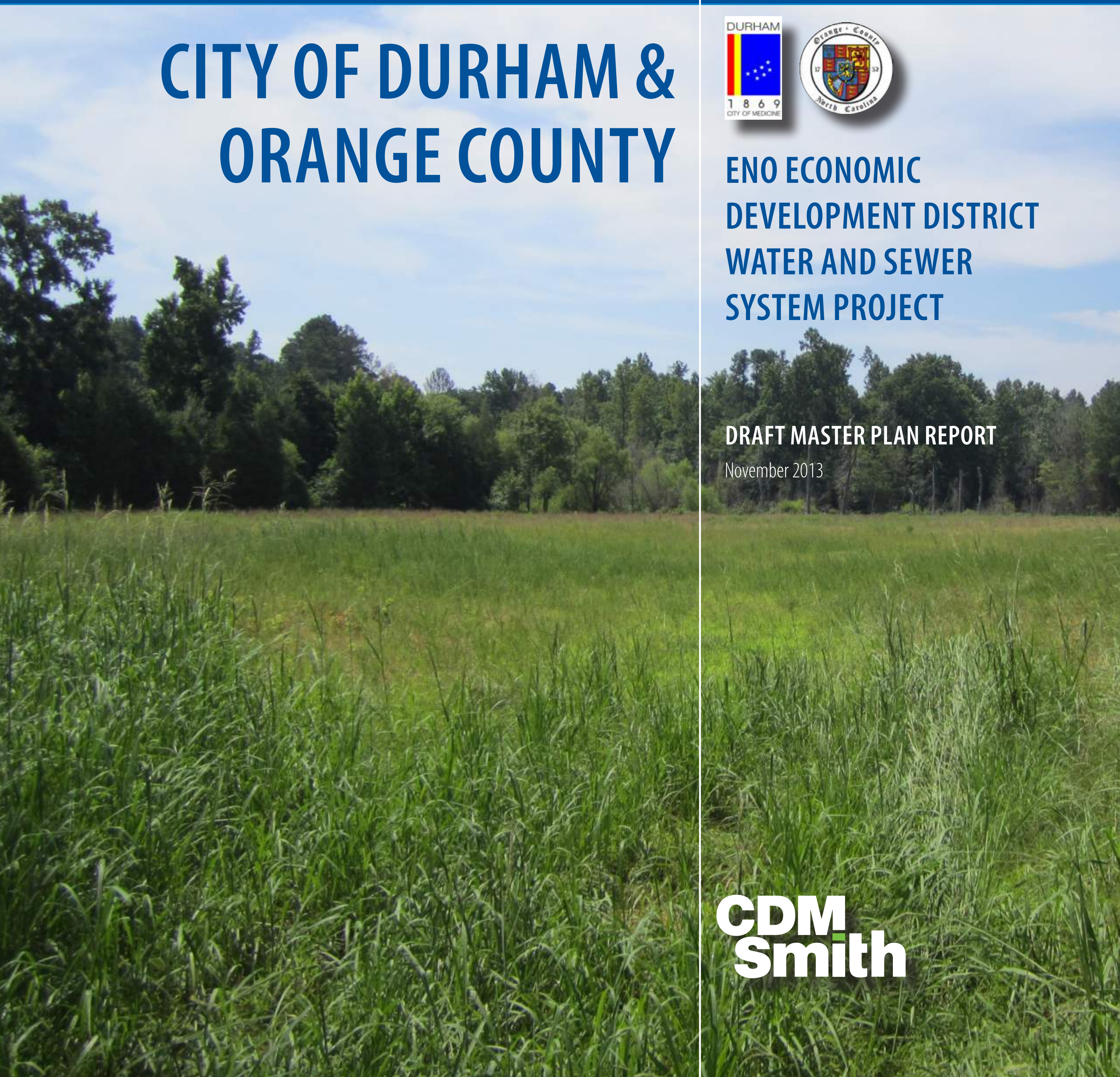
CITY OF DURHAM & ORANGE COUNTY

ENO ECONOMIC DEVELOPMENT DISTRICT WATER AND SEWER SYSTEM PROJECT



DRAFT MASTER PLAN REPORT

November 2013

CDM Smith

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Introduction

1.1 Project Background and Objectives

In recent years, Orange County (County) has taken a proactive role in the recruitment of business and industry and has established three strategic economic development districts as part of its strategy. One of those districts is the Eno Economic Development District (Eno EDD), previously known as the Interstate 85/US Highway 70 (I-85/US Hwy 70) Economic Development District, and is strategically located near the intersection of I-85 and US Hwy 70. This economic development area will be able to capitalize on its location within the City of Durham's (City) Urban Growth Area to provide water and sewer service to future customers, which are zoned to include a mixture of industrial, commercial, and high density residential development.

With this project, the City and County are collaborating to construct the backbone of a water and sewer system within the Eno EDD that will promote an effective growth pattern in the County with respect to location and phasing. The major objectives of this master plan are as follows:

- Develop water demand and sewer flow projections
- Determine the appropriate size and location for a sewer lift station
- Determine the appropriate size and route of a force main to carry wastewater flow from the proposed sewer lift station to a discharge point within the City's sewer collection system
- Determine the appropriate size and location of a gravity sewer collection system and water transmission system backbone
- Develop conceptual opinions of probable cost for the recommended improvements

1.2 Project Area

The Eno EDD is approximately 796 acres and is located in eastern Orange County, bordered to the north by I-85 and US Hwy 70, to the east by the Durham and Orange County border, to the south by the Norfolk Southern railroad, and to the west by Stony Creek, as shown on **Figure 1-1**. The area is primarily undeveloped with some rural residential and light business scattered south of I-85.

