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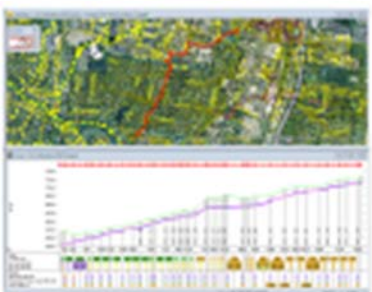

City of Brentwood
Sewer System Master Plan

Job no

October 2016

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List of Acronyms

Abbreviation	Definition
BPS	Brentwood Pump Station
CAP/ER	Corrective Action Plan / Engineering Report
CMOM	Capacity, Management, Operation, and Maintenance
d/D	Ratio of Peak Dry-Weather Depth to Full-Pipe Depth
DWF	Dry-Weather Flow
EQ	Equalization
HGL	Hydraulic Grade Line
I&I	Inflow and Infiltration
LHRB	Little Harpeth River Basin
LS	Lift Station
MGD	Million Gallons Per Day
MP	Brentwood Sewer Master Plan
MPO	Nashville Area Metropolitan Planning Organization
MWS	Metro Water Services
OCB	Owl Creek Basin
TDEC	Tennessee Department of Environment and Conservation
UGB	Urban Growth Boundary

Executive Summary

The City of Brentwood (Brentwood) continues to implement an aggressive collection system rehabilitation program to address inflow and infiltration (I&I). Tremendous success has been documented regarding the on-going program. To date, many of the larger sources of I&I have now been identified and corrected. Brentwood's on-going rehabilitation program will continue to result in improved system performance and provide infrastructure renewal to extend the life of existing pipelines.

In addition to removing I&I from the collection system, Brentwood also determined the need for a comprehensive wastewater collection system master plan. The intent of the master plan is to provide the city with a detailed plan to proactively address future collection system improvement needs. Hazen and Sawyer (Hazen) was contracted by Brentwood to develop the comprehensive master plan (MP) for both short and long-term planning. Development of the MP utilized existing reports, multiple-source historical and planning records, and a calibrated hydraulic model developed specifically for the Brentwood collection system.

To facilitate the timing and planning for recommended improvements, future collection system flows were projected for various planning horizons. The selected planning horizons included Years 2020, 2030, and an ultimate buildout scenario in which no further growth would be allowed under current zoning regulations.

The MP was developed to provide a level of service corresponding to a 2-year, 24-hour dormant season design storm. The design storm was previously developed and adopted for the Brentwood Corrective Action Plan and Engineering Report (CAP/ER). This design storm is used regularly and approved by Tennessee's Department of Environment and Conservation (TDEC) for collection system master planning throughout the state of Tennessee. The design storm represents 3.15 inches of rain over a 24-hour period. Recommended improvements are aimed at providing the required capacity to store and convey projected flows that are predicted to occur during the design storm event. To put in perspective, the statistical odds of such an event occurring in any particular year is 50%; or once every two years.

Various types of collection system improvements were evaluated to address predicted exceedances of hydraulic capacity. These included on-going sewer rehabilitation, upsizing lines and pumps, and constructing equalization storage.

The MP provides a detailed roadmap for needed capital improvements within Brentwood's collection system including conveyance, storage, and rehabilitation. A schedule and cost estimates are provided for the recommended system improvements.

Population and Flow Projections

The starting point or base year for projections was chosen as Year 2015 since the hydraulic model was generally developed and calibrated to this period. For the MP, planning horizons were chosen as Year 2020, Year 2030, and a non-specified year in the future representing complete buildout for Brentwood in terms of reaching its maximum sewer capacity.

The four primary sources of data utilized for flow projection were the following:

- Winter Average Water Billing Data
- Sewer Availability Applications
- Nashville Area Metropolitan Planning Organization (MPO) Population and Employee Projections
- Brentwood Zoning Ordinance

MP flow projections, which were based on residential population and employee count, were determined with two different methodologies. For the planning horizons of Years 2020 and 2030, MPO projections were used exclusively for areas outside of known developments. However, since the MPO data only extended to Year 2040, the ultimate buildout scenario combined MPO projections in Year 2040 for developed areas with a tabulation of available lots for undeveloped areas based on allowable zoning densities.

It should be noted that not all City of Brentwood residents were included in the flow projections for this planning report since some Brentwood residents are served by other providers. For example, an area in the northeast quadrant of the city is served by MWS and a small area at the intersection of Moores Lane and CSX Railroad is served by the City of Franklin. Table ES-1 shows the final resulting residential population projections for Brentwood's sewer service area.

Table E-1: Projected Population of Sewer Service Area

	2015	***2020***	***2030***	***2040***	***Ultimate***
Little Harpeth Basin	27,300	30,200	33,300	34,500	36,700
Owl Creek Basin	6,000	7,100	8,800	10,100	12,800
Total Service Area	**33,300**	**37,300**	**42,200**	**44,600**	**49,500**

System Evaluation

The Brentwood collection system was modeled under both current and future conditions to determine locations where overflows are predicted to occur during the design storm event. For future conditions, it was assumed that a certain amount of I&I would be removed due to rehabilitation efforts. The areas identified for 25 % I&I reduction represent sub-basins where rehabilitation plans are known to be underway and 10% I&I reduction for other areas in the system likely to be rehabilitated. Since rehabilitation is ongoing as a component of Brentwood's Capacity, Management, Operations, and Maintenance (CMOM) program, planners assumed that I&I reductions from rehabilitation are maintained over the planning horizons beginning in Year 2020.

Results from model simulations predict future overflows could occur along the trunk sewer leading to Brentwood Pump Station (BPS) during the design storm event. While the magnitude increases as projected flows increase, the impacted locations along the trunk sewer essentially remain the same. The primary cause of hydraulic capacity exceedance is a high surcharge during peak flows.

Starting in Year 2030, localized capacity exceedance is predicted to occur in the vicinity of the Scales School LS, Chenoweth LS, and in two other locations due to capacity exceedance due to future increases in flow along certain gravity line segments.

Alternative Evaluation

Alternatives were developed and evaluated for capacity-limited areas over the established planning horizons. Although the trigger to identify needed improvements was solely based on the presence of predicted potential overflow during the design storm, three standard performance measures were considered in development of alternatives. These measures relate to the depth of flow in the pipeline during dry weather conditions or the wet-weather peak hydraulic grade line (HGL),

Alternatives were categorized into those areas along the trunk sewer and those occurring in other areas within the collection system. For trunk sewer improvements, flow equalization (EQ), upsize of BPS and upsize of the trunk itself were evaluated. In areas away from the trunk, improvements (e.g. upsizing of pump station capacity or gravity line upsizing) were modeled to determine how future-predicted hydraulic limitations could be eliminated.

Recommendations

It was determined that the capital improvements having the largest impact toward reducing predicted overflow and surcharge in Brentwood's system are those that address the trunk sewer from Concord Rd to BPS. Two EQ tanks were shown to significantly improve current operating conditions and eliminate overflows while meeting desired surcharge levels for the majority of the trunk. One EQ tank is recommended at BPS and the other midway upstream along the trunk sewer near the I-65 and Concord Rd area (Mid-Trunk).

The optimum EQ configuration at BPS was modeled as a passive diversion structure with a 5.5-MGD EQPS and 3-MG storage tank. Once filled, this tank would drain back slowly by gravity into BPS as peak flows subside.

The optimum Mid-Trunk EQ was modeled as a passive/dynamic diversion structure with a flow restriction on the trunk sewer to force the majority of wet-weather peak flow into the EQ tank. The control for this restriction would be a slide gate based on limiting surcharge in the downstream trunk sewer to acceptable levels. A 9-MGD EQPS and 7-MG storage tank would be required. Once filled, this tank would drain back slowly by gravity into the trunk sewer as peak flows subside.

According to growth projections and hydraulic modeling, the BPS EQ is recommended for construction in the near term. This would immediately address hydraulic restrictions in the lower portion of the Brentwood collection system upstream of BPS. The Mid-Trunk EQ is recommended for construction by Year 2030. In the interim, the effectiveness of the BPS EQ can be monitored and the Mid-Trunk EQ concept and controls can be refined as warranted.

Locations outside the influence of the trunk sewer where the model predicted capacity limitation during future conditions should be monitored periodically to determine if/when improvements should be made.

These locations include the Scales School LS, Chenoweth LS, gravity lines in the vicinity of Franklin Road/Longstreet Drive, and gravity lines near the MWS connection in the Owl Creek Basin (OCB).

Finally, an I&I study is recommended for the OCB to identify areas in need of rehabilitation. I&I in this basin is higher than Little Harpeth River Basin (LHRB). Once the study is complete, ultimate buildout flow projections can be revisited to determine needed capacity from MWS at the OCB connection.

Table ES-2 provides a summary of recommended projects with scheduled duration and projected cost resulting from the MP.

Table E-2: Summary of Recommended Improvements

Recommended Project by 2020	Start	Finish	Cost
Brentwood Pump Station EQ	Jul-2019	Jun-2021	6,109,000
Recommended Projects by 2030			
Owl Creek I&I Study and Rehabilitation	Dec-2016	Jul-2030	1,500,000
Mid-Trunk EQ	Jul-2027	Dec-2029	9,546,000
Franklin Road / Longstreet Drive Gravity Upsize	Jul-2020	Jun-2030	200,000
Recommended Projects by Ultimate Buildout			
Owl Creek Gravity Upsize	Jul-2030	Jun-2040	380,000
Chenoweth LS Improvements	Jul-2025	Jun-2035	100,000
Scales School LS Improvements	Jul-2025	Jun-2035	150,000

Total **17,985,000**

1. Introduction

1.1 Collection System Overview

Brentwood maintains a sanitary sewer collection system, which serves approximately 33,000 residential customers plus commercial areas, and consists of approximately 280 miles of sanitary sewers, 2,800 grinder pumps, and 11 lift stations. All wastewater generated by Brentwood is ultimately conveyed to MWS for treatment.

Brentwood consists of two primary sewer basins: Little Harpeth River and Owl Creek. Although largely insignificant and not considered in this report, four much smaller areas in Brentwood's system are also connected by gravity to MWS. These locations are Williams Grove, Inavale, Stanfield Road, and Bonbrooke. In addition to connections that *send* flow to MWS, Brentwood also has eleven connections that *receive* flow from MWS. Figures 1-1 and 1-2 show an overview of Brentwood's system with and all interconnections between Brentwood and MWS.

Figure 1-1: Brentwood Collection System Overview Map

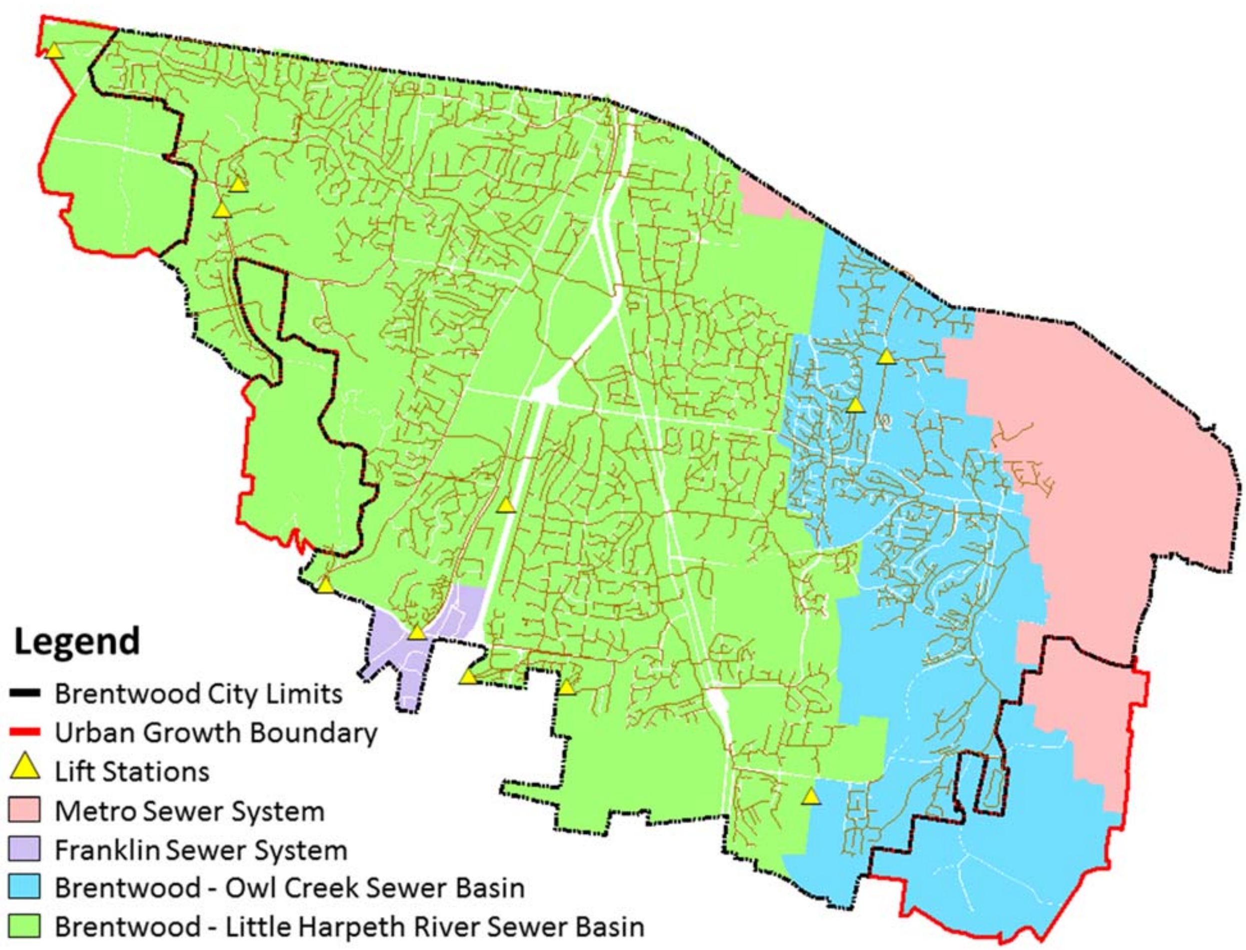
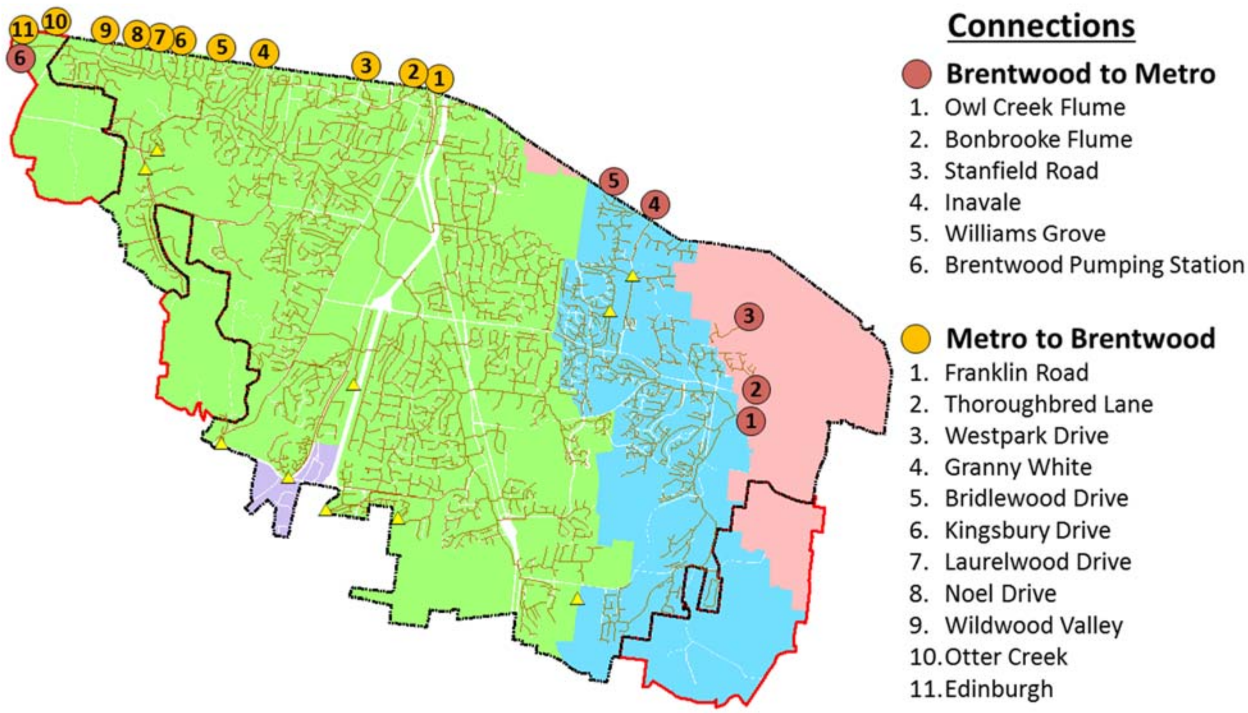
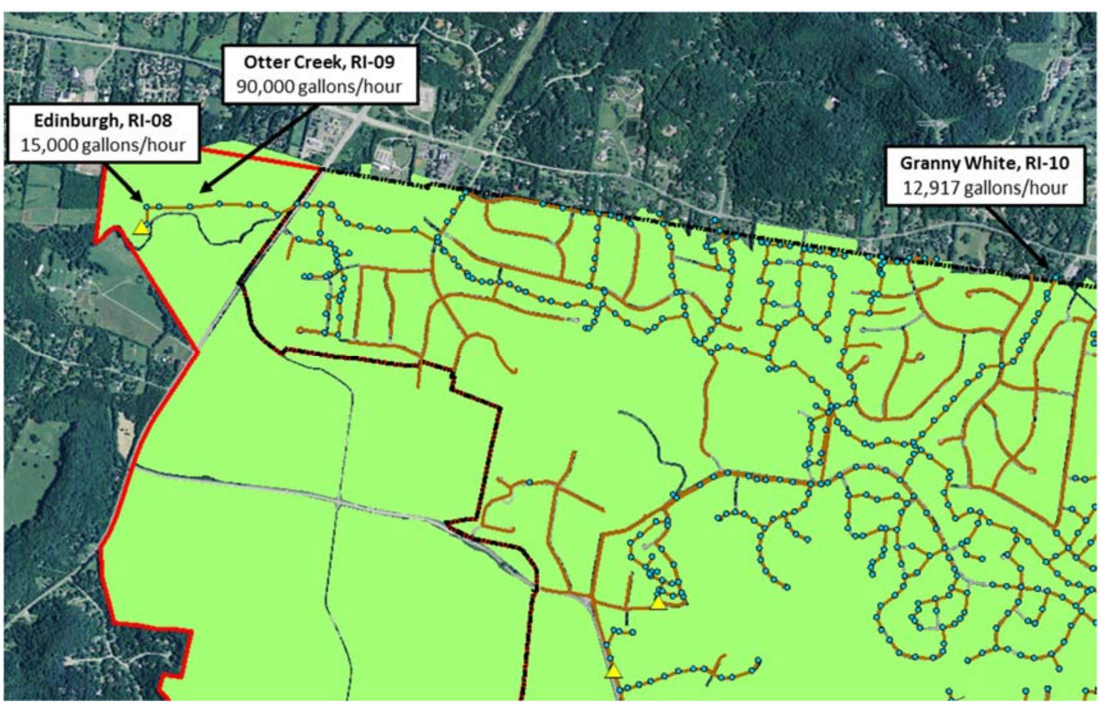


Figure 1-2: Brentwood Collection System Connections



All eleven connections that receive flow from MWS are re-pumped back to MWS by BPS. Maximum flow through these connections is limited by contractual terms between Brentwood and MWS and summarized in Figure 1-3.

