KAW VALLEY ENGINEERING, INC.

SANITARY SEWER STUDY

To Serve

STREETS OF WEST PRYOR

NWQ PRYOR ROAD AND LOWENSTEIN DRIVE
LEE'S SUMMIT, MISSOURI

Revisions:

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KVE Project No. A14D7067-1

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INTRODUCTION

This sanitary sewer system analysis report was prepared to accompany the submittal of the Preliminary Development Plan for the proposed Streets of West Pryor development improvements located at NWQ Pryor Road and Lowenstein Drive in Lee's Summit, Missouri. The improvements included in this analysis are approximately 72.7 of mixed use commercial, multi-family, retail development and single-family residential, as well as retention/detention areas and green spaces. The development lies at the high point of the area, with the discharges directed to three downstream systems, as shown in Figure 1.

Figure 1: Project Location Map

The northeast area is directed to the existing Bogg's Hollow watershed via connections to manholes on Pryor Road, east of the site. The central portion of the site discharges southerly to the City's sanitary sewer system for Clear Creek which runs south along Highcliffe Drive. The western area of the project will discharge to the Clear Creek system that serves the neighborhood west of Black Twig Lane. The south and west systems each require main extensions to connect the site to the receiving system. The south system will be designed to connect in six existing residences that lie along Black Twig Lane that are currently on septic system.

DESIGN CRITERIA

- Lee's Summit Wastewater Master Plan (2006)
- City of Lee's Summit Design Criteria; Section 6500 – Sanitary Sewer

PROJECT LOCATION

As shown in Figure 1, the project is located in Lee's Summit, Missouri, south of I-470 highway, West of Pryor Road, and north of Chipman Road. The nearest major interchange is I-470 and US-50, to the west.

SERVICE AREA AND LAND USE

The project site is located at the upper limits of the Cedar Creek and Bogg's Hollow Watersheds. The project site is undeveloped and well covered with a low scrubby vegetation interspersed with dense stands of trees. See figure 3.2 of the Lee's Summit Wastewater Master Plan for a projected 2015 land use map of the project area.

The northeast area (Zone A) will be developed for commercial and hotel usage. Flow from this area is directed to the existing Bogg's Hollow watershed via connection to a manhole on Pryor Road, east of the site. Per the City's agreement with Kansas City, Missouri, the area of flow to this location is not to exceed the pre-development area. As shown on Exhibit A, the post-project service area is consistent in total area and location to the existing ridge line. Only a slight squaring off of the service areas has been made to match development parcels.

Although no main extension is required, the capacity of the existing East system to the City limits has been analyzed as requested by City development staff. This downstream area consists of the Summit Wood commercial development (designated Zone F), then crossing under I-470. A small area of residential property east of US-350 and north of I-470 crosses under US-350 to join the system (Zone G). The remaining area west of US-350 and north of I-470 is largely undeveloped, with some rural tracts and a large quarry. Future development plans are unclear. An allotment of 20 acres of additional residential development in this area has been included in this study, leaving the remaining 294 acres as non-contributing for the purposes of this study. See Location Exhibits in **APPENDIX A.**

The central area (Zone B) will be developed as commercial, restaurant, and multi-family dwellings. A main extension is required from the southern boundary of the development, to run through Lowenstein Park and along Black Twig Lane until it reaches existing manhole "A" on Chipman Road. In this area, a zone of six existing residences (Zone D) that lie along Black Twig Lane will be connected in. These homes are currently on septic system. This area will discharge southerly to the City's sanitary sewer system for Clear Creek which runs south along Highcliffe Drive. A portion of this existing system (called the "South System") has been analyzed for capacity. This existing downstream system runs through single-family residential areas. See location exhibits in **APPENDIX A**.

The western area of the project (Zone C) will be developed as single-family residential. This area will also include the regional stormwater detention basin for the site (which has been excluded from the service area calculations). A main extension would connect this system to the manhole at Summerfield and Autumn Lane, south of Lowenstein. A portion of this existing system (called the "West System") has been analyzed for capacity. This existing downstream system runs through single-family residential areas. See location exhibits in APPENDIX A. The tie in point is indicated as a new manhole just downstream of existing Manhole "2-7".

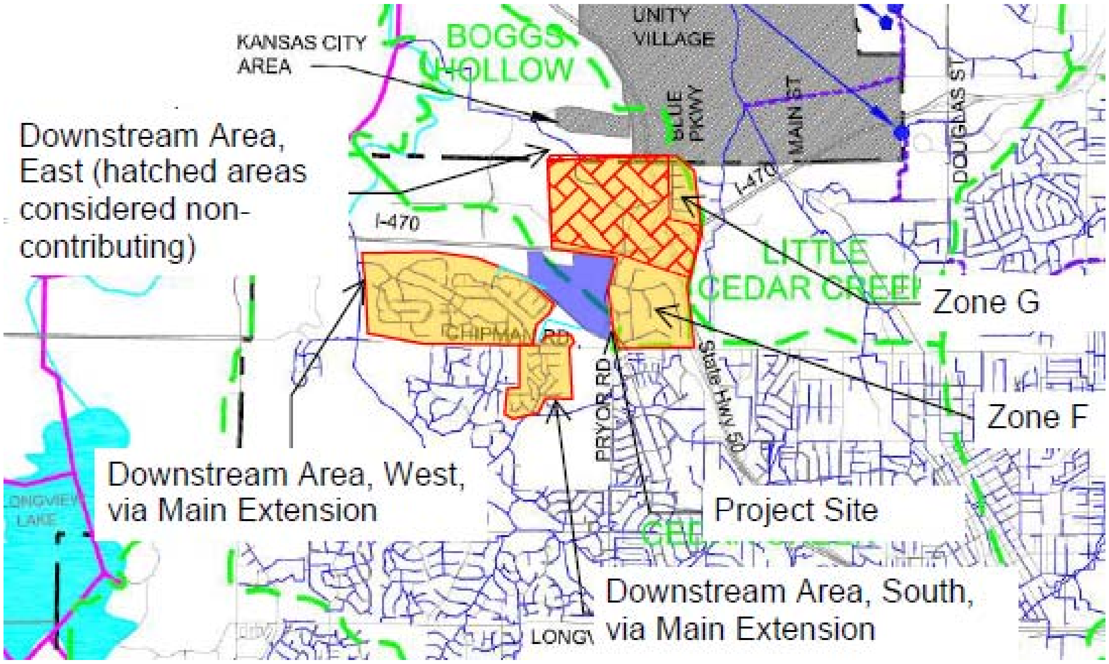

Figure 2: Downstream Areas Map

DESIGN FLOWS

Existing and proposed design flows were calculated using the design methodologies as presented in City of Lee's Summit Design Criteria; Section 6500 – Sanitary Sewer and include the following:

- Peak Base Flows
- Peak Infiltration
- Peak Inflow
- Time of Concentration

The base flow to single-family residential areas is calculated at 1,500 gallons per day (gpd) per acre. The peak baseflow to other land-uses is calculated using an "equivalent dwelling unit" method, where each EDU is presumed to generate 300 gpd of peak base flow. For apartment complexes, each individual apartment is assigned one EDU, as well as an additional EDU for the clubhouse.

The infiltration flow is calculated as 500 gpd for single-family residential areas and 250 gpd for multi-family and non-residential zones.

The peak inflows were calculated using the City's standard formula, with modifications as discussed below. The standard formula uses a rational-method type approach for a 50-year design storm. The land area is based on the service area (excluding non-served areas such as park or detention basins). The time of concentration is calculated for the cumulative service area at each calculated node in the system, using the formula in the City's design manual.

A significant component of the flow calculated by these methods is this inflow. These are estimates of an uncertain flow that can vary widely between watersheds. The City's standard values for peaking factor (K) for non-residential and multi-family construction is 0.003 whereas 0.006 is used for single-family residential. Modified estimates of the peaking factor "K" were used in this study, based on flow monitoring data and the experience of the City with wet weather performance of different ages of subdivisions and sewer material types. A more detailed discussion of individualized adjustments of the peaking factor is contained in the individual report sections that follow.

The calculation for each zone's contribution to their respective systems is presented in **APPENDIX B**. Table B1 presents the peak base flow component for both residential and non-residential uses for all zones. For the multi-family and non-residential components, the EDU is back-calculated as an equivalent flow rate (in gpd) per acre of service area.

Tables B2, B3 and B4 then combine the peak infiltration and inflow component for each system, including the downstream analyses area for each. Table B2 provides the calculations for the South System. Table B3 provides the calculations for the West System. Table B4 provides the calculation for the East System.

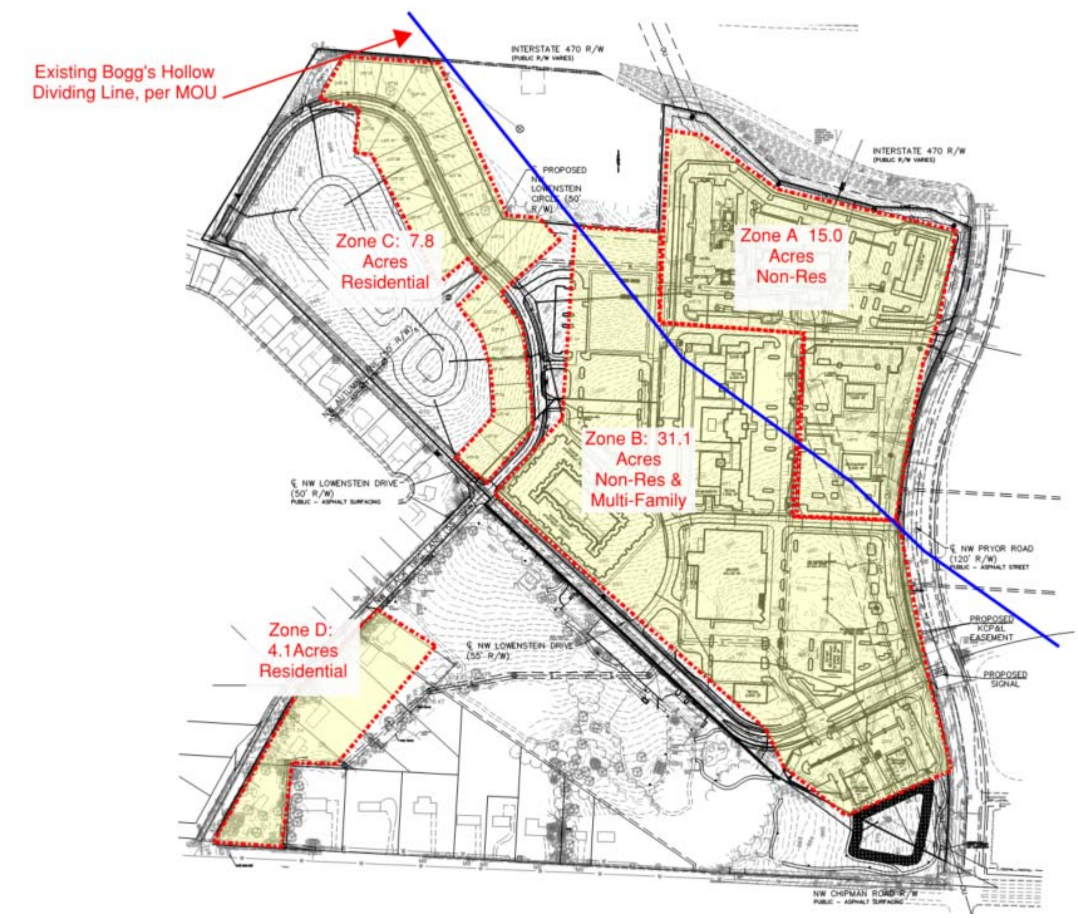

Figure 3: Zones and Service Areas

For the East System, a substantial portion of the area is undeveloped. The presence of the quarry and difficulty of the terrain leaves uncertainty as to the plausible maximum area of future development.

HYDRAULIC METHODS

The existing system was modeled in Hydraflow Storm Sewer to present a dynamic model for the analysis and to propose improvements to the existing system as required. See **APPENDIX C, D and E** for the program results for pipe capacities and flows as well as system profiles. The Manning's n friction factor used for pipes was 0.014, except for areas of existing ductile iron pipe in the West system, which were modeled with a friction factor of 0.015. Junction loss coefficients were used at manholes, based on the angle of turn. Flows were input into the model from the design flow calculation spreadsheets in **APPENDIX B.**

SOUTH SYSTEM (ZONES B & D)– ANALYSES AND PROPOSED IMPROVEMENTS

Table B2 shows that Zone B & D combined bring 35.2 acres of contributing watershed into the service area for the downstream system.

Due to easement restrictions, the most direct route of connection to the system on Chipman Road was not available. Therefore, the system is routed from the development westerly across the park to the east side of Black Twig Lane, then along an alignment in the backyards of the 5 homes on Black Twig Lane to be connected to the system, then along the back-lot line of two lots to Manhole "A" on Chipman Road. Due to the distance of sewer involved, this line is proposed as an 8" PVC with a slope of 0.60%, which is less than the City's minimum of 0.64%. This slope is required to keep the main connection at the project boundary low enough to accommodate the critical depth location of the crossing at relocated Lowenstein Road 350 feet west of Pryor Road. As currently designed, the flowline at this critical point is 4.2 feet below the pavement surface. The maximum depth to flow line for pipe is up to 22.9 feet in the rear yards of the homes along Black Twig.

This particular alignment will remove mature trees from these home's backyards and we indications are that the residents prefer to see the alignment in the front yard, which was initially considered. A front yard alignment increases the maximum depth over the pipe flow line by another 4 feet, to 27 feet. It is also somewhat longer, impacting the minimum available slope. At the request of the City, the backyard alignment is shown as the current alternative. The capacity calculations contained in this report, however, were based on the original alignment in front of the homes. This calculation was not altered since the currently proposed alignment is similar, but somewhat better, for purposes of capacity.

The existing Clear Creek system running south of the development was analyzed using the Brookridge Estates Sanitary Sewer Facilities as-built drawings prepared by Blue Valley Engineering and E.T. Archer and Company. Existing drainage areas were prepared using aerial photography and GIS system data where available. See the Exhibit in **APPENDIX A** for a section of the existing sewer system being analyzed as part of this report.

Initial model runs would have predicted capacity issues using the standard assumed values for peaking factor in this watershed. Those initial results, however, did not appear to adequately reflect the flow data and history of the existing system. The City had conducted more recent flow monitoring tests in this basin as part of the planning for improvements to the downstream interceptor.

