

SANITARY SEWER CAPACITY STUDY

291 & 150 Multi-Family Residential Development

SITE ACREAGE: 48.2 ACRES

Lee's Summit, MO

PREPARED BY:



Revision

Date	Comment	By
8-25-20	Revised per City Comments	AEP
9-29-20	Revised per City Comments Dated 9-4-2020	AEP
10-13-20	Revised per City Comments Dated 10-12-2020	AEP

TABLE OF CONTENTS

- 1. REPORT COVER SHEET**
- 2. TABLE OF CONTENTS**
- 3. GENERAL INFORMATION**
 - 3.1 BACKGROUND**
- 4. METHODOLOGY**
- 5. EXISTING CONDITIONS ANALYSIS**
- 6. PROPOSED CONDITIONS ANALYSIS**
- 7. ULTIMATE BUILDOUT ANALYSIS**
- 8. CONCLUSIONS & RECOMMENDATIONS**
- 9. EXHIBITS**

3. GENERAL INFORMATION

This Sanitary Sewer Capacity Study has been prepared to evaluate potential hydraulic impacts to the existing downstream sanitary sewer system attributable to the proposed development and recommend improvements to mitigate any potential negative impacts downstream if anticipated. The 291 & 150 Residential Development (Development) is a proposed multi-family residential development consisting of a combination of duplex units and 4-plex units to be constructed in multiple phases. The proposed development is located in the southern portion of the City approximately 1,000 feet south of 150 Highway and adjacent to the east outer road of 291 Highway. The site is bounded by farmland to the north and east, Saddlebrook single-family residential development to the south and 291 Highway to the west. The proposed development encompasses 48.2 acres. The property is located in Section 8, Township 48N, Range 31 W, Lee's Summit, Jackson County, Missouri. A portion of the property drains to an unnamed tributary on the east side of the property and the remainder of the property drains to Tributary G1 to Lake Winnebago along the southwest side of the property. The downstream sanitary sewer system is located within the Saddlebrook Development. The interceptor splits into an east and west branch just south of the Development at MH 62-046. Both interceptors are 8-inch diameter PVC which run adjacent to the stated tributaries. The west branch currently serves 79.23 acres of developed property and will not be utilized for this project nor evaluated. The east branch currently serves 8.85 acres of developed property and will be utilized to sewer the entire Development. The Development will connect directly to MH 62-048 on the east branch.

See Exhibit A for a Sanitary Sewer Map of the watershed in addition to the proposed utility plan for the Development. A downstream interceptor map is also available in Exhibit B.

3.1 BACKGROUND

The following figures from the Wastewater Master Plan were evaluated to identify any known issues within the area.

Figure 7-3

Figure 8-1

Figure 8-2

Based on these Figures there are no known issues or future plans to improve the existing sanitary sewer system within the development area watershed. See Exhibit C for Wastewater Master Plan Figures 7-3, 8-1 and 8-2.

4. METHODOLOGY

The sanitary sewer capacity analysis was performed in accordance with the City's Design and Construction Manual. City contours were utilized to generate the watershed and sub-basin boundaries. The existing sewer capacity was calculated using Manning's Equation. All variables utilized in the equation were determined from City GIS, As-Built Data or the Design and Construction Manual. Design peak wet weather flows for the proposed development along with existing development areas were calculated via analytical equations outlined in Section 6500 of the City of Lee's Summit Design and Construction Manual. As-builts were utilized to calculate presumed MBFEs for downstream structures, see example below.

MBFE Calculation Procedure with (Example):

- 1) Identify Lot of Interest and Determine Plat (Lot 30, Saddlebrook East)
- 2) Determine Tributary Lateral and Service Stub Station along Lateral from As-Built (Lateral 5, Sta: 1+80.00)
- 3) Determine Stub Size and Length from As-Built (4" Dia., Length = 6')

- 4) Calculate Flowline of Lateral at Service Stub from As-Built (929.93 El. Interpolated b/t Inv. In and Inv. Out)
- 5) Calculate Flowline at EOS, Add Tee/Wye Offset 0.67', Presume 2% Min. Slope ($929.93 + 0.67 + (6 * 0.02) = 930.72$)
- 6) Calculate MBFE, Add 3' to EOS per APWA ($930.72 + 3 = 933.72$)

*All service stub information and calculations may be found in Exhibits D, E and F.

