructure to service this condition's development potential. The recommended improvements along the Indian Creek trunk sewer trunk sewer are described in greater detail in the following Recommended Improvements Section.

Scenario 11 (2040 population with Growth Area 4 Conditions)

Model results for this scenario during 5-year wet weather is shown in Figure B37 in Appendix B. The model results indicate growth development areas included in this scenario would cause bottleneck pipes and three potential basement backups in the Squaw Creek truck sewer located east of 44th Street and south of 8th Avenue. Capacity improvements in the Squaw Creek trunk sewer are recommended to addresses the deficiencies identified in this growth scenario. The recommended improvements are described in greater detail in the following Recommended Improvements Section.

Scenario 12 (2040 population with Growth Area 5 Conditions)

Model results for this scenario during 5-year wet weather is shown in Figure B38 in Appendix B. Similar to the results described in the 2-year wet weather results for this scenario, the model results indicate the planned growth near the Marion Airport (AirCom Park) and south of Grant Wood bike trail would cause potential SSOs in the 12-inch sewer located east of Highway 13 along Grant Wood trail. The recommended improvement to address deficiencies near the Marion Airport is described in greater detail in the following Recommended Improvements Section.

Scenario 13 (Full Development Conditions)

Model results for full development conditions during 5-year wet weather are shown in Figure B39 in Appendix B. The potential development and future population included in this scenario would cause several bottlenecks with the potential for widespread sanitary SSOs and potential basement backups throughout the Indian Creek Basin, along the Grant Wood trail and south of 8th Avenue in the Squaw Creek Basin, and south of Cambridge Drive SE in the Christopher Creek Basin. As described in the 2-year wet weather model results for this scenario, significant capacity improvements along the entire Indian Creek trunk sewer and the Berrys Run Creek trunk sewer would be required to provide adequate infrastructure to service the full development condition development potential.

The additional flows from the Indian Creek Basin also result in capacity deficiencies in Segment 8 through Segment 10 of the Regional Trunk Sewer. To address the deficiencies in these segments, a secondary sewer line would need to be constructed parallel to the proposed trunk sewer. The required size for the secondary sewer line is 24-inch diameter pipe; however, the model does not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids). Future growth beyond the study area may require additional secondary capacity in Segment 8 through Segment 10 of the Regional Trunk Sewer. A further investigation of the overall Indian Creek/Dry Run Creek sewersheds would be required before the proposed improvements are designed and constructed. Additional improvements in the other capacity issue areas would also be required. The recommended improvements for this full development condition scenario are described in greater detail in the following Recommended Improvements Section.

Recommended Improvements

Recommended improvements to the citywide sanitary sewer are prioritized to a) enable further development within the existing service area, b) to enable expansion to the five growth areas with 2040 population and employment forecasts, and c) to enable full development of the identified future service area.

The sanitary sewer system capacity improvements were sized to meet requirements for the 5-year wet weather event. The capacity improvement needs for the full development condition (Scenario 13) differ significantly from the needs for the other scenarios (Scenario 1 through Scenario 12). Therefore, the proposed improvements have been sized for two separate development conditions, (1) up to the individual growth areas, Scenarios 1 through 12; and (2) up to the full development conditions, Scenarios 1 through 13.

Alternatively, the sanitary sewer network could be sized to convey the 2-year wet weather rather than the 5-year wet weather. Sizing the sanitary sewer network for the 2-year wet weather would reduce the cost for capacity improvements but would not reduce the risk of overflows and basement backups that potentially occur during the 5-year wet weather. Should the City choose to size the sanitary sewer network for the 2-year wet weather, additional evaluation would be required to determine size and costs of recommended improvements.

Except where noted otherwise, capacity improvements were assumed to be a parallel line sized to convey the peak flow modeled during the wet weather scenario in combination with the existing sanitary sewer. Where the existing sanitary sewer is in poor condition and should be replaced, the new sewer size and associated costs will increase. Approximate capital costs (construction and engineering) for each improvement were estimated using a rate of $17.5 per inch diameter per linear foot of pipe. This estimate is based on an industry standard of $15 to $20 per inch diameter per linear foot of pipe. I/I reduction costs were estimated at $10,000 per acre.

The recommended improvements for this study are outlined in Table 18 through Table 25. The recommended improvements in Table 18 address the deficiencies that occur for current development conditions in the existing service area (Scenario 1 through Scenario 5). To address the deficiencies in the current development conditions, an estimated $1.68 million in recommended pipe improvements is needed within the City and an estimated $11.54 million in recommended pipe improvements is needed in the Regional Trunk Sewer. These improvements are shown spatially in Figure 6 of Appendix A (2007 Report) for Projects 1 through 3, and in Figure 55 for Projects 4 and 5. The highest priority projects to address deficiencies in the current development conditions are located in the Regional Trunk Sewer (Segment 6, Segment 7, and Segment 10).

Table 18. Recommended Improvements to Address Current Development Deficiencies (Scenario 1 through 5)

#	Name	Description	Cost
1	Regional Trunk Sewer, Segment 7[1]	Replace existing sewer with 60-inch	$6,010,000
2	Regional Trunk Sewer, Segment 10[1]	Replace existing sewer with 48-inch	$1,810,000
3	Regional Trunk Sewer, Segment 6[1]	Replace existing sewer with 60-inch	$3,720,000
4	Indian Creek Basin, Trunk Line – 10th Street to Alburnett Road (0.5 miles of sewer pipe)	Additional 5.8 MGD sewer capacity (2x existing capacity)	$1,190,000
5	Indian Creek Basin, Main Line – Alburnett Road and Larick Drive (0.6 miles of sewer pipe)	Additional 1.2 MGD sewer capacity (2x existing capacity)	$490,000
Total Cost			In Indian Creek basin: $1,680,000 Regional Trunk Sewer[1]: $11,540,000 **Total: $ 13,220,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

The recommended improvements in Table 19, in conjunction with Table 18, address the deficiencies that occur in 2040 population and employment in the current service area conditions (Scenario 6 and Scenario 7). To address the deficiencies in these two conditions, all improvements listed in Table 18 and Table 19 are needed. The total combined cost (Table 18 and Table 19) for recommended pipe improvements to address deficiencies (Scenario 1 through Scenario 7) within the City is $4.08 million, the total cost for recommending I/I reduction improvements is $8.55 million, and the total cost for recommended improvements in the Indian Creek/Dry Run Creek regional trunk sewer $32.23 million. Project 6, Project 7, and Project 9 are shown spatially in Figure 56 through Figure 58, respectively. Project 8 is shown in Figure 6 of Appendix A.

Table 19. Recommended Improvements to Address 2040 population and employment in Current Service Area Deficiencies (Scenario 6 and 7)

#	Name	Description	Cost
6	Christopher Creek Basin, Trunk Line – Cambridge Drive NE to Dry Run Creek Trunk, part of Segment 12 (0.58 miles of sewer pipe)	Additional 30 MGD sewer capacity (3x existing capacity)	$2,260,000
7	Squaw Creek Basin, Main Line – South of Chapelridge Circle, near Ski Lodge Road (585 LF of sewer pipe)	Replace existing with 15-inch	$150,000
8	Regional Trunk Sewer, (Segments 3, 4, 5, 8, 9, 11)[1]	Replace existing sewer with 48-inch (Segments 8, 9, 11), 54-inch (Segment 11), and 60-inch (Segments 3, 4, and 5)	$20,690,000
9	Lower Indian Creek Basin, I/I reduction in Old Marion	Reduce I/I through pipe sliplining, disconnecting illegal connections (downspouts and sump pumps), etc.	$8,550,000
Total Cost (Including Table 18 Projects)			In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional Trunk Sewer[1]: $32,230,000 **Total: $ 44,870,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

Tables 20 through 24 show the recommended improvements for the five growth scenarios. The recommended improvement for Growth Area 1 (Scenario 8) is shown in Table 4 and in Figure 59. The total cost for the recommended improvements for Growth Area 1 (including Table 2 and Table 3) within the City is $12.74 million. Recommended improvements for Growth Area 2 (Scenario 9) are shown in Table 5 and in Figure 60 through Figure 63. The total cost for the recommended improvements in Growth Area 2 (including Table 2 and Table 3) within the City is $24.67 million. Recommended improvements for Growth Area 3 (Scenario 10) are shown in Table 6 and Figure 64. The total cost for the recommended improvements in Growth Area 3 (including Table 2 and Table 3) within the City is $28.06 million. Recommended improvements for Growth Area 4 (Scenario 11) are shown in Table 7 and Figure 65. The total cost for the recommended improvements (including Table 2 and Table 3) within the City is $14.70 million. Recommended improvements for Growth Area 5 (Scenario 12) are shown in Table 8 and Figure 66. The total cost for the recommended improvements (including Table 2 and Table 3) within the City is $14.76 million.

Table 20. Recommended Improvements to Address Growth Area 1 (Scenario 8)

#	Name	Description	Cost
10	Christopher Creek Basin, Growth Area 1 – New Sewer	Extend sewer in Growth Area 1 to accommodate additional flow.	$100,000
Total Cost (Including Table 18 and Table 19 Projects)			In Christopher Creek basin: $2,360,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 44,970,000**

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 21. Recommended Improvements to Address Growth Area 2 (Scenario 9)

#	Name	Description	Cost
11	Indian Creek Basin, Growth Area 2 – New Sewer	Extend sewer in Growth Area 2 to accommodate additional flow.	$4,170,000
12	Indian Creek Basin, Trunk Line – Berrys Run Creek trunk to 10th Street (2.2 miles of sewer pipe)	Additional 1.0 MGD sewer capacity (1.5x existing capacity)	$4,400,000
13	Indian Creek Basin, Trunk Line – Alburnett Road to W 8th Street (0.4 miles of sewer pipe	Additional 5 MGD sewer capacity (2x existing capacity)	$910,000
14	Indian Creek Basin, Berrys Run Creek Trunk Line – Valentine Circle to Indian Creek trunk (1.4 miles of sewer pipe)	Additional 1.8-7.9 MGD (average 2.0x existing capacity)	$2,550,000
Total Cost (Including Table 18 and Table 19 Projects)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $13,710,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 56,900,000**	

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 22. Recommended Improvements to Address Growth Area 3 (Scenario 10)

#	Name	Description	Cost
15	Indian Creek Basin, Growth Area 3 – New Sewer	Extend sewer in Growth Area 3 to accommodate additional flow.	$7,950,000
16	Indian Creek Basin, Trunk Line – Stanley Cup Drive to Berrys Run Creek trunk (2.2 miles of sewer pipe)	Additional 4.3 MGD sewer capacity (2.5x existing capacity)	$2,160,000
Total Cost (Including Table 18, Table 19 Projects, and Project 12 and 13 from Table 21)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $150,000 In Indian Creek basin: $17,100,000[1] In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[2]: $32,230,000 **Total: $ 60,290,000**	

[1] Also Includes Projects 12 and 13 from Table 21 because those projects are needed to address deficiencies in both Growth Areas

[2] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 23. Recommended Improvements to Address Growth Area 4 (Scenario 11)

#	Name	Description	Cost
17	Squaw Creek Basin, Growth Area 4 – New Sewer	Extend sewer in Growth Area 4 to accommodate additional flow.	$710,000
18	Squaw Creek Basin, Trunk Line – Grant Wood Trail to south of 3rd Avenue (0.6 miles of sewer pipe)	Replace existing sewer with 24-inch	$1,350,000
Total Cost (Including Table 18 and Table 19 Projects)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $2,210,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $32,230,000 **Total: $ 46,930,000**	

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

Table 24. Recommended Improvements to Address Growth Area 5 (Scenario 12)

#	Name	Description	Cost
19	Squaw Creek Basin, Growth Area 5 – New Sewer	Extend sewer in Growth Area 5 to accommodate additional flow.	$1,260,000
20	Squaw Creek Basin, Main Line along Grant Wood Trail – Partners Avenue to east of Highway 13 (0.6 miles of sewer pipe)	Replace existing sewer with 15-inch	$860,000
Total Cost (Including Table 18 and Table 19 Projects)		In Christopher Creek basin: $2,260,000 In Squaw Creek basin: $2,270,000 In Indian Creek basin: $1,680,000 In Lower Indian Creek basin: $8,550,000 Regional Trunk Sewer[1]: $32,230,000 **Total: $ 46,990,000**	

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer.

The recommended improvements and total costs for the full development condition are shown in Table 25. Also included in Table 25 are the Figures that correspond to each project that is recommended for Full Development Conditions. The total cost for the recommended improvements within the City is $44.85 million and the total cost for recommended improvements in the Regional Trunk Sewer is $37.83 million.

The modeling included in this evaluation indicate that Regional Trunk Sewer downstream of segment 8 has capacity to convey the additional sanitary flows for full development conditions. However, the model does not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids) that are served by the regional trunk sewer. Future growth beyond the study area may actually limit the available capacity of the Regional Trunk Sewer. If future growth does limit the capacity of the Regional Trunk Sewer, then full development conditions in the study area may not be achievable. A further investigation of the overall Indian Creek/Dry Run Creek sewersheds would be required to quantify the available capacity of the recommended improvements in the Regional Trunk Sewer. This further investigation should be completed before the recommended improvements identified in this TM are designed and constructed.

Table 25. Recommended Improvements to Address Full Development Conditions (Scenario 13)

#	Name	Description	Cost	Figure
1	Regional Trunk Sewer, Segment 7[1]	Replace existing sewer with 60-inch	$6,010,000	6, App. A
2	Regional Trunk Sewer, Segment 10[1]	Replace existing sewer with 48-inch	$1,810,000	6, App. A
3	Regional Trunk Sewer, Segment 6[1]	Replace existing sewer with 60-inch	$3,720,000	6, App. A
5	Indian Creek Basin, Main Line – Alburnett Road and Larick Drive (0.6 miles of sewer pipe)	Additional 1.2 MGD sewer capacity (2x existing capacity)	$490,000	55
6	Christopher Creek Basin, Trunk Line – Cambridge Drive NE to Dry Run Creek Trunk, part of Segment 12 (0.58 miles of sewer pipe)	Additional 30 MGD sewer capacity (3x existing capacity)	$2,260,000	56
7	Squaw Creek Basin, Main Line – South of Chapelridge Circle, near Ski Lodge Road (585 LF of sewer pipe)	Replace existing sewer with 15-inch	$150,000	57
8	Regional Trunk Sewer, (Segments 3, 4, 5, 8, 9, 11)[1]	Replace existing sewer with 48-inch (Segments 8, 9, 11), 54-inch (Segment 11), and 60-inch (Segments 3, 4, and 5)	$20,690,000	6, App. A
9	Lower Indian Creek Basin, I/I reduction in Old Marion	Reduce I/I through pipe sliplining, disconnecting illegal connections (downspouts and sump pumps), etc.	$8,550,000	58
10	Christopher Creek Basin, Growth Area 1 – New Sewer	Extend sewer in Growth Area 1 to accommodate additional flow.	$100,000	59
11	Indian Creek Basin, Growth Area 2 – New Sewer	Extend sewer in Growth Area 2 to accommodate additional flow.	$4,170,000	60
14	Indian Creek Basin, Berrys Run Creek Trunk Line – Valentine Circle to Indian Creek trunk (1.4 miles of sewer pipe)	Additional 1.8-7.9 MGD (average 2.0x existing capacity)	$2,550,000	63

#	Name	Description	Cost	Figure
15	Indian Creek Basin, Growth Area 3 – New Sewer	Extend sewer in Growth Area 3 to accommodate additional flow.	$7,950,000	64
17	Squaw Creek Basin, Growth Area 4 – New Sewer	Extend sewer in Growth Area 4 to accommodate additional flow.	$710,000	65
19	Squaw Creek Basin, Growth Area 5 – New Sewer	Extend sewer in Growth Area 5 to accommodate additional flow.	$420,000	66
20	Squaw Creek Basin, Main Line along Grant Wood Trail – Partners Avenue to east of Highway 13 (0.6 miles of sewer pipe)	Replace existing sewer with 15-inch	$860,000	66
21	Indian Creek Basin, Trunk Line – Stanley Cup Drive to W 8th Avenue (3.7 miles of sewer pipe)	Additional 3.5-21.1 MGD (average 3.0x existing capacity)	$12,660,000	68/69
22	Squaw Creek Basin, Trunk Line – Grant Wood Trail to south of 3rd Avenue (0.6 miles of sewer pipe)	Replace existing sewer with 27-inch	$1,520,000	67
23	Regional Trunk Sewer, Additional Segment 10 through Segment 8[2] (1.7 miles of sewer pipe)	Additional 17 MGD (average 2x more capacity than what is presented in 2007 Report)	$5,600,000	69
24	Squaw Creek Basin, Trunk Line – South of 3rd Avenue to south of Ski Lodge Road (1.1 miles of sewer pipe)	Additional 4.5 MGD (average 1.8x existing capacity)	$2,460,000	67
Total Cost		In Christopher Creek basin: $2,360,000 In Squaw Creek basin: $6,120,000 In Indian Creek basin: $27,820,000 In Lower Indian Creek basin: $8,550,000 Regional trunk Sewer[1]: $37,830,000 **Total: $ 82,680,000**		

[1] These are priority improvements that were identified in the 2007 Report regarding the Regional Trunk Sewer. The segments are shown spatially in Figure 6 of Appendix A.

[2] This improvement is required in addition to the already planned sewer replacement as described in the 2007 Report.

Conclusions

In 2019, a hydraulic model was developed and calibrated for the Indian Creek Basin sanitary sewer system. Results of the 2019 Study are presented in *Technical Memorandum 5: Capacity Analysis.* The objective of this 2020 Sanitary Sewer Capacity Study was to provide a detailed and accurate evaluation of the remainder of the City's sanitary sewer system, including the Christopher & Dry Run Creek, Lower Indian Creek, and Squaw Creek Basins. The evaluation presented in this TM includes model calibration using flow meter data, determining current and future capacity deficiencies in the citywide sanitary sewer system, identifying recommended improvements to address deficiencies, and developing costs for the recommended improvements.

Model results indicate that the existing sanitary sewer system has sufficient capacity to convey the dry weather flows for all evaluated scenarios except Scenario 12 and Scenario 13. In Scenario 12 there is one segment of pipe in the Squaw Creek Basin that does not have the capacity to convey the additional flows from Growth Area 5. In Scenario 13, the existing sanitary sewer system in capacity deficient in several locations including along the Indian Creek, Berrys Run Creek, and Dry Run Creek trunk sewers.

Model results indicate that the existing system does not have the capacity to convey sanitary flows for the 2-year and 5-year wet weather events for both existing conditions (Scenario 1) and for several future development conditions (Scenarios 8 through Scenario 11, and Scenario 13). Additionally, model results indicate that even with all recommended improvements to the Regional Trunk Sewer, there are still several capacity deficiencies within the Indian Creek Basin during existing development conditions (Scenario 1 and Scenario 2). The capacity deficiencies within the Indian Creek Basin for existing development conditions are located along the Indian Creek trunk line between 10th Street to Alburnett Road and along Alburnett Road and Larick Drive, west of Indian Creek. These capacity deficiencies predict surcharges which could potentially result in SSOs and basement backups during the 2-year and 5-year wet weather events. The deficiencies within the Indian Creek Basin would require $1.68 million in improvements to prevent the risk of the potential SSOs and basement backups in the area.

Additional sanitary flow (Growth Areas) cannot currently be added to the sanitary sewer system upstream of without increasing the risk of potential sanitary overflows and basement backups during wet weather events. The following recommendations were identified to address the capacity deficiencies in the sewer system. These improvements would then allow for growth throughout the City without increasing the risk of the potential overflows and basement backups.

- An estimated $1.68 million dollars in sanitary sewer pipe improvements in the Indian Creek Basin and $11.54 million dollars in sanitary sewer improvements in the Regional Trunk Sewer (Segment 6, Segment 7, and Segment 10) to address the capacity deficiencies that occur during the current development (existing conditions scenario) wet weather events. The highest priority improvements, to address current development deficiencies, are Segment 7, Segment 10, and Segment 6.
- An estimated total $4.09 million dollars in sanitary sewer pipe improvements, an estimated $8.55 million in I/I reduction improvements, and a total of $32.23 million dollars in sanitary sewer improvements the Regional Trunk Sewer (Segment 3 through

Segment 11) are needed to convey flows for the projected 2040 population and employment in Current Service Area (Scenario 6 and Scenario 7). The I/I reduction improvements are needed to address deficiencies in the Lower Indian Creek Basin (including the Uptown District); if I/I improvements are not completed, then additional sewer pipe should be added to meet the future capacity needs.

- In addition to the recommended improvements and costs listed above, the following recommended improvements and costs would be required to address deficiencies for the five growth areas around the City:
  - Growth Area 1 (Christopher Creek Basin): An estimated $100,000 to construct a new interceptor line in the growth area.
  - Growth Area 2 (Berrys Run Creek/Indian Creek Basin): An estimated $4.17 million to construct new interceptor lines in the growth area, and an estimated $7.86 million in sewer pipe improvements.
  - Growth Area 3 (Indian Creek Basin): An estimated $7.95 million to construct new interceptor lines in the growth area, and an estimated $7.47 million in sewer pipe improvements.
  - Growth Area 4 (Squaw Creek Basin): An estimated $710,000 to construct a new interceptor line in the growth area, and an estimated $1.35 million in sewer pipe improvements.
  - Growth Area 5 (Squaw Creek Basin and Lower Indian Creek Basin): An estimated $1.26 million to construct a new interceptor line in the growth area, and an estimated $860,000 in sewer pipe improvements.
- The modeling and results do not represent any future growth in areas beyond the study area (Robins, Hiawatha, or Cedar Rapids) that are served by the downstream regional trunk sewer. An additional investigation of the complete Indian Creek/Dry Run Creek sewersheds to quantify the future available capacity of the Regional Trunk Sewer (Segment 3 through Segment 11) should be completed. If future growth does limit the capacity of the Regional Trunk Sewer, then full development conditions in the study area may not be achievable.

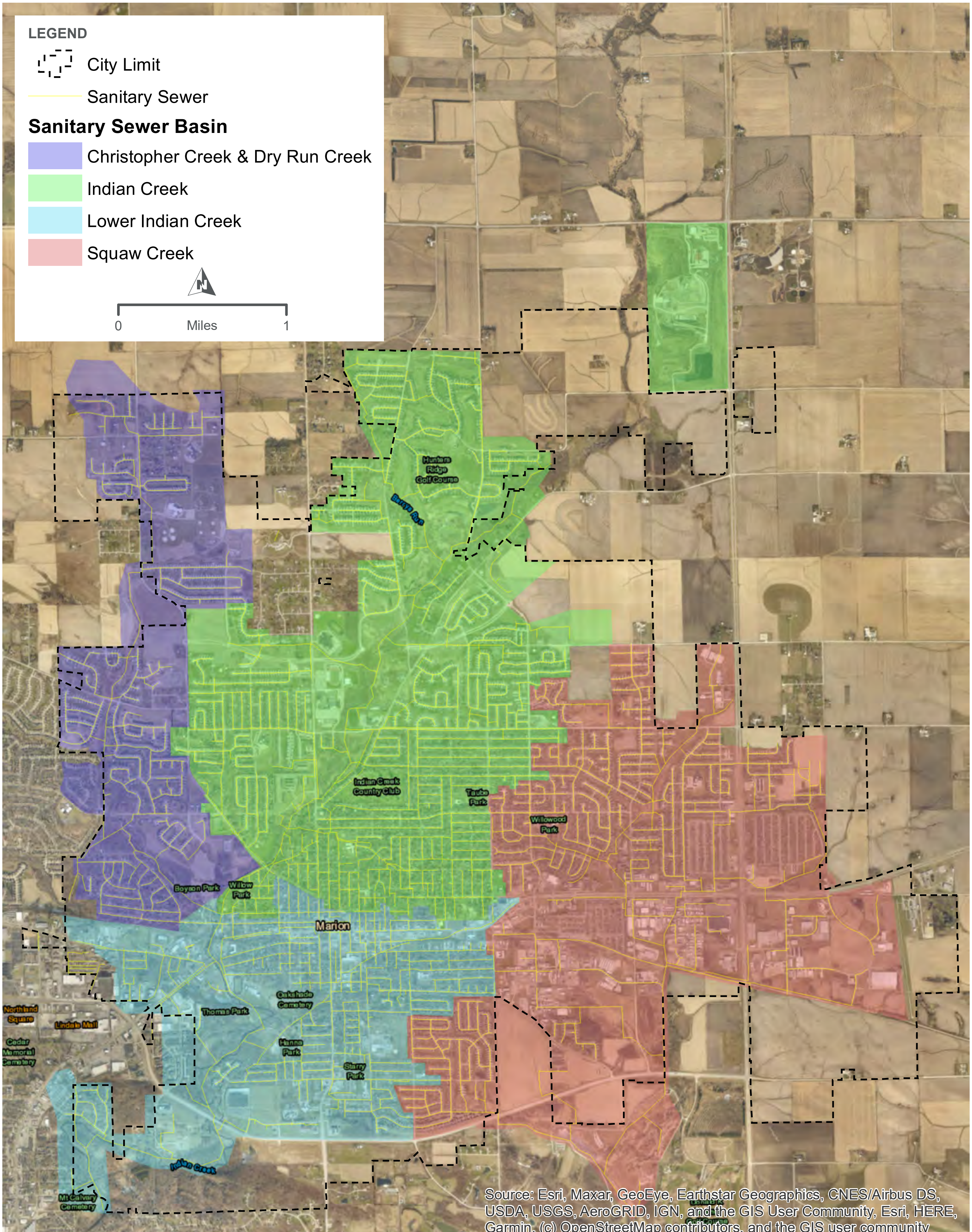
The recommended capacity improvements were sized to convey the 5-year wet weather event. However, the sanitary sewer network could be sized to convey the 2-year wet weather rather than the 5-year wet weather. Sizing the sanitary sewer network for the 2-year wet weather event would reduce the cost for capacity improvements but would not reduce the risk of overflows and basement backups that potentially occur during the 5-year wet weather event. Should the City choose to size the sanitary sewer network for the 2-year wet weather, additional evaluation would be required to determine size and costs of recommended improvements.

References

ASCE. (2007). *Engineering Practice No. 60, Gravity Sewer Design and Construction.*

IDNR. (1987). *IOWA WASTEWATER FACILITIES DESIGN STANDARDS: Chapter 12 Iowa Standards for Sewer Systems.*

Figures



HDR City of Marion IOWA

PRIMARY SANITARY SEWER BASINS

CITY OF MARION, IA

FIGURE 1

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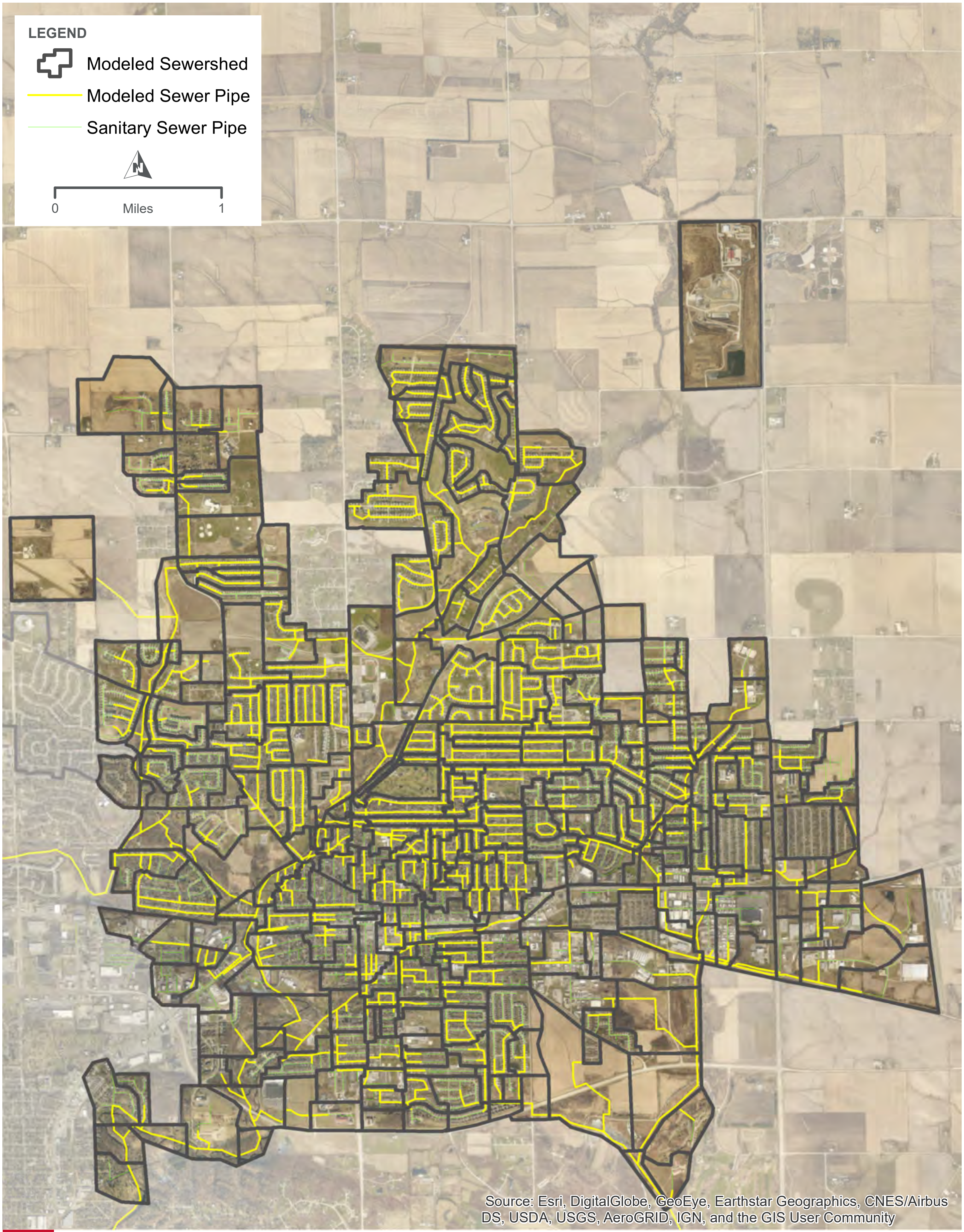
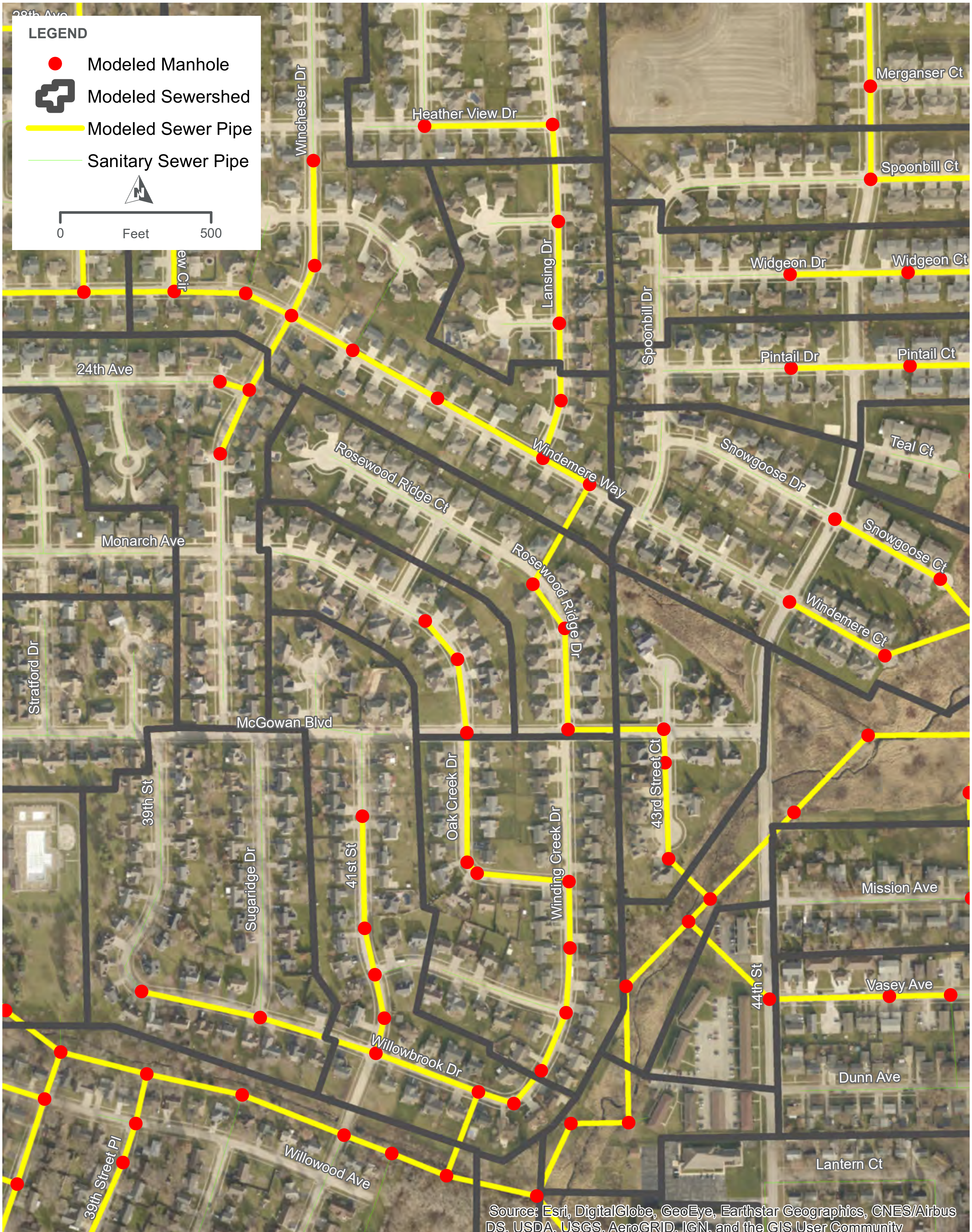


MODELED SEWER NETWORK

CITY OF MARION, IA

FIGURE 2



EXAMPLE SEWERSHEDS AND MODELED NETWORK

CITY OF MARION, IA

FIGURE 3

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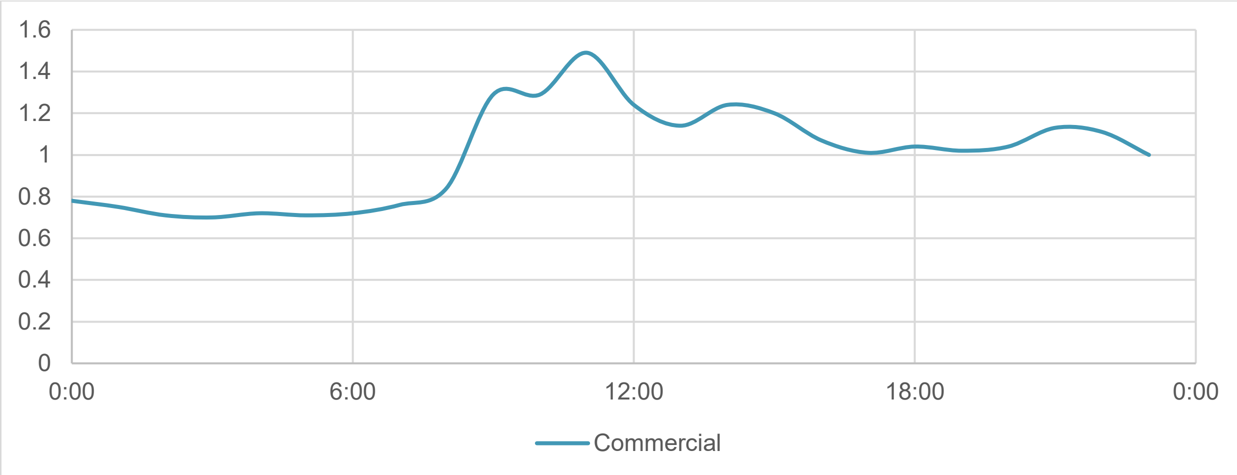


Figure 4. Commercial Diurnal Pattern developed for the Cedar Rapids Metropolitan Area

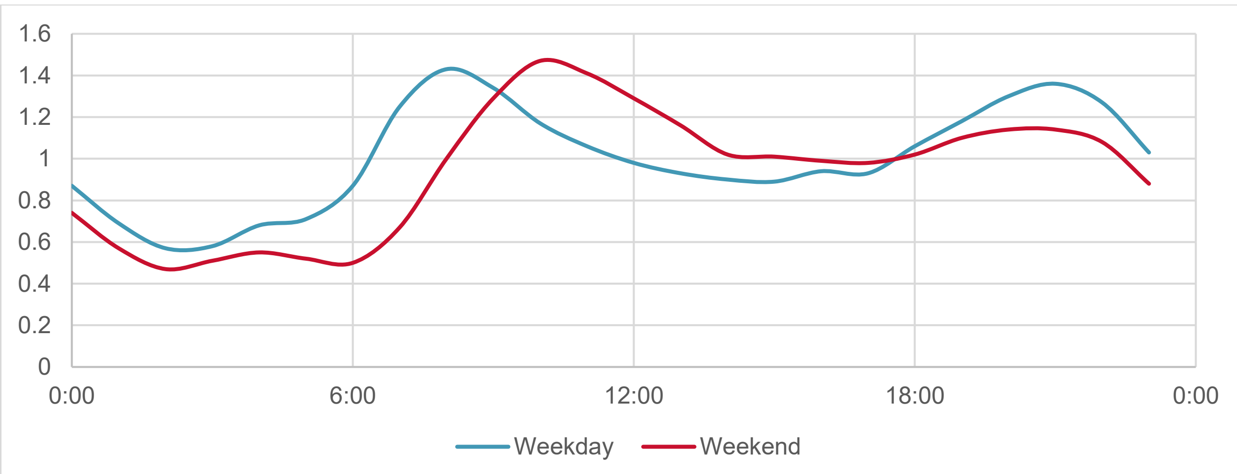


Figure 5. Residential Diurnal Pattern from 2019 Study - Meter 1

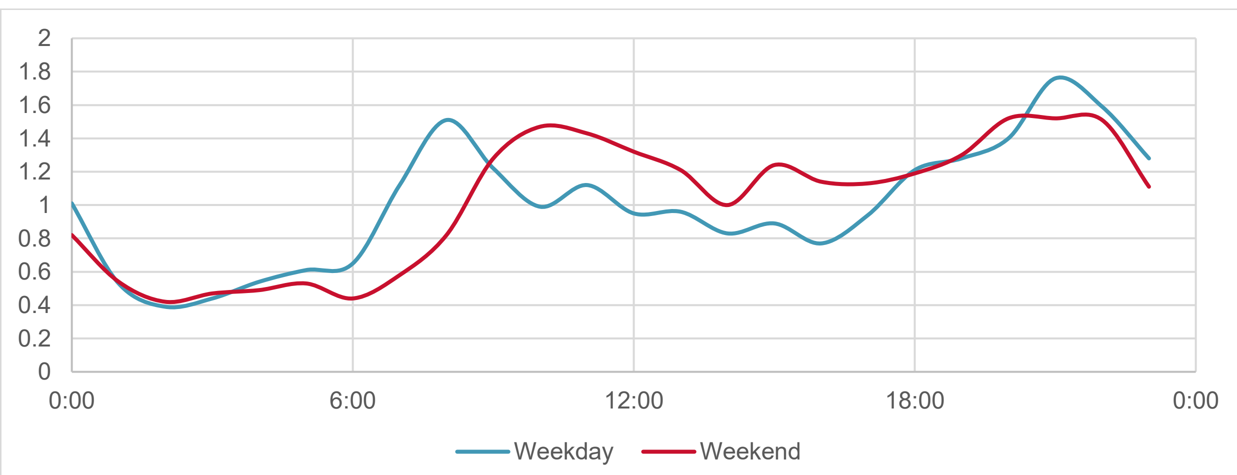


Figure 6. Residential Diurnal Pattern from 2019 Study - Meter 2

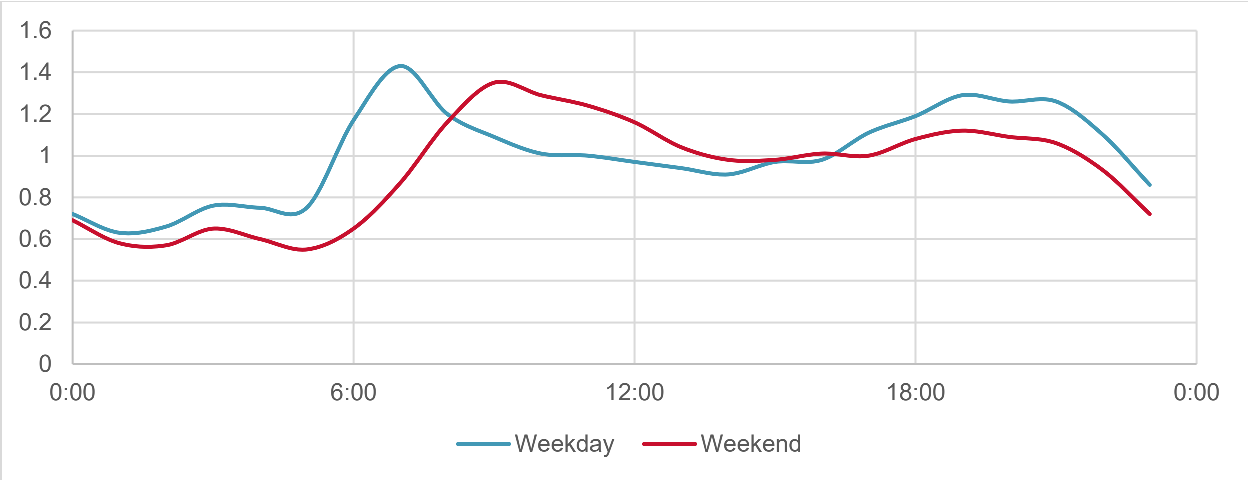


Figure 7. Residential Diurnal Pattern from 2019 Study - Meter 3

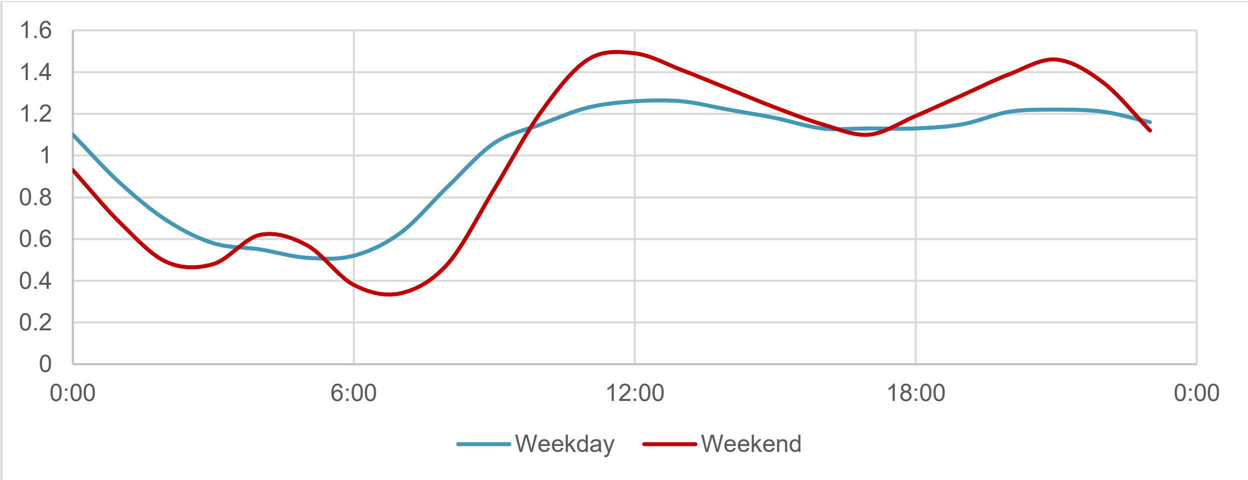


Figure 8. Residential Diurnal Pattern for 2020 Study – Meter 4

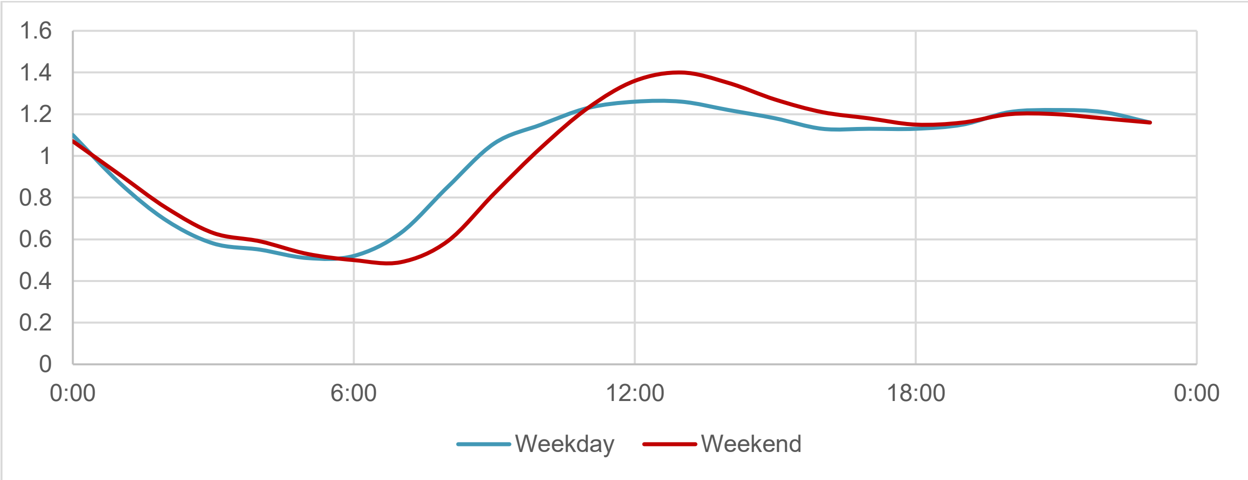


Figure 9. Residential Diurnal Pattern for 2020 Study – Meter 5

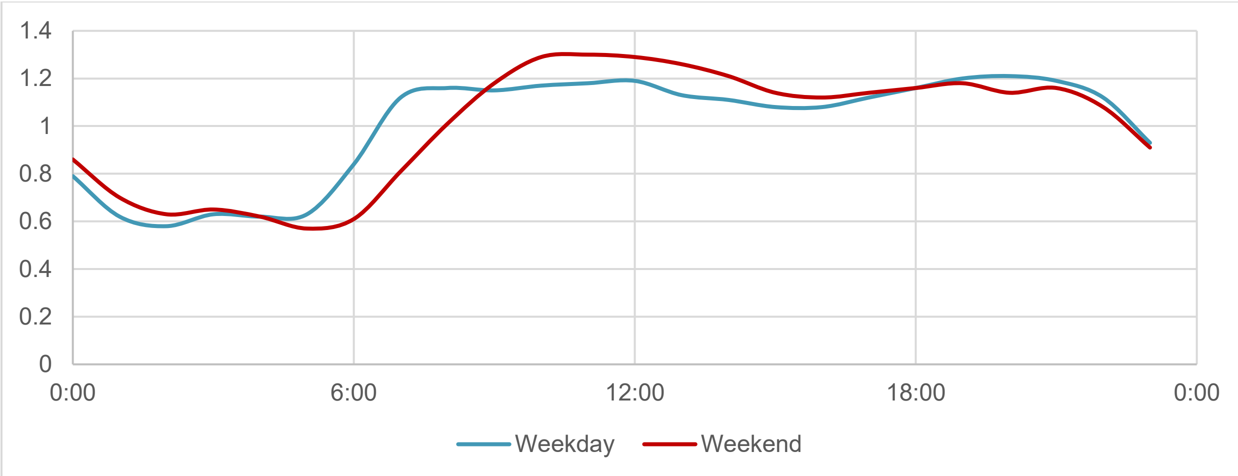


Figure 10. Residential Diurnal Pattern for 2020 Study – Meter 6

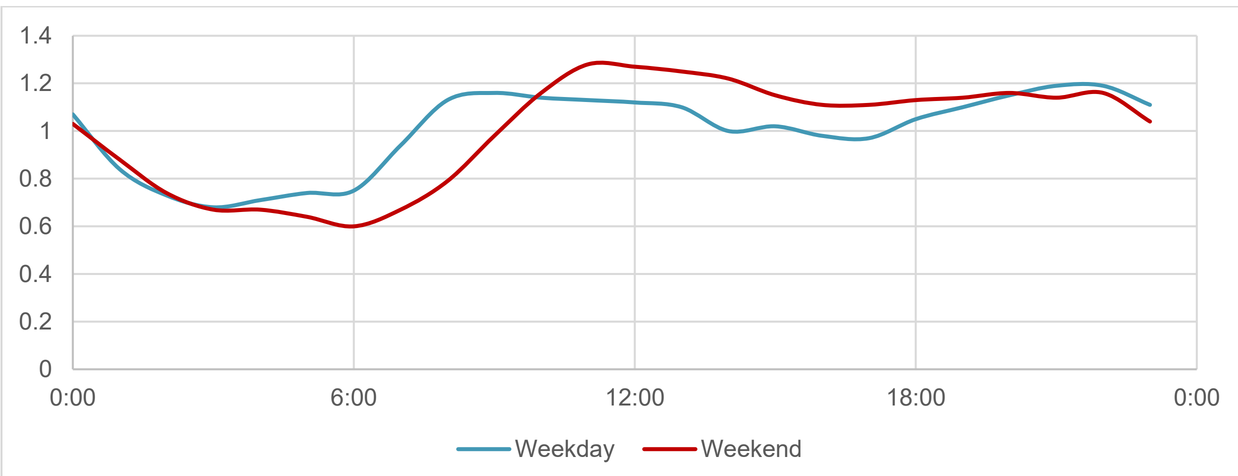


Figure 11. Residential Diurnal Pattern for 2020 Study – Meter 7

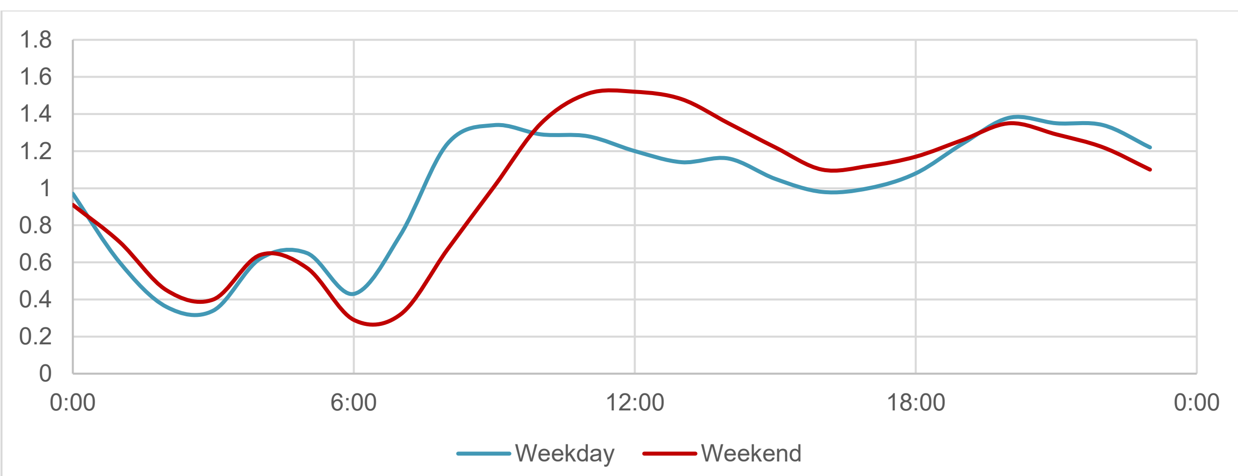


Figure 12. Residential Diurnal Pattern for 2020 Study – Meter 8

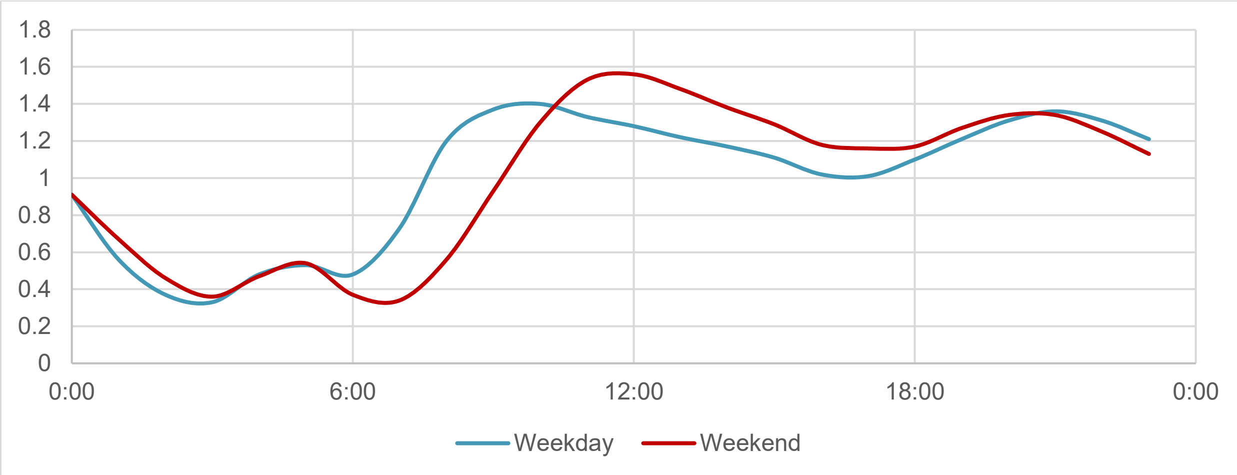


Figure 13. Residential Diurnal Pattern for 2020 Study – Meter 9

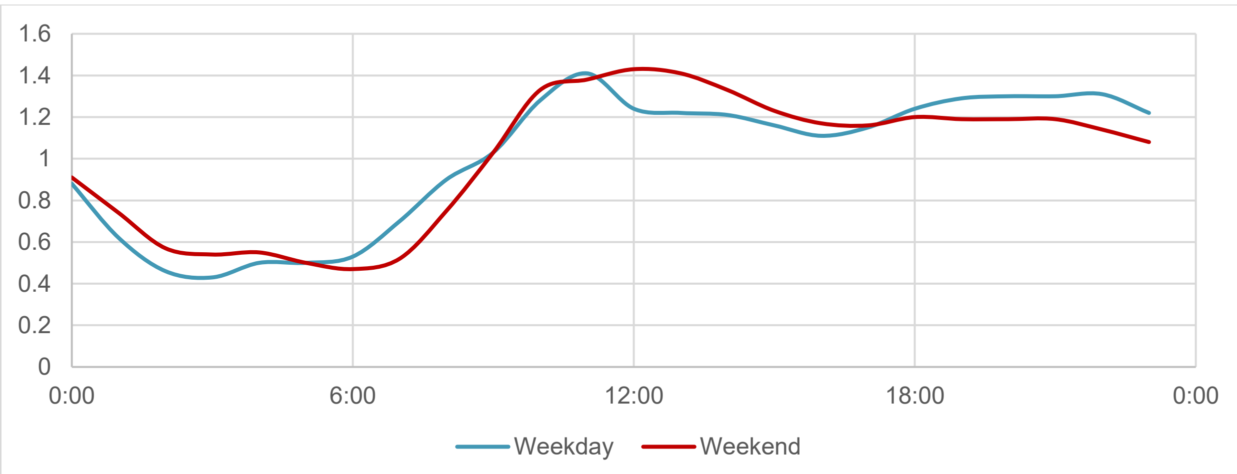


Figure 14. Residential Diurnal Pattern for 2020 Study – Meter 10

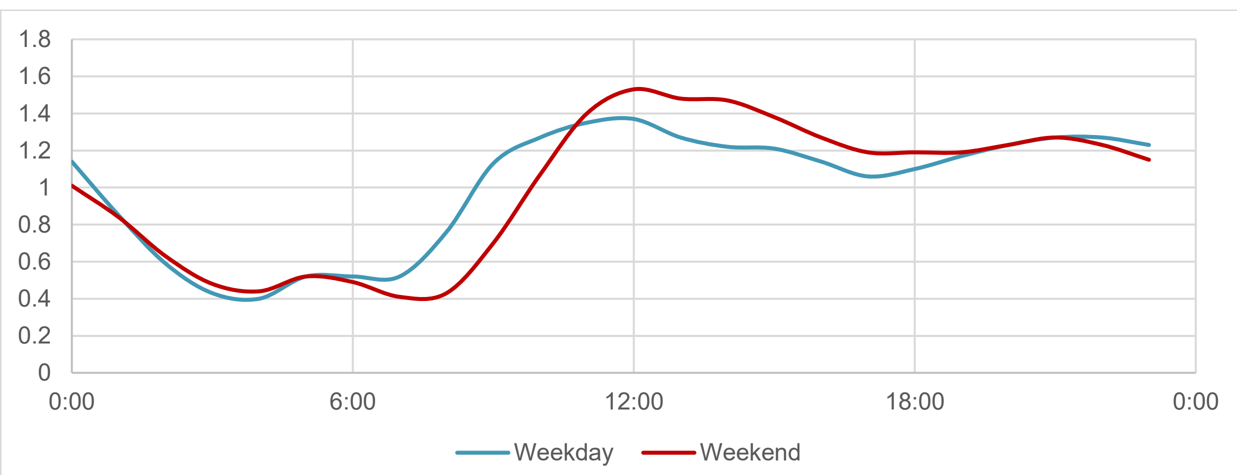
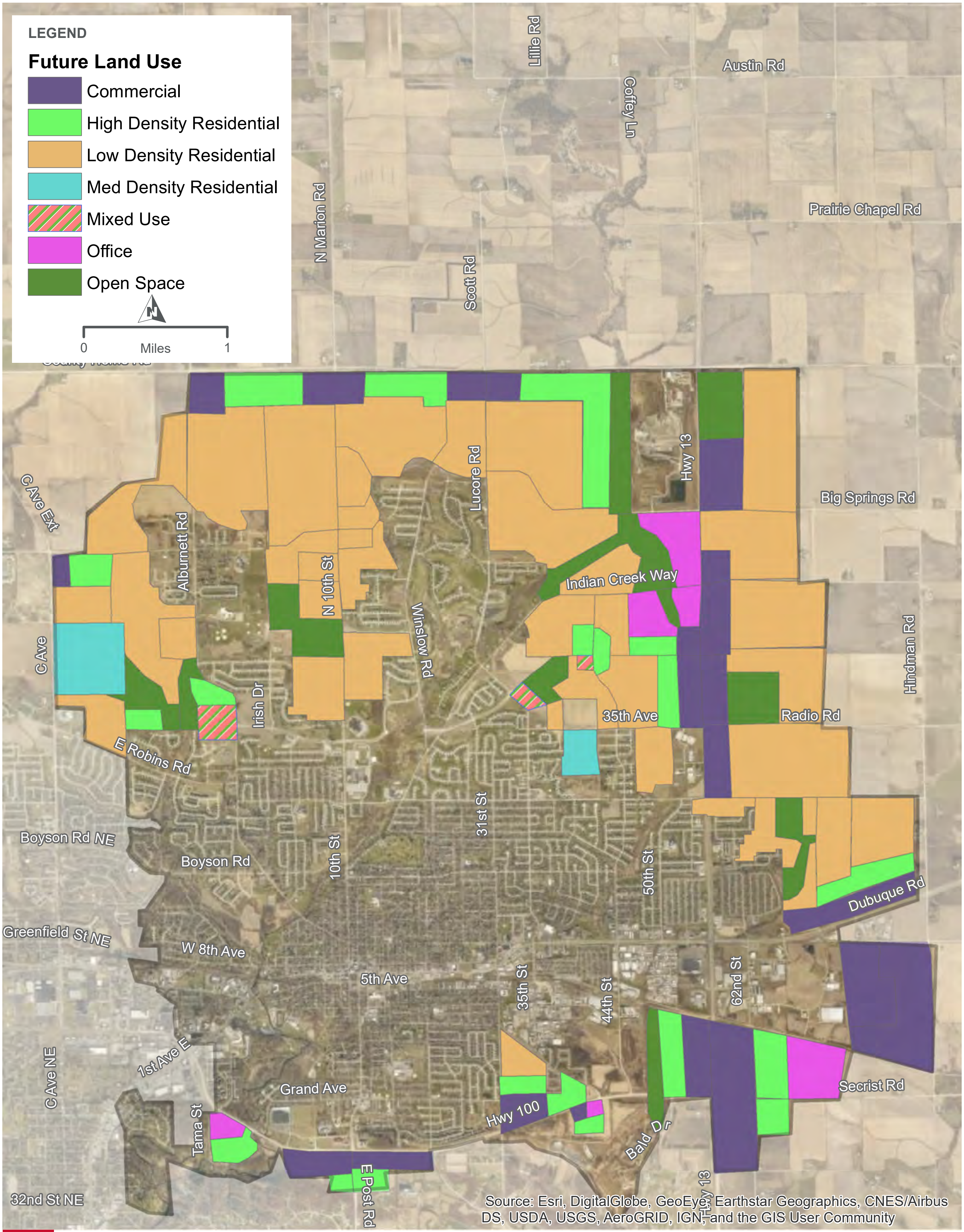