Based on consultation with the City, a K factor of 0.002 was assigned to all of the existing neighborhood system. This area is relatively more recent construction with PVC pipe. Likewise, a K of 0.002 was the peaking factor for all new commercial construction that is part of this development. Under these modeling assumptions, the downstream system was shown to be adequate, with no surcharging. We reviewed these results with City staff and received their concurrence that these results are reasonable given available flow data. A summary of the calculation and hydraulic grade profile under this scenario is given in **APPENDIX C.**

On the basis of these findings, no downstream improvements to the South system are deemed necessary.

WEST SYSTEM (ZONE C) – ANALYSES AND PROPOSED IMPROVEMENTS

Table B3 shows that Zone C brings 7.8 acres of contributing watershed into the service area for the downstream system. This corresponds to 29 single-family residential lots.

The connection from this development to the downstream system is made through a main extension that connects to the line just downstream of Manhole 2-7 at Autumn Lane. This tie-in location is required since it is the only accessible location via public right-of-way. The flowline at this manhole is 947.73, which sets the lowest available options for gravity service. The proposed main extension of 8" PVC runs between the two water features to the residential street. Due to elevation constraints, homes on the south side of the residential street may need individual pumps to reach the line from any basement spaces. This alignment is shown in **APPENDIX A**.

The existing Clear Creek system running west of the development was analyzed using the as-built drawings from various projects. This system was built as part of numerous separate projects associated with downstream development. The outfall connection was given as part of the Bogg's Hollow Sanitary Sewer Facilities as-built drawings prepared by Burns and McDonnell Engineering Co. and dated August 1972. Existing drainage areas were prepared using aerial photography and GIS system data where available.

This revision of the study corrected several items in the model, including the addition of manhole J-6, several downstream pipe sizes, and several flow lines. As with the South system, use of the standard peaking "K" factors was deemed overly conservative for this system. Initial modeling runs using standard values would a have indicated surcharge conditions under the existing case (prior to this project) that have not been reflected in experience. Unfortunately, recent flow history data was not currently available. Therefore, a final conclusion about modified "K" factors cannot yet be made. We understand that the City will be initiating flow monitoring in the near future and consultations will continue.

The situation in this basin is further complicated by the number of years and differences in pipe material used. Much of the downstream system was constructed of PVC pipe. However, the lowest reach contains a subdivision with vitrified clay pipe (VCP) which would be expected to have higher infiltration. There is also a region of ductile iron pipe.

The total contributing watershed to the outfall of the West system is estimated at 212.5 acres.

As a preliminary analysis, we have examined a scenario in which a K of 0.006 was assigned about 36.3 acres of the lowest part of the watershed, which had the oldest construction and VCP pipe. This represents about 17% of the modeled watershed. The remainder of the existing development area (approximately 168.4 acres, or 79% of the watershed) was assigned K=0.003. The newly proposed lots to be built with this project (7.8 acres, or less than 4% of the total watershed) was assigned K=0.002. This lower factor is justified by improved construction techniques and inspection on new construction.

Flow rate estimate for this scenario are given in **APPENDIX B** and the sanitary system hydraulic calculations are given in **APPENDIX D**. A plot of the hydraulic grade line in the system is also shown.

Under this scenario, the upper reach of the downstream system (from our connection near manhole 2-7 to manhole 1-1) appears to operate acceptably. There is only minor surcharging of in manhole 1-3, as indicated by in the data report under column "Hw" which is the headwater depth measured from hydraulic grade line down to the invert. For this scenario, Hw = 0.98 ft, which is 0.31 ft above the crown of the 8" pipe.

In the lower reach (manhole 1-1 to the outlet), there is a choke point that causes more significant surcharging, which is evident in the profile view of the system shown in **APPENDIX D**. The surcharged at manhole G-1 is 4.12 feet, which is 1.96 ft below the rim. The effect of that surcharge carries upstream to the next two manholes, with J-1 having an Hw of 2.41 ft. and J-2 of 2.45 ft. None of these surcharges exceeded the manhole rim.

This particular section of the lower reach lies in a lower valley compared to the homes around it. A survey of basement elevations would be needed to confirm if these surcharge levels would lead to interior basement back-ups.

If elimination of the surcharge were needed, it could be accomplished by upsizing one segment of pipe from 8-inch to 10-inch. The segment would be 200 feet from manhole A-2 to manhole G-1 (model segment 5). This particular area has rugged terrain, with dense vegetation and creek crossings. The existing pipe segment in this reach is a combination of PVC and ductile iron and contains several creek crossings.

This lower reach of the existing system is sensitive to different assumptions regarding flow rates. Several sensitivity checks were run with different assumptions:

> For each sensitivity scenario, the assigned values of K=0.006 in the lowest reach and K=0.002 for this developments area were retained. But the K factor for the majority of

the existing residential area served by PVC pipe was adjusted from K=0.003 to values of K=0.0025, 0.0035 and 0.004.

For the scenario with K=0.0025, the surcharging at G-1 is reduced to Hw=2.19, or 3.9 feet below the rim, and the surcharge condition does not extend upstream to J-1 or J-2. For this scenario, it is likely that no improvement would be needed.

On the other hand, if infiltration rates were higher than the base scenario, the extent of improvements would need to increase. For a scenario with K=0.0035, the surcharging extends further upstream and exceeds the rim of manholes from G-1 to J-4. Surcharging is only eliminated if the upsizing project is extended to upsize 8-inch lines to 10-inch from manhole A-2 to manhole J-2, a length of 923 feet (modeling segments 5, 6 and 7).

For a scenario with K=0.004, the surcharging extends even further, with the hydraulic grade line above the manholes rims from G-1 to J-6. The upsizing of pipes from 8-inch to 10-inch would need to extend from G-1 to J-3, a length of 1,230 feet (modeling segments 5, 6, 7 and 8). It is unknown if actual surcharge events similar to these estimated conditions have occurred.

A summary of the hydraulic calculation of these alternate flow scenarios applied to the existing pipe sizes is shown in **APPENDIX D, part D2.**

If an improvement project was pursued in this area, construction constraints would need to be considered. Due to the terrain and drainage channel crossings, some or most of the upsizing may need to be of encased PVC or ductile iron. The alignment for the replaced pipe would need to be cleared. Since much of the existing pipe is ductile iron, pipe bursting would not be an option. As an alternative to a direct replacement of the line, an option of installing a parallel bypass via directional drilling may be more feasible.

As summarized previously, the new addition of residential areas to this watershed comprises less than 4% of the total contributing watershed at the outlet. In terms of flow rates, the estimated flow rate at manhole G-1 in the K=0.003 scenario is 2.15 cfs. The contribution from the proposed lots of Streets of West Pryor is 0.10 cfs, less than 5% of the total flow.

This area was not identified in the improvements list under the 2006 Master Plan. However, the segment is shown as a known Collection System Bottleneck for ultimate development, as shown in Figure 8-3 of that study.

The conditions of this west system require further analyses and data before a conclusion could be reached on downstream improvements. The west system appears to have several specific and isolated choke points that, if eliminated, could allow the system to operate more uniform and with increased conveyance. Given the small size of this development's contribution to the overall system, it is recommended that the focus for any improvements be in eliminating the most significant chokepoints, while recognizing that the Level of Service of the broader system is largely an existing condition.

Depending upon the results of flow monitoring, it appears that a project of upsizing 8-inch to 10-inch pipes beginning at Manhole A-2 and extending between 200 and 1,230 feet upstream could be needed. Equivalent alternatives that reduce the construction costs associated with working in this adverse terrain should be explored. It would also be recommended that the City and the developer determine an appropriate cost-sharing arrangement for any such project, given the small contribution of the proposed development to the overall condition.

EAST SYSTEM (ZONE A) – ANALYSES AND PROPOSED IMPROVEMENTS

Table B4 shows that the Zone A contributes 0.29 cfs of peak flow to the downstream system (East) at the connection manhole on Pryor Avenue (T-30). The service area at 15 acres directed from Zone A is equivalent to the pre-development watershed for this Bogg's Hollow system.

At the request of the City, the downstream system was analyzed to the City Limit line. This resulted in the analyses of approximately 4,580 feet of main, ranging in size between 10", 12" and 15". Profiles of this reach were derived from the City's as-built plans and checked again the GIS inventory. As built plans included plans for the Boggs Hollow Interceptor from 1972 by Burns and McDonnell Engineering as well as the plans for Summit Woods Crossing by Olsson Associates in 2000.

The contributing drainage areas to the system include our development (Zone A), as well as the Summit Woods development (Zone F) and an existing residential area (Zone G). The Summit Woods is commercial development. Due to its size (over 80 acres) and the unknown contribution of uses, it was modeled as the equivalent of single-family residential. These three zones, along with a hypothetical 20 acres of additional residential development (Zone H) would comprise about 138.2 acres, or 32% of the total watershed area of approximately 432 acres upstream of the City limit and within this subarea but bring the system to capacity for sections downstream of manhole N6. Of the remaining 294 acres, approximately 140 acres of that is occupied by MoDOT right of way for the freeway and interchange and could be excluded permanently from development potential. The other 154 acres is quarry or other zones that could be developed if sewer capacities permitted.

The segment of pipe built by Summit Woods (R30 to P1) is actually 12" diameter, larger than the 10" diameter it ties into. There were no capacity issues within the 12" upstream system itself. This would indicate that the downstream issues were anticipated at the time of prior development of Summit Woods and that it was designed to at least allow the upstream segment to be carried.

Due to the large uncertainties about the nature of the downstream area for future development, as well as a lack of flow monitoring data on the existing system, we did not attempt to run any specific scenarios of reduced infiltration and inflow. Instead, the standard city K factor of 0.003 was used to analyze the proposed development and a K factor of 0.006 was assigned to all existing residential and commercial areas, as well as to a to a hypothetical 20 acres of additional residential somewhere downstream.

Under this set of assumptions, the existing system does appear to have the capacity to carry its current load as well as the project's contribution. It could also accommodate a small amount of additional development somewhere in the lower sections of the watershed. At development levels beyond this point, further downstream improvements may be warranted. We do not find that any upgrades to the downstream system are needed to accommodate this development.

DOWNSTREAM IMPROVEMENTS

From the hydraulic analyses, the existing downstream system to the south is adequate to accept sanitary sewer flows from the proposed area of this development. A main extension is required to reach the existing system at Chipman Road.

For the west system, a main extension is required to reach a connection point near existing manhole 2-7 at Summerfield and Autumn Lane. The existing system downstream of this point is adequate for flows until approximately manhole 1-1, after which there is a zone of capacity constraints. A project to improve capacity in the downstream lower reach may be advisable, although the detailed scope is sensitive to the estimate of inflow. Additional flow monitoring and consultation with the City is required to determine the scope and cost-sharing of any recommended improvement. The contribution of the proposed development is small, and the capacity constraints noted are an existing condition.

The discharge area to the East has been matched to the pre-existing watershed. The system to the East is not yet over-capacity but would be so if much future development beyond this project occurs downstream. No improvements are required to accommodate this development.

CONCLUSION

The proposed development will be served by three separate existing systems. No improvements appear to be required for the South or East system. Some improvements to the West system may be needed, which we recommend be focused on the specific choke points between manholes A-2 and J-3, particularly the 200 feet segment between A-2 and G-1. Further flow data and analyses is required to finalize the limits of such a project, but if a project is necessary, it would likely involve between 200 and 1,230 feet of upsizing existing 8-inch pipes to 10-inch.

APPENDIX A – LOCATION EXHIBITS AND MAPS

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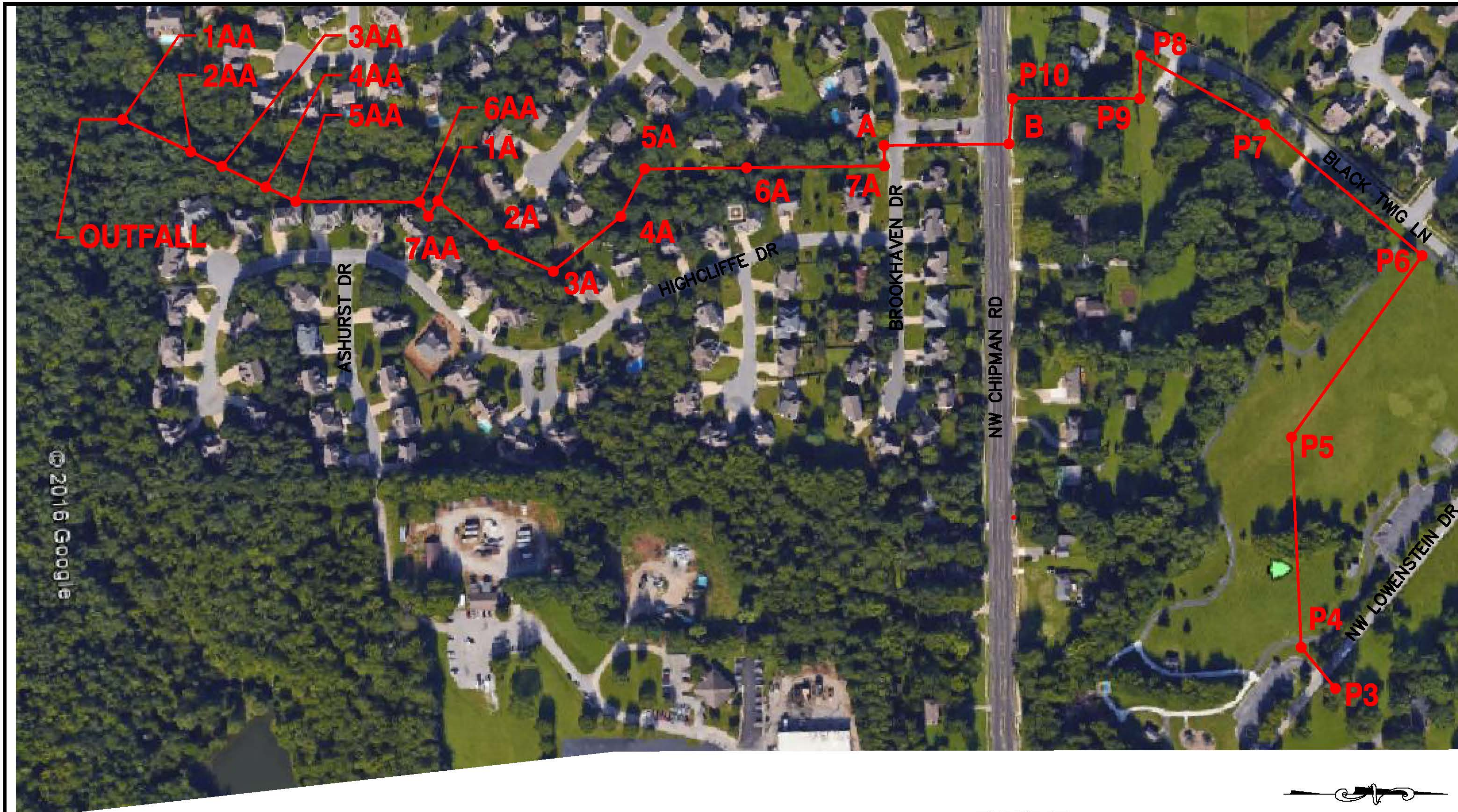
EXHIBIT