The Eno EDD is located within the Eno River Watershed, which eventually discharges into the Neuse River. In general, the area flows in a northerly direction into tributaries to the Eno River. There is significant topographic change within the area, ranging in elevation from 414 feet to 538 feet, a difference of 124 feet.

1.3 Scope of Study

The scope of work for this master plan was developed by CDM Smith, City, and County staff and consists of the following primary tasks:

- Flow and Demand Projections
- Proposed Water and Wastewater Infrastructure within Eno EDD
- Force Main Discharge Alternatives
- Permit Agency Coordination
- Cost Estimates
- Master Plan Report

A brief description of each task follows.

Flow and Demand Projections

The purpose of this task was to utilize available zoning and planned-development data to develop water demand and wastewater flow projections within the Eno EDD, which in turn would be used to layout the proposed water and wastewater infrastructure backbone.

Proposed Water and Wastewater Infrastructure within Eno EDD

The purpose of this task was to develop a conceptual layout of the recommended water distribution, wastewater collection, and wastewater pump station and force main infrastructure within the Eno EDD. A combination of wastewater flow/water demand projections and physical site characteristics, such as topography, streams, and roads, were used to layout the proposed infrastructure that would serve as the backbone of the system.

Force Main Discharge Alternatives

The purpose of this task was to identify and evaluate various alternatives for where the wastewater flow generated within the Eno EDD could be discharged into the City's wastewater collection and conveyance system. The location of the Eno EDD basin is such that the wastewater flow could potentially be discharged into either one of the City's two water reclamation facility (WRF) basins, the North Durham WRF or the South Durham WRF. There are three potential outfalls the Eno EDD flow could be discharged to:

- North Durham WRF Basin
  - The Eno Outfall, which is located in the Eno Basin
  - The Ellerbe Creek Outfall, which is located in the North Durham Basin
- South Durham WRF Basin
  - The Mud Creek Outfall, which is located in the Farrington Basin

For the purposes of this report, the three potential discharge locations will be referred to as the Eno Outfall, Ellerbe Creek Outfall, and Mud Creek Outfall.

