SANITARY SEWER CAPACITY ANALYSIS: MIDDLE SCHOOL 4

Prepared for:

Lee's Summit School District 7

Lee's Summit, Missouri

DRAFT

May 2020

Olsson Project No. 020-0103

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APPENDICES

1. BACKGROUND

The proposed development is a new middle school on a 52 acre (ac) site located on the south side of Bailey Road at the intersection of Country Lane and SE Bailey Road in Lee's Summit, Missouri (City). A capacity analysis was performed on the City's existing sanitary sewer from the proposed connection point to a downstream interceptor identified by the city. The purpose of this analysis was to determine if the existing sanitary sewer could accommodate future flows following the completion of the proposed development of the middle school.

The proposed development will tie into the existing sanitary sewer manhole (MH) #47-082. For the proposed connection, the following three (3) analyses were performed:

- Existing Conditions – Estimated sanitary sewer design flow generated by land within the drainage basin that currently has sanitary service. Exhibits 1 and 2 of Appendix A show the existing drainage areas and land uses for this condition.
- Proposed Conditions – Estimated sanitary sewer design flow generated by the existing conditions (above) and the proposed development. Exhibit 3 of Appendix A shows the anticipated drainage areas and land uses for this condition.
- Ultimate Basin Build-Out Conditions – Estimated sanitary sewer design flow generated by the entire drainage basin. Exhibit 4 of Appendix A shows the anticipated drainage areas for this condition.

The analysis presented here considers the capacity of sewer from the proposed connection point at MH #47-082 to MH #47-020.

2. METHODOLOGY

Wastewater flows were estimated and modeled for the existing, proposed, and ultimate build-out conditions of the sanitary sewer system from the proposed connection point to the interceptor downstream. The City's Design Criteria Section 6501.C.1 was used to assign flows to residential areas and non-residential areas greater than 100 ac. Agricultural areas were treated as residential land and design flows were estimated per section 6501.C.1. In the existing and proposed conditions, sections of sewer main through undeveloped areas were assumed to receive inflow and infiltration from an area 100 feet on either side of the pipe. Design flow peak base flow for the Sunset Valley Elementary School (Area 12) was estimated using the equivalent dwelling unit (EDU) methodology of section 6501.C.2. Design peak infiltration and inflow rates were estimated per section 6501.C.1 for non-residential areas. Area 11 encompassed the existing gravity main through Silvia Bailey Park. Table 1 shows the flow calculation of sanitary sewer flow for the existing conditions.

Table 1. Projected Sanitary Sewer Flow for Existing Conditions.

Existing Conditions – Current Basin Build-Out						
Existing Development Area	Area (ac)	Base Flow (gpd)	Peak Infiltration (gpd)	Peak Inflow (cfs*)	Design Flow Rate (MGD**)	Design Flow Rate (cfs*)
Area 1	3.5	5,240	1,750	0.12	0.08	0.13
Area 2	0.9	1,400	470	0.04	0.03	0.04
Area 3	1.8	2,700	900	0.06	0.05	0.07
Area 4	2.6	3,900	1,300	0.09	0.06	0.10
Area 5	2.4	3,570	1,190	0.08	0.06	0.09
Area 6	7.3	10,100	3,670	0.22	0.15	0.24
Area 7	1.3	1,950	650	0.05	**0.03**	0.05
Area 8	165.9	248,900	82,970	3.10	**2.33**	3.61
Area 9	186.0	279,000	46,500	1.71	**1.43**	2.22
Area 10	6.7	10,050	3,350	0.20	**0.14**	0.22
Area 11	5.7	8,550	2,850	0.17	**0.12**	0.19
Area 12	6.8	22,400	1,700	0.10	**0.09**	0.14
					Total	7.10

*cfs = cubic feet per second; **MGD = million gallons per day

The proposed development consists of a middle school main building, athletic complex, and the surrounding area. Design flow peak base flow was estimated in accordance with the EDU methodology of section 6501.C.2. The first and second floors of the middle school were

considered separately because the second floor has a lower occupied area. Design peak infiltration and inflow rates were estimated per section 6501.C.1 for non-residential areas. Table 2 shows the projected sanitary sewer flow calculation for the proposed development.

Table 2. Projected Sanitary Sewer Flow for Proposed Development.

Proposed Middle School					
Building Area	Value (sq. ft.)	EDU	Parameter	Stories	Base Flow (gpd)
Main Building First Floor	129.7	1	per 1,000 sq. ft.	1	38,920
Main Building Second Floor	60.3	1	per 1,000 sq. ft.	1	17,080
Athletics Building	5.0	1	Per 1,000 sq. ft.	1	1,500
				Total Base Flow (gpd)	58,500
				Total Area (Ac)	52.6
				Peak Infiltration (gpd)	13,150
				Peak Inflow (cfs)	0.60
				Design Flow (cfs)	0.72

The ultimate basin build-out condition estimates the impact on the sanitary system when all land in the drainage basin upstream of MH #47-020 is developed for residential or non-residential use. It was assumed that the elementary school (Area 12) and park (Area 11) would be serviced by gravity mains following contours to the south and tie into the interceptor downstream of the area of study. Table 3 shows the projected sanitary sewer flow calculations for the ultimate build-out condition.