DOWNSTREAM SYSTEM, EAST SYSTEM

JUNE 19, 2018
7067-1EXBF_SAN



0 100 200 400

SCALE: 1" = 200'

EXHIBIT

MAIN EXTENSION AND DOWNSTREAM SYSTEM, SOUTH SYSTEM

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EXHIBIT

MAIN EXTENSION AND DOWNSTREAM SYSTEM, WEST SYSTEM

SEPTEMBER 18, 2018
7067-1EXBN_SAN

APPENDIX B – FLOW CALCULATIONS

Table B1
Peak Base Flow Calculation for Non-Residential and Multi-Family EDU

Lot ID	Use Type	EDU per Unit	Unit of Measure	# of Units	# of EDU	Total EDU per Sewer Zone	Total Peak Base Flow (at 300 gpd per EDU) per Zone	Sewered Acres in Zone	Peak Base Flow Per Acre Sewered in Zone
Zone A - to Bog's Hollow System (East)									
8	Restaurant	3.5	1000 sf	7500	26.3				
9	Restaurant	3.5	1000 sf	7500	26.3				
10	Restaurant (2 Tenants)	3.5	1000 sf	12300	43.1				
11	Hotel (80 Room)	0.3	room	80	24.0				
12	Hotel (105 rooms)	0.3	room	105	31.5				
						151.1	45,315	15.0	3,017
		will use the higher factor from original study for calculation=						***15.0***	***3244***
Zone B - Direct Contribution to System South									
na	Detention/Water Feature	0	n/a	0	-				
1	Restaurant (Sit Down)	3.5	1000 sf	6500	22.8				
2	Restaurant (Sit Down)	3.5	1000 sf	6500	22.8				
5	Grocery	0.2	1000 sf	63119	12.6				
4	Retail	0.2	1000 sf	6500	1.3				
3	Restaurant w/Drive Thru	1.6	1000 sf	5500	8.8				
7	Apartments w/Club House	1	Apt	251	251.0				
part of 7	Retail	0.2	1000 sf	10000	2.0				
part of 7	Restaurant	3.5	1000 sf	5000	17.5				
13	Ball Court	0	n/a	0	-				
6	Senior Living w/Clubhouse	1	Apt	166	166.0				
						504.7	151,417	31.1	4,862
Zone C - to System West									
Lots 14-42	Single Family Residential (29 lots)							7.8	1500
Zone D - Addition for Homes on Black Twig to City Sewers, to System South									
Existing Lots	Single Family Residential							4.1	1500

Table B2

Total Sewer Flow Calculation for Streets of West Pryor Systems

South System

Line	Peak base flow (gpd/ac)	Res./Com. Peak infil. (gpd/ac)	Drainage Area (acres)	Cuml Drainage Area (acres)	Peak Base + Infiltration (gpd)	Peak Base + Infiltration (cfs)	(a) Cuml Peak Base +Infill (cfs)	K (Incr)	K*A Incr	Cuml K*A	Tc (min)	Rainfall Intensity (i) (50 yr)	(b) Cuml Peak inflow, Q = kAi (cfs)	(a+b) Cuml Total Peak Flow = Base + Infil + Inflow (cfs)
South System (Zones B and D) (using K=0.002 for both new and existing areas)														
P3 - P6 (Zone B)	4675	250	31.1	31.1	153,168	0.237	0.237	**0.002**	0.062	0.062	44	4.18	0.26	0.50
P6 - 10 (Zone D)	1500	500	4.1	35.2	8,200	0.013	0.250	**0.002**	0.008	0.070	46	4.12	0.29	0.54
B-A	1500	500	7.05	42.3	14,100	0.022	0.271	**0.002**	0.014	0.085	48	4.01	0.34	0.61
A-7A	1500	500	2.95	45.2	5,900	0.009	0.281	**0.002**	0.006	0.090	49	3.95	0.36	0.64
7A-6A	1500	500	5.57	50.8	11,140	0.017	0.298	**0.002**	0.011	0.102	50	3.83	0.39	0.69
6A-5A	1500	500	5.53	56.3	11,060	0.017	0.315	**0.002**	0.011	0.113	51	3.78	0.43	0.74
5A-4A	1500	500	5.09	61.4	10,180	0.016	0.331	**0.002**	0.010	0.123	52	3.72	0.46	0.79
4A-3A	1500	500	0.33	61.7	660	0.001	0.332	**0.002**	0.001	0.123	53	3.72	0.46	0.79
3A-2A	1500	500	0.32	62.0	640	0.001	0.333	**0.002**	0.001	0.124	53	3.72	0.46	0.79
2A-1A	1500	500	0.42	62.5	840	0.001	0.334	**0.002**	0.001	0.125	53	3.72	0.46	0.80
1A-7AA	1500	500	2.81	65.3	5,620	0.009	0.343	**0.002**	0.006	0.131	53	3.66	0.48	0.82
7AA-6AA	1500	500		65.3			0.343	**0.002**	-	0.131	53	3.66	0.48	0.82
6AA-5AA	1500	500	9.78	75.1	19,560	0.030	0.373	**0.002**	0.020	0.150	55	3.55	0.53	0.91
5AA-ADD	1500	500		75.1			0.373	**0.002**	-	0.150	55	3.55	0.53	0.91
ADD-4AA	1500	500	9.55	84.6	19,100	0.030	0.403	**0.002**	0.019	0.169	57	3.49	0.59	0.99
4AA-3AA	1500	500		84.6			0.403	**0.002**	-	0.169	57	3.49	0.59	0.99
3AA-2AA	1500	500	7.36	92.0	14,720	0.023	0.425	**0.002**	0.015	0.184	58	3.37	0.62	1.05
2AA-1AA	1500	500		92.0			0.425		-	0.184	58	3.37	0.62	1.05

Table B3
Total Sewer Flow Calculation for Streets of West Pryor Systems

West System, for K=0.003 in most areas

Line	Peak base flow (gpd/ac)	Res./Com. Peak infil. (gpd/ac)	Drainage Area (acres)	Cuml Drainage Area (acres)	Peak Base + Infiltration (gpd)	Peak Base + Infiltration (cfs)	(a) Cuml Peak Base +Infill (cfs)	K (Incr)	K*A Incr	Cuml K*A	Tc (min)	Rainfall Intensity (i) (50 yr)	(b) Cuml Peak inflow, Q = kAi (cfs)	(a+b) Cuml Total Peak Flow = Base + Infil + Inflow (cfs)
West System (Zones C) (Base Scenario using K=0.002 for new project, K=0.0030 for existing residential areas served with PVC, and K=0.006 the lowest reach)														
B2(Zone C) to B-1	1500	500	7.80	7.8	15,600	0.024	0.024	0.002	0.016	0.016	31	4.92	0.08	0.10
B-1 to 2-6	1500	500	8.00	15.8	16,000	0.025	0.049	**0.003**	0.024	0.040	37	4.58	0.18	0.23
2-6 to 2-3	1500	500	10.00	25.8	20,000	0.031	0.080	**0.003**	0.030	0.070	42	4.29	0.30	0.38
2-3 to 2-1	1500	500	8.00	33.8	16,000	0.025	0.105	**0.003**	0.024	0.094	45	4.12	0.39	0.49
2-1 to 1-11	1500	500	5.00	38.8	10,000	0.015	0.120	**0.003**	0.015	0.109	47	4.06	0.44	0.56
1-11 TO 1-10	1500	500	7.48	46.3	14,960	0.023	0.143	**0.003**	0.022	0.131	49	3.95	0.52	0.66
1-10 TO 1-9	1500	500	4.85	51.1	9,700	0.015	0.158	**0.003**	0.015	0.146	50	3.83	0.56	0.72
1-9 TO 1-8	1500	500	1.02	52.2	2,040	0.003	0.161	**0.003**	0.003	0.149	50	3.83	0.57	0.73
1-8 TO 1-7	1500	500	1.84	54.0	3,680	0.006	0.167	**0.003**	0.006	0.154	51	3.83	0.59	0.76
1-7 TO 1-6	1500	500	1.34	55.3	2,680	0.004	0.171	**0.003**	0.004	0.158	51	3.78	0.60	0.77
1-4 TO 1-3	1500	500	2.34	57.7	4,680	0.007	0.178	**0.003**	0.007	0.165	52	3.78	0.62	0.80
1-3 TO 1-2	1500	500	5.27	62.9	10,540	0.016	0.195	**0.003**	0.016	0.181	53	3.72	0.67	0.87
1-2 TO 1-1	1500	500	21.08	84.0	42,160	0.065	0.260	**0.003**	0.063	0.244	57	3.49	0.85	1.11
J-5 TO J-4	1500	500	54.26	138.3	108,520	0.168	0.428	**0.003**	0.163	0.407	64	3.17	1.29	1.72
G-1 TO A-2	1500	500	37.92	176.2	75,840	0.117	0.545	**0.003**	0.114	0.521	68	3.09	1.61	2.15
A-2 TO A-1 (*)	1500	500	36.31	212.5	72,620	0.112	0.658	0.006	0.218	0.739	72	3.03	2.23	2.89
(*) Dominate type in this area is VCP, though some PVC														

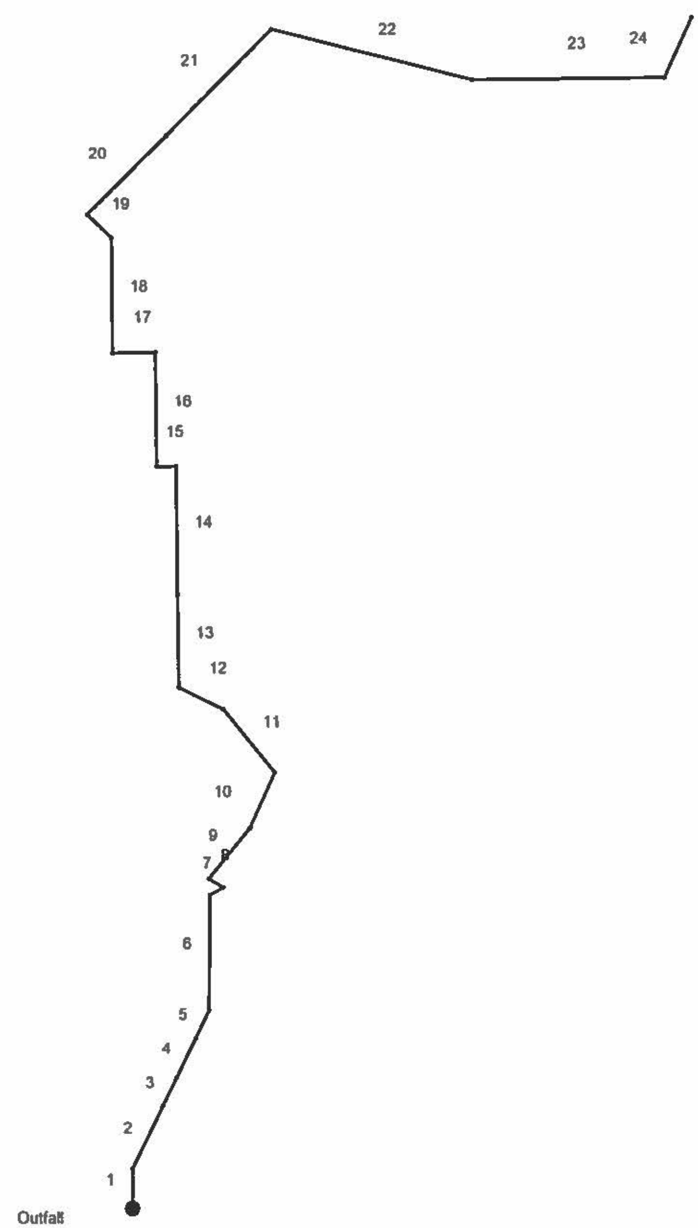
Table B4
Total Sewer Flow Calculation for Streets of West Pryor Systems
East Zone System

Line	Peak base flow (gpd/ac)	Res./Com. Peak infil. (gpd/ac)	Drainage Area (acres)	Cuml Drainage Area (acres)	Peak Base + Infiltration (gpd)	Peak Base + Infiltration (cfs)	(a) Cuml Peak Base +Infill (cfs)	K (Incr)	K*A Incr	Cuml K*A	Tc (min)	Rainfall Intensity (i) (50 yr)	(b) Cuml Peak inflow, Q = kAi (cfs)	(a+b) Cuml Total Peak Flow = Base + Infil + Inflow (cfs)
East System (Zone A and Downstream Zones F, G and H) (Standard Infiltration and Inflow Calculation Used)														
T30 (Zone A)	3244	250	15.0	15.0	52,410	0.081	0.081	0.003	0.045	0.045	37	4.64	0.21	0.29
S1 (Zone F)	1500	500	89.6	104.6	179,200	0.277	0.358	0.006	0.538	0.583	60	3.26	1.90	2.26
N6 (Zone G)	1500	500	13.6	118.2	27,200	0.042	0.400	0.006	0.082	0.664	62	3.24	2.15	2.55
N4 (Zone H)	1500	500	20	138.2	40,000	0.062	0.462	0.006	0.120	0.784	64	3.17	2.49	2.95
non contributing *	0	0	154	292.2										
non contributing (MoDOT) **	0	0	140	432.2										

* The majority of area in the Northwest quadrant of I-435 and US-350 was considered non-contributary, as either undeveloped land or as current quarry. A hypothetical 20 acre portion is shown as future residential (Zone H). If future development patterns are more intense, then capacity issues are anticipated.
** Area occupied by MoDOT right of way for freeway and interchange and which would remain permanently non-contributing

APPENDIX C – HYDRAFLOW CALCULATIONS - SOUTH SYSTEM

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: South with k 002.stm	Number of lines: 24	Date: 9/14/2018