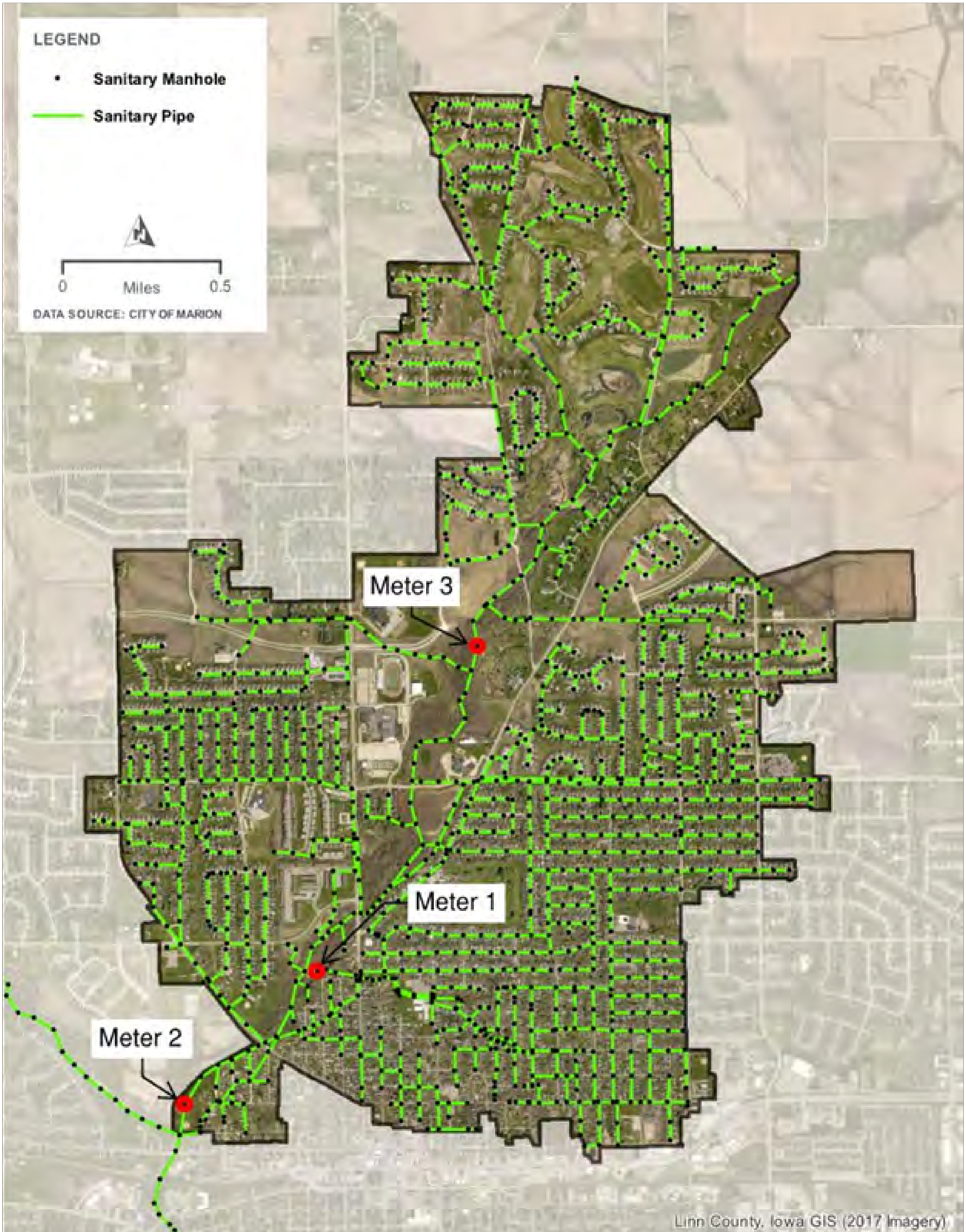
Figure 15. Residential Diurnal Pattern for 2020 Study – Meter 11



FUTURE LAND USE PLAN

CITY OF MARION, IA

FIGURE 16



2019 STUDY FLOW METER LOCATIONS

CITY OF MARION, IA

FIGURE 17

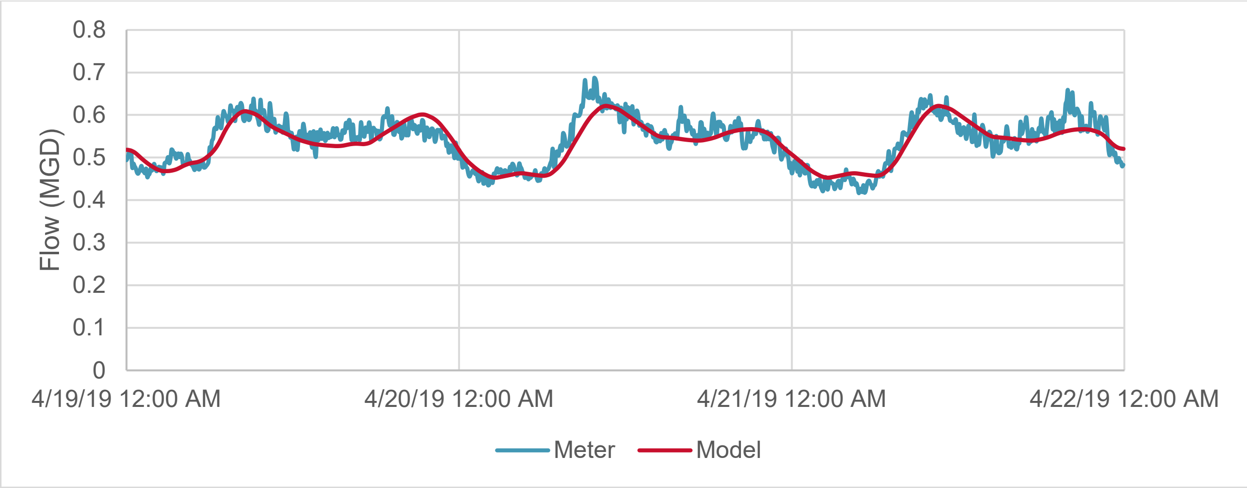


Figure 18. Base Flow Calibration Results - Meter 1

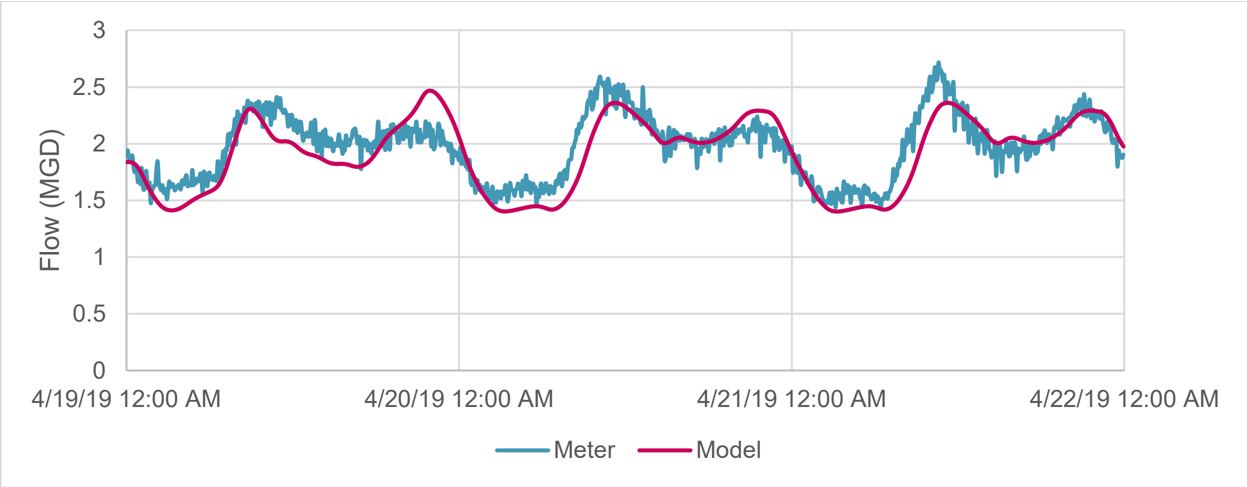


Figure 19. Base Flow Calibration Results - Meter 2

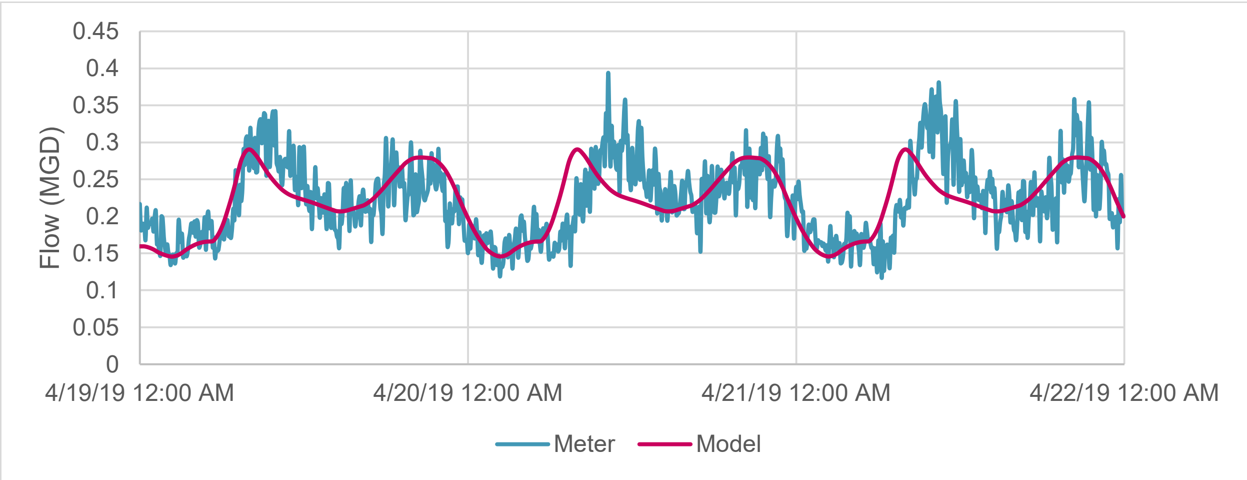


Figure 20. Base Flow Calibration Results - Meter 3

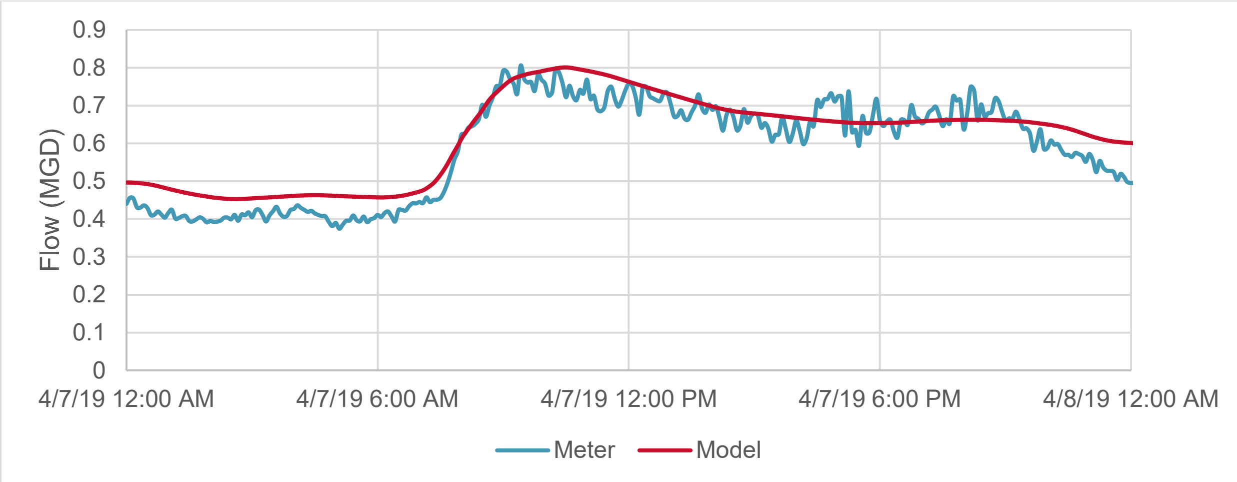


Figure 21. RDII Calibration Results – Meter 1

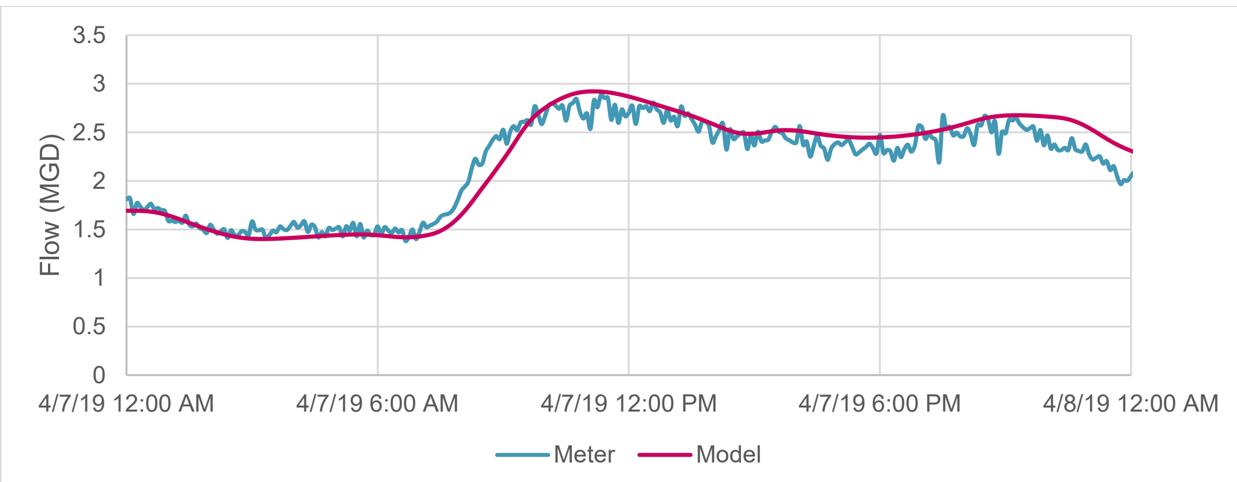


Figure 22. RDII Calibration Results – Meter 2

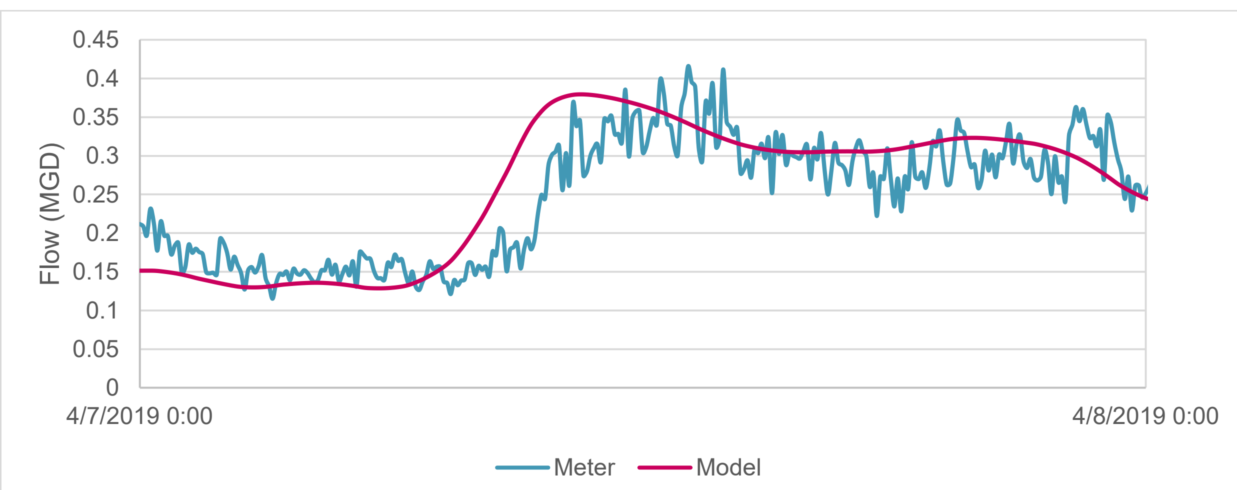
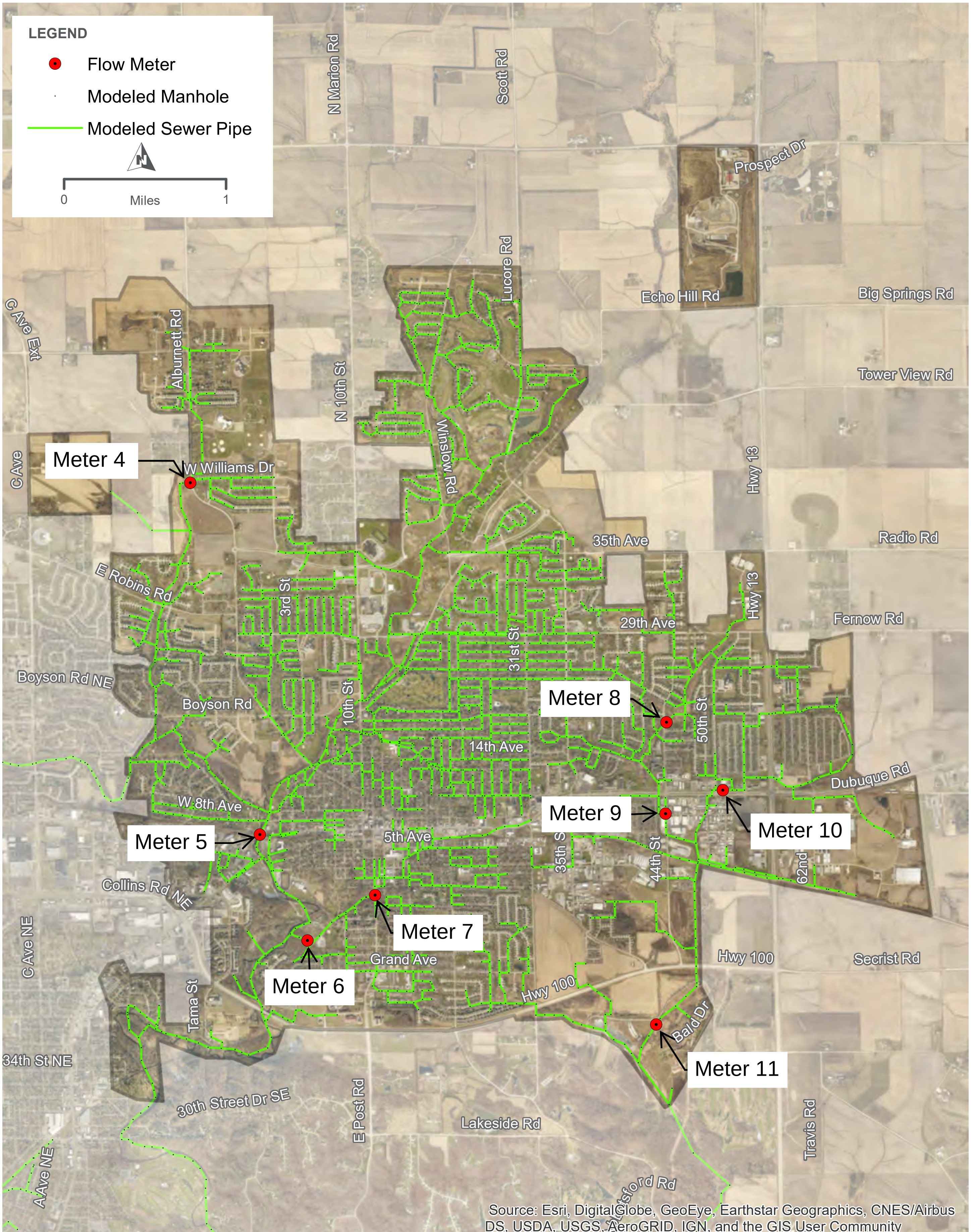


Figure 23. RDII Calibration Results – Meter 3



2020 STUDY FLOW METER LOCATIONS

CITY OF MARION, IA

FIGURE 24

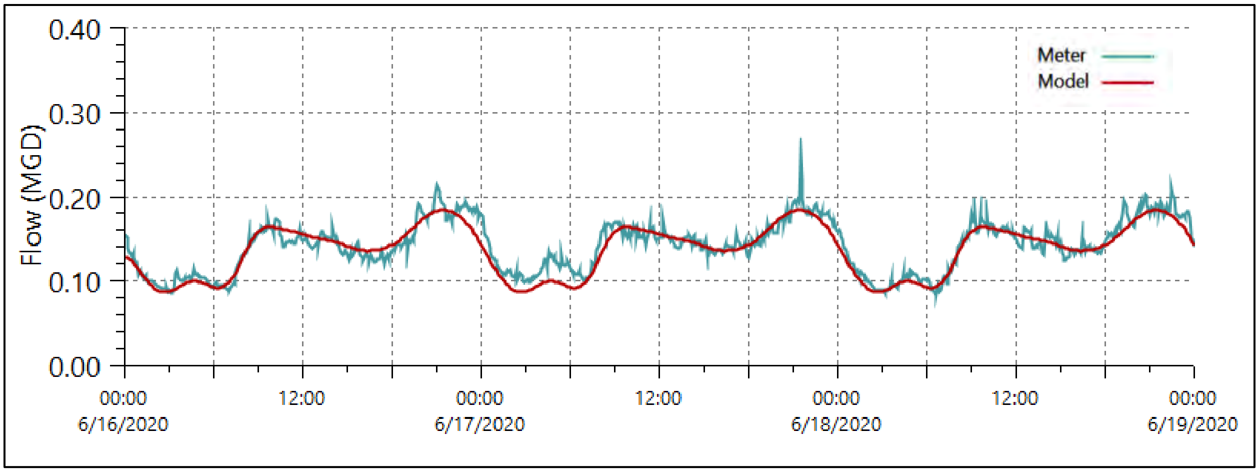


Figure 25. Base Flow Calibration Results - Meter 4

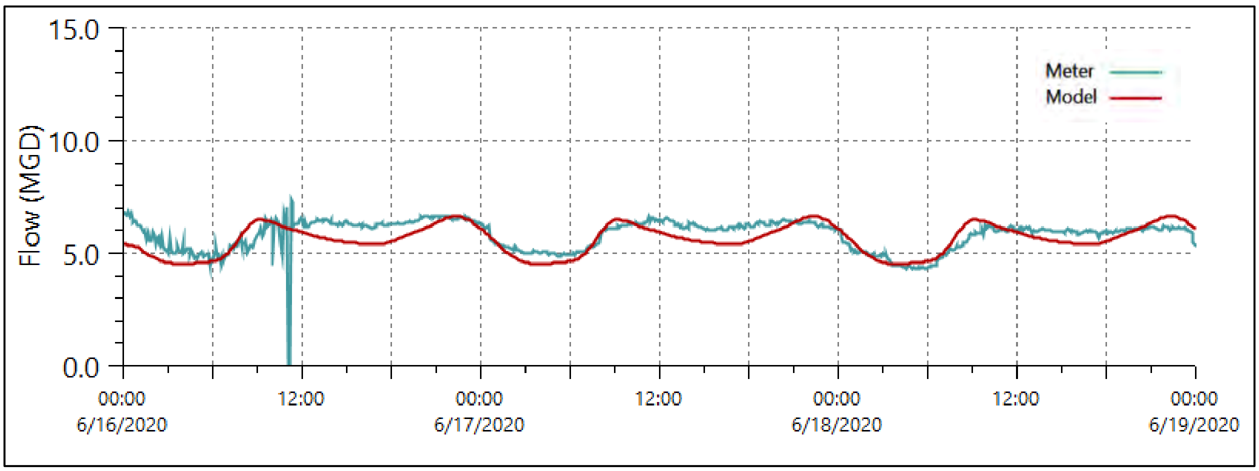


Figure 26. Base Flow Calibration Results - Meter 5

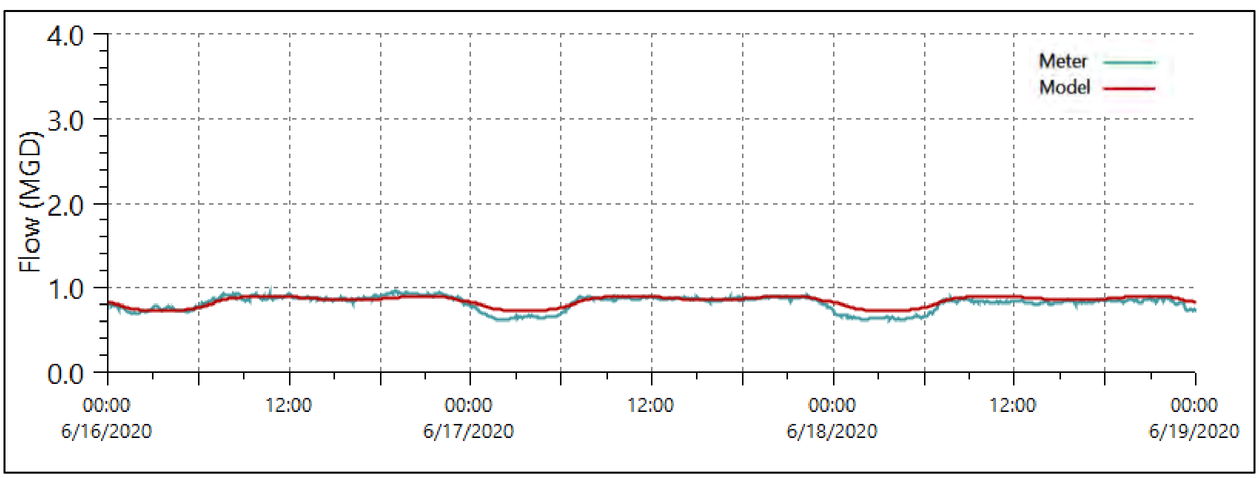


Figure 27. Base Flow Calibration Results - Meter 6

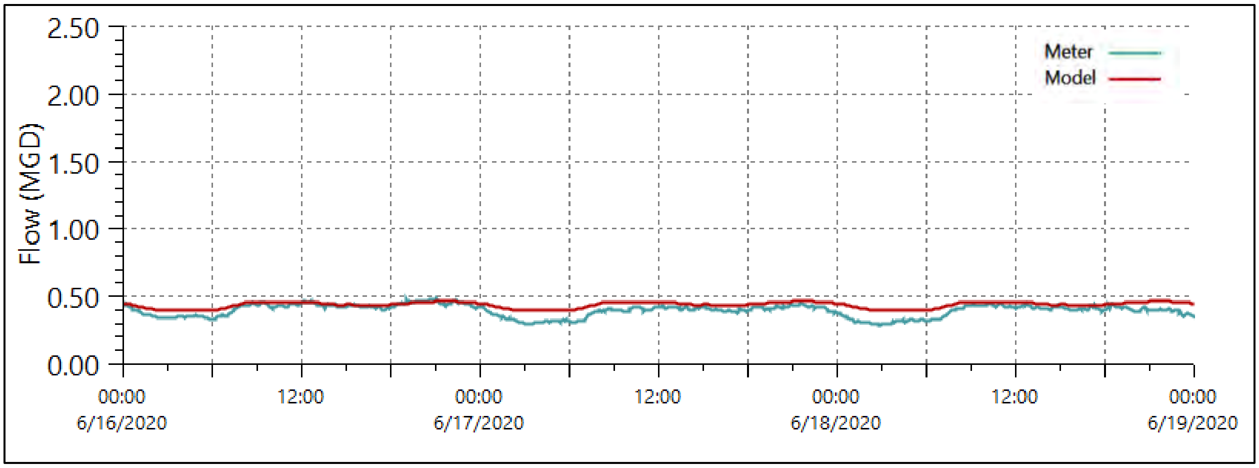


Figure 28. Base Flow Calibration Results - Meter 7

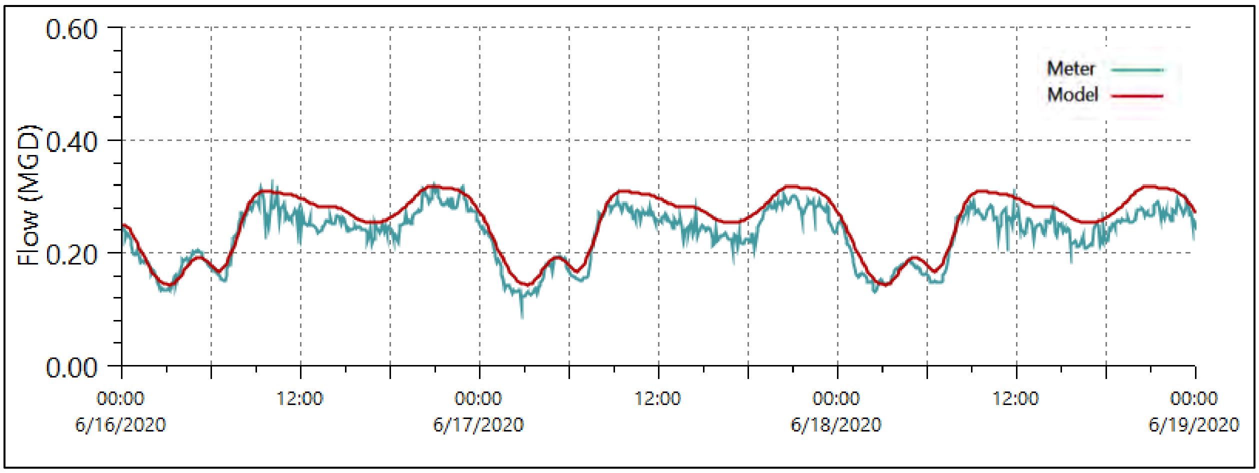


Figure 29. Base Flow Calibration Results - Meter 8

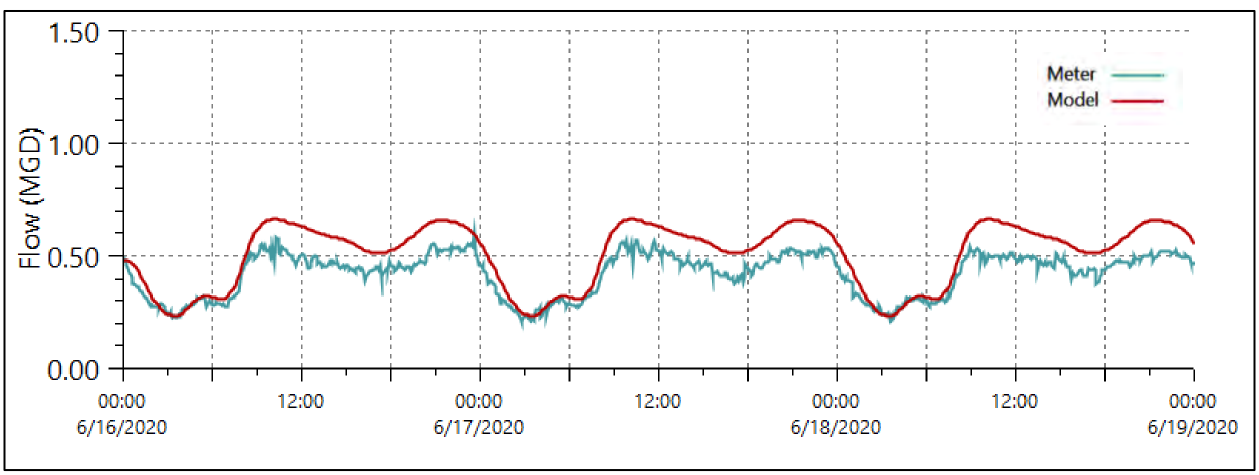


Figure 30. Base Flow Calibration Results - Meter 9

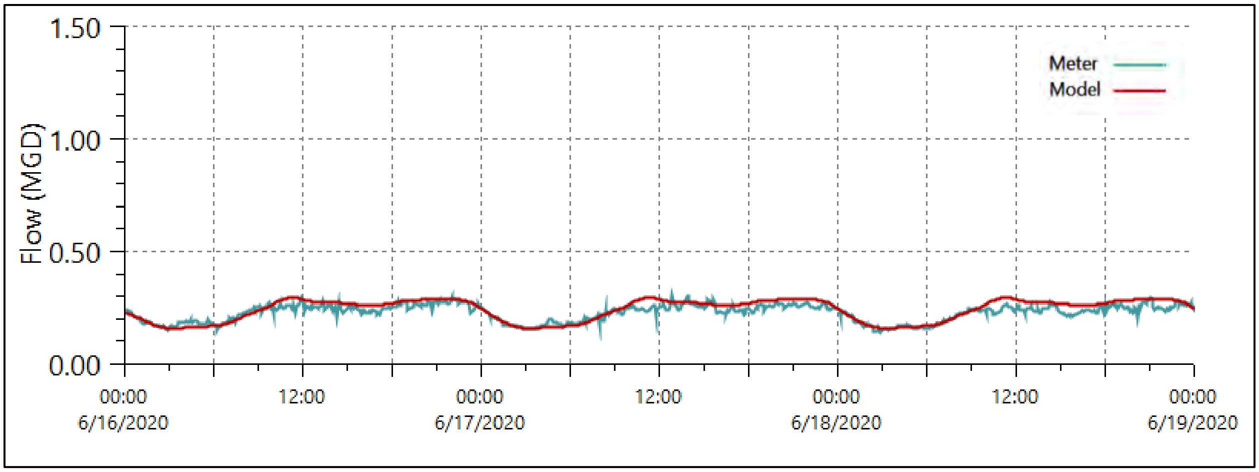


Figure 31. Base Flow Calibration Results - Meter 10

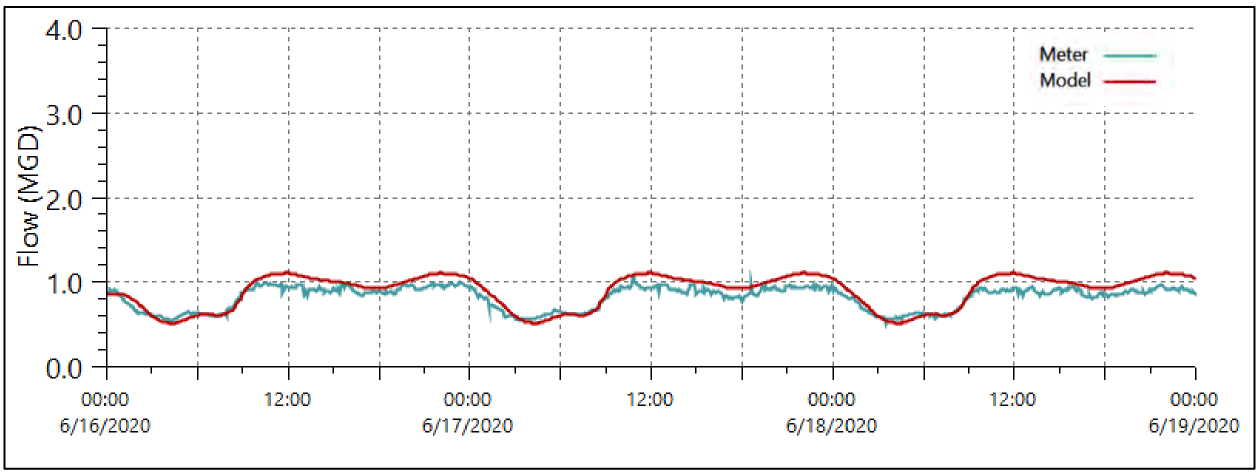


Figure 32. Base Flow Calibration Results - Meter 11

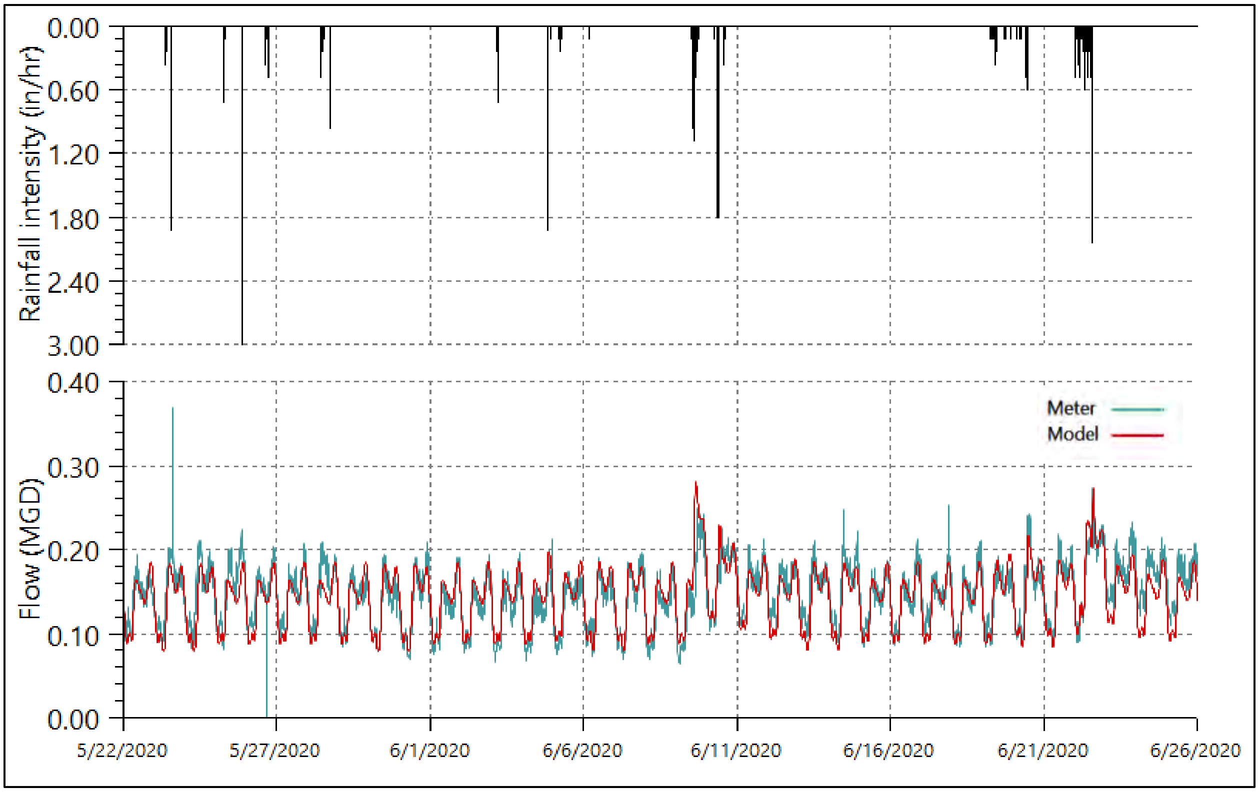


Figure 33. RDII Calibration Results – Meter 4

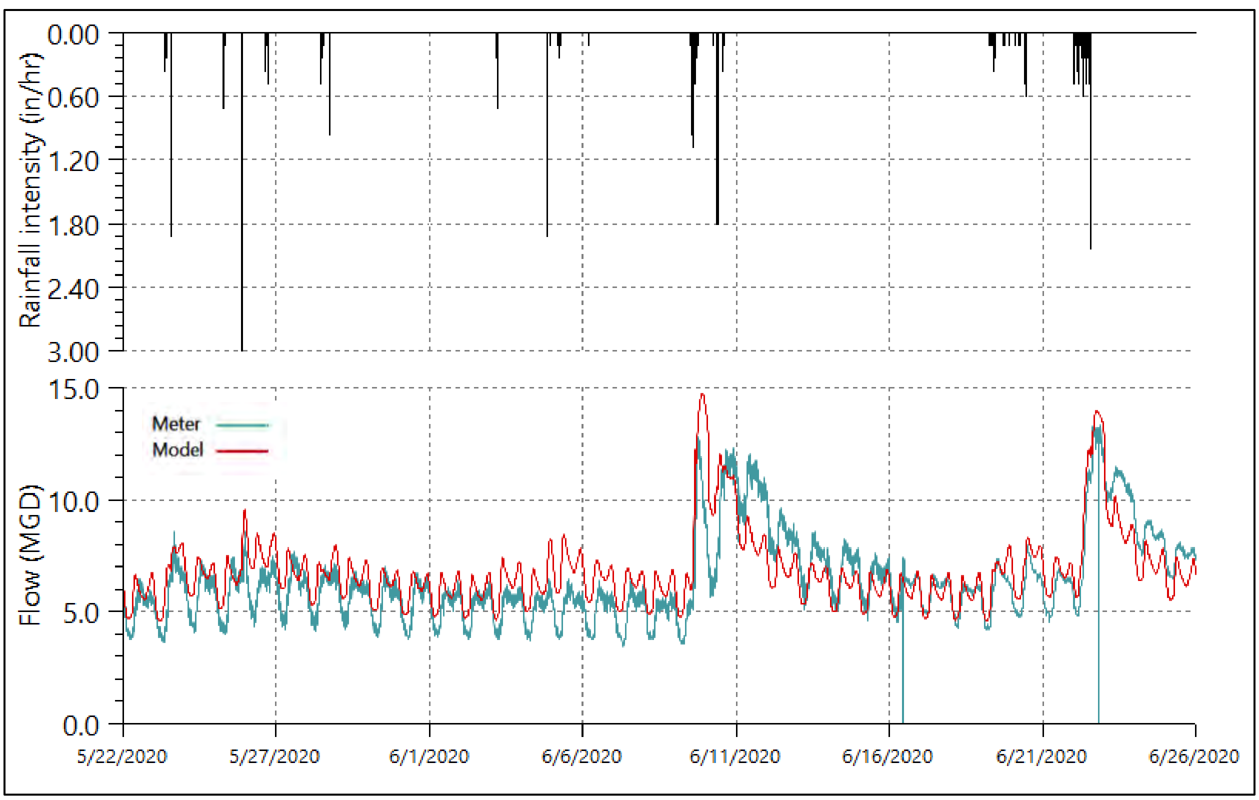


Figure 34. RDII Calibration Results – Meter 5

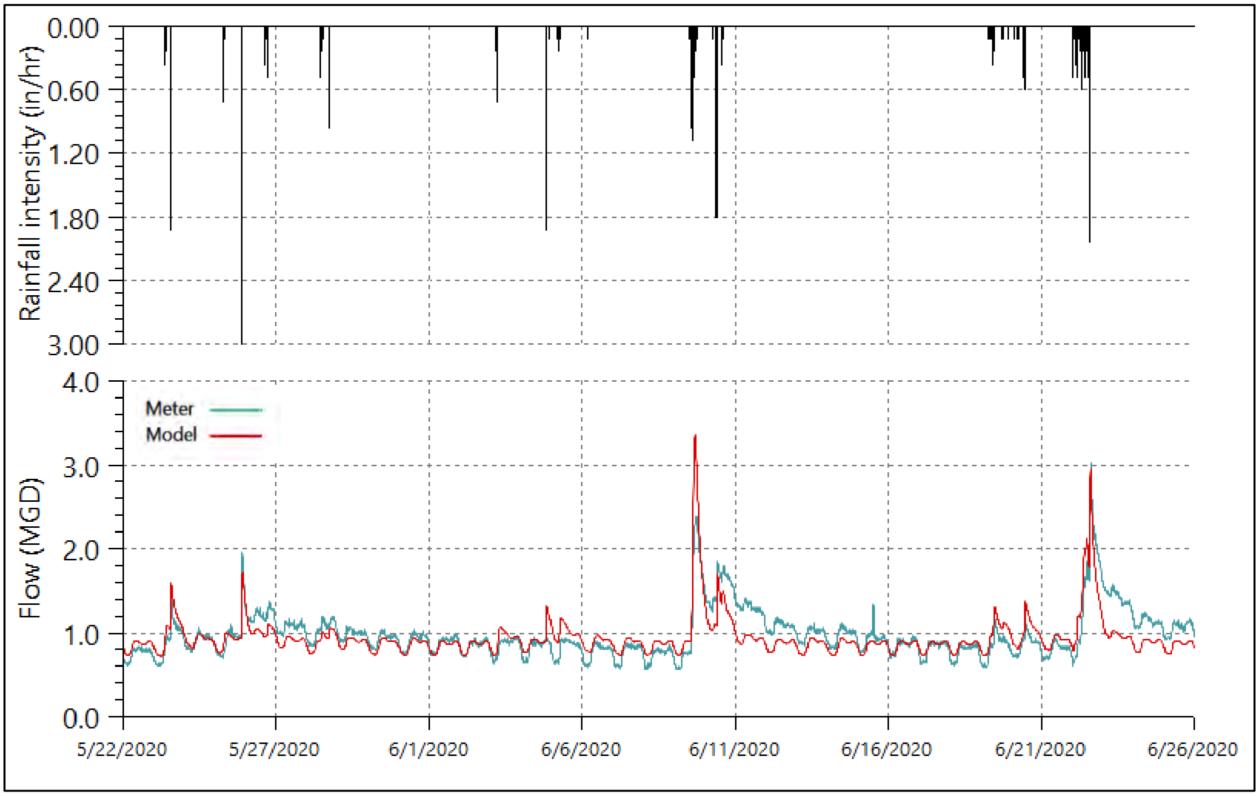


Figure 35. RDII Calibration Results – Meter 6

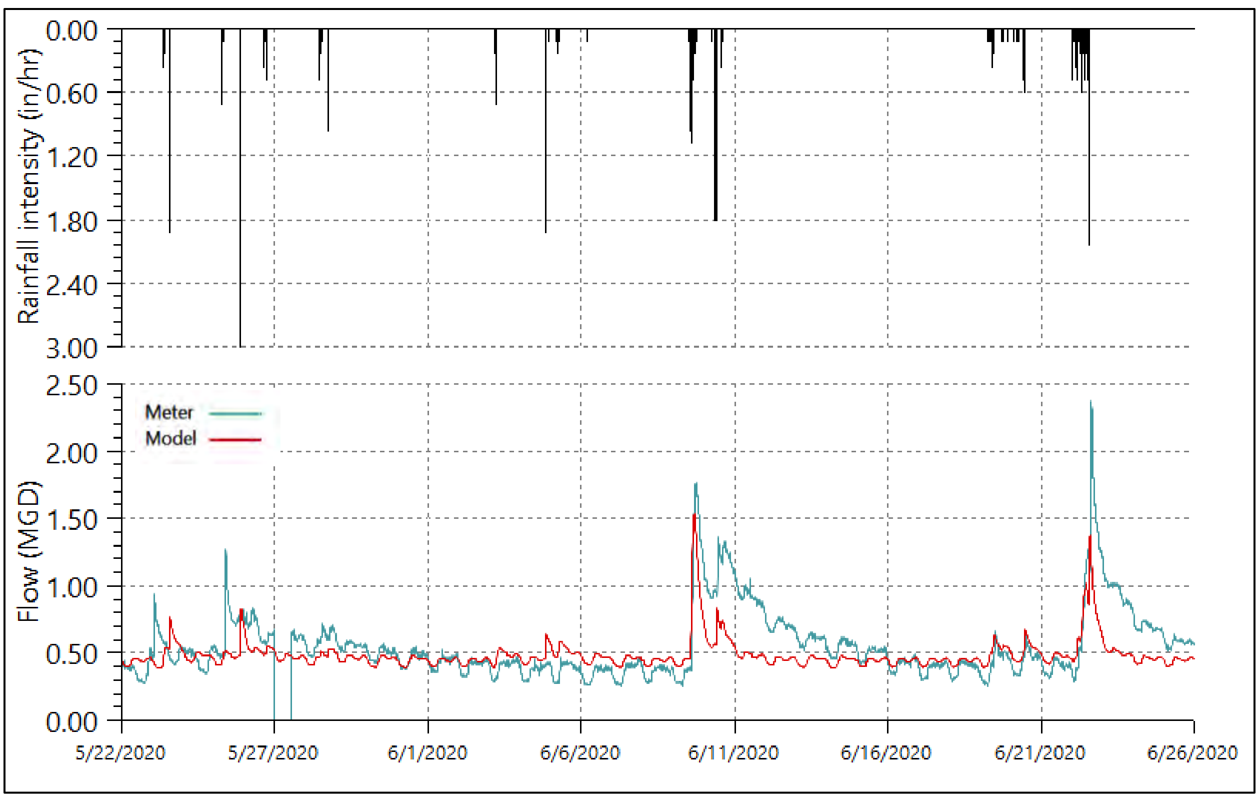


Figure 36. RDII Calibration Results – Meter 7

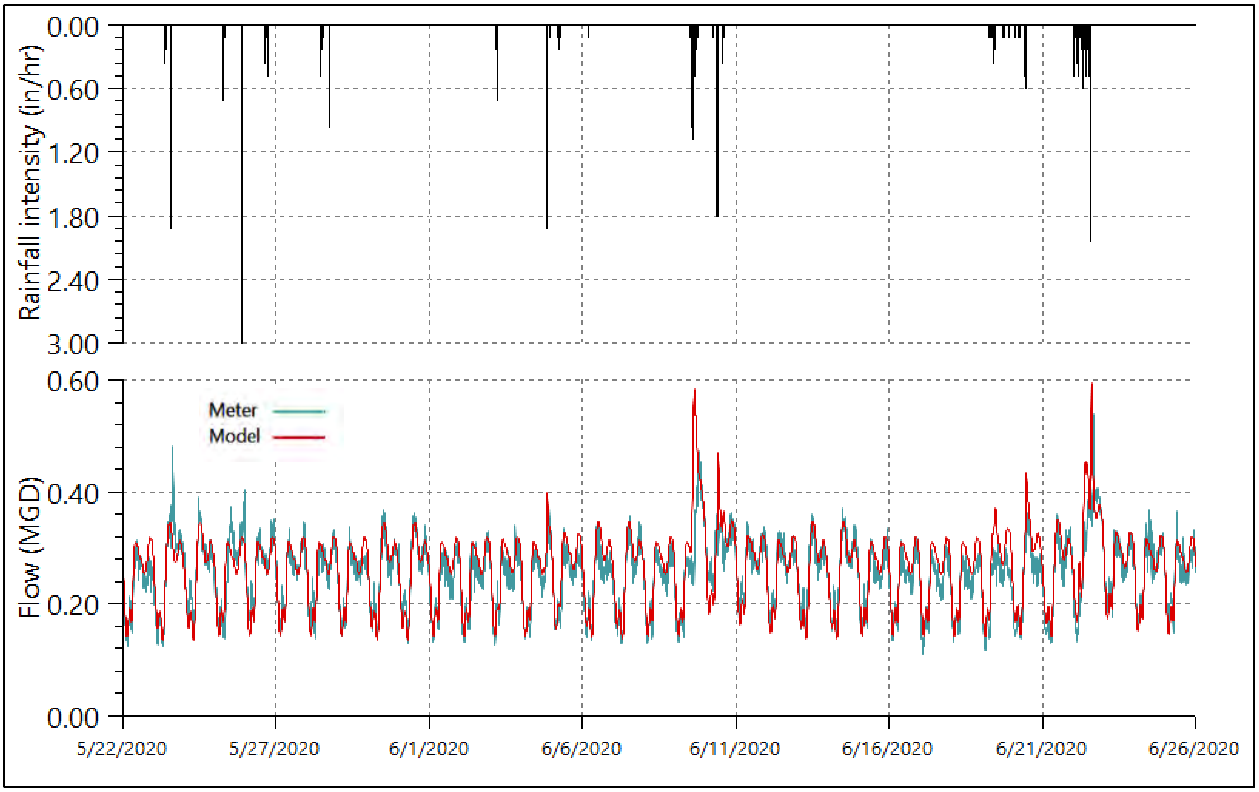


Figure 37. RDII Calibration Results – Meter 8

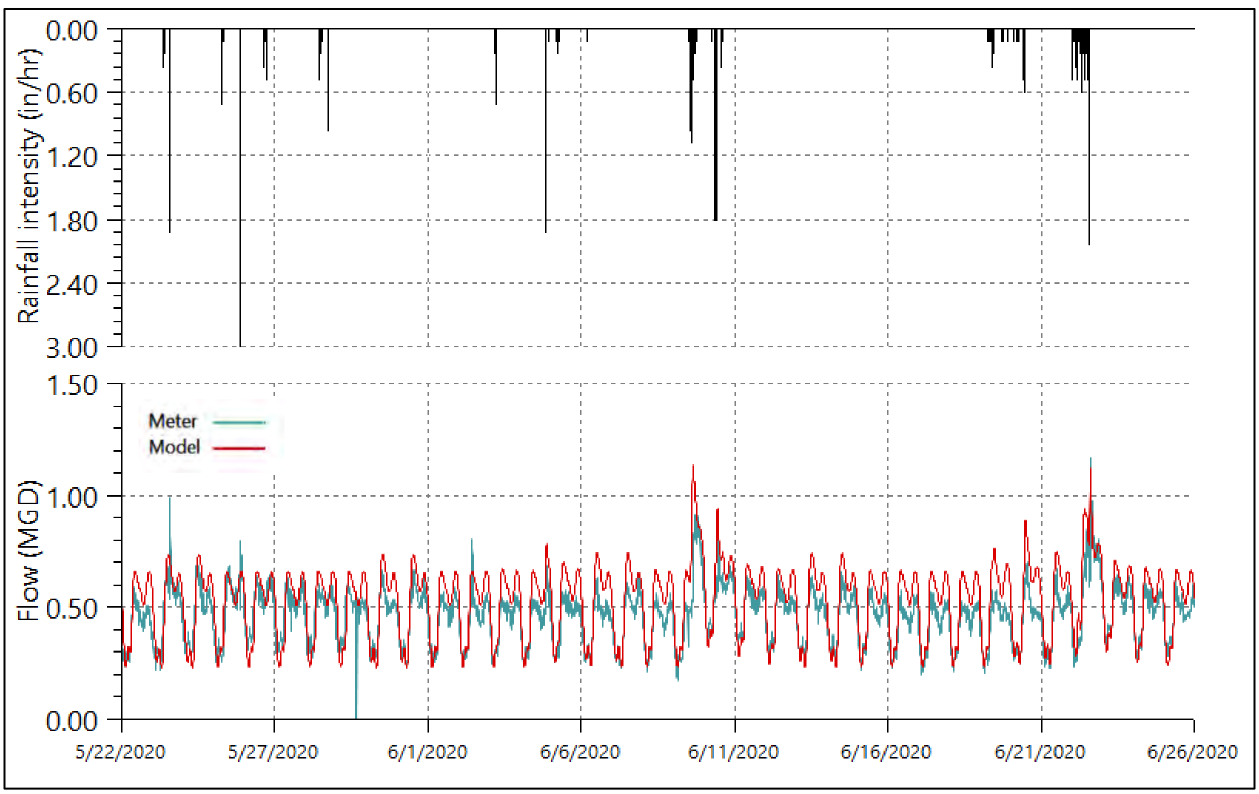
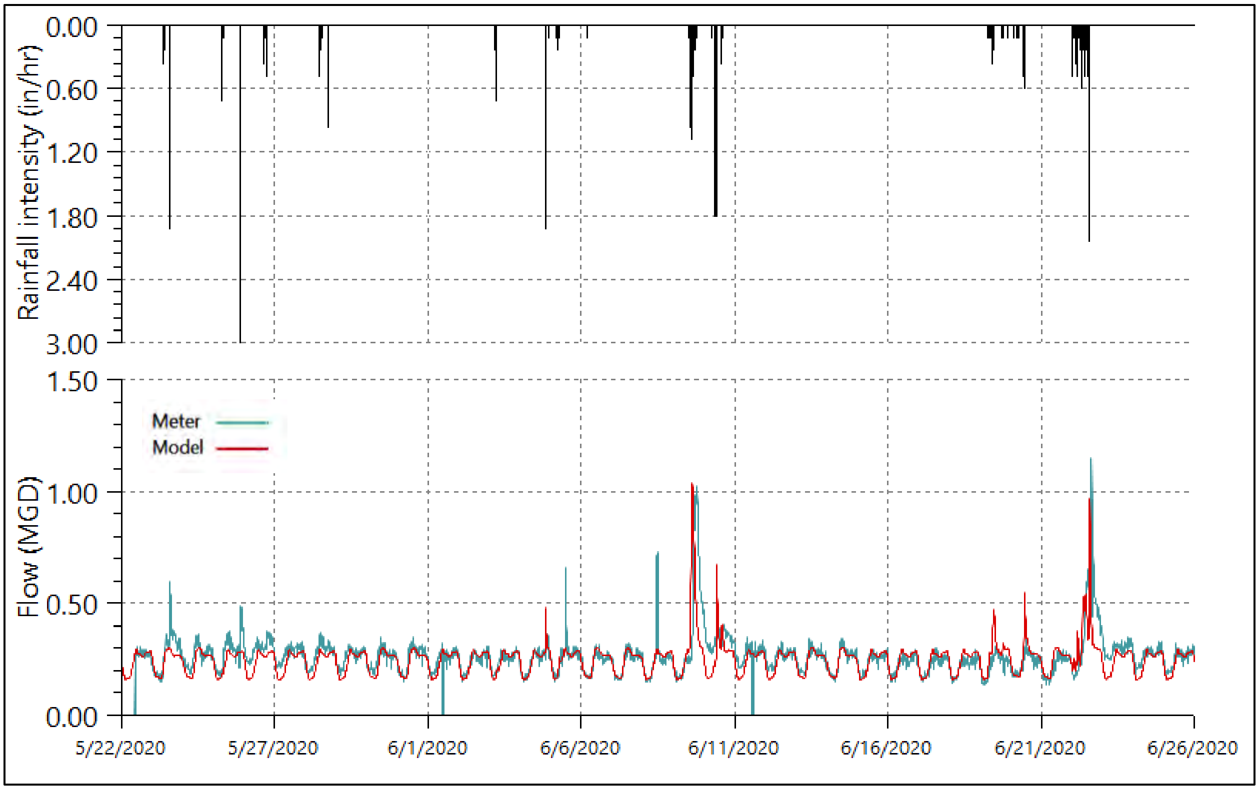