Table 3. Projected Sanitary Sewer Flow for Ultimate Basin Build-out Condition.

Ultimate Conditions - Basin Build-Out						
Existing Development Area	Area (ac)	Base Flow (gpd)	Peak Infiltration (gpd)	Peak Inflow (cfs*)	Design Flow Rate (MGD**)	Design Flow Rate (cfs*)
Development Area	52.6	58,500	13150	0.60	0.46	0.72
Area 1	3.49	5,240	1,750	0.12	0.08	0.13
Area 2	0.93	1,400	470	0.04	0.03	0.04
Area 3	1.8	2,700	900	0.06	0.05	0.07
Area 4	2.6	3,900	1,300	0.09	0.06	0.10
Area 5	2.38	3,570	1,190	0.08	0.06	0.09
Area 6	7.33	11,000	3,670	0.22	0.15	0.24
Area 7	1.3	1,950	650	0.05	0.03	0.05
Area 8	165.9	248,900	82,970	3.10	2.33	3.61
Area 9	270.8	406,200	67,700	2.37	2.01	3.10
Area 10	66.9	100,350	33,450	1.45	1.07	1.65
Area 13	10.5	15,750	5,250	0.30	0.21	0.33
Area 14	173.8	260,700	86,900	3.22	2.43	3.76
					Total	13.89

* cfs = cubic feet per second; ** MGD = million gallons per day

3. ANALYSIS

Information for the existing sanitary sewer system was taken from the City's GIS data. The slope of each pipe segment was calculated using the upstream and downstream inverts and the length of pipe listed in the City's GIS system. Existing sub-basin boundaries were determined using the current sanitary sewer layout and parcel maps. Ultimate condition sub-basin boundaries were determined using area contours. Sub-basin areas for each condition are shown in Appendix A. Per the Lee's Summit design criteria, flows were estimated based on drainage area and time of concentration. Manning's equation was used to determine current pipe flow capacities. The Manning's n roughness coefficient used was 0.014 for PVC pipe. The calculations and results of the analyses are shown in Appendix B.

Hydraulic grade lines (HGL) were also calculated for each analysis using a flow modeling extension in AutoCAD Civil 3D. The downstream pipe segment was assumed to be an outfall with an HGL at $(d_c + D)/2$, where d_c is the critical depth and D is the pipe diameter. A line is considered inadequate if the HGL is higher than the pipe crown. A sanitary sewer overflow occurs when the HGL rises above the manhole rim elevation. The HGL model for each analysis is shown in Appendix C.

4. RESULTS

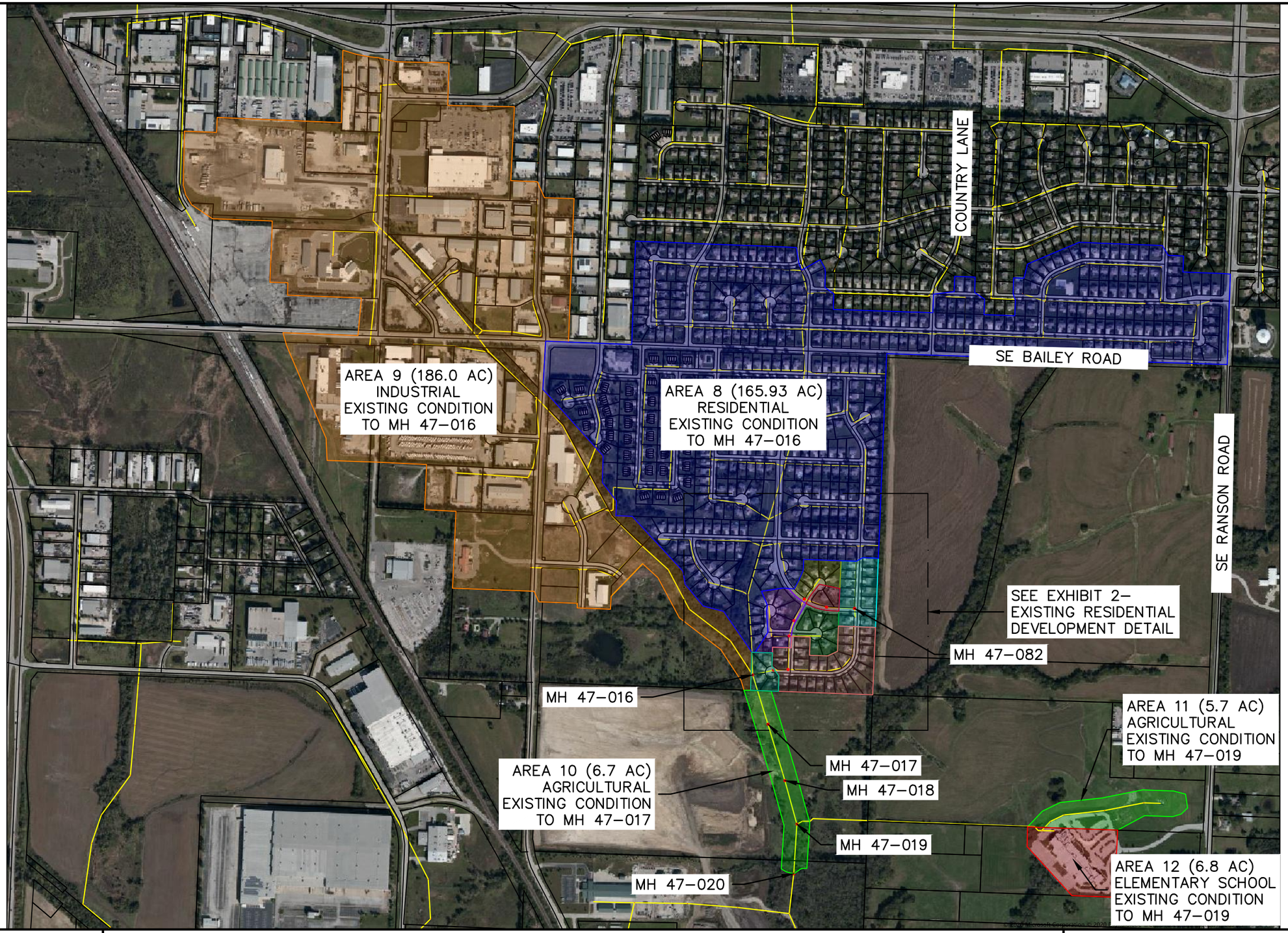
Hydraulic analysis of the existing condition for pipe segments from MH #47-082 to MH #47-020 indicates that the HGL is above the crown of the pipe segment from MH #47-019 to MH #47-020. For all other pipe segments studied, the analysis indicates sanitary sewer overflows. The pipe capacity calculations for this segment can be found in table 1 of Appendix B. A profile of the existing condition HGL is shown in exhibit 5 of Appendix C.