Storm Sewers v10.514

C 1

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe	
1	1.07	8	89.200	876.50	880.78	4.80	877.12	881.27 j	881.27	2.46	1	2AA - OUTFALL (1AA)	0.49	0.00	887.35	0.014	
2	1.07	8	161.310	880.98	883.82	1.76	881.40	884.31	884.31	1.49	2	3AA - 2AA	0.49	0.09	889.07	0.014	
3	0.98	8	73.550	883.97	889.32	7.27	884.31	889.79	889.79	3.02	3	4AA - 3AA	0.47	0.00	893.62	0.014	
4	0.98	8	103.600	889.55	890.48	0.90	890.06	890.98	891.01	1.06	4	ADD - 4AA	0.53	0.09	896.23	0.014	
5	0.89	8	71.520	890.58	891.16	0.81	891.07	891.65	891.73	1.01	5	5AA - ADD	0.57	0.00	899.20	0.014	
6	0.89	8	264.850	891.92	896.63	1.78	892.29	897.08	897.08	1.50	6	6AA - 5AA	0.45	0.08	902.11	0.014	
7	0.81	8	35.430	896.67	899.02	6.63	897.08	899.45	899.45	2.89	7	7AA - 6AA	0.43	0.00	905.82	0.014	
8	0.81	8	38.380	899.12	907.92	22.93	899.45	908.35	908.35	5.37	8	1A - 7AA	0.43	0.02	917.00	0.014	
9	0.79	8	151.230	908.12	910.62	1.65	908.47	911.04	911.04	1.44	9	2A - 1A	0.42	0.00	920.80	0.014	
10	0.79	8	140.000	910.69	912.12	1.02	911.10	912.54	912.54	1.13	10	3A - 2A	0.42	0.00	919.51	0.014	
11	0.79	8	185.900	912.26	917.67	2.91	912.56	918.09	918.09	1.91	11	4A - 3A	0.42	0.00	925.91	0.014	
12	0.79	8	113.800	917.82	924.91	6.23	918.09	925.33	925.33	2.80	12	5A - 4A	0.42	0.05	934.91	0.014	
13	0.74	8	218.000	925.01	926.94	0.89	925.42	927.35	927.38	1.06	13	6A - 5A	0.44	0.05	936.49	0.014	
14	0.69	8	294.740	927.18	942.01	5.03	927.42	942.40	942.40	2.52	14	7A - 6A	0.39	0.05	951.53	0.014	
15	0.64	8	44.000	942.35	942.84	1.11	942.70	943.22	943.22	1.18	15	A - 7A	0.38	0.03	951.55	0.014	
16	0.61	8	267.000	942.84	950.32	2.80	943.22	950.69 j	950.69	1.88	16	B - A	0.37	0.07	962.72	0.014	
17	0.54	8	97.430	950.71	951.20	0.50	951.11	951.60	951.70	0.80	17	P10 -B	0.50	0.00	959.50	0.014	
18	0.54	8	263.850	951.70	953.00	0.49	952.11	953.41	953.47	0.79	18	P9 - P10	0.47	0.00	972.49	0.014	
19	0.54	8	77.670	953.50	953.88	0.49	953.91	954.29	954.38	0.78	19	P8 - P9	0.50	0.00	973.36	0.014	
20	0.54	8	260.000	954.38	955.68	0.50	954.78	956.08	956.10	0.79	20	P7 - P8	0.42	0.04	982.75	0.014	
21	0.50	8	342.770	956.18	957.89	0.50	956.56	958.27	958.35	0.79	21	P6 - P7	0.46	0.00	980.31	0.014	
22	0.50	8	471.970	958.39	960.75	0.50	958.77	961.13	961.16	0.79	22	P5 - P6	0.41	0.00	974.53	0.014	

Project File: South with k 002.stm | Number of lines: 24 | Date: 9/14/2018

NOTES: ** Critical depth

C 2

Sanitary

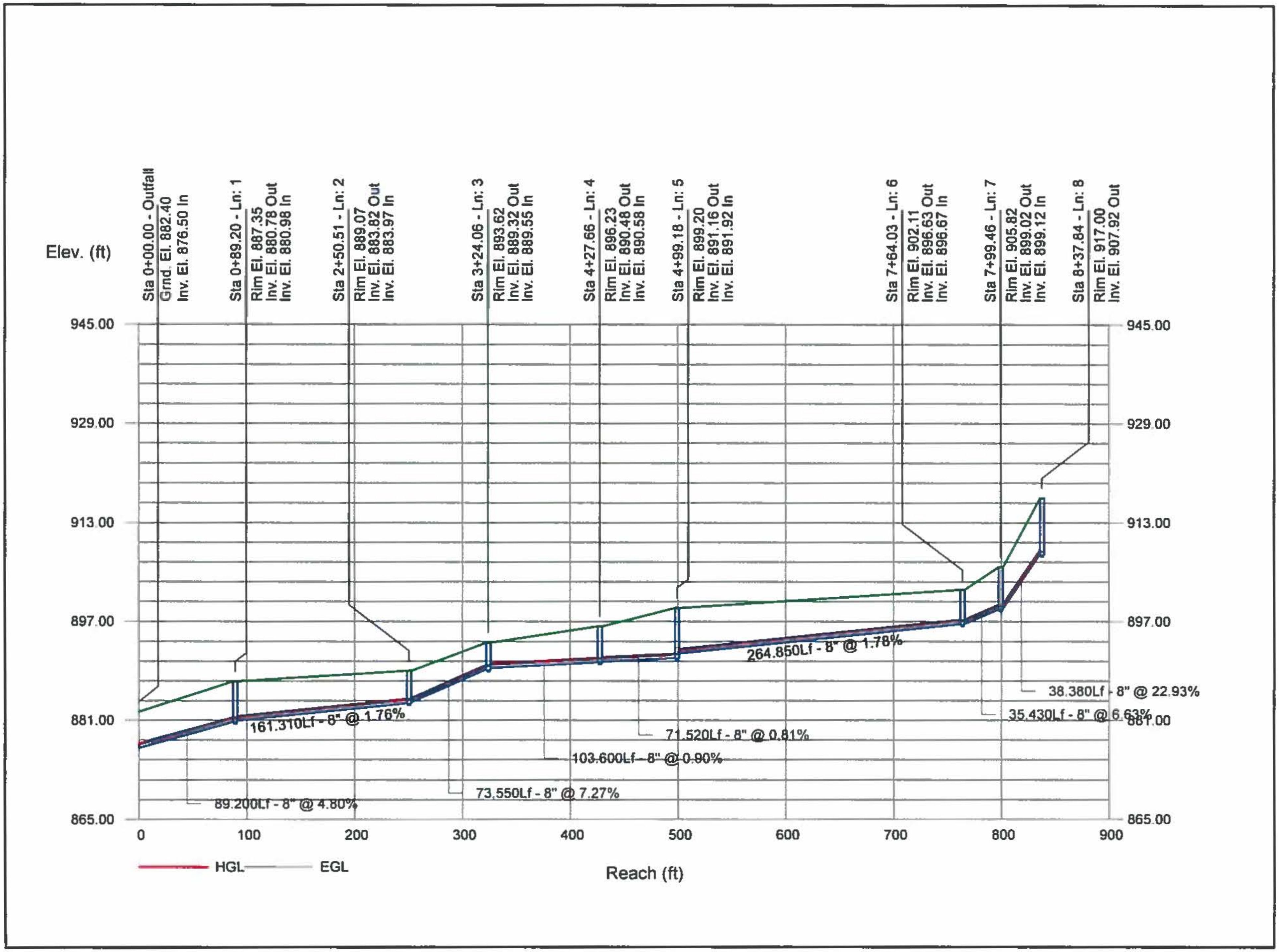
Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe	
23	0.50	8	440.000	960.95	963.15	0.50	961.33	963.53	963.62	0.79	23	P4 - P5	0.47	0.00	972.19	0.014	
24	0.50	8	152.270	963.65	964.41	0.50	964.03	964.79	964.88	0.79	24	P3 - P4	0.47	0.50	982.00	0.014	