Figure 1-3: Maximum Limits for MWS to Brentwood Connection Points



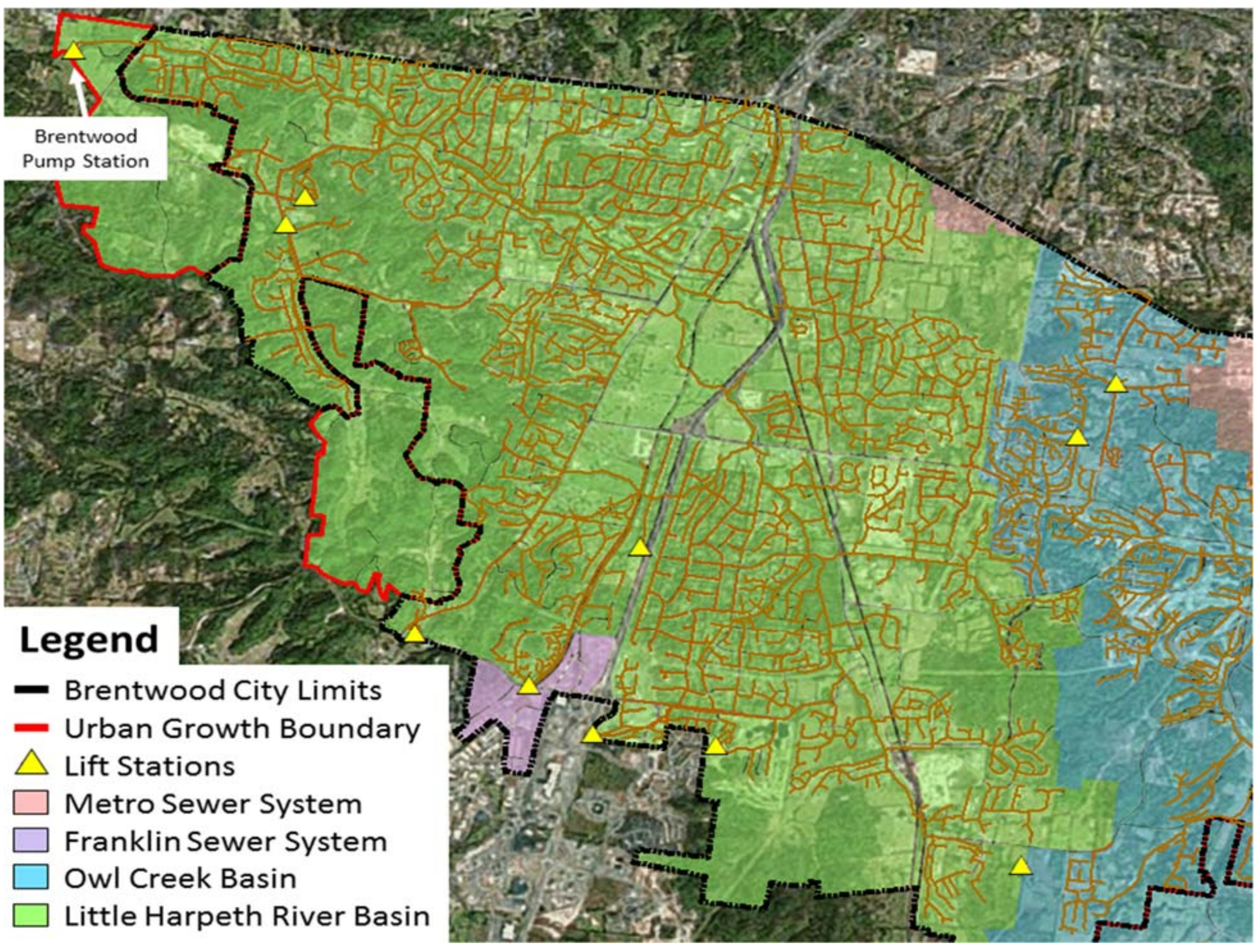
The area within Brentwood's sewer service area is not defined exclusively by its city limits or its urban growth boundary (UGB). While based on these areas, the sewer service area also must have topography that allows it to be served by gravity conveyance or near enough to such an area that a small pump station could be constructed to pump flow "over the hill" to reach the nearest gravity line. As such, a significant portion of the eastern part of Brentwood's city limits and UGB either are currently or will in the future be served by MWS. Also, a small area near Moores Lane and General George Patton Drive is currently served by the city of Franklin and therefore outside of Brentwood's sewer service limits.

1.1.1 Sewer Basins

1.1.1.1 Little Harpeth River Basin

As shown in Figure 1-4, LHRB is Brentwood's largest basin at just over 18,000 acres (or 28 square miles) and constitutes the majority of its total wastewater flow. All flow from LHRB is pumped to MWS from Brentwood Pump Station (BPS).

Figure 1-4: Little Harpeth River Basin



1.1.1.1.1 Brentwood Pump Station

BPS is Brentwood's largest station and the single point of conveyance for the majority of its wastewater flow to MWS. As stipulated in the contract between Brentwood and MWS, the maximum allowable pumping rate at BPS is currently set at 9.5 mgd.

As shown in Figure 1-5, the average dry-weather daily flow coming to BPS, including sanitary flow and groundwater infiltration, is approximately 3.68 mgd. This number can be further broken down into MWS and Brentwood flow as shown in Figure 1-6.

Figure 1-5: Average Dry-Weather Daily Flow to Brentwood Pump Station

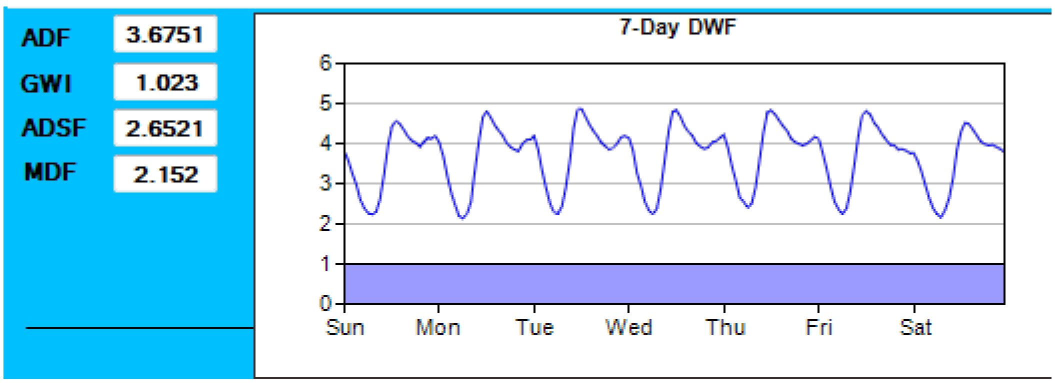
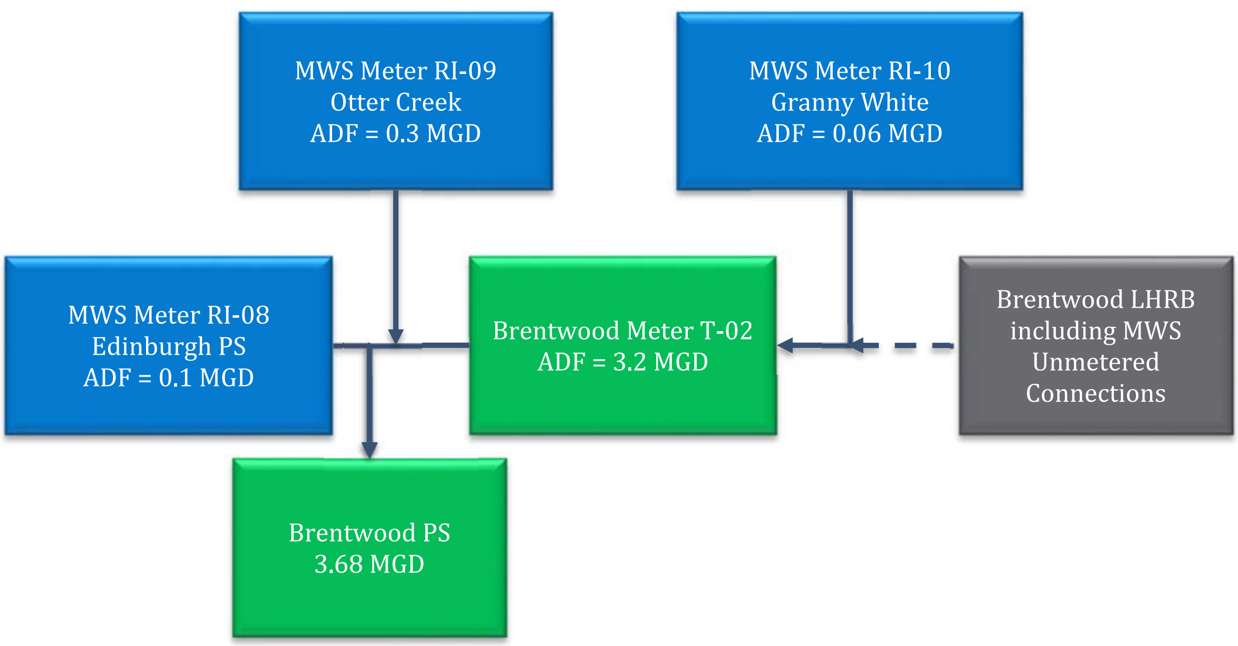


Figure 1-6: Brentwood Pump Station Receiving Flow



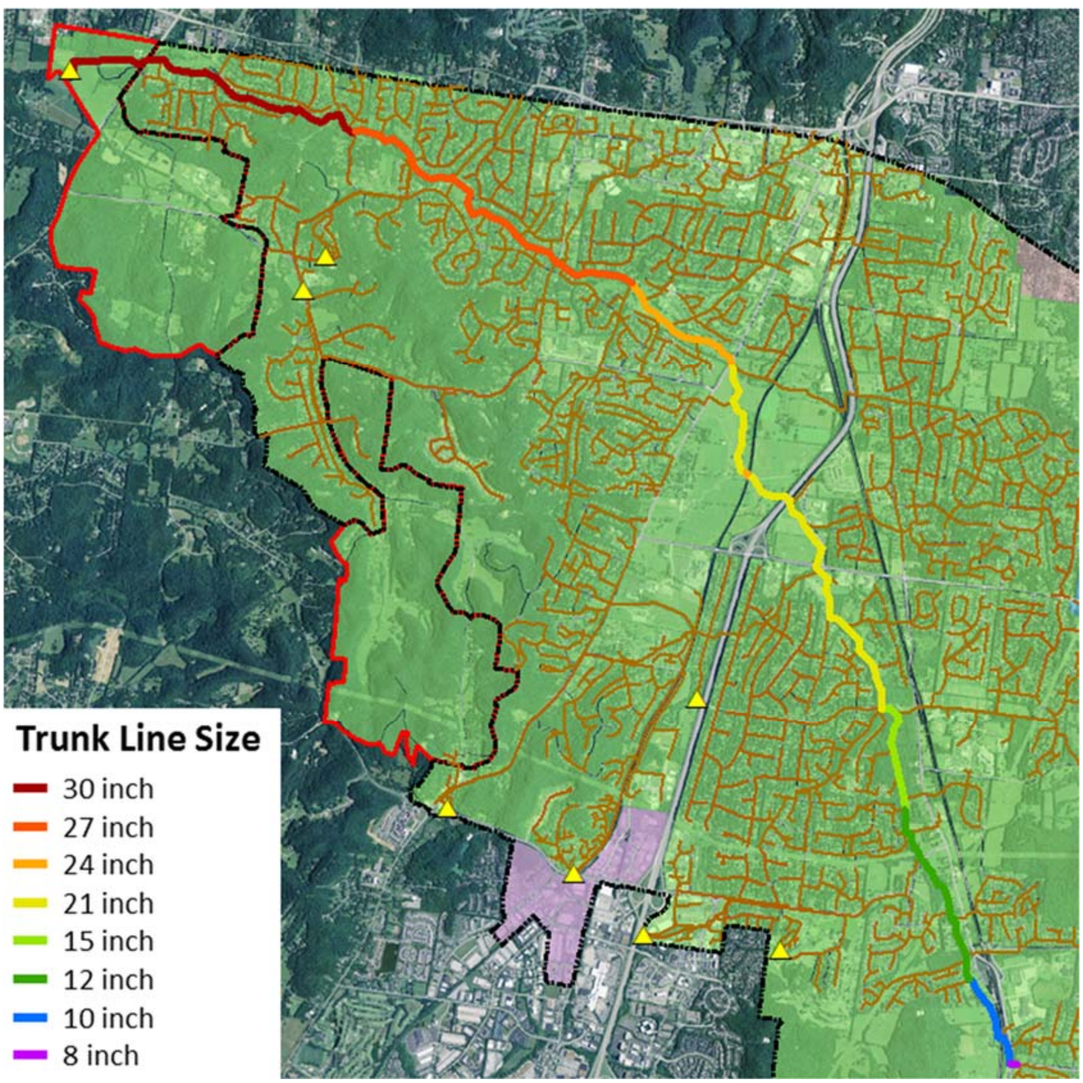
1.1.1.1.2 Characterization of Flow

Although LHRB is mostly residential, it contains the commercially zoned parcels in Brentwood's business districts. The LHRB residential population is approximately 26,000. The non-residential component of LHRB is comprised of nearly 500 accounts or an estimated 0.9 mgd average daily flow. These figures are based on analysis of water billing records for the LHRB service area and data from Brentwood's flow meters.

1.1.1.1.3 Trunk Sewer

As shown in Figure 1-7, the LHRB contains a large trunk sewer that ranges in size from 10 to 30 inches and extends over 10.7 miles from Split Log Road to BPS. This line is routed alongside the Little Harpeth River. Most manholes along the trunk have watertight covers installed to prevent receiving inflow from ponding or flooding during wet-weather events.