Permit Agency Coordination

The purpose of this task was to identify the potential permitting needs and coordinate with the associated regulatory agencies, if needed, on what the permit requirements would be. The types of permitting needs related to work such as stream channel crossings, wetland crossings, and North Carolina Department of Transportation (NCDOT) encroachment.

Cost Estimates

The purpose of this task was to develop conceptual opinions of probable cost for the proposed water and wastewater infrastructure within the Eno EDD.

Master Plan Report

The purpose of this section was to document the evaluations and findings from the previous tasks into a comprehensive master plan report that would guide the City and County moving forward.

1.4 Report Format

The remainder of this report is organized into the following sections, with a brief description of each sections purpose following the name:

- Section 2 – Water Demand and Wastewater Flow Projections: This section provides a description of the methodology and assumptions by which the demand and flow projections were developed.
- Section 3 – Evaluation of Existing Water Infrastructure within the Eno EDD: This section provides a description of the existing water infrastructure within the Eno EDD followed by the evaluation that was performed to determine the additional infrastructure required to provide the backbone for the system.
- Section 4 – Proposed Wastewater Collection System within Eno EDD: This section describes the process by which the recommended wastewater collection system infrastructure within the Eno EDD was developed.
- Section 5 – Conveyance to the City of Durham's Wastewater Collection System: This section describes the alternatives analysis that was performed to determine where in the City's wastewater system the wastewater flows generated in the Eno EDD should be discharged.
- Section 6 – Engineer's Opinion of Probable Cost: This section provides a description of how the costs were developed as well as a breakdown of the cost by each of the major infrastructure components.
- Section 7 – Permit Requirements: This section provides a description of the environmental impacts that are anticipated if the proposed infrastructure were constructed as well as a list of all permits that would be anticipated to be required prior to initiating construction.
- Section 8 – Conclusions and Recommendations: This section provides a brief summary of the recommended infrastructure and associated cost followed by the options for how the City and County can advance the project forward.

Section 2

Water Demand and Wastewater Flow Projections

Water demand and wastewater flow estimates were developed for the Eno EDD for planning periods in 10-year increments from 2020 through 2070 (build-out). This section describes the development of the demand and flow projections.

2.1 Land Use Assumption

The County provided an approved future land use and zoning coverage for the Eno EDD, and the City provided two sets of future land use data for the Eno EDD basin, one that was adopted and one that was being submitted for adoption in June 2013. After discussion with the City and County the proposed future land use coverage, as adopted by the City in June 2013 and developed in conjunction with the County, was used as a basis for projecting water demands and wastewater flows within the Eno EDD. The land use coverage was intersected with the project area boundary and tax parcels to develop a parcel-specific future land use coverage, which is shown on **Figure 2-1**. Orange County ordinances require 30 percent open space for new developments, with the remaining 70 percent available for impervious coverage. Therefore, it is assumed that 70 percent of the available land for commercial, industrial, residential, and office use could be developed, with the remaining 30 percent as open space. **Table 2-1** summarizes both the total parcel acreage by land use and the acreage dedicated to each land use assuming 70 percent impervious area.

The NCDOT is planning improvements to the intersection of US Hwy 70 and I-85. The new interchange may affect some of the land available for development in the Eno EDD (Figure 2-1). Although the land that will potentially be used for the intersection is not subtracted from the developable acreage presented in Table 2-1, this should be taken into consideration as more specific development plans for the Eno EDD become available.