Peak flows were calculated based on tributary area and added to the overall flow in the main at downstream manhole locations along the interceptor. Excess flow is the difference between sewer capacity and design flow. If excess flow is positive there is additional gravity sewer capacity in the segment. If excess flow is negative the sewer segment does not have adequate gravity sewer capacity and the sewer line is considered surcharged. Surchage represents the water elevation (HGL) above the crown of the pipe that creates pressure flow in the system. Overflow capacity refers to the maximum capacity of the line segment when fully surcharged (HGL is at or above the Upstream Manhole Rim). Overflow capacity may very dependent on the HGL of the downstream manhole. Overflow capacity does not account for a theoretical unconfined water column. Zero potential is assumed above the manhole rim. If a value appears in the overflow capacity column in the capacity analysis then the upstream manhole is fully surcharged and overflowing.

5. EXISTING CONDITIONS ANALYSIS

The sanitary sewer analysis was terminated at manhole 64-004BS which is located just south of North Winnebago Drive and tributary to the Middle Big Creek Interceptor which runs under Lake Winnebago. There are 592.89 +/- acres tributary to manhole 64-004BS, see Exhibit A, Sanitary Sewer Map. A large percentage, 14.46%, of the tributary area is not developable and consists of 291 and 150 Highway right-of-ways. In addition a large percentage, $257.7 / 507.15 * 100 = 50.81\%$, of the developable ground is currently undeveloped. The attached sanitary sewer map delineates these areas along with the proposed 291 and 150 development. The existing interceptor forks just south of the proposed development into an east and west branch at MH 62-046. The west branch will not be analyzed in this study since the Development will not contribute any wastewater flow directly to it. The entire Development will be connected to the east branch interceptor at MH 62-048.

The limiting segment (MH 62-048 to MH 62-047) of the east branch has excess capacity of 0.70 cfs which will be utilized to serve the Development, see the Existing Sanitary Sewer Capacity Analysis for details in Exhibit D. The capacity analysis represents a steady state worst case snap shot of the system for the given scenario. There are a few downstream line segments that indicate minor surcharging may be occurring. In order to quantify the impact of interceptor surcharging a service stub analysis was also performed along the sanitary sewer interceptor for both Existing and Proposed Conditions. As-Built data utilized for individual lot services may be found in Exhibit E. The existing service stub analysis does not indicate any backflow issues along the downstream interceptor. Based on As-built records there are no individual service lines tied directly to the downstream interceptor. All contributing flows to the interceptor are conveyed via common laterals from the various developments and connected to the interceptor at manholes.

The existing service stub analysis located in Exhibit D details the following for each residence of interest; Development, Lot Number, Tributary (Interceptor) Manhole, Lateral Designation, Lateral Station, Stub Length, Flowline at Lateral, Flowline at EOS, MBFE, Surchage Depth, HGL and Freeboard. Both the surcharge depth and HGL indicated on the service stub analysis are taken from the respective sanitary sewer capacity analysis corresponding to the given tributary manhole on the interceptor. Each lateral is assumed to have adequate capacity, no issues have been reported to the Engineer. Therefore the HGL calculated at each manhole along the interceptor may be compared against calculated MBFEs to determine available freeboard. As shown in the service stub analysis the lowest freeboard calculated (worst case) is 5.49 feet at Lot 30, Saddlebrook East.

6. PROPOSED CONDITIONS ANALYSIS

The Proposed Conditions Analysis consists of existing conditions as stated above in addition to the proposed 48.22 acre 291 and 150 development. The Development has been designed (graded and sewered) to collect all proposed residences sanitary waste and convey them to MH 62-048. This area represents 41.25 acres of the Development with the remaining 6.97 acres in the southwest to be undisturbed. The remaining 6.97 acres will continue to have the potential to contribute I&I to the west branch and has been accounted.