Figure 38. RDII Calibration Results – Meter 9



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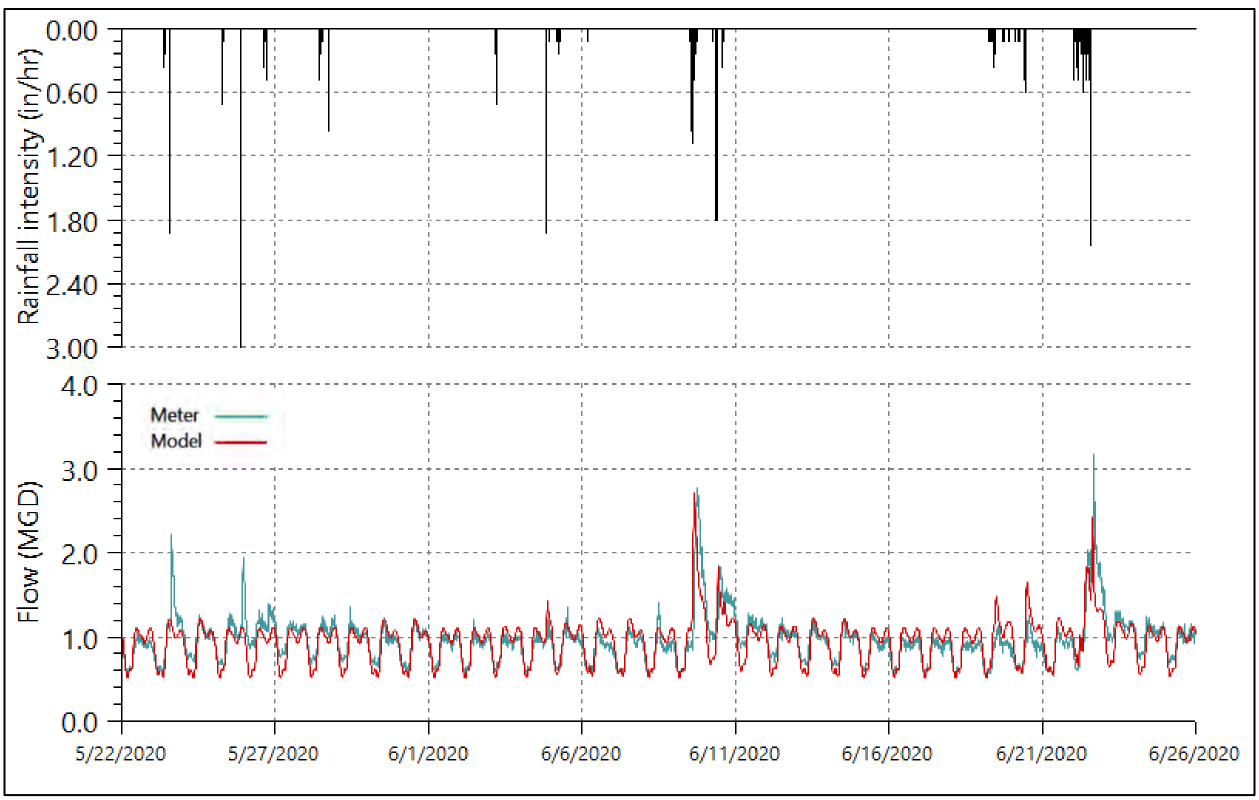
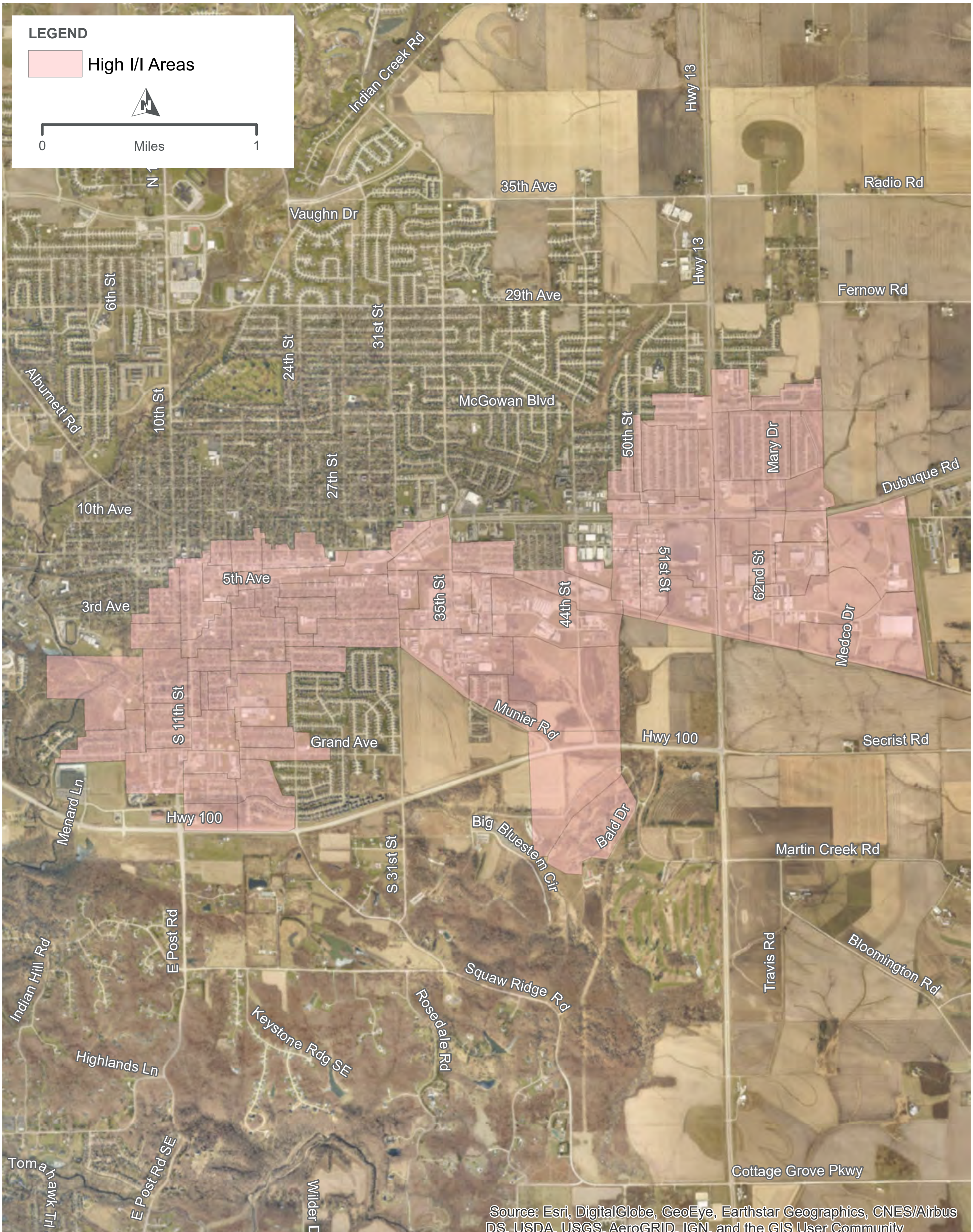


Figure 40. RDII Calibration Results – Meter 11



HDR City of Marion IOWA

AREAS WITH HIGH I/I, INDICATED BY FLOW METERING

CITY OF MARION, IA

FIGURE 41

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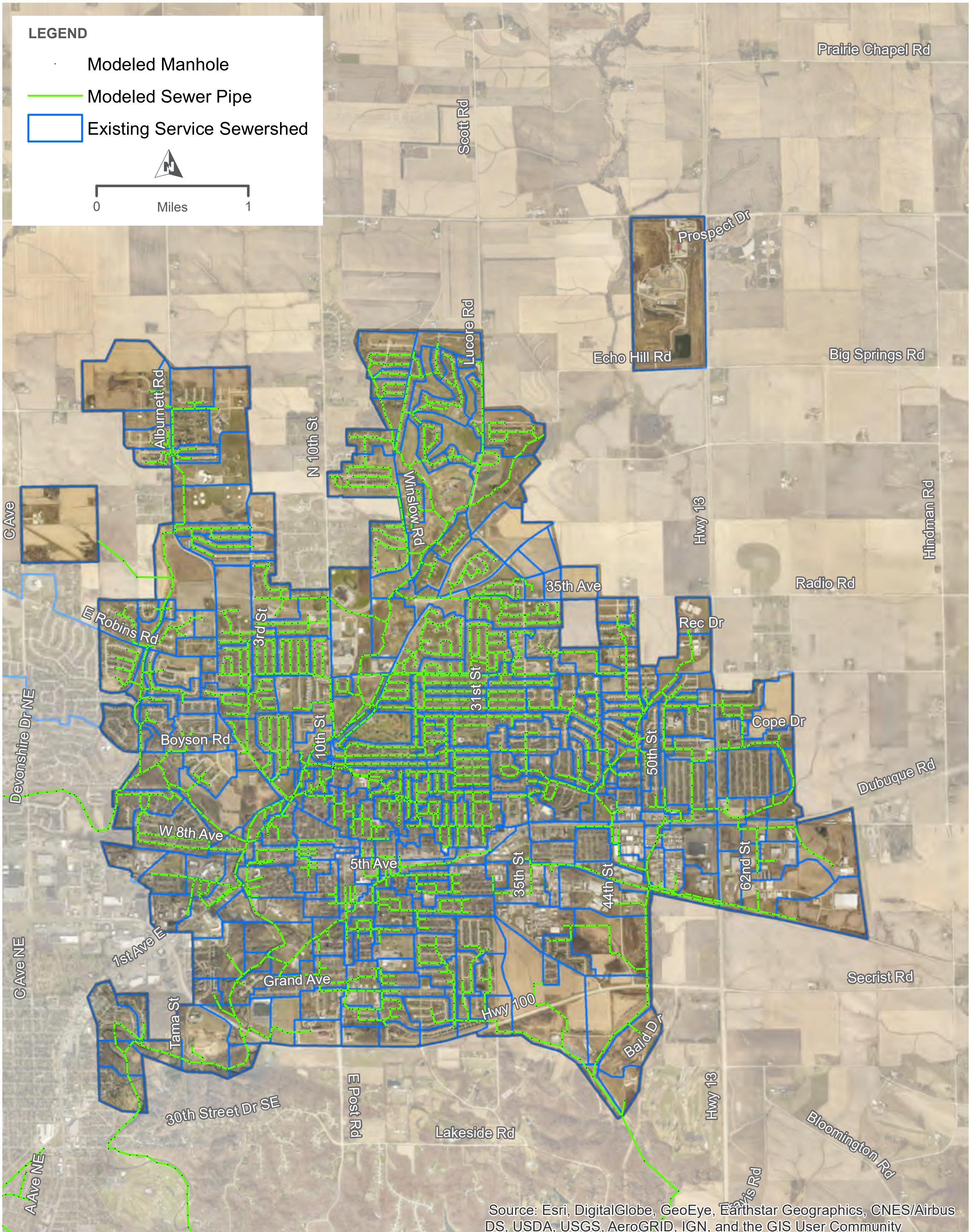


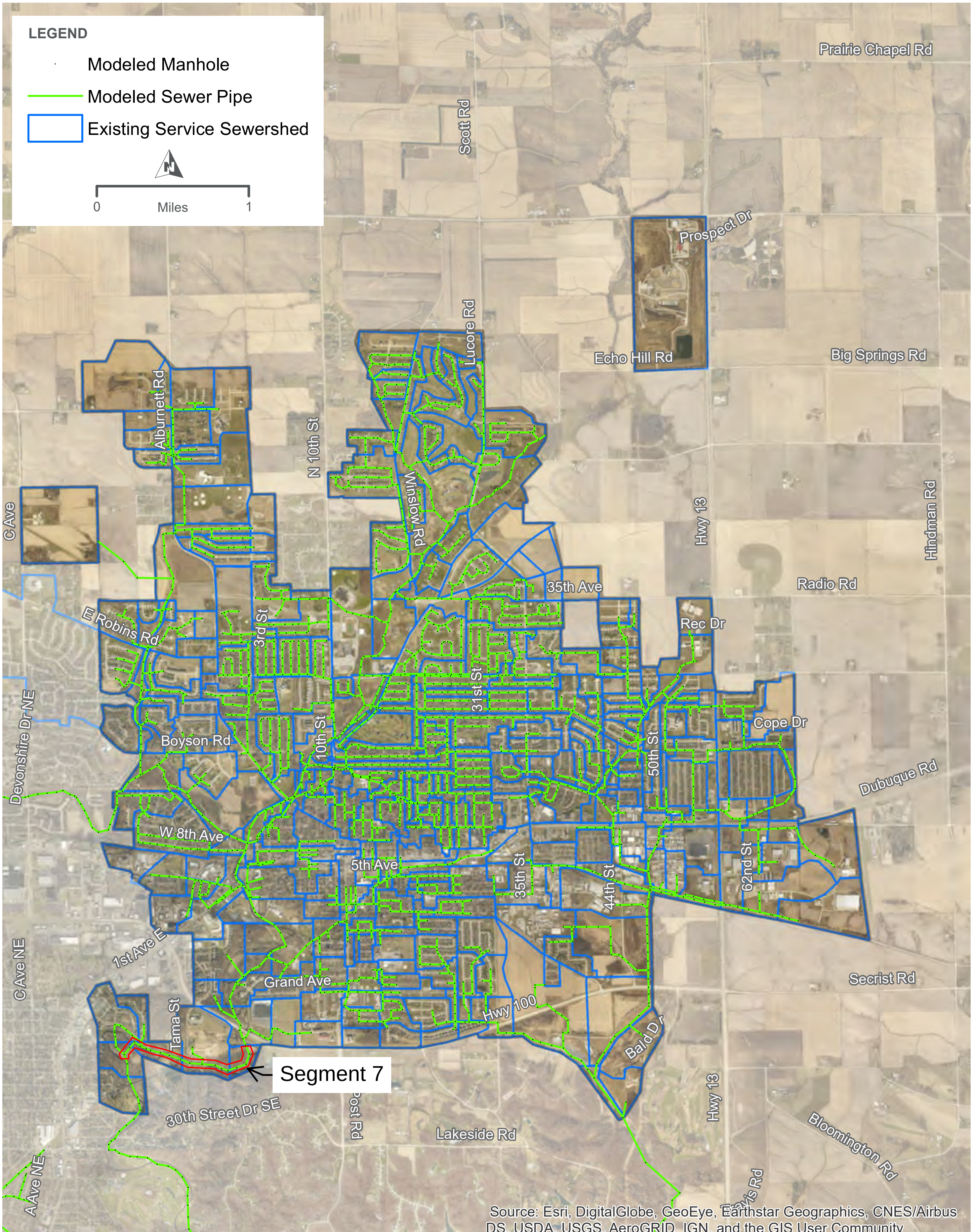
HDR City of Marion Iowa

EXISTING CONDITION (SCENARIO 1)

CITY OF MARION, IA

FIGURE 42

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\PRIMARYBASINS.MXD - USER: STHEN - DATE: 1/11/2021



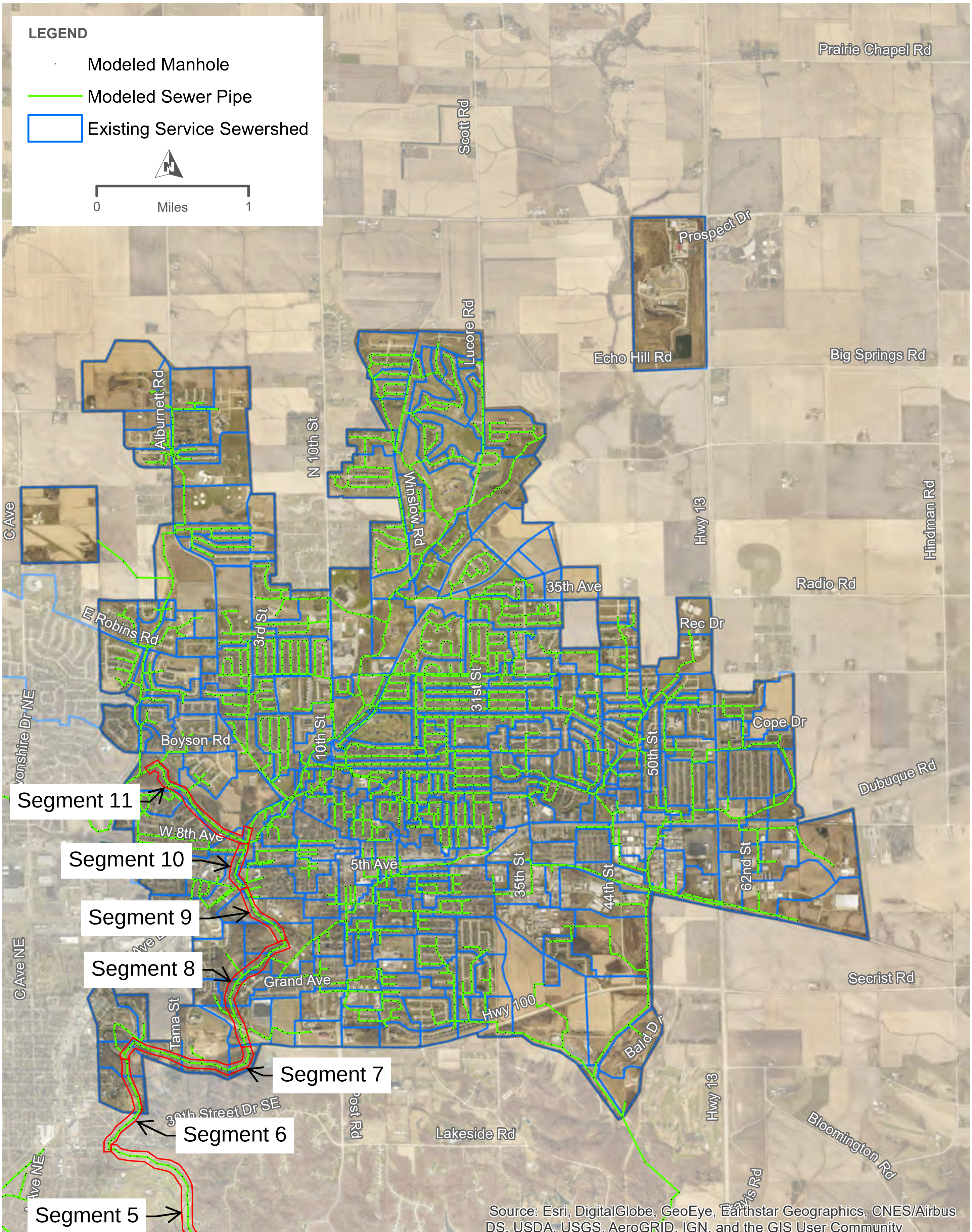
HDR City of Marion IOWA

BASELINE CONDITION (SCENARIO 2)

CITY OF MARION, IA

FIGURE 43

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 2.MXD - USER: STHEN - DATE: 1/11/2021

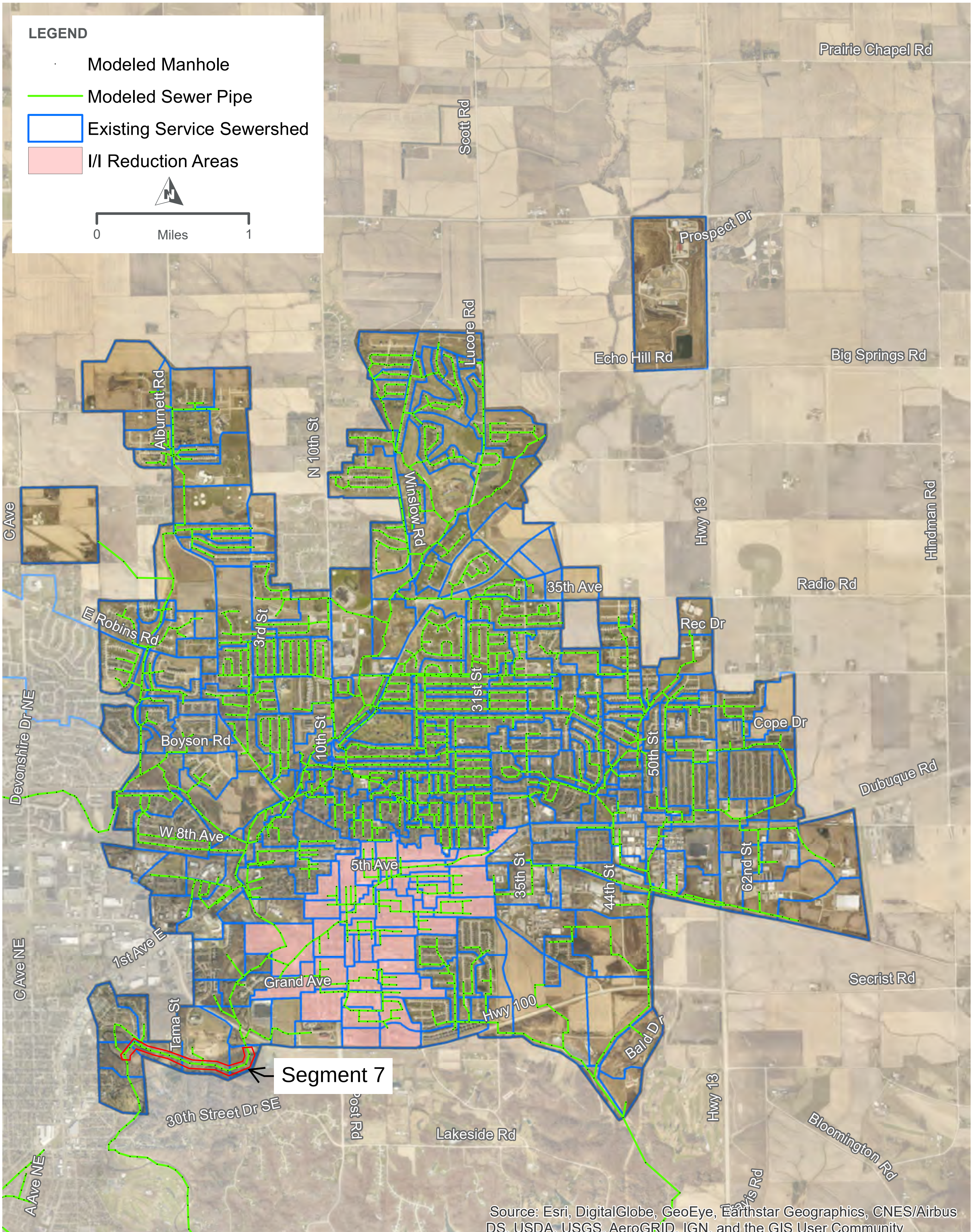


HDR City of Marion IOWA

PROPOSED INDIAN CREEK & DRY RUN CREEK TRUNK SEWER CONDITION (SCENARIO 3)

CITY OF MARION, IA

FIGURE 44



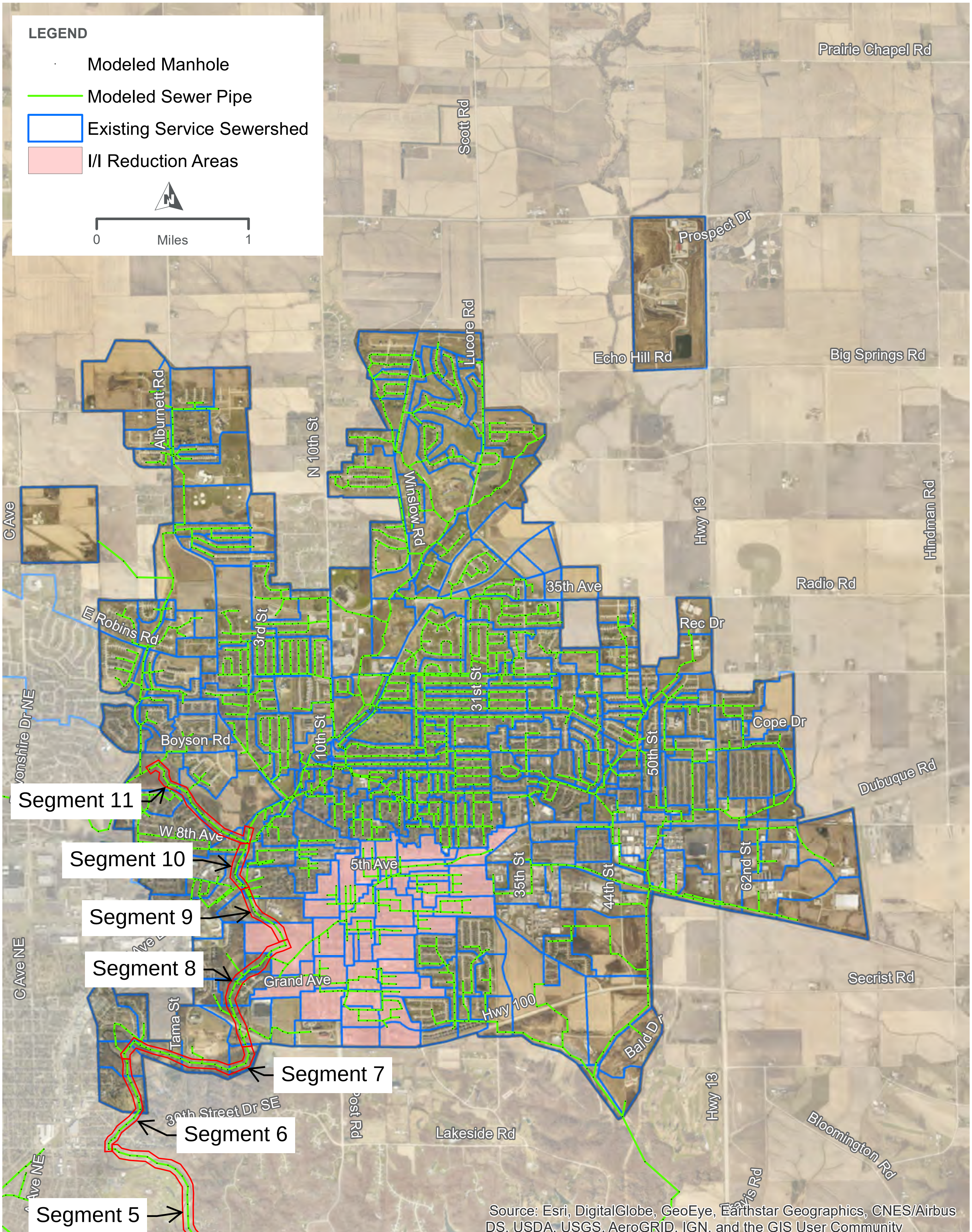
HDR City of Marion IOWA

BASELINE CONDITION WITH I/I REDUCTION CONDITION (SCENARIO 4)

CITY OF MARION, IA

FIGURE 45

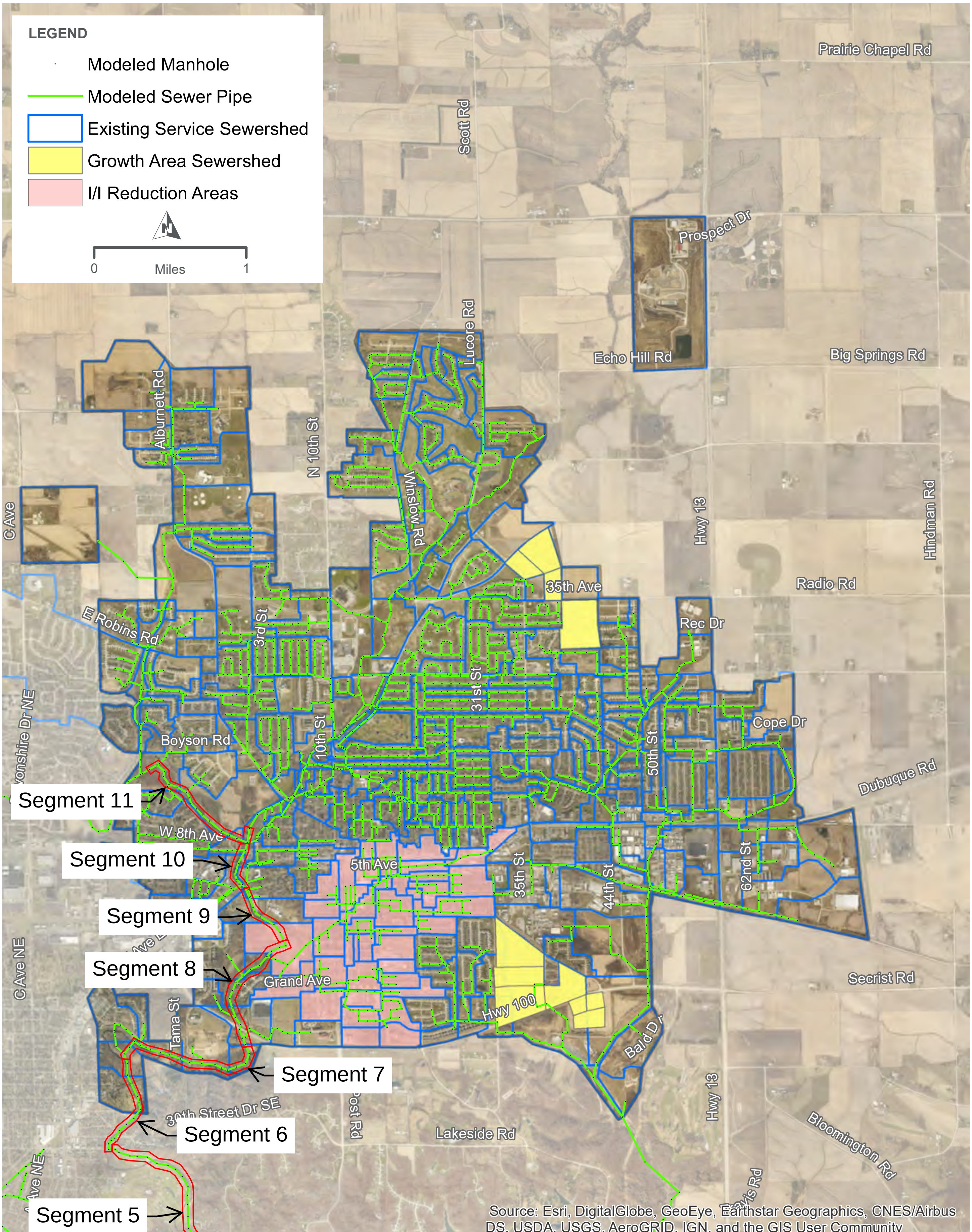
PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 4.MXD - USER: STHEN - DATE: 1/11/2021



PROPOSED INDIAN CREEK & DRY RUN CREEK TRUNK SEWER WITH I/I REDUCTION CONDITION (SCENARIO 5)

CITY OF MARION, IA

FIGURE 46

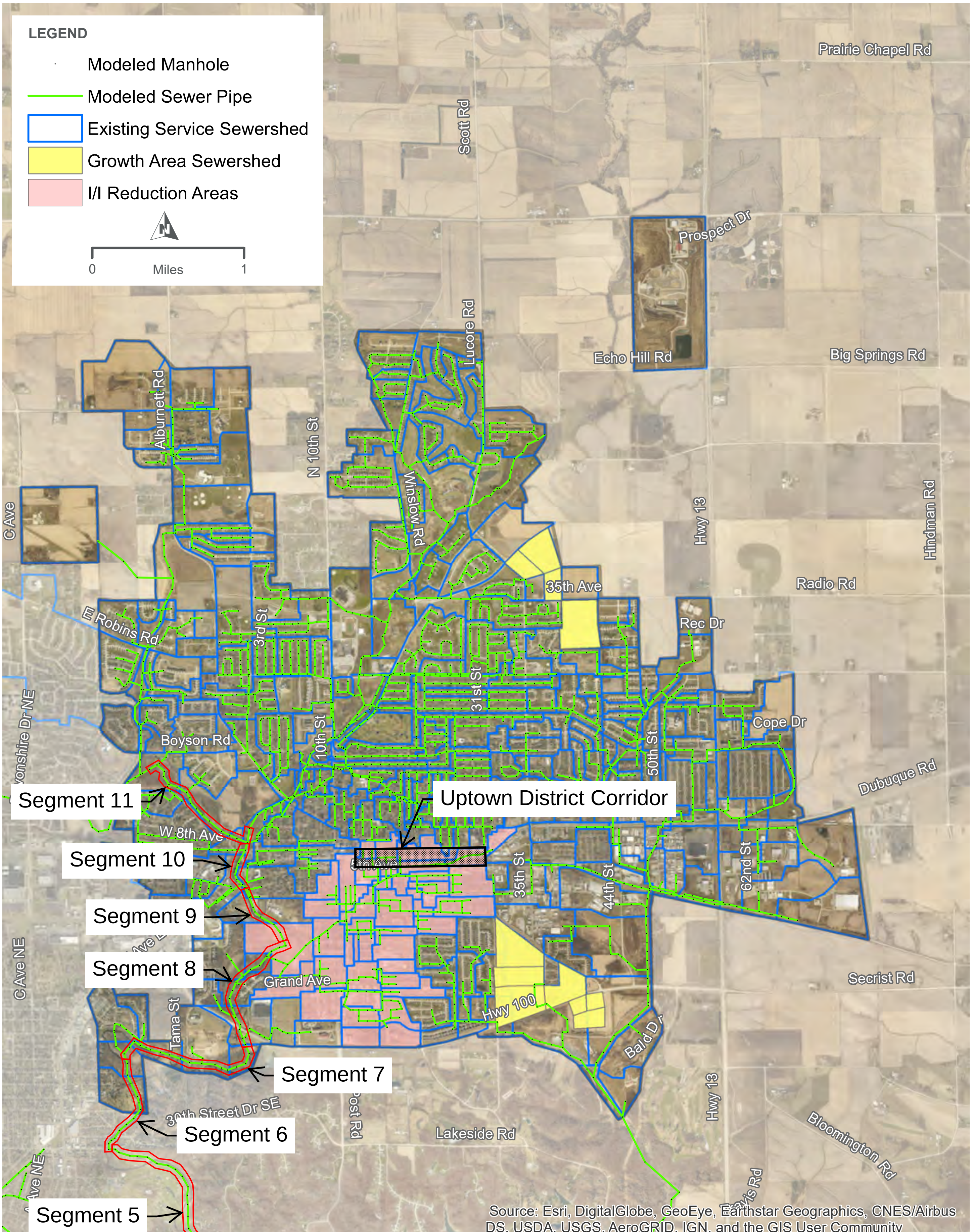


HDR City of Marion Iowa

2040 POPULATION IN EXISTING SERVICE AREA CONDITION (SCENARIO 6)

CITY OF MARION, IA

FIGURE 47



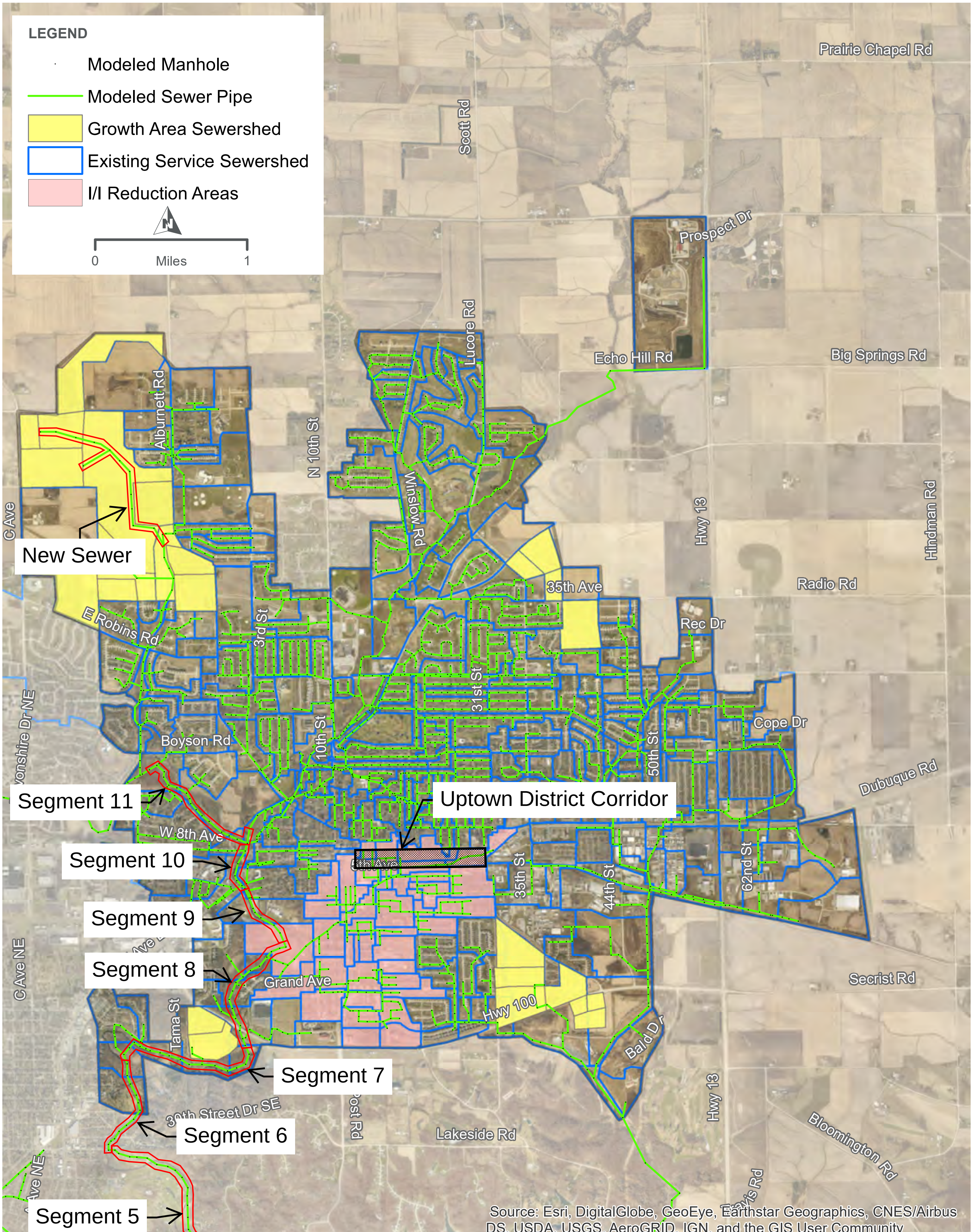
HDR City of Marion Iowa

2040 POPULATION IN EXISTING SERVICE AREA PLUS DENSER UPTOWN DISTRICT CONDITION (SCENARIO 7)

CITY OF MARION, IA

FIGURE 48

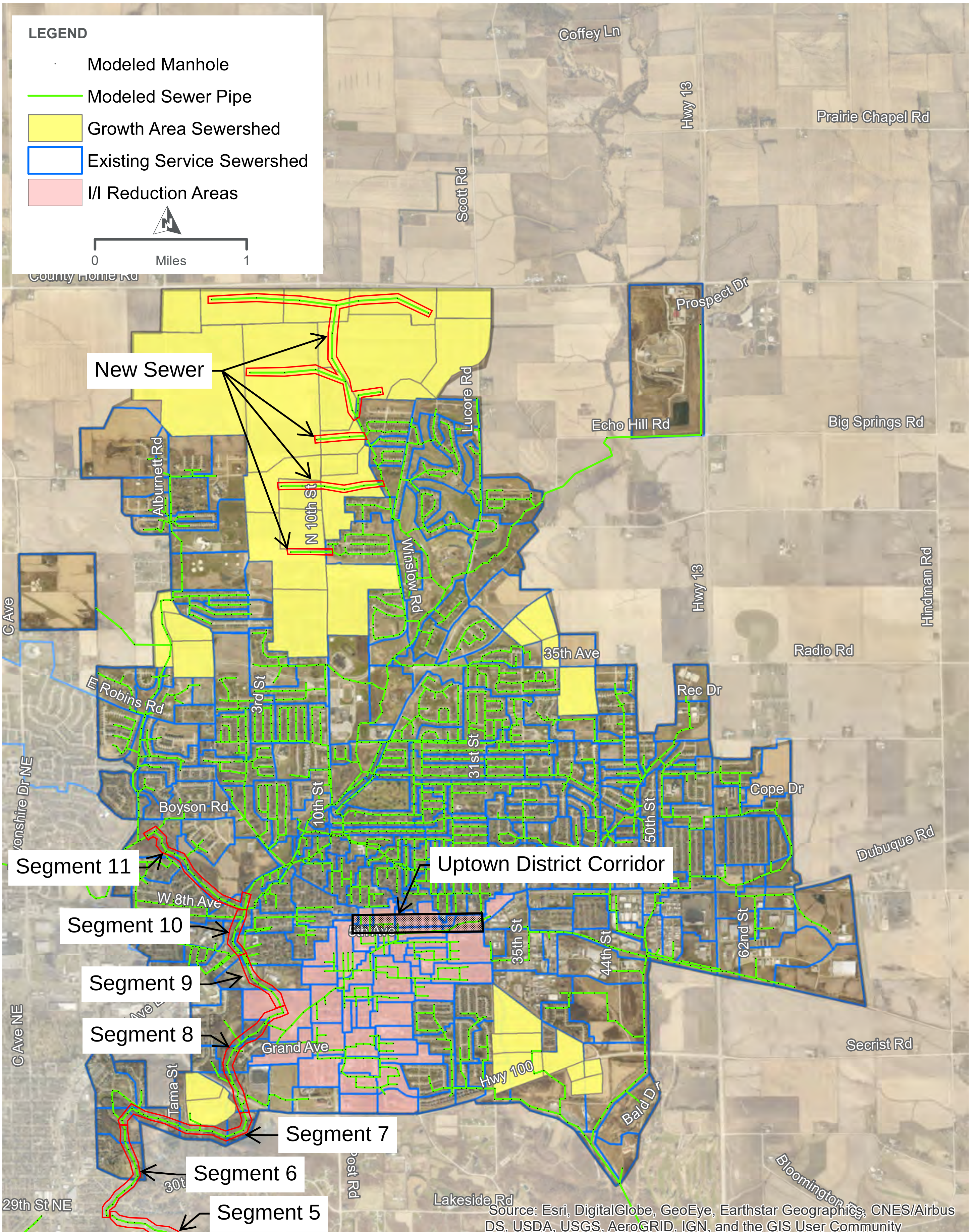
PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 7.MXD - USER: STHEN - DATE: 1/11/2021



2040 POPULATION IN EXISTING SERVICE AREA PLUS GROWTH AREA 1 CONDITION (SCENARIO 8)

CITY OF MARION, IA

FIGURE 49



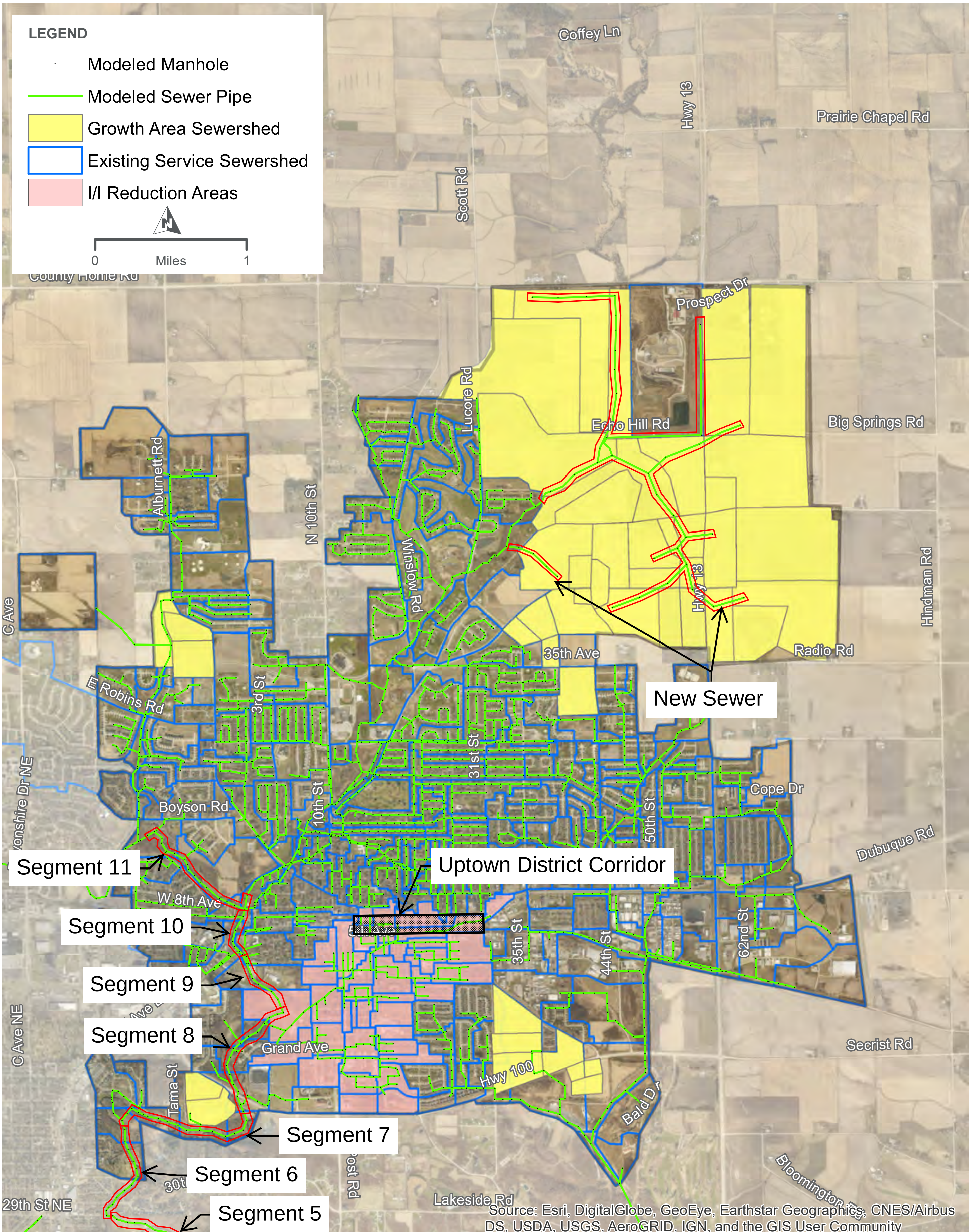
2040 POPULATION IN EXISTING SERVICE AREA PLUS GROWTH AREA 2 CONDITION (SCENARIO 9)

CITY OF MARION, IA

FIGURE 50

2020 SANITARY SEWER STUDY

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 9.MXD - USER: STHEN - DATE: 1/11/2021



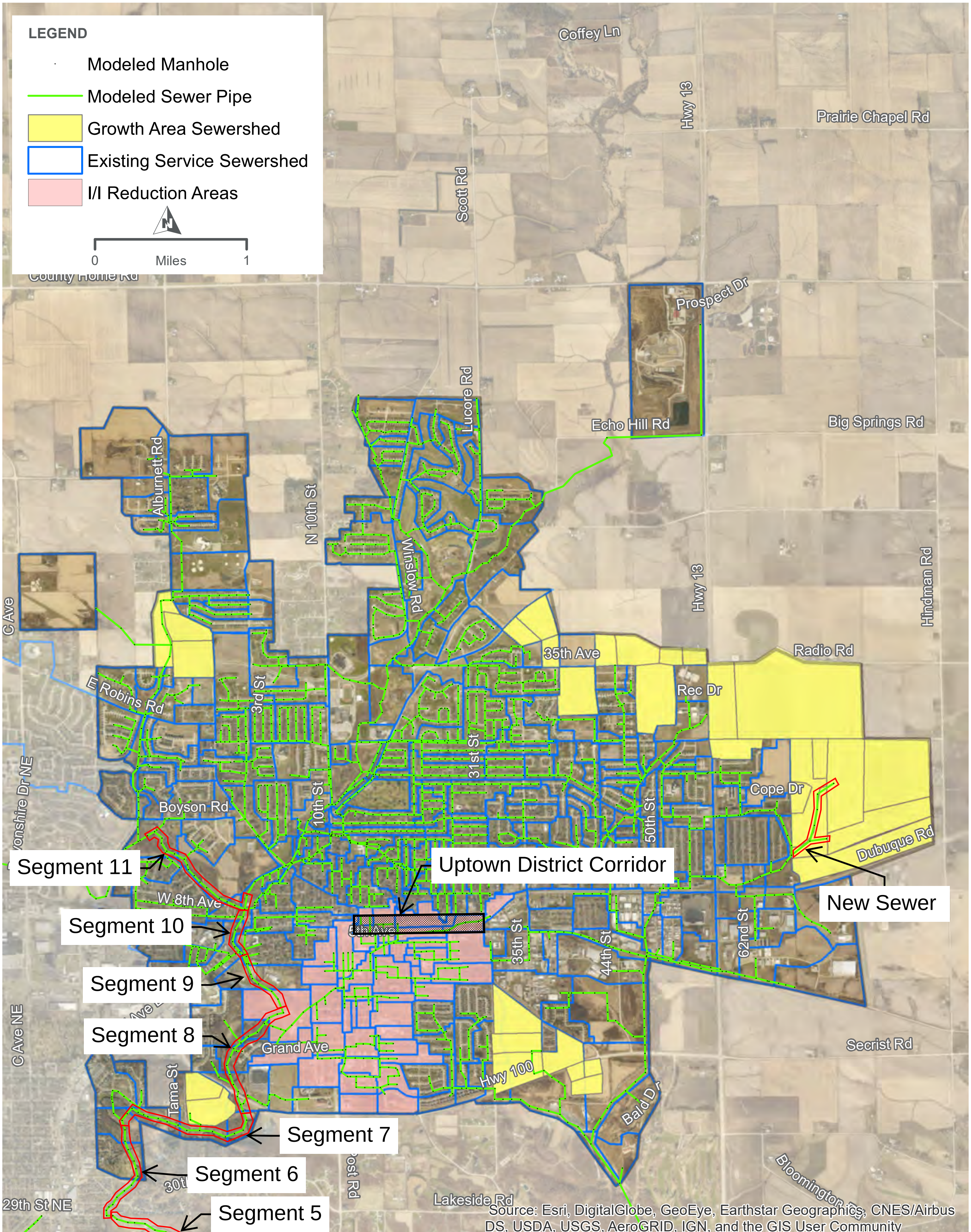
HDR City of Marion Iowa

2040 POPULATION IN EXISTING SERVICE AREA PLUS GROWTH AREA 3 CONDITION (SCENARIO 10)

CITY OF MARION, IA

FIGURE 51

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 10.MXD - USER: STHEN - DATE: 1/11/2021



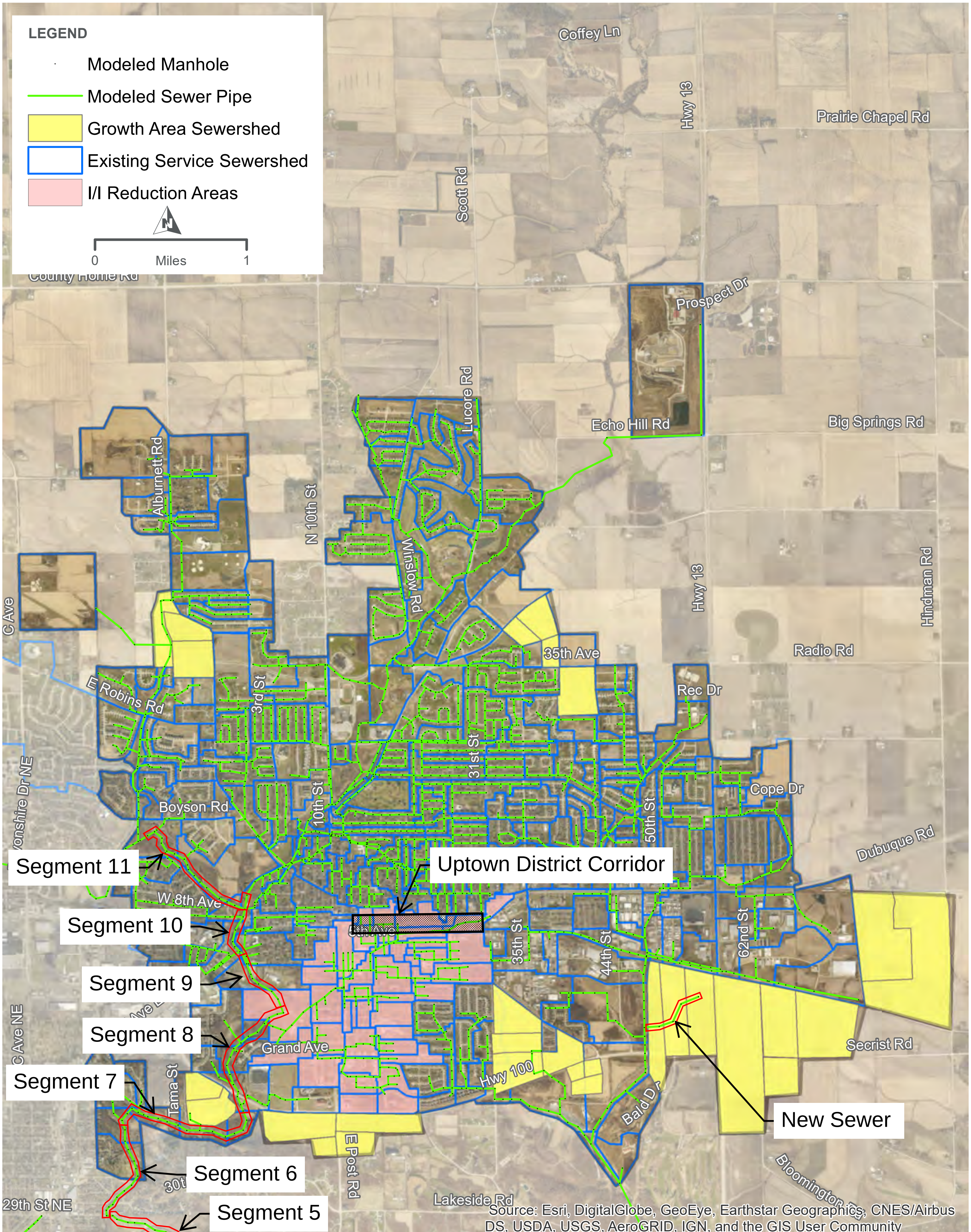
HDR City of Marion Iowa

2040 POPULATION IN EXISTING SERVICE AREA PLUS GROWTH AREA 4 CONDITION (SCENARIO 11)

CITY OF MARION, IA

FIGURE 52

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 11.MXD - USER: STHEN - DATE: 1/11/2021



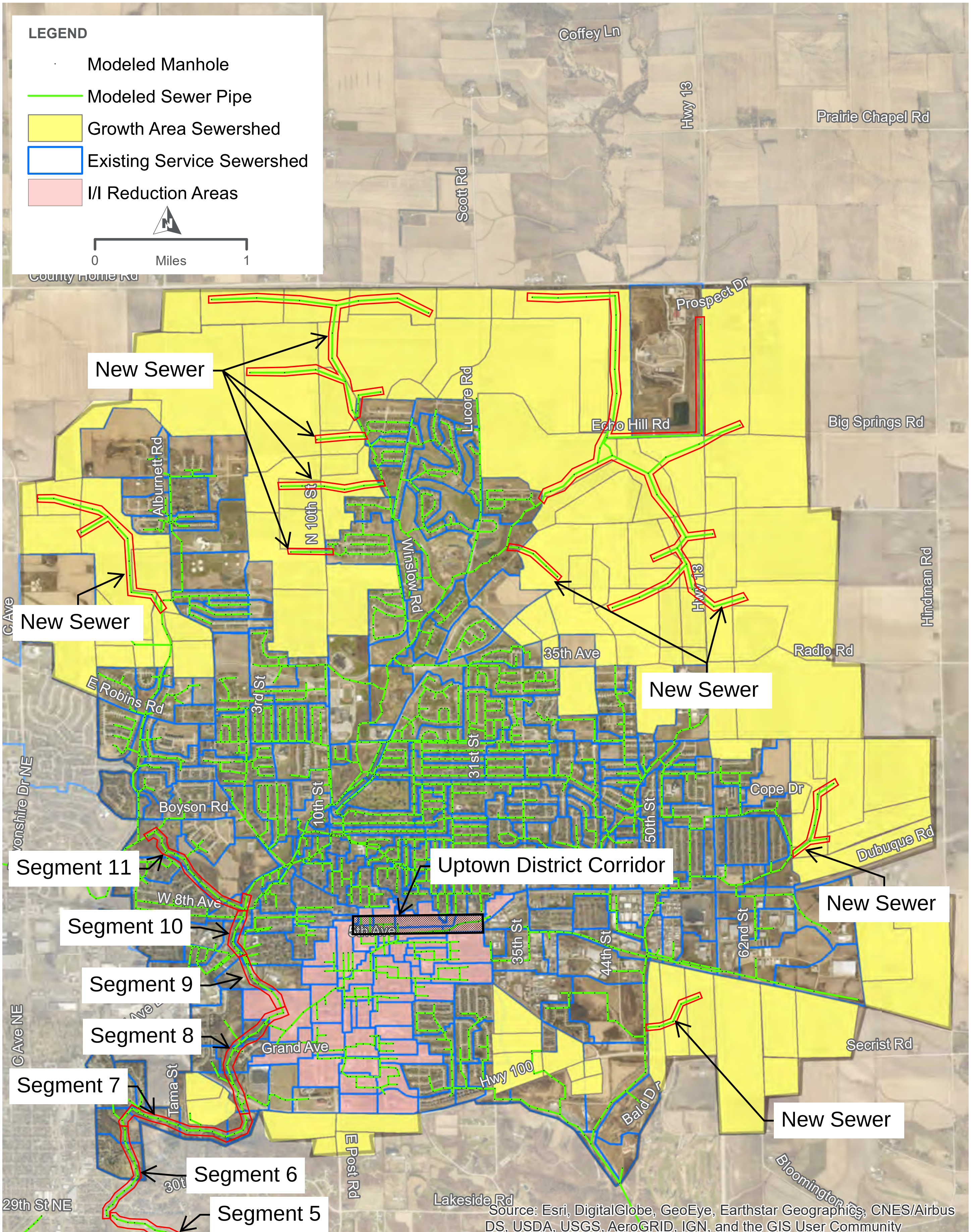
2040 POPULATION IN EXISTING SERVICE AREA PLUS GROWTH AREA 5 CONDITION (SCENARIO 12)

CITY OF MARION, IA

FIGURE 53

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\SCENARIO 12.MXD - USER: STHEN - DATE: 1/11/2021

2020 SANITARY SEWER STUDY

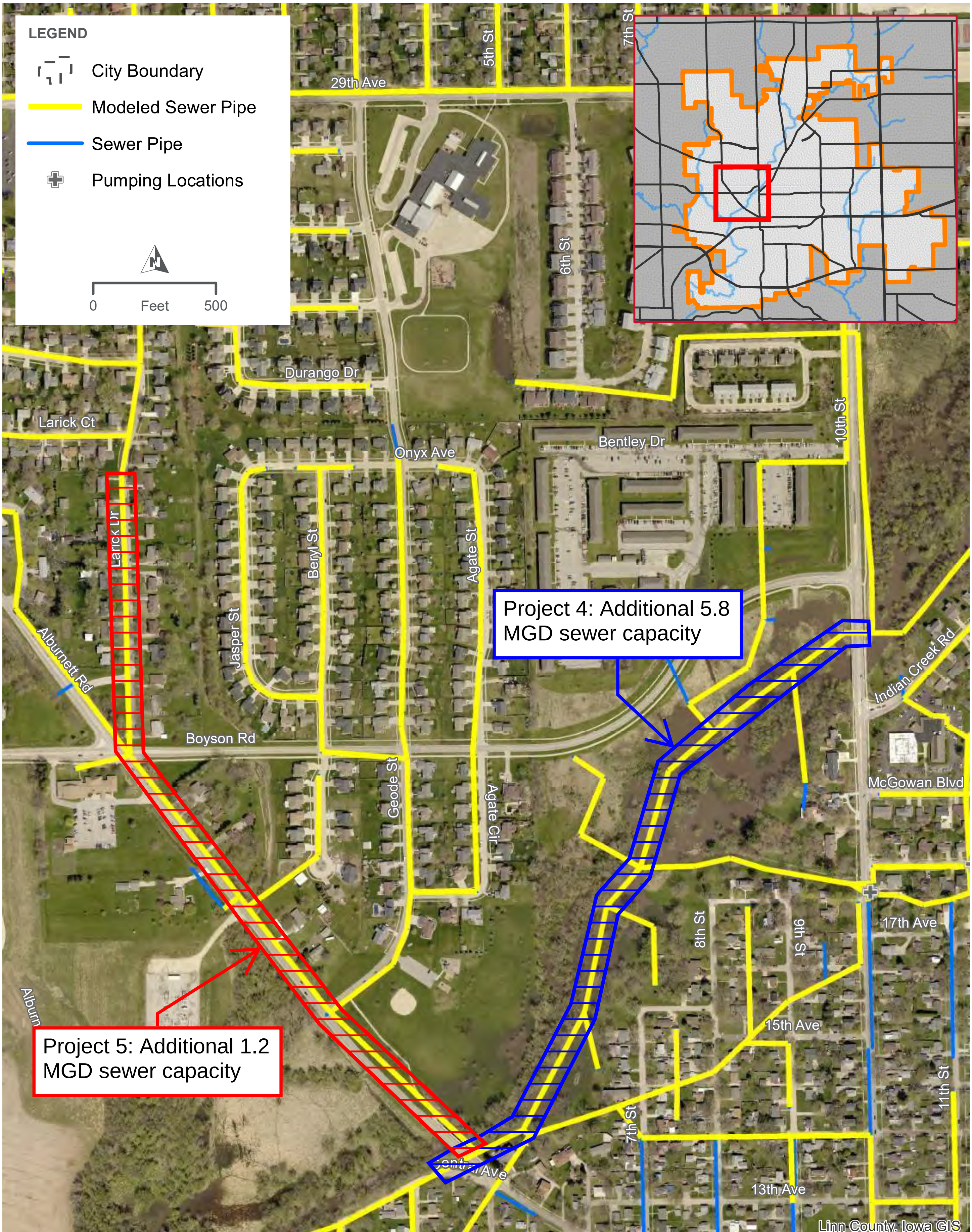


HDR City of Marion Iowa

FULL DEVELOPMENT CONDITION (SCENARIO 13)