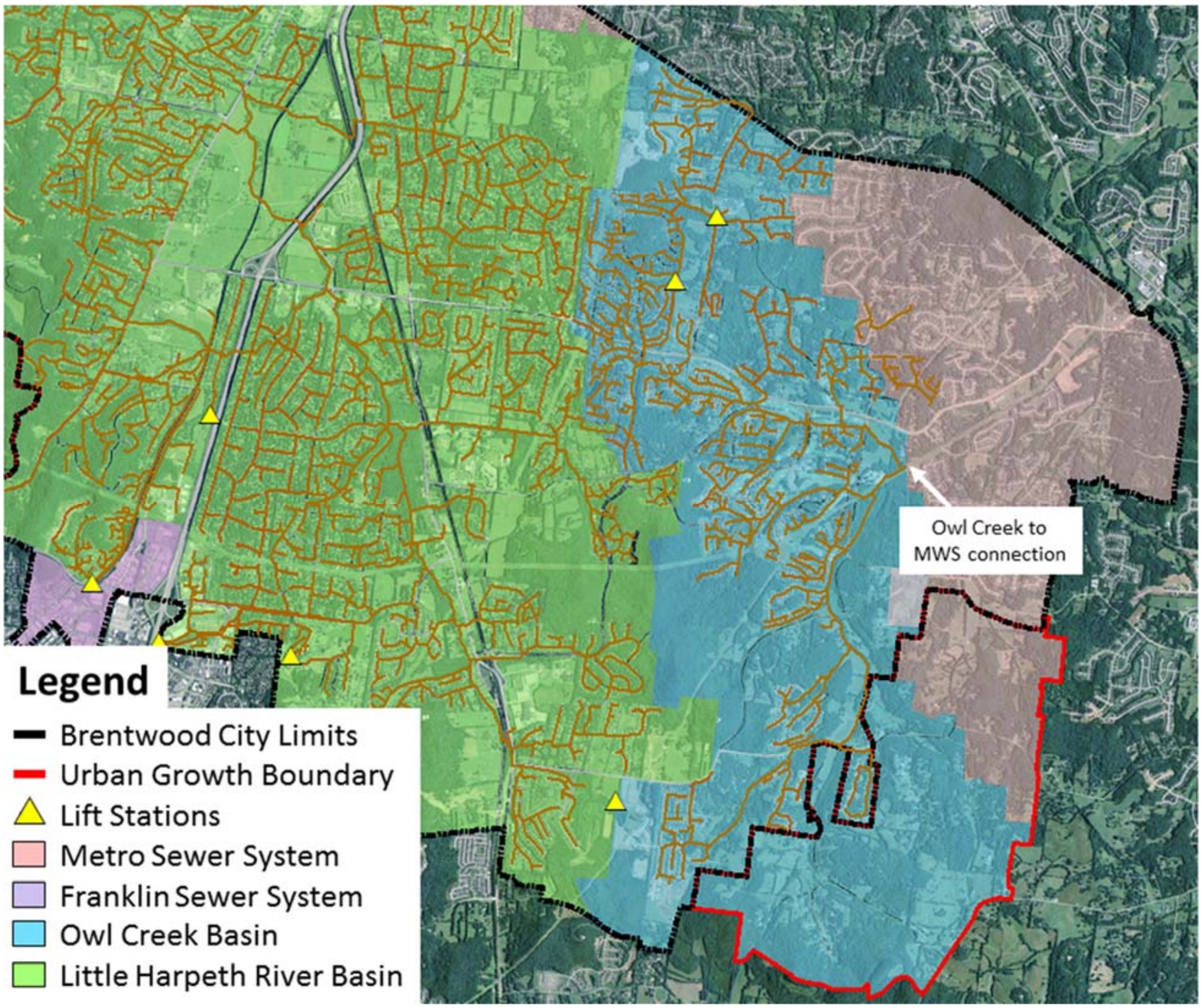
Figure 1-7: Trunk Line



1.1.1.2 Owl Creek Basin

As shown in Figure 1-8, Owl Creek Sewer Basin (OCB) is situated on the eastern side of Brentwood's system and connects to MWS at a single gravity connection point in the vicinity of Sunset Road and Concord Road. Including all potential service areas in the UGB, OCB covers an area of over 6,000 acres (or just under 10 square miles). It is both smaller in size and less developed then LHRB.

Figure 1-8: Owl Creek Basin



The average dry-weather daily flow from OCB, including sanitary flow and groundwater infiltration, is approximately 0.6 mgd. As stipulated in the contract between Brentwood and MWS, the maximum allowable flow from OCB to MWS is currently set at 2.5 mgd.

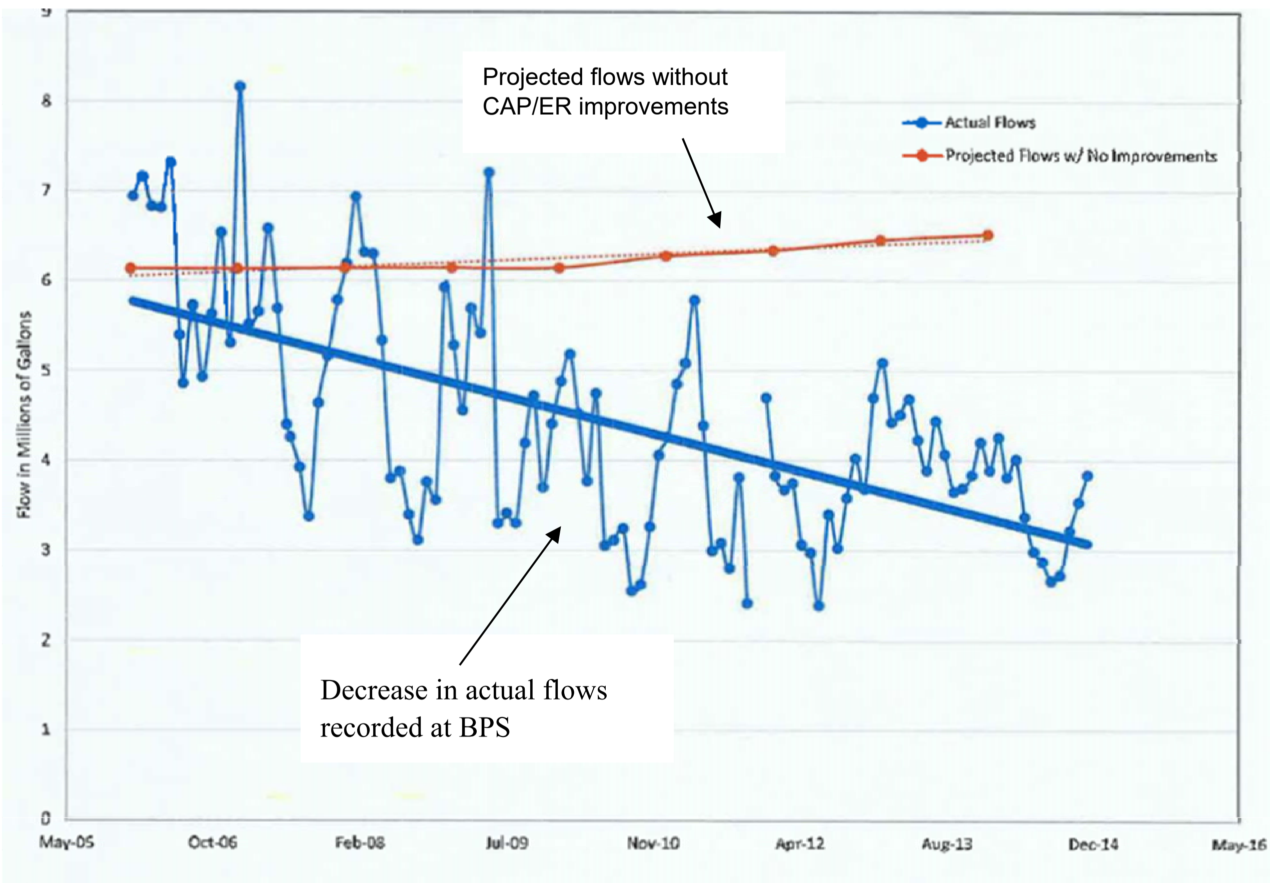
OCB is predominantly residential and the current total population served is approximately 7,000 based on analysis of water billing records and average daily sanitary flow from the flow meter at the Owl Creek connection with MWS.

1.2 Brentwood CAP/ER Rehabilitation Success

Since 2004, Brentwood has completed three CAP/ER phases in response to an Agreed Order between Brentwood, MWS, and TDEC. During this time Brentwood has made progress in reducing overflows at BPS by implementation of a targeted rehabilitation program designed to reduce I&I from entering its system.

Figure 1-9 shows the reduction of average daily flows at BPS over a 10-year period. Without rehabilitation, flows would have most likely increased rather than decreased given the growth that occurred over this period. The MP is the next step in Brentwood's efforts to build upon past successes and attempt to proactively address capacity needed for future conditions.

Figure 1-9: Flows at BPS 2005 - 2015



2. Population and Flow Projections

The starting point or base year for projections was chosen as 2015 since the hydraulic model was generally developed and calibrated to this period. For the MP, planning horizons were chosen as Year 2020, Year 2030, and a non-specified year in the future representing complete buildout for Brentwood in terms of reaching its maximum sewer capacity.

2.1 Sources of Information

2.1.1 Winter Average Water Billing Data

Brentwood provided its billing data for water customers, which included a winter average calculation. This number is representative of the true residential or non-residential water usage per water meter account without irrigation or seasonal usage. This data was particularly useful for the commercially zoned districts of Brentwood to determine flows for existing customers.

2.1.2 Sewer Availability Application Forms

Developers are required to submit a formal request for water and/or sewer availability prior to any new residential or non-residential development within Brentwood. In cases where this information was available, it was used as the basis for projecting flows in the hydraulic model. Examples of such recent developments are the Tapestry Condominiums, Hill Center, and Spring Hill Suites Hotel. All developments in this category were assumed to be fully built out by Year 2020.

2.1.3 Nashville Area Metropolitan Planning Organization

As shown in Figure 2-1, the Nashville Area MPO Planning Area officially includes seven counties (blue) which includes Williamson County (orange outline), and is responsible for the development of the region's long-range transportation plan in conjunction with state and federal transportation authorities. Population forecasts developed by the MPO are based on a regional land use model, which allocates future households and employment throughout the region based on the land use policies and each parcel of land's ability to attract new growth.

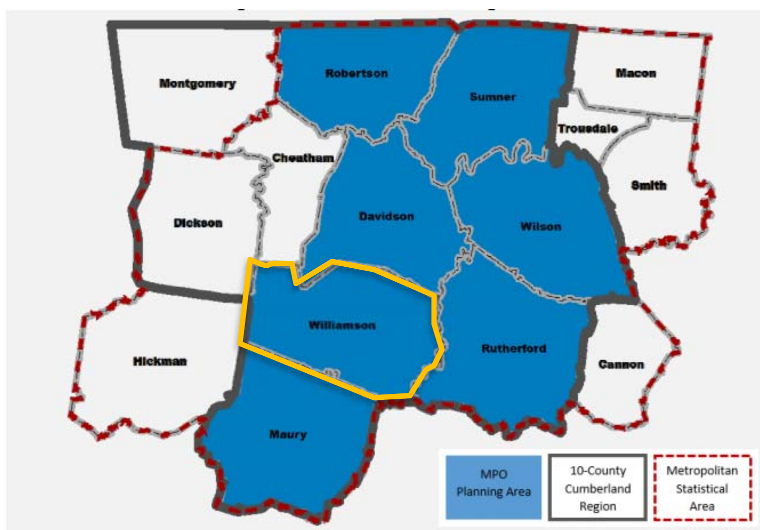


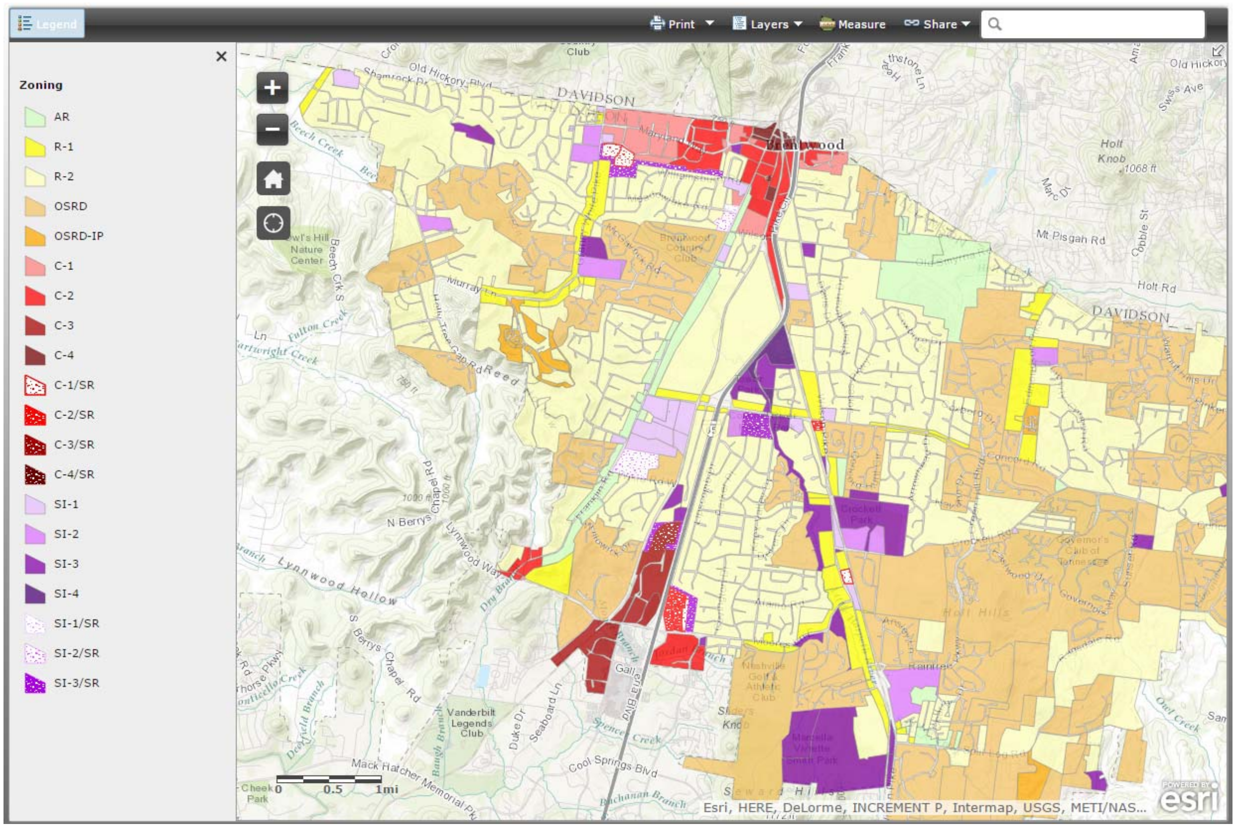
Figure 2-1: Nashville Area MPO Planning Area

Although data from the MPO was used for Years 2020 and 2030, it was not considered suitable to use by itself for the ultimate buildout scenario. Buildout in OCB is not projected to be completely built out until well after Year 2040. Therefore, available land and allowable zoning densities were also considered for the ultimate buildout scenario.

2.1.4 Brentwood Zoning Ordinance

The current zoning ordinance for Brentwood is found in Chapter 78 of the City of Brentwood's Municipal Code. It outlines descriptions of allowable zoning designations and is the primary technique of land use planning utilized by Brentwood. Among the unique aspects of Brentwood's zoning policy is a maximum allowable density of one dwelling unit per acre for residential use. The zoning policy also requires a minimum lot size of three acres for parcels located at elevations above 850 feet, which is identified as the Hillside Protection District. Figure 2-2 below shows the current zoning for Brentwood.

Figure 2-2: Current Brentwood Zoning



2.2 Flow Projections

Future wastewater flows were projected for Brentwood based on MPO forecast modeling results, which is a snapshot of how the population of Brentwood could grow. The modeling for the MPO projections was based on several factors including parcel size, property desirability, steepness of terrain, current zoning and future land use guidelines.

Should Brentwood change any of its guidance documents for future land use or zoning, the effects of these changes will be reflected during the next MPO modeling period. For example, if Brentwood allowed attached residential in a certain zoning district during a MPO modeling period but then chose to remove it from either their Zoning Ordinances or Long-Range Development Plan, the MPO would over-predict population for that zone for that modeling period.

It should be noted that any particular re-zoning of parcels to a different usage type to accommodate a higher-density development would be addressed in a separate capacity evaluation as part of the water/sewer availability application process. During this process, any additional capacity upgrades (if necessary) for the collection system would be identified.

2.2.1 Planning Horizons 2020 and 2030

In order to identify local population and socioeconomic trends, Hazen was able to obtain data and projections from the MPO for Year 2020 and 2030. These MPO population projections were used to calculate collection system flows for areas that did not already have projected flows related to known developments.

The MPO population data for the city limits of Brentwood was first verified with Brentwood's special census data from 2015. By overlaying the MPO population shapefile on the Brentwood city limits, it was determined that the MPO was indeed a good match in terms of residential population. The MPO population in 2015 was estimated[1] at 42,200 compared to the Special Census result of 40,401.

In order to obtain population data for only the Brentwood sewer service area, the MPO shapefile was clipped to the collection service boundary and was further divided into the Owl Creek and Little Harpeth sewer basins. It should be noted that all areas within Brentwood city limits are *not* included in Brentwood's sewer service area, which is the relevant area for the purpose of the MP. It should also be noted that all area within the UGB is again *not* included in Brentwood's sewer service area. The sewer service area was determined primarily by ability to receive sewer flow, which is dependent more on watershed topography than anything else.

Figure 2-3 shows Brentwood's Service Area overlaid with the MPO blocks. Additionally, the MPO population data projections for Brentwood's sewer service area can be found in Table 2-1.

[1] The word "estimated" is used since the overlay of the MPO shapefile onto the city limits was not perfectly the same. Estimation by proportionally adjusting population by area was performed on MPO tracts that "straddled" the city limit boundary.