Hydraulic analysis of the proposed condition indicates that the HGL is above the crown of the pipe segment from MH #47-019 to MH #47-020. For all other pipe segments studied, the analysis indicates sanitary sewer overflows. The pipe capacity calculations for this segment can be found in Table 2 of Appendix B. A profile of the proposed condition HGL is shown in exhibit 6 of Appendix C.

Hydraulic analysis of the ultimate build-out condition indicates sanitary sewer overflow conditions for all pipe segments from MH # 47-082 to MH #47-020. The pipe capacity calculations for this segment can be found in Table 3 of Appendix B. A profile of the ultimate build-out condition HGL is shown in exhibit 7 of Appendix C.

5. CONCLUSION

APPENDIX A
Sub-Basin Maps



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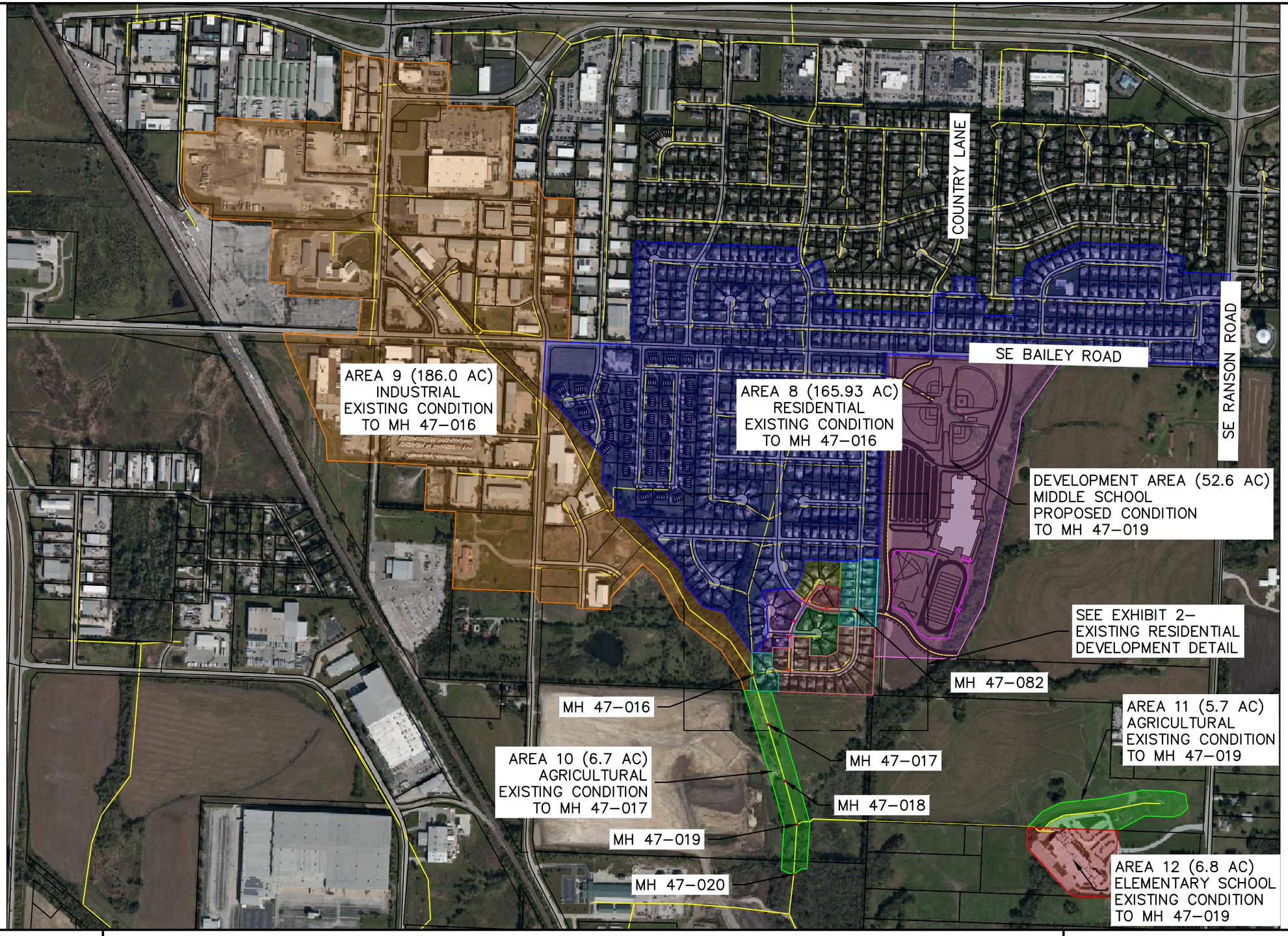