There are four (4) segments on the downstream interceptor that are calculated to become fully surcharged in the proposed condition, see the Proposed Sanitary Sewer Capacity Analysis for details in Exhibit F. The majority of the remaining segments indicate significant surcharging may also occur.

Fully Surcharged: 62-031 to 62-033, 62-045 to 62-082, 62-047 to 62-046, 62-048 to 62-047

In order to quantify the impact of interceptor surcharging a service stub analysis was performed. The proposed service stub analysis which may also be found in Exhibit F does not indicate any backflow issues along the downstream interceptor due to interceptor overflow elevations in relation to presumed finish floor elevations. As shown in the proposed service stub analysis the lowest freeboard calculated (worst case) is 3.08 feet at Lot 75, Saddlebrook East 4th Plat.

The proposed analysis indicates potential overflow conditions in the interceptor however there have been no reported issues with the system to date regarding overflows or backflows. The system design flows account for a large percentage of infiltration and inflow in the system which may or may not be occurring. The watershed will be approximately 53.95% developed in the proposed condition. The existing condition has 225.37 acres tributary while the proposed condition has an additional 48.22 acres tributary for a total of 273.59 acres. The calculated system overflows are based solely on the addition of the proposed development. The new sanitary sewer system constructed with the proposed development should have essentially zero infiltration and inflow contributing in the near term due to modern day construction materials, techniques, inspection and testing.

For comparison purposes an alternate proposed capacity analysis was run utilizing a weighted K value that accounts for both commercial and residential development contributing to the interceptor. A K value of 0.003 was used for commercial development and a K value of 0.006 was used for residential development. The lowest weighted K value calculated was 0.0049.

Weighted K Calculation Example MH 62-046:

Commercial Area = 48.79 acres, K = 0.003

Residential Area = 89.85 acres, K = 0.006

Total Area = 138.64

Weighted K = $((48.79 * 0.003) + (89.85 * 0.006)) / 138.64 = 0.0049$

The alternate analysis indicates that no system overflows will be encountered nor backflows. The alternate analysis Proposed Conditions Weighted K may be found in Exhibit F. A Weighted K Service Stub Analysis was also performed based on the alternate analysis and may be found in Exhibit F. No backflows were indicated in the alternate service stub analysis. As shown in the alternate proposed service stub analysis the lowest freeboard calculated (worst case) is 4.87 feet at Lot 30, Saddlebrook East.

- The existing analysis indicates surcharging along the entire downstream interceptor with a maximum surcharge depth of 2.03 feet at MH 62-031 and a corresponding worst case downstream service stub freeboard of 5.49 feet at Lot 30, Saddlebrook East.

- The proposed analysis (standard) indicates system overflows in four segments. Due to projected system overflows based solely on new construction an alternate analysis was formulated and provided utilizing standard K values for residential (0.006) and commercial (0.003) developments.
- Design flows in the alternate proposed method account for the amount of commercial and residential area contained within the service area. The tributary area to each manhole has been weighted in accordance with the type and amount of area contributing. The weighted K values range from 0.0049 to 0.0055. The lower the K value the larger the percentage of commercial area contributing.
- The alternate proposed analysis (weighted K) indicates adequate system capacity with no overflows. A maximum surcharge depth of 3.19 feet is projected at MH 62-031 providing an in system freeboard of 0.37 feet. The corresponding worst case downstream service stub freeboard is 4.87 feet at Lot 30, Saddlebrook East.
- As shown on the sewer map and in the service stub analysis sheets there are multiple developments downstream that utilize the interceptor they include; Saddlebrook East, Saddlebrook East 4th Plat, Estates of Saddlebrook 2nd Plat, Belmont Farms 1st Plat, Belmont Farms 2nd Plat and Belmont Farms 4th Plat. The worst case (lowest freeboard) residence downstream based on information available occurs at Lot 30, Saddlebrook East. The City does not have record of any residence downstream being connected directly to the interceptor.
- Both the existing and proposed conditions analysis indicate surcharging throughout the downstream system. The calculated surcharge in all scenarios may be attributed directly to projected infiltration and inflow not base flows. City design flow criteria shows through analysis that the entire downstream interceptor should be upsized to eliminate surcharge. However in the near term the alternate proposed analysis indicates that the existing system has the capacity with surcharge to service the proposed development without developing system overflows nor residential backflows.