Figure 2-3: Brentwood Service Area MPO Blocks

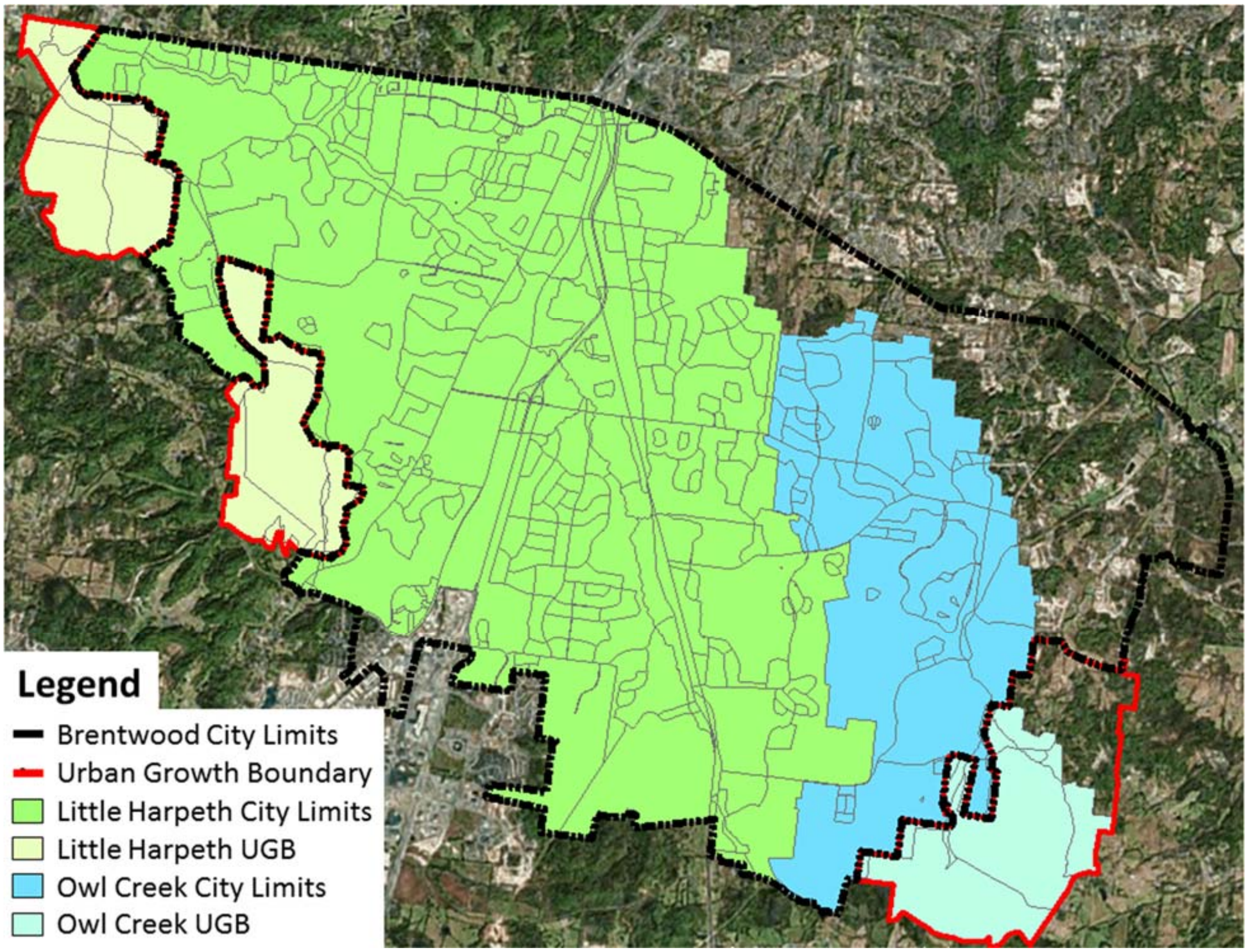


Table 2-1: Brentwood MPO Population Projections - (Sewer Service Area Only)

	Population			
	2015	**2020**	**2030**	**2040**
Little Harpeth Basin	27,300	30,200	33,300	34,500
Owl Creek Basin	6,000	7,100	8,800	10,100
Total	**33,300**	**37,300**	**42,100**	**44,600**
Annual Growth Rate		2.3%	1.2%	0.6%

A large portion of the population increase within the collection system area over the next 15 years is seen in the undeveloped areas in the northwest and southeast portions of the service area, shown in Figures 2-4 and 2-5.

Figure 2-4: Projected Population Change (2015 - 2020)

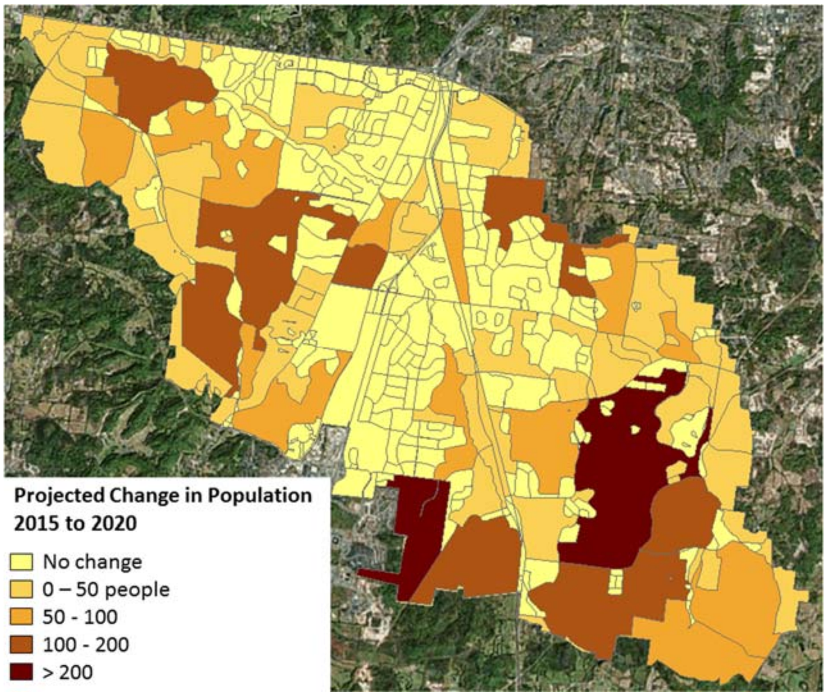
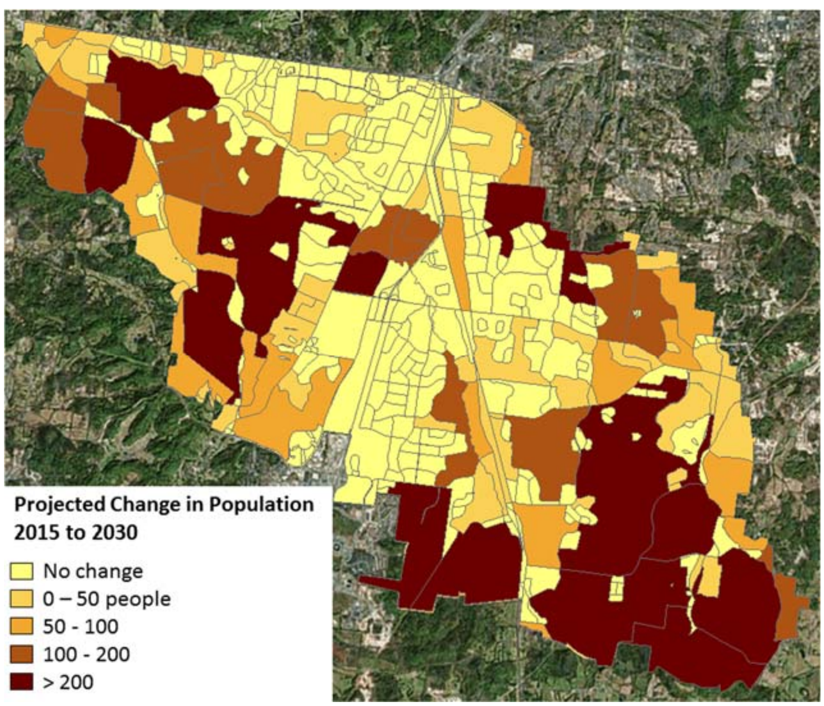


Figure 2-5: Projected Population Change (2015 - 2030)



The MPO provides employee data that is vital to projecting future collection system flow for commercial areas. The largest such projected increases, as shown in Figures 2-6 and 2-7, are seen in the northern and southern portions of the collection system that are in close proximity to Interstate 65.

Figure 2-6: Projected Employment Change (2015 - 2020)

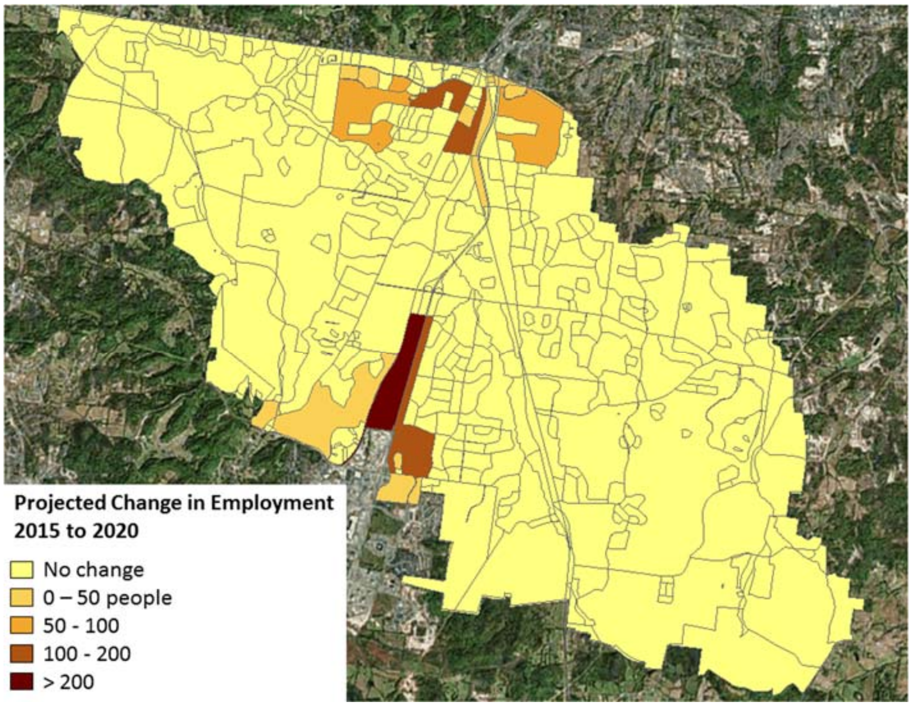
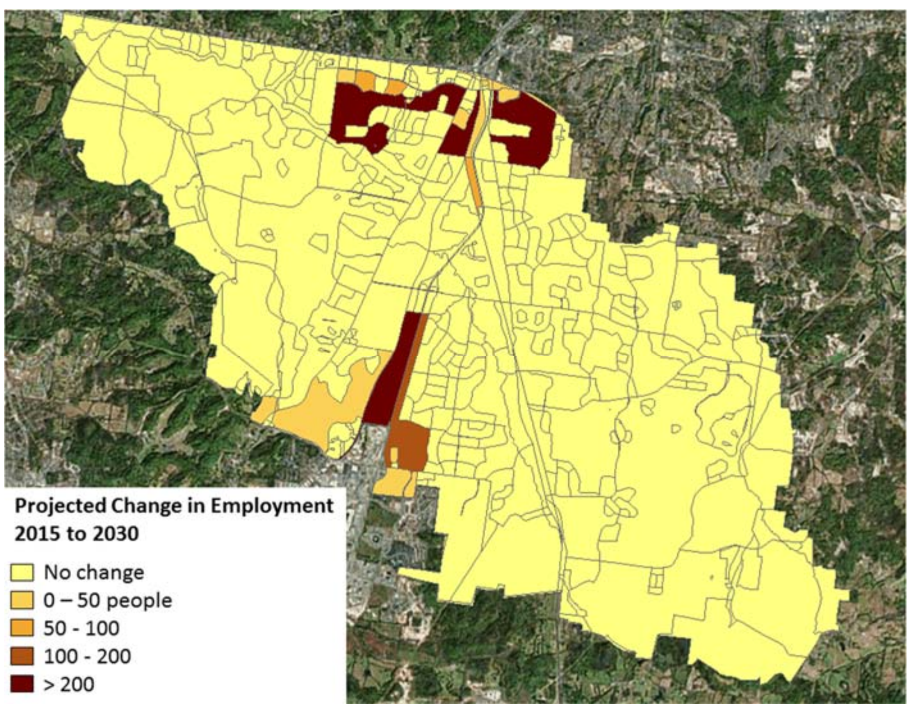


Figure 2-7: Projected Employment Change (2015 - 2030)



2.2.2 Ultimate Buildout

Beyond the planning horizons of Year 2020 and 2030, a non-time-specific ultimate buildout scenario was developed to represent the maximum theoretical flows for Brentwood. Undeveloped land such as forest, farm land and areas within the Hillside Protection District were considered for potential development in this ultimate buildout situation. The population for undeveloped areas was calculated as a function of the amount of available land and allowable zoning density.

The evaluation resulted in a total of 2,900 and 2,200 potential residential lots within the LHRB and OCB, respectively. Figure 2-8 shows the potential developable lands considered for use in the calculations. The resulting population for the ultimate buildout scenario is shown in Table 2-2.

Figure 2-8: Potential Development

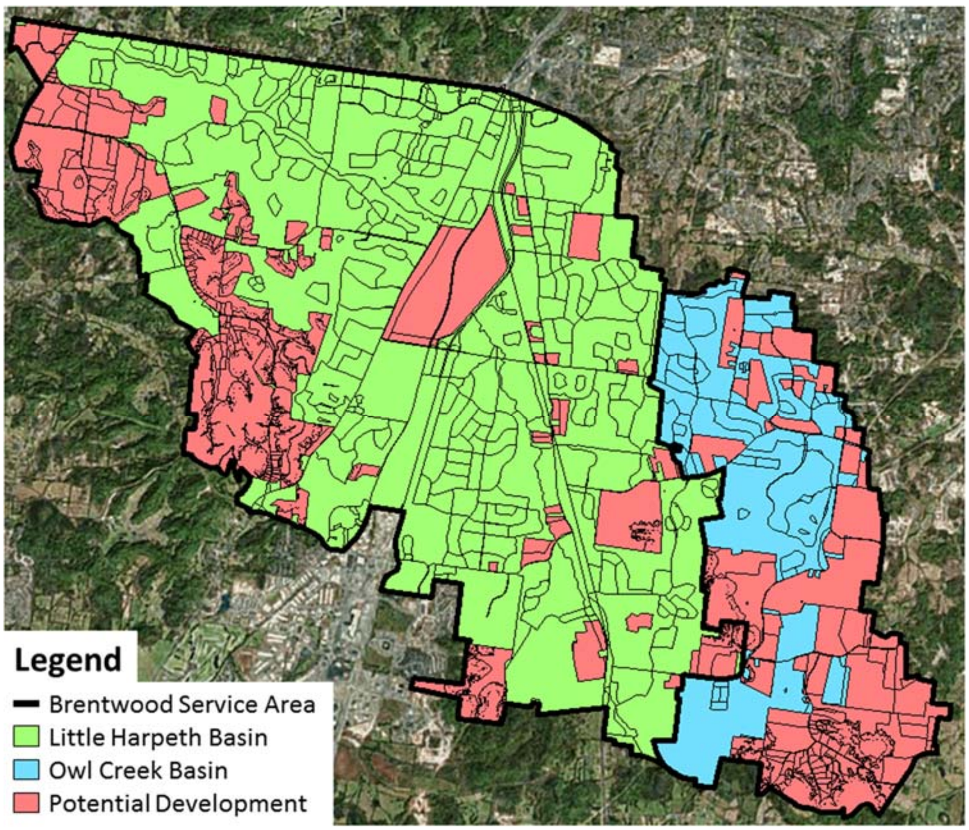


Table 2-2: Projected Ultimate Buildout Population - (Sewer Service Area Only)

	Population
Little Harpeth Basin	36,700
Owl Creek Basin	12,800
Total Service Area	**49,500**

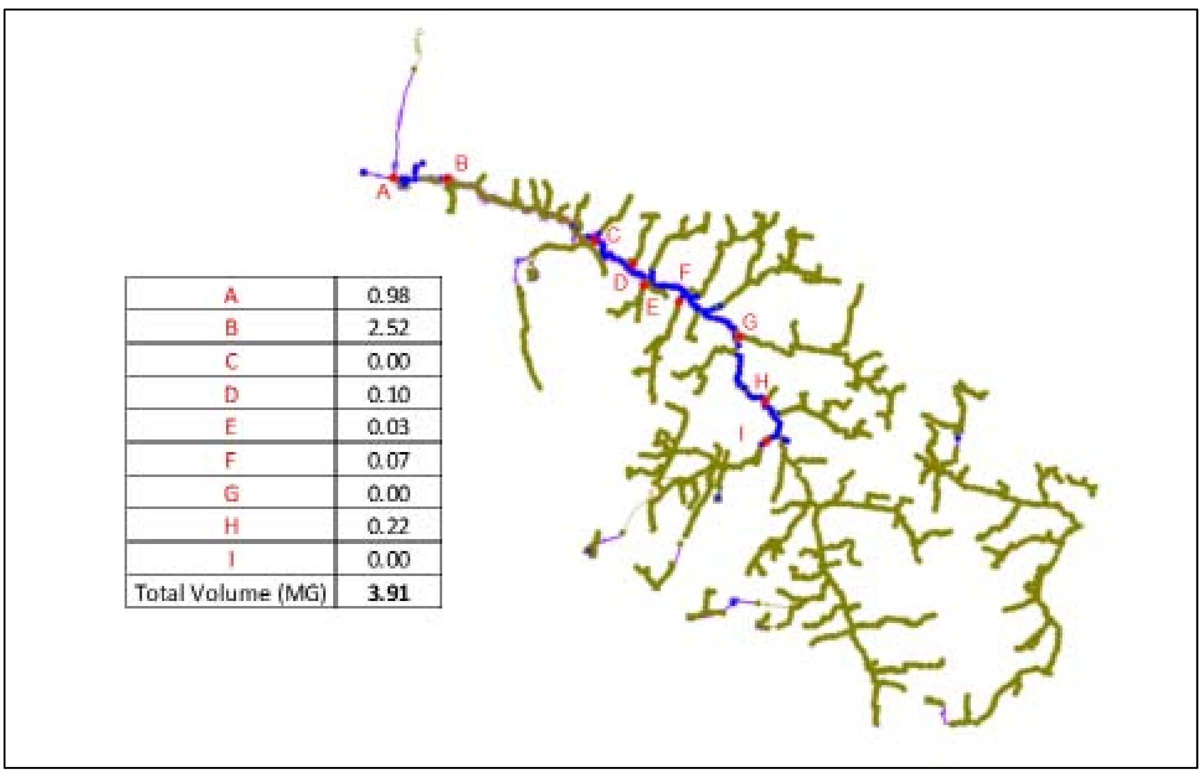
3. System Evaluation

Brentwood's collection system was modeled under both current and future conditions to determine locations where overflows are predicted to occur during the design storm event. For future conditions, it was assumed that a certain amount of I&I would be removed due to rehabilitation efforts. The areas identified for 25 % I&I reduction represent sub-basins where rehabilitation plans are known to be underway and 10% I&I reduction for other areas in the system likely to be rehabilitated. Since rehabilitation will continually be performed as a component of Brentwood's CMOM program, it was assumed that any reductions from rehabilitation would be maintained over the planning horizons beginning in Year 2020.