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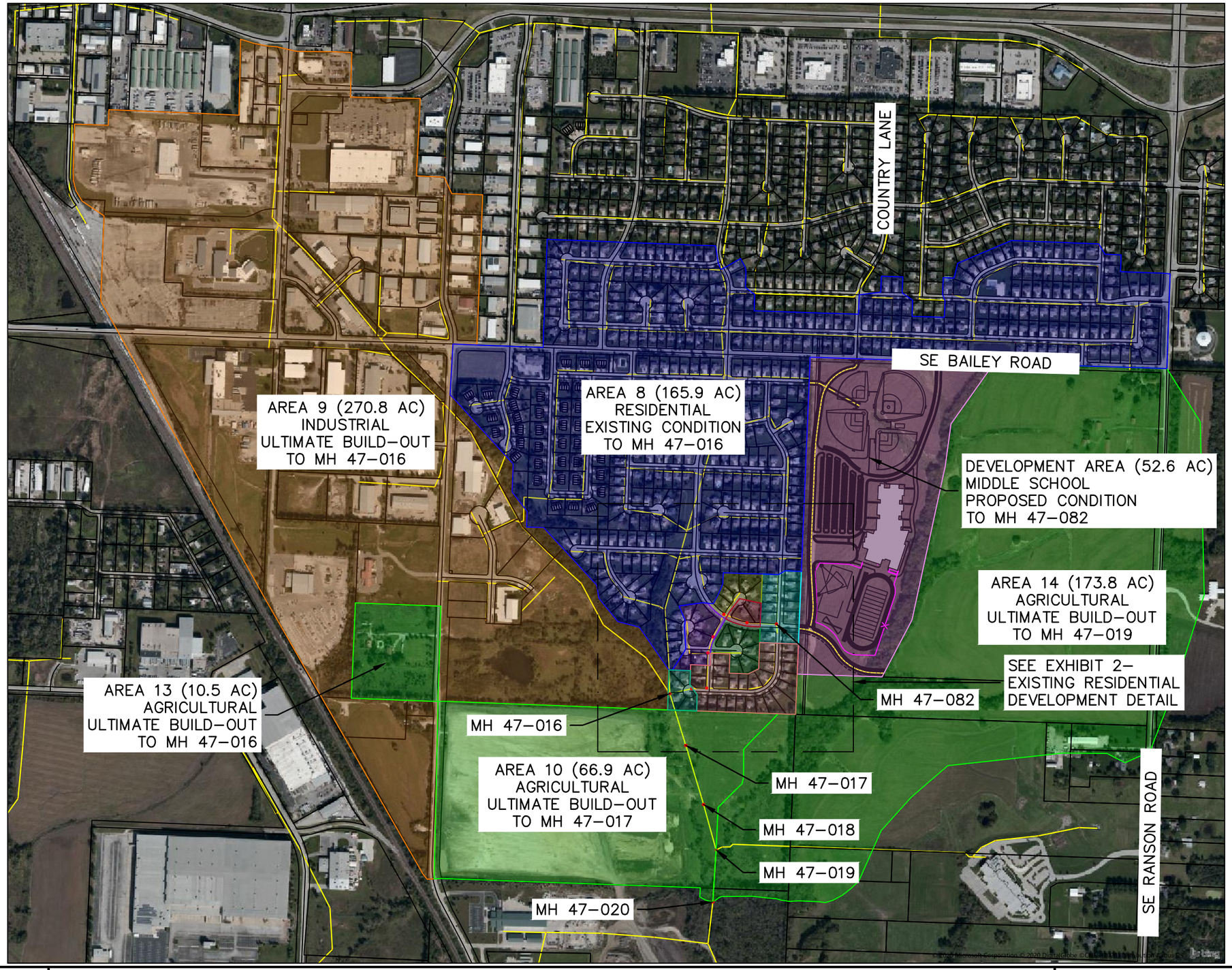