Project File: South with k 002.stm | Number of lines: 24 | Date: 9/14/2018

NOTES: ** Critical depth

C 3

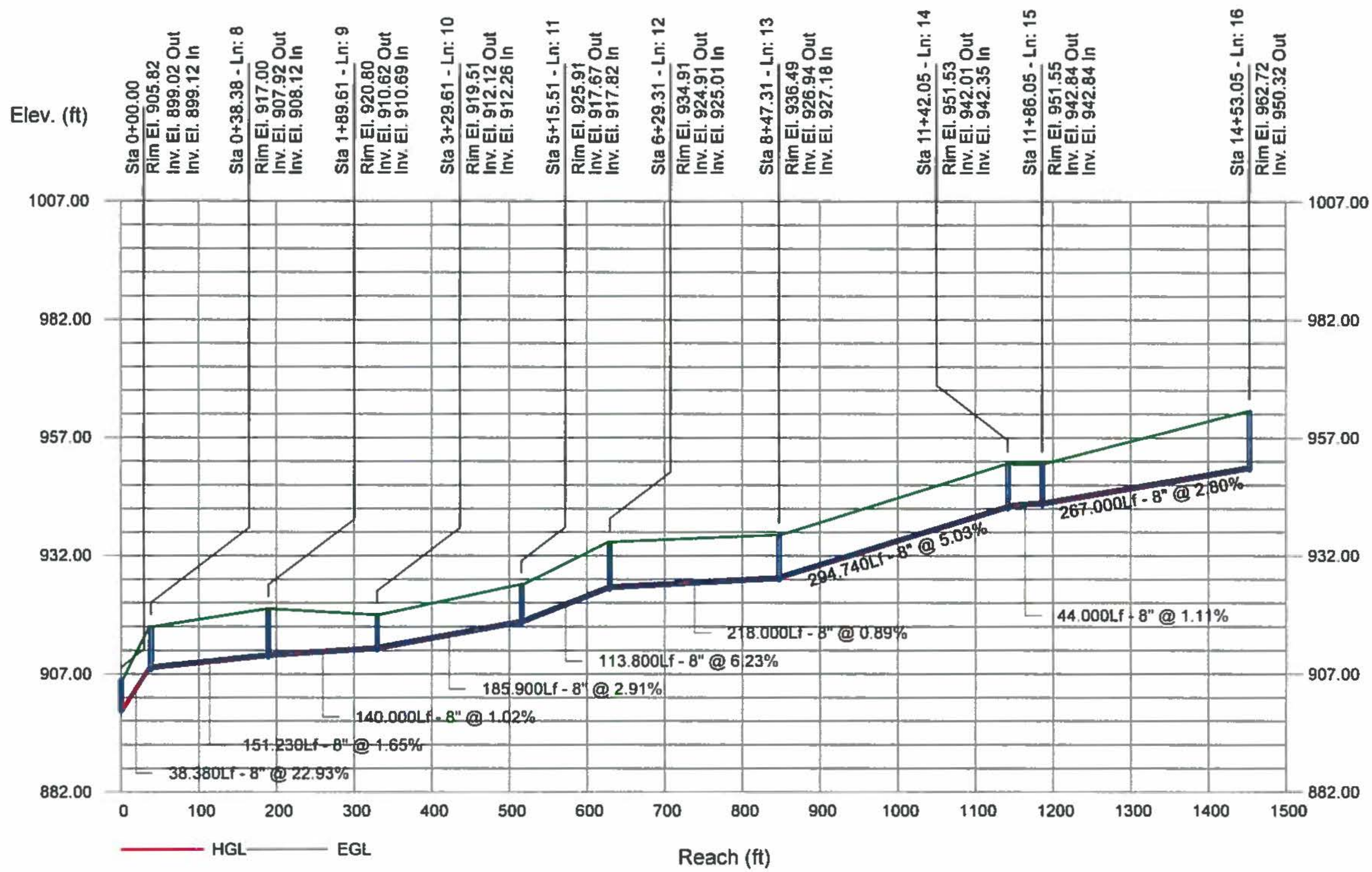
Storm Sewer Profile



C 4

Storm Sewer Profile

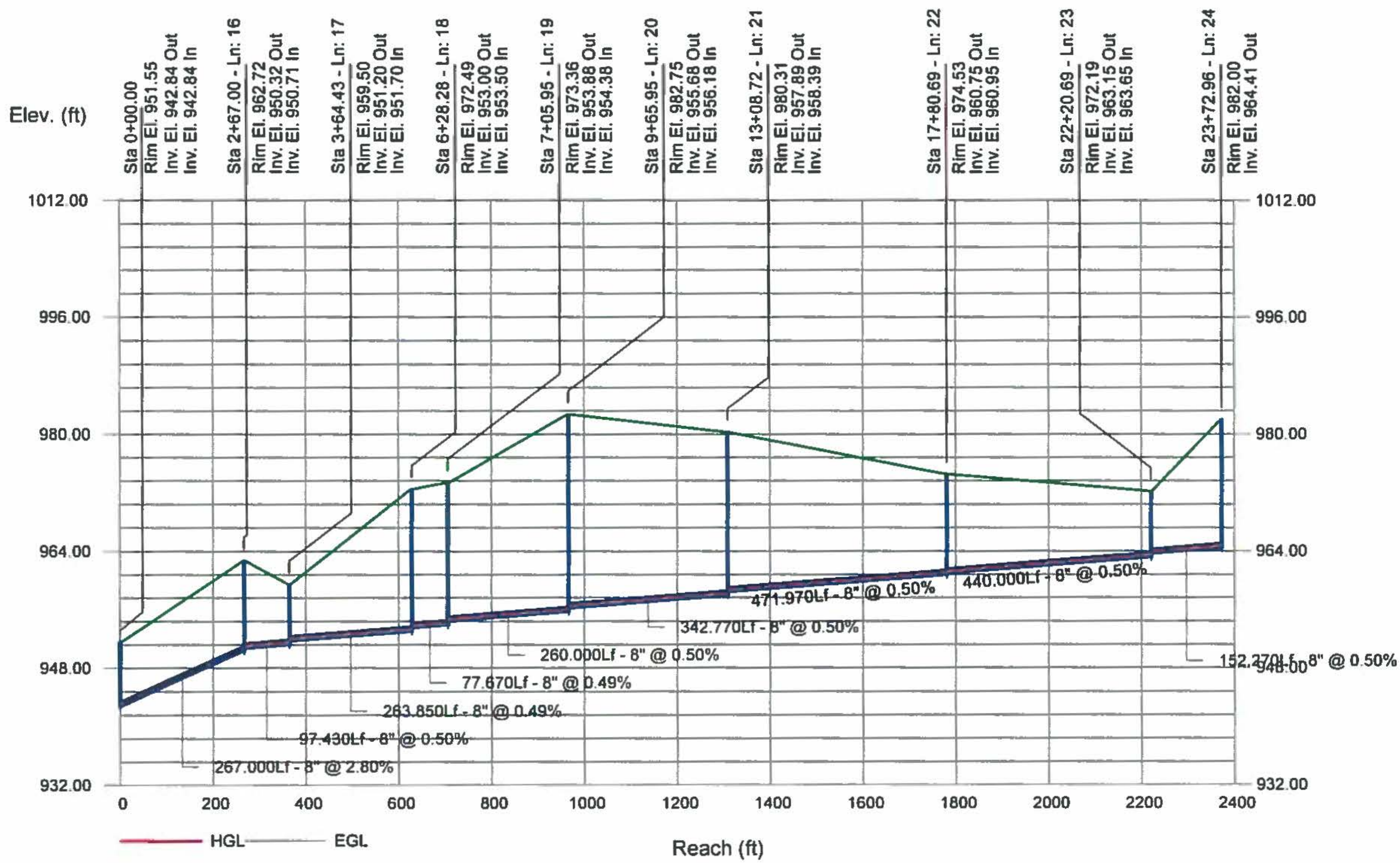
Proj. file: South with k 002.stm



C 5

Storm Sewers

Storm Sewer Profile



c 6

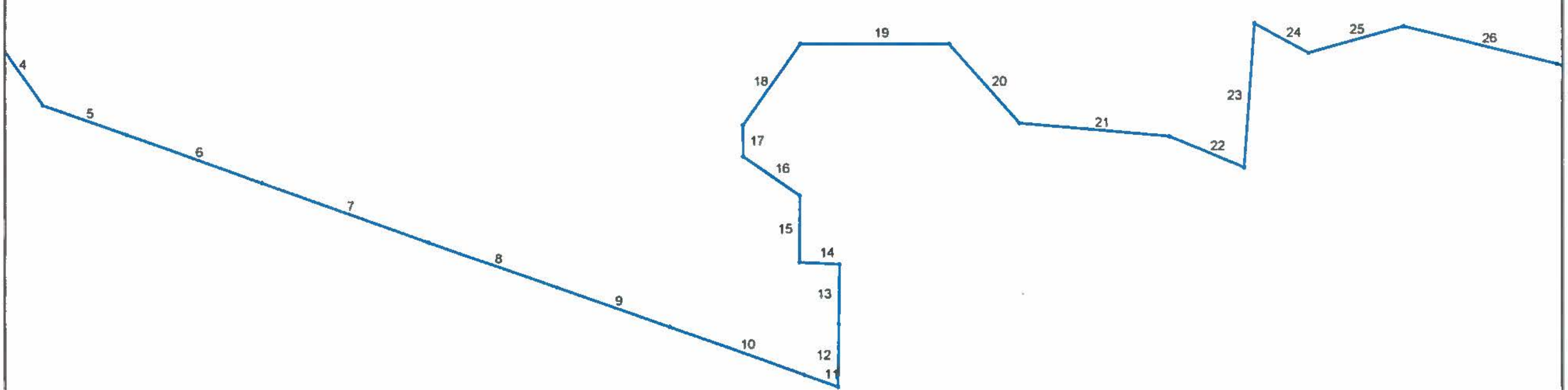
APPENDIX D – HYDRAFLOW CALCULATIONS - WEST SYSTEM

D1 – Existing System, with K=0.003 for most of existing residential (w/profile)
D2 – Alternate Flow Scenarios for K=0.0025, 0.0035 and 0.004 (no profile)

APPENDIX D – HYDRAFLOW CALCULATIONS - WEST SYSTEM

D1 – Existing System, with K=0.003 for most of existing residential (w/profile)

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: West corrected slopes and n with K002 0030 and 006.stm	Number of lines: 30	Date: 9/14/2018

Storm Sewers v10.514

D1 -1

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
1	2.89	12	169.000	789.83	791.86	1.20	790.83	792.59 j	792.59	3.38	1	#1 TO OUTFALL (DIP)	0.73	0.00	802.36	0.015
2	2.89	12	391.000	792.06	798.79	1.72	792.68	799.52	799.52	4.05	2	#2 TO #1 (VCP)	0.73	0.00	809.09	0.015
3	2.89	10	315.850	798.82	807.61	2.78	799.52	808.35	808.35	3.39	3	A-1 TO #2 (PVC)	0.74	0.00	812.91	0.014
4	2.89	10	223.200	807.86	814.84	3.13	808.43	815.58	815.58	3.60	4	A-2 TO A-1 (PVC)	0.74	0.74	820.87	0.014
5	2.15	8	199.380	815.00	820.05	2.53	815.67	824.08	824.17	1.67	5	G-1 TO A-2 (PVC/DIP)	4.12	0.43	826.13	0.015
6	1.72	8	324.000	820.18	830.57	3.21	824.17	832.92	832.98	1.87	6	J-1 TO G-1 (DIP)	2.41	0.00	835.50	0.015
7	1.72	8	399.500	830.77	841.38	2.66	832.98	843.77	843.83	1.71	7	J-2 TO J-1 (DIP)	2.45	0.00	846.68	0.015
8	1.72	8	307.500	841.58	850.96	3.05	843.83	851.57	851.63	1.83	8	J-3 TO J-2 (DIP)	0.67	0.00	857.08	0.015
9	1.72	8	268.000	851.16	865.95	5.52	851.63	866.55	866.55	2.46	9	J-4 TO J-3 (DIP)	0.60	0.00	870.35	0.015
10	1.72	8	322.000	866.15	877.83	3.63	866.63	878.43	878.43	1.99	10	J-5 TO J-4 (DIP)	0.60	0.00	892.53	0.015
11	1.72	8	80.300	878.00	895.29	21.53	878.43	895.89	895.89	5.20	11	J-6 to J-5 (PVC)	0.60	0.61	900.49	0.014
12	1.11	8	143.450	895.66	907.28	8.10	895.93	907.78	907.78	3.19	12	1-1 TO J-6	0.50	0.00	916.21	0.014
13	1.11	8	137.800	907.80	911.08	2.38	908.19	911.58	911.58	1.73	13	1-2 TO 1-1	0.50	0.24	928.78	0.014
14	0.87	8	89.750	911.72	912.04	0.36	912.39	912.93	913.02	0.67	14	1-3 TO 1-2	0.98	0.07	928.60	0.014
15	0.80	8	152.230	912.25	913.49	0.81	913.02	913.94	914.08	1.01	15	1-4 TO 1-3	0.59	0.03	935.65	0.014
16	0.77	8	154.950	913.84	914.92	0.70	914.30	915.38	915.50	0.94	16	1-5 TO 1-4	0.58	0.00	936.27	0.014
17	0.77	8	72.750	915.17	915.97	1.10	915.56	916.38	916.38	1.18	17	1-6 TO 1-5	0.41	0.00	940.97	0.014
18	0.77	8	228.000	916.19	917.82	0.71	916.65	918.28	918.40	0.95	18	1-7 TO 1-6	0.58	0.01	938.74	0.014
19	0.76	8	334.900	918.04	920.69	0.79	918.48	921.13	921.25	1.00	19	1-8 TO 1-7	0.56	0.03	927.13	0.014
20	0.73	8	241.900	920.94	923.40	1.02	921.33	923.80	923.80	1.13	20	1-9 TO 1-8	0.40	0.01	932.44	0.014
21	0.72	8	338.330	923.27	926.11	0.84	923.80	926.51	926.51	1.03	21	1-10 TO 1-9	0.40	0.06	929.51	0.014
22	0.66	8	183.400	926.28	928.53	1.23	926.63	928.91	928.91	1.24	22	1-11 TO 1-10	0.38	0.10	937.84	0.014

Project File: West corrected slopes and n with K002 0030 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth

D1-2

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe	
23	0.56	8	332.300	929.19	931.90	0.82	929.54	932.25	932.39	1.01	23	2-1 TO 1-11	0.49	0.07	941.73	0.014	
24	0.49	8	139.000	932.10	933.34	0.89	932.42	933.67	933.67	1.06	24	2-2 to 2-1	0.33	0.00	953.25	0.014	
25	0.49	8	223.000	933.49	935.29	0.81	933.82	935.62	935.69	1.01	25	2-3 to 2-2	0.40	0.11	954.64	0.014	
26	0.38	8	355.000	935.51	938.26	0.77	935.80	938.55	938.56	0.99	26	2-4 to 2-3	0.30	0.00	956.51	0.014	
27	0.38	8	169.000	938.54	940.00	0.86	938.82	940.29	940.29	1.04	27	2-5 to 2-4	0.29	0.00	951.11	0.014	
28	0.38	8	237.000	940.21	942.16	0.82	940.49	942.45	942.45	1.02	28	2-6 to 2-5	0.29	0.15	952.00	0.014	
29	0.23	8	316.000	943.01	947.73	1.49	943.19	947.95	947.95	1.37	29	B-1 (nr 2-7) to 2-6	0.22	0.13	954.28	0.014	
30	0.10	8	133.950	947.93	948.87	0.70	948.08	949.02	949.06	0.94	30	B-2 to B-1	0.19	0.10	959.15	0.014	

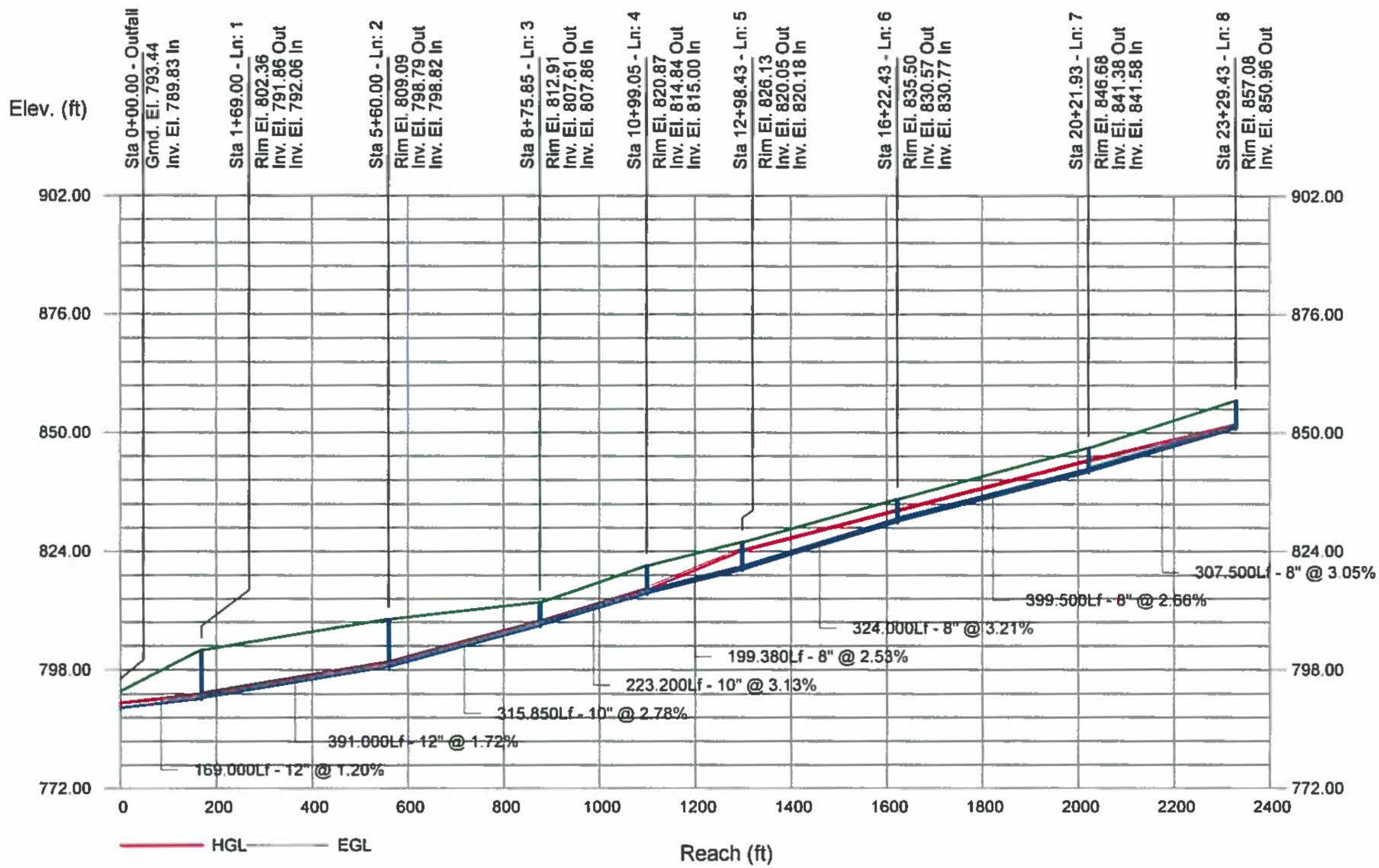
Project File: West corrected slopes and n with K002 0030 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth

01-3

Storm Sewer Profile

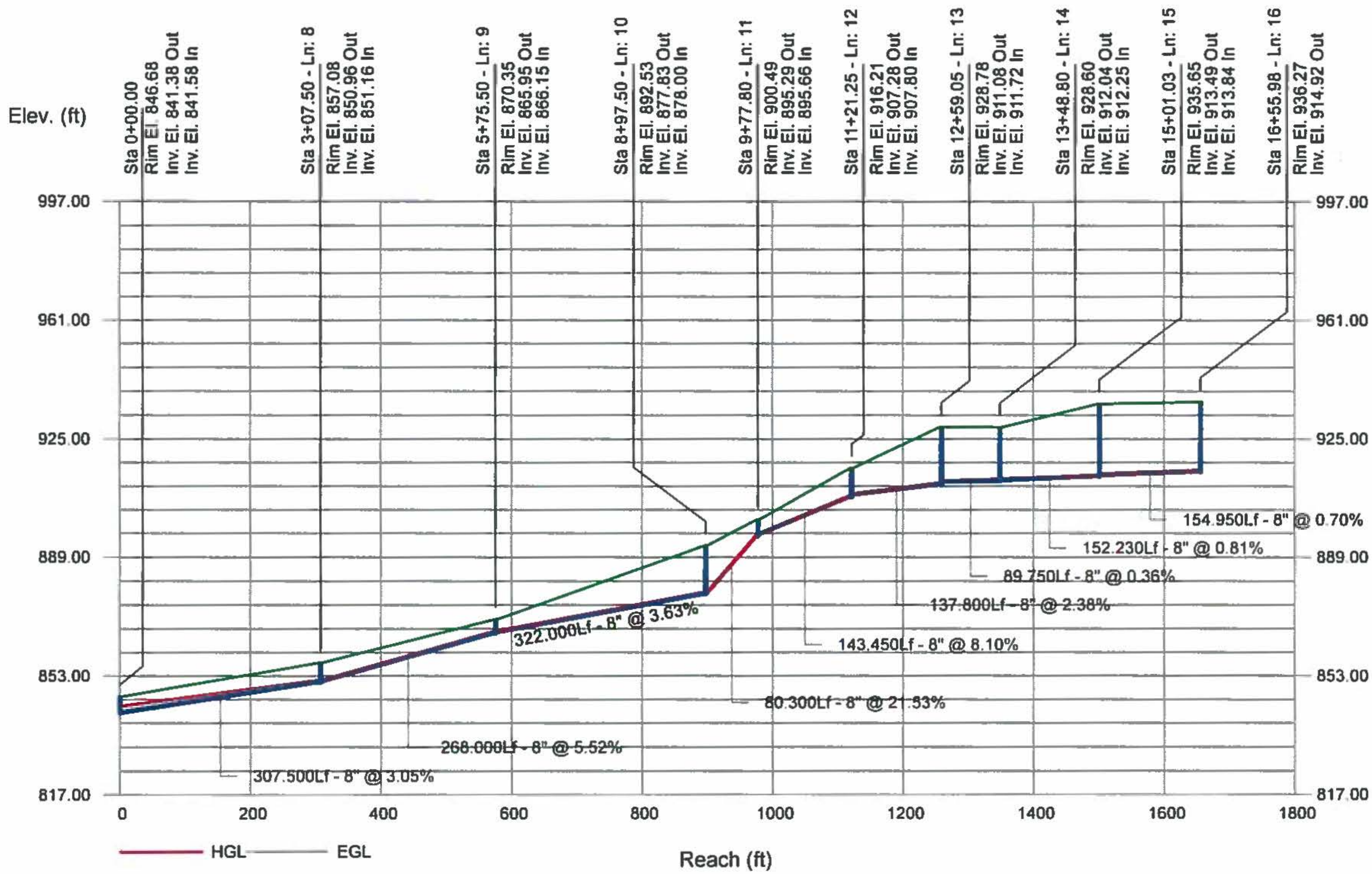
Proj. file: West corrected slopes and n with K002 0030 and 006.stm



D1-4

Storm Sewer Profile

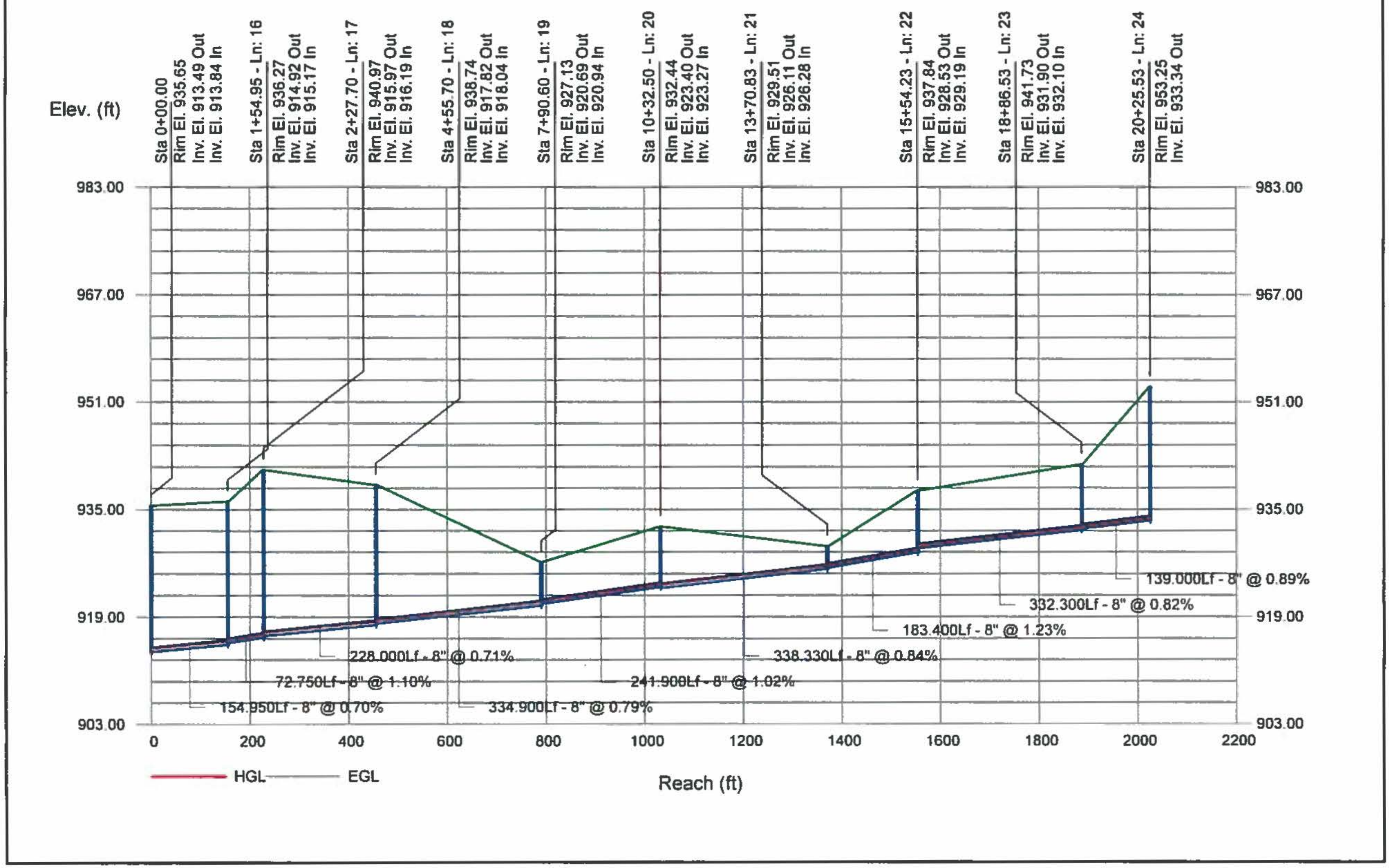
Proj. file: West corrected slopes and n with K002 0030 and 006.stm



D1-5

Storm Sewer Profile

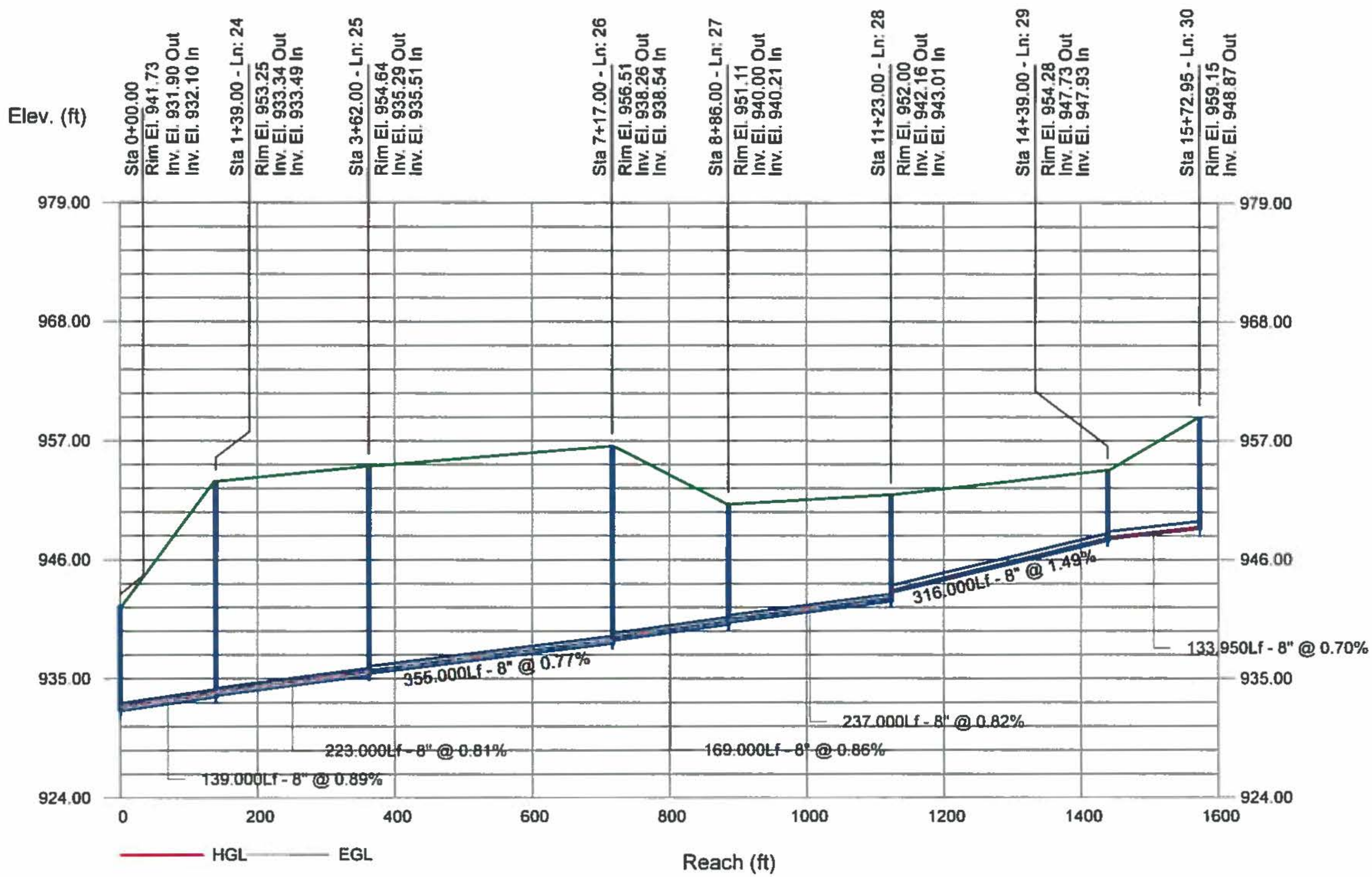
Proj. file: West corrected slopes and n with K002 0030 and 006.stm



Storm Sewers

D1-6

Storm Sewer Profile



APPENDIX D – HYDRAFLOW CALCULATIONS - WEST SYSTEM

D2 – Alternate Flow Scenarios for K=0.0025, 0.0035 and 0.004 (no profile

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
1	2.63	12	169.000	789.83	791.86	1.20	790.83	792.55 j	792.55	3.38	1	#1 TO OUTFALL (DIP)	0.69	0.00	802.36	0.015
2	2.63	12	391.000	792.06	798.79	1.72	792.65	799.48	799.48	4.05	2	#2 TO #1 (VCP)	0.69	0.00	809.09	0.015
3	2.63	10	315.850	798.82	807.61	2.78	799.48	808.33	808.33	3.39	3	A-1 TO #2 (PVC)	0.72	0.00	812.91	0.014
4	2.63	10	223.200	807.86	814.84	3.13	808.39	815.56	815.56	3.60	4	A-2 TO A-1 (PVC)	0.72	0.74	820.87	0.014
5	1.89	8	199.380	815.00	820.05	2.53	815.67	822.17	822.24	1.67	5	G-1 TO A-2 (PVC/DIP)	2.19	0.38	826.13	0.015
6	1.51	8	324.000	820.18	830.57	3.21	822.24	831.14 j	831.14	1.87	6	J-1 TO G-1 (DIP)	0.57	0.00	835.50	0.015
7	1.51	8	399.500	830.77	841.38	2.66	831.26	841.95	841.95	1.71	7	J-2 TO J-1 (DIP)	0.57	0.00	846.68	0.015
8	1.51	8	307.500	841.58	850.96	3.05	842.04	851.53	851.53	1.83	8	J-3 TO J-2 (DIP)	0.57	0.00	857.08	0.015
9	1.51	8	268.000	851.16	865.95	5.52	851.54	866.52	866.52	2.46	9	J-4 TO J-3 (DIP)	0.57	0.00	870.35	0.015
10	1.51	8	322.000	866.15	877.83	3.63	866.58	878.40	878.40	1.99	10	J-5 TO J-4 (DIP)	0.57	0.00	892.53	0.015
11	1.51	8	80.300	878.00	895.29	21.53	878.40	895.86	895.86	5.20	11	J-6 to J-5 (PVC)	0.57	0.53	900.49	0.014
12	0.98	8	143.450	895.66	907.28	8.10	895.91	907.75	907.75	3.19	12	1-1 TO J-6	0.47	0.00	916.21	0.014
13	0.98	8	137.800	907.80	911.08	2.38	908.16	911.55	911.55	1.73	13	1-2 TO 1-1	0.47	0.21	928.78	0.014
14	0.77	8	89.750	911.72	912.04	0.36	912.39	912.81	912.89	0.67	14	1-3 TO 1-2	0.85	0.06	928.60	0.014
15	0.71	8	152.230	912.25	913.49	0.81	912.89	913.89	913.89	1.01	15	1-4 TO 1-3	0.40	0.03	935.65	0.014
16	0.68	8	154.950	913.84	914.92	0.70	914.26	915.34	915.45	0.94	16	1-5 TO 1-4	0.53	0.00	936.27	0.014
17	0.68	8	72.750	915.17	915.97	1.10	915.53	916.36	916.36	1.18	17	1-6 TO 1-5	0.39	0.00	940.97	0.014
18	0.68	8	228.000	916.19	917.82	0.71	916.61	918.24	918.35	0.95	18	1-7 TO 1-6	0.53	0.01	938.74	0.014
19	0.67	8	334.900	918.04	920.69	0.79	918.44	921.09	921.21	1.00	19	1-8 TO 1-7	0.52	0.02	927.13	0.014
20	0.65	8	241.900	920.94	923.40	1.02	921.30	923.78	923.78	1.13	20	1-9 TO 1-8	0.38	0.01	932.44	0.014
21	0.64	8	338.330	923.27	926.11	0.84	923.78	926.49	926.49	1.03	21	1-10 TO 1-9	0.38	0.05	929.51	0.014
22	0.59	8	183.400	926.28	928.53	1.23	926.60	928.89	928.89	1.24	22	1-11 TO 1-10	0.36	0.09	937.84	0.014

Project File: West corrected slopes and n with K002 0025 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth   .0025 Scenario