CITY OF MARION, IA

FIGURE 54

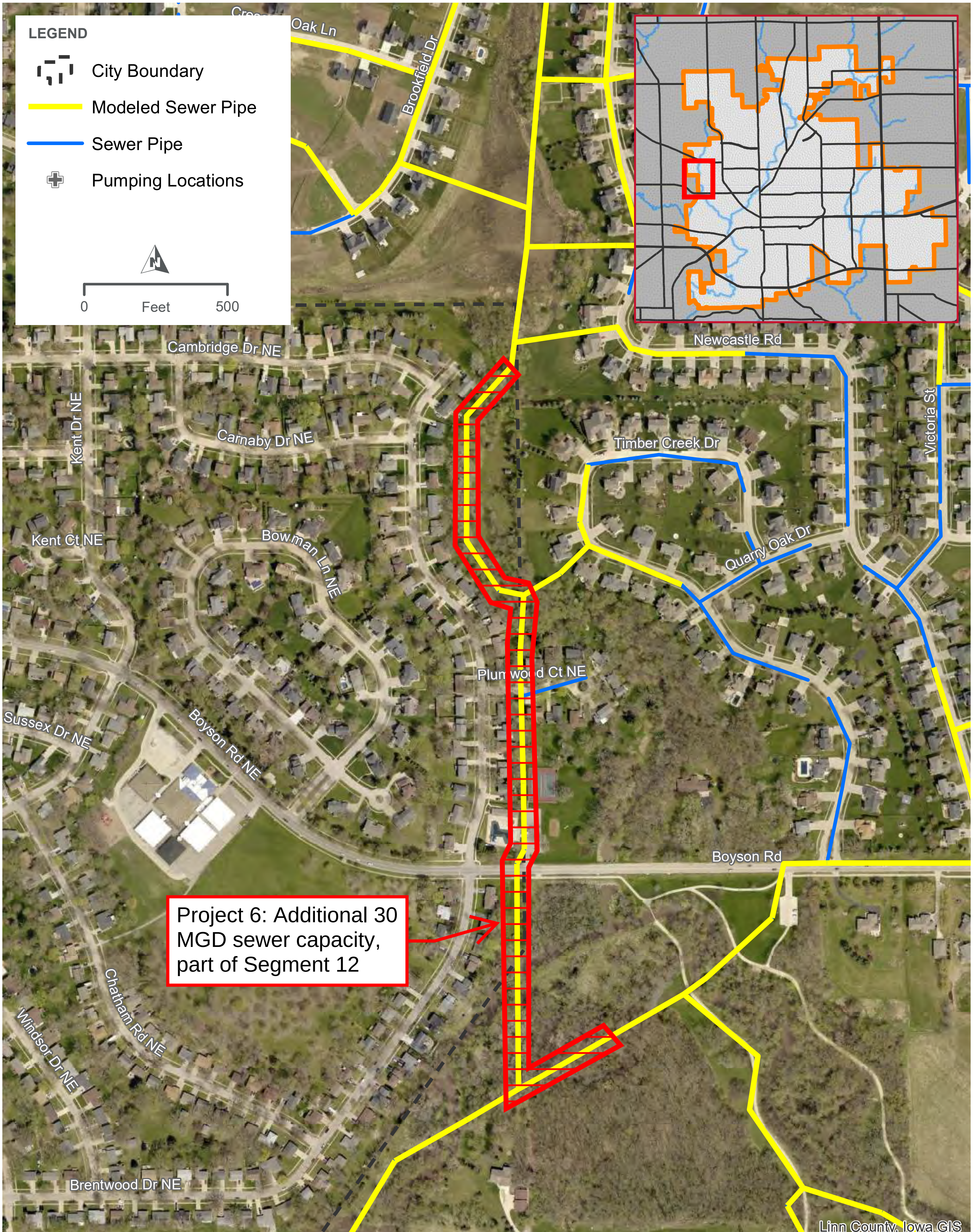


City of Marion Iowa

RECOMMENDED IMPROVEMENTS FOR EXISTING CONDITIONS:

INDIAN CREEK BASIN, PROJECT 4 AND PROJECT 5

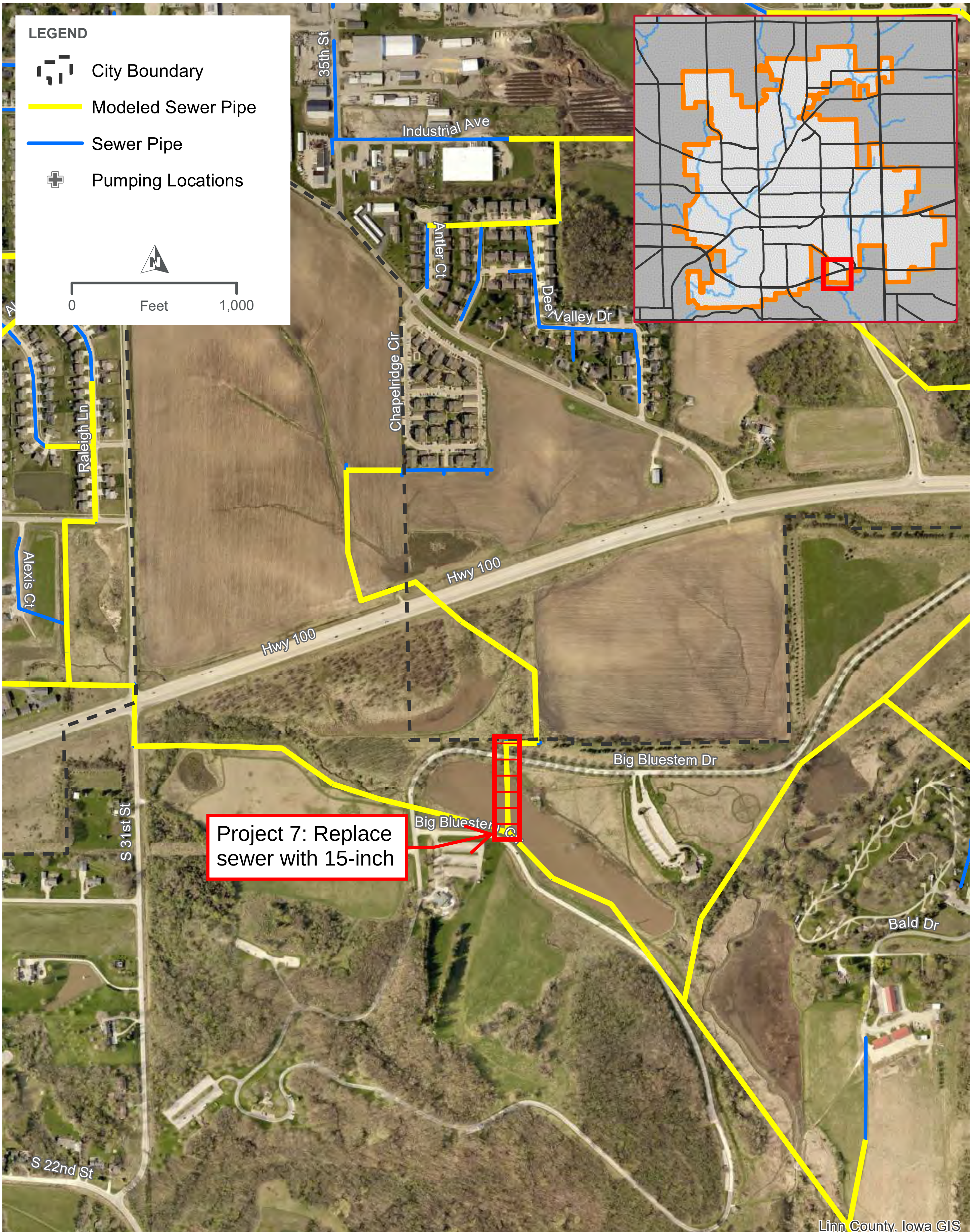
FIGURE 55



RECOMMENDED IMPROVEMENTS FOR 2040 POPULATION CONDITIONS

CHRISTOPHER CREEK & DRY RUN CREEK BASIN, PROJECT 6

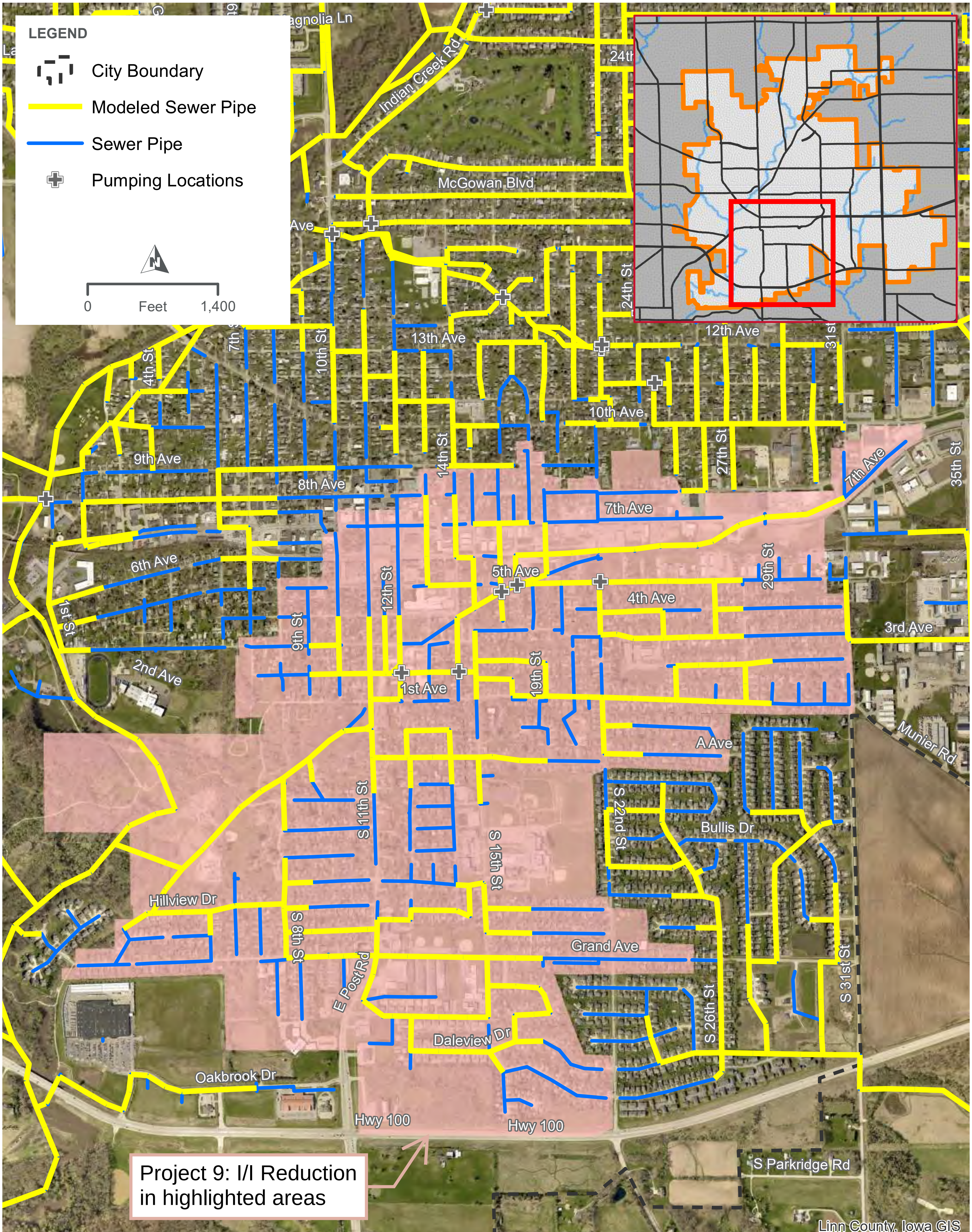
FIGURE 56



RECOMMENDED IMPROVEMENTS FOR 2040 POPULATION CONDITIONS

SQUAW CREEK BASIN, PROJECT 7

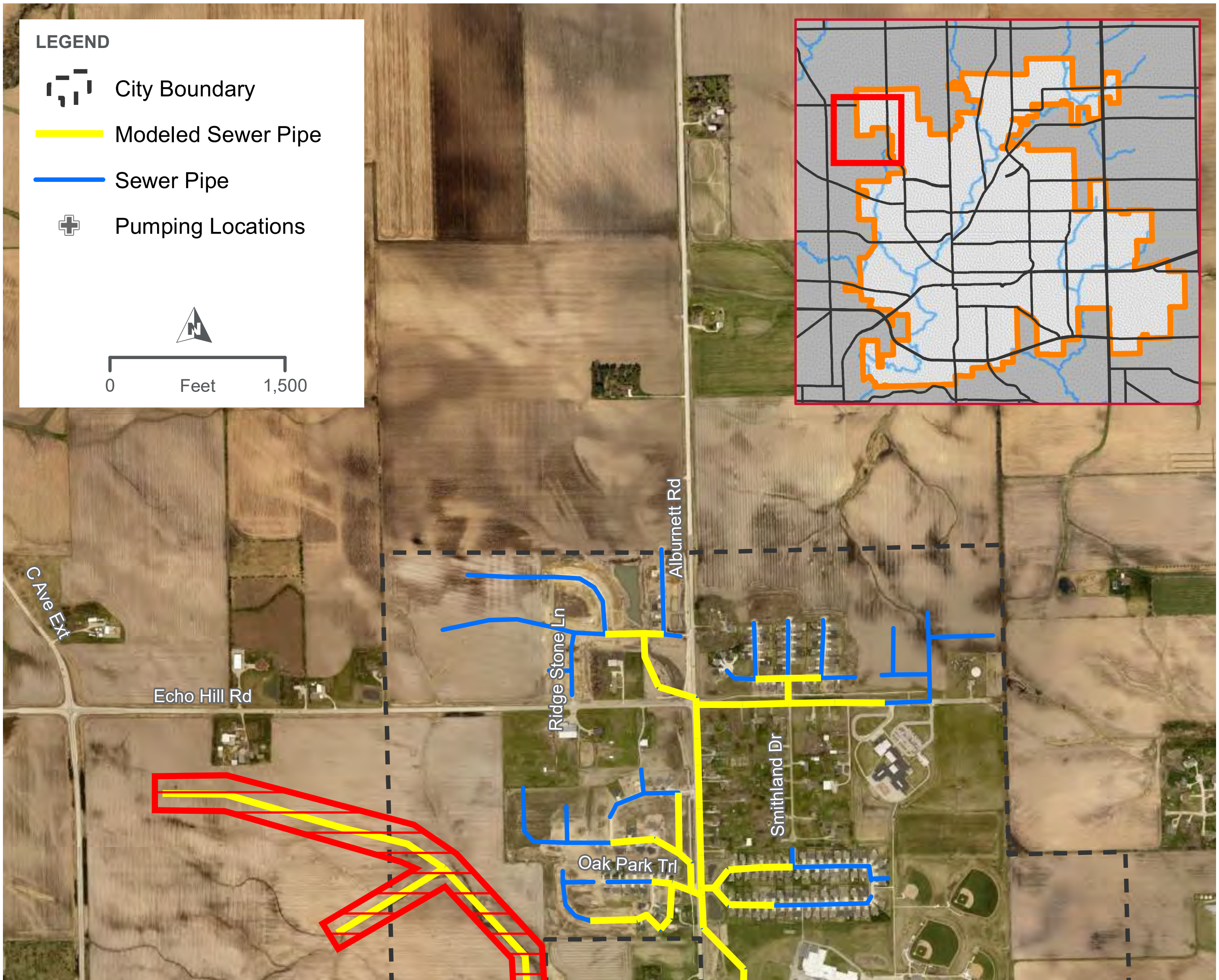
FIGURE 57



RECOMMENDED IMPROVEMENTS FOR 2040 POPULATION CONDITIONS

LOWER INDIAN CREEK BASIN, PROJECT 9

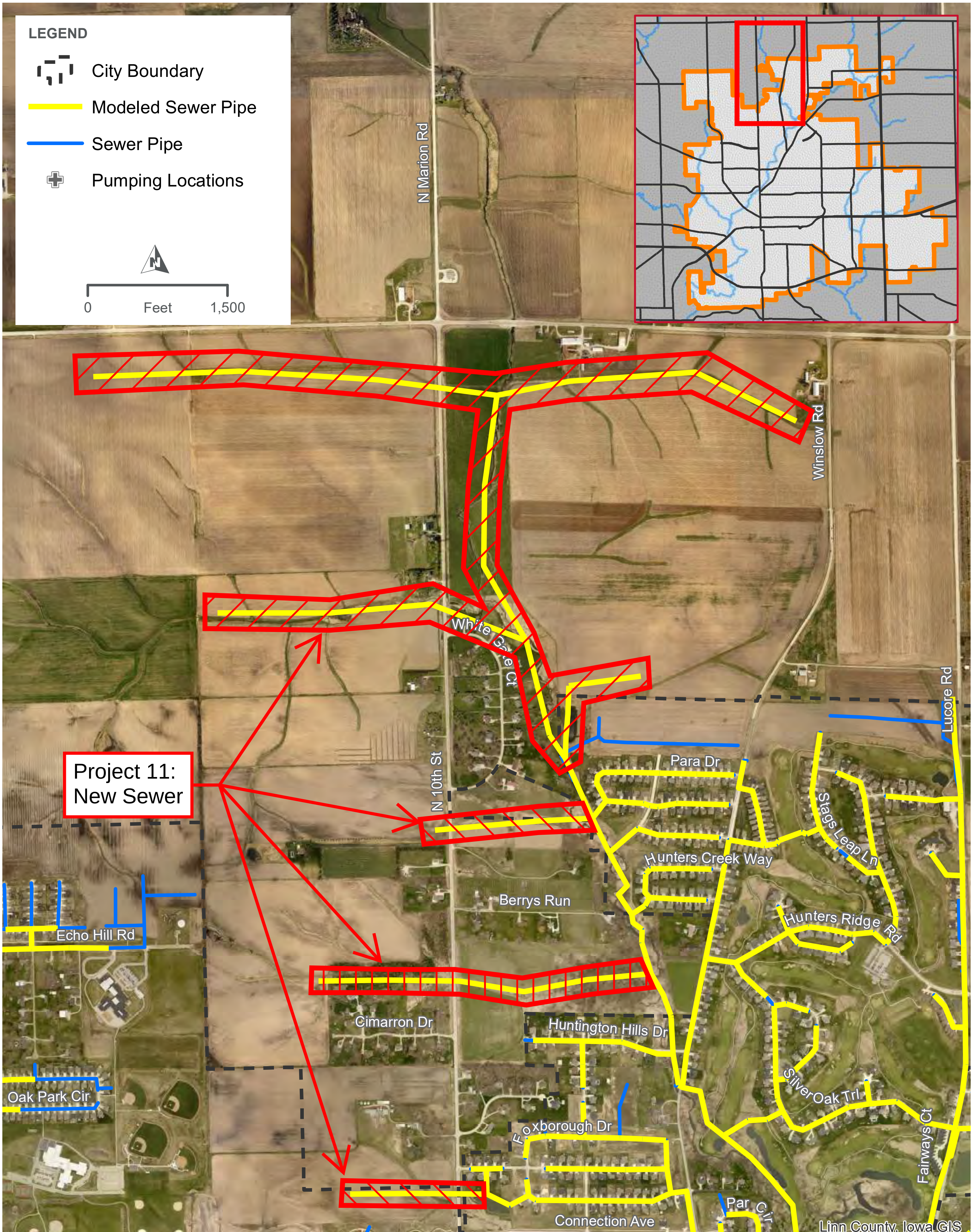
FIGURE 58



RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 1

CHRISTOPHER CREEK & DRY RUN CREEK BASIN, PROJECT 10

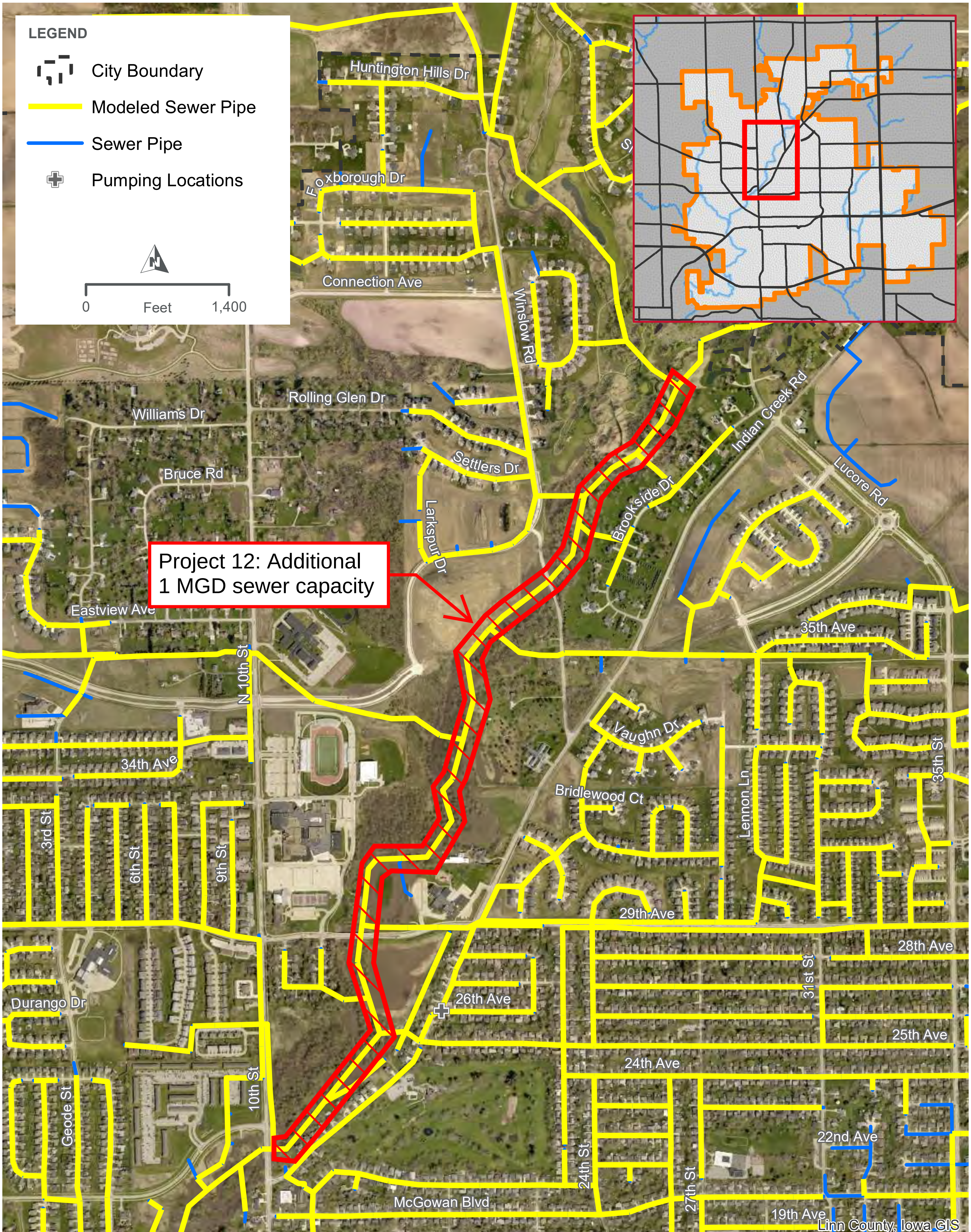
FIGURE 59



RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 2

BERRYS RUN CREEK & INDIAN CREEK BASIN, PROJECT 11

FIGURE 60



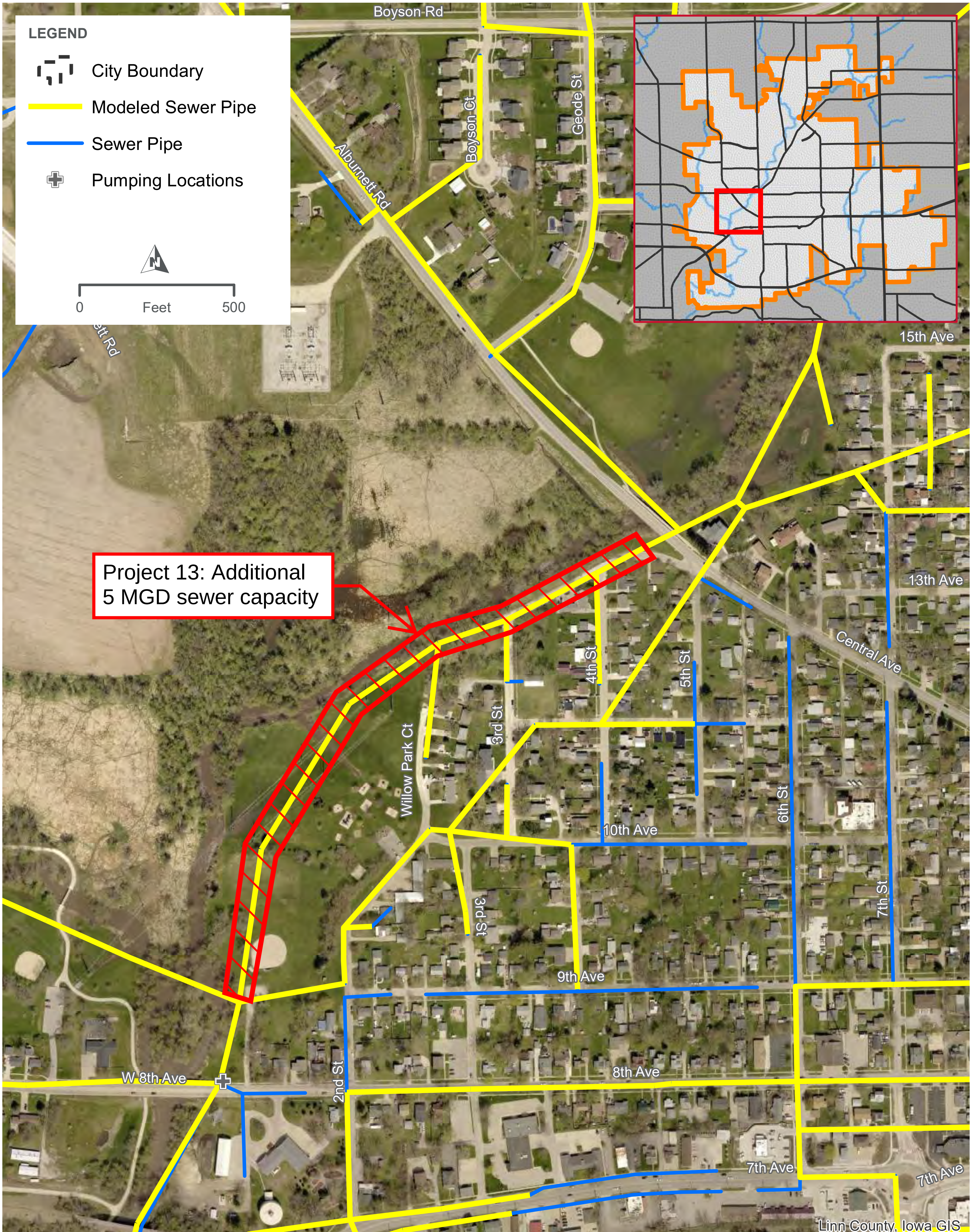
HDR

City of Marion Iowa

RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 2

INDIAN CREEK BASIN, PROJECT 12

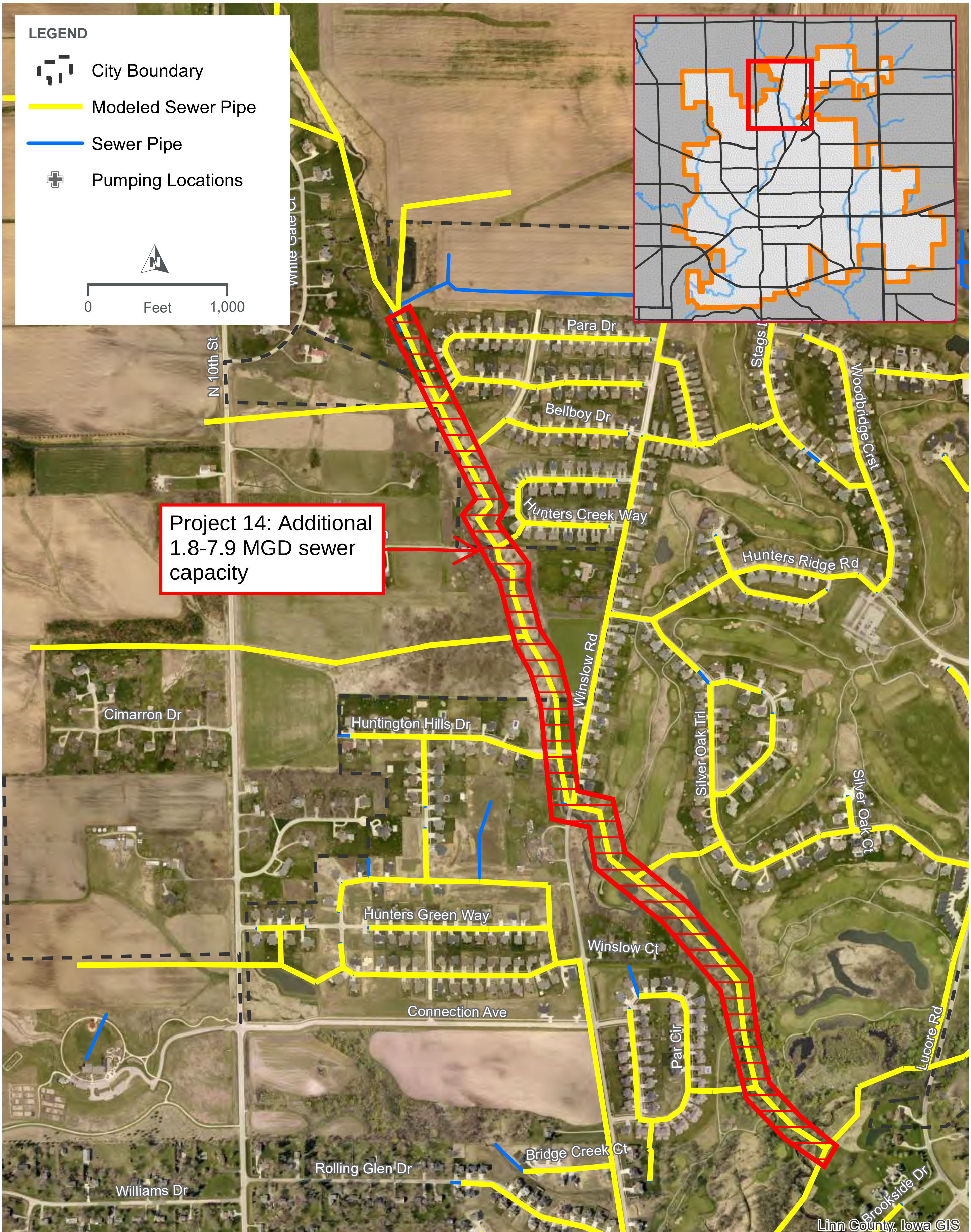
FIGURE 61



RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 2

INDIAN CREEK BASIN, PROJECT 13

FIGURE 62

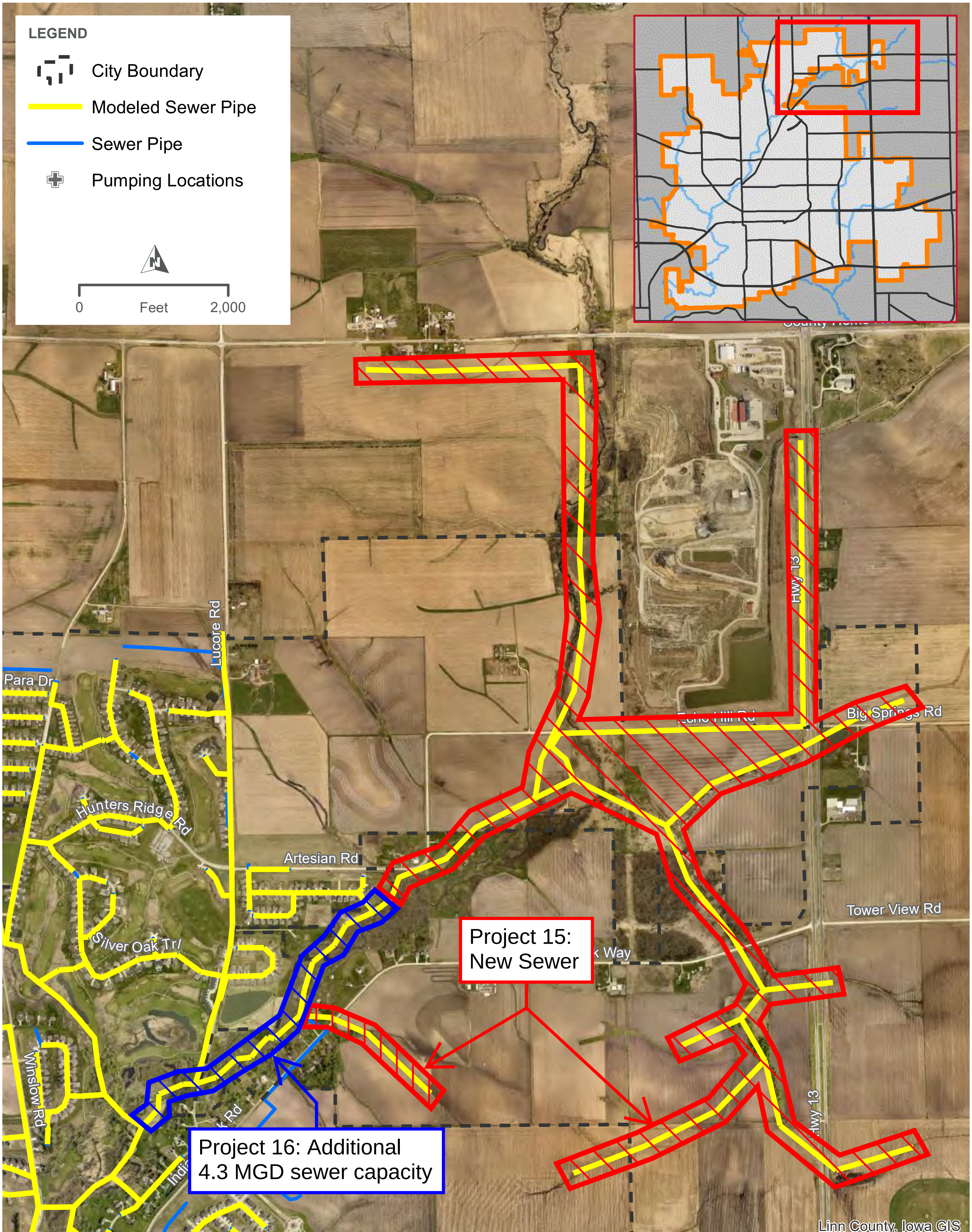


HDR City of Marion IOWA

RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 2

BERRYS RUN CREEK & INDIAN CREEK BASIN, PROJECT 14

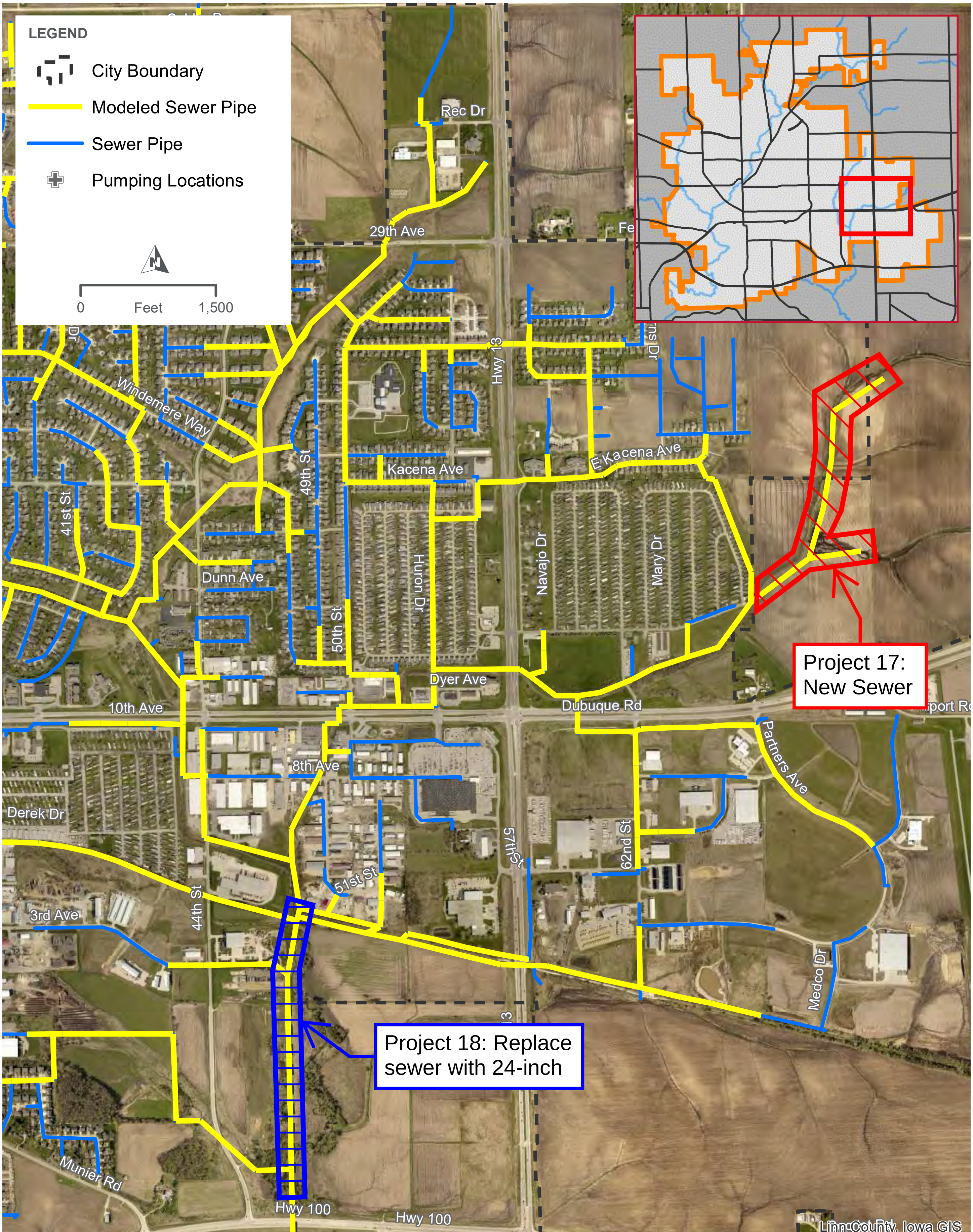
FIGURE 63



RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 3

INDIAN CREEK BASIN, PROJECT 15 AND PROJECT 16

FIGURE 64

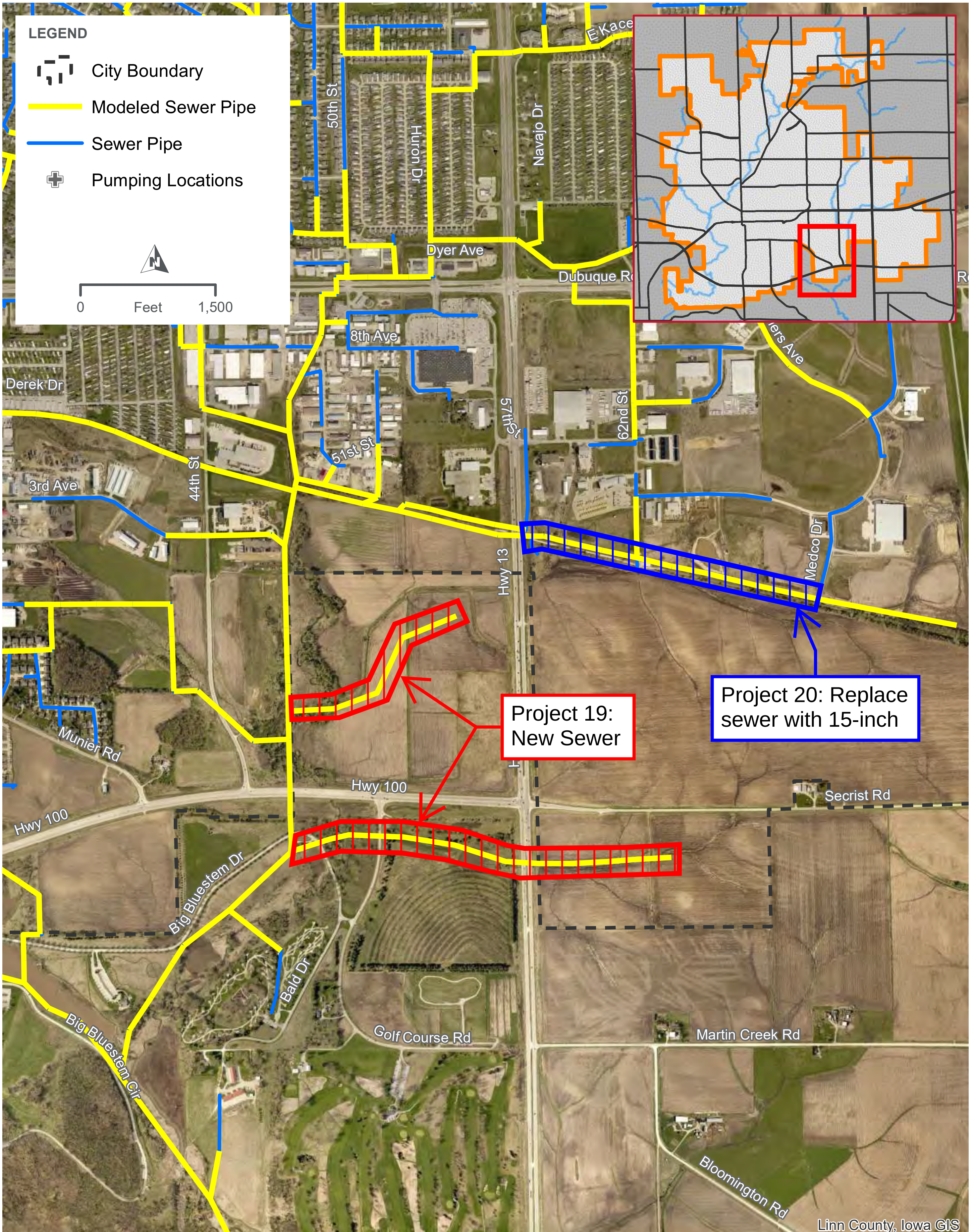


RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 4

SQUAW CREEK BASIN, PROJECT 17 AND PROJECT 18

FIGURE 65

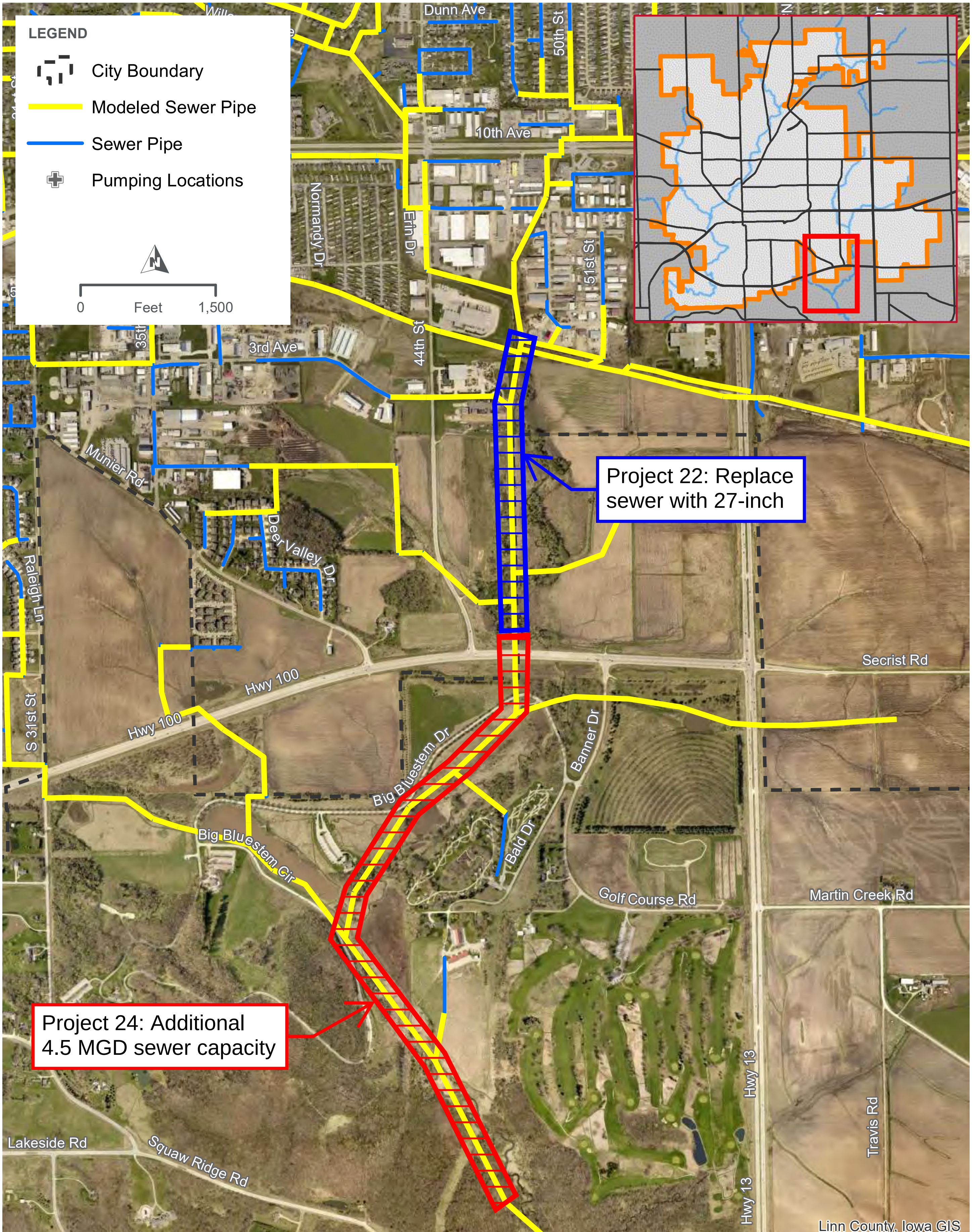
PATH: - USER: STHEN - DATE: 1/26/2021



RECOMMENDED IMPROVEMENTS FOR GROWTH AREA 5

SQUAW CREEK BASIN, PROJECT 19 AND PROJECT 20

FIGURE 66



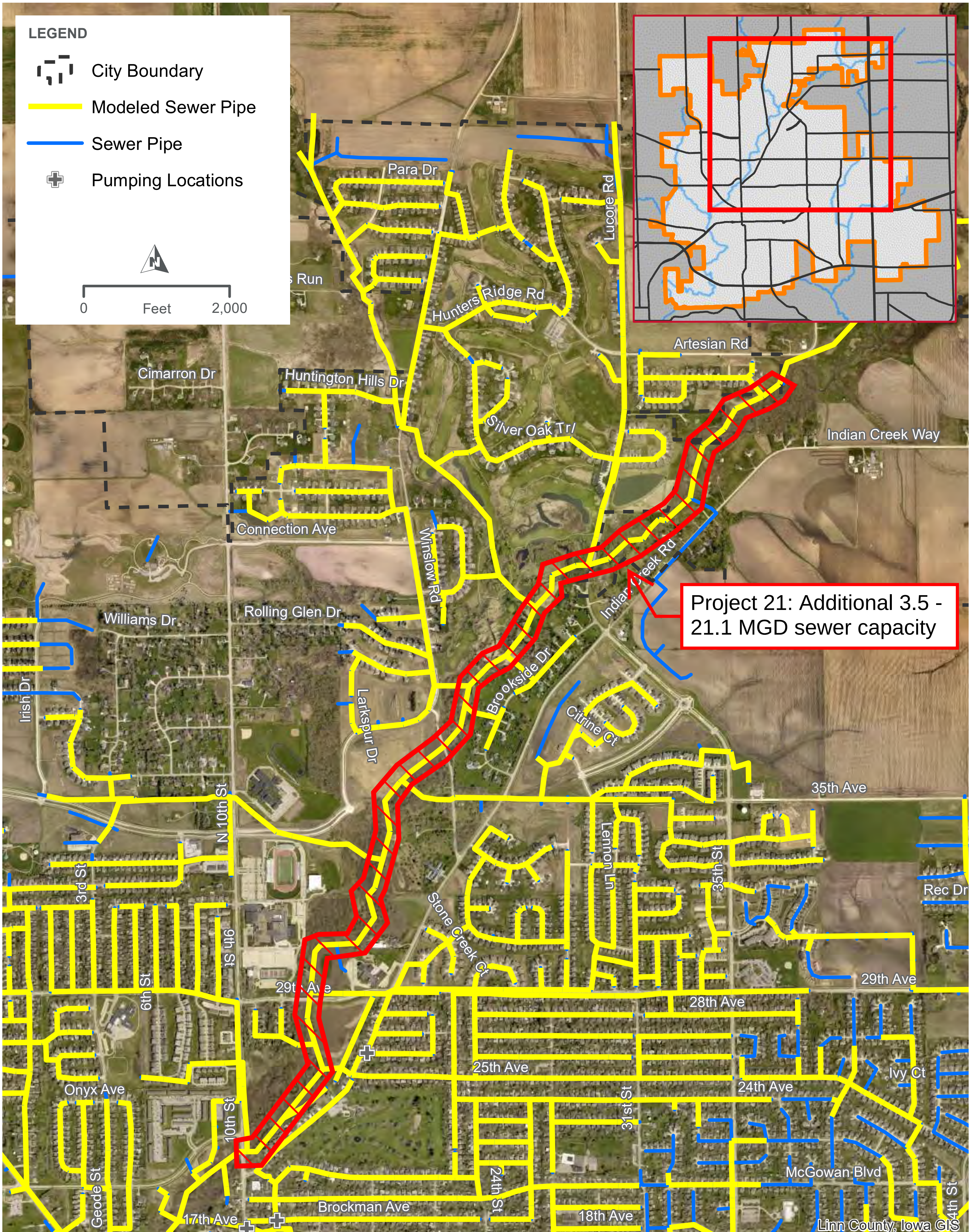
City of Marion Iowa

RECOMMENDED IMPROVEMENTS FOR FULL DEVELOPMENT CONDITION

SQUAW CREEK BASIN, PROJECT 22 AND PROJECT 24

FIGURE 67

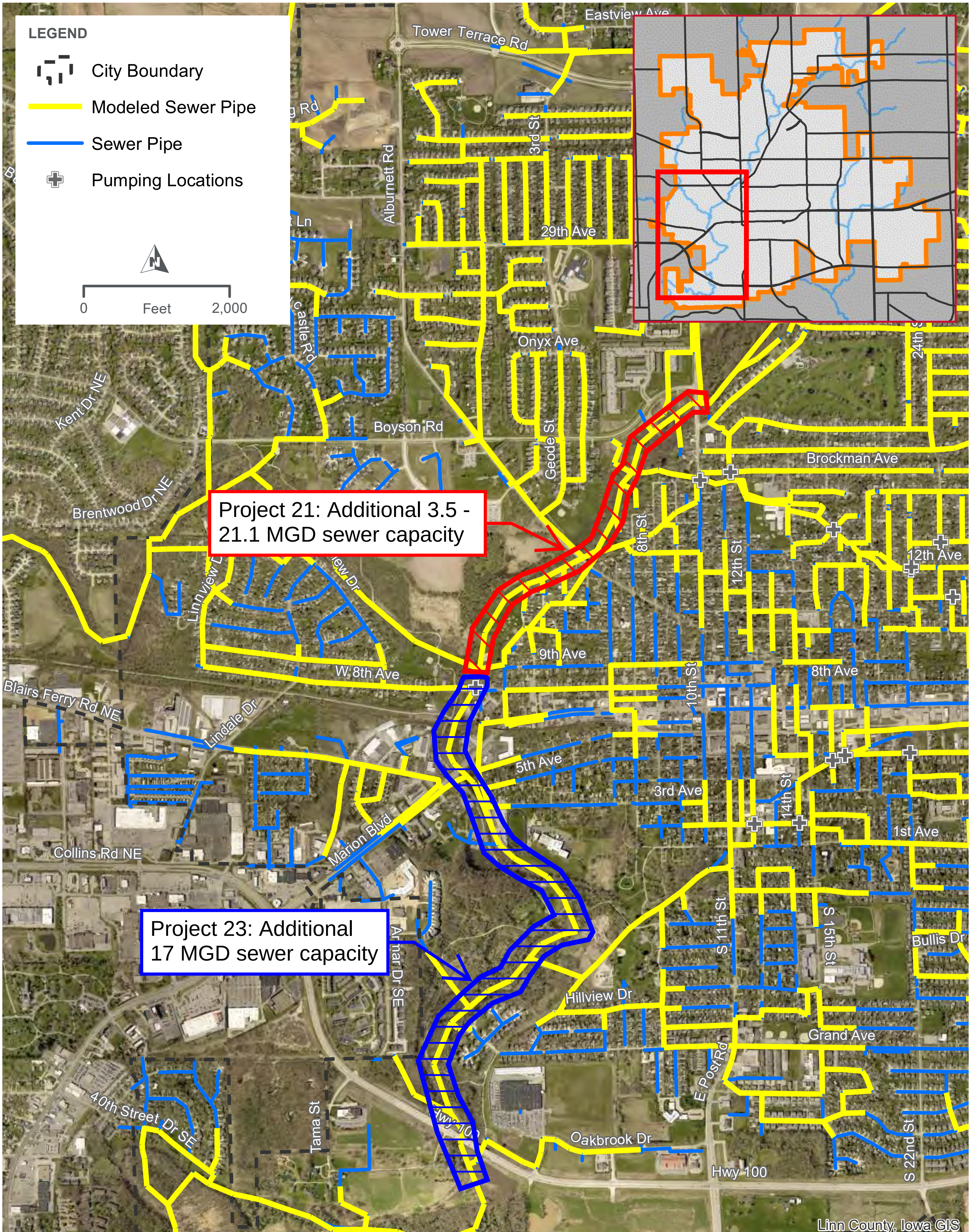
PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\REPORT FIGURES\PROJECTFIGURES.MXD - USER: STHEN - DATE: 1/26/2021



RECOMMENDED IMPROVEMENTS FOR FULL DEVELOPMENT CONDITION

INDIAN CREEK BASIN, PROJECT 21 (PART A)

FIGURE 68



HDR City of Marion Iowa

RECOMMENDED IMPROVEMENTS FOR FULL DEVELOPMENT CONDITION

LOWER INDIAN CREEK & INDIAN CREEK BASIN, PROJECT 21 (PART B) AND PROJECT 23

FIGURE 69

Appendix A

HDR | ONE COMPANY *Many Solutions*℠

Technical Memorandum

To:	Linn County Regional Planning Commission		
From:	Dave Dechant /HDR Todd Williams /HDR Erin Wohlrab /HDR	Project:	Indian Creek and Dry Run Creek Trunk Sanitary Sewer Capacity Improvements Project
Date:	December 11, 2007	Job No:	HDR 59247

RE: Executive Summary

BACKGROUND

The Indian Creek and Dry Run Creek Trunk Sanitary Sewers are located within Linn County and serve the cities of Cedar Rapids, Hiawatha, Marion, and Robins. Portions of the existing sewers are at or are approaching hydraulic capacity. Continued growth is projected for the areas they serve representing the potential for progressively more significant sewer backups during wet weather events.

The ultimate goal of this Capacity Improvements Project was to size and prioritize a replacement trunk sewer based on capacity needs and cost, using a fully developed Hydraulic XPSWMM Model. This Model provides the capability of adjusting future phases to actual community growth patterns. This goal was accomplished through a series of tasks with the following Technical Memoranda documenting the associated effort and results.

- TM 100 Develop Hydraulic Model
- TM 200 Model Current Flows
- TM 300 Model Requested Future Flows
- TM 400 Replacement Sewer Analysis

Linn County Regional Planning, Linn County, and the cities of Cedar Rapids, Hiawatha, Marion, and Robins provided available sewer mapping, recent aerial photography, tributary area maps, 2001 base mapping files, inventory spreadsheets, manhole inspection reports, preliminary SewerCAD files, GIS mapping data, and 15-minute interval rain gauge and flow meter data involving the Dry Run and Indian Creek Trunk Sewer, and documentation with respect to future flow projections and associated populations. Subconsultant Anderson-Bogart assisted with collection and assembly of the data.

Additionally, the following reports were available to HDR for reference during the study:

- 1998 Cedar Rapids Sanitary Sewer Master Plan and supporting SWMM files.
- 2001 Indian Creek Sewer Interceptor Study
- 2002 Marion Sanitary Sewer Trunk Study.

SUMMARY

The existing Dry Run and Indian Creek trunk sewers and associated service area boundaries for the cities of Cedar Rapids, Hiawatha, Marion, and Robins are shown in Figure 1. Furthermore, Figure 1 depicts the following.

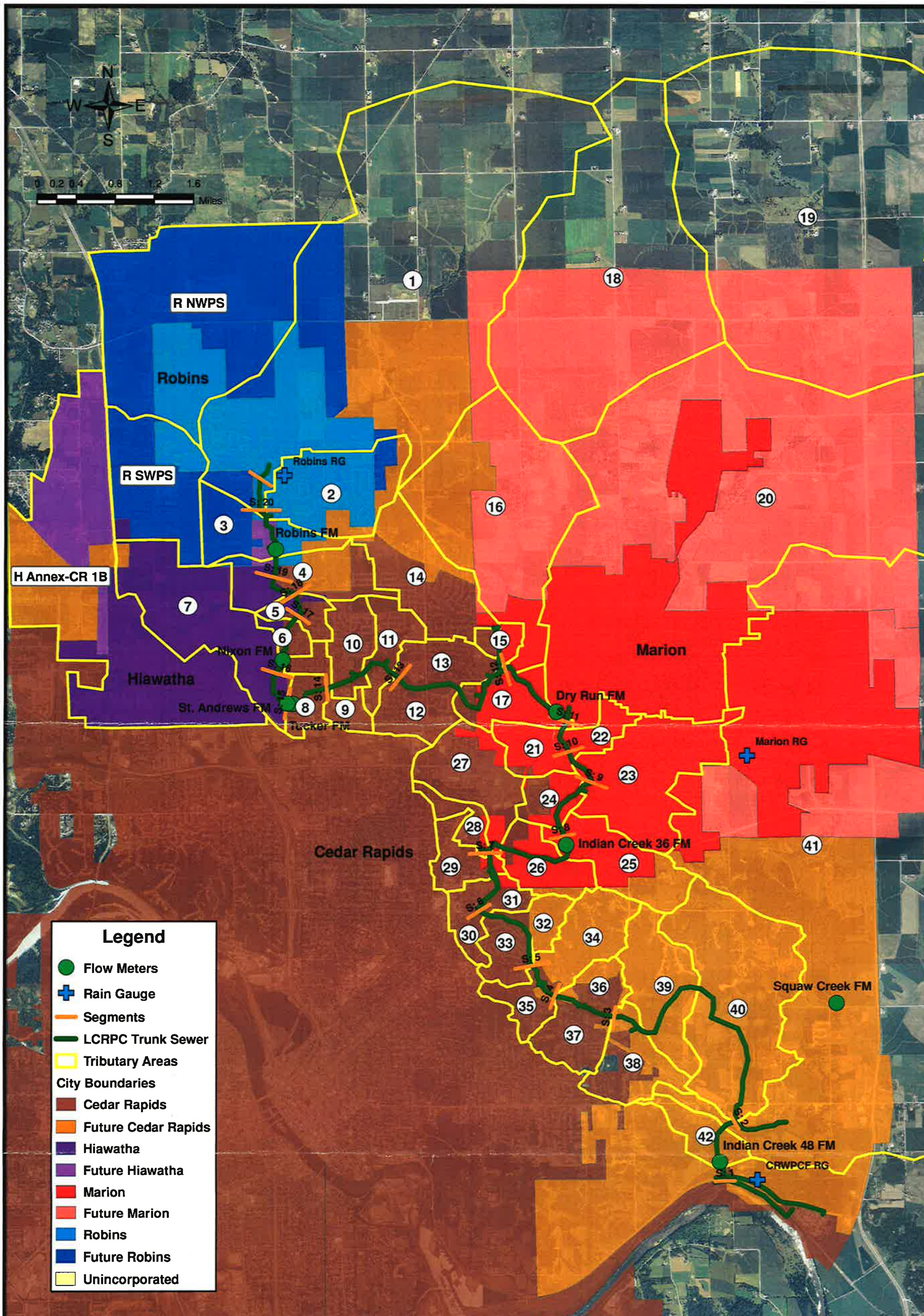
- Delineation of the 20 segments (S: 1 through S:20) that comprise the modeled portion of the existing Dry Run and Indian Creek trunk sewers

- Delineation of the 45 tributary areas (1 through 42 and the 3 future pump station areas added near Robins and Hiawatha) served by the Dry Run and Indian Creek trunk sewers

- Locations of the flow meters and rain gauges providing the historical data to which the hydraulic model of the Dry Run and Indian Creek trunk sewers is calibrated.

A comprehensive summary of each tributary area is presented in Table 1; including the total acres, currently developed acres, and existing and projected population broken down by jurisdiction (Cedar Rapids, Hiawatha, Linn County, Marion, and Robins). It also includes the 2015 population used to determine the impacts of future development on the proposed improvements. 2015 is the approximate year when the first five replacement projects will be completed. This table is the foundation on which the model was based to simulate current and future dry and wet weather flows in the Dry Run and Indian Creek trunk sewers. Table 1 should be periodically reviewed in comparison to actual growth patterns and, if necessary, revised in conjunction with an updated hydraulic model to refine the replacement sewer sizing and prioritization recommended herein.