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APPENDIX B

Sanitary Sewer Analysis Calculations

Table 1 - Existing Conditions

US MH	DS MH	Pipe No.	Sub-basin	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US MH HGL Elev.
MH 47-019	MH 47-020	P-56543	Area 11 & 12	12.5	391.0	0.0181	7.10	4,585,790	960.54	959.28	966.50	0.38%	18.00	334.4	6.46	4,174,319	109.9%	962.55*
MH 47-018	MH 47-019	P-56542	-	0.0	378.5	0.0179	6.77	4,373,278	961.28	960.94	968.00	0.11%	12.00	313.3	1.18	759,856	575.5%	975.91*
MH 47-017	MH 47-018	P-56541	Area 10	6.7	378.5	0.0179	6.77	4,373,278	961.38	961.30	970.00	0.02%	12.00	400.0	0.50	326,176	1340.8%	992.85*
MH 47-016	MH 47-017	P-49694	Area 8 & 9	351.9	371.8	0.0176	6.55	4,230,487	962.80	961.40	980.85	0.35%	12.00	400.0	2.11	1,364,493	310.0%	1009.79*
MH 47-075	MH 47-016	P-51711	Area 7	1.3	19.8	0.0363	0.72	465,032	972.82	971.10	982.12	1.11%	8.00	155.5	1.27	822,734	56.5%	1011.59*
MH 47-076	MH 47-075	P-51712	Area 6	7.3	18.5	0.0360	0.67	430,840	975.43	973.02	983.71	1.99%	8.00	121.4	1.71	1,102,153	39.1%	1012.04*
MH 47-077	MH 47-076	P-51713	Area 4 & 5	5.0	11.2	0.0382	0.43	276,252	977.90	975.63	987.97	0.88%	8.00	256.7	1.14	735,661	37.6%	1012.47*
MH 47-078	MH 47-077	P-51714	-	0.0	6.2	0.0383	0.24	154,021	979.78	978.39	993.92	1.05%	8.00	131.8	1.24	803,391	19.2%	1012.56*
MH 47-079	MH 47-078	P-51715	Area 3	1.8	6.2	0.0383	0.24	154,021	984.57	979.98	994.50	2.45%	8.00	187.3	1.89	1,224,480	12.6%	1012.65*
MH 47-081	MH 47-079	P-51717	Area 2	0.9	4.4	0.0380	0.17	108,475	986.51	984.77	994.90	0.95%	8.00	182.7	1.18	763,341	14.2%	1012.69*
MH 47-082	MH 47-081	P-51718	Area 1	3.5	3.5	0.0368	0.13	83,086	988.03	986.71	998.38	0.60%	8.00	220.0	0.94	605,949	13.7%	1012.72*

=HGL above crown

Table 2 - Proposed Conditions

US MH	DS MH	Pipe No.	Sub-basin	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US MH HGL Elev.
MH 47-019	MH 47-020	P-56543	Area 11 & 12	12.5	443.6	0.0176	7.81	5,048,401	960.54	959.28	966.50	0.38%	18.00	334.4	6.46	4,174,319	120.9%	962.92*
MH 47-018	MH 47-019	P-56542	-	0.0	431.1	0.0174	7.48	4,835,888	961.28	960.94	968.00	0.11%	12.00	313.3	1.18	759,856	636.4%	979.21*
MH 47-017	MH 47-018	P-56541	Area 10	6.7	431.1	0.0174	7.48	4,835,888	961.38	961.30	970.00	0.02%	12.00	400.0	0.50	326,176	1482.6%	999.88*
MH 47-016	MH 47-017	P-49694	Area 8 & 9	351.9	424.4	0.0171	7.26	4,693,097	962.80	961.40	980.85	0.35%	12.00	400.0	2.11	1,364,493	343.9%	1020.55*
MH 47-075	MH 47-016	P-51711	Area 7	1.3	72.4	0.0198	1.44	927,643	972.82	971.10	982.12	1.11%	8.00	155.5	1.27	822,734	112.8%	1024.50*
MH 47-076	MH 47-075	P-51712	Area 6	7.3	71.1	0.0194	1.38	893,450	975.43	973.02	983.71	1.99%	8.00	121.4	1.71	1,102,153	81.1%	1026.39*
MH 47-077	MH 47-076	P-51713	Area 4 & 5	5.0	63.8	0.0179	1.14	738,863	977.90	975.63	987.97	0.88%	8.00	256.7	1.14	735,661	100.4%	1029.39*
MH 47-078	MH 47-077	P-51714	-	0.0	58.8	0.0162	0.95	616,632	979.78	978.39	993.92	1.05%	8.00	131.8	1.24	803,391	76.8%	1030.41*
MH 47-079	MH 47-078	P-51715	Area 3	1.8	58.8	0.0162	0.95	616,632	984.57	979.98	994.50	2.45%	8.00	187.3	1.89	1,224,480	50.4%	1031.78*
MH 47-081	MH 47-079	P-51717	Area 2	0.9	57.0	0.0155	0.88	571,085	986.51	984.77	994.90	0.95%	8.00	182.7	1.18	763,341	74.8%	1033.03*
MH 47-082	MH 47-081	P-51718	Area 1	3.5	56.1	0.0151	0.84	545,697	988.03	986.71	998.38	0.60%	8.00	220.0	0.94	605,949	90.1%	1034.31*
MH 47-082	MH 47-081	P-51718	Proposed Development	52.60	52.60	0.0136	0.72	462,611	988.03	986.71	998.38	0.60%	8.00	220.0	0.94	605,949	76.3%	1034.31*