D2-1

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
23	0.50	8	332.300	929.19	931.90	0.82	929.52	932.23	932.36	1.01	23	2-1 TO 1-11	0.46	0.06	941.73	0.014
24	0.44	8	139.000	932.10	933.34	0.89	932.40	933.65	933.65	1.06	24	2-2 to 2-1	0.31	0.00	953.25	0.014
25	0.44	8	223.000	933.49	935.29	0.81	933.80	935.60	935.60	1.01	25	2-3 to 2-2	0.31	0.10	954.64	0.014
26	0.34	8	355.000	935.51	938.26	0.77	935.78	938.53	938.53	0.99	26	2-4 to 2-3	0.27	0.00	956.51	0.014
27	0.34	8	169.000	938.54	940.00	0.86	938.80	940.27	940.27	1.04	27	2-5 to 2-4	0.27	0.00	951.11	0.014
28	0.34	8	237.000	940.21	942.16	0.82	940.48	942.43	942.43	1.02	28	2-6 to 2-5	0.27	0.13	952.00	0.014
29	0.21	8	316.000	943.01	947.73	1.49	943.19	947.94	947.94	1.37	29	B-1 (nr 2-7) to 2-6	0.21	0.11	954.28	0.014
30	0.10	8	133.950	947.93	948.87	0.70	948.08	949.02	949.06	0.94	30	B-2 to B-1	0.19	0.10	959.15	0.014

Project File: West corrected slopes and n with K002 0025 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth .0025 Scenorio

D2-2

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
1	3.14	12	169.000	789.83	791.86	1.20	790.83	792.62	792.68	3.38	1	#1 TO OUTFALL (DIP)	0.82	0.00	802.36	0.015
2	3.14	12	391.000	792.06	798.79	1.72	792.72	799.55	799.55	4.05	2	#2 TO #1 (VCP)	0.76	0.00	809.09	0.015
3	3.14	10	315.850	798.82	807.61	2.78	799.55	808.37	808.37	3.39	3	A-1 TO #2 (PVC)	0.76	0.00	812.91	0.014
4	3.14	10	223.200	807.86	814.84	3.13	808.46	815.60	815.60	3.60	4	A-2 TO A-1 (PVC)	0.76	0.73	820.87	0.014
5	2.41	8	199.380	815.00	820.05	2.53	815.67	826.24	826.35	1.67	5	G-1 TO A-2 (PVC/DIP)	6.30	0.49	826.13	0.015
6	1.92	8	324.000	820.18	830.57	3.21	826.35	837.26	837.33	1.87	6	J-1 TO G-1 (DIP)	6.76	0.00	835.50	0.015
7	1.92	8	399.500	830.77	841.38	2.66	837.33	850.77	850.84	1.71	7	J-2 TO J-1 (DIP)	9.46	0.00	846.68	0.015
8	1.92	8	307.500	841.58	850.96	3.05	850.84	861.19	861.26	1.83	8	J-3 TO J-2 (DIP)	10.30	0.00	857.08	0.015
9	1.92	8	268.000	851.16	865.95	5.52	861.26	870.28	870.35	2.46	9	J-4 TO J-3 (DIP)	4.40	0.00	870.35	0.015
10	1.92	8	322.000	866.15	877.83	3.63	870.35	881.19	881.26	1.99	10	J-5 TO J-4 (DIP)	3.43	0.00	892.53	0.015
11	1.92	8	80.300	878.00	895.29	21.53	881.26	895.91 j	895.91	5.20	11	J-6 to J-5 (PVC)	0.62	0.68	900.49	0.014
12	1.24	8	143.450	895.66	907.28	8.10	895.95	907.81	907.81	3.19	12	1-1 TO J-6	0.53	0.00	916.21	0.014
13	1.24	8	137.800	907.80	911.08	2.38	908.22	911.61	911.61	1.73	13	1-2 TO 1-1	0.53	0.27	928.78	0.014
14	0.97	8	89.750	911.72	912.04	0.36	912.39	913.06	913.18	0.67	14	1-3 TO 1-2	1.14	0.07	928.60	0.014
15	0.90	8	152.230	912.25	913.49	0.81	913.18	914.16	914.24	1.01	15	1-4 TO 1-3	0.75	0.04	935.65	0.014
16	0.86	8	154.950	913.84	914.92	0.70	914.34	915.42	915.55	0.94	16	1-5 TO 1-4	0.63	0.00	936.27	0.014
17	0.86	8	72.750	915.17	915.97	1.10	915.59	916.41	916.41	1.18	17	1-6 TO 1-5	0.44	0.00	940.97	0.014
18	0.86	8	228.000	916.19	917.82	0.71	916.69	918.32	918.44	0.95	18	1-7 TO 1-6	0.62	0.01	938.74	0.014
19	0.85	8	334.900	918.04	920.69	0.79	918.51	921.16	921.29	1.00	19	1-8 TO 1-7	0.60	0.03	927.13	0.014
20	0.82	8	241.900	920.94	923.40	1.02	921.36	923.83	923.83	1.13	20	1-9 TO 1-8	0.43	0.02	932.44	0.014
21	0.80	8	338.330	923.27	926.11	0.84	923.83	926.53	926.53	1.03	21	1-10 TO 1-9	0.42	0.06	929.51	0.014
22	0.74	8	183.400	926.28	928.53	1.23	926.65	928.94	928.94	1.24	22	1-11 TO 1-10	0.41	0.11	937.84	0.014

Project File: West corrected slopes and n with K002 0035 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth .0035 Scenorio

D2-3

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe	
23	0.63	8	332.300	929.19	931.90	0.82	929.57	932.28 j	932.43	1.01	23	2-1 TO 1-11	0.53	0.08	941.73	0.014	
24	0.55	8	139.000	932.10	933.34	0.89	932.44	933.69	933.69	1.06	24	2-2 to 2-1	0.35	0.00	953.25	0.014	
25	0.55	8	223.000	933.49	935.29	0.81	933.84	935.64	935.72	1.01	25	2-3 to 2-2	0.43	0.13	954.64	0.014	
26	0.42	8	355.000	935.51	938.26	0.77	935.81	938.56	938.58	0.99	26	2-4 to 2-3	0.32	0.00	956.51	0.014	
27	0.42	8	169.000	938.54	940.00	0.86	938.83	940.30	940.30	1.04	27	2-5 to 2-4	0.30	0.00	951.11	0.014	
28	0.42	8	237.000	940.21	942.16	0.82	940.51	942.46	942.46	1.02	28	2-6 to 2-5	0.30	0.17	952.00	0.014	
29	0.25	8	316.000	943.01	947.73	1.49	943.20	947.96	947.96	1.37	29	B-1 (nr 2-7) to 2-6	0.23	0.15	954.28	0.014	
30	0.10	8	133.950	947.93	948.87	0.70	948.08	949.02	949.06	0.94	30	B-2 to B-1	0.19	0.10	959.15	0.014	

Project File: West corrected slopes and n with K002 0035 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth   0.0035 Scenario

D2-4

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
1	3.41	12	169.000	789.83	791.86	1.20	790.83	792.74	792.79	3.38	1	#1 TO OUTFALL (DIP)	0.93	0.00	802.36	0.015
2	3.41	12	391.000	792.06	798.79	1.72	792.79	799.58	799.58	4.05	2	#2 TO #1 (VCP)	0.79	0.00	809.09	0.015
3	3.41	10	315.850	798.82	807.61	2.78	799.58	808.39	808.39	3.39	3	A-1 TO #2 (PVC)	0.78	0.00	812.91	0.014
4	3.41	10	223.200	807.86	814.84	3.13	808.51	815.62	815.62	3.60	4	A-2 TO A-1 (PVC)	0.78	0.73	820.87	0.014
5	2.68	8	199.380	815.00	820.05	2.53	815.67	828.74	828.88	1.67	5	G-1 TO A-2 (PVC/DIP)	8.83	0.54	826.13	0.015
6	2.14	8	324.000	820.18	830.57	3.21	828.88	842.43	842.51	1.87	6	J-1 TO G-1 (DIP)	11.94	0.00	835.50	0.015
7	2.14	8	399.500	830.77	841.38	2.66	842.51	859.22	859.30	1.71	7	J-2 TO J-1 (DIP)	17.92	0.00	846.68	0.015
8	2.14	8	307.500	841.58	850.96	3.05	859.30	872.16	872.25	1.83	8	J-3 TO J-2 (DIP)	21.29	0.00	857.08	0.015
9	2.14	8	268.000	851.16	865.95	5.52	872.25	883.46	883.54	2.46	9	J-4 TO J-3 (DIP)	17.59	0.00	870.35	0.015
10	2.14	8	322.000	866.15	877.83	3.63	883.54	897.01	897.09	1.99	10	J-5 TO J-4 (DIP)	19.26	0.00	892.53	0.015
11	2.14	8	80.300	878.00	895.29	21.53	897.09	900.02	900.60	5.20	11	J-6 to J-5 (PVC)	5.31	0.76	900.49	0.014
12	1.38	8	143.450	895.66	907.28	8.10	900.60	907.83 j	907.83	3.19	12	1-1 TO J-6	0.55	0.00	916.21	0.014
13	1.38	8	137.800	907.80	911.08	2.38	908.25	911.63	911.63	1.73	13	1-2 TO 1-1	0.55	0.31	928.78	0.014
14	1.07	8	89.750	911.72	912.04	0.36	912.39	913.20	913.35	0.67	14	1-3 TO 1-2	1.31	0.08	928.60	0.014
15	0.99	8	152.230	912.25	913.49	0.81	913.35	914.54	914.64	1.01	15	1-4 TO 1-3	1.15	0.04	935.65	0.014
16	0.95	8	154.950	913.84	914.92	0.70	914.64	915.76	915.85	0.94	16	1-5 TO 1-4	0.93	0.00	936.27	0.014
17	0.95	8	72.750	915.17	915.97	1.10	915.85	916.43	916.57	1.18	17	1-6 TO 1-5	0.60	0.00	940.97	0.014
18	0.95	8	228.000	916.19	917.82	0.71	916.74	918.37	918.49	0.95	18	1-7 TO 1-6	0.67	0.01	938.74	0.014
19	0.94	8	334.900	918.04	920.69	0.79	918.55	921.21	921.33	1.00	19	1-8 TO 1-7	0.64	0.03	927.13	0.014
20	0.91	8	241.900	920.94	923.40	1.02	921.39	923.85	924.00	1.13	20	1-9 TO 1-8	0.60	0.02	932.44	0.014
21	0.89	8	338.330	923.27	926.11	0.84	924.00	926.57	926.64	1.03	21	1-10 TO 1-9	0.53	0.07	929.51	0.014
22	0.82	8	183.400	926.28	928.53	1.23	926.68	928.96	928.96	1.24	22	1-11 TO 1-10	0.43	0.13	937.84	0.014

Project File: West corrected slopes and n with K002 0040 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth 0.004 Scenario

D2-5

Sanitary

Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe
23	0.69	8	332.300	929.19	931.90	0.82	929.59	932.30	932.46	1.01	23	2-1 TO 1-11	0.56	0.09	941.73	0.014
24	0.60	8	139.000	932.10	933.34	0.89	932.46	933.70	933.70	1.06	24	2-2 to 2-1	0.36	0.00	953.25	0.014
25	0.60	8	223.000	933.49	935.29	0.81	933.86	935.66	935.74	1.01	25	2-3 to 2-2	0.45	0.14	954.64	0.014
26	0.46	8	355.000	935.51	938.26	0.77	935.83	938.58	938.60	0.99	26	2-4 to 2-3	0.34	0.00	956.51	0.014
27	0.46	8	169.000	938.54	940.00	0.86	938.85	940.32	940.32	1.04	27	2-5 to 2-4	0.32	0.00	951.11	0.014
28	0.46	8	237.000	940.21	942.16	0.82	940.52	942.48	942.48	1.02	28	2-6 to 2-5	0.32	0.19	952.00	0.014
29	0.27	8	316.000	943.01	947.73	1.49	943.21	947.97	947.97	1.37	29	B-1 (nr 2-7) to 2-6	0.24	0.17	954.28	0.014
30	0.10	8	133.950	947.93	948.87	0.70	948.08	949.02	949.06	0.94	30	B-2 to B-1	0.19	0.10	959.15	0.014

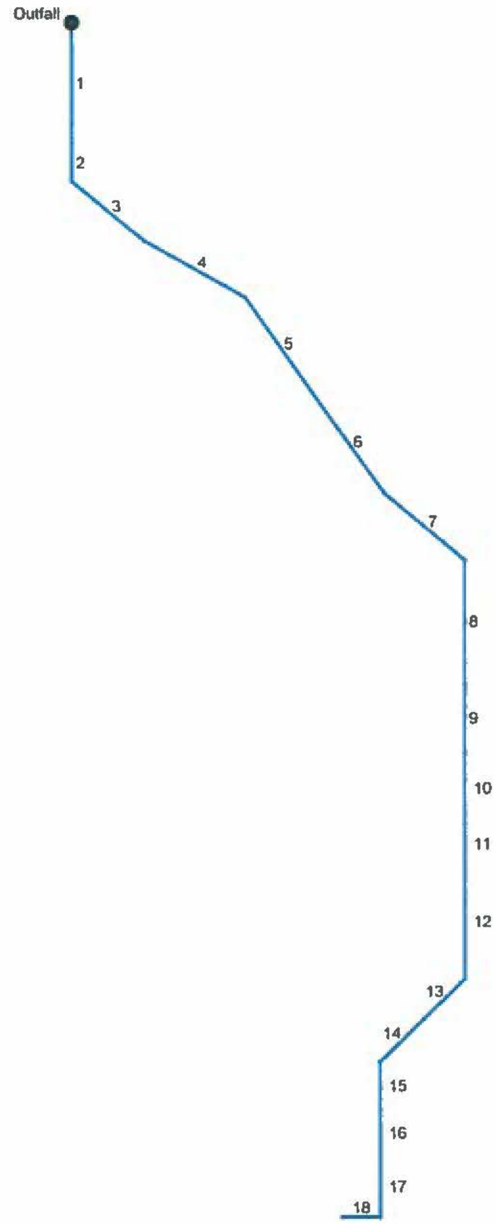
Project File: West corrected slopes and n with K002 0040 and 006.stm | Number of lines: 30 | Date: 9/14/2018

NOTES: ** Critical depth   0.004 Scenario

D2-6

APPENDIX E – HYDRAFLOW CALCULATIONS - EAST SYSTEM

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: 7067 Sewer - East.stm	Number of lines: 18	Date: 9/14/2018