Figure 1 – Indian & Dry Run Creek Trunk Sanitary Sewer



Indian & Dry Run Creek Trunk Sanitary Sewer

Linn County Regional Planning Commission
Hydraulic Model Study
Executive Summary

Table 1 - Distribution of Project Population

Tributary Area	Model Manhole Name	Total Area[1]	Developed Area[2]	Robins Population				Hiawatha Population				Cedar Rapids Population				Marion Population				Linn County Population		
				Projected[3]	Existing[4]	Difference	Pop. in 2015[5]	Projected[3]	Existing[4]	Difference	Pop. in 2015[5]	Projected[3]	Existing[4]	Difference	Pop. in 2015[5]	Projected[3]	Existing[4]	Difference	Pop. in 2015[5]	Projected[3]	Existing[4]	Difference
1	22	5,573.49	2,112.69	7,225	489	6,736	2,510				0				0				0	0		0
2	24	672.19	383.07	1,084	1,084	0	1,084				0	9,000	0	9,000	2,700				0	0		0
3	25	615.11	151.60	167	167	0	167				0				0				0	0		0
4	13242W-001	485.45	242.09	60	60	0	60	1,377	377	1,000	677	4,400	403	3,997	1,602				0	0		0
5	14241W-002	138.03	83.91				0	604	504	100	534	525	460	65	480				0	0		0
6	14243W-005	93.19	60.36				0	23	23	0	23	450	444	6	446				0	0		0
7	15242W-017	896.15	581.29				0	8,111	2,107	6,004	3,908	42	42	0	42				0	0		0
8	15243W-005	145.46	17.37				0	16	16	0	16	1,450	388	1,062	707				0			
9	15244W-001	175.50	122.19				0				0	1,313	727	586	903				0			
10	15232W-012	264.76	152.98				0				0	1,988	800	1,188	1,156				0			
11	14223W-001	236.67	148.54				0				0	1,800	604	1,196	963				0			
12	15222W-006	275.41	94.66				0				0	2,063	660	1,403	1,081				0			
13	15202W-007	275.83	192.75				0				0	2,750	2,195	555	2,362	3	3	0	3			
14	14202W-003	653.61	410.21				0				0	4,875	2,452	2,423	3,179	2,373	39	2,334	739	0		0
15	14203W-025	95.80	69.29				0				0	375	299	76	322	131	131	0	131			
16	15201W-005	1,800.11	694.50				0				0	4,500	0	4,500	1,350	192	192	0	192	0		0
17	15214W-007	326.98	165.95				0				0	300	136	164	185	1,188	1,188	0	1,188	0		0
18	16191W-007	3,319.35	988.16				0				0				0	300	300	0	300	0		0
19	16191W-007	5,492.03	1,626.24				0				0				0				0	0		0
20	16191W-007	6,447.19	3,271.48				0				0				0	16,205	9,872	6,333	11,772	0		0
21	16194W-005	223.56	166.65				0				0	61	61	0	61	560	560	0	560	0		0
22	16194W-003	150.35	133.13				0				0				0	3,392	909	2,483	1,654	0		
23	02-03-3769	868.86	686.67				0				0				0	13,094	5,468	7,626	7,756	0		0
24	18191W-005	190.85	93.43				0				0	480	463	17	468	180	180	0	180	0		0
25	04-02-3040	479.18	238.83				0				0				0	202	202	0	202	0		0
26	18193W-001	307.75	113.66				0				0	150	21	129	60	42	42	0	42	0		0
27	18203W-006	507.10	462.68				0				0	3,375	367	3,008	1,269	430	430	0	430	0		0
28	18203W-005	136.40	118.93				0				0	675	420	255	497	70	70	0	70	0		0
29	19202W-011	207.44	176.63				0				0	1,575	1,167	408	1,289	17	17	0	17	0		
30	19203W-016	174.12	163.02				0				0	1,313	844	469	985	7	7	0	7	0		
31	19203W-003	87.77	68.81				0				0	375	196	179	250	9	9	0	9	0		0
32	20201W-003	149.52	111.54				0				0	450	26	424	153				0	0		0
33	21201W-002	202.34	187.31				0				0	600	219	381	333				0	0		0
34	21192W-007	402.32	302.52				0				0	1,200	50	1,150	395				0	0		0
35	21192W-002	170.85	134.80				0				0	510	335	175	388				0	0		0
36	21183W-003	171.16	130.25				0				0	850	218	632	408				0	0		0
37	21194W-001	271.96	249.16				0				0	1,350	966	384	1,081				0	0		0
38	22172W-005	373.82	265.85				0				0	1,125	528	597	707				0	0		0
39	21174W-006	551.80	172.98				0				0	1,650	0	1,650	495				0	85	85	0
40	22152W-001	1,426.70	676.35				0				0	4,290	0	4,290	1,287				0	317	317	0
41	24142W-001 or 24151W-004	9,127.19	3,618.71				0				0	7,500	1,318	6,182	3,173	11,215	5,944	5,271	7,525	0		0
42	24164W-003	217.75	115.01				0				0	1,650	0	1,650	495				0			0
H Annex _CR 1B	*H Annex _CR 1B*	*1,529.00*					0	*7,490*	0	7,490	2,247	*6,600*	0	6,600	1,980				0			
R NWPS	*R NWPS*	*1720.00*		*8,592*	0	8,592	2,578				0				0				0			
R SWPS	*R SWPS*	*592.00*		*2,616*	0	2,616	785				0				0				0			
Totals				19,744	1,800	17,944	7,183	17,621	3,027	14,594	7,405	71,610	16,809	54,801	33,249	49,610	25,563	24,047	32,777	402	402	0

[1] Total area pertains to all the area within a given tributary area.

[2] Developed area was taken from 2003 parcel data and pertains to the area developed as of 2003 for the given tributary area.

[3] Projected population refers to the population for the year 2050 for the given tributary area.

[4] Existing population is based on 2000 census data and refers to the population in the year 2000 for the given tributary area.

[5] 2015 population was calculated based on a linear interpolation from 2000 to 2050. Population in 2015 is 30% of the total projected population. 2015 is the year estimated for the completion of the 5 recommended projects.

Existing and replacement sewer sizing for the Dry Run and Indian Creek trunk sewer are presented in Table 2. Replacement sewer sizing is based on anticipated 2050 flows for a 10 year storm event and moderate antecedent moisture conditions. Table 2 also identifies the associated capital cost for the replacement sewer. All costs are reported in 2007 dollars and should be inflated to the anticipated mid-point of construction for budgeting purposes. Construction costs have increased at the rate of 4 to 5 percent per year over the past 10 years collectively and a higher rate of 8 to 10 percent per year over the past 4 years collectively.

Table 2 - 10-Year Future Pipe Sizing

Pipe Segment	Existing Pipe Size (in)	Required Future Pipe Size (in)	Average Existing Pipe Capacity (cfs)	Maximum Future Dry Weather Peak Flow (cfs)	Max. Future Design Flows 10-Year Design Storm (cfs)	Average Pipe Slope (%)	Future Flow 10-Yr Design Storm Average HGL Slope	Rank	Total Capital Cost Per Segment (2007 $)
20	**18**	**30**	16.91	4.64	4.84	0.170%	0.009%	20	$2,219,508
19	**18**	**30**	5.04	7.96	8.14	0.139%	0.191%	19	$8,090,149
18	**18**	**30**	4.64	8.75	9.69	0.190%	0.252%	17	$1,712,100
17	**18**	**36**	4.51	8.87	10.21	0.194%	0.335%	12	$992,114
16	**21**	**36**	4.76	10.04	14.01	0.127%	0.365%	8	$2,584,624
15	**21**	**36**	5.85	10.09	14.00	0.160%	0.427%	5	$1,831,498
14	**21**	**36**	6.68	10.39	14.37	0.179%	0.442%	4	$3,027,046
13	**24**	**36**	8.33	11.47	17.12	0.147%	0.343%	10	$1,780,651
12	**27**	**42**	12.33	14.18	22.59	0.160%	0.336%	11	$855,645
11	**27**	**48**	13.33	18.12	28.48	0.180%	0.507%	3	$802,437
10	**33**	**48**	23.73	18.12	30.07	0.194%	0.321%	13	$1,599,283
9	**33**	**48**	30.03	18.60	31.62	0.238%	0.246%	18	$2,585,346
8	**36**	**48**	23.36	20.66	36.30	0.141%	0.318%	14	$1,682,496
7	**36**	**60**	28.19	22.97	40.55	0.151%	0.350%	9	$864,099
6	**42**	**60**	36.05	23.85	44.19	0.137%	0.282%	16	$768,426
5	**42**	**60**	40.59	25.71	45.80	0.194%	0.303%	15	$1,234,397
4	**42**	**60**	44.52	26.97	49.90	0.214%	0.375%	7	$659,947
3	**42**	**60**	45.66	27.64	52.14	0.214%	0.416%	6	$1,749,246
2	**42**	**60**	41.24	30.76	67.59	0.174%	0.555%	1	$1,154,714
1	**48**	**60**	55.65	35.11	73.62	0.277%	0.534%	2	$365,246

The corresponding peak flows by segment for the each City and the County are summarized in Table 3. This table reflects changes relative to originally requested flows for Cedar Rapids, Hiawatha, and Robins. The changes were due in large part to an expanded service area west of Hiawatha and north of Robins.

Table 3 – Revised Requested Flows (09/14/07)

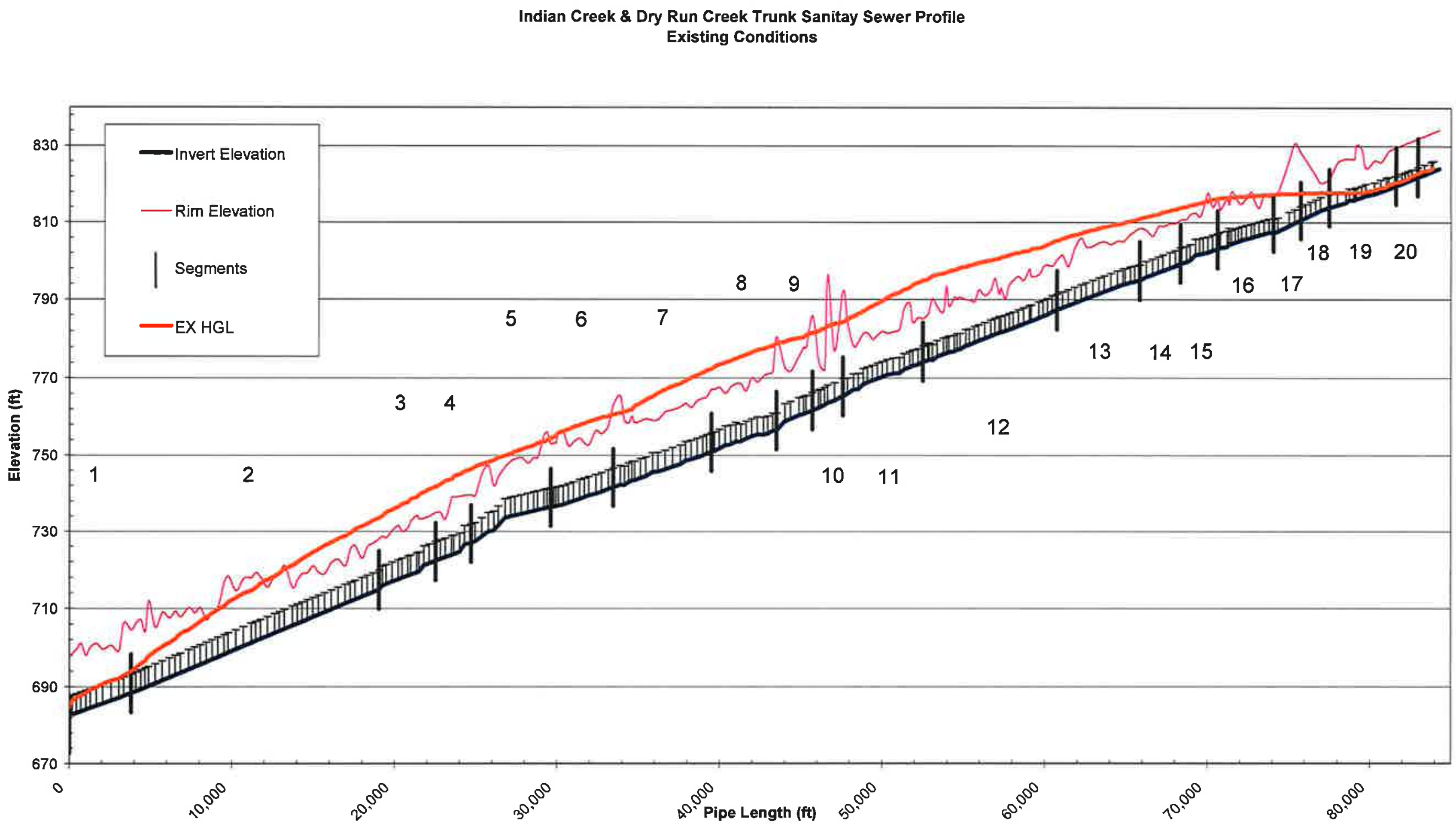
Total Requested Peak Flow (mgd)						
Pipe Segment	Robins	Hiawatha	Cedar Rapids	Marion	Linn County	Total Requested Peak Flow (MGD)
20	6.38	0	2.7	0	0	9.08
19	8.22	0.01	2.7	0	0	10.93
18	8.22	3.2	5.3	0	0	16.72
17	8.22	3.2	5.42	0	0	16.84
16	8.22	3.5	5.52	0	0	17.24
15	8.22	6.41	5.53	0	0	20.16
14	8.22	6.41	5.85	0	0	20.48
13	8.22	6.41	6.93	0	0	21.56
12	8.22	6.41	9.89	0	0	24.52
11	8.22	6.41	9.89	1.41	0	25.93
10	8.22	6.41	9.89	6.28	0	30.80
9	8.22	6.41	9.89	7.48	0	32.00
8	8.22	6.41	9.98	12.44	0	37.05
7	8.22	6.41	10.78	12.44	0	37.85
6	8.22	6.41	11.39	12.44	0	38.46
5	8.22	6.41	11.59	12.44	0	38.66
4	8.22	6.41	11.9	12.44	0	38.97
3	8.22	6.41	12.31	12.44	0	39.38
2	8.22	6.41	13.58	12.44	0	40.65
1	8.22	6.41	15.19	16.75	0.152	46.72

The following segments, in order noted, were determined to be the highest priority to eliminate current bottlenecks and begin to accommodate the projected flows associated with forecast growth.

- Segment 2 – 15,238 linear feet of 60-inch
- Segment 7 – 6,051 linear feet of 60-inch
- Segment 11 – 271 linear feet of 54-inch and 4,646 linear feet of 48-inch
- Segment 10 – 1876 linear feet of 54-inch
- Segment 6 – 3845 linear feet of 60-inch

Profiles of the Dry Run and Indian Creek trunk sewers with model predicted hydraulic grade lines, ie water surface, are presented in Figures 2, 3, and 4 are. All three reflect wet weather flows based on a 10 year storm event with moderate antecedent moisture conditions.

Figure 2 – Existing Sewer with Existing HGL from 10-year Design Storm



HDR Engineering, Inc.

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Figure 3 – Segments 2, 7, & 11 Replacement Results

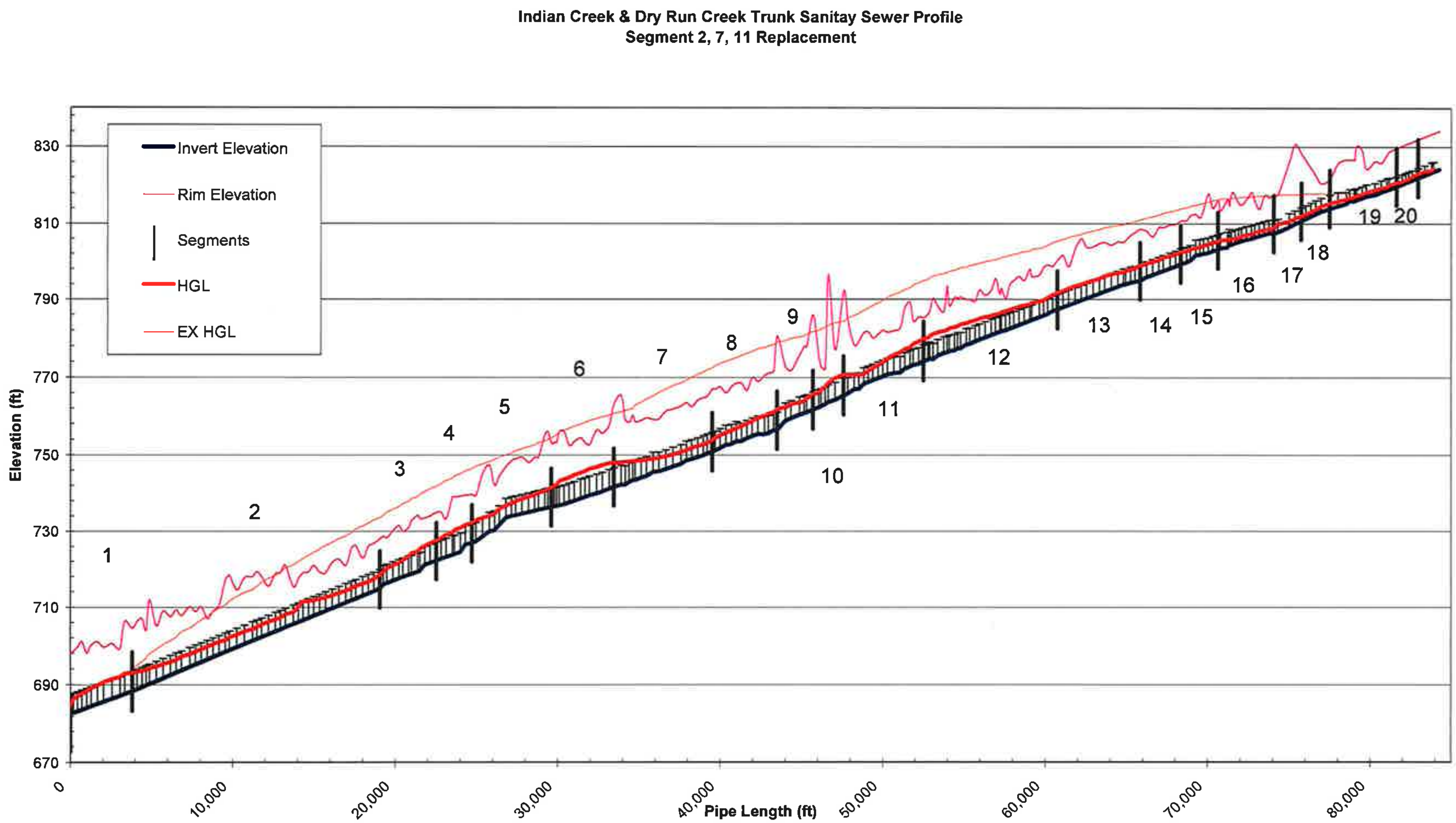

Figure 4 – Segments 2, 7, & 11 Replacement Results for the Year 2015 Projected Flows

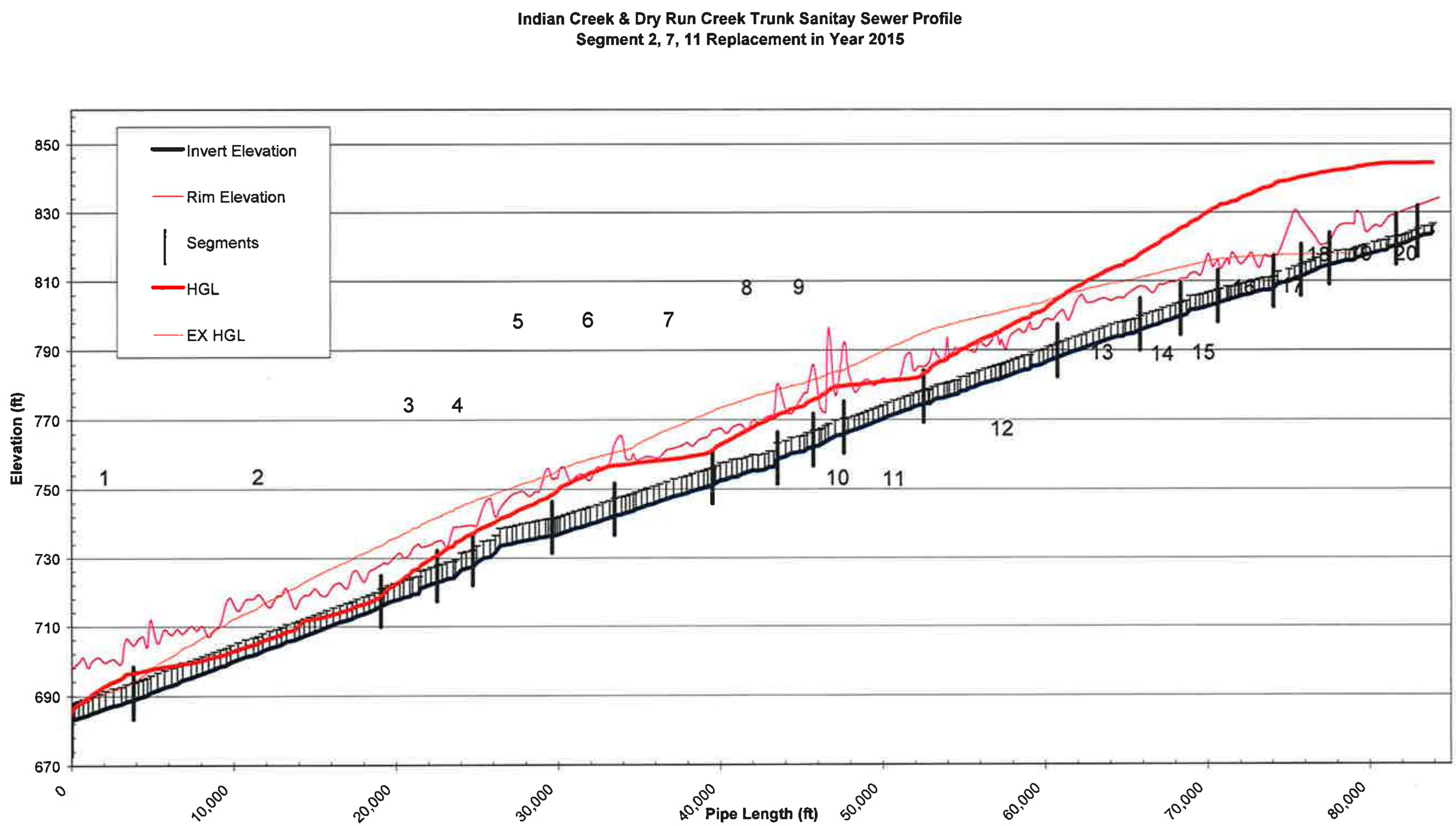

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Figure 2 shows the model predicted hydraulic grade for the 10-year design storm in the existing trunk sewers. As indicated, much of the existing trunk sewer, beginning in Segment 2 and continuing through Segment 16, would be surcharged likely producing manhole overflows and/or basement backups in connecting sewers.

Figure 3 shows the model predicted hydraulic grade line for existing conditions, but with the first three priority segments 2, 7, and 11 replaced. As indicated, essentially all of the surcharging has been eliminated.

Figure 4 shows the model predicted hydraulic grade line for anticipated 2015 populations and flows with the first three priority segments above replaced. 2015 populations were calculated based on linear interpolation between the years 2000 and 2050. 2015 is thirty percent of the projected 2050 population. As indicated, the anticipated growth between now and 2015 will again produce moderate to significant surcharging in segments 3 through 18 without continued replacement of the existing Dry Run and Indian Creek trunk sewers. Most likely, replacement will continue with Segments 10 and 6 as the next highest priorities.

Allocations of replacement sewer costs to each City and the County are summarized in Table 4. Again, it should be noted that the costs presented are in 2007 dollars and should be inflated to the anticipated mid point of construction. Table 4 lists the five segments with highest priority in order first, and then the remaining segments sequentially from upstream to downstream. Given the length and cost of Segment 2, it is suggested that it be broken into three phases 2a, 2b, and 2c, each with roughly one third the total length beginning downstream and working upstream.

Table 4 – Cost Allocation in 2007 Dollars

Pipe Segment	Total Cost per Segment	Robins	Hiawatha	Cedar Rapids	Marion	Linn County
2	**$8,090,149**	$1,635,942	$1,275,716	$2,702,687	$2,475,804	$0
7	**$3,027,046**	$657,393	$512,638	$862,128	$994,886	$0
11	**$1,599,283**	$506,984	$395,349	$609,985	$86,964	$0
10	**$802,437**	$214,157	$167,001	$257,666	$163,614	$0
6	**$1,831,498**	$391,443	$305,250	$542,401	$592,403	$0
20	**$365,246**	$256,638	$0	$108,608	$0	$0
19	**$1,154,714**	$868,413	$1,056	$285,245	$0	$0
18	**$1,749,246**	$859,976	$334,784	$554,486	$0	$0
17	**$659,947**	$322,136	$125,406	$212,406	$0	$0
16	**$1,234,397**	$588,558	$250,603	$395,236	$0	$0
15	**$768,426**	$313,317	$244,326	$210,784	$0	$0
14	**$864,099**	$346,821	$270,453	$246,825	$0	$0
13	**$1,682,496**	$641,471	$500,223	$540,802	$0	$0
12	**$2,585,346**	$866,702	$675,859	$1,042,784	$0	$0
9	**$855,645**	$219,794	$171,396	$264,448	$200,007	$0
8	**$1,780,651**	$395,059	$308,070	$479,646	$597,876	$0
5	**$2,584,624**	$549,550	$428,542	$774,852	$831,679	$0
4	**$992,114**	$209,268	$163,188	$302,955	$316,703	$0
3	**$1,712,100**	$357,376	$278,684	$535,194	$540,846	$0
1	**$2,219,508**	$390,487	$304,504	$721,594	$795,701	$7,221
Total	**$36,558,972**	$10,591,485	$6,713,047	$11,650,734	$7,596,485	$7,221

DATA ANALYSIS

The study began by obtaining and analyzing available flow and rainfall monitoring data for the meters and rain gauges shown on Figure 1. Dry weather periods were first established to characterize dry weather flows for all flow meters, and then strong to moderate wet weather periods were identified to characterize wet weather flows for all flow meters.

Five of the seven flow meters had data from 2000-2007 as follows: Indian Creek 48, Indian Creek 36, Dry Run, Nixon, and Robins. The remaining two flow meters were St. Andrews with data from 2004-2006 and Tucker with data from 2005-2007. Each flow meter was assigned to the nearest of the three rain gauges available for the purpose of comparing precipitation to resulting wet weather flows.

Table 5 summarizes the associated rain gauge, tributary acreage, and population contribution for each flow meter.

Table 5 – Flow Meter & Tributary Area Characteristics

Flow Meter	Rain Gauge	Tributary Area (acres)	Population Contribution (# of People)
Indian Creek 48	CRWPCF	44,381	50,701
Indian Creek 36	Marion	29,895	36,094
Dry Run	Marion	12,723	16,902
St. Andrews	Robins	8795	7698
Tucker	Robins	8474	6569
Nixon	Robins	7578	4367
Robins	Robins	6861	1845

Tributary areas delineated for each flow meter were further divided to identify the tributary area for each significant connecting sewer and to isolate known contributors of rainfall dependent inflow and infiltration (RDII) such as foundation drains connected to the sanitary sewer in Northbrook, Bowman Woods, and Linn View and documented problems such as basement backups. In all, forty-five tributary areas were delineated as shown in Figure 1.

GIS data with updated elevations were imported into the XPSWMM model to populate the model with physical data for each of the 20 Dry Run and Indian Creek Trunk sewer segments. Model structure and pipes names used the naming convention in the City of Cedar Rapids GIS System.

DRY WEATHER ANALYSIS

Dry weather flow, consisting primarily of sanitary flow from domestic sources, is largely dependent on the population density of the basin. Dry weather periods were selected for each flow meter and converted from 15-minute time intervals to hourly time intervals to produce a representative diurnal dry weather flow curve. The ideal dry weather period was considered to have at least three weeks of dry weather. Differences between model predicted and actual metered dry weather flows required calibration of the model input parameters to match the metered flow.

Three parameters were adjusted to facilitate the dry weather calibration. The representative diurnal dry weather curve was adjusted to refine the model hydrograph shape. A second diurnal curve was developed for the Squaw Creek tributary area given its much greater size relative to the other tributary areas. Adjusting the diurnal curves primarily impacted the model predicted peak flow rate.

Secondly, the direct flow value, which is the dry weather flow per capita, was adjusted to control the total volume of dry weather flow for the project area. This direct flow value is a multiplier to the diurnal flow pattern developed for the basin. Ultimately, it was determined that 75 gallons per capita per day was a realistic dry weather flow for the Dry Run and Indian Creek trunk sewer service area.

Lastly, dry weather infiltration was added as a constant flow to account for groundwater entering the system even during dry weather. The latter adjustment was made primarily in the lower portion of the Indian Creek trunk sewer where the sewer itself parallels and crosses below the continuously flowing Indian Creek.

Table 6 presents the results of the dry weather calibration model runs with the volume and peak flows compared to metered data at each basin. Typically, model results should predict flows and volumes within 10-15% of the meter to be considered valid. Such a calibration was achieved on this project with the exception of the Tucker and St. Andrews meters for which data during the driest weather period was not available. As such, the calibrated model predicted less flow at those two meters than actually metered during the best available, not so dry weather period.

Table 6 - Indian Creek/Dry Run - Dry Season Calibration Results

Pipe G_ID	Meter	Basin	Year	Volume (cu.ft.) Meter	Volume (cu.ft.) Model	Volume (cu.ft.) % Difference	Peak Flow (cfs) Meter	Peak Flow (cfs) Model	Peak Flow (cfs) % Difference	Comment
Robins	Robins	Dry Run	2002	15,470	14,915	-4%	0.29	0.27	-7%	November 2002 (P=0.18-inches)
Nixon	Nixon	Dry Run	2002	33,228	37,310	12%	0.63	0.62	-1%	November 2002 (P=0.18-inches)
Tucker	Tucker	Dry Run	2006	72,067	62,968	-13%	1.21	1.02	-16%	November 2006 (P=2.11-inches)
STA_B	St. Andrews	Dry Run	2004	199,499	58,928	-70%	1.61	0.96	-40%	September 2004 (P=0.58-inches)
Dry	Dry Run	Dry Run	2002	176,146	183,658	4%	2.79	2.66	-5%	November 2002 (P=0.18-inches)
I36	I36	Indian Cr.	2003	381,066	427,878	12%	5.29	6.05	14%	November 2002 (P=2.11-inches)
SC	Squaw Cr.	Squaw Cr.	2002	74,690	86,285	16%	1.21	1.18	-2%	November 2002 (P=0.18-inches)
I48	I48	Indian Cr.	2002	723,478	757,382	5%	10.18	10.12	-1%	November 2002 (P=0.18-inches)

WET WEATHER ANALYSIS

Two storm events were selected for calibration of the XPSWMM Model. The events were chosen based on metered rainfall intensity and duration, the availability of flow meter data and the antecedent moisture condition of the soil. For calibration, it is important to select a variety of storm intensities and durations, as each may impact the system differently. Similarly, the antecedent condition of the soil has a significant impact on the total flow that enters the system during a wet weather event.

The November 1-4, 2003 storm represents a typical storm during the dry season storms when antecedent soil moisture and relative runoff volume is lower. The July 16-17, 2007 storm represents a storm event following other storm events when antecedent soil moisture and relative runoff volume are moderate. The May 21-23, 2004 storm event reflects wet antecedent soil moisture and even higher runoff volumes. The May event had significant surcharging and suspected system overflows at a couple of locations and was used to validate the model calibration.

The May storm event was initially selected and used as the calibration event, and checked against the November storm event. However, because of the suspected system overflows during the May storm event, the model was subsequently recalibrated to the November storm event and checked against the May storm event. As such, the model is more reflective of moderate antecedent moisture conditions than wet antecedent moisture conditions.

Wet weather flows consist of three components: wet weather inflow, rainfall dependant infiltration contributed from the storm event, and wet season infiltration. The first two components represent the RDII. Inflow to the system is a result of directly connected impervious area, such as leaking manhole lids, and is estimated by the model based on the Inflow Ratio multiplied by the impervious area of the system. Rapid Infiltration is a result of infiltration immediately following the associated storm event. This flow is typical of foundation drains, and other subsurface defects. The impact to the system is typically delayed several hours to days.

Table 7 summarizes the average RDII at each meter for the rainfall events, translated into average ratios of the inch-diameter mile (IDM) of sewer that is upstream of the meter. It illustrates that the commonly assumed standard 200 gal/IDM used for designing new sewers underestimates the average volumes of inflow and infiltration (I/I) in the existing Dry Run and Indian Creek trunk system.

Table 7 – Flow Meter Average WWI

Storm Events – Rainfall Dependant Inflow and Infiltration (RDII)						
	November 2003		July 2007		May 2004	
Flow Meter	**(cfs)**	**(gal/IDM)**	**(cfs)**	**(gal/IDM)**	**(cfs)**	**(gal/IDM)**
Indian Creek 48	3.53	1356	7.15	1220	10.56	3177
Indian Creek 36	1.21	1381	2.63	N/A	2.29	1616
Dry Run	0.98	1386	2.49	2659	3.59	1893
St. Andrews/Tucker	N/A	N/A	0.78	N/A	1.30	8338
Nixon	0.12	1097	0.42	1339	N/A	N/A
Robins	0.02	374	0.14	984	0.18	476

The third component represents the infiltration due to high ground water during the wet season, also influenced by the antecedent moisture conditions, which varies for each storm event. The total volume estimated for wet weather infiltration was divided by the number of pipes and injected along the trunk sewer as a constant flow in each pipe upstream of the meter. This infiltration, along with the dry weather sanitary flow, reduces the overall capacity of the system to convey wet weather flows.

A summary of the wet weather calibration model runs and results is presented in Table 8. The model was calibrated to moderate antecedent moisture conditions. Flow meters with shaded results did not collect useable data during the given storm event.

Table 8 - Indian Creek/Dry Run Creek Wet-Season Calibration Results - Modeled Vs. Metered Flow Comparison July 15-21, 2007 Storm Event - Moderate Antecedent Conditions

Meter ID	Volume (cu.ft.) Metered	Volume (cu.ft.) Model	Volume (cu.ft.) % Difference	Peak Flow (cfs) Metered	Peak Flow (cfs) Model	Peak Flow (cfs) % Difference
Robins	266,820	156,209	-41%	1.21	1.50	24%
Nixon	553,368	504,018	-9%	3.00	2.97	-1%
Tucker	0	0	-	0.00	0.00	-
St. Andrew	0	0	-	0.00	0.00	-
Dry Run	3,331,734	3,432,100	3%	14.73	11.46	-22%
I36	0	0	-	0.00	0.00	-
Squaw Creek	0	0	-	0.00	0.00	-
I48	8,279,972	10,450,193	26%	35.37	35.72	1%
Totals	12,431,894	14,542,520	15%	6.79	6.46	-5%

TOTAL REQUESTED PEAK FLOWS

The total flows originally requested by the Cities of Cedar Rapids, Hiawatha, Marion, and Robins, and Linn County are defined under the terms of a 28E Agreement to establish capacity and funding by each participating jurisdiction in proportion to their requested design flow contribution. A summary of the originally requested flows is shown in Table 9. During the course of this study, Cedar Rapids, Hiawatha, and Robins identified expanded service areas and each entity took the opportunity to review and affirm or refine the requested flows and the associated population projections. Table 3 summarizes the revised flow requests incorporated into the hydraulic model and the results of this study.

Table 9 – Originally Requested Flows

Revised 4/27/05

Dry Run and Indian Creek Trunk Sewers

Summary of Design Flow by Jurisdiction

Pipe Segment	Robins	Hiawatha	Cedar Rapids	Marion	Linn County	Total Requested Peak Flow (mgd)
	Total Requested Peak Flow (mgd)					
20	4.90	0.00	3.50	0.00	0.00	**8.40**
19	4.90	0.01	5.40	0.00	0.00	**10.31**
18	4.90	0.01	5.50	0.00	0.00	**10.41**
17	4.90	0.01	5.60	0.00	0.00	**10.51**
16	4.90	0.40	5.70	0.00	0.00	**11.00**
15	4.90	3.22	5.70	0.00	0.00	**13.82**
14	4.90	3.22	6.00	0.00	0.00	**14.12**
13	4.90	3.22	7.50	0.00	0.00	**15.62**
12	4.90	3.22	8.00	0.00	0.00	**16.12**
11	4.90	3.22	10.10	1.14	0.00	**19.36**
10	4.90	3.22	10.10	6.17	0.00	**24.39**
9	4.90	3.22	10.10	7.37	0.00	**25.59**
8	4.90	3.22	10.10	12.33	0.00	**30.55**
7	4.90	3.22	10.30	12.33	0.00	**30.75**
6	4.90	3.22	11.00	12.33	0.00	**31.45**
5	4.90	3.22	12.00	12.33	0.00	**32.45**
4	4.90	3.22	13.00	12.33	0.00	**33.45**
3	4.90	3.22	14.00	12.33	0.00	**34.45**
2	4.90	3.22	15.10	12.33	0.00	**35.55**
1	4.90	3.22	20.00	17.00	0.152	**45.27**

FUTURE POPULATION ANALYSIS

Hydraulic modeling was based on current (2000) census tract derived populations and future populations associated with the requested flows reported in Table 3. Table 1 shows how current and future population was distributed to individual tributary areas throughout the watershed based on census tract information and other information provided by each jurisdiction. Three new tributary areas west of Hiawatha and north of Robins, all served by pump stations, were added to account for identified annexations or sanitary sewer service extensions to areas outside the existing watershed. The three new tributary areas are identified in Table 1 as follows: NWPS, SWPS, H ANNEX_CR 1B.

DESIGN STORM

Design storm events were developed using Huff quartile methodology detailed in Bulletin 71 of the Illinois State Water Survey. Huff synthetic storms represent synoptic type events similar to the November 2003 Calibration Storm. Synoptic rainfall is characteristic of long duration, low intensity storms that cover large areas. Synoptic type events have the biggest impact on sewer service areas like the Indian Creek/Dry Run Creek service area, where there are significant numbers of foundation connected foundation drains and other rapid infiltration sources. In these service areas, rainfall dependant infiltration accounts for the majority of the wet weather flow within the system.

The design storms represent the 2-year, 5-year, and 10-year return interval 24- hour rainfall for Linn County, IA. With existing populations, the model simulated 10-year 24-hour design storm generated peak flows very similar to the peak flows requested by SSWG for the Indian Creek/Dry Run Creek sewers and provides a level of protection with only a 10-percent chance of being exceeded in any given year.

FUTURE CONDITION DESIGN FLOWS

The XPSWMM model was updated to reflect future projected populations, and associated future inflow and infiltration. The current calibrated per capita contribution of 75 gpcd was used for both current and future population to establish existing and future dry weather flows. The current calibrated RDII, ranging from 374 to 1386 gal/IDM, was used for currently developed areas, but an assumed rate of 600 gal/IDM was used for future developed areas.

It should be noted that the assumption of 600 gal/IDM for future sewers reflects a commitment to qualify construction and ongoing efforts to reduce existing system inflow and infiltration. Table 10 provides a comparison of existing and future dry and wet weather flows predicted by the calibrated model to emphasize the significance of I/I in general and the significance of the future I/I assumptions relative to current I/I levels. Looking at Segment 10 for example, the existing dry weather peak flow (4.38 MGD) is less than one fourth the existing wet weather peak flow (18.12 MGD). In general, the I/I component of the future wet weather peak flow (14.01 MGD) is approximately 1 cfs higher than the I/I component of the existing wet weather peak flow (13.08 MGD).

Table 10 - Inflow and Infiltration Comparison

Pipe Segment	Maximum Existing Dry Weather Peak Flow (cfs)	Maximum Future Dry Weather Peak Flow (cfs)	Max. Existing Peak Wet Weather Flows 10-Year Design Storm (cfs)	Max. Future Peak Wet Weather Flows 10-Year Design Storm (cfs)	Existing I/I Flow (cfs)	Future I/I Flow (cfs)
20	0.07	4.64	0.32	5.43	0.25	1.52
19	0.27	7.96	1.21	9.93	0.94	2.21
18	0.42	8.75	1.83	11.82	1.41	2.68
17	0.56	8.87	2.33	12.36	1.77	3.03
16	0.97	10.04	5.12	16.11	4.15	5.36
15	0.97	10.09	5.29	16.17	4.32	5.50
14	1.03	10.39	5.64	16.63	4.61	5.73
13	1.34	11.47	7.83	19.26	6.49	7.56
12	2.63	14.18	12.19	24.34	9.56	10.56
11	4.13	18.12	15.85	31.33	11.72	12.67
10	4.38	18.12	17.46	32.87	13.08	14.01
9	4.67	18.60	18.70	34.77	14.03	14.91
8	5.99	20.66	22.44	39.13	16.45	17.27
7	6.17	22.97	26.29	43.19	20.12	20.89
6	6.57	23.85	29.84	47.45	23.27	23.98
5	6.55	25.71	31.14	49.11	24.59	25.23
4	6.63	26.97	34.18	53.2	27.55	28.09
3	6.78	27.64	35.91	55.46	29.13	29.55
2	8.11	30.76	40.69	70.5	32.58	32.92
1	10.34	35.11	45.54	76.45	35.20	35.29

PIPE SIZING AND PRIORITIZATION

Table 2 provides a summary of the replacement pipe size for each segment to provide the required capacity for the projected future 10-Year design storm event. It also shows the current pipe size for each segment.

Figure 2 shows a profile of the existing sewer and ground surface with the model predicted HGL for existing wet weather flows assuming a 10 year storm event superimposed. To produce this profile, the Model was coded to have all manholes sealed in order to force all the flow into and through the system. As shown, there is considerable surcharging beginning with Segment 2 and continuing through Segment 16.

Various approaches were considered to establish priorities for constructing the replacement sewer as sized in Table 2 to provide the future capacities noted in Table 10. An emphasis was placed on eliminating bottlenecks that were creating surcharges, as shown in Figure 2. It was generally agreed that the segments with the highest potential for surcharging, basement backups, or overflows in the short term should be a priority.

As such, prioritization was suggested based on the degree of surcharging during the existing 10-year design storm. That prioritization indicated that Segments 8, 9, 12, 4 and 10 experienced the worst surcharging.

Further investigation indicated that the degree of surcharging was not the best analysis tool to determine pipe segment replacement. The backwater effect from surcharging in the downstream segments was concealing the location of the true bottlenecks.

The greatest slope in HGL was identified as the parameter that bests isolates the most significant hydraulic bottlenecks in the system. Priorities were reordered to reflect the slope of the HGL as shown in Table 2.

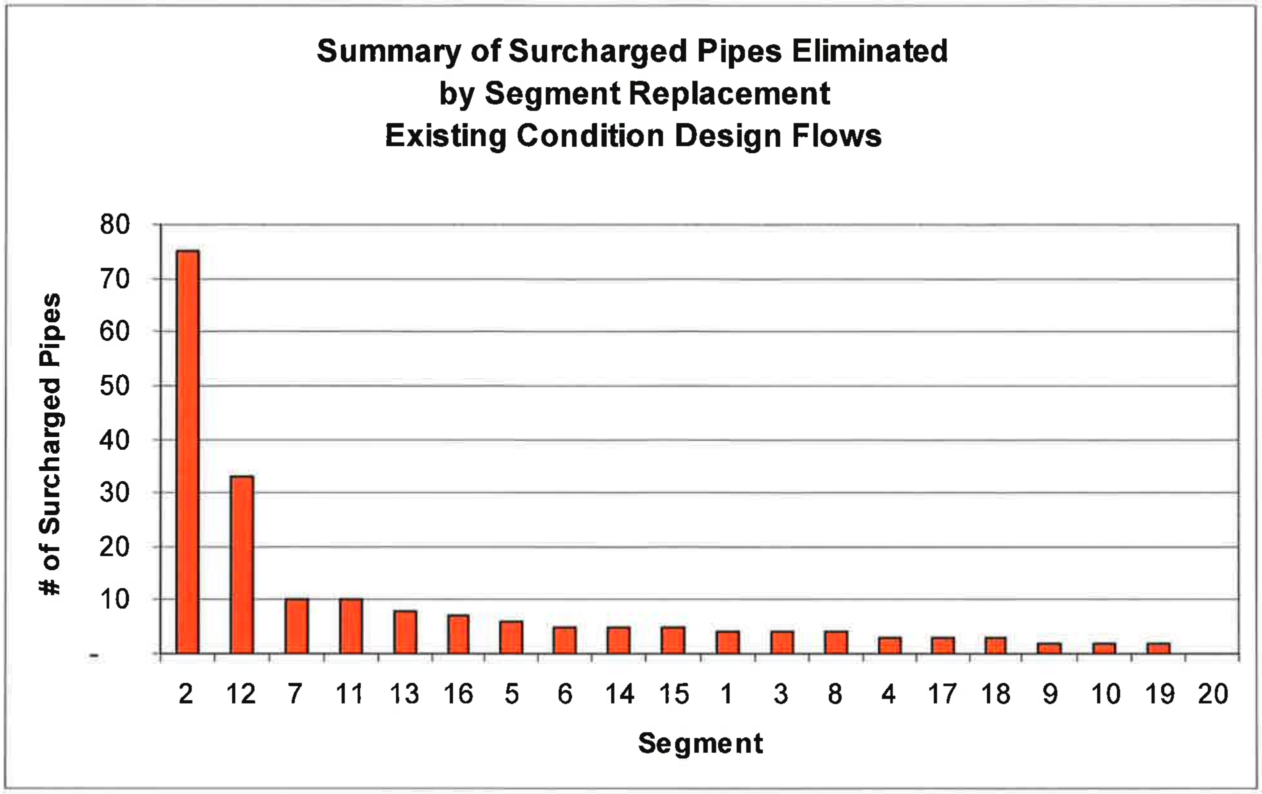
The slope of the HGL for each segment was compared to the existing pipe slope. HGL slopes steeper than the existing pipe slope represent reaches that are creating backwater within the system. Table 11 summarizes the difference in slopes between the average HGL slope and the average pipe slope for each segment at the existing 10 year design flow. Segments with a difference greater that one percent represent reaches that are creating the backwater within the system.

The 20 segments of the existing Dry Run and Indian Creek trunk sewers include a total of 233 pipes that the model predicts are surcharging during the existing condition 10-year design storm. To better understand the benefits of replacing an individual segment, the model was used to determine the impact of replacing each individual segment with a replacement pipe and slope sized for the future conditions 10-year design storm. Figure 5 provides a summary of the number of surcharged pipes that are eliminated due to the replacement of each individual segment.

Table 11 - Percent Difference HGL/Pipe Slope

Segment	Average Pipe Slope (%)	Existing HGL Slope (%)	(%) Difference HGL/Pipe Slope
1	0.143%	0.217%	52%
2	0.174%	0.263%	51%
3	0.214%	0.236%	10%
4	0.214%	0.214%	-
5	0.194%	0.168%	-
6	0.137%	0.161%	18%
7	0.151%	0.194%	28%
8	0.141%	0.161%	14%
9	0.238%	0.122%	-
10	0.194%	0.151%	-
11	0.180%	0.213%	18%
12	0.160%	0.127%	-
13	0.147%	0.112%	-
14	0.179%	0.119%	-
15	0.160%	0.113%	-
16	0.127%	0.038%	-
17	0.194%	0.017%	-
18	0.190%	0.012%	-
19	0.139%	0.050%	-
20	0.170%	0.170%	-

Figure 5 – Surcharging Elimination by Segment Replacement



As indicated, replacement of Segment 2 has by far the most positive impact with respect to eliminating surcharging. Replacement of Segment 12 also has significant potential to eliminate surcharging.

PRIORITIZATION OF REPLACEMENT SEWER

Ultimately, the recommended prioritization was based on the following as predicted by the model for the existing 10 year storm.

1. Prioritizing segments with greatest difference in HGL slope over existing pipe slope.

2. Prioritizing the most significant reduction of surcharging pipes.

Note that while Segment 1 has a HGL slope greater than the existing pipe slope, the segment has no pipes that are surcharging.

Table 12 provides a summary of the prioritization results. Replacement of Segments 2, 7 and 11 provide the greatest benefit to the existing system, eliminating more than 80% of the model predicted surcharging in the system during the existing 10 year design storm condition

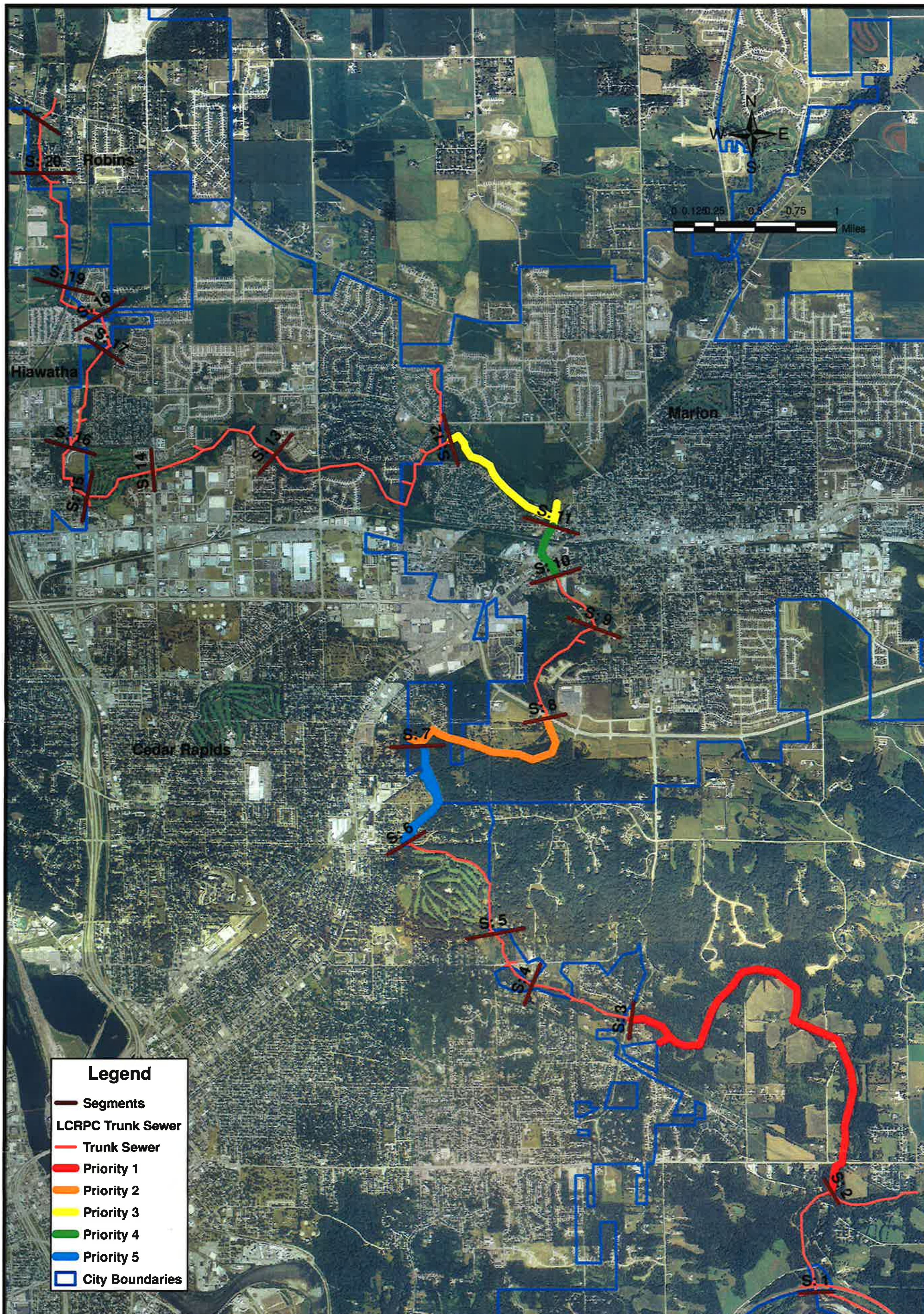
Table 12 - Prioritization Results

Segment	Average Pipe Slope (%)	(%) Difference HGL/Pipe Slope	(%) Difference HGL/Pipe Slope *Segment Replacement*			# of Surcharging Pipes by Seg. *Segment Replacement*			
			2	**2,7**	**2,7,11**	**Existing Conditions**	**2**	**2,7**	**2,7,11**
1	0.14%	52%	53%	52%	50%	-	-	-	-
2	0.17%	51%	-	-	-	41.000	-	-	-
3	0.21%	10%	30%	30%	27%	12.000	2.00	2.00	1.00
4	0.21%	-	7%	6%	3%	7.000	6.00	6.00	4.00
5	0.19%	-	-	-	-	15.000	1.00	1.00	-
6	0.14%	18%	32%	33%	30%	13.000	13.00	13.00	12.00
7	0.15%	28%	39%	-	-	18.000	18.00	5.00	3.00
8	0.14%	14%	24%	31%	39%	13.000	13.00	-	1.00
9	0.24%	-	-	-	-	6.000	6.00	-	-
10	0.19%	-	-	-	41%	6.000	6.00	-	-
11	0.18%	18%	31%	38%	5%	16.000	16.00	7.00	8.00
12	0.16%	-	-	-	-	31.000	31.00	31.00	26.00
13	0.15%	-	-	-	-	15.000	15.00	15.00	-
14	0.18%	-	-	-	-	7.000	7.00	1.00	-
15	0.16%	-	-	-	-	8.000	8.00	-	-
16	0.13%	-	-	-	-	14.000	14.00	-	-
17	0.19%	-	-	-	-	4.000	1.00	-	-
18	0.19%	-	-	-	-	5.000	-	-	-
19	0.14%	-	-	-	-	-	-	-	-
20	0.17%	-	-	-	-	-	-	-	-
			Total - Surcharging Pipes			**231.00**	**157.00**	**81.00**	**55.00**

In the future, once segments 2, 7 and 11 have been replaced, additional analysis should be completed to consider the impacts of the future flows and pipe replacement beyond this point. At this point, it would appear that Segments 10 and 6 are the next highest priorities.

Figure 6 shows the location of the top five priorities identified in the analysis.

Figure 6 – Segment Prioritization



Top Priority for Sewer Replacement

Linn County Regional Planning Commission
Hydraulic Model Study
Executive Summary

Segment Costs

Table 13 provides a summary of the estimated capital costs for the priority segments sized for future 10-year Design Flows as predicted by the model. Note that all costs are reported in 2007 dollars and should be inflated to the anticipated mid-point of construction for budgeting purposes. As indicated in Table 13, the priority segments for replacement are summarized as follows:

- Segment 2 - 15,238 linear feet of 60-inch diameter sewer at an estimated capital cost of $8.09 Million if constructed.
- Segment 7 – 6,051 linear feet of 60-inch diameter sewer at an estimated capital cost of $3.03 Million if constructed.
- Segment 11 – 271 linear feet of 54-inch diameter sewer and 4,646 linear feet of 48-inch diameter sewer at an estimated capital cost of $1.60 Million if constructed.
- Segment 10 – 1,876 linear feet of 54-inch diameter sewer at an estimated capital cost of $0.80 Million if constructed.
- Segment 6 – 3,845 linear feet of 60-inch diameter sewer at an estimated capital cost of $1.83 Million if constructed.

Table 13 - Estimate of Project Quantities

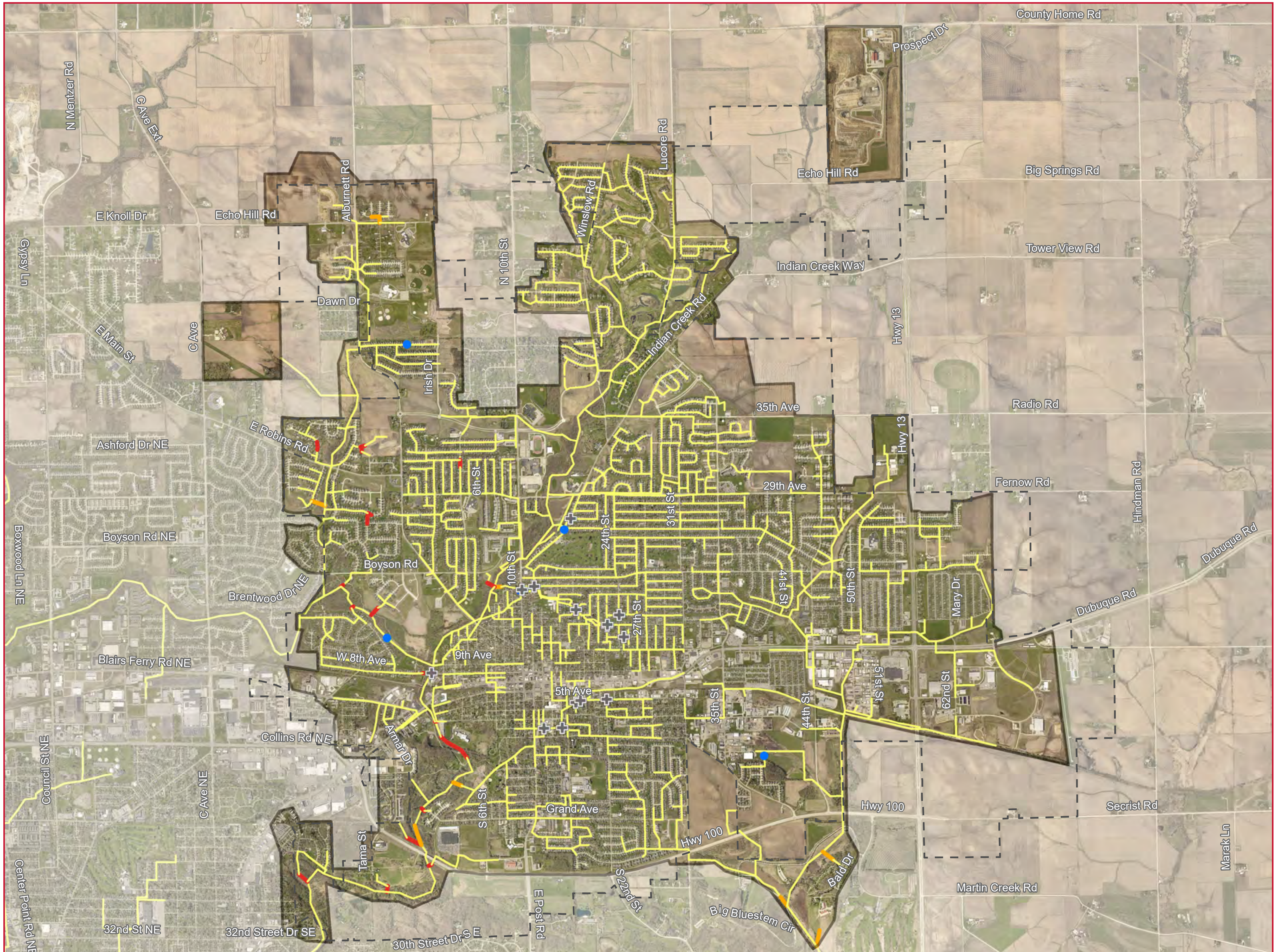
ID	Pay Item	Unit	Unit Cost	Segment 2	Segment 7	Segment 11	Segment 10	Segment 6
12	TRENCH EXCAVATION THROUGH ROCK	CY	$75.00	1,054	0	0	0	0
19	TRENCH EXCAVATION	CY	$14.00	48,230	28,801	2,162	3,796	13,604
23	GRANULAR BACKFILL	CY	$37.00	2,558	0	0	1,410	0
88	REINFORCED CONCRETE PIPE SEWER 30 INCH CLASS III	LF	$85.00	0	0	0	0	0
91	REINFORCED CONCRETE PIPE SEWER 36 INCH CLASS III	LF	$100.00	0	0	0	0	0
95	REINFORCED CONCRETE PIPE SEWER 48 INCH CLASS III	LF	$170.00	0	0	4,646	0	0
97	REINFORCED CONCRETE PIPE SEWER 54 INCH CLASS III	LF	$181.00	0	0	271	1,876	0
99	REINFORCED CONCRETE PIPE SEWER 60 INCH CLASS III	LF	$210.00	15,238	6,051	0	0	3,845
101	REINFORCED CONCRETE PIPE SEWER 66 INCH CLASS III	LF	$255.00	0	0	0	0	0
104	REINFORCED CONCRETE PIPE SEWER 78 INCH CLASS III	LF	$340.00	0	0	0	0	0
93	REINFORCED CONCRETE PIPE SEWER 42 INCH CLASS III	LF	$130.00	0	0	0	0	0
139	PIPE IN TUNNEL 30 INCH	LF	$1,240.00	0	0	0	0	0
143	PIPE IN TUNNEL 48 INCH	LF	$1,490.00	0	0	0	0	0
145	PIPE IN TUNNEL 60 INCH	LF	$1,900.00	0	0	0	0	0
146	PIPE IN TUNNEL 66 INCH	LF	$1,910.00	0	0	0	0	0
149	PIPE IN TUNNEL 84 INCH	LF	$2,400.00	0	0	0	0	0
286	CLEARING AND GRUBING	AC	$8,000.00	13	5	3	1	3
385	MANHOLE - STANDARD CONSTRUCTION	LF	$200.00	446	120	33	47	125
413	STREET PAVEMENT - ASPH. CONC REM. AND REP.	SY	$64.00	6,610	0	0	95	0
433	ROCK BLANKET	SY	$51.00	3,333	889	667	0	444
435	SEEDING	SY	$2.00	62,645	24,876	16,177	4,561	15,807
436	SODDING - BLUEGRASS	SY	$7.00	0	0	3,416	3,031	0
452	BYPASS PUMPING	DAYS	$1,500.00	152	61	25	13	38
470	DEWATERING	DAYS	$500.00	152	61	25	13	38
	SUBTOTAL COST PER SHEET	=		$5,238,451	$1,955,065	$1,042,794	$523,299	$1,180,283
550	CONTINGENCY	LS	20%	$1,047,690	$391,013	$208,559	$104,660	$236,057
562	MOBILIZATION (projects over $75,000)	LS	3%	$157,154	$58,652	$31,284	$15,699	$35,408
563	PROTECTION AND RESTORATION OF SITE	LS	10%	$523,845	$195,507	$104,279	$52,330	$118,028
564	UTILITY RELOCATION	LS	$10,000.00	$288,598	$114,602	$47,418	$23,687	$72,822
	TOTAL CONSTRUCTION COST	=		$7,255,739	$2,714,839	$1,434,335	$719,675	$1,642,599
	ESTIMATED ENGINEERING COSTS (15%)	=	15%	$834,410	$312,207	$164,948	$82,763	$188,899
	TOTAL CAPITAL COST PER SEGMENT (2007 DOLLARS)	=		$8,090,149	$3,027,046	$1,599,283	$802,437	$1,831,498

Based on each city's total requested peak flow from Table 3, the percentage of flow each city is responsible for per pipe segment was calculated. This percentage was applied to the total cost per segment to define the cost per city per segment. Table 4, presented previously, identifies the capital cost by segment allocated to each jurisdiction on the basis of the portion of flow each contributes to that segment.