=HGL above crown

Table 3 - Ultimate Build-Out Conditions

US MH	DS MH	Pipe No.	Sub-basin	Drainage Area (acre)	Cumulative Drainage Area (acre)	Design Flow Rate (cfs/acre)	Design Flow Rate (cfs)	Design Flow Rate (gpd)	US Invert	DS Invert	US MH Rim Elev.	Slope (%)	Pipe Diam. (in)	Pipe Length (ft)	Pipe Capacity (cfs)	Pipe Capacity (gpd)	Percent Pipe Capacity (%)	US MH HGL Elev.
MH 47-019	MH 47-020	P-56543	Area 14	173.8	760.4	0.0183	13.89	8,980,558	960.54	959.28	966.50	0.38%	18.00	334.4	6.46	4,174,319	215.1%	971.60*
MH 47-018	MH 47-019	P-56542	-	0.0	586.6	0.0173	10.14	6,550,787	961.28	960.94	968.00	0.11%	12.00	313.3	1.18	759,856	862.1%	1001.86*
MH 47-017	MH 47-018	P-56541	Area 10	66.9	586.6	0.0173	10.14	6,550,787	961.38	961.30	970.00	0.02%	12.00	400.0	0.50	326,176	2008.4%	1039.81*
MH 47-016	MH 47-017	P-49694	Area 8, 9, & 13	447.2	519.7	0.0163	8.48	5,481,986	962.80	961.40	980.85	0.35%	12.00	400.0	2.11	1,364,493	401.8%	1077.76*
MH 47-075	MH 47-016	P-51711	Area 7	1.3	72.4	0.0198	1.44	927,643	972.82	971.10	982.12	1.11%	8.00	155.5	1.27	822,734	112.8%	1082.86*
MH 47-076	MH 47-075	P-51712	Area 6	7.3	71.1	0.0194	1.38	893,450	975.43	973.02	983.71	1.99%	8.00	121.4	1.71	1,102,153	81.1%	1084.78*
MH 47-077	MH 47-076	P-51713	Area 4 & 5	5.0	63.8	0.0179	1.14	738,863	977.90	975.63	987.97	0.88%	8.00	256.7	1.14	735,661	100.4%	1087.67*
MH 47-078	MH 47-077	P-51714	-	0.0	58.8	0.0162	0.95	616,632	979.78	978.39	993.92	1.05%	8.00	131.8	1.24	803,391	76.8%	1088.79*
MH 47-079	MH 47-078	P-51715	Area 3	1.8	58.8	0.0162	0.95	616,632	984.57	979.98	994.50	2.45%	8.00	187.3	1.89	1,224,480	50.4%	1090.17*
MH 47-081	MH 47-079	P-51717	Area 2	0.9	57.0	0.0155	0.88	571,085	986.51	984.77	994.90	0.95%	8.00	182.7	1.18	763,341	74.8%	1091.42*
MH 47-082	MH 47-081	P-51718	Area 1	3.5	56.1	0.0151	0.84	545,697	988.03	986.71	998.38	0.60%	8.00	220.0	0.94	605,949	90.1%	1092.70*
MH 47-082	MH 47-081	P-51718	Proposed Development	52.60	52.60	0.0136	0.72	462,611	988.03	986.71	998.38	0.60%	8.00	220.0	0.94	605,949	76.3%	1090.29*