Table 2-1. Eno EDD Acreage by Future Land Use

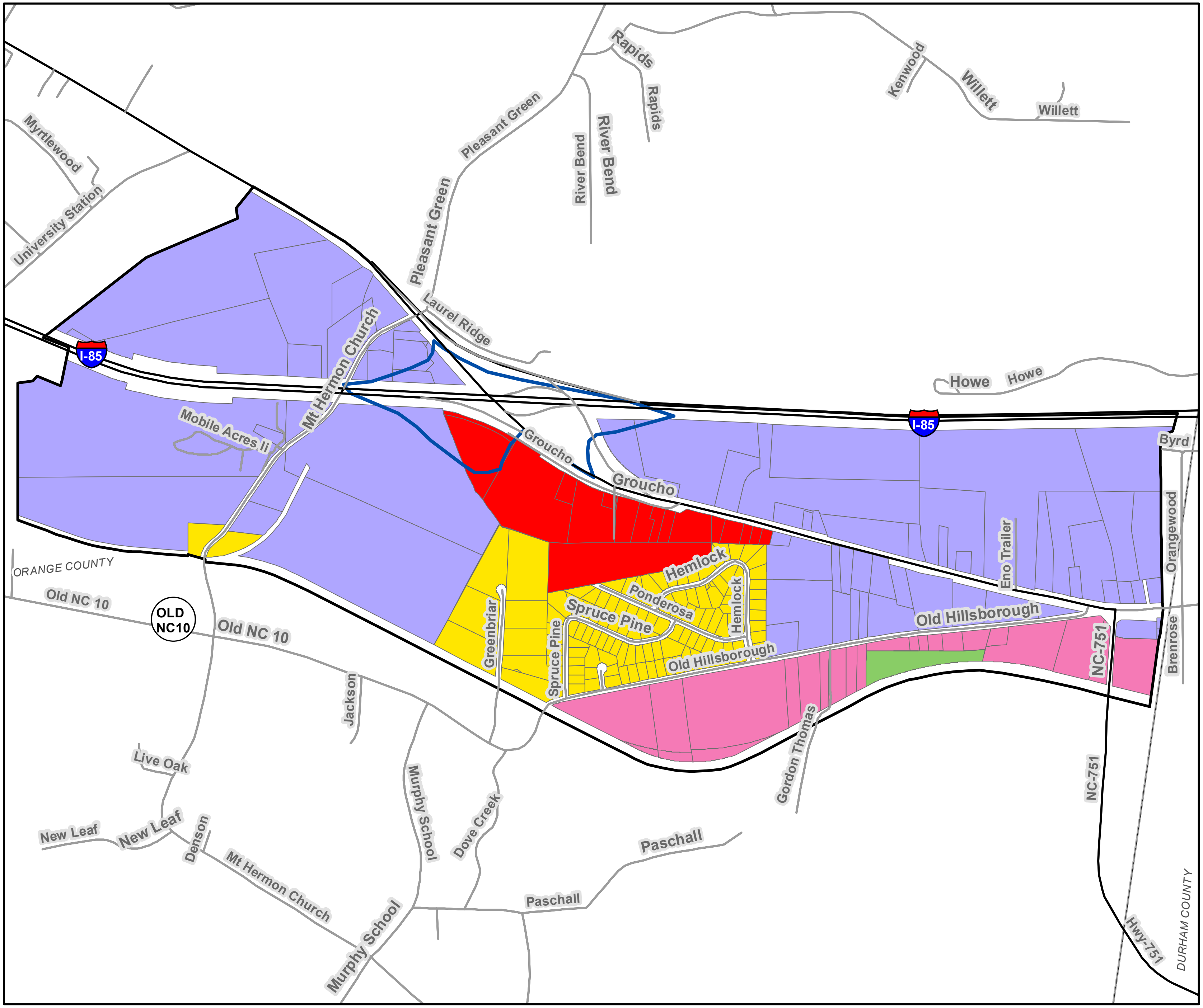
Land Use Description	Eno EDD Area by Land Use (acres)	Eno EDD Area Assuming 70% Impervious (acres)
Commercial	60	42
Industrial	559	391
Low Density Residential (4 DU/Acre or less)	93	65
Office	79	56
Recreation / Open Space (1)	6	243
Total	**797**	**797**

1) Includes both parcels designated as Recreation/Open Space land use and the 30 percent pervious area/open space associated with other land uses.