Stipulated by the SWGG members, five projects were originally to be identified, one per year, of an approximate cost of $3,000,000 per year. Given the length and cost, it has been suggested that Segment 2 be constructed in three phases, each roughly one-third the length and cost. In this fashion, seven projects are suggested with the Segment prioritization noted above, each ranging from $0.8 to just over $3.0 million. This includes Segments 2, 7, and 11 as the first five projects followed by a reevaluation before continuing with Segments 10 and 6.

Appendix B

EXISTING CONDITIONS (S1)
DRY WEATHER FLOW
FIGURE B1



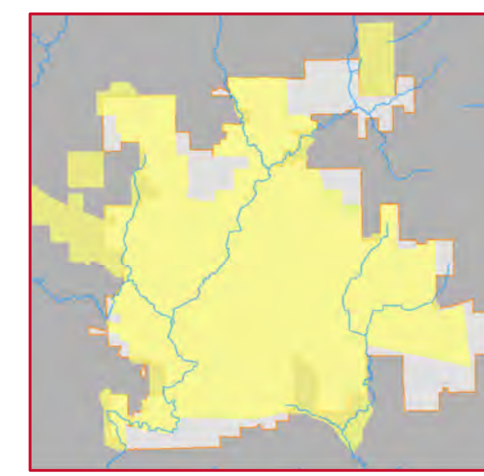
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

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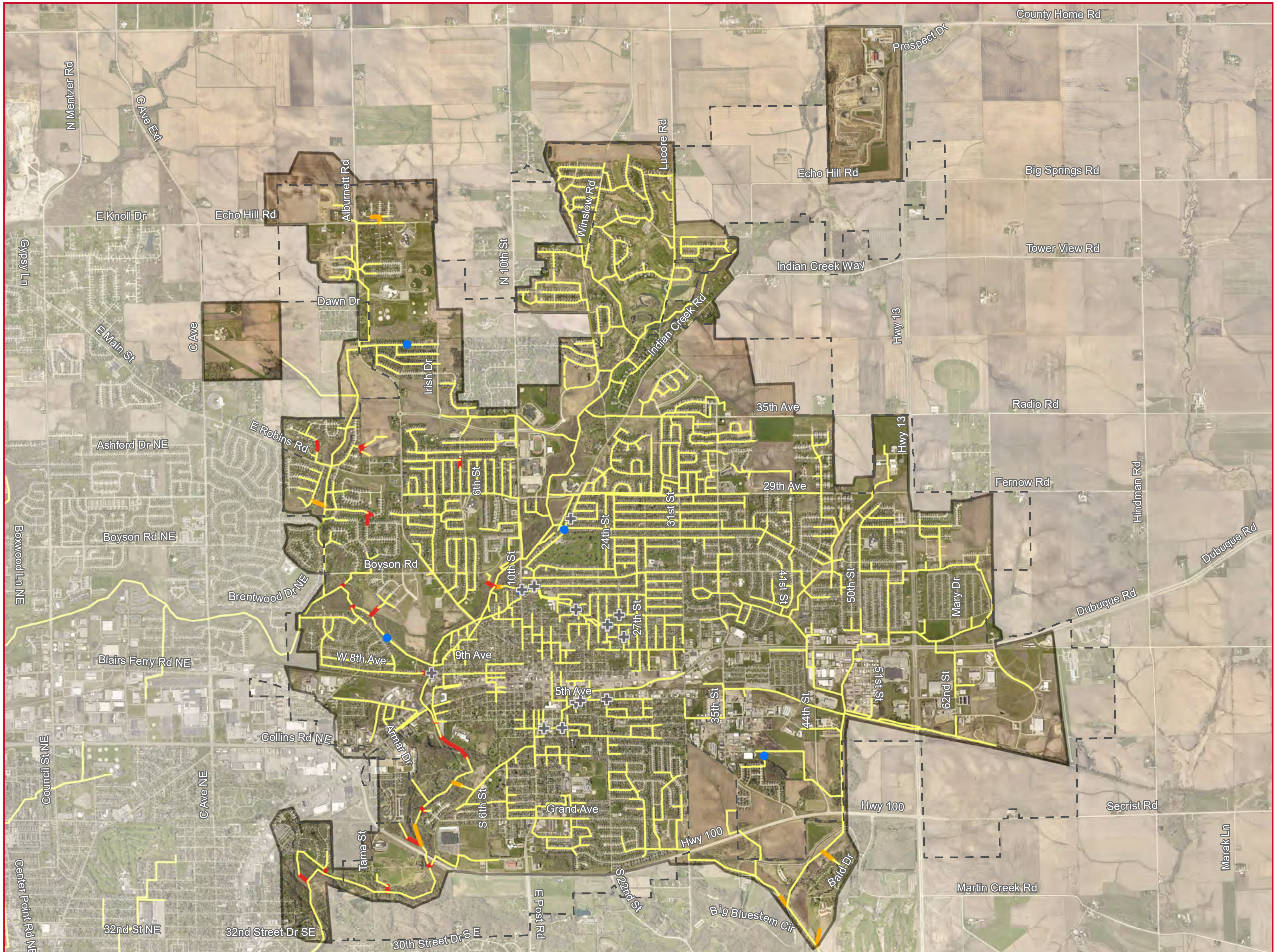
BASELINE CONDITIONS (S2)
DRY WEATHER FLOW
FIGURE B2



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

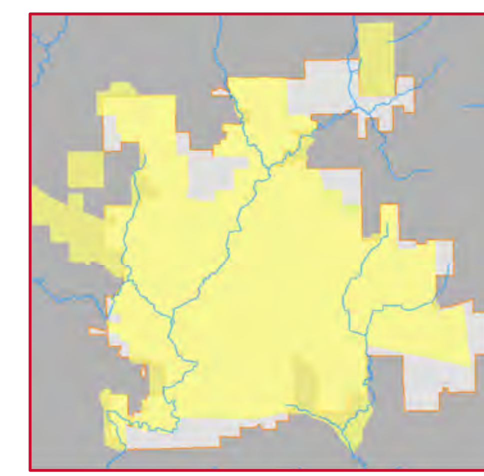
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



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DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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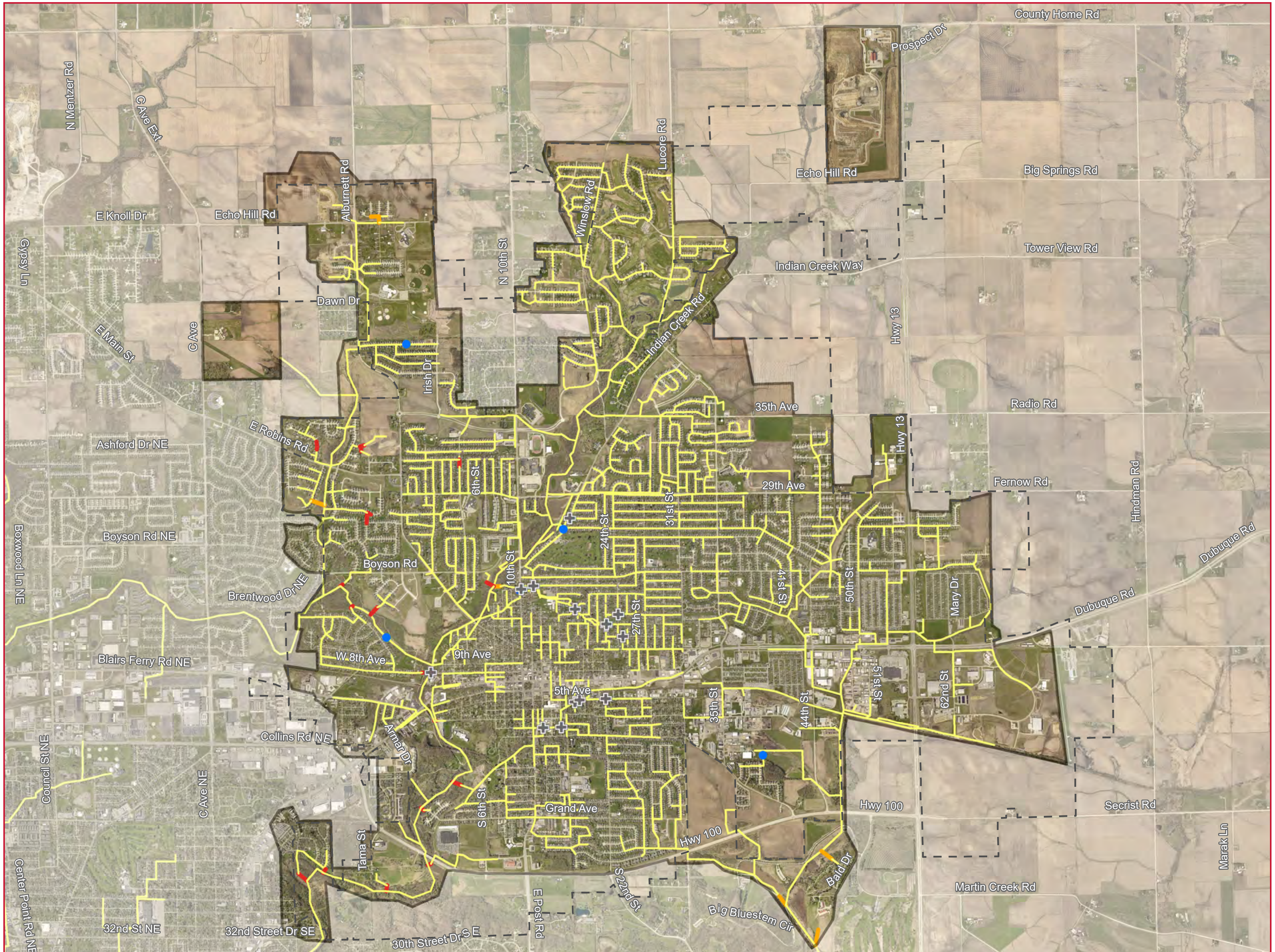


PROP. INDIAN & DRY RUN CREEKS TRUNK SEWER CONDITION (S3) DRY WEATHER FLOW FIGURE B3

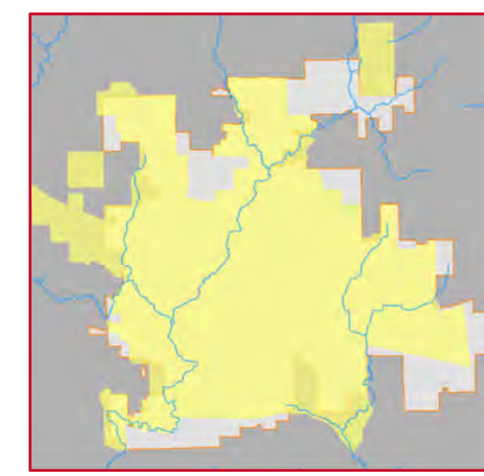
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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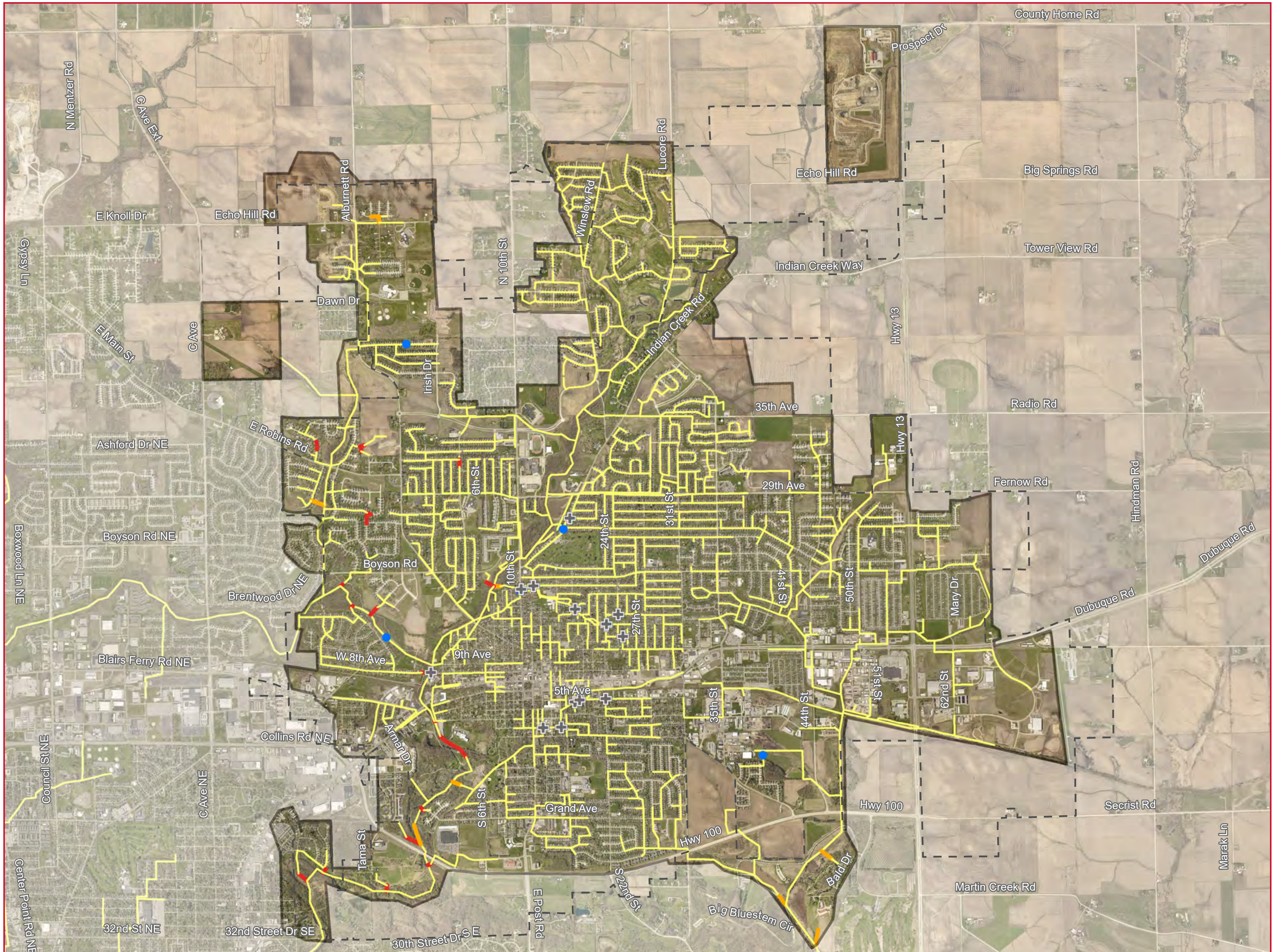


BASELINE CONDITIONS WITH I/I REDUCTION IN OLD MARION (S4) DRY WEATHER FLOW FIGURE B4

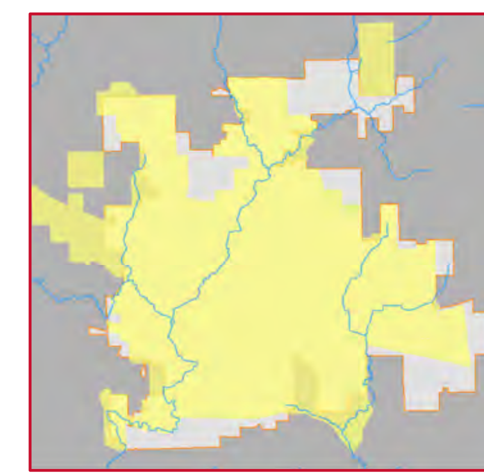
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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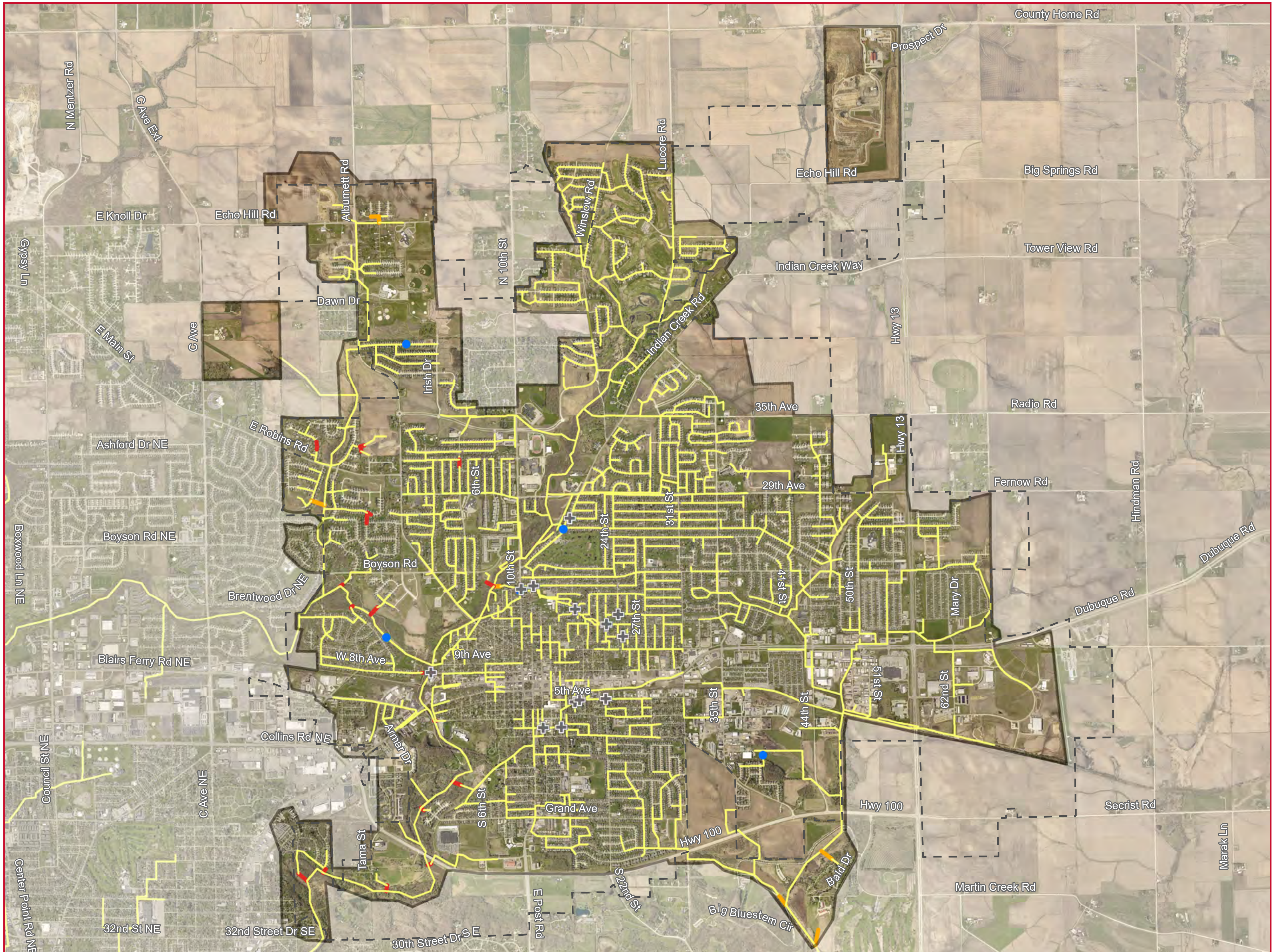


PROP. IC & DRCTRUNK SEWER WITH I/I REDUCTION CONDITION (S5)
DRY WEATHER FLOW
FIGURE B5

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

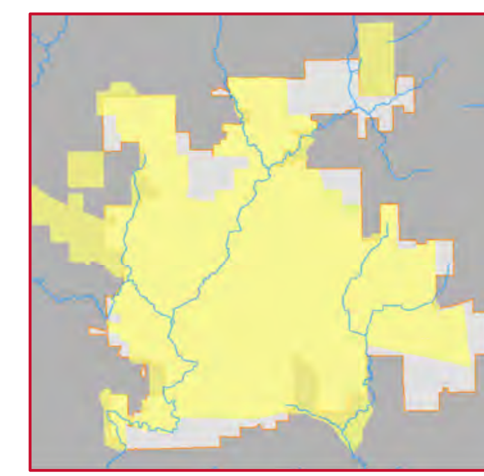
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



DATA SOURCE: City of Marion

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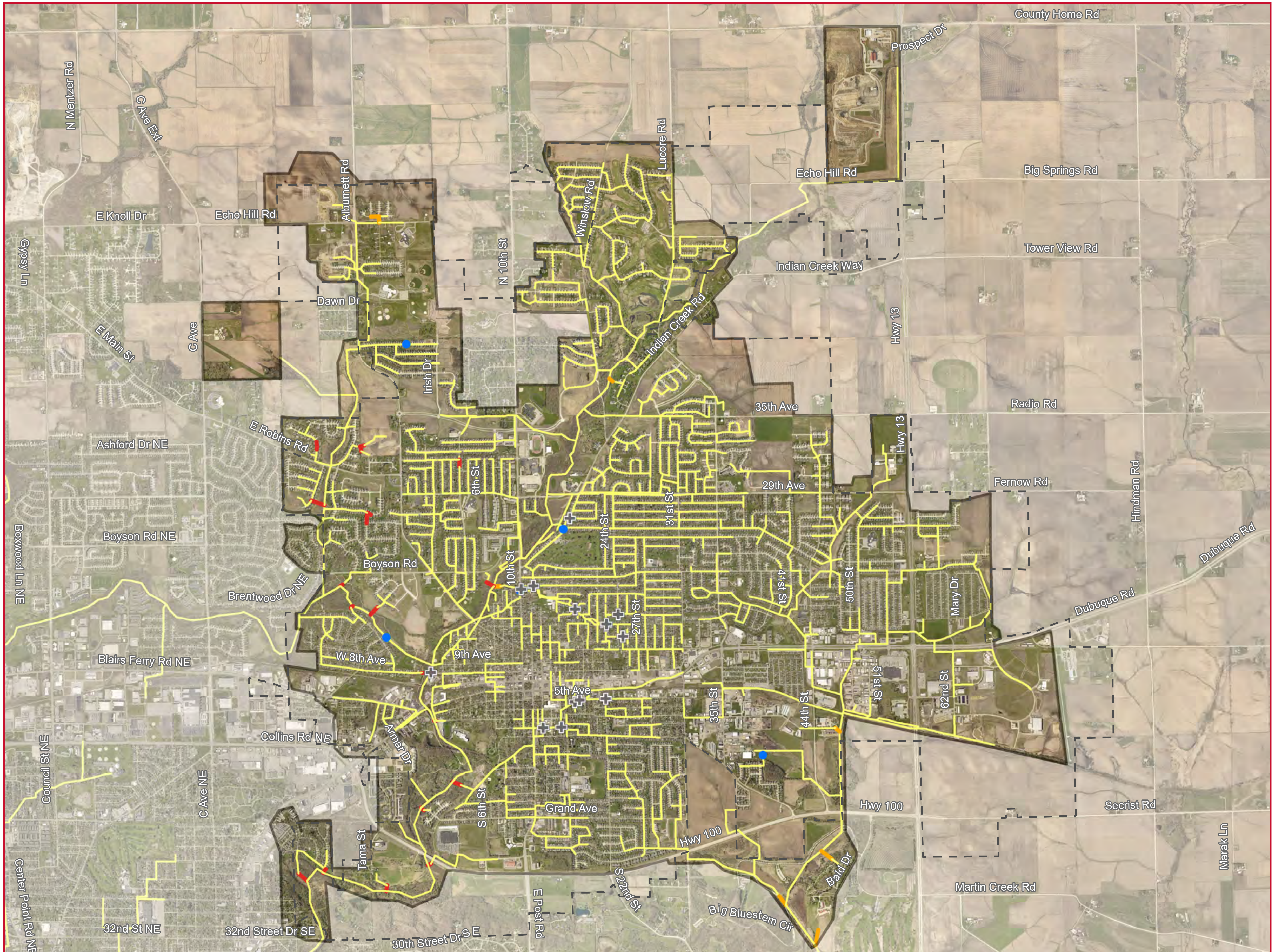
2040 POPULATION IN EXISTING SERVICE AREA CONDITION (S6) DRY WEATHER FLOW FIGURE B6



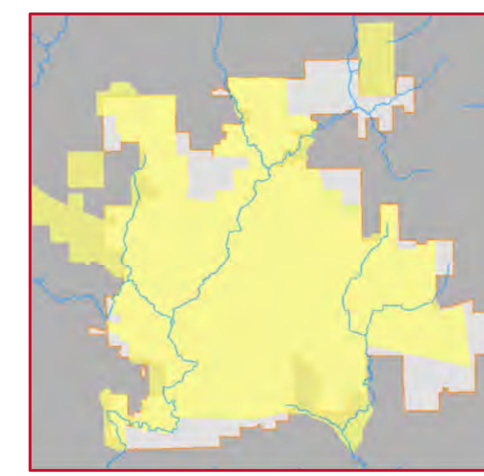
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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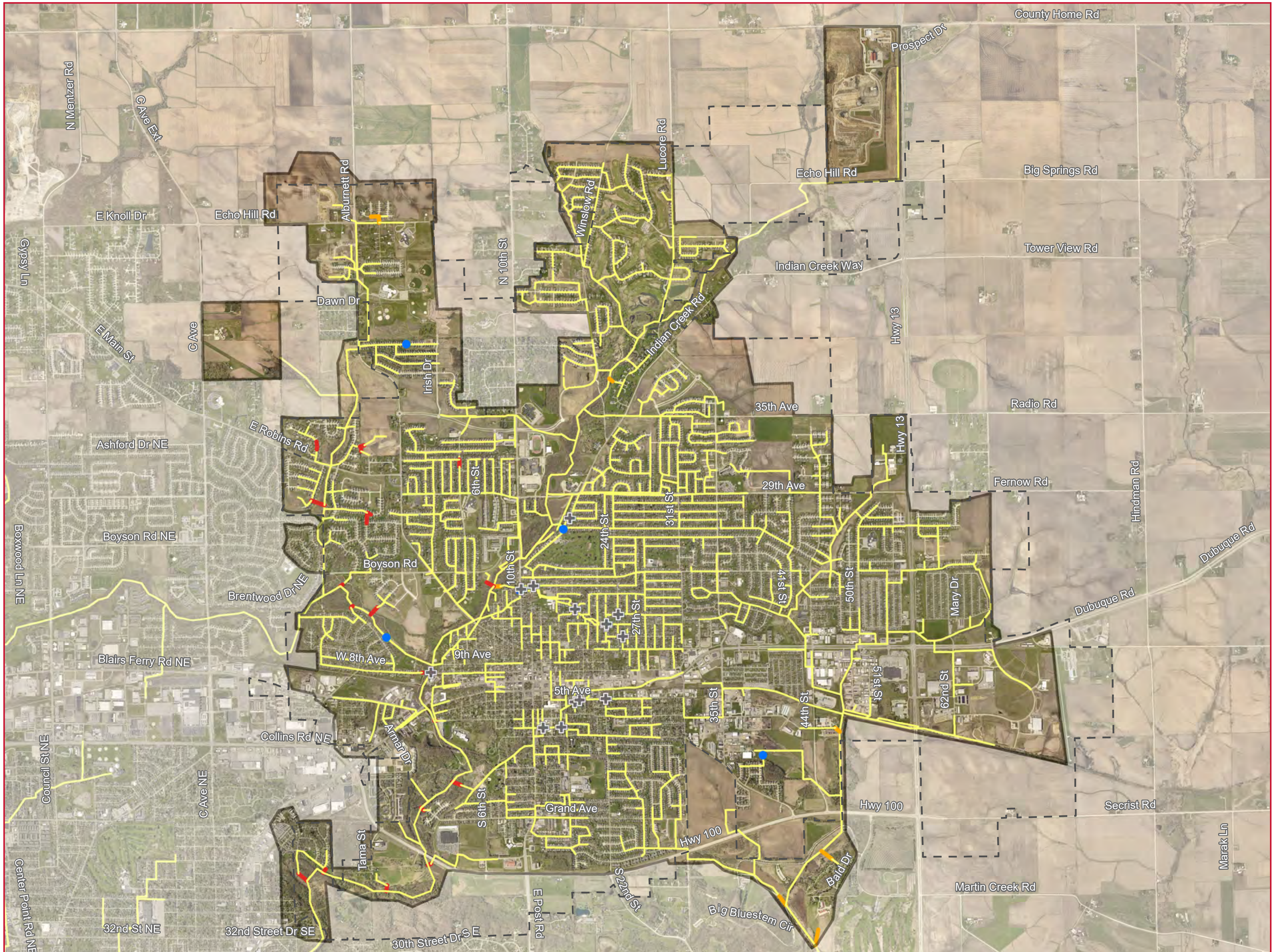
2040 POP. IN EXIST. SERVICE AREA WITH DENSER UPTOWN COND. (S7) DRY WEATHER FLOW FIGURE B7



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

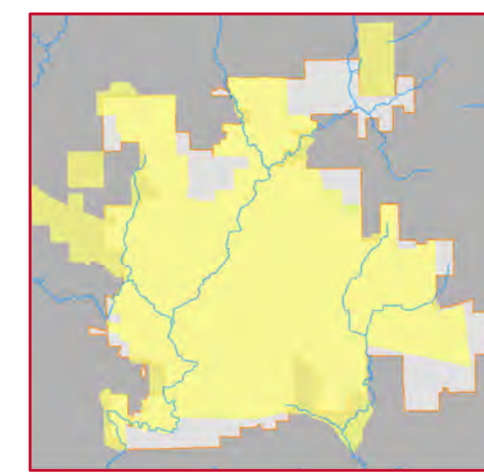
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

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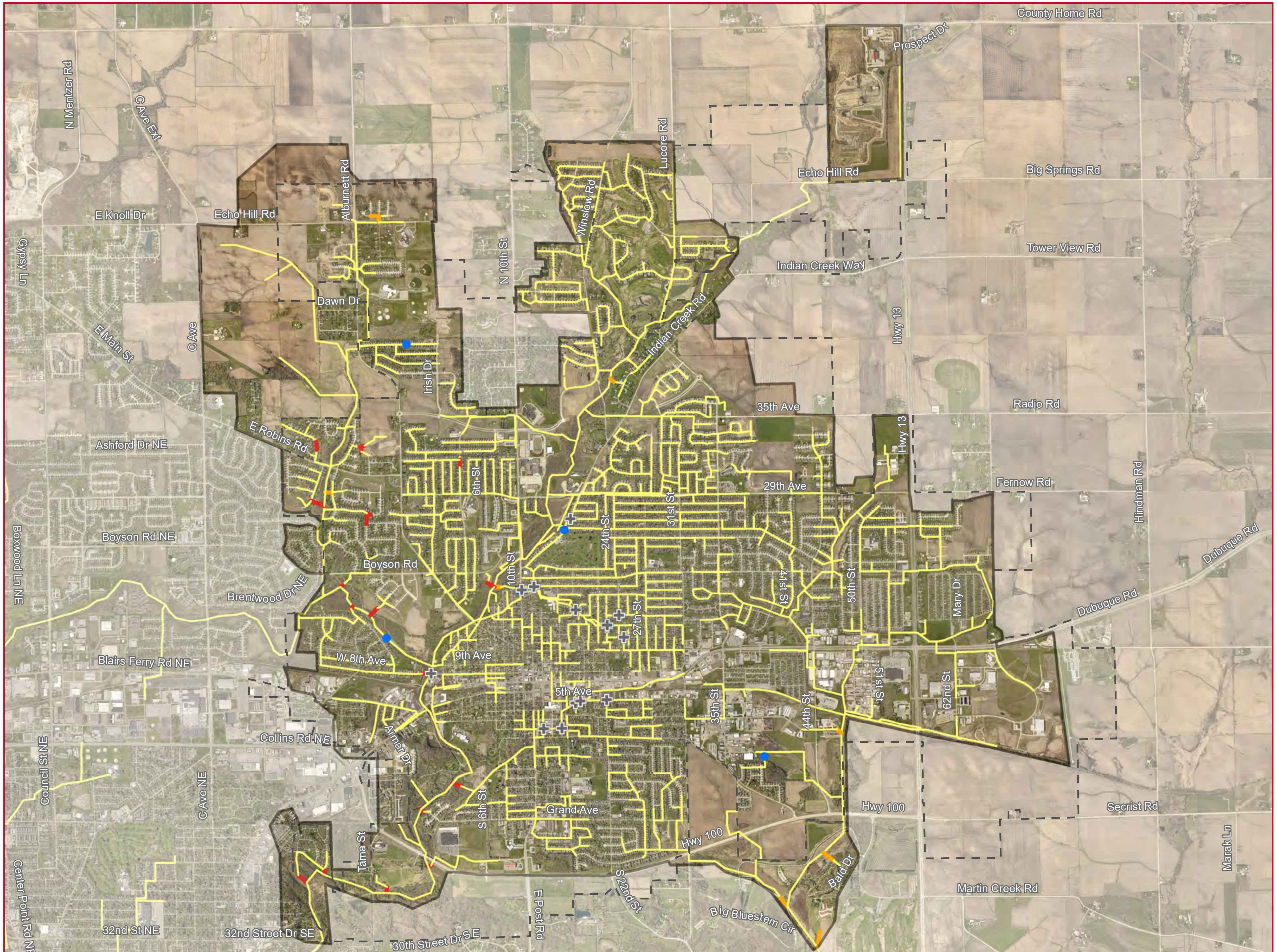
2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 1 COND. (S8) DRY WEATHER FLOW FIGURE B8



City Boundary

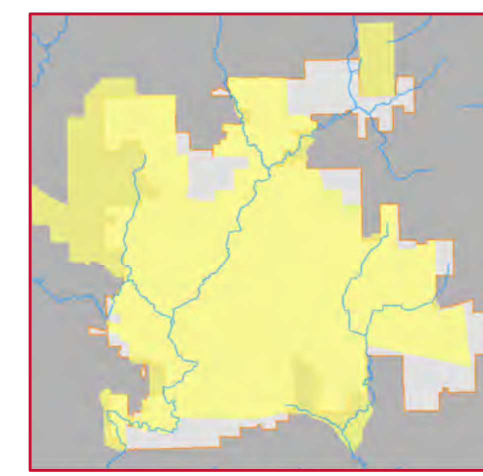
Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

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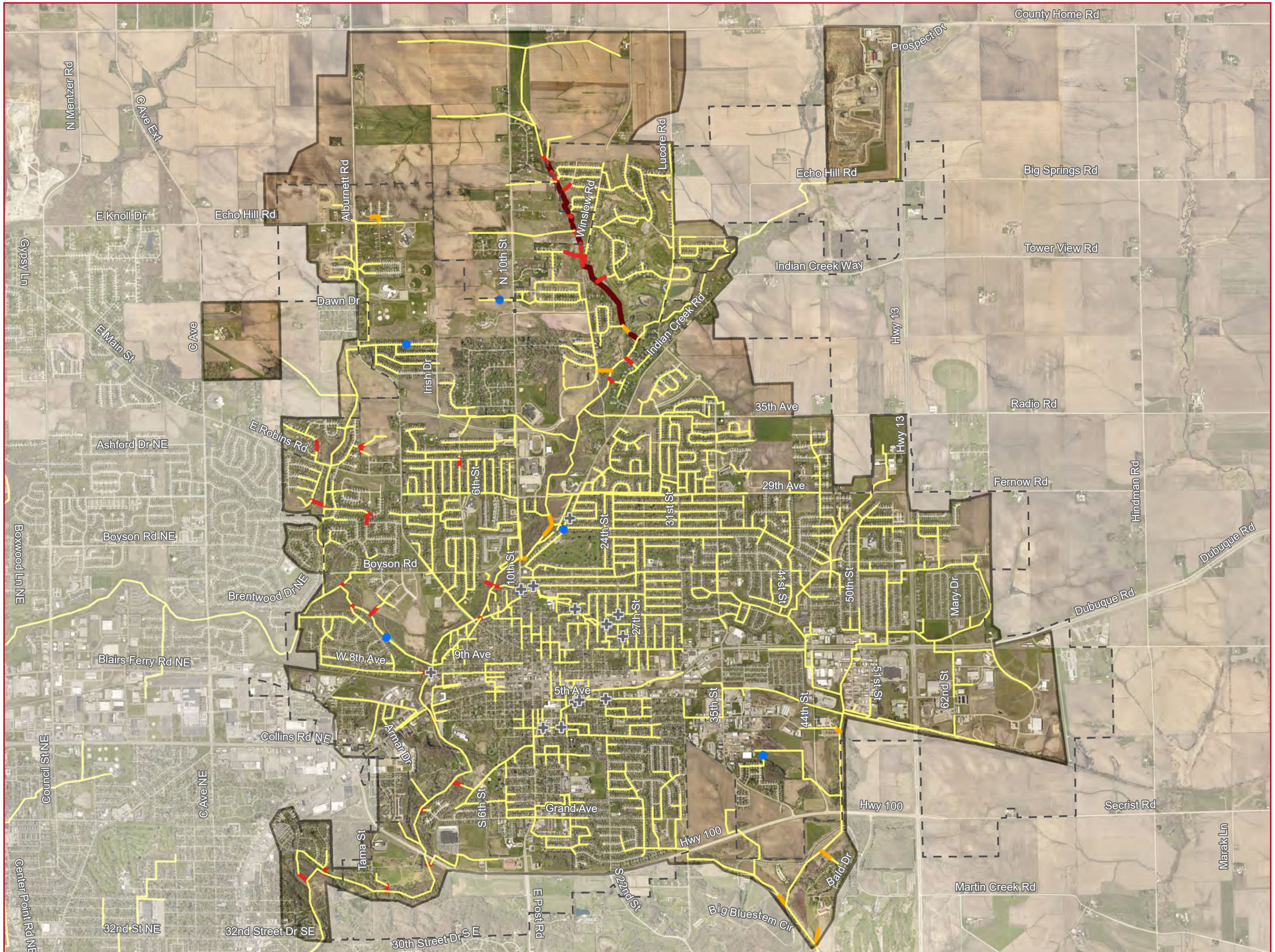


2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 2 COND. (S9) DRY WEATHER FLOW
FIGURE B9

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

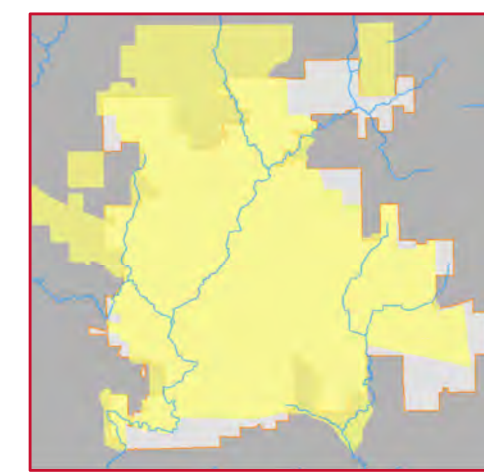
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

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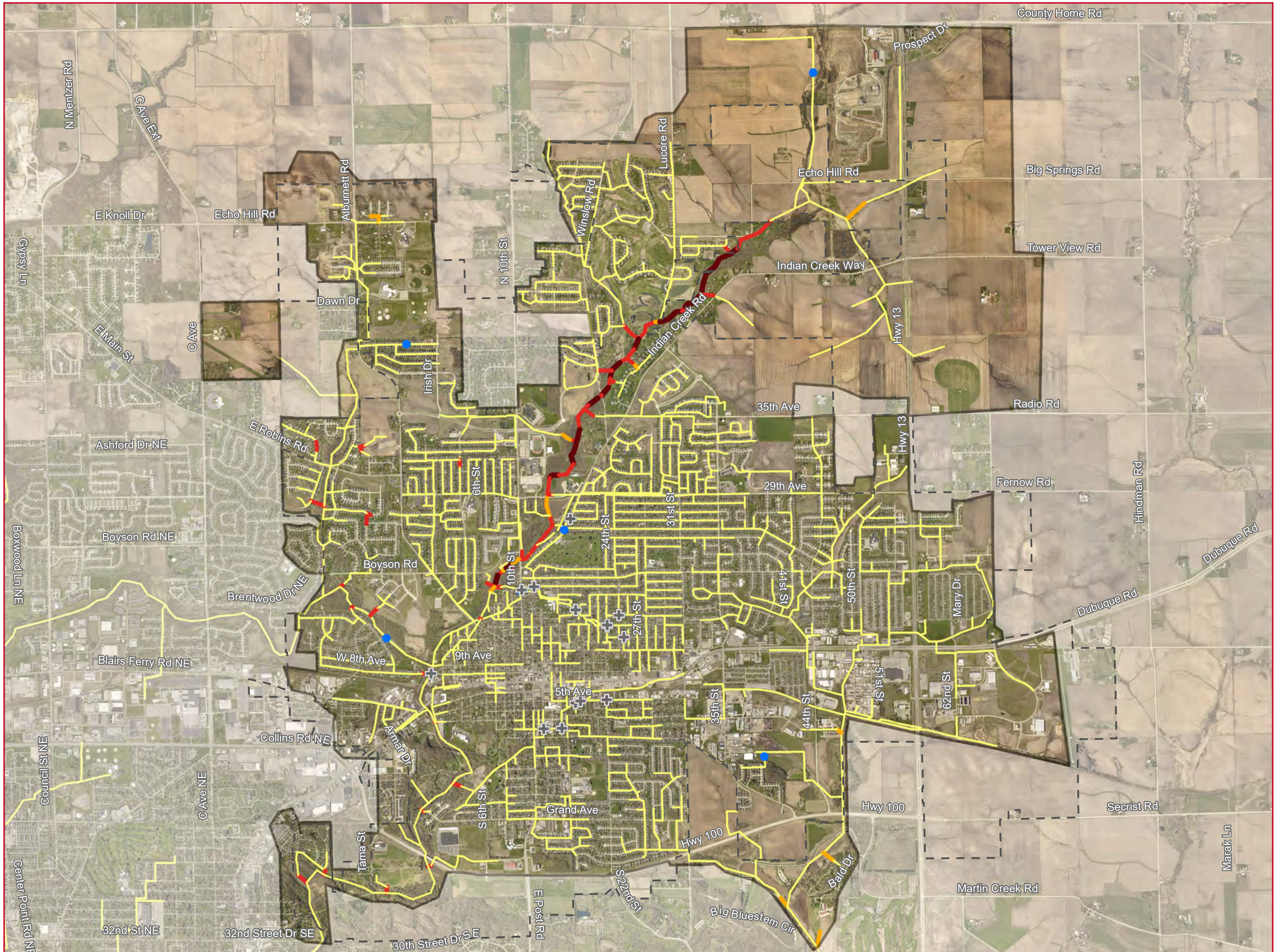
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S9_DWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 3 COND. (S10) DRY WEATHER FLOW FIGURE B10

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

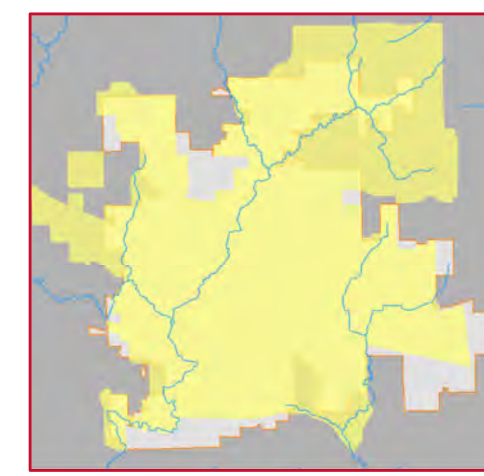
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

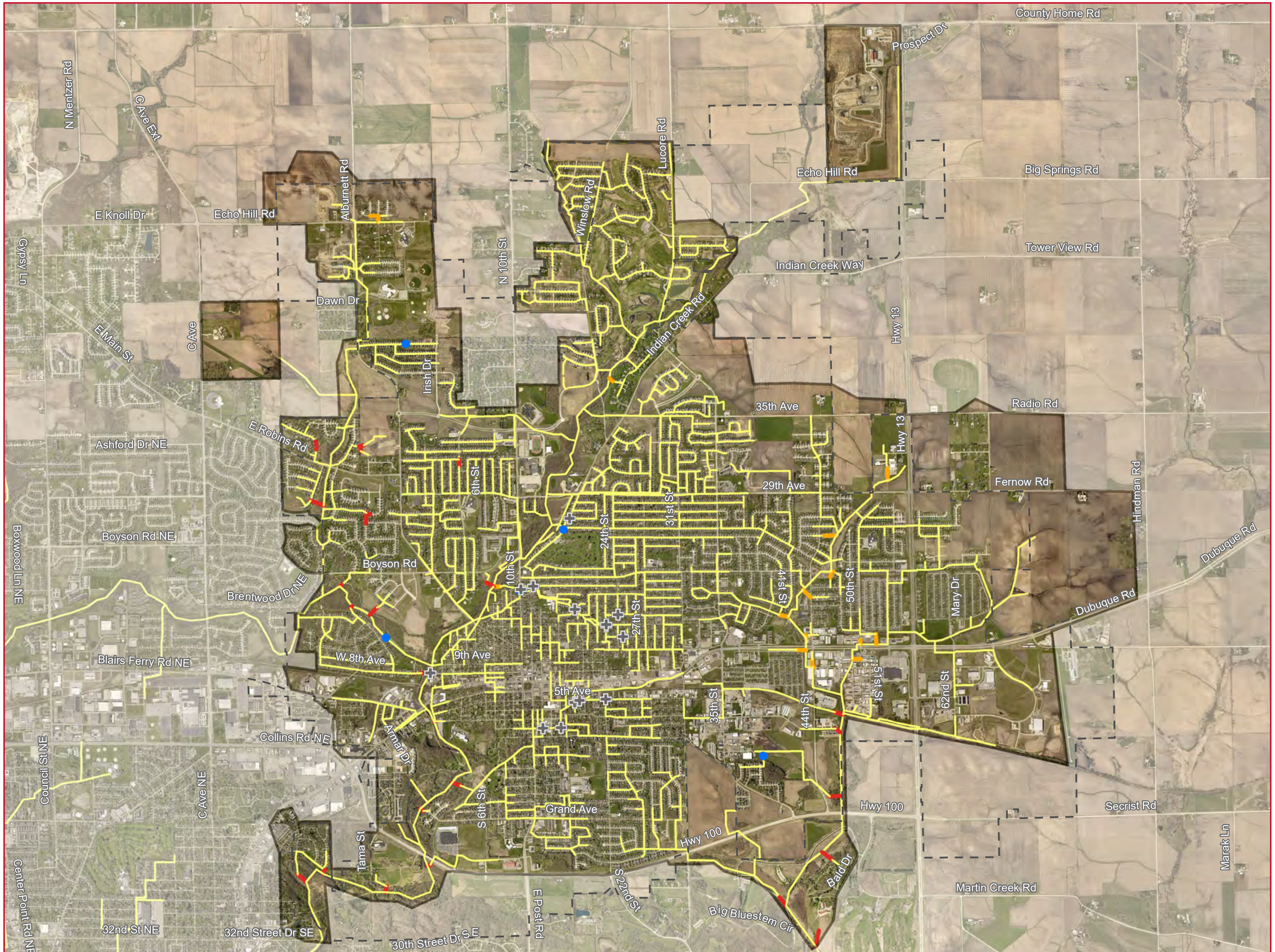
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S10_DWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S11) 2-YR WET WEATHER FLOW FIGURE B11

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

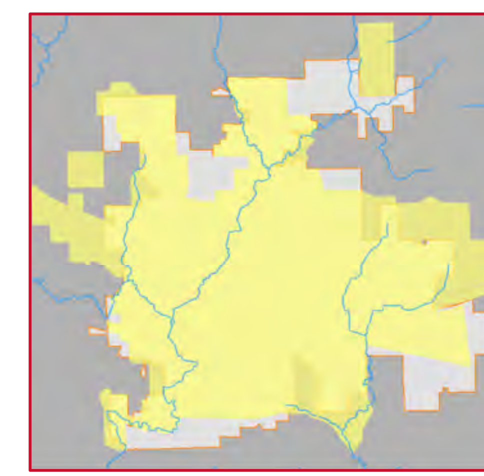
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



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DATA SOURCE: City of Marion

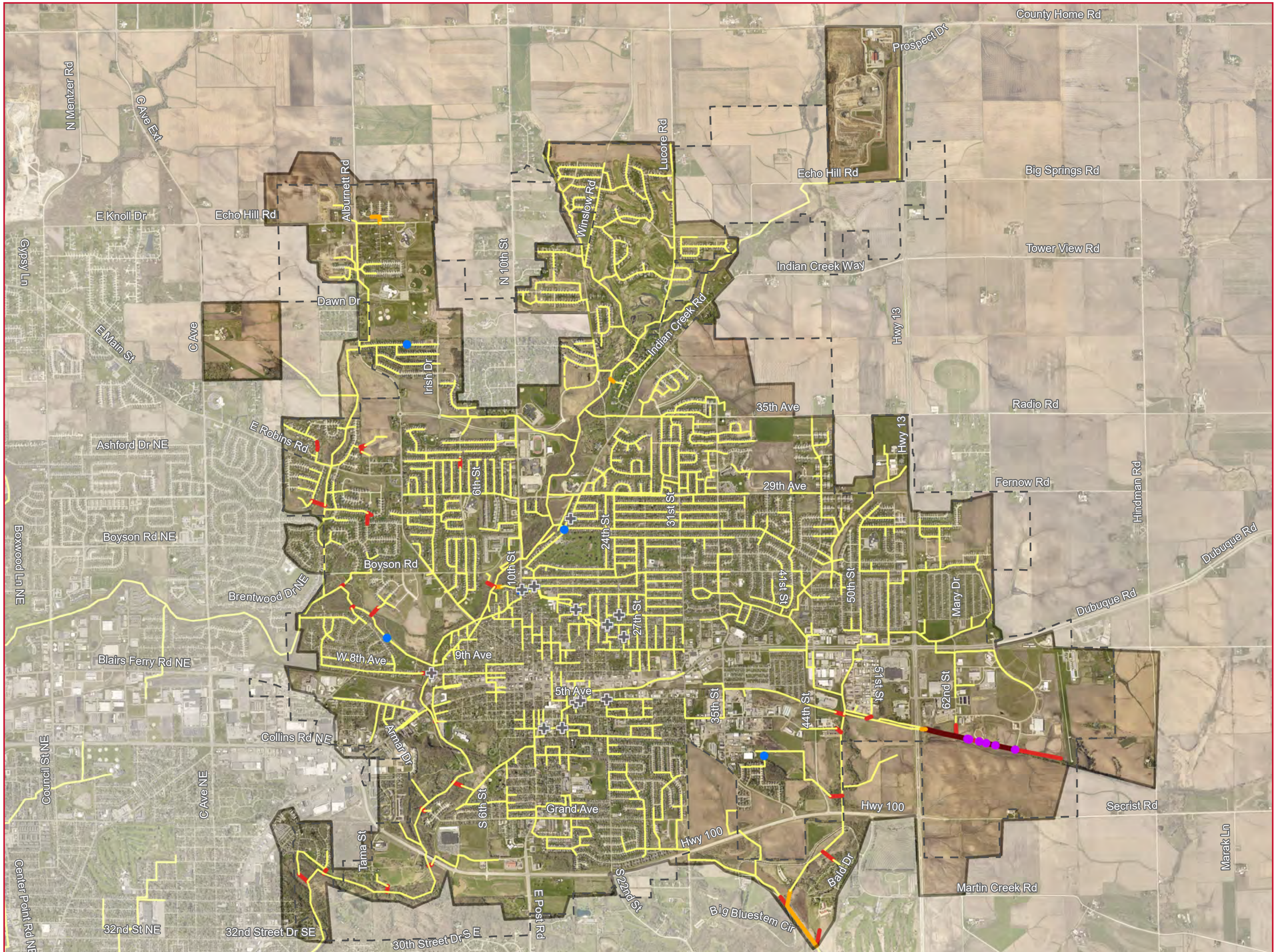
Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S11_DWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S12) DRY WEATHER FLOW
FIGURE B12



City Boundary

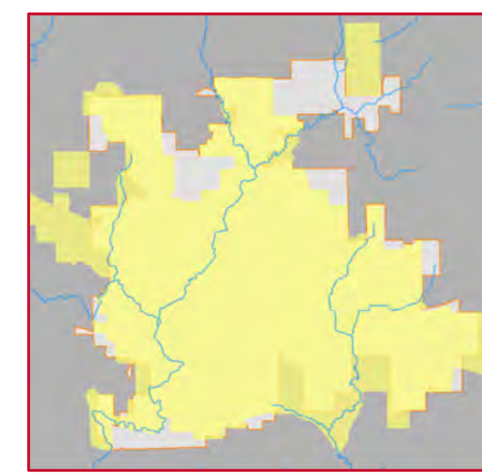
Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

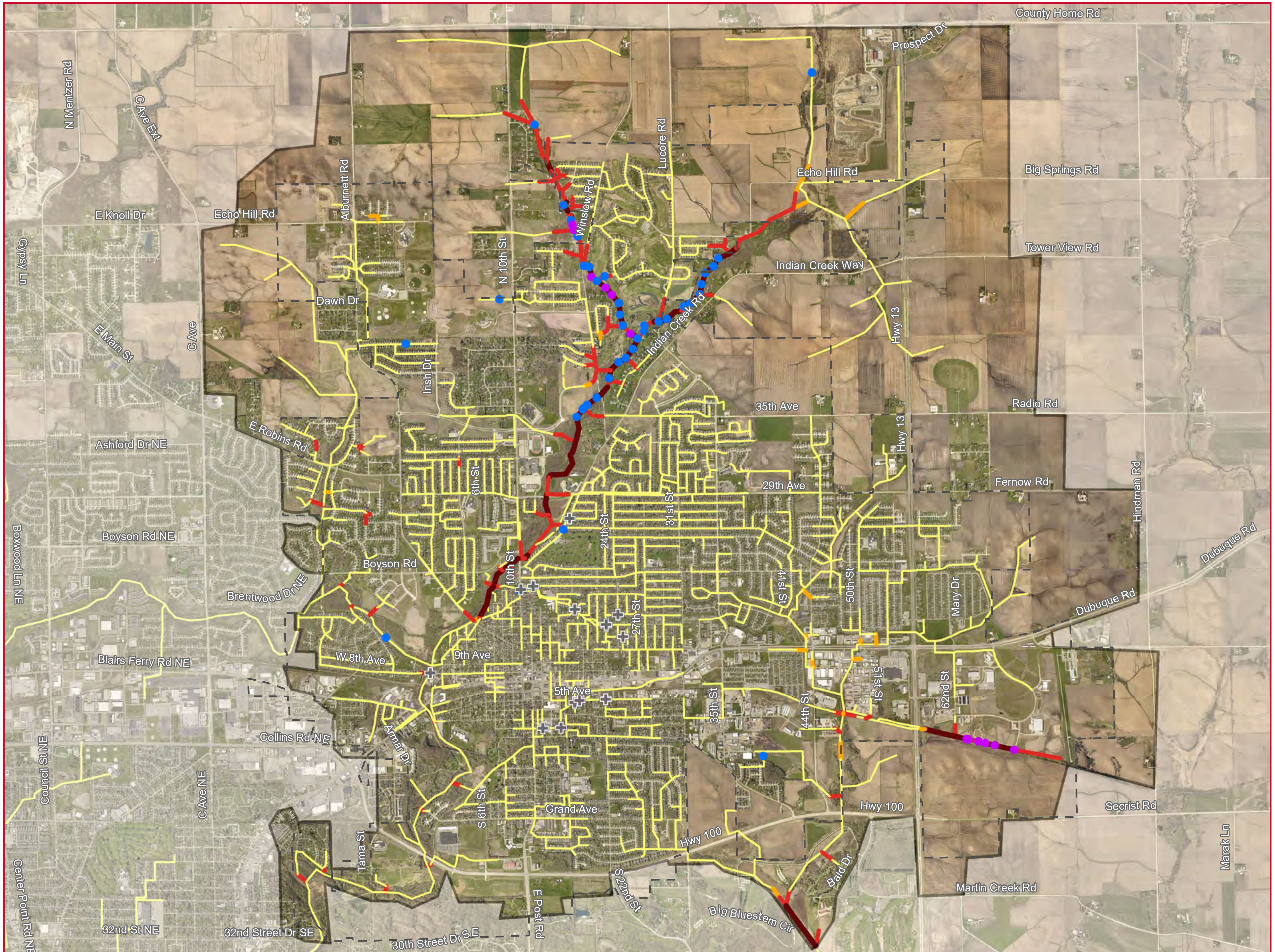
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S12_DWF.MXD - USER: STHEN - DATE: 1/26/2021



FULL DEVELOPMENT CONDITION (S13)
DRY WEATHER FLOW
FIGURE B13

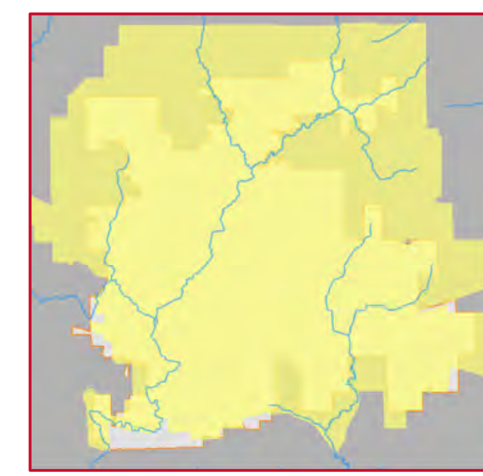
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