=HGL above crown

APPENDIX C

Sanitary Sewer Hydraulic Grade Line

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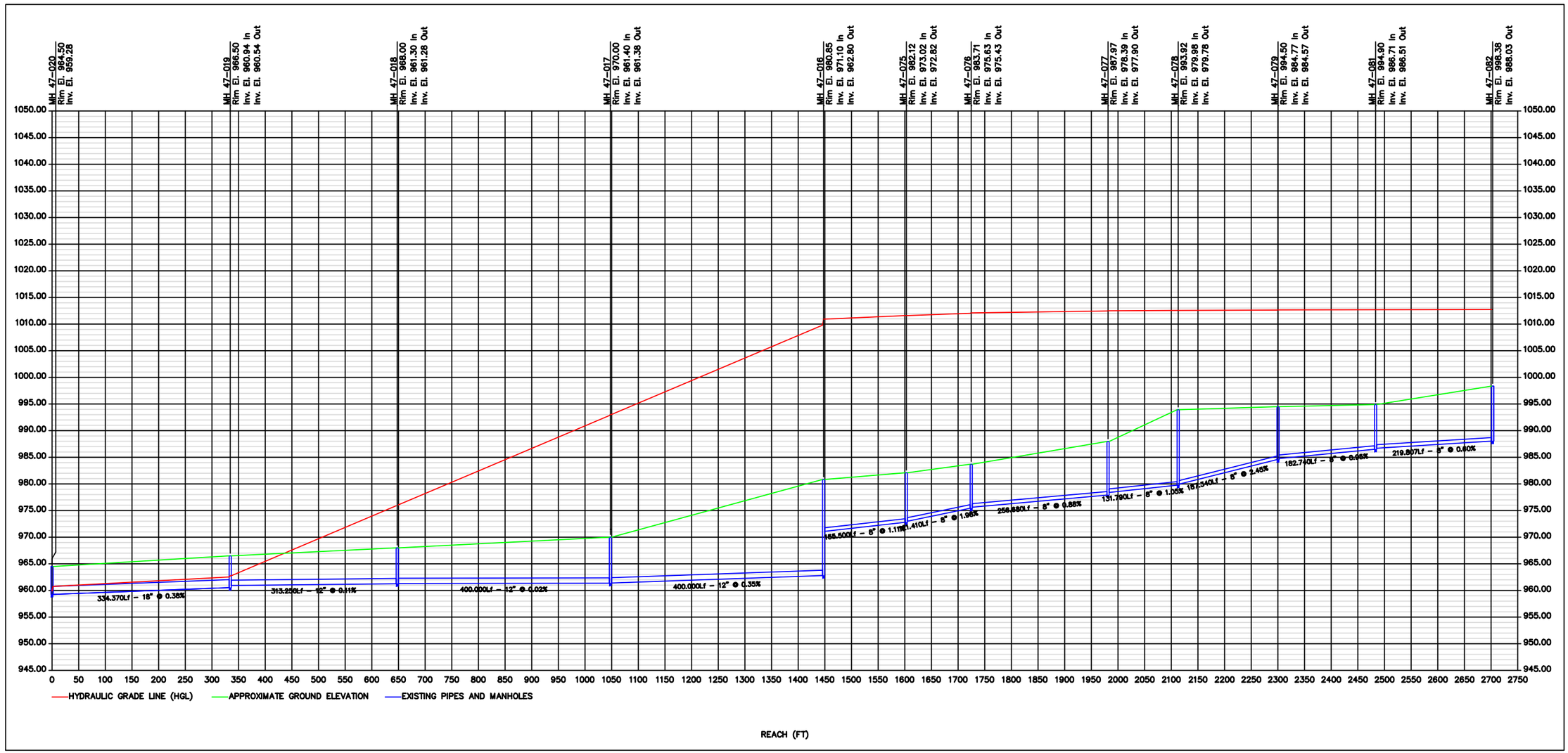

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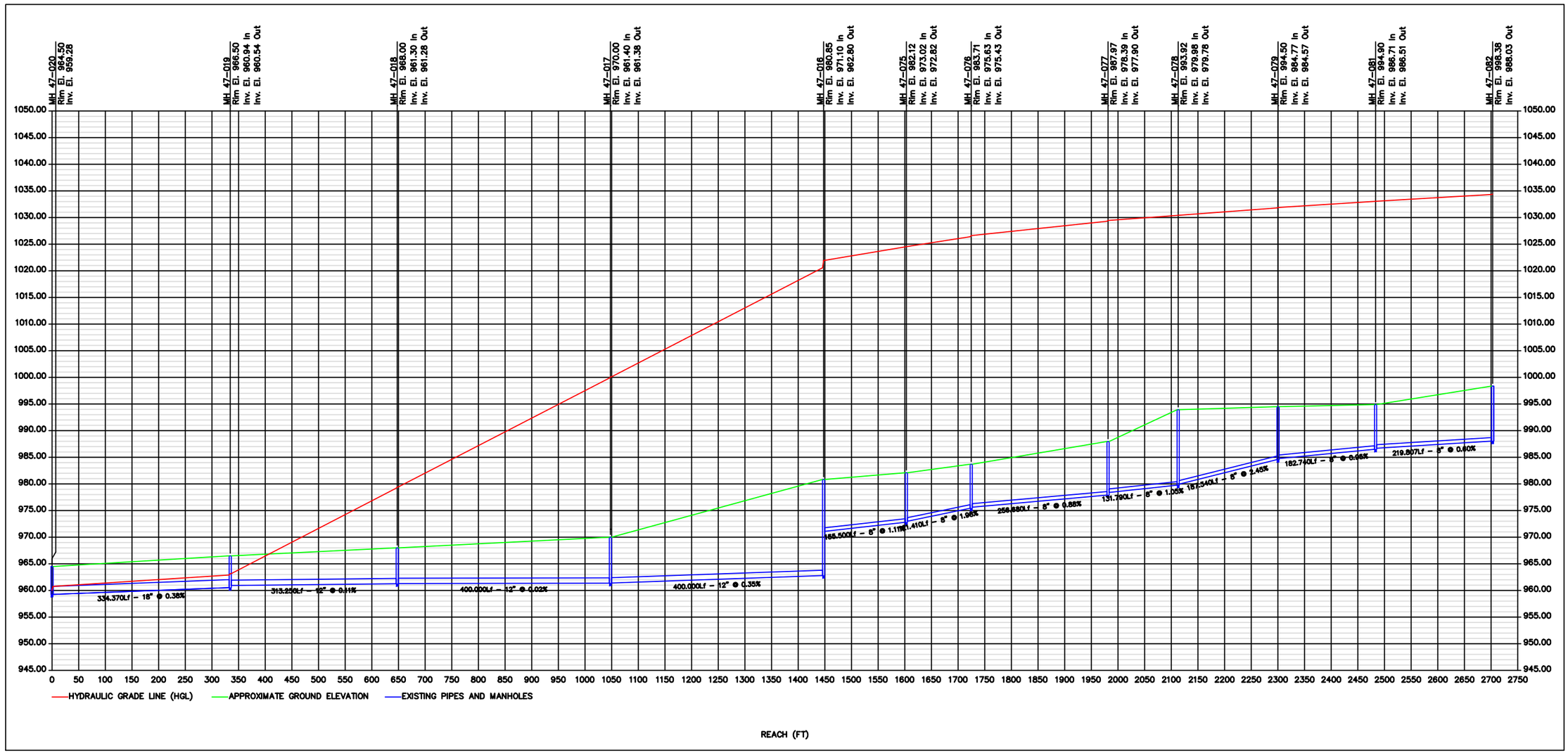