E1

Sanitary

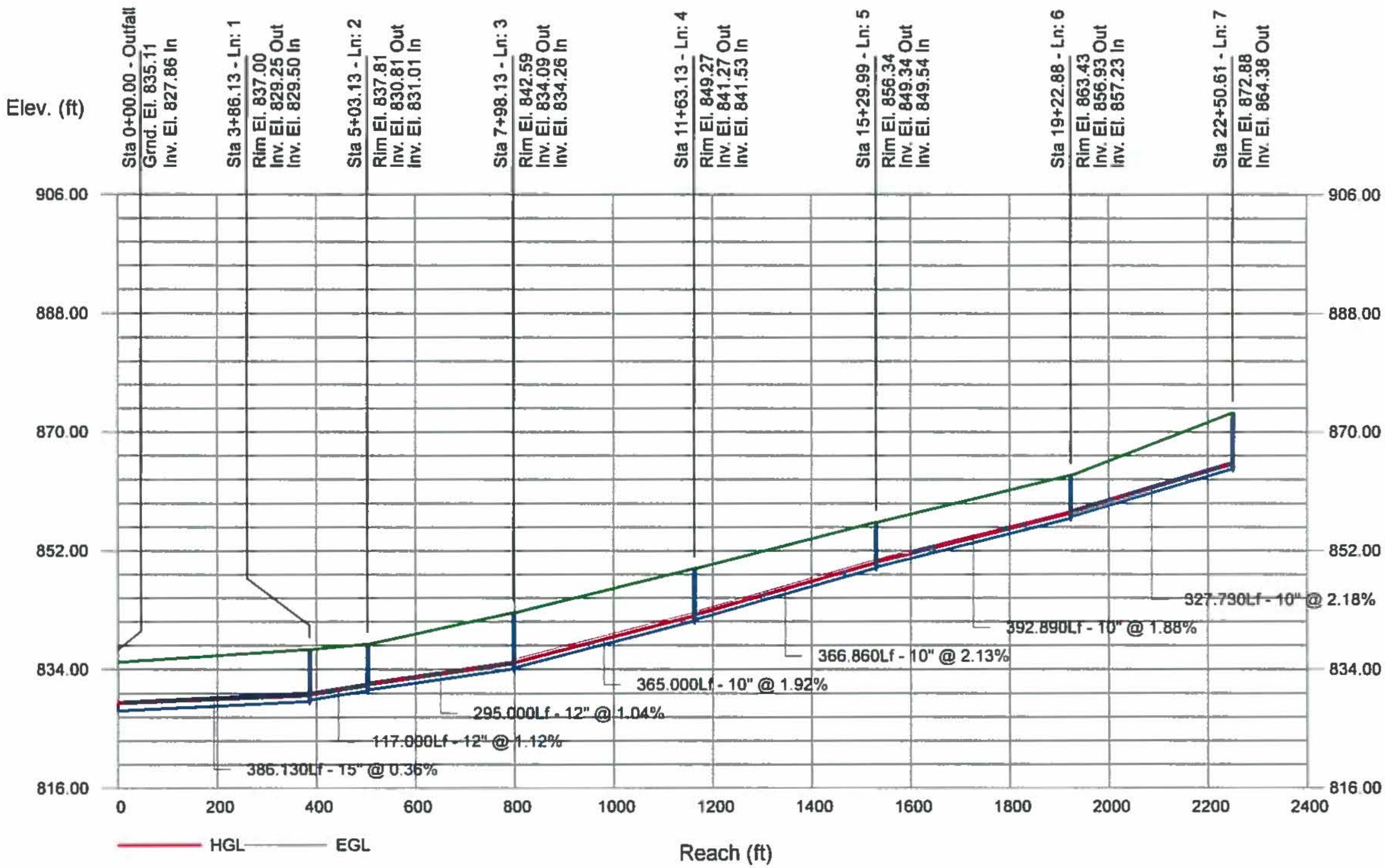
Line No.	Flow Rate (cfs)	Line Size (in)	Line Length (ft)	Invert Dn (ft)	Invert Up (ft)	Line Slope (%)	HGL Dn (ft)	HGL Up (ft)	HGL Jnct (ft)	Capac Full (cfs)	Line No.	Line ID	Hw (ft)	Known Q (cfs)	Gnd/Rim El Up (ft)	n-val Pipe	
1	2.95	15	386.130	827.86	829.25	0.36	828.95	830.08	830.10	3.60	1	M2 to M1	0.85	0.00	837.00	0.014	
2	2.95	12	117.000	829.50	830.81	1.12	830.20	831.55	831.55	3.50	2	N1 to M2	0.74	0.00	837.81	0.014	
3	2.95	12	295.000	831.01	834.09	1.04	831.73	834.83	834.83	3.38	3	N2 to N1	0.74	0.00	842.59	0.014	
4	2.95	10	365.000	834.26	841.27	1.92	834.98	842.02	842.02	2.82	4	N3 to N2	0.75	0.00	849.27	0.014	
5	2.95	10	366.860	841.53	849.34	2.13	842.21	850.09	850.09	2.97	5	N4 to N3	0.75	0.40	856.34	0.014	
6	2.55	10	392.890	849.54	856.93	1.88	850.26	857.64 j	857.64	2.79	6	N5 to N4	0.71	0.00	863.43	0.014	
7	2.55	10	327.730	857.23	864.38	2.18	857.82	865.09	865.09	3.00	7	N6 to N5	0.71	0.29	872.88	0.014	
8	2.26	12	392.000	864.55	875.47	2.79	865.37	876.11 j	876.11	5.52	8	R1 to N6	0.64	0.00	882.93	0.014	
9	2.26	12	225.000	875.67	877.02	0.60	876.40	877.75	877.78	2.56	9	R2 to R1	0.76	0.00	888.28	0.014	
10	2.26	12	221.000	880.43	893.26	5.81	880.79	893.90	893.90	7.97	10	R3 to R2	0.64	0.00	906.81	0.014	
11	2.26	12	131.000	900.00	905.74	4.38	900.39	906.38	906.38	6.92	11	R4 to R3	0.64	0.00	910.19	0.014	
12	2.26	12	364.000	905.94	923.14	4.73	906.53	923.78	923.78	7.19	12	R5 to R4	0.64	0.00	928.58	0.014	
13	2.26	12	179.000	923.34	935.61	6.85	923.93	936.25	936.25	8.66	13	R6 to R5	0.64	0.00	966.71	0.014	
14	2.26	12	196.000	935.81	947.86	6.15	936.40	948.50	948.50	8.20	14	R7 to R6	0.64	0.00	966.02	0.014	
15	2.26	12	152.000	948.06	949.97	1.26	948.65	950.61	950.61	3.71	15	R8 to R7	0.64	0.00	967.10	0.014	
16	2.26	12	151.000	950.17	951.08	0.60	950.90	951.81	951.84	2.57	16	R9 to R8	0.76	0.00	967.76	0.014	
17	2.26	12	194.000	951.28	952.36	0.56	952.03	953.11	953.31	2.47	17	S1 to R9	0.95	1.97	971.60	0.014	
18	0.29	8	118.000	961.39	964.48	2.62	961.57	964.73	964.73	1.81	18	T30 to S1	0.25	0.29	972.50	0.014	

Project File: 7067 Sewer - East.stm | Number of lines: 18 | Date: 9/14/2018

NOTES: ** Critical depth

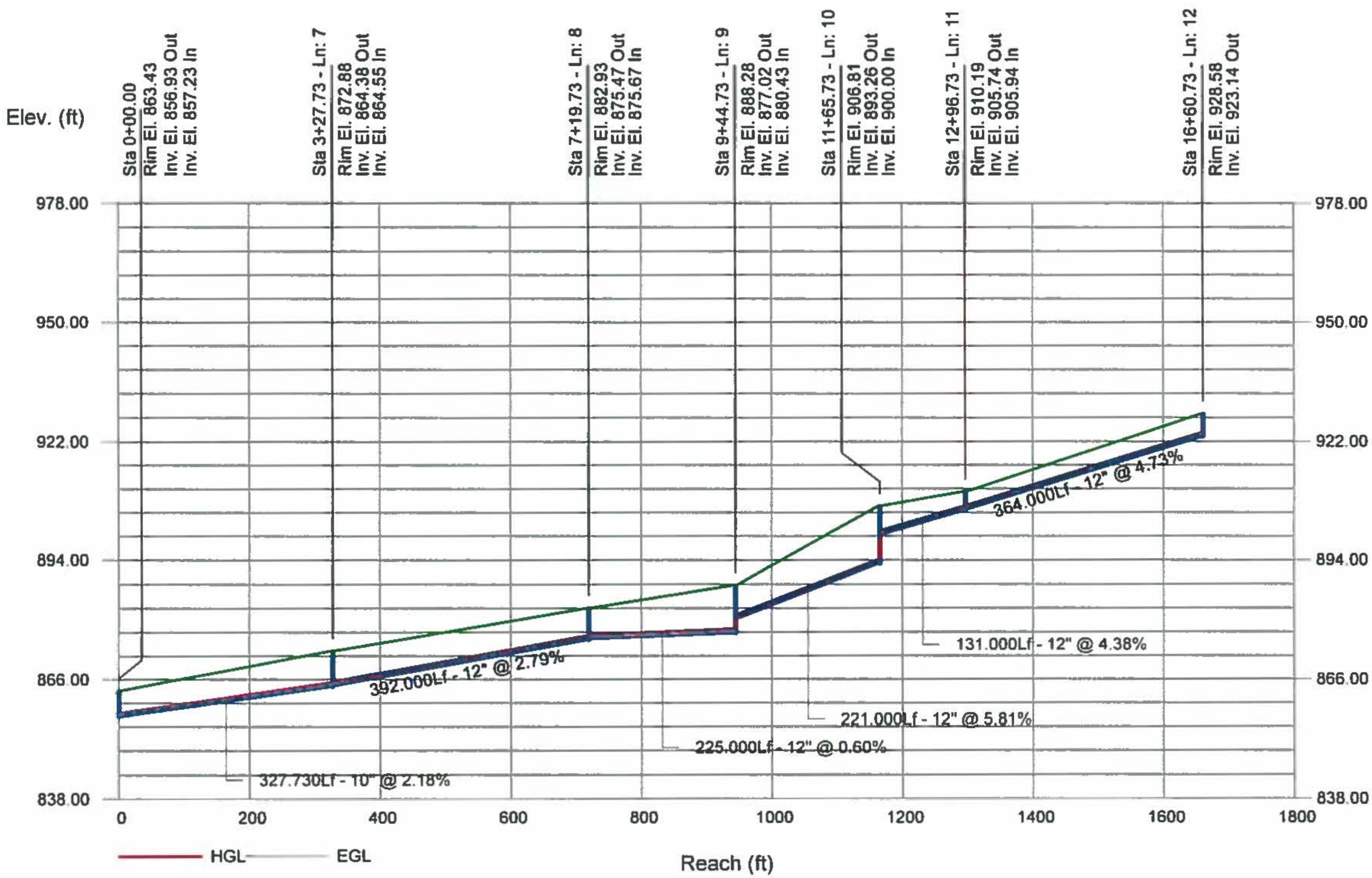
E2

Storm Sewer Profile



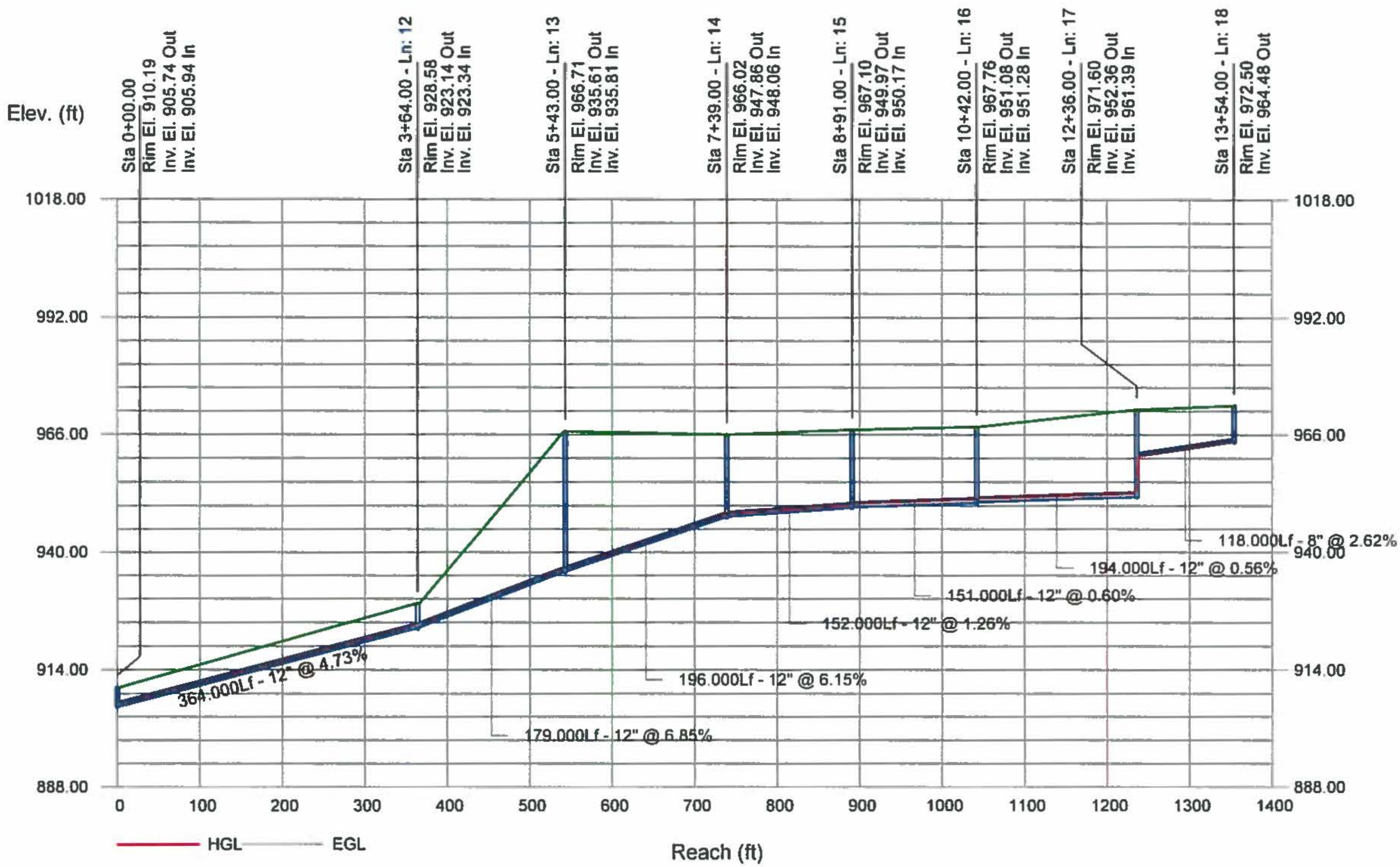
E-3

Storm Sewer Profile



E-4

Storm Sewer Profile



E-5