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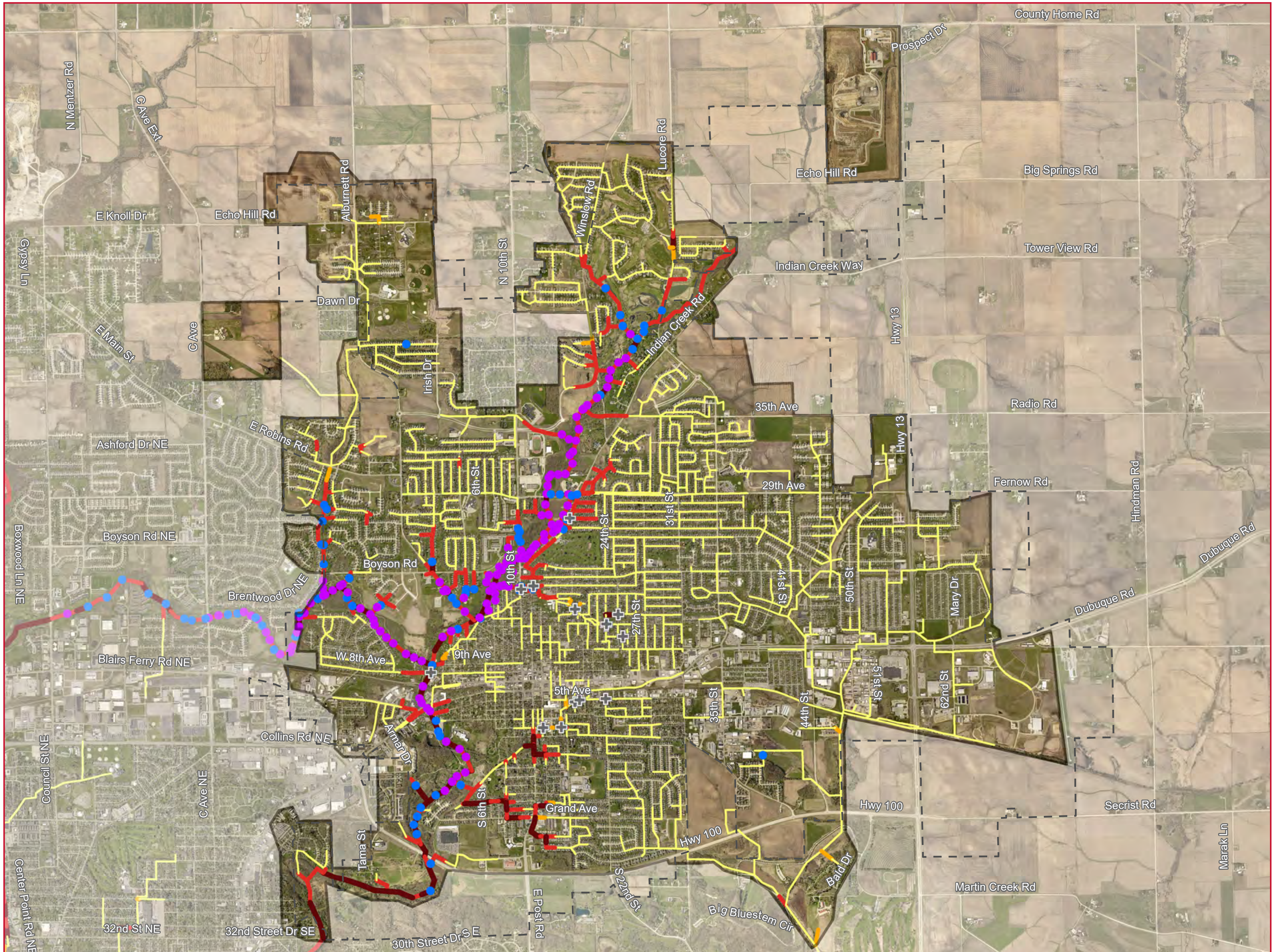
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS (2017 Imagery)

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S13_DWF.MXD - USER: STHEN - DATE: 1/26/2021



EXISTING CONDITIONS (S1)
2-YR WET WEATHER FLOW
FIGURE B14

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

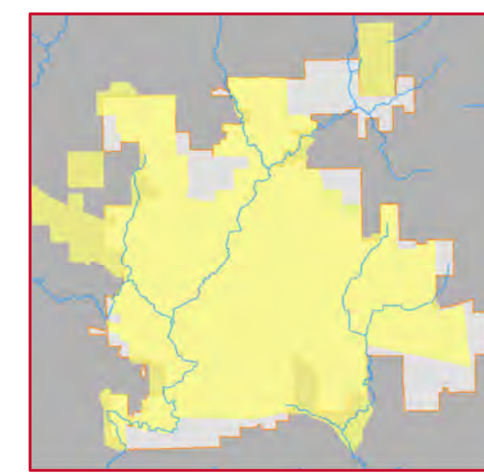
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

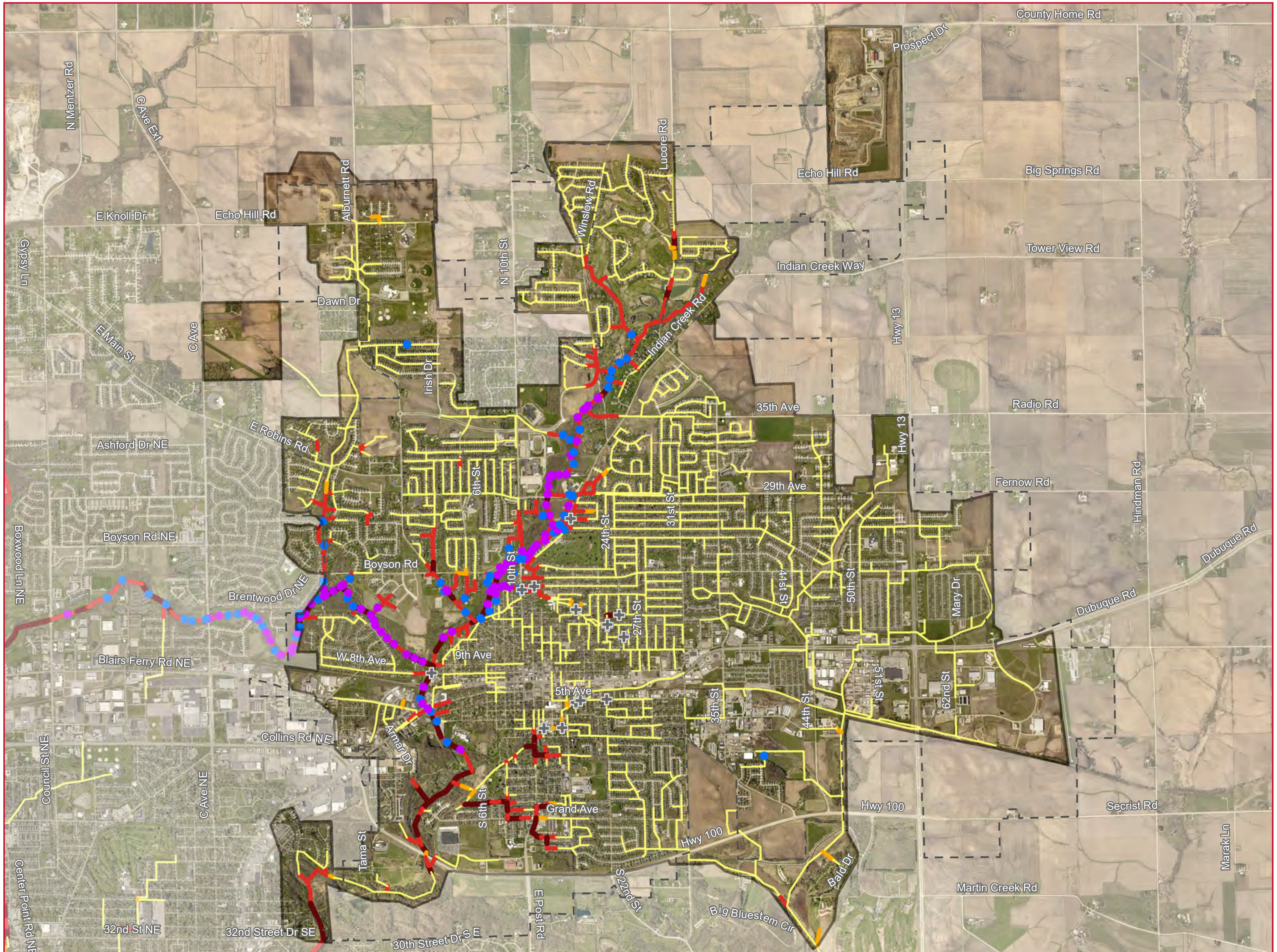
Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

HDR City of Marion IOWA

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S1_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

BASELINE CONDITIONS (S2)
2-YR WET WEATHER FLOW
FIGURE B15



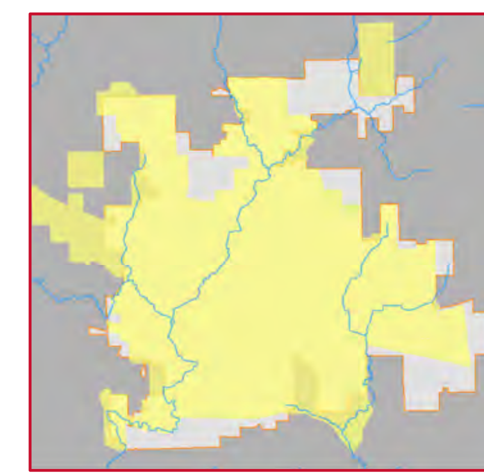
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

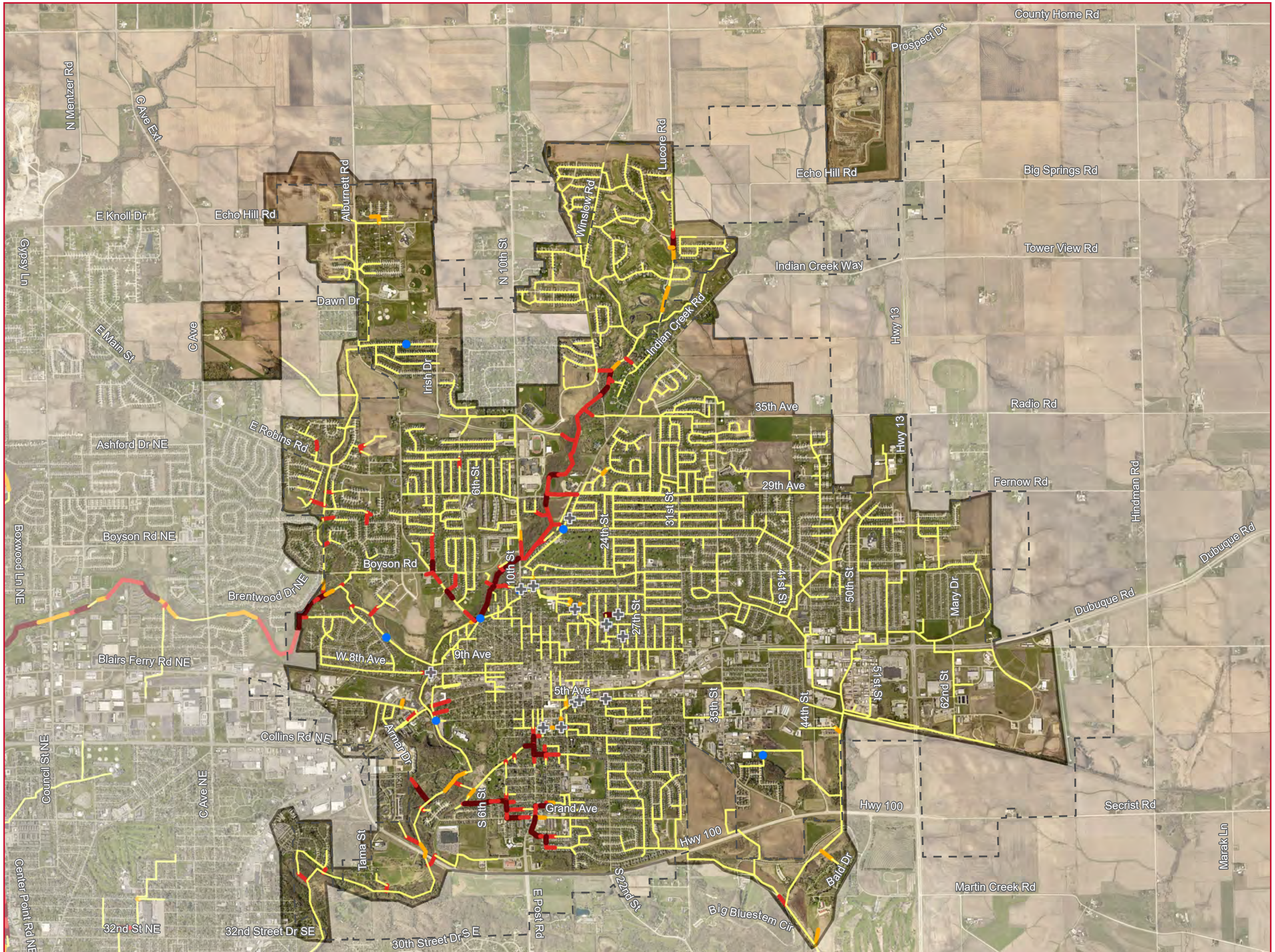
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S2_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

PROP. INDIAN & DRY RUN CREEKS TRUNK SEWER CONDITION (S3)
2-YR WET WEATHER FLOW
FIGURE B16



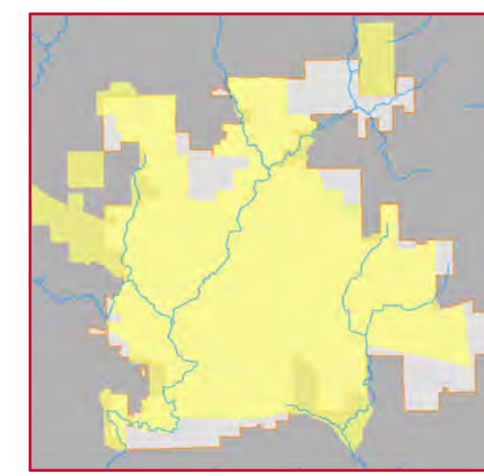
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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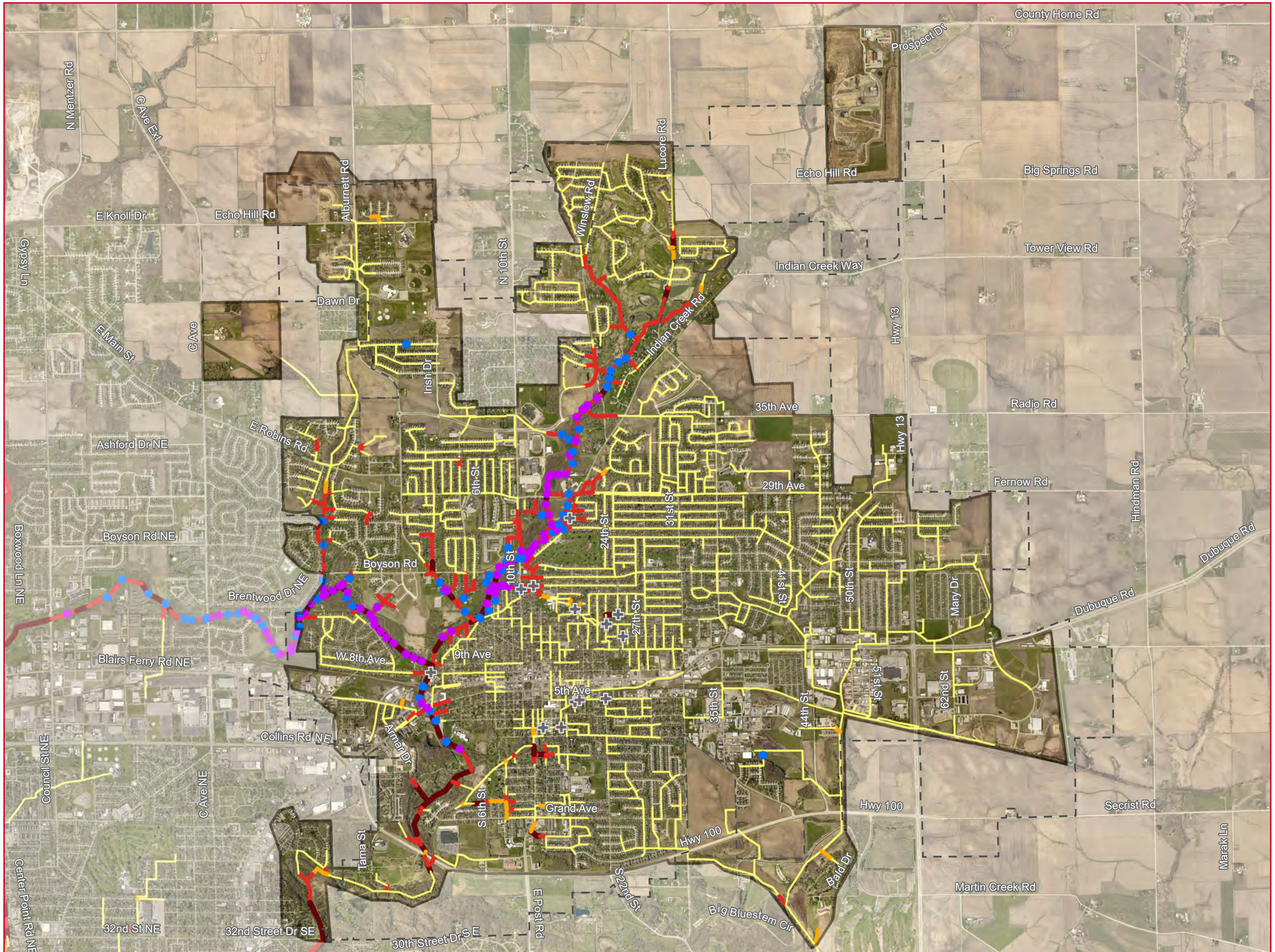
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S3_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



BASELINE CONDITIONS WITH I/I REDUCTION IN OLD MARION (S4) 2-YR WET WEATHER FLOW FIGURE B17

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

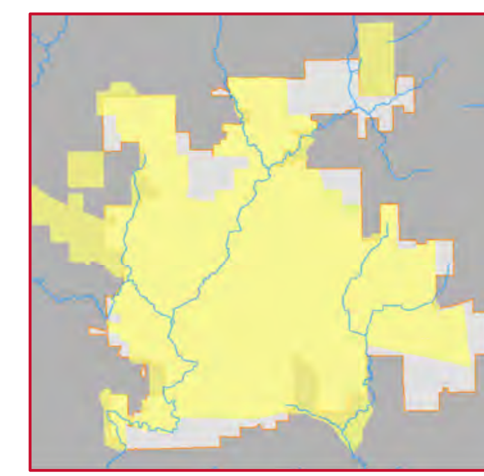
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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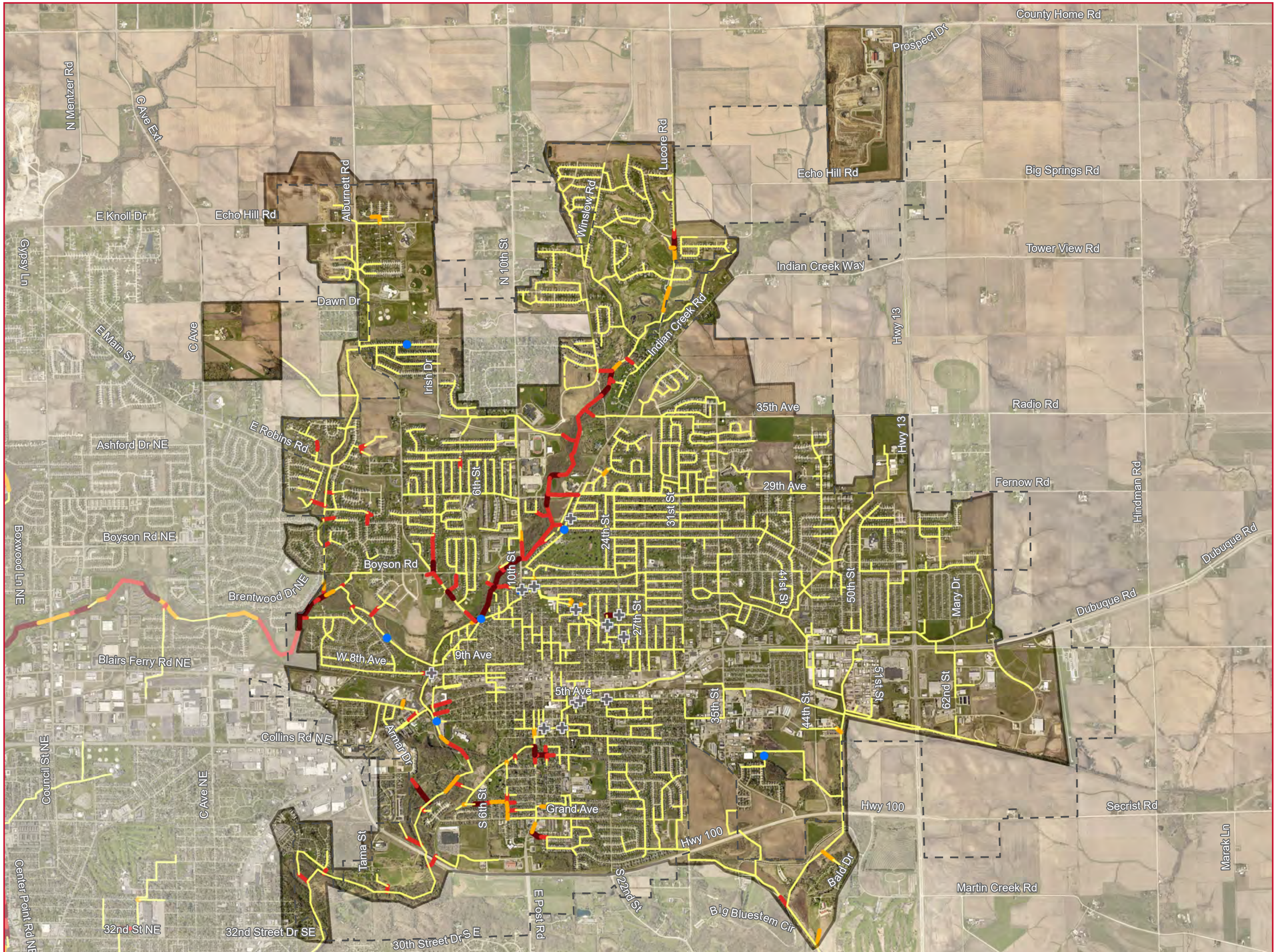
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S4_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



PROP. IC & DRCTRUNK SEWER WITH I/I REDUCTION CONDITION (S5) 2-YR WET WEATHER FLOW FIGURE B18

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

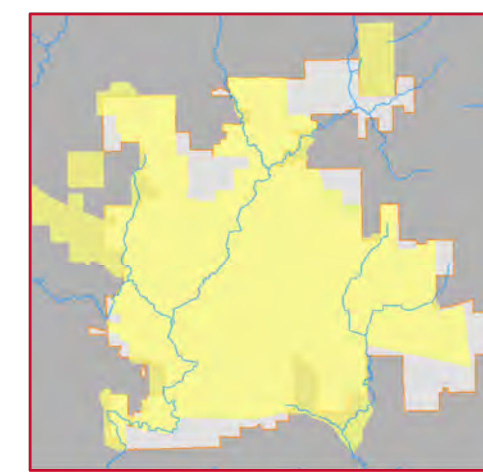
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



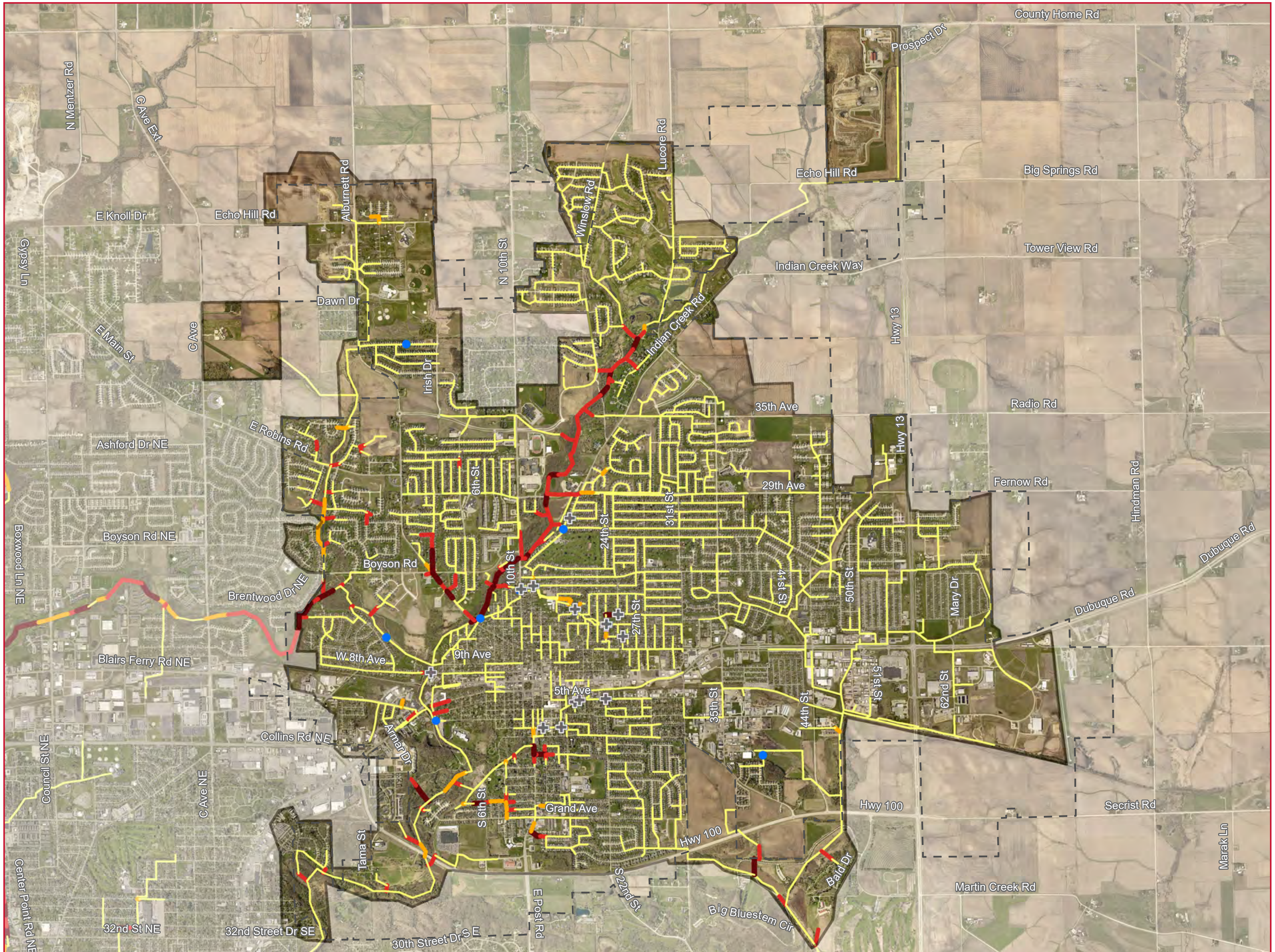
0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S5_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POPULATION IN EXISTING SERVICE AREA CONDITION (S6)
2-YR WET WEATHER FLOW
FIGURE B19

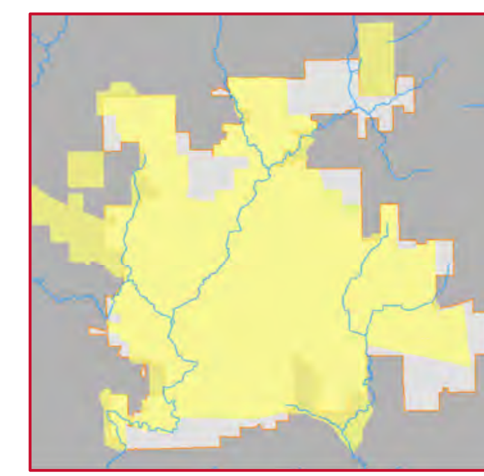
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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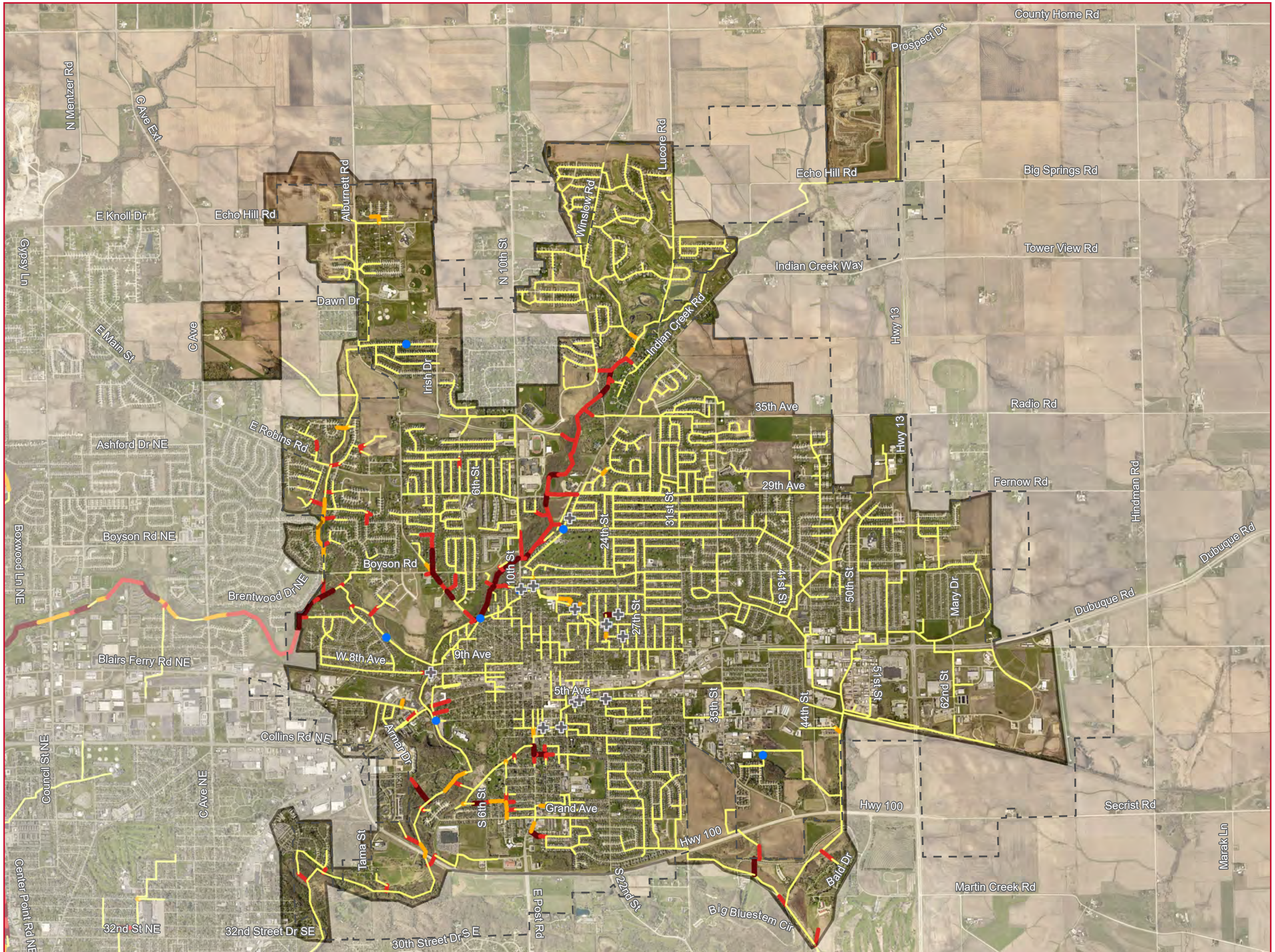
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S6_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH DENSER UPTOWN COND. (S7) 2-YR WET WEATHER FLOW FIGURE B20

City Boundary

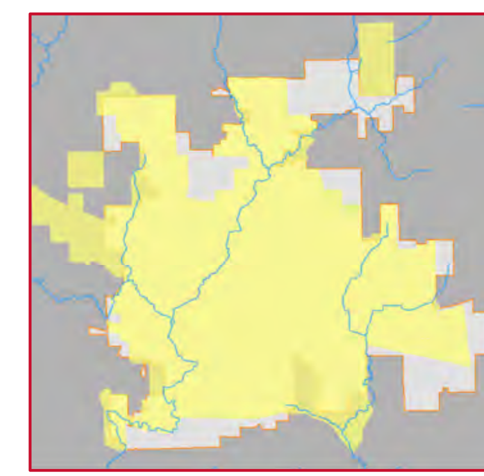
Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

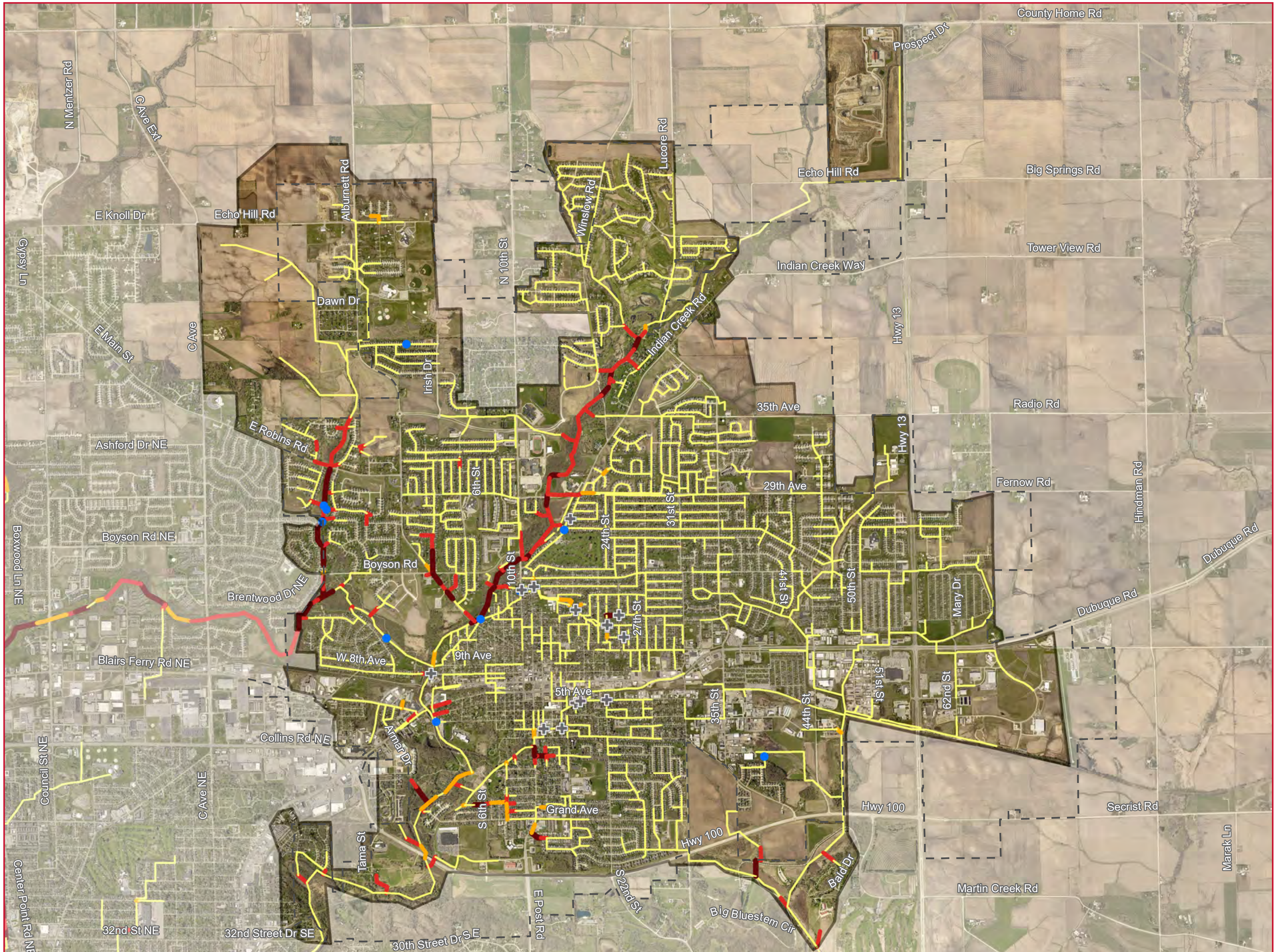
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S7_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 1 COND. (S8)
2-YR WET WEATHER FLOW
FIGURE B21



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

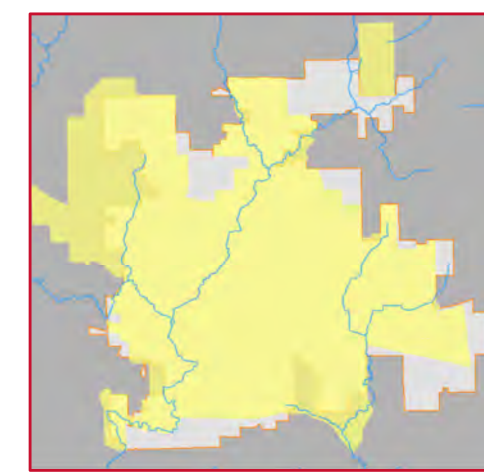
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

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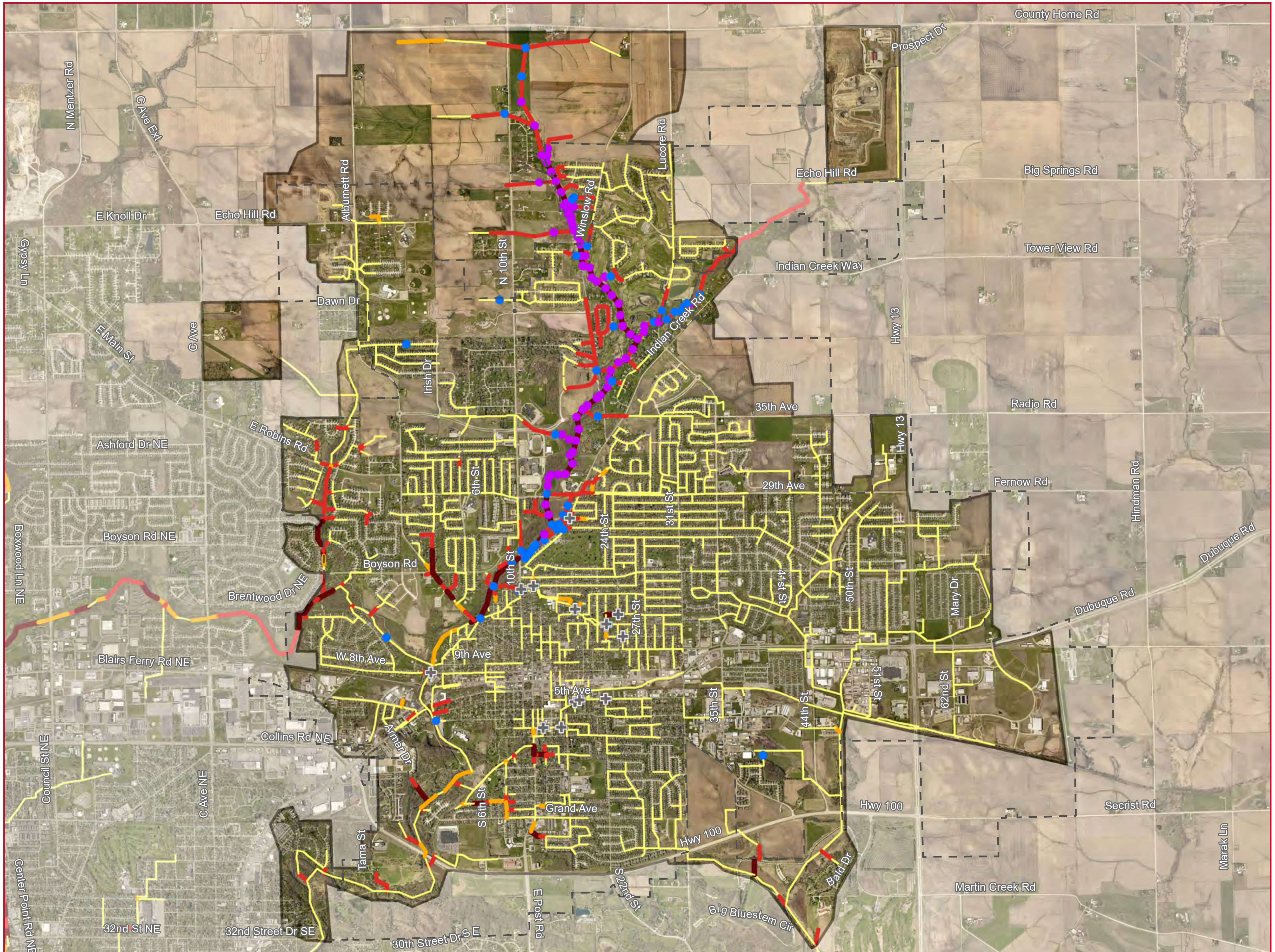
PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S8_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 2 COND. (S9) 2-YR WET WEATHER FLOW FIGURE B22



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

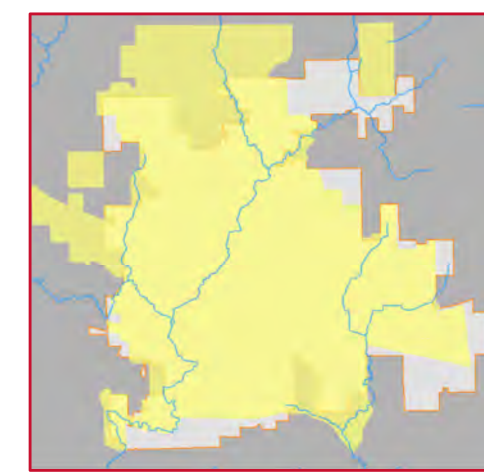
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

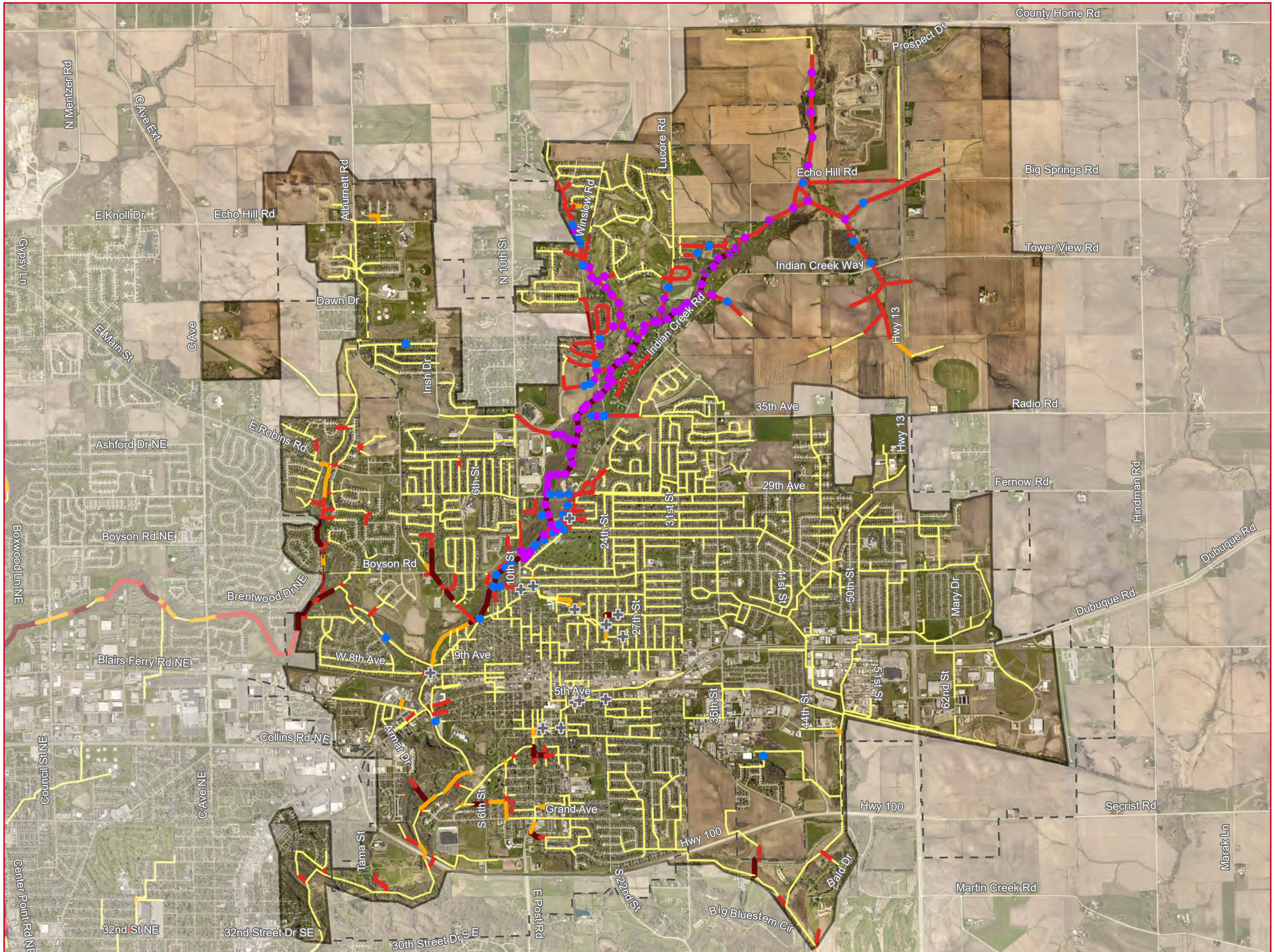
Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion IOWA

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S9_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 3 COND. (S10)
2-YR WET WEATHER FLOW
FIGURE B23



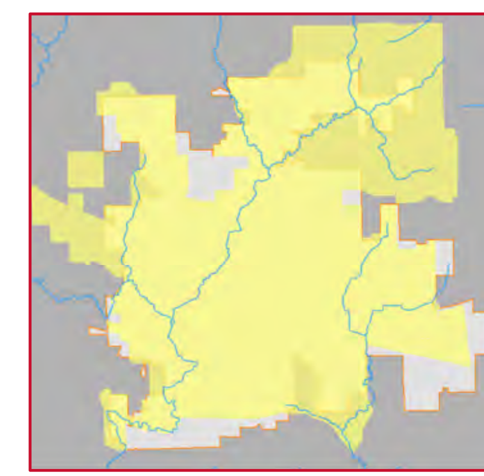
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

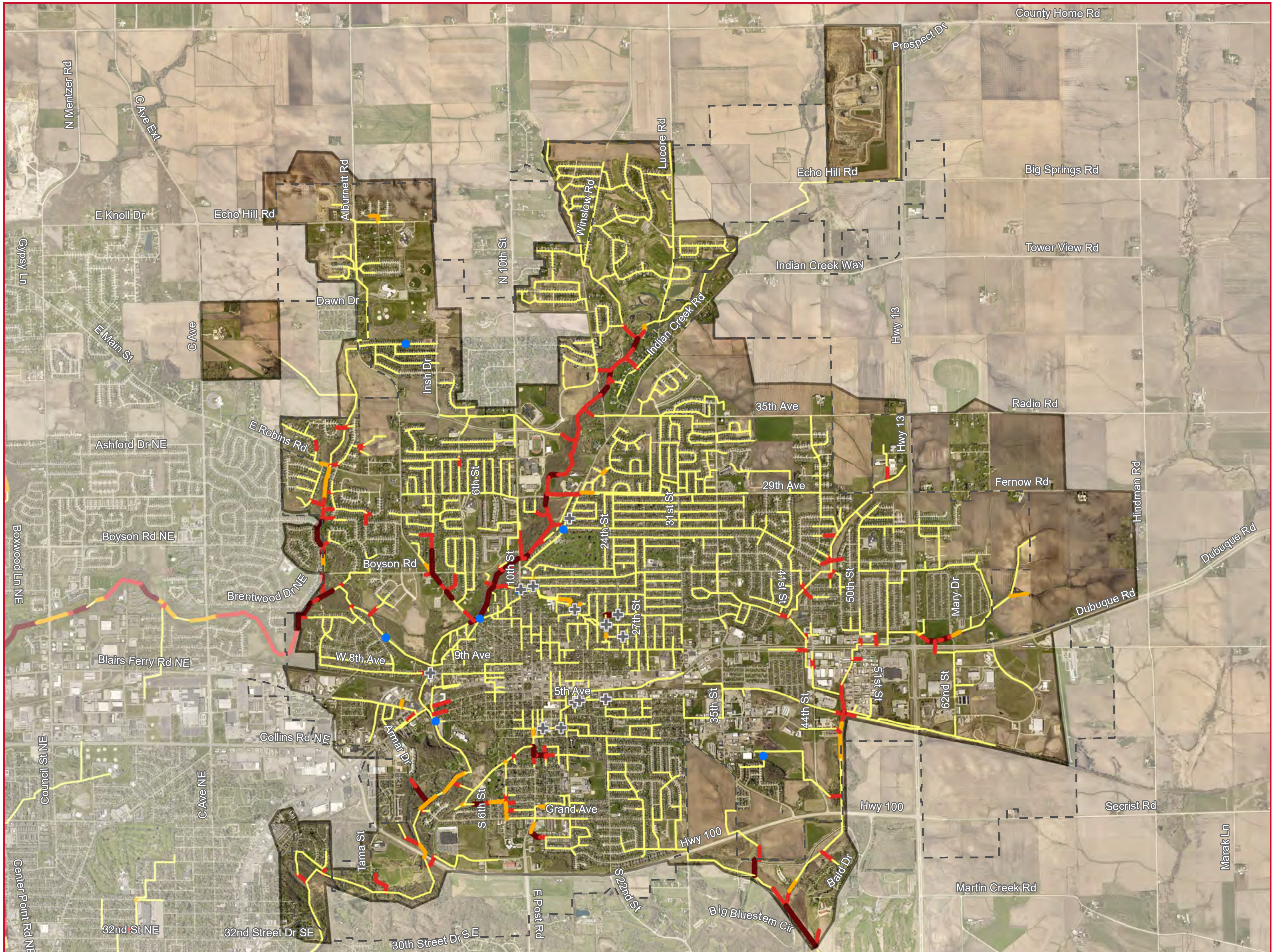
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion IOWA

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S10_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S11)
2-YR WET WEATHER FLOW
FIGURE B24

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

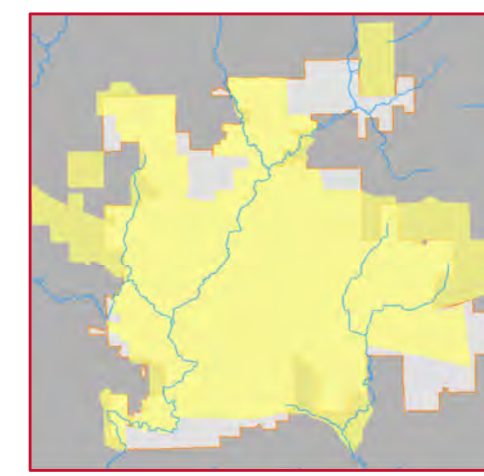
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

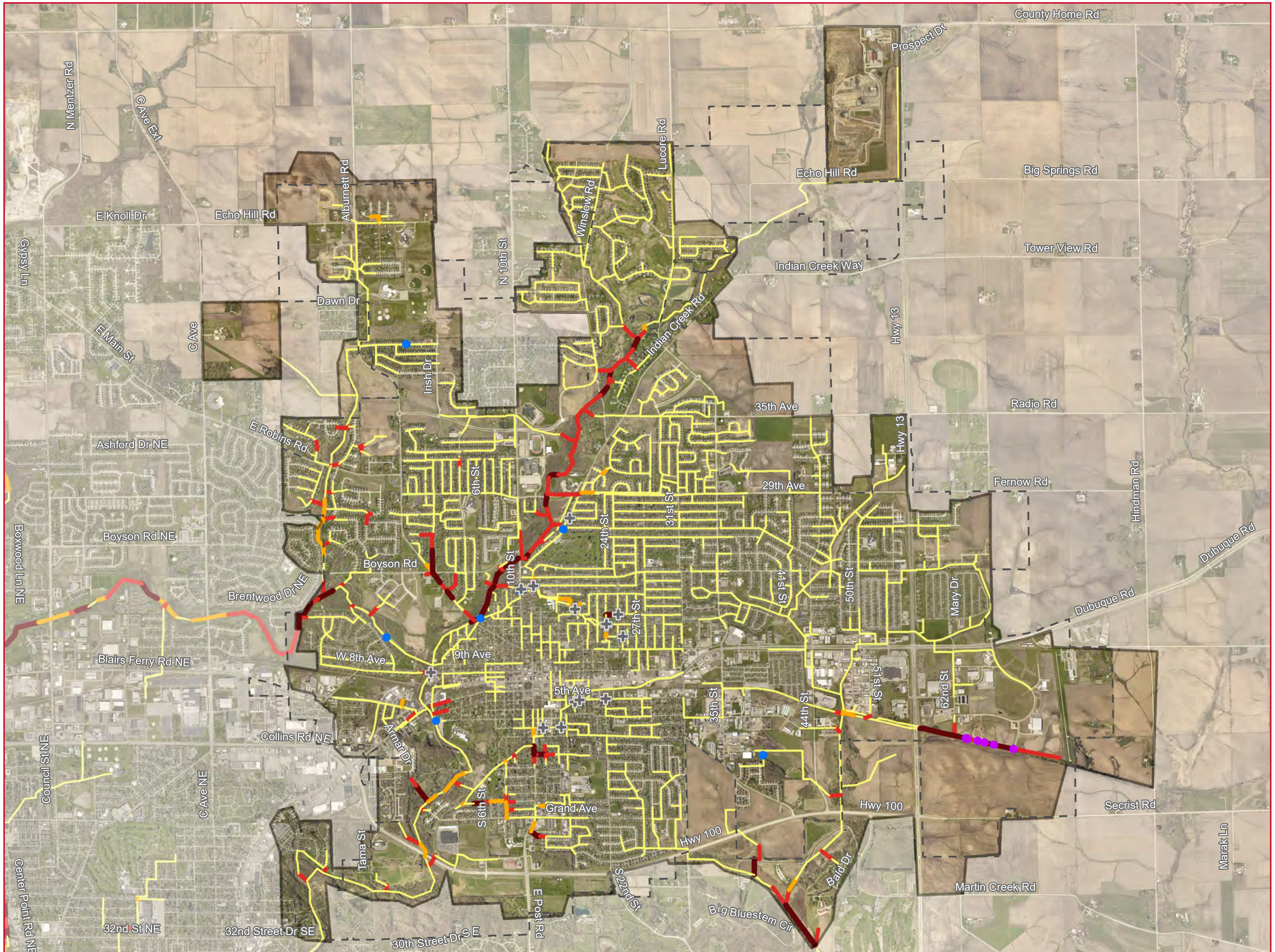
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion IOWA

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S11_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S12) 2-YR WET WEATHER FLOW FIGURE B25

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

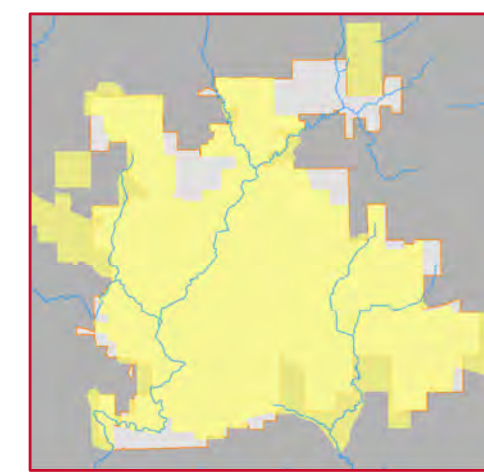
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

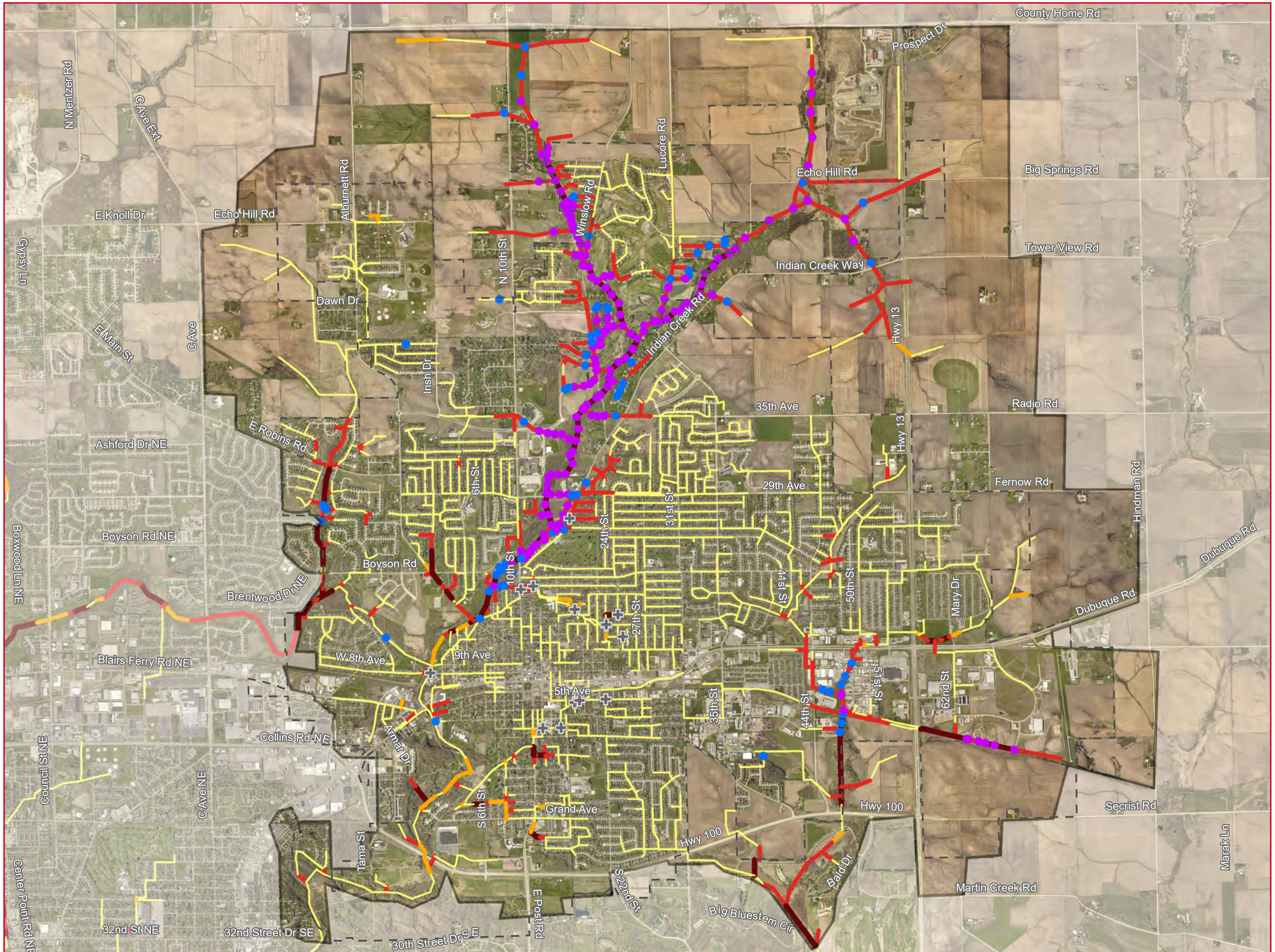
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S12_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



FULL DEVELOPMENT CONDITION (S13)
2-YR WET WEATHER FLOW
FIGURE B26

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

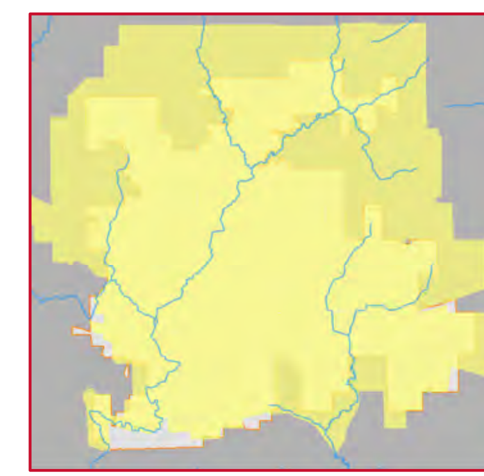
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