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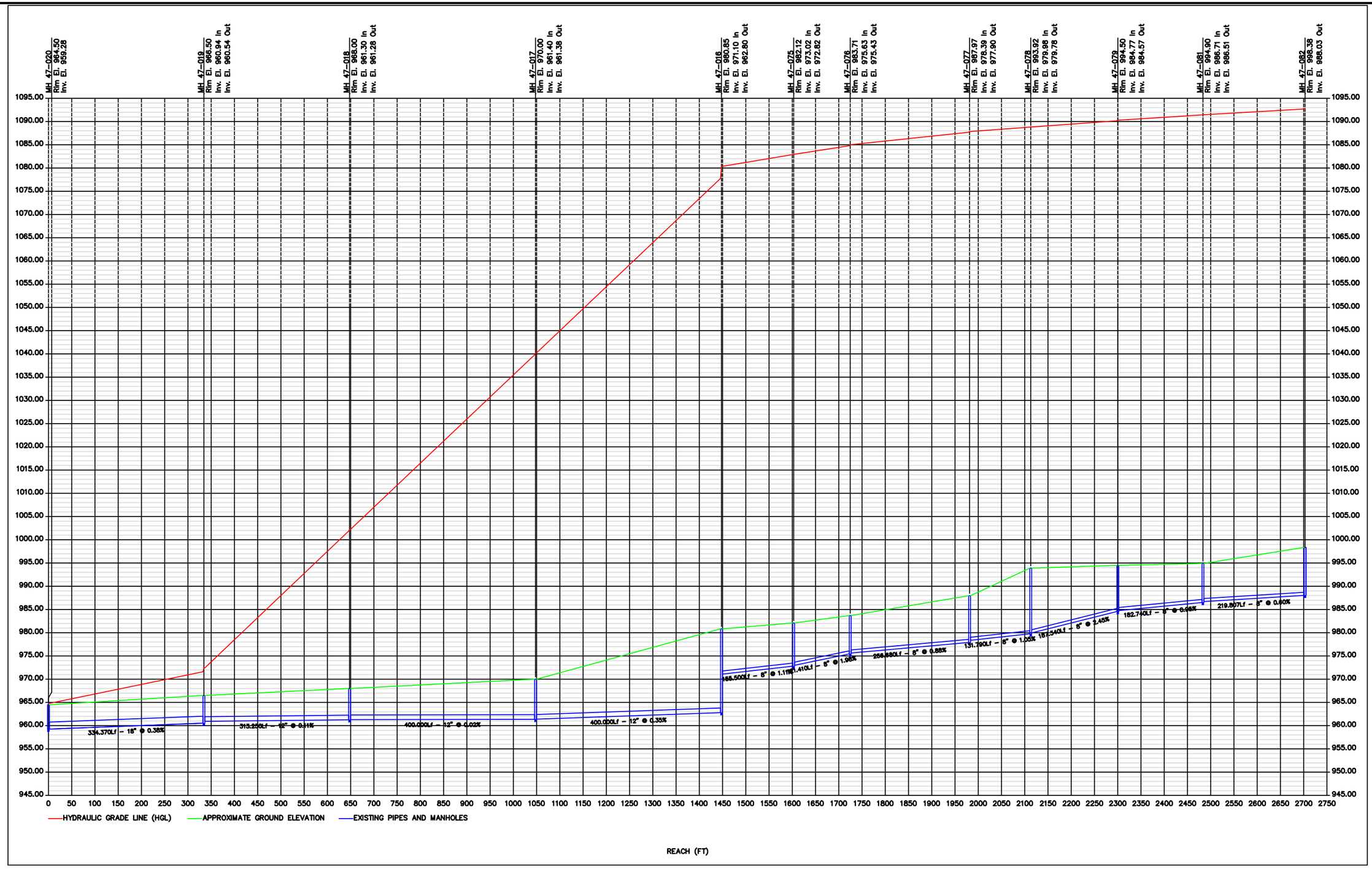

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Lee's Summit, Missouri - 2020

May 2020

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