The alternate proposed condition analysis indicates that there is capacity available in the downstream sewer system. Understanding that the alternate method is not the officially adopted methodology of the City it does have merits. Due to circumstances beyond the developers control the alternate method would allow the proposed development to be constructed and occupied while the City finalizes their plans and completes construction of the necessary upgrades so the remaining 46% plus of the watershed may be developed in the future. An I&I study with flow monitoring would also provide invaluable information as to the degree of I&I currently entering the system.

7. ULTIMATE BUILDOUT ANALYSIS

The Ultimate Buildout Analysis consists of all ground in the tributary area contributing design flow minus larger thoroughfare right-of-ways for a total of 507.15 acres. As detailed in the Ultimate Buildout Sanitary Sewer Capacity Analysis the entire interceptor sewer will not meet the design flow capacity requirements outlined by the City. See the Ultimate Sanitary Sewer Capacity Analysis for details in Exhibit G. The entire interceptor would be in an overflow condition during the design event limiting the sewer capacity to the overflow capacity as outlined earlier in the methodology section. An analysis was performed to determine the interceptor size required to convey the ultimate buildout peak wet weather flows via gravity. The analysis showed that the most downstream pipe segment needs to be a 24" diameter and the most upstream segment needs to be a 15" diameter based on existing slopes. Results of the analysis may be found in Exhibit G along with a side by side comparison of existing verse proposed pipe diameters. Slopes were maintained in the analysis due to the various lateral connections along the line. Due to potential capacity limitations in the system all future developments in this watershed should be analyzed to ensure adequate capacity.

8. CONCLUSIONS & RECOMMENDATIONS

The sanitary sewer analysis shows there is excess capacity in the system prior to the development (Existing Condition) of the 291 and 150 multi-family housing project. The existing condition analysis indicates surcharging may occur in 13 of 14 segments during lower frequency wet weather events. Due to potential capacity limitations in the system we recommend that the proposed development be connected to MH 62-048 on the east branch. The Proposed Conditions Capacity Analysis indicates that four segments of sewer will be fully surcharged. Segments with defined overflow capacities are fully surcharged as shown in the capacity analysis. The proposed analysis shows that the system may fully surcharge and overflow however a minimum of 3.08 feet of freeboard will be available as a factor of safety from potential backflows. An alternate proposed capacity analysis with weighted K factors was performed to determine the effect on capacity of the downstream interceptor. The alternate analysis indicated that the downstream interceptor would not overflow and the subsequent Proposed Service Stub Analysis with Weighted K indicates a worst case freeboard of 4.87 feet at Lot 30, Saddlebrook East. The alternate proposed condition analysis indicates that there would be capacity available in the downstream sewer system with the construction of the Development. The new sanitary sewer mains constructed within the Development should have essentially zero infiltration and inflow contributing in the near term due to modern day construction materials, techniques, inspection and testing.