Eno EDD

Proposed Future Landuse

Figure 2-1



Legend

- Proposed DOT ROW for Improvements to 70/85 Interchange
- Eno EDD Area
- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space

0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,500 feet

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2.2 Water Demand Projections

Typical water demands per acre for commercial/office, industrial and low density residential land uses for studies performed in the southeast are presented in **Table 2-2**. Based on the values presented in Table 2-2 and discussion with the County and City, it was decided that a unit demand factor of 750 gallons per day per acre (gpd/acre) for commercial and office land use and a unit demand factor of 600 gpd/acre for low density residential would be used in this study. A factor of 0 gpd/acre is assumed for recreation/open space land use, including the 30 percent pervious open space applied to each parcel.

Industrial water demands can vary significantly depending on the type of industry. For this reason, water demand projections were developed for a low water use scenario assuming industrial water use of 1,000 gpd/acre, a mid water use scenario assuming industrial water use of 1,500 gpd/acre, and a high water use scenario assuming industrial water use of 2,000 gpd/acre.

Table 2-2. Water Demand Factors

	Water Demands (gpd/acre)		
Source	**Commercial**	**Industrial**	**Low Density Residential (4 DU/Acre or less)**
Typical Unit Factors	**500 to 800**	**1,000 to 3,000**	**500 to 700**
Perimeter Park Study (Cary, NC) [1]	722	1,111	667
City of Durham Water Demand Projections (September 2010)[2],[3]	760	245	600
PWC of Fayetteville	N/A	2,200	N/A
Town of Cary (IWRMP CH2M Hill, 2007)	1,740	72	N/A
Town of Morrisville (Town of Cary IWRMP CH2M Hill, 2007)	436	166	N/A
Recommended for Eno EDD	**750**	**1,000 to 2,000**	**600**

1) Water demand factors are calculated using the wastewater flow factors from the Perimeter Park Study (Cary, NC) and assuming a 90 percent wastewater return rate.
2) Water demand factors are calculated using the 2009 demand (mgd) divided by the total existing land use area and multiplied by 70 percent
3) Water demand factors calculated from City of Durham Water Demand Projections Scenario2, which assumes residential demand of 60 gallons per capita per day. The Low Density Residential demand is calculated assuming 2.5 people per household * 4 houses per acre * 60 gallons per capita per day = 600 gpd/acre

Tables 2-3, 2-4, and 2-5 present the average day water demand projections based on land use for build-out conditions within the Eno EDD for the low, mid, and high scenarios, respectively based on industrial demand factors ranging from 1,000 to 2,000 gpd/acre. Peaking factors used for evaluation and design of the water system are discussed in Section 3.

Table 2-3: Demand and Flow Factors based on Parcel Area (Low Scenario, 1,000 gpd/acre Industrial Demand)

Landuse Description	Total Area (acres)	70% Impervious Space (acres)	Water Demand Factor (gpd/acre)	Water Demand (gpd)	Water Return Rate	Wastewater Flow Factor (gpd/acre)	Wastewater Flow (gpd)
Commercial	60	42	750	32,000	80%	600	25,000
Industrial	559	391	**1,000**	391,000	80%	**800**	313,000
Low Density Residential (4 DU/Acre or less)	93	65	600	39,000	80%	480	31,000
Office	79	56	750	42,000	80%	600	33,000
Recreation / Open Space	6	243	0	0	80%	0	0
Total	**797**	**797**		**504,000**			**402,000**

Table 2-4: Demand and Flow Factors based on Parcel Area (Mid Scenario, 1,500 gpd/ac Industrial Demand)