3.1 Current Conditions

Model simulations were conducted under current conditions to understand how the collection system responds during rainfall events. During peak flows, a section of the trunk sewer (blue) shows surcharge within pipe and overflows are predicted to occur at the locations shown in Figure 3-1. The overflow located at (B) is in the vicinity of Hillsboro Road and represents the largest volume of overflow. As shown, the overflows are exclusively located along the trunk.

Figure 3-1: Existing System Predicted Overflow



A	0.98
B	2.52
C	0.00
D	0.10
E	0.03
F	0.07
G	0.00
H	0.22
I	0.00
Total Volume (MG)	**3.91**

It should be noted that during model development of the baseline scenario, model predictions were discussed with Brentwood staff to obtain input based on long-term experience and familiarity with the sewer system during rainfall events. Through review of initial modeling results, adjustments were made as appropriate to ensure the model results were consistent with field observations.

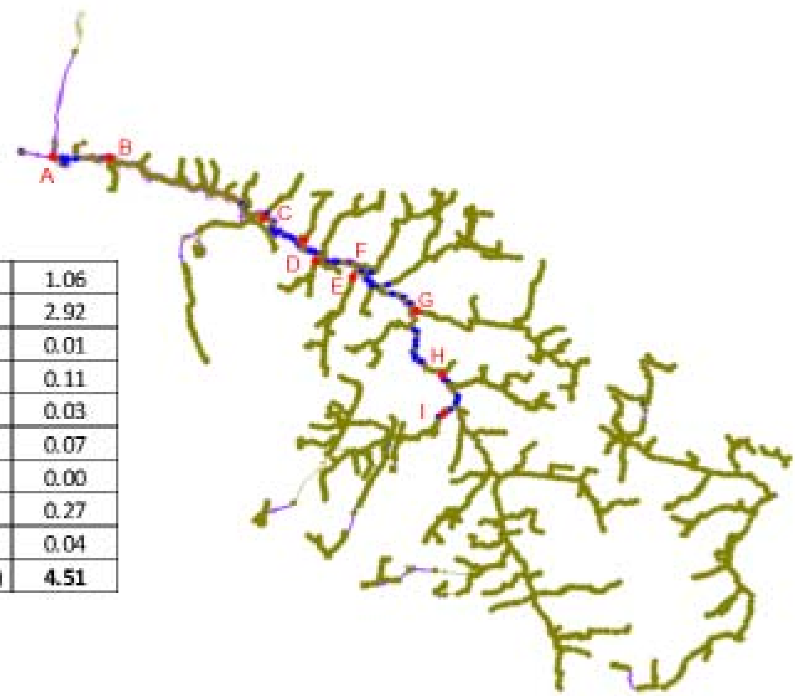
3.2 Future Conditions

3.2.1 Year 2020

For Year 2020, the model resulted in overflows as shown in Figure 3-2. As shown, the overflow locations are the same as those in current conditions. This scenario includes all known developments and projected increases in flow taken from MPO projections.

Figure 3-2: Year 2020 System Predicted Overflow

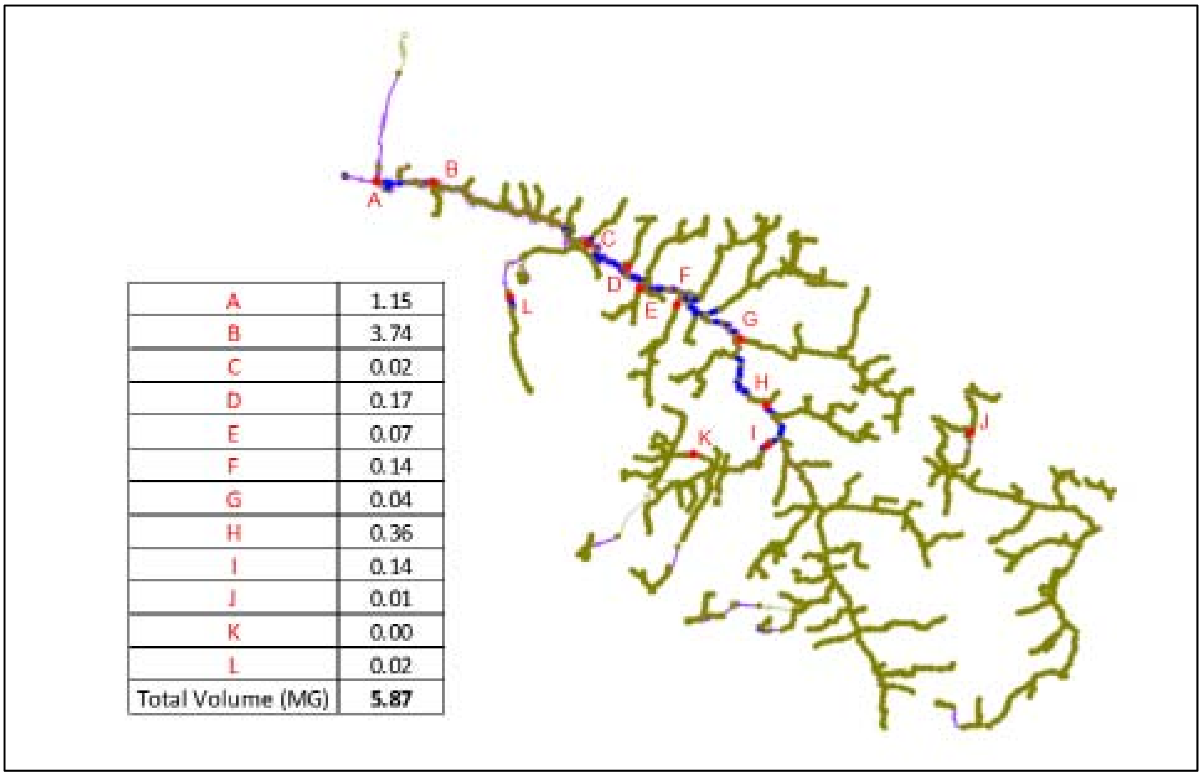
A	1.06
B	2.92
C	0.01
D	0.11
E	0.03
F	0.07
G	0.00
H	0.27
I	0.04
Total Volume (MG)	**4.51**



3.2.2 Year 2030

For Year 2030, the model resulted in overflows as shown in Figure 3-3. As shown, the overflow locations increase to include areas away from the trunk including the Franklin Rd / Longstreet Dr area (Ref. "K" - Figure 3-3) and Scales School LS (Ref. "L" - Figure 3-3). This scenario includes all known developments and projected increases in flow taken from MPO projections.

Figure 3-3: Year 2030 System Predicted Overflow

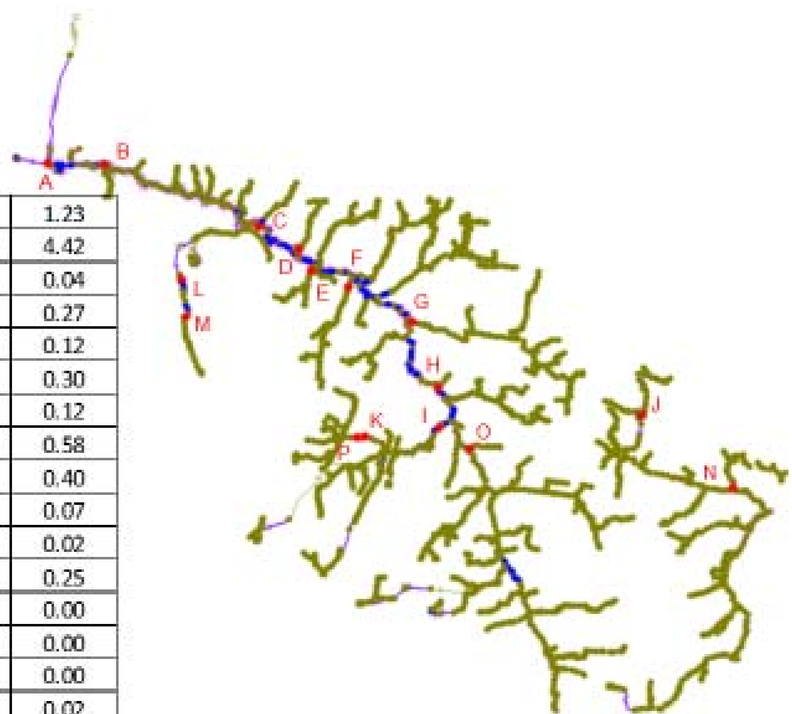


A	1.15
B	3.74
C	0.02
D	0.17
E	0.07
F	0.14
G	0.04
H	0.36
I	0.14
J	0.01
K	0.00
L	0.02
Total Volume (MG)	**5.87**

3.2.3 Ultimate Buildout

For the ultimate buildout scenario, the model resulted in overflows as shown in Figure 3-4. As shown, the overflow locations increase to include additional areas away from the trunk including Chenoweth LS (Ref. "J" - Figure 3-4) and a section of sewer near the MWS Owl Creek Connection (Ref. "N" - Figure 3-4). This scenario includes all known developments and projected increases in flow taken from MPO projections and calculations of number of lots remaining to be built on undeveloped land.

Figure 3-4: Ultimate Buildout System Predicted Overflow



A	1.23
B	4.42
C	0.04
D	0.27
E	0.12
F	0.30
G	0.12
H	0.58
I	0.40
J	0.07
K	0.02
L	0.25
M	0.00
N	0.00
O	0.00
P	0.02
Total Volume (MG)	**7.84**

3.3 MWS Maximum Flows

One additional consideration unrelated to predicted overflows in OCB is the maximum allowable flow MWS will take per the current Brentwood/MWS agreement. For the BPS connection, maximum flow rate can be controlled by the operation of the pumps. However, the gravity connection at Owl Creek cannot be throttled and must be considered as Brentwood flows steadily increase. Modeling shows the peak flow from the 2-year, 24-hour design storm currently exceeds the current limit. Flow rates exceeding the limit are also shown to occur by flow meter data at the OCB/MWS connection.

4. Alternative Evaluation

4.1 Identification of Needed Improvements

The overall goal of the MP is to provide Brentwood's City leaders a guidance document for their collection system. The MP will enable City leaders to prepare for future growth by providing a schedule of capital improvement projects that will address potential issues that could occur, the worst being an overflow somewhere in the system. As such, the sole trigger in the MP for developing improvement alternatives was the need to eliminate model-predicted overflows during the 2-year, 24-hour dormant season design storm event, which was developed and used in the Brentwood and MWS CAP/ERs.

4.2 Performance Measures

Although the trigger to identify needed improvements was solely based on the presence of overflow during the design storm, the following three performance measures, which relate to the dry-weather depth of flow and the wet-weather peak HGL, were considered in development of alternatives.

4.2.1 Peak Dry-Weather Flow as a Percent of Full Pipe

This performance measure is based on achieving a peak dry-weather flow (DWF) that is less than or equal to an acceptable percentage of the full-pipe, free-flow capacity. This percentage was calculated by dividing the peak dry-weather depth of flow (d) into the full-pipe depth (D). For the MP, this ratio (d/D) was established as 0.5 based on the MWS CAP/ER and TDEC design guidelines for new sewers.

4.2.2 Peak Wet-Weather HGL Relative to Crown of Pipe

This performance measure is based on limiting the peak HGL that occurs during wet-weather events to a specific height above the crown of pipe. For the MP, this height was established as no more than 2 feet.

4.2.3 Peak Wet-Weather HGL Relative to Manhole Rim Elevation

This performance measure is based on limiting the peak HGL that occurs during wet-weather events to a specific distance beneath the manhole rim elevation. For the MP, a 3-foot depth was established for normal unsealed manholes while a 1-foot depth was established for watertight manholes.

4.3 Modeled Alternatives Analysis

As discussed in Section 3 – System Evaluation, the system was modeled under both current and future conditions with a 2-year, 24-hour design storm. The areas that showed predicted overflow can be categorized between those occurring near the trunk sewer due to surcharge and those occurring in areas away from the trunk sewer.

4.3.1 Predicted Overflows in Trunk Sewer

Modeling shows that overflows along the trunk at the downstream end nearer to BPS are a result of a high HGL caused primarily from inadequate capacity and backup from BPS. Overflows occurring along the trunk further upstream from BPS starting in the 27-inch sewer around Deerwood Lane are more related to capacity restrictions in the trunk itself to handle peak flows from upstream.

Under current dry-weather conditions, some of the flatter sections of the trunk between Deerwood Ln and Granny White Pk slightly exceed a d/D ration of 0.5 as shown (red) in Figure 4-1. Figure 4-2 shows this condition worsens in the ultimate buildout scenario where the majority of the trunk exceeds a ratio of 0.5.

Figure 4-1: Dry Weather Flow Greater than 50% Pipe Flowing Full – Existing Conditions

Figure 4-2: Dry Weather Flow Greater than 50% Pipe Flowing Full – Ultimate Buildout Conditions

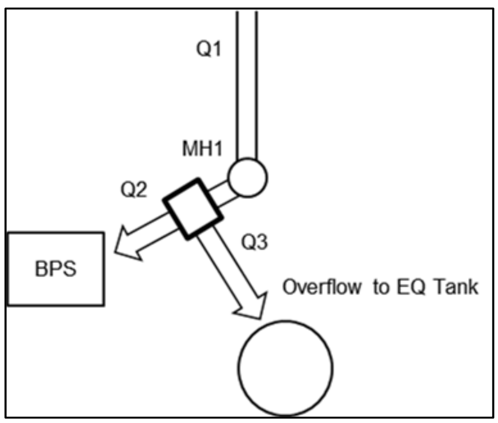
4.3.1.1 Equalization

EQ was evaluated as a method to reduce peak flows and HGL in the trunk. Two locations with potential for construction identified in previous studies and in discussion with Brentwood staff are at BPS and the Mid-Trunk area.

4.3.1.1.1 BPS Only

EQ at BPS was modeled to determine how much the peak HGL could be reduced in the trunk to address overflows. The EQ was modeled with a passive diversion structure just outside the station such that it began to fill once the HGL in the trunk reached a certain threshold. As shown in Figure 4-3, Q1 represents all incoming flow to BPS. During dry weather conditions Q1 = Q2. However, during wet weather flow conditions, Q2 would be limited by construction of a side diversion structure downstream of MH1 with an overflow weir set to the maximum allowable HGL. Any excess flow would then go over the weir as Q3 and to the EQ Tank for storage.