- The existing analysis indicates surcharging in 13 of 14 interceptor segments downstream except for the very first.
- The existing analysis maximum downstream surcharge is 2.03 feet at MH 62-031 with 1.53 feet of available system freeboard.
- The existing analysis minimum service stub freeboard is 5.49 feet at Lot 30, Saddlebrook East.
- The proposed analysis indicates system overflows may occur at 4 line segments downstream.
- System overflows are not allowed in any case and therefore are not quantified once they leave the system. Overflow capacity is calculated at fully surcharged manholes and can be useful in determining available in system capacity. Overflow capacities are shown at each element if applicable.
- There are no known issues associated with the downstream interceptor.
- Due to projected overflows associated solely to the proposed development and no known interceptor issues an alternate method was formulated to analyze the proposed condition.
- The alternate method attempts to drill down from the macro analysis and account for actual land usage. In watersheds less than 100 acres the City's standard method utilizes a K value which is dependent upon the land usage, 0.006 for residential and 0.003 for commercial. In watersheds over 100 acres a K value of 0.006 is used regardless of land usage. In the proposed alternate method land usages are accounted for and an appropriate weighted K value assigned at each manhole. The K value is directly related to I&I.
- The proposed alternate analysis does not indicate any system overflows. The maximum projected surcharge is 3.19 feet at MH 62-031 with 0.37 feet of available system freeboard.
- The proposed alternate analysis minimum service stub freeboard is 4.87 feet at Lot 30, Saddlebrook East which equates to a reduction of 0.62 feet of freeboard.
- The system has capacity to serve the Development however the ultimate capacity (No Overflows) of the interceptor based upon the City's current design criteria is diminishing rapidly as the watershed builds out.
- No system improvements are required to serve the proposed property based on the alternate (Weighted K) proposed analysis. The interceptor will need to be upgraded to serve the watershed at ultimate buildout. A table has been included in the Exhibits detailing the required interceptor segment sizes to serve ultimate buildout.
- The proposed development, 48.22 acres, accounts for 9.51% of the watershed.

The new sewer for the Development would introduce essentially zero I&I however the standard capacity analysis indicates the Development would be responsible for system overflows occurring in the downstream

interceptor. An alternate analysis was performed which used the standard weighting for commercial and residential development's and we found that the system under this scenario would have additional capacity and no system overflow. The following table details the net increase in surcharge/HGL along the downstream interceptor.

Manhole	Existing Surcharge (ft)	Proposed Alternate Surcharge (ft)	Surcharge Net Increase (ft)
62-036	0	0	0
62-035	1.09	1.47	0.38
62-034	1.68	2.30	0.62
62-033	1.60	2.46	0.86
62-031	2.03	3.19	1.16
62-030	1.99	3.15	1.16
62-156	1.69	2.85	1.16
62-044	1.11	2.27	1.16
62-087	0.90	2.06	1.16
62-082	1.11	2.83	1.72
62-045	0.88	2.60	1.72
62-046	0.61	2.85	2.24
62-047	0.36	2.60	2.24
62-048	0.14	2.38	2.24

The alternate method also accounts for a large percentage of I&I which as discussed the new Development should introduce nearly zero in the near term as the City begins planning, design and construction of necessary improvements for ultimate buildout. Ultimate buildout includes another 47%+/- of the watershed which is currently undeveloped. Proposed ultimate capacity interceptor sizes are included in the report for reference. The Alternate Proposed Capacity Analysis and Service Stub Analysis indicate that anticipated surcharging will not create system overflows nor create any backflows in the system therefore the Development should be released for construction.

Proposed Alternate Condition: No downstream interceptor segments require upgrade to service the Development.

Ultimate Buildout Condition: The entire downstream interceptor should be upsized to accommodate gravity flow.

Waiver Requests:

1) Section 6500 Sanitary Sewers, 6501 Design Criteria, Item D, 2. Hydraulic Grade, a. Average Velocity: "Sewers shall be designed to be free flowing with the hydraulic grade below the top of pipe ..." The existing interceptor is currently being surcharged under existing conditions based on design capacity criteria. The proposed Development will not create any negative downstream impacts as detailed in the Proposed Conditions Weighted K Capacity Analysis or Weighted K Service Stub Analysis. The maximum surcharge depth utilizing the alternate method (weighted K) is calculated at 3.19 feet at MH 62-031 and the net increase in surcharge is 2.24 feet for three segments which is well within the structural limits of PVC pipe. The minimum freeboard calculated to the MBFE using the alternate method was 4.87 feet at Lot 30, Saddlebrook East which provides necessary capacity with a more than adequate factor of safety allowing for additional development in the future.