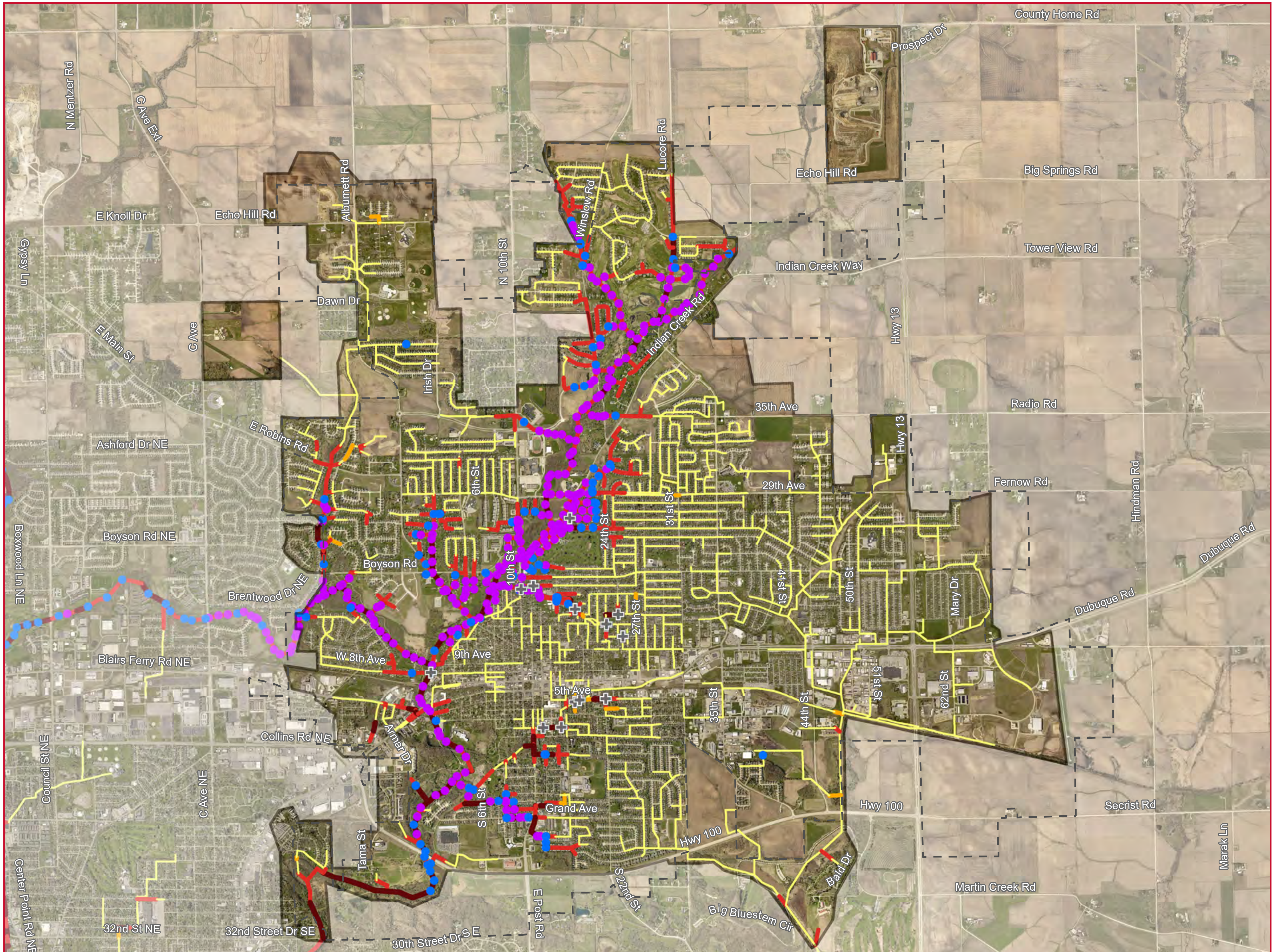
0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S13_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



EXISTING CONDITIONS (S1)
5-YR WET WEATHER FLOW
FIGURE B27

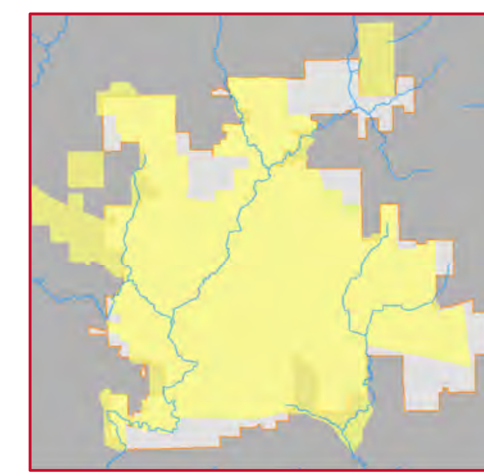
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



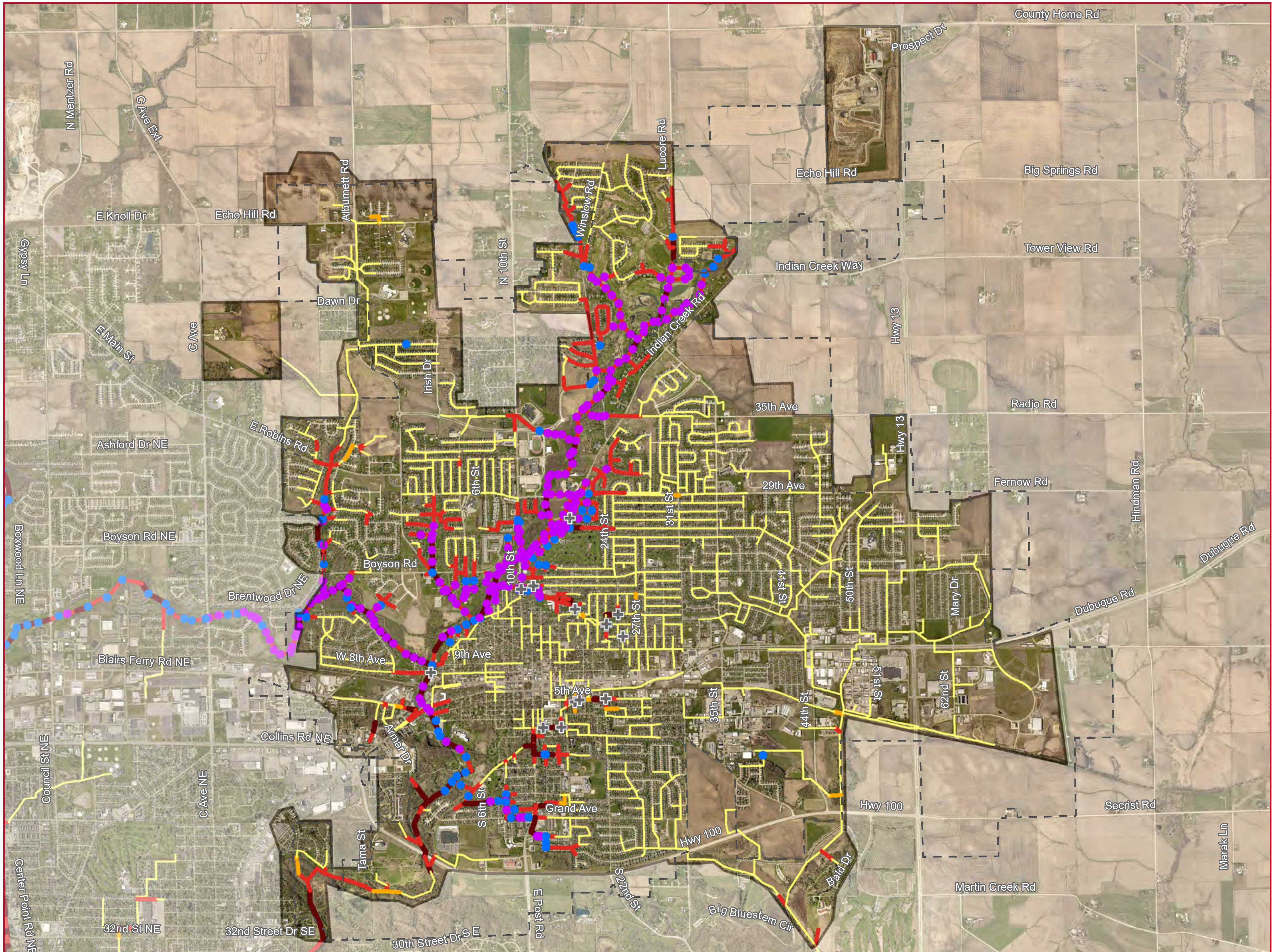
0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S1_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021



BASELINE CONDITIONS (S2)
5-YR WET WEATHER FLOW
FIGURE B28

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

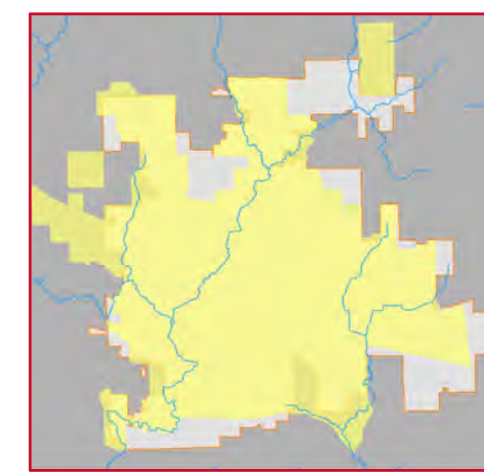
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

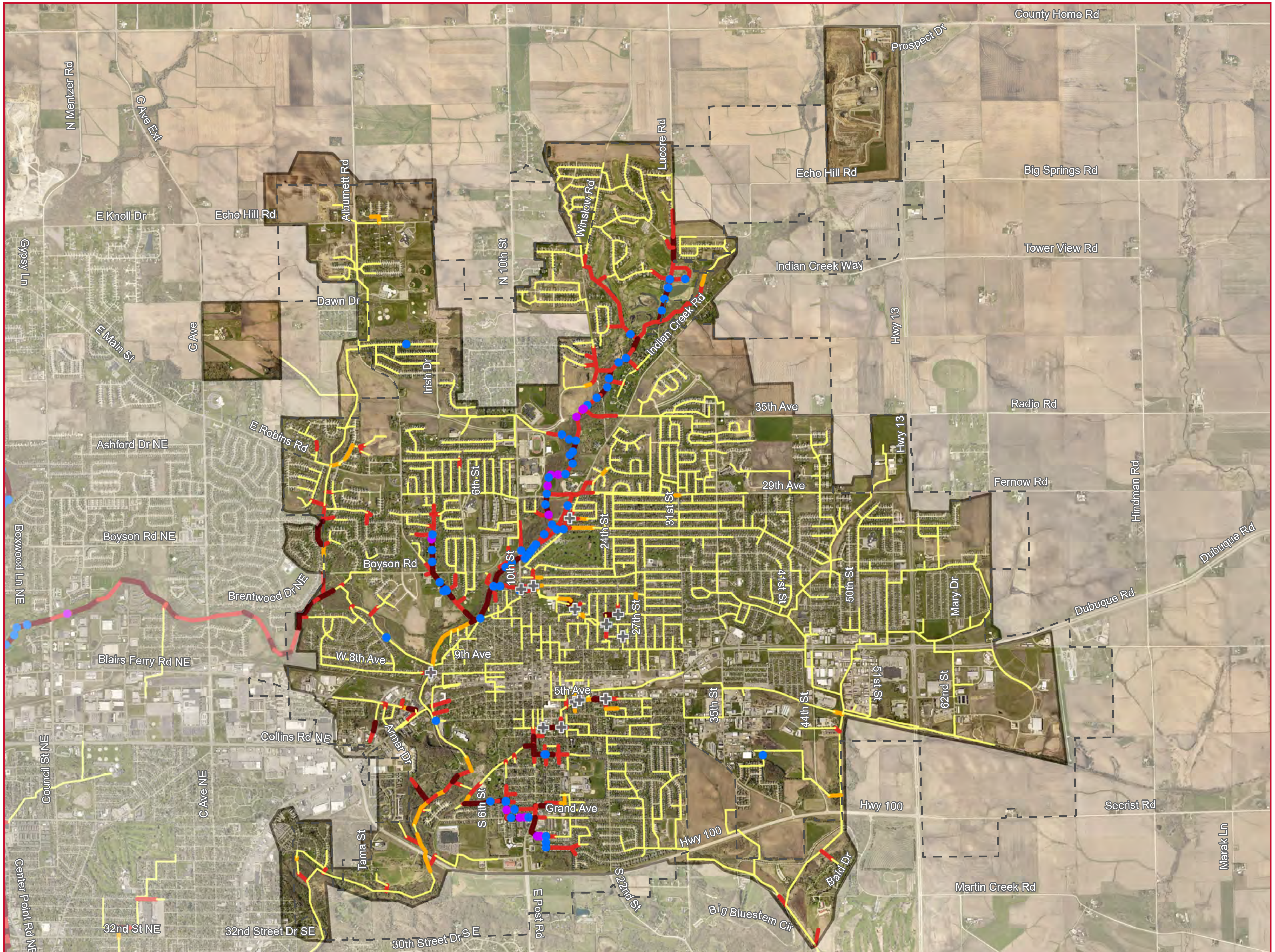
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S2_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021

PROP. INDIAN & DRY RUN CREEKS TRUNK SEWER CONDITION (S3) 5-YR WET WEATHER FLOW FIGURE B29



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

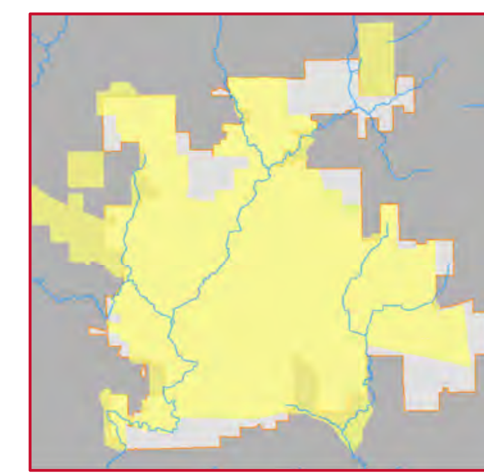
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



DATA SOURCE: City of Marion

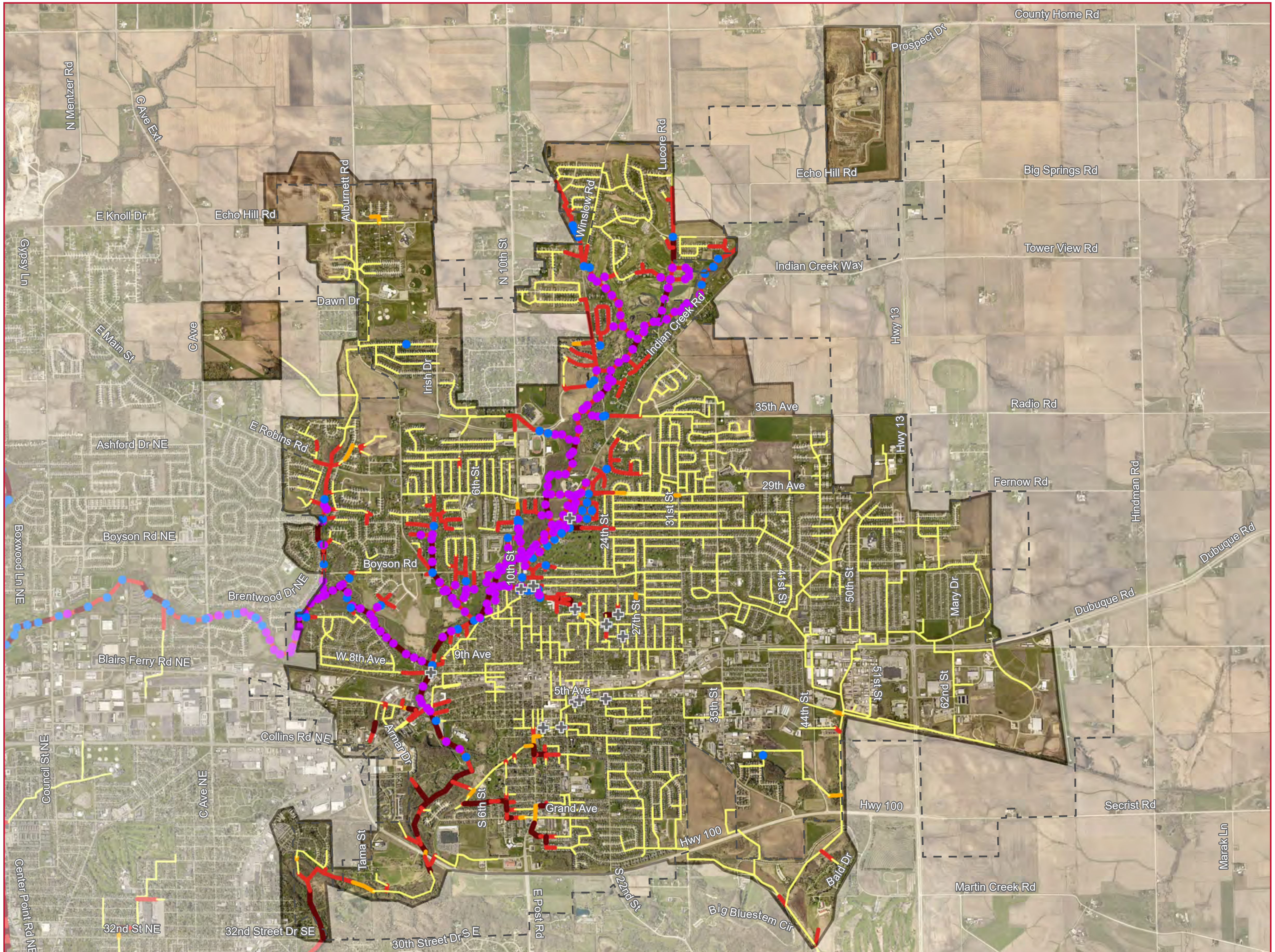
Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion IOWA

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S3_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021

BASELINE CONDITIONS WITH I/I REDUCTION IN OLD MARION (S4) 5-YR WET WEATHER FLOW FIGURE B30



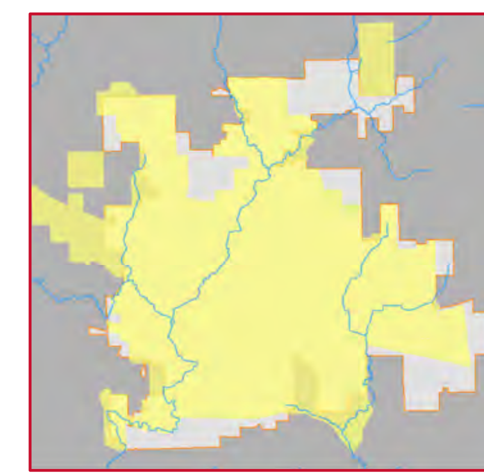
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

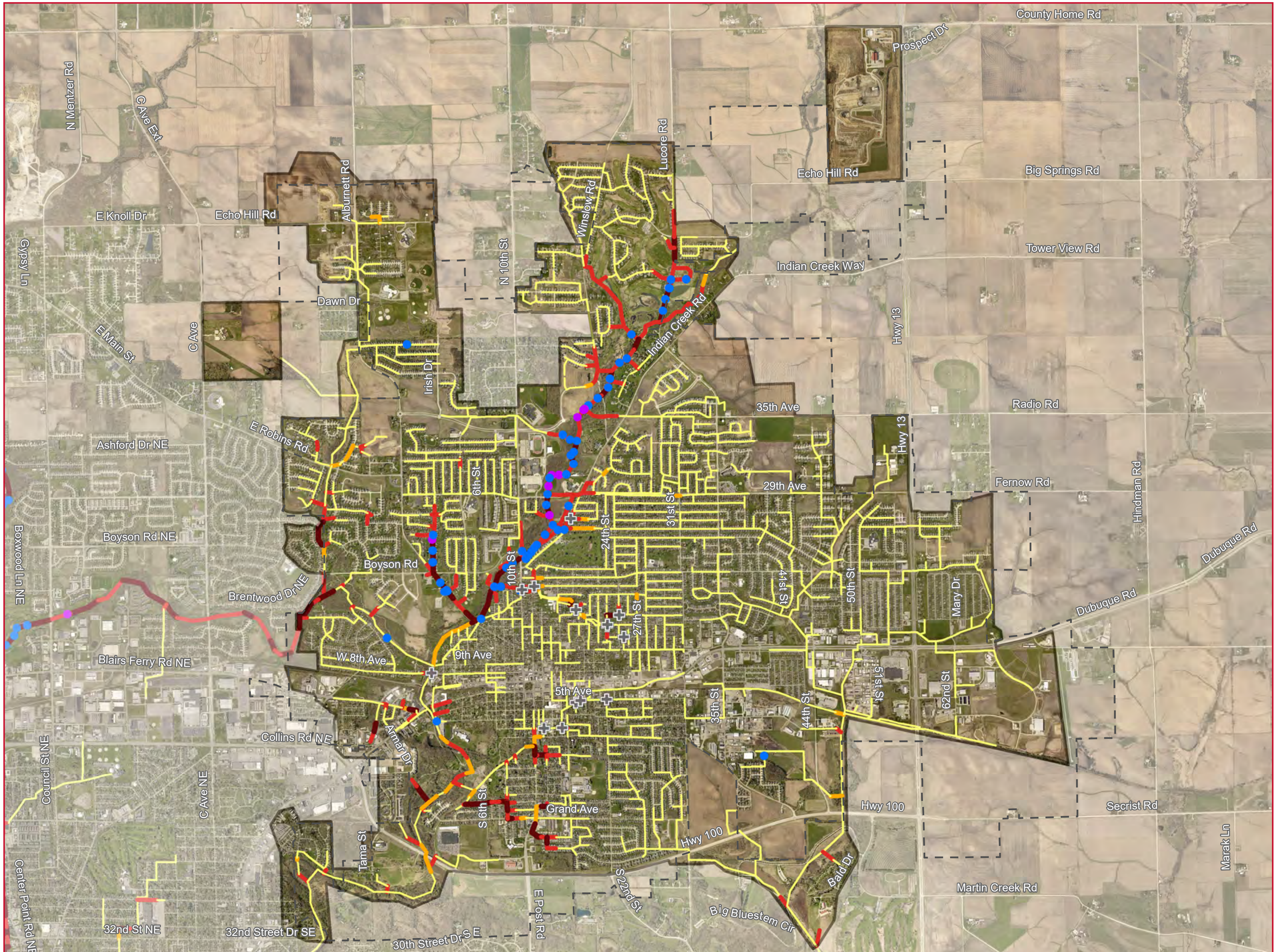
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S4_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021

PROP. IC & DRCTRUNK SEWER WITH I/I REDUCTION CONDITION (S5) 5-YR WET WEATHER FLOW FIGURE B31



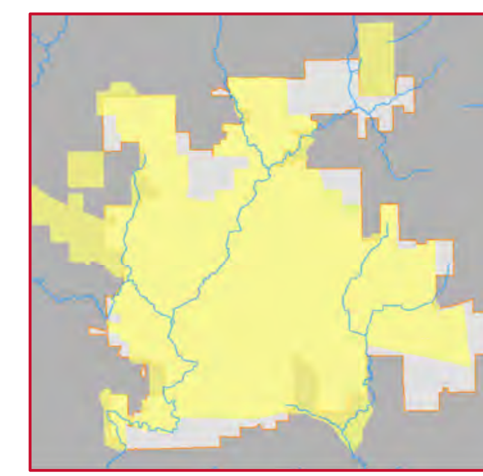
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

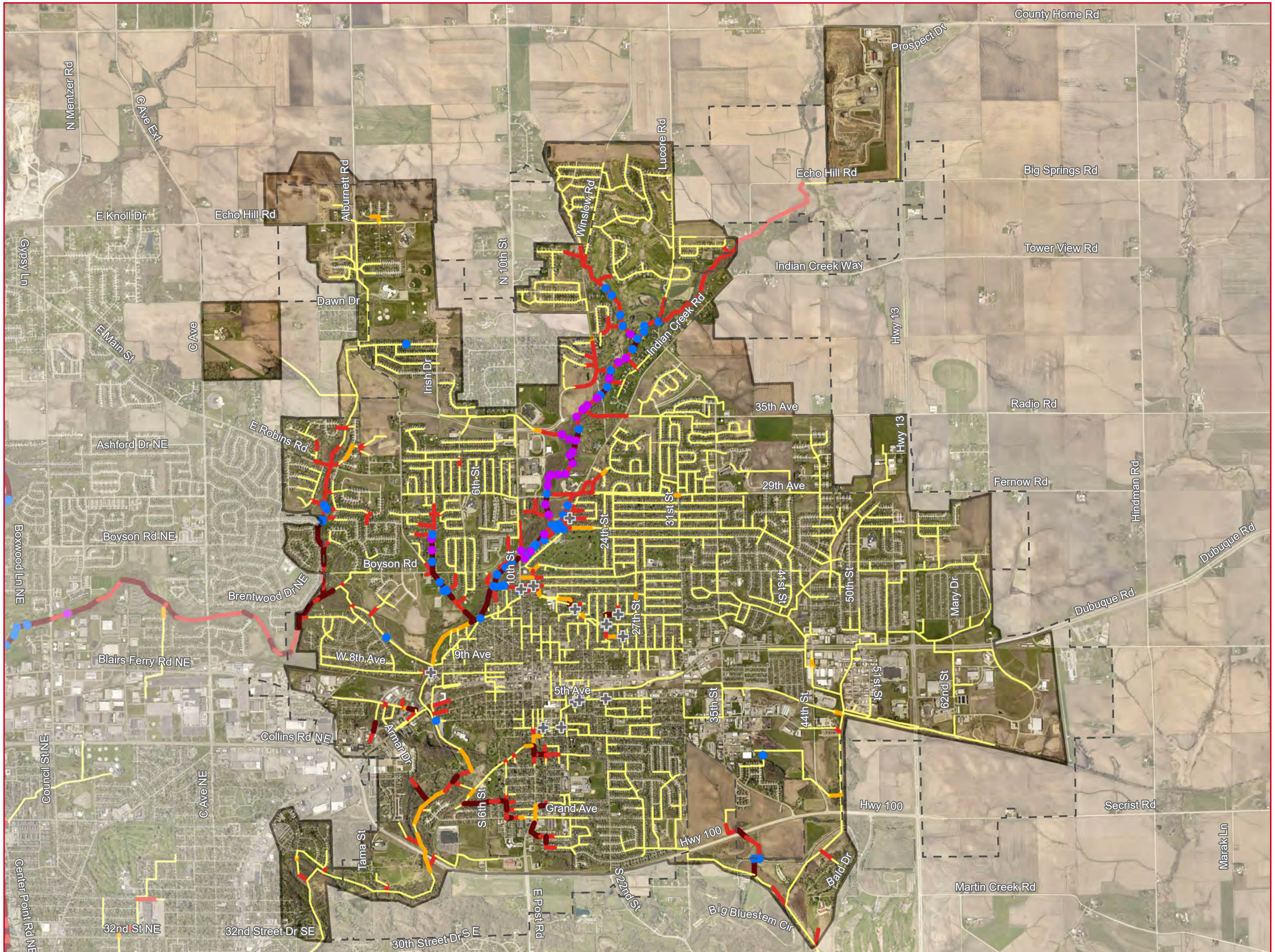
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

HDR City of Marion Iowa

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S5_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POPULATION IN EXISTING SERVICE AREA CONDITION (S6) 5-YR WET WEATHER FLOW FIGURE B32

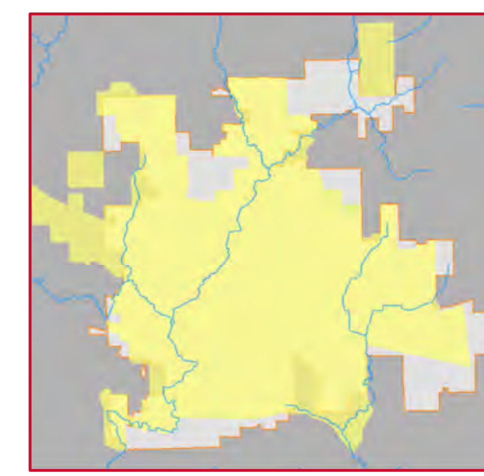
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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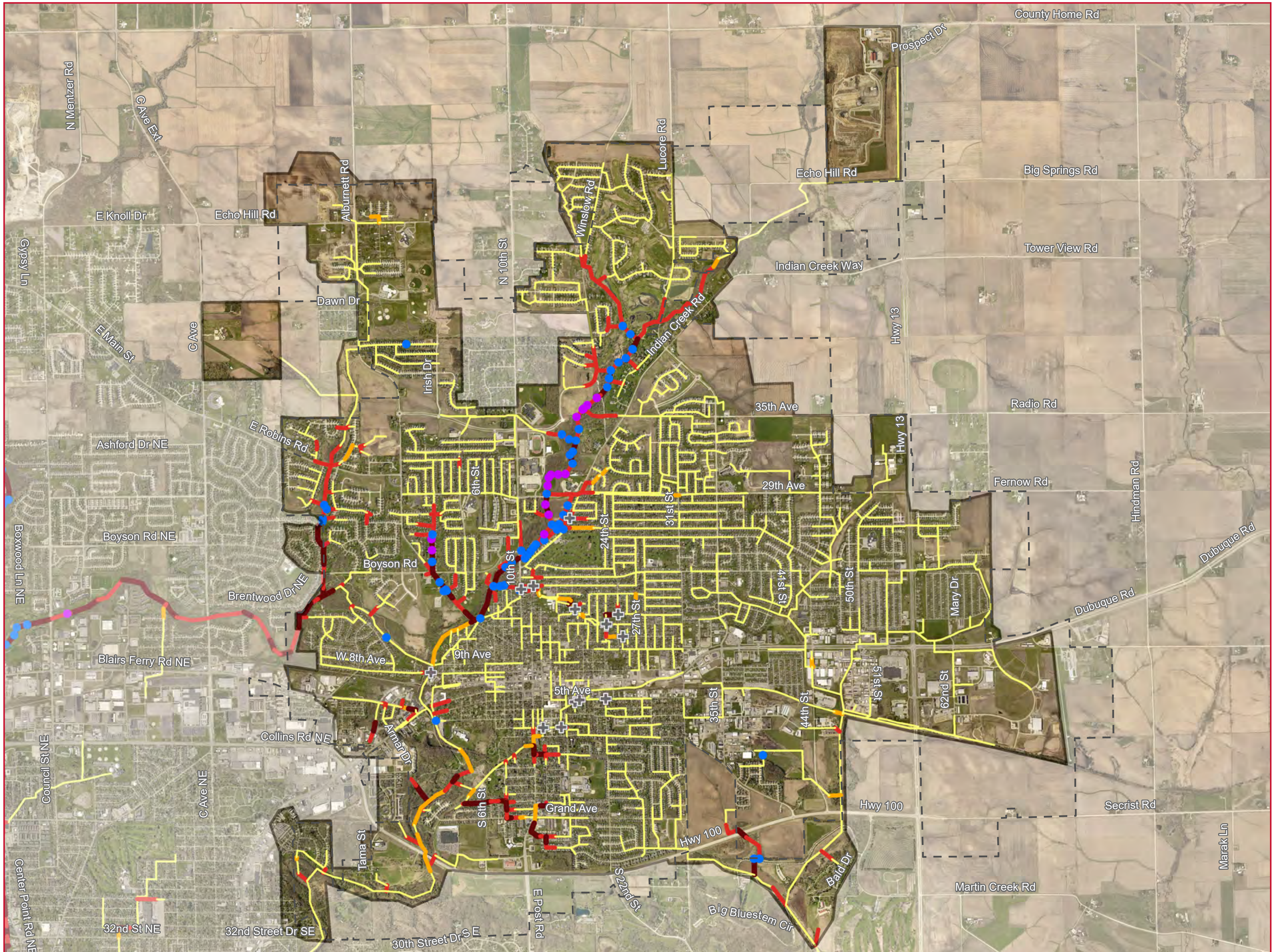
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S6_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH DENSER UPTOWN COND. (S7) 5-YR WET WEATHER FLOW FIGURE B33

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

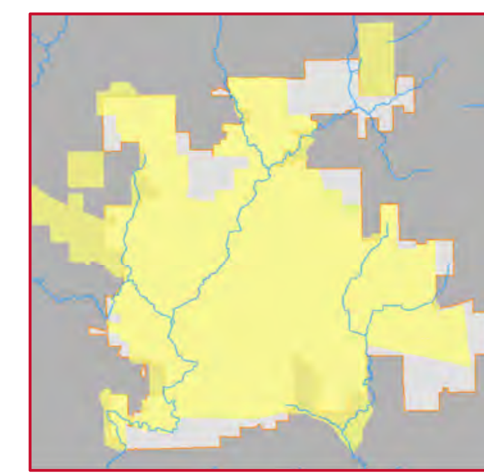
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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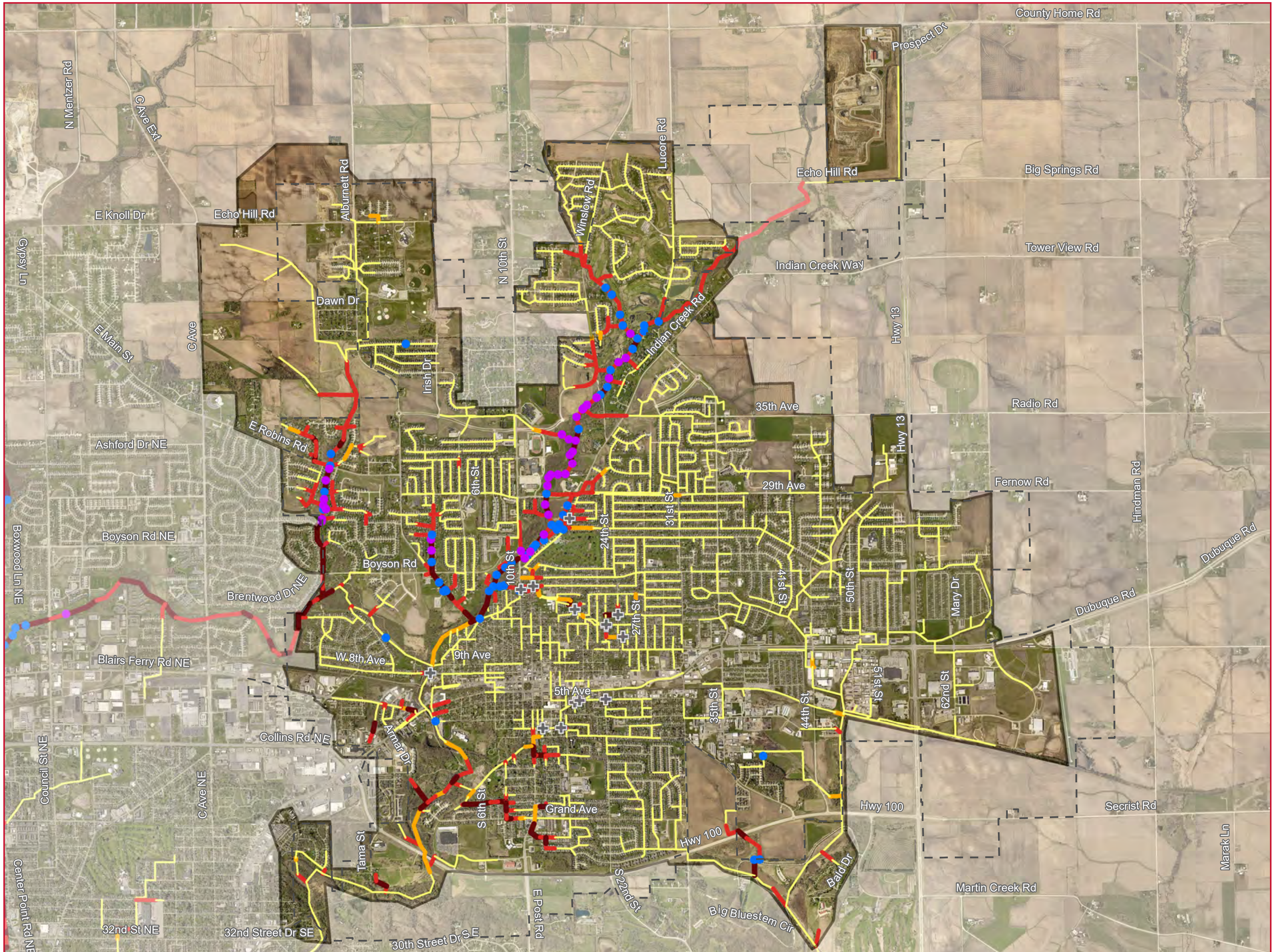
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S7_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 1 COND. (S8) 5-YR WET WEATHER FLOW FIGURE B34

City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

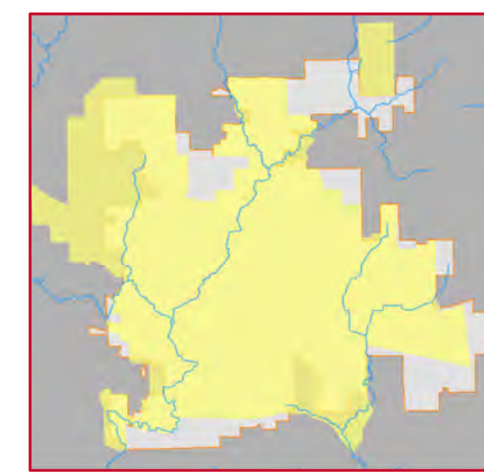
Full - Bottleneck Downstream

Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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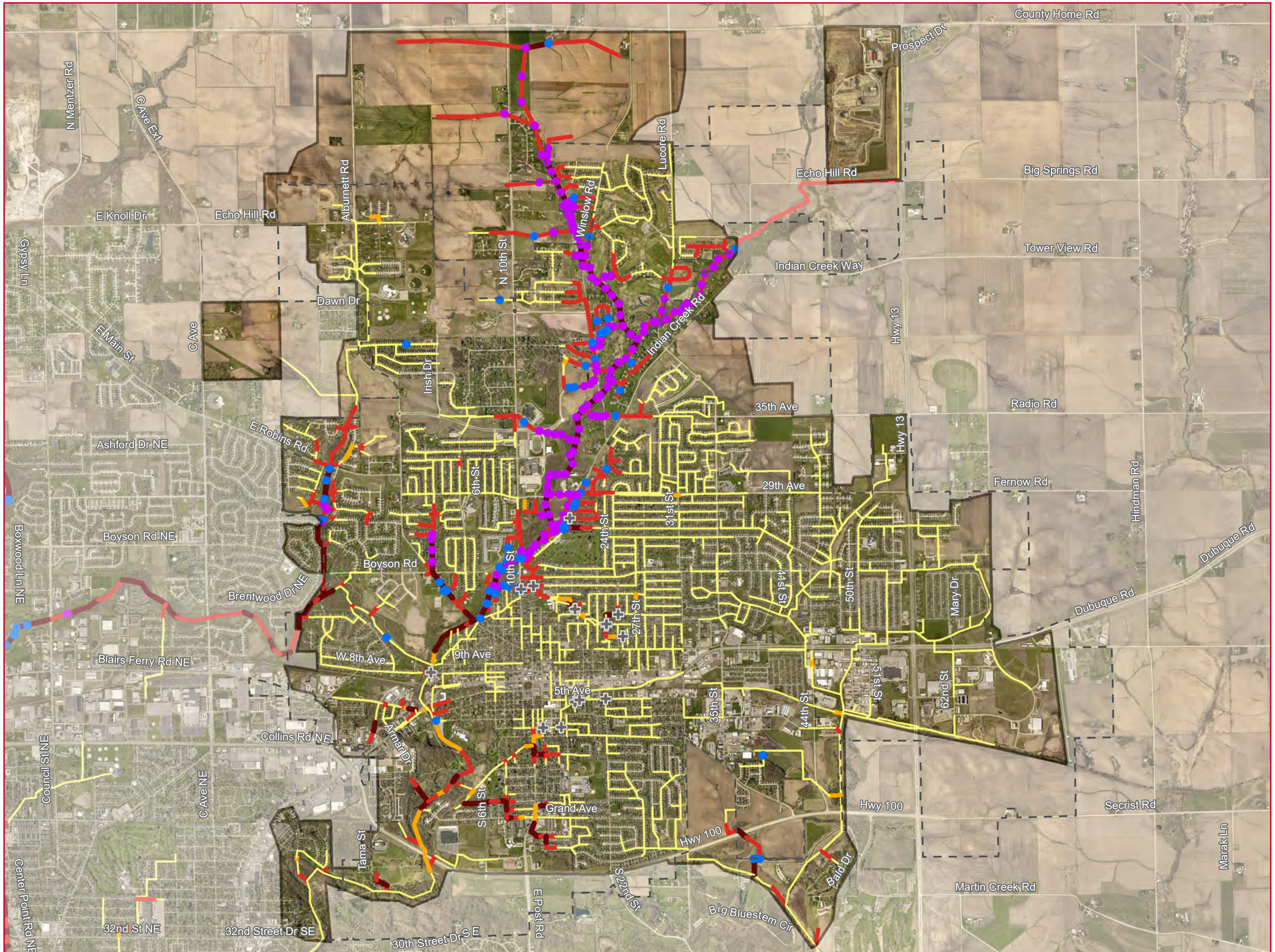
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S8_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021



2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 2 COND. (S9)
5-YR WET WEATHER FLOW
FIGURE B35

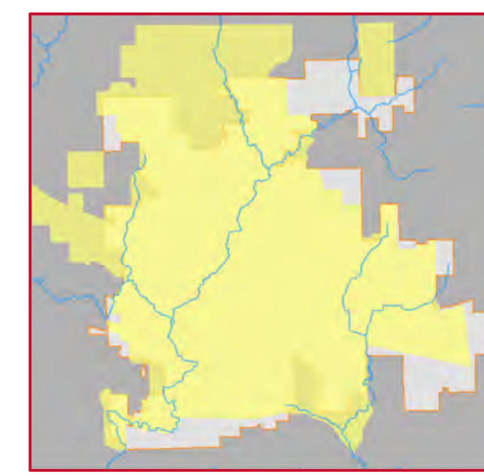
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



0 Feet 5,000

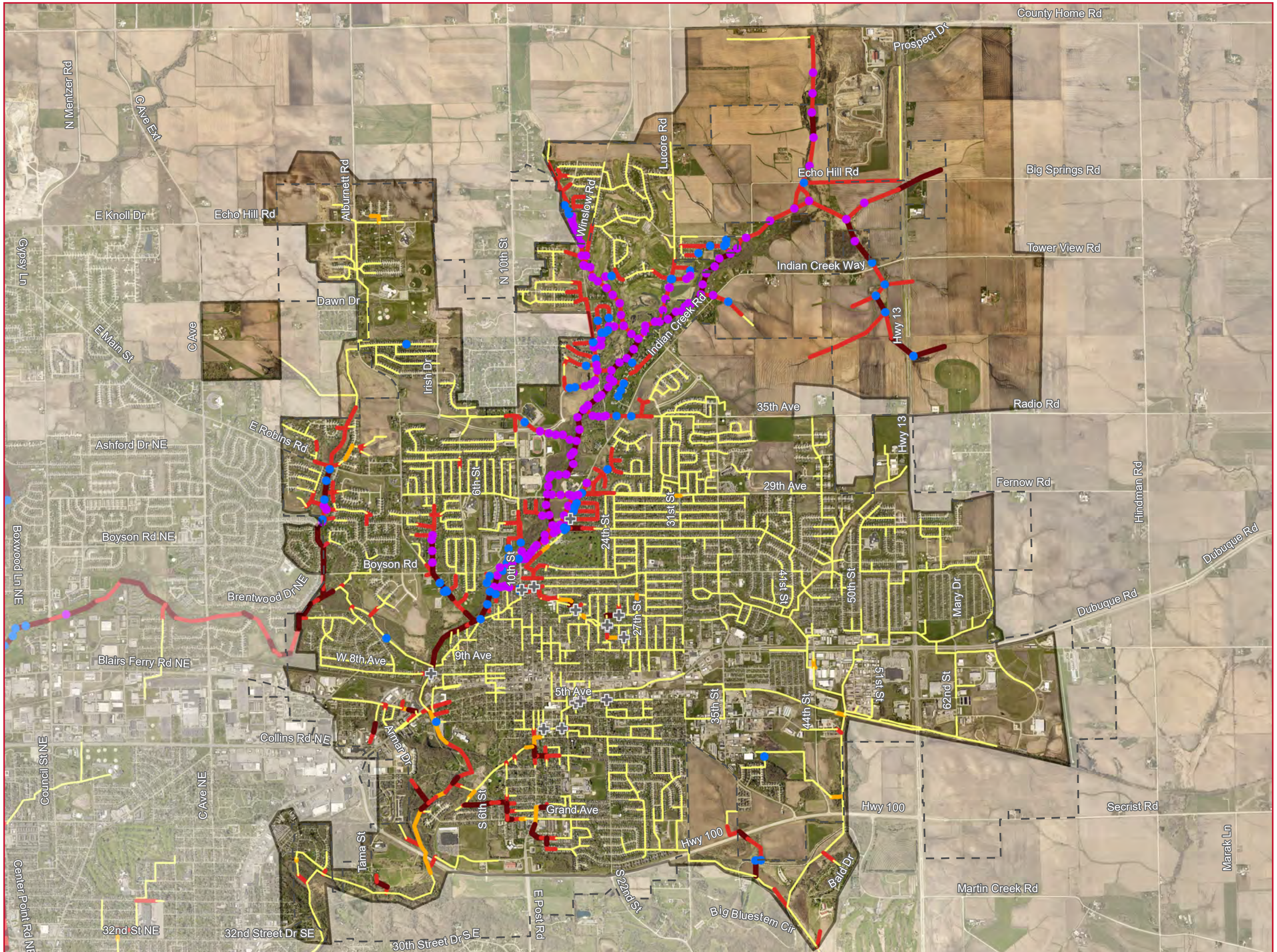
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S9_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 3 COND. (S10) 5-YR WET WEATHER FLOW FIGURE B36



City Boundary

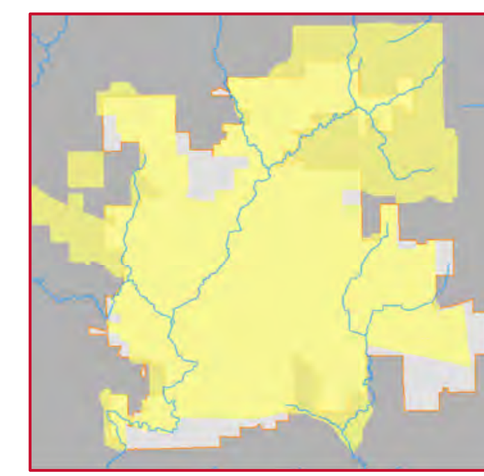
Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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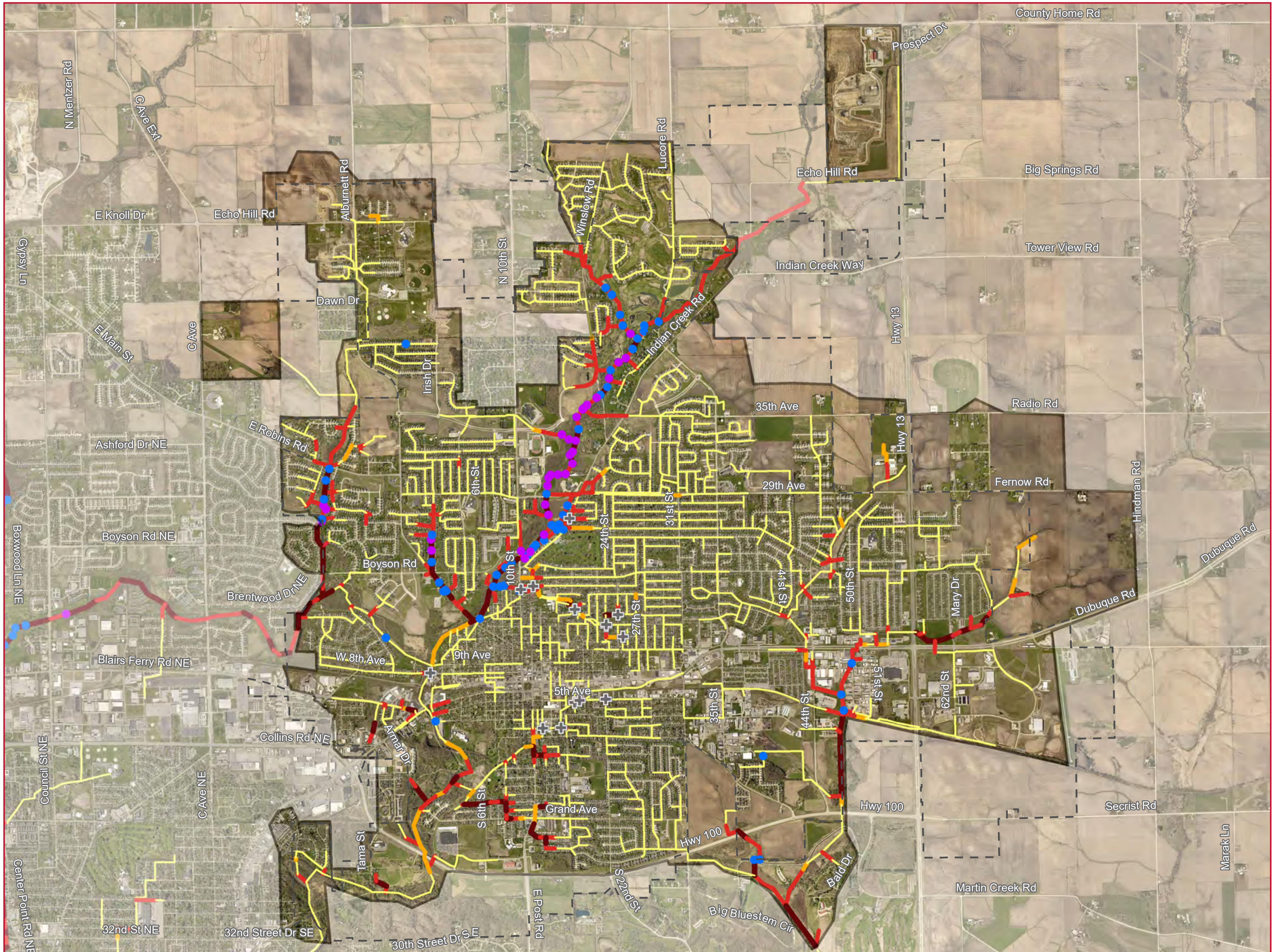
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S10_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S11) 5-YR WET WEATHER FLOW FIGURE B37



City Boundary

Pumping Locations

Surcharge State

d/D < 0.8

d/D > 0.8

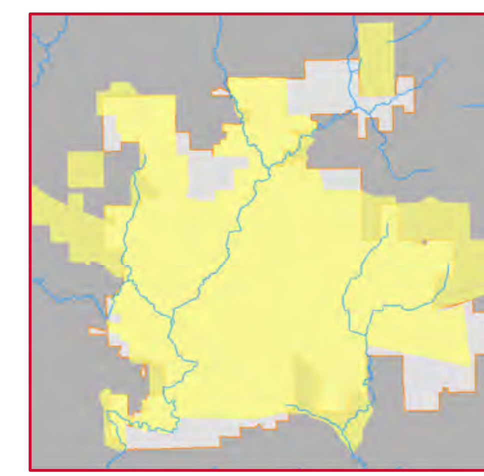
Full - Bottleneck Downstream

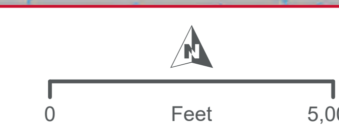
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)

Potential Overflow (0 ft)





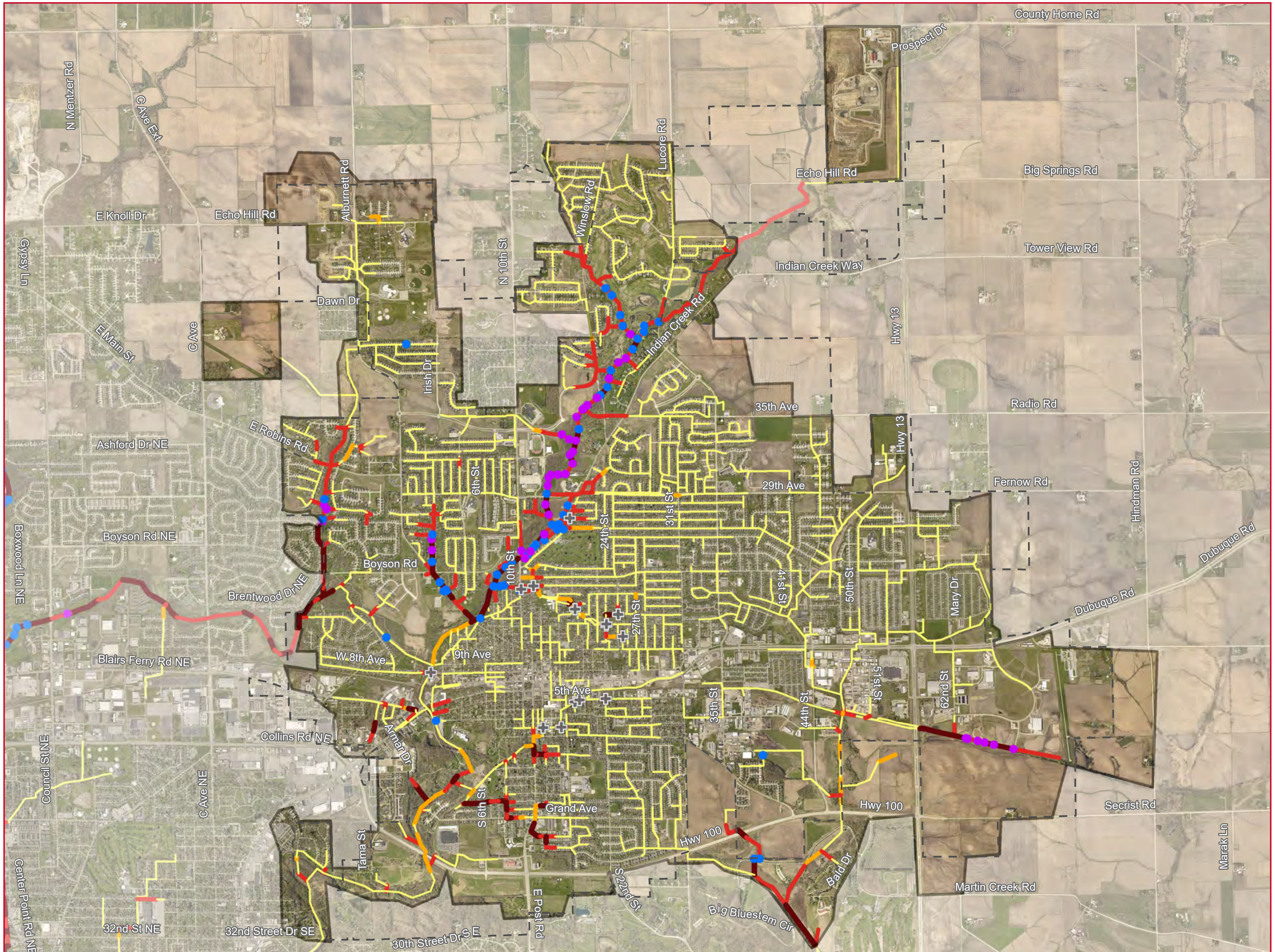
DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S11_2YRWF.MXD - USER: STHEN - DATE: 1/26/2021

2040 POP. IN EXIST. SERVICE AREA WITH GROWTH AREA 4 COND. (S12) 5-YR WET WEATHER FLOW FIGURE B38



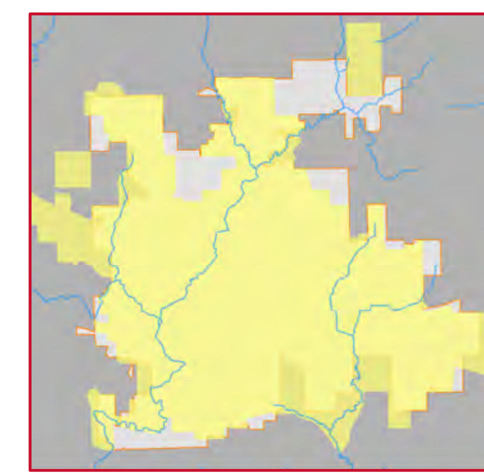
- City Boundary
- Pumping Locations

Surcharge State

- d/D < 0.8
- d/D > 0.8
- Full - Bottleneck Downstream
- Full - Bottleneck Pipe

Freeboard

- Potential Backup (<3 ft)
- Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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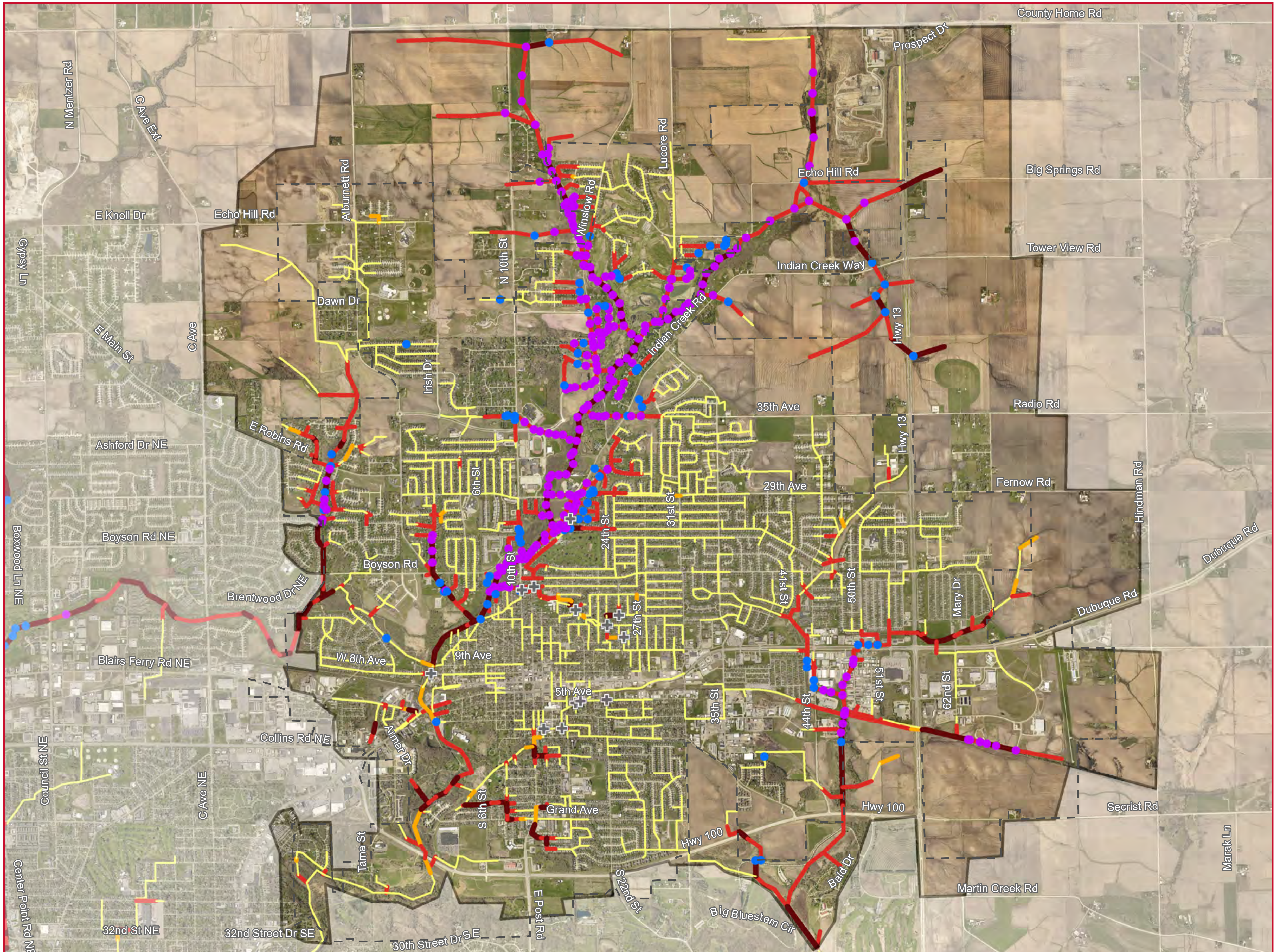
MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S12_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021



FULL DEVELOPMENT CONDITION (S13)
5-YR WET WEATHER FLOW
FIGURE B39

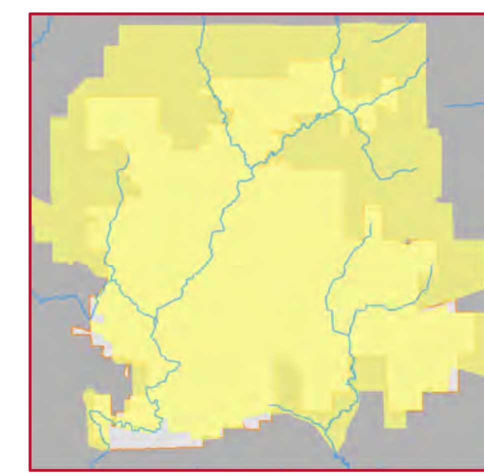
City Boundary
Pumping Locations

Surcharge State

d/D < 0.8
d/D > 0.8
Full - Bottleneck Downstream
Full - Bottleneck Pipe

Freeboard

Potential Backup (<3 ft)
Potential Overflow (0 ft)



0 Feet 5,000

DATA SOURCE: City of Marion

Service Layer Credits: Linn County, Iowa GIS

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MODEL RESULTS
2020 SANITARY SEWER CAPACITY STUDY
CITY OF MARION

PATH: L:\CITY_OF_MARION_2020_SANITARY_SEWER_CAPACITY_STUDY\GIS\MAP_DOCS\DRAFT\FINALRESULTS\MARION_S13_5YRWF.MXD - USER: STHEN - DATE: 1/26/2021