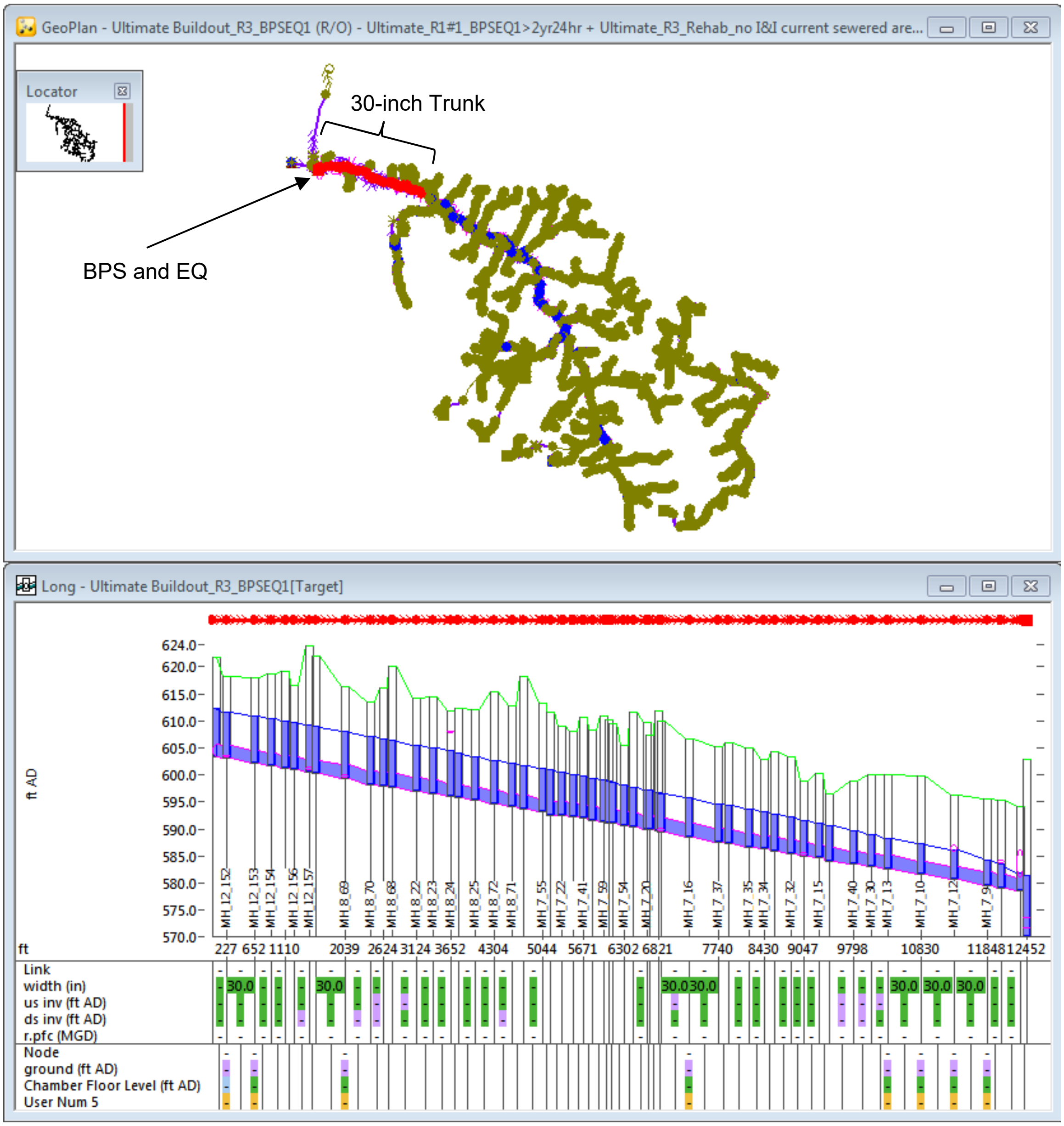
Figure 4-3: EQ & Diversion Structure at BPS



Although the model shows that an EQ at BPS by itself could address all overflows in the downstream section of the trunk, overflows still occur in the upstream regions of the trunk. So, while the EQ at BPS would eliminate the largest of Brentwood's current overflows, it would not by itself eliminate overflows in the entire trunk.

The primary trunk section that would benefit is 30-inch sewer shown in Figure 4-4. It should be noted that although peak HGL in the ultimate buildout scenario did not get within 3 ft of the manhole rim elevation for this section, surcharge above 2 ft of the crown did occur. Therefore, this solution did not meet all performance measures.

Figure 4-4: Trunk Sewer Segment with Greatest Benefit from BPS EQ



4.3.1.1.2 Mid-Trunk Only

Modeling of EQ at Mid-Trunk only was performed to determine its effect on lowering peak HGL and reducing overflows within the trunk. First, the EQ was added with a passive diversion structure set to fill once the HGL in the trunk reached a certain threshold. In this manner, a certain percentage of the peak flow would be stored and the amount of flow and HGL in the trunk itself would be reduced.

Figure 4-5: EQ & Diversion Structure at Mid-Trunk

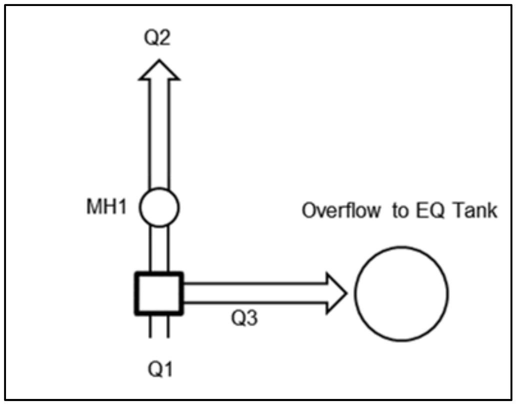
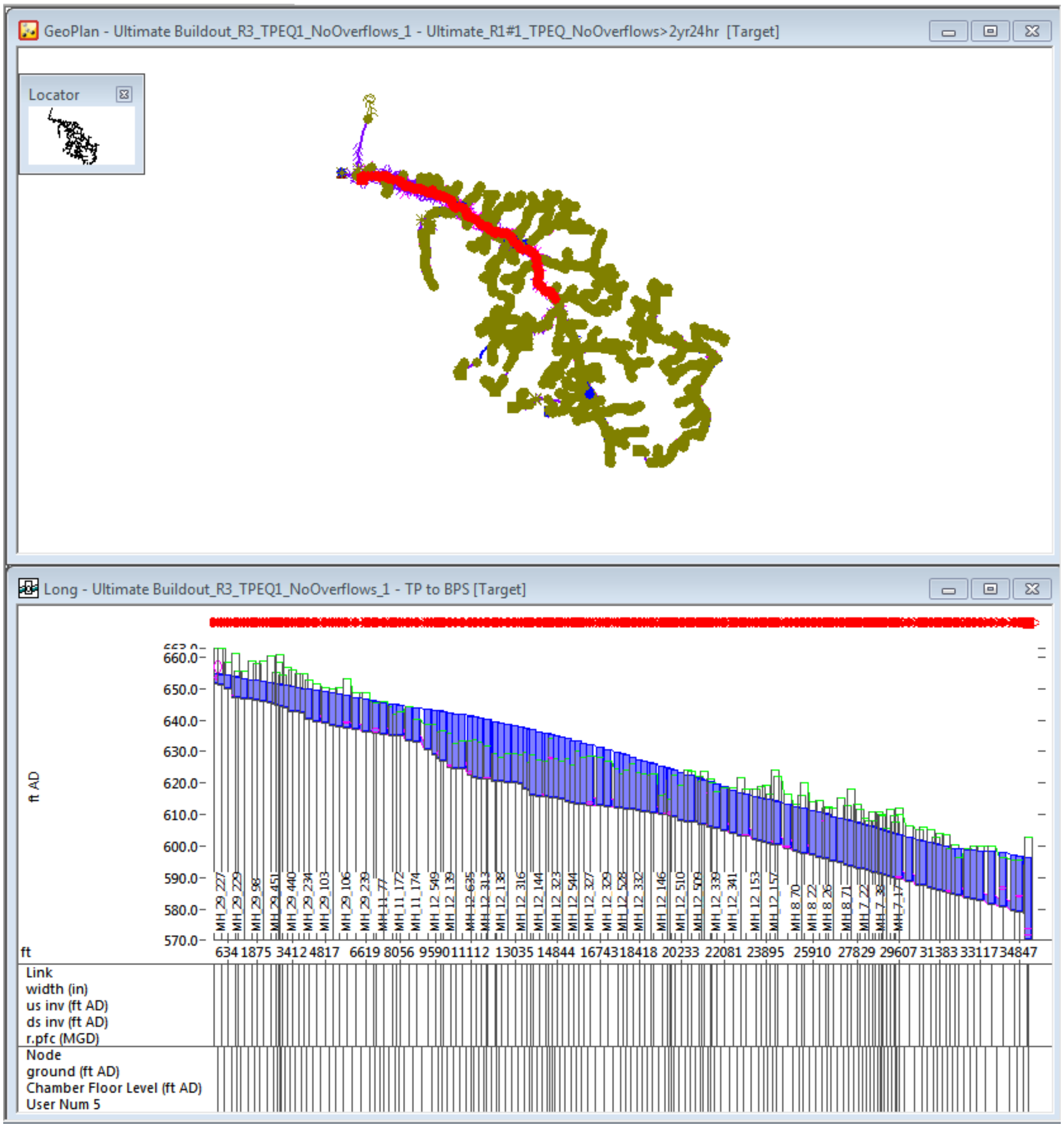


Figure 4-5 represents the trunk sewer in the Mid-Trunk area with a diversion structure upstream of MH1 being connected to the EQ. The trunk flow would always be described as Q1 = Q2 + Q3. During dry weather flow conditions, Q1 would simply equal Q2. However, during wet weather flow conditions, Q2 would be limited by the maximum allowable HGL, which would in turn be determined by the overflow weir elevation in the diversion structure. Any excess flow would then be diverted to the EQ Tank for storage as Q3.

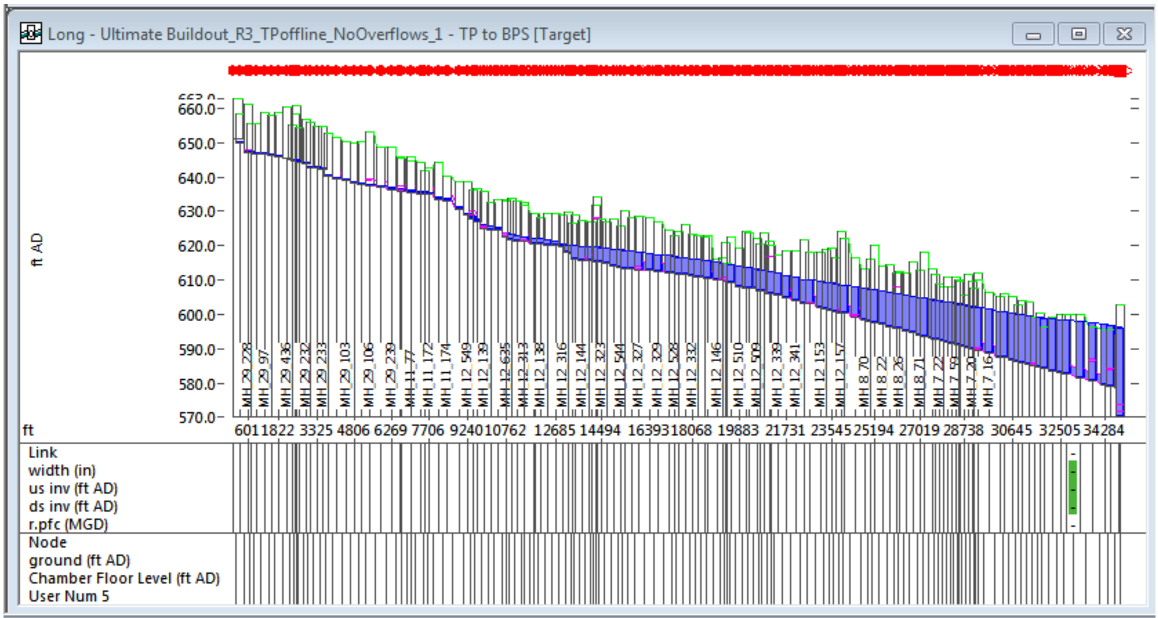
Although modeling showed that peak flows (Q2) would be reduced in this configuration, downstream trunk HGL still reached levels above the desired performance targets. Figure 4-6 shows the peak HGL in the trunk in the ultimate buildout scenario. As shown, the trunk is quite surcharged and undersized to handle the peak flow – even with the Mid-Trunk EQ in place. Therefore, this option by itself was determined to be ineffective.

Figure 4-6: Trunk HGL with EQ at Mid-Trunk with Passive Overflow



Next, the EQ at Mid-Trunk was configured to store all peak flows during wet weather conditions to determine the maximum impact an EQ by itself would have on limiting the downstream HGL and achieving performance measure targets. In other words, Q1 = Q3 for the entire simulation and Q2 was set at zero. The result of this simulation showed that although downstream trunk HGL was significantly lowered, overflow still occurred further downstream on the trunk near BPS. Figure 4-7 shows the results of this Mid-Trunk-only scenario under ultimate buildout flow conditions.

Figure 4-7: EQ at Mid-Trunk with All Trunk Flow Diverted



4.3.1.1.3 BPS and Mid-Trunk Together

One of the conclusions from the individual evaluation of EQ at both locations is that neither by itself is a viable solution to addressing overflows and meeting performance measurement targets for the entire trunk. Therefore, as the next step, both EQ tanks were evaluated together.

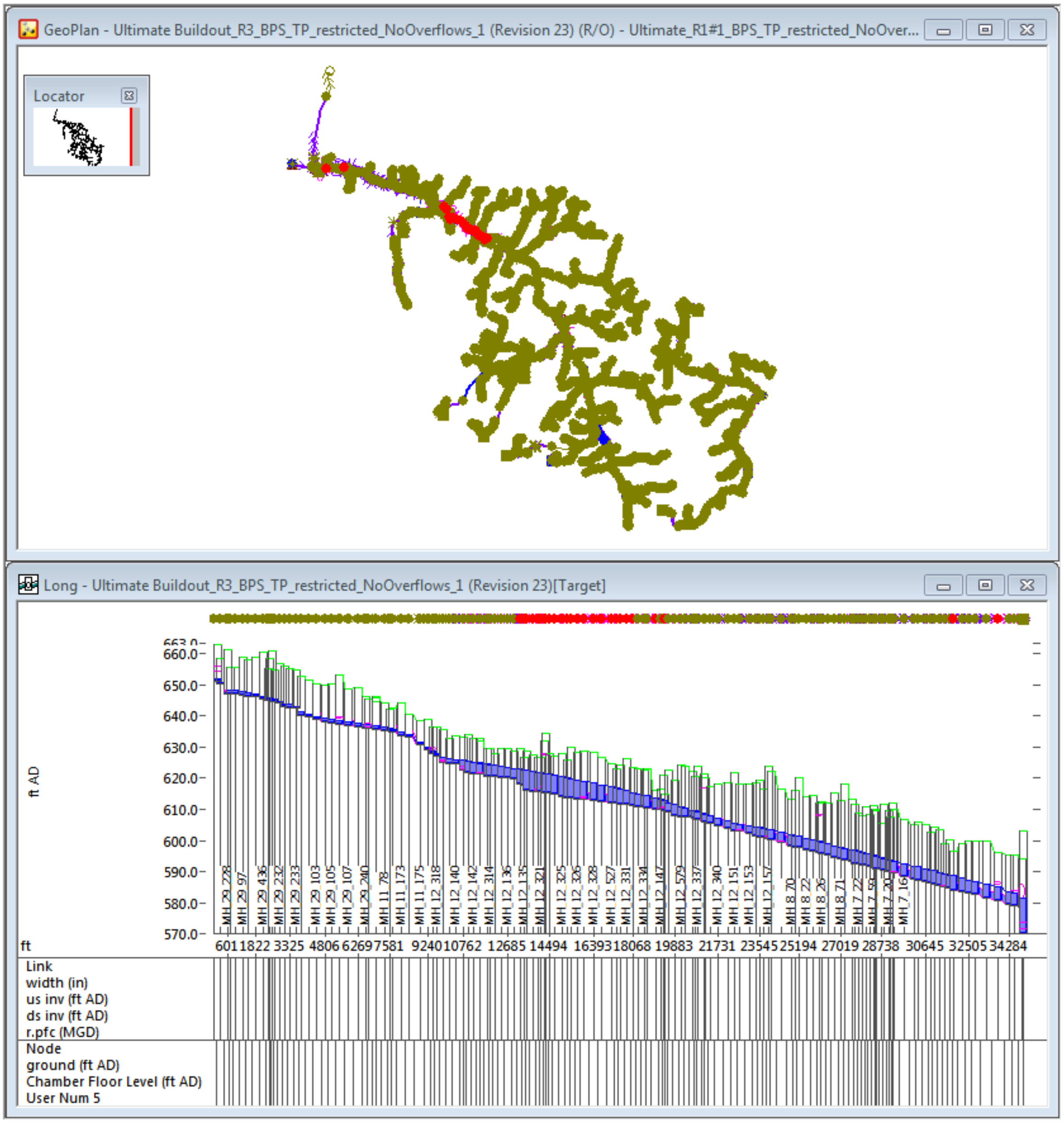
The configuration at BPS was the same passive diversion structure as discussed in Section 4.3.1.1.1 – BPS Only. Mid-Trunk EQ was modeled with a restriction on the flow that was allowed to pass in the trunk (Ref. flow Q2 in Figure 4-5). This restriction was aimed at meeting performance measurement targets in the downstream trunk. Figure 4-8 shows the profile with both EQ tanks in place. The model indicated restricting Q2 to approximately 2 mgd would meet both performance measurements in a majority of the trunk. Although a flat section of the profile (Belle Rive area to just east of Granny White Pk) was shown to surcharge greater than 2 feet above the crown elevation, all but two manholes in the profile met the performance measurement of 3 feet beneath the manhole rim elevation.

The size of the EQ tanks necessary to achieve desired results varied according to the planning horizon. Table 4-1 shows the predicted volumes that would be needed for each time period.

Table 4-1: Model-Predicted EQ Volume Requirements

	Needed EQ Volume (MG)		
	BPS	Mid-Trunk	BPS + Mid-Trunk
Year 2020	1.5	4.7	6.2
Year 2030	1.9	5.5	7.4
Ultimate	2.8	6.7	9.5

Figure 4-8: EQ at BPS and Mid-Trunk Together with Trunk Flow Limited



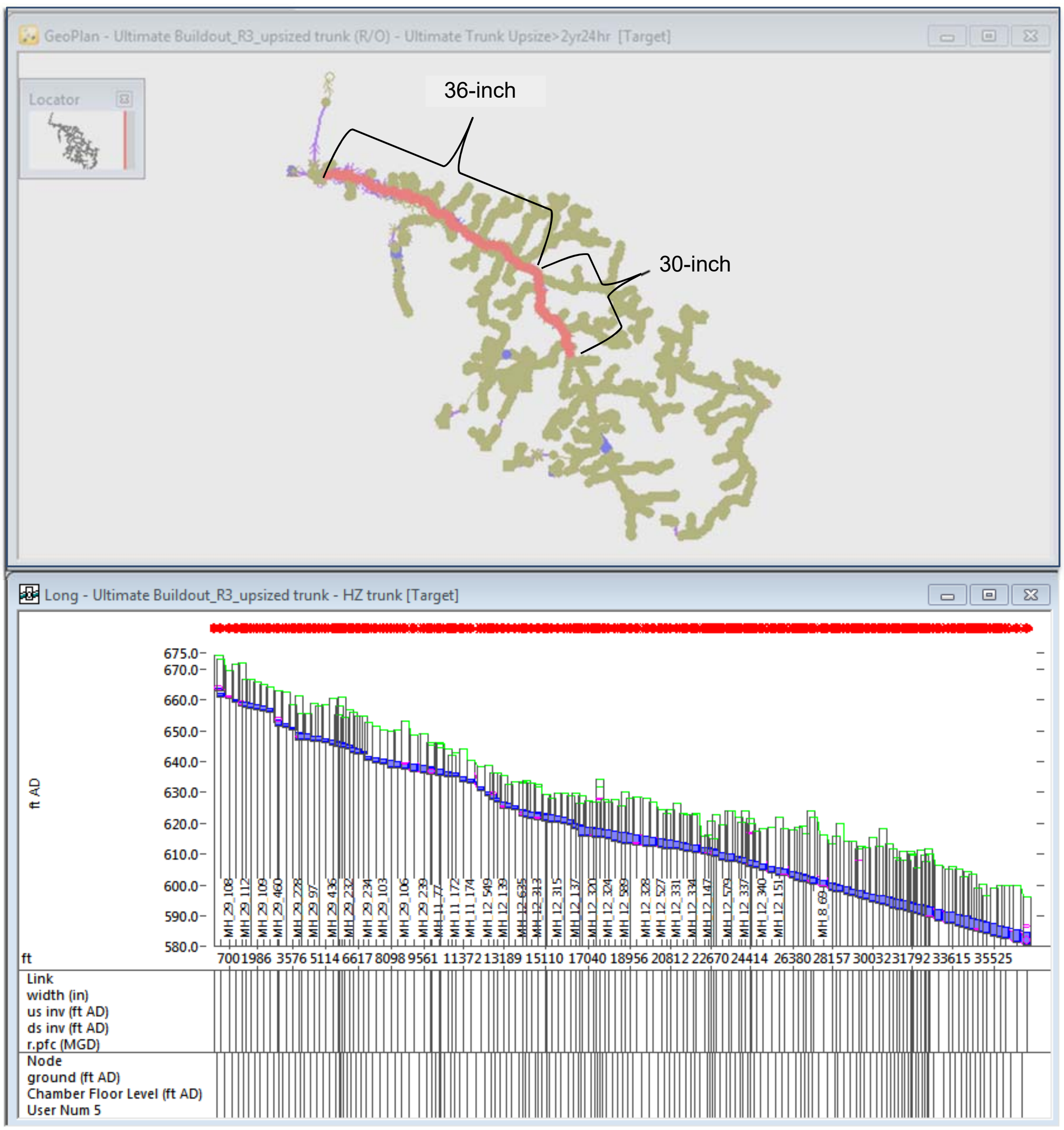
4.3.1.2 BPS Upsize

Upsizing BPS from its current maximum pumping rate of 9.5 mgd would lower trunk HGL in the same manner as placing EQ just outside the station. Practically speaking, the amount of capacity increase at BPS is limited due to associated costs to upgrade MWS capacity discussed in Brentwood's CAP/ER. Modeling showed that BPS would need to be upgraded to approximately 17 mgd in the ultimate buildout scenario to have the same effectiveness in overflow reduction as EQ at BPS only.

4.3.1.3 Trunk Upsize

Increasing the trunk capacity was evaluated as an alternative to lower HGL in the trunk and convey all flow to BPS where it would be addressed with either/both EQ or/and pump upsizing. This option would be challenging/expensive to construct due to service reconnections, utility relocations, and bypass pumping. However, the model was run to determine sizing for this alternative since it could eliminate the need for Mid-Trunk EQ. The diameter of the trunk was incrementally adjusted to match the capacity of peak flow. The result of the model optimization is shown in Figure 4-9. It should be noted that all performance measure targets were achieved with this alternative.

Figure 4-9: Upsizing Trunk to Increase Capacity



4.3.2 Predicted Overflows in Areas Other Than Trunk Sewer

These localized areas were identified as having the potential to experience overflows in the future. Therefore, adjustments were made in the model to increase capacity where needed. It should be noted that since these predicted overflows do not occur until at least Year 2030 and the relative size of the affected areas are small, re-assessment of these areas is recommended for verification of flows prior to implementation of any improvement projects.

4.3.2.1 Scales School Lift Station Upsize

Overflows were predicted to occur at Scales School LS in 2030. In order to eliminate overflows at this location, the station capacity was upgraded to match influent flows. The result was a peak discharge from Scales School LS of approximately 1 mgd. As a point of reference, the peak discharge out of the station with both existing Ebara submersible pumps running is predicted to be approximately 0.4 mgd.

4.3.2.2 Chenoweth Lift Station Upsize

Overflows were predicted to occur at Chenoweth LS in 2030. In order to eliminate overflows at this location, the station capacity was upgraded to match influent flows. The result was a peak discharge from Chenoweth LS of approximately 0.6 mgd. As a point of reference, the peak discharge out of the station with both existing Ebara submersible pumps running is predicted to be approximately 0.3 mgd.

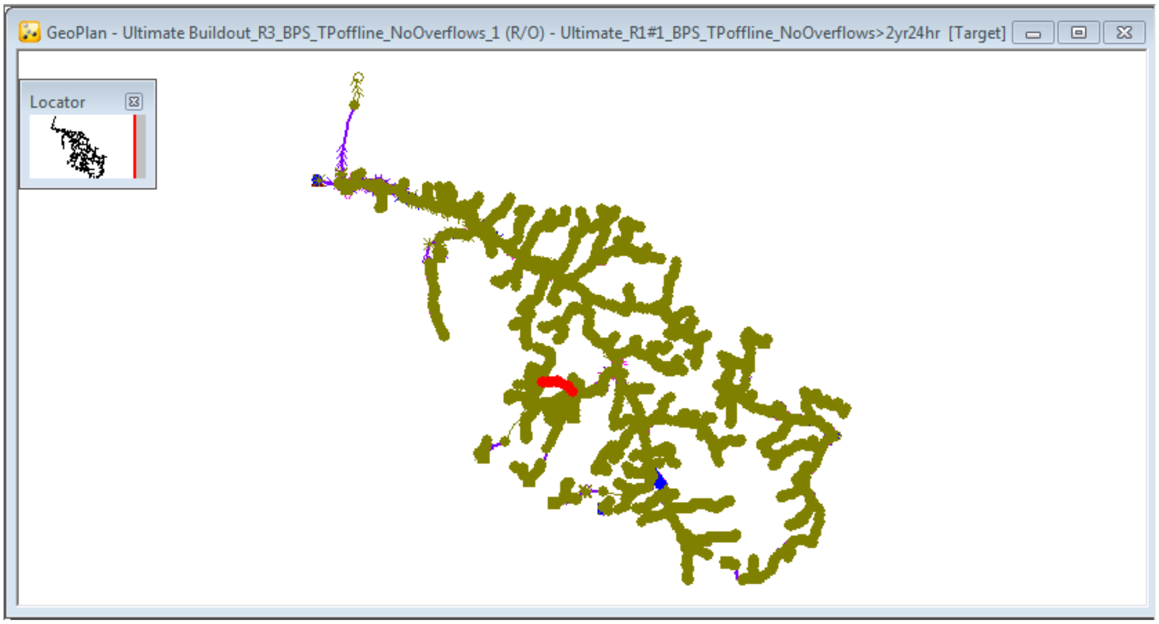
4.3.2.3 Gravity Line Upsizing

The only lines other than the trunk sewer that were identified as needing additional capacity due to predicted overflow were as follows:

3,300 LF of 8-inch sewer south of Concord Rd in the vicinity of Brentwood's First Presbyterian Church near Franklin Rd and Longstreet Dr

This segment was identified as causing overflow in 2030. This section of sewer was upsized to 12 inches to eliminate overflow. All performance measurement targets were achieved. Figure 4-10 shows the extents of this line segment.

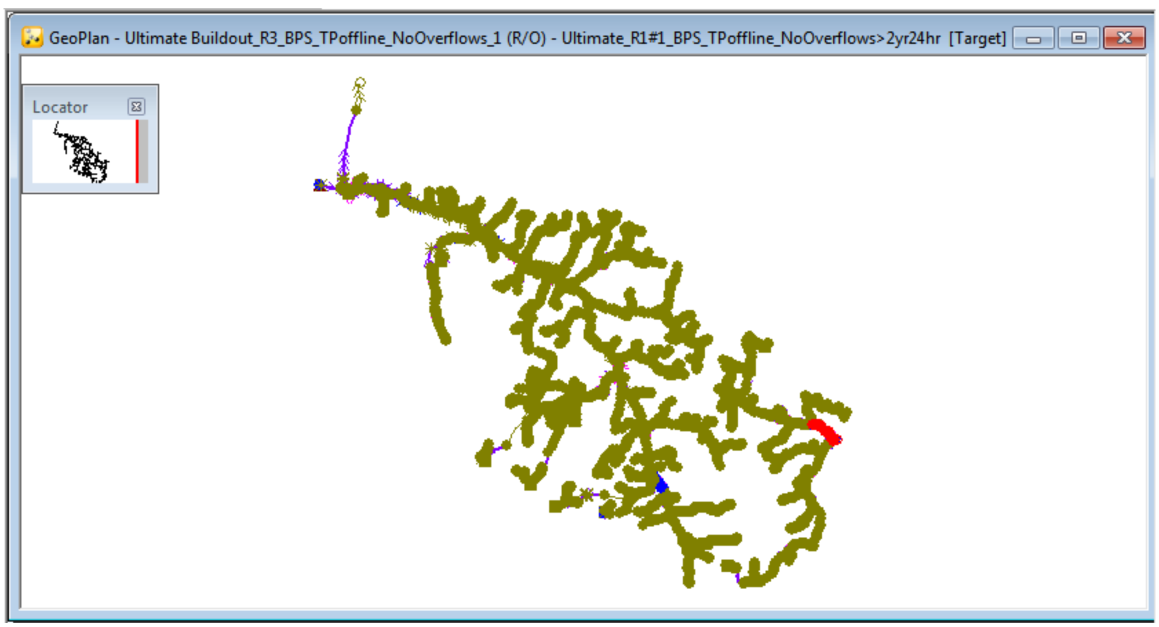
Figure 4-10: Franklin Rd/Longstreet Dr Gravity Upsize



2,910 LF of 12-inch & 380 LF of 15-inch sewer at the downstream end of the Owl Creek basin in the vicinity of Concord Rd and Sunset Rd

These segments were identified as causing overflow in the ultimate buildout scenario. The sections were upsized respectively to 15 & 18 inches to eliminate overflow. All performance measurement targets were achieved. Figure 4-11 shows the extents of this line segment.

Figure 4-11: Owl Creek Gravity Upsize



4.4 Alternative Cost Estimates

Cost estimates for the alternatives identified in Section 4.3 were developed from similar project bid tabulations, input from sales representatives, and general engineering judgement. Appendix A provides cost estimates for the various alternatives categorized into EQ, gravity line upsizes, and pump station upsizes.

4.5 Equalization Storage

Since the findings from the alternative evaluation of the trunk sewer point toward EQ storage as the most economical means to accomplish the objectives set forth in this planning document, a brief discussion of EQ is included for general reference.

4.5.1 Typical Configurations

EQ tanks are generally constructed in near proximity to the sewer line for which peak flow needs to be reduced. In most cases, a separate pump station is required to fill or drain the EQ tank during its operation. The most common configuration is to intercept the gravity trunk sewer with a diversion structure that diverts flow into a pump station which pumps into the tank to later gravity flow out back into the trunk sewer following the wet weather event.

4.5.1.1 Pump-In, Gravity-Out

This is a common configuration, which consists of an EQ tank that sits on top of the ground. During periods of peak flow, excess flow is diverted from the trunk sewer by a diversion structure, with an overflow weir set at a specified elevation, into a separate pump station that proceeds to fill the EQ tank. After peak flows have subsided, flow stored in the EQ tank is slowly released by gravity back into the system at a controlled rate, normally over a 24 hour period. The size of the pumps needed to fill the tank in this configuration can be quite large to combat the peak flow in the sewer.

4.5.1.2 Gravity-In, Pump-Out

In this configuration, the EQ tank is situated in such a way that peak flow is diverted from the trunk sewer by a diversion structure and directed by gravity into the EQ tank. After peak flows have subsided, flow stored in the EQ tank is pumped back into the trunk sewer at a controlled rate. The size of the pumps needed to empty the tank in this configuration is smaller than the previous configuration because you're not matching peak flows. The goal in this option is to empty, normally during 24 hours, to have the facility ready for the next event. Typically this configuration requires the tank to be subsurface to allow for gravity fill of the tank and is typically more expensive than pump-in/gravity-out due to excavation requirements.

4.5.1.3 Gravity-In, Gravity-Out

Although this configuration is typically the most economical since a separate pump station is not required, it is only possible for areas where significant surcharge in the incoming trunk sewer can occur without causing backup in connected services into dwellings. Typically for these cases, trunk sewers approaching the EQ tank will be designed to withstand enough surcharge to fill the EQ tank to the maximum design water level. After peak flows have subsided, flow stored in the EQ tank is slowly released by gravity back into the system at a controlled rate. This option requires the existing gravity sewer be replaced by a pressure system type system where surcharge occurs. In this case, all manholes along the segment should be one-piece fiberglass pressure vessels and must include bolt-down water tight covers.

4.5.2 Comparison of Above and Below-Grade Installations

The costs for below-grade tanks are significantly higher than those for above-ground tanks due to required excavation and construction methods. A review of projects at other locations in the area constructed with each type of tank show the difference in cost can be over twice as much depending on factors including soil condition, flood plain proximity, and tank size.

Although above-grade tanks can be visually unpleasing, strategic landscaping and paint color selection can camouflage the facility. However, land for the tank site obviously can't be used for other purposes.

The primary advantage of below-grade tanks is the ability to hide the tank and potentially have multiple uses of the land at the tank location. (e.g. recreational fields, parking lots, etc.).

4.5.3 Examples in Surrounding Area

4.5.3.1 West Park – Nashville, TN

The 21-MG tank shown in Figure 4-12 is under construction and scheduled for completion in 2017. It is a pump-in, gravity-out configuration.

Figure 4-12: West Park EQ Tank Under Construction

4.5.3.2 Knoxville Utility Board – Knoxville, TN

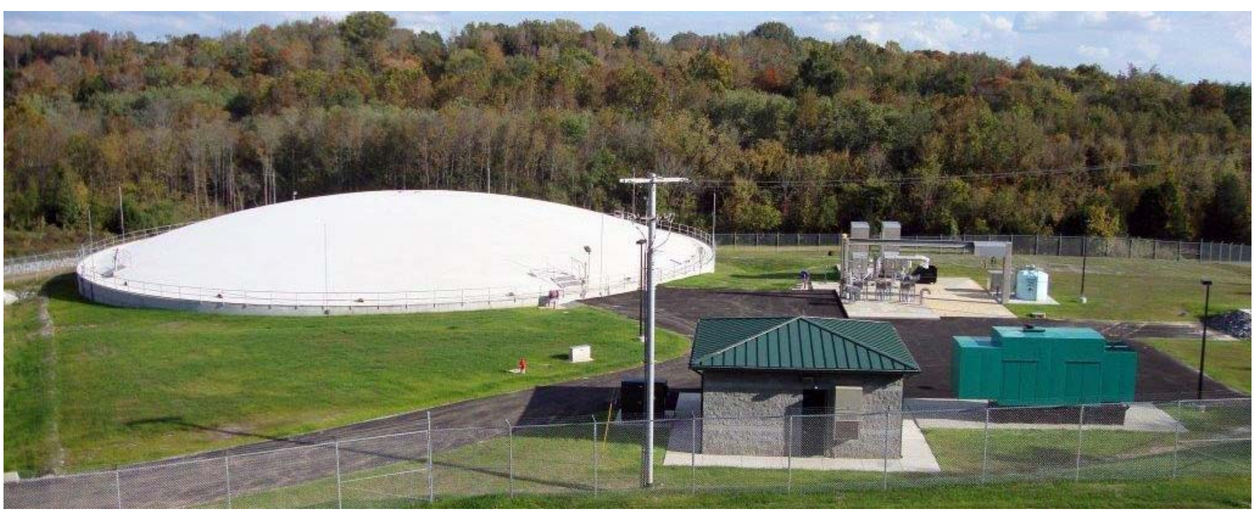
The EQ Tank shown in Figure 4-13 is a below-grade 9-MG tank completed in 2007. It is a gravity-in, pump-out configuration.

Figure 4-13: Below-Grade EQ Tank

4.5.3.3 Beacon Hills – Clarksville, TN

As shown in Figure 4-14, this 7.3-MG tank was completed in 2011. It is a gravity-in, gravity-out configuration.

Figure 4-14: Beacon Hills EQ Tank Project Site



4.6 Conclusions and Recommendations

The following general conclusions were developed after evaluation of alternatives to address model-predicted overflow locations within Brentwood's collection system:

1. The trunk sewer extending from Concord Rd to BPS experiences surcharge during the design storm rainfall event during evaluation of the various planning horizons. This surcharge is due to lack of capacity both at BPS and in the size of the trunk itself.
2. Rehabilitation, which is currently being performed, is only a part of the ultimate solution.
3. Upsizing the trunk sewer could theoretically convey all flow to BPS and completely control surcharge and model-predicted overflows in the upper segments of the trunk before Deerwood Ln. However, the current capacity of BPS would not be sufficient long term to handle the flow.
4. In order to increase capacity at BPS, coordination with MWS to construct significant improvements downstream of the BPS force main discharge into the MWS collection system. These improvements are thought to be prohibitively expensive.
5. Equalization at BPS by itself would not address future-predicted overflows in the upper segments of the trunk before Deerwood Ln. However, it would alleviate the largest overflow located in the vicinity of Hillsboro Rd.
6. Equalization at Mid-Trunk by itself would not address future-predicted overflows in the lower end of the trunk near BPS. However, it would reduce maximum surcharge level significantly in the upper segments of the trunk before Deerwood Ln.
7. Equalization at both BPS and Mid-Trunk would eliminate future-predicted overflows along the trunk and control surcharge within adopted performance measures in most cases along the entire length of trunk.
8. Predicted overflows in places away from the trunk were limited to two lift stations and two segments of gravity sewer.

Therefore, the general recommendations are as follows:

1. Construct EQ tanks at BPS and Mid-Trunk to address future-predicted trunk sewer overflows.
2. Visually monitor surcharge at Scales School and Chenoweth LS periodically during rainfall events to determine if pumps can keep up. If hydraulic issues arise, begin flow monitoring to assist in design of upsizing pumps and/or force mains.
3. Visually monitor surcharge in the Franklin Rd / Longstreet Dr 8-inch gravity line periodically during rainfall events to determine if surcharge occurs. If excessive surcharge is observed, upsize this line to 12 inch.
4. Although no significant overflows were predicted to occur within OCB, data suggest the area has higher I&I than LHRB. Although OCB sanitary flow is 0.6 mgd, it periodically exceeds the MWS limit of 2.5 mgd. This frequency of exceedance is anticipated to increase during the planning period. It is recommended to implement an I&I study for OCB to identify rehabilitation needs and verify the system can maintain a target R-value. Once this task has been performed, it is recommended that Brentwood re-evaluate the ultimate flow projections for OCB and the capacity needed at the Owl Creek connection to MWS.

The timing of construction for the recommended improvements outlined above is based on hydraulic model results throughout the planning horizons of Year 2020, Year 2030, and the ultimate buildout scenario.

Since rehabilitation of the collection system as part of the CAP/ER is scheduled to conclude at the end of 2018, design and final sizing of the EQ at BPS is recommended to begin after the review of post-rehabilitation flow data and submittal of the CAP/ER final report in 2019. A proposed schedule for all improvements is provided in Appendix B.

Appendix A: Cost Estimates

Equalization (includes pump station in cost)

Project	Description	Required Volume for EQ (MG)	Peak Flow into EQ (MGD)	Cost Estimate
Brentwood Pump Station EQ Storage & Diversion Chamber	Above-grade 3-MG tank with 5.5-MGD EQPS and associated piping & diversion chamber[2]	3.0	5.1	(Ref. page A-2 for Detailed Estimate)
Mid-Trunk EQ Storage & Diversion Chamber	Above-grade 7-MG tank with 9-MGD EQPS and associated piping & diversion chamber	7.0	8.6	(Ref. page A-4 for Detailed Estimate)

Gravity Line Upsize

Project	Description	Upsized Diameter (in)	Length (ft)	Cost
Franklin Rd / Longstreet Dr	Upsize capacity-limited 8-inch segment heading east toward Lipscomb Dr	12	3,300	200,000
Owl Creek I	Upsize capacity-limited 12-inch segment from The Governors Club Golf Course to intersection with 12-inch line near MWS Owl Creek connection	15	2,910	320,000
Owl Creek II	Upsize capacity-limited 15-inch segment at MWS Owl Creek connection	18	400	60,000

Upsize Pumps

Location	Description	Proposed Peak Flow (MGD)	Cost
Chenoweth LS	Upsize station to control overflows	0.6	100,000
Scales School LS	Upsize station to control overflows	1.0	150,000

[2] EQ cost estimates assume above-grade storage tank installation. If Brentwood chooses a below-grade installation, costs will be higher.

Brentwood Pump Station 3MG EQ Storage Facility w/5.5MGD EQPS					
Sewer Master Plan					
ITEM NO.	**DESCRIPTION OF ITEM**	**QTY**	**UNIT OF MEASURE**	**COST PER UNIT**	**TOTAL COST OF ITEM**
1	**Storage Tank Subsurface Foundation , VF**	5000	VF	$ 67.00	$ 335,000.00
2	**Pump StationSubsurface Foundation, VF**	1000	VF	$ 50.00	$ 50,000.00
3	**Mobilization and Planning, LS**	1	LS	$ 125,000.00	$ 125,000.00
4	**Bonds and Insurance, LS**	1	LS	$ 80,000.00	$ 80,000.00
5	**Asphalt Paving, LS**	1	LS	$ 68,000.00	$ 68,000.00
6	**Temporary Chain Link Fence, LS**	1	LS	$ 15,000.00	$ 15,000.00
7	**Permanent Chain Link Fence, LS**	1	LS	$ 25,000.00	$ 25,000.00
8	**Install Erosion Control, LS**	1	LS	$ 25,000.00	$ 25,000.00
9	**Maintain Erosion Control, MNS**	12	MNS	$ 1,250.00	$ 15,000.00
10	**Blast Rock, LS**	1	LS	$ 25,000.00	$ 25,000.00
11	**Excavation, CY**	25000	CY	$ 10.00	$ 250,000.00
12	**Clear and Grub, LS**	1	LS	$ 20,000.00	$ 20,000.00
13	**Backfill, CY**	20000	CY	$ 5.00	$ 100,000.00
14	**Final Grade, LS**	1	LS	$ 10,000.00	$ 10,000.00
15	**Seed and Mulch, LS**	1	LS	$ 10,500.00	$ 10,500.00
16	**Prestressed Concrete Tank, LS**	1	LS	$ 1,200,000.00	$ 1,200,000.00
17	**Rebar, TN**	100	TN	$ 1,200.00	$ 120,000.00
18	**Concrete on Grade, CY**	250	CY	$ 650.00	$ 162,500.00
19	**Concrete Walls, CY**	750	CY	$ 750.00	$ 562,500.00
20	**Concrete Supported, CY**	50	CY	$ 900.00	$ 45,000.00
21	**Masonry, LS**	1	LS	$ 15,000.00	$ 15,000.00
22	**Electrical Building Carpentry, LS**	1	LS	$ 10,000.00	$ 10,000.00
23	**Standing Seam Roof, LS**	1	LS	$ 15,000.00	$ 15,000.00
24	**FRP Doors,Frames and Hardware, LS**	1	LS	$ 6,000.00	$ 6,000.00
25	**HVAC System, LS**	1	LS	$ 23,000.00	$ 23,000.00
26	**Sluice Gates (1 ea 24" and 1 ea 36"), LS**	1	LS	$ 30,000.00	$ 30,000.00
27	**Plug Valves, LS**	1	LS	$ 30,000.00	$ 30,000.00
28	**Gate Valves, LS**	1	LS	$ 2,000.00	$ 2,000.00
29	**Check Valves, EA**	3	EA	$ 17,000.00	$ 51,000.00
30	**Surge Relief Valve, EA**	1	EA	$ 10,250.00	$ 10,250.00
31	**4" Flg Air/Vac Relief Valves, EA**	3	EA	$ 10,000.00	$ 30,000.00
32	**2" Air Release Valve, EA**	1	EA	$ 2,100.00	$ 2,100.00
33	**Ductile Iron Pipe Material Only, LS**	1	LS	$ 115,000.00	$ 115,000.00
34	**Yard Hydrants w/ Hose Reels, EA**	2	EA	$ 3,000.00	$ 6,000.00
35	**2" Backflow Preventer w/ Hot Box, LS**	1	LS	$ 1,500.00	$ 1,500.00

Brentwood Pump Station 3MG EQ Storage Facility w/5.5MGD EQPS					
Sewer Master Plan					
36	Fire Hydrant, EA	1	EA	$ 1,500.00	$ 1,500.00
37	Equipment House for Hoses and Accessories, EA	1	EA	$ 2,250.00	$ 2,250.00
38	Submersible Pumps and Accessories, LS	3	EA	$ 125,000.00	$ 375,000.00
39	Hatches, LS	1	LS	$ 35,000.00	$ 35,000.00
40	Sump Pump, EA	1	EA	$ 1,000.00	$ 1,000.00
41	Hoist and Trolley, LS	1	LS	$ 24,000.00	$ 24,000.00
42	Miscellaneous Metals, LS	1	LS	$ 28,000.00	$ 28,000.00
43	Painting, LS	1	LS	$ 135,000.00	$ 135,000.00
44	Generator, LS	1	LS	$ 175,000.00	$ 175,000.00
45	Basic Electrical Material, LS	1	LS	$ 150,000.00	$ 150,000.00
46	Basic Electrical Labor, LS	1	LS	$ 50,000.00	$ 50,000.00
47	Electrical Equipment Material, LS	1	LS	$ 220,000.00	$ 220,000.00
48	Electrical Equipment Labor, LS	1	LS	$ 25,000.00	$ 25,000.00
49	Instrumentation and Controls, LS	1	LS	$ 75,000.00	$ 75,000.00
		Subtotal			$ 4,887,100.00
		Contingency		25%	$ 1,221,775.00
Engineers Estimate of Probable Cost					$ 6,108,875.00

Mid-Trunk 7MG EQ Storage Facility w/9MGD EQPS					
Sewer Master Plan					
ITEM NO.	**DESCRIPTION OF ITEM**	**QTY**	**UNIT OF MEASURE**	**COST PER UNIT**	**TOTAL COST OF ITEM**
1	**Storage Tank Subsurface Foundation , VF**	7500	VF	$ 67.00	$ 502,500.00
2	**Pump StationSubsurface Foundation, VF**	1000	VF	$ 50.00	$ 50,000.00
3	**Carbon Filter Odor Control System, LS**	1	LS	$ 65,000.00	$ 65,000.00
4	**Accessories for Carbon Filter System, LS**	1	LS	$ 10,000.00	$ 10,000.00
5	**Mobilization and Planning, LS**	1	LS	$ 130,000.00	$ 130,000.00
6	**Bonds and Insurance, LS**	1	LS	$ 100,000.00	$ 100,000.00
7	**Asphalt Paving, LS**	1	LS	$ 90,000.00	$ 90,000.00
8	**Temporary Chain Link Fence, LS**	1	LS	$ 15,000.00	$ 15,000.00
9	**Permanent Chain Link Fence, LS**	1	LS	$ 30,000.00	$ 30,000.00
10	**Install Erosion Control, LS**	1	LS	$ 25,000.00	$ 25,000.00
11	**Maintain Erosion Control, MNS**	12	MNS	$ 1,500.00	$ 18,000.00
12	**Blast Rock, LS**	1	LS	$ 25,000.00	$ 25,000.00
13	**Excavation, CY**	35000	CY	$ 10.00	$ 350,000.00
14	**Clear and Grub, LS**	1	LS	$ 25,000.00	$ 25,000.00
15	**Backfill, CY**	30000	CY	$ 5.00	$ 150,000.00
16	**Final Grade, LS**	1	LS	$ 15,000.00	$ 15,000.00
17	**Seed and Mulch, LS**	1	LS	$ 15,000.00	$ 15,000.00
18	**Prestressed Concrete Tank, LS**	1	LS	$ 3,250,000.00	$ 3,250,000.00
19	**Rebar, TN**	120	TN	$ 1,200.00	$ 144,000.00
20	**Concrete on Grade, CY**	250	CY	$ 650.00	$ 162,500.00
21	**Concrete Walls, CY**	750	CY	$ 750.00	$ 562,500.00
22	**Concrete Supported, CY**	50	CY	$ 900.00	$ 45,000.00
23	**Masonry, LS**	1	LS	$ 15,000.00	$ 15,000.00
24	**Electrical Building Carpentry, LS**	1	LS	$ 10,000.00	$ 10,000.00
25	**Standing Seam Roof, LS**	1	LS	$ 15,000.00	$ 15,000.00
26	**FRP Doors,Frames and Hardware, LS**	1	LS	$ 6,000.00	$ 6,000.00
27	**HVAC System, LS**	1	LS	$ 23,000.00	$ 23,000.00
28	**Sluice Gates (1 ea 24" and 1 ea 36"), LS**	1	LS	$ 30,000.00	$ 30,000.00
29	**Plug Valves, LS**	1	LS	$ 30,000.00	$ 30,000.00
30	**Gate Valves, LS**	1	LS	$ 2,000.00	$ 2,000.00
31	**Check Valves, EA**	4	EA	$ 17,000.00	$ 68,000.00
32	**Surge Relief Valve, EA**	1	EA	$ 10,250.00	$ 10,250.00
33	**4" Flg Air/Vac Relief Valves, EA**	4	EA	$ 10,000.00	$ 40,000.00
34	**2" Air Release Valve, EA**	1	EA	$ 2,100.00	$ 2,100.00
35	**Ductile Iron Pipe Material Only, LS**	1	LS	$ 125,000.00	$ 125,000.00

Mid-Trunk 7MG EQ Storage Facility w/9MGD EQPS					
Sewer Master Plan					
36	**Yard Hydrants w/ Hose Reels, EA**	2	EA	$ 3,000.00	$ 6,000.00
37	**2" Backflow Preventer w/ Hot Box, LS**	1	LS	$ 1,500.00	$ 1,500.00
38	**Fire Hydrant, EA**	1	EA	$ 1,500.00	$ 1,500.00
39	**Equipment House for Hoses and Accessories, EA**	1	EA	$ 2,250.00	$ 2,250.00
40	**Submersible Pumps and Accessories, LS**	4	EA	$ 125,000.00	$ 500,000.00
41	**Hatches, LS**	1	LS	$ 35,000.00	$ 35,000.00
42	**Sump Pump, EA**	1	EA	$ 1,000.00	$ 1,000.00
43	**Hoist and Trolley, LS**	1	LS	$ 30,000.00	$ 30,000.00
44	**Miscellaneous Metals, LS**	1	LS	$ 28,000.00	$ 28,000.00
45	**Painting, LS**	1	LS	$ 135,000.00	$ 135,000.00
46	**Generator, LS**	1	LS	$ 200,000.00	$ 200,000.00
47	**Basic Electrical Material, LS**	1	LS	$ 150,000.00	$ 150,000.00
48	**Basic Electrical Labor, LS**	1	LS	$ 55,000.00	$ 55,000.00
49	**Electrical Equipment Material, LS**	1	LS	$ 225,000.00	$ 225,000.00
50	**Electrical Equipment Labor, LS**	1	LS	$ 30,000.00	$ 30,000.00
51	**Instrumentation and Controls, LS**	1	LS	$ 80,000.00	$ 80,000.00
			Subtotal		**$ 7,636,100.00**
			Contingency	**25%**	**$ 1,909,025.00**
				Engineers Estimate of Probable Cost	**$ 9,545,125.00**

Appendix B: Proposed Projects Schedule

Brentwood Water Services
Proposed Projects Schedule by Fiscal Year
October 2016

ID	Task Name	Start	Finish
0	**Brentwood Proposed Improvements Schedule**	**Dec 2016**	**June 2040**
1			
2	**Owl Creek I&I Study and Rehabilitation**	**Dec 2016**	**July 2030**
3	Conduct additional flow monitoring and identify areas with I&I. Conduct rehabilitation	Dec 2016	July 2030
4	**Brentwood Pump Station EQ**	**July 2019**	**June 2021**
5	Design - EQ Tank, EQ PS, Diversion Chamber, Line Work, SCADA Integration	July 2019	June 2020
6	Construction - EQ Tank, EQ PS, Diversion Chamber, Line Work, SCADA Integration	July 2020	June 2021
7	**Mid-Trunk EQ**	**July 2027**	**December 2029**
8	Design - EQ Tank, EQ PS, Diversion Chamber, Line Work, Level Controls, SCADA Integration	July 2027	June 2028
9	Construction - EQ Tank, EQ PS, Diversion Chamber, Line Work, Level Controls, SCADA Integration	July 2028	December 2029
10	**Franklin Road / Longstreet Drive Gravity Upsize**	**July 2020**	**June 2030**
11	Monitor 8-inch line for evidence of surcharge and upsize to 12-inch accordingly	July 2020	June 2030
12	**Chenoweth LS Improvements**	**July 2025**	**June 2035**
13	Monitor PS to determine if it cannot keep up with peak flow. Conduct additional flow monitoring and upgrade station accordingly.	July 2025	June 2035
14	**Scales School LS Improvements**	**July 2025**	**June 2035**
15	Monitor PS to determine if it cannot keep up with peak flow. Conduct additional flow monitoring and upgrade station accordingly.	July 2025	June 2035
16	**Owl Creek Gravity Upsize**	**July 2030**	**June 2040**
17	Monitor line segments for evidence of surcharge and upsize to 15-inch and 18-inch accordingly	July 2030	June 2040