Landuse Description	Total Area (acres)	70% Impervious Space (acres)	Water Demand Factor (gpd/acre)	Water Demand (gpd)	Water Return Rate	Wastewater Flow Factor (gpd/acre)	Wastewater Flow (gpd)
Commercial	60	42	750	32,000	80%	600	25,000
Industrial	559	391	**1,500**	586,000	80%	**1,200**	469,000
Low Density Residential (4 DU/Acre or less)	93	65	600	39,000	80%	480	31,000
Office	79	56	750	42,000	80%	600	33,000
Recreation / Open Space	6	243	0	0	80%	0	0
Total	**797**	**797**		**699,000**			**558,000**

Table 2-5: Demand and Flow Factors based on Parcel Area (High Scenario, 2,000 gpd/acre Industrial Demand)

Landuse Description	Total Area (acres)	70% Impervious Space (acres)	Water Demand Factor (gpd/acre)	Water Demand (gpd)	Water Return Rate	Wastewater Flow Factor (gpd/acre)	Wastewater Flow (gpd)
Commercial	60	42	750	32,000	80%	600	25,000
Industrial	559	391	**2,000**	782,000	80%	**1,600**	626,000
Low Density Residential (4 DU/Acre or less)	93	65	600	39,000	80%	480	31,000
Office	79	56	750	42,000	80%	600	33,000
Recreation / Open Space	6	243	0	0	80%	0	0
Total	**797**	**797**		**895,000**			**715,000**

2.3 Wastewater Flow Projections

Wastewater flow factors for the Eno EDD were determined by applying a wastewater return rate to the water demand projections. A typical return rate is 80 percent, meaning that 80 percent of the water demand is returned to the wastewater collection system. However, the return rate for industrial areas can vary significantly depending on the type of industry. Industries that use a significant portion of their water in the final product (for example, food and beverage manufacturers) would be expected to have a much lower wastewater return rate. Because the type of industry in the Eno EDD is not known yet, it was decided to assume an 80 percent return rate for development of wastewater flows. However, the County should keep this assumption in mind when evaluating future industries which may discharge less to the wastewater system than typical.

Tables 2-3, 2-4, and 2-5 present the average day wastewater flows for build-out conditions within the Eno EDD for the low, mid, and high scenarios, respectively. Peaking factors used for evaluation and design of the wastewater system are discussed in Section 4.

2.4 Phasing and Summary

The sections above have described the processes by which the total water demand and wastewater flow was developed for the Eno EDD area under build-out land use conditions. In order to evaluate a potential phasing approach for implementation of the infrastructure improvements, described in more detail in subsequent sections of this report, the demands and flows were phased in 10 year increments from 2020 through build-out. The County has developed a draft phasing plan for development within the Eno EDD, with the percent growth presented in **Table 2-6**.

Table 2-6. Water Demand Factors

Planning Period	Percent Developed Area in Eno EDD
2020	15%
2030	35%
2040	55%
2050	75%
2060	95%

Figure 2-2 shows average day water demand projections for each planning period for the low, mid, and high scenarios. Phased water demand and wastewater flow projections are listed in **Table 2-7**.

Table 2-7. Summary of Average Day Water Demand and Wastewater Flow Projections by Planning Period

	Planning Period Flows[3] (gpd)					
Projections[1,2]	2020	2030	2040	2050	2060	Build-out
Low Water	76,000	176,000	277,000	378,000	479,000	504,000
Mid Water	105,000	245,000	384,000	524,000	664,000	699,000
High Water	134,000	313,000	492,000	671,000	850,000	895,000
Low Wastewater	60,000	141,000	221,000	302,000	382,000	402,000
Mid Wastewater	84,000	195,000	307,000	419,000	530,000	558,000
High Wastewater	107,000	250,000	393,000	536,000	679,000	715,000

Notes:
1) The Low, Mid, and High projections differ based on the assumed unit water demand factor for industrial development. The Low projection assumed 1,000 gpd/acre, the Mid projection 1,500 gpd/acre, and the High projection 2,000 gpd/acre.
2) The wastewater projections are based on an assumed water return rate of 80 percent.
3) The percentage of growth between planning periods was provided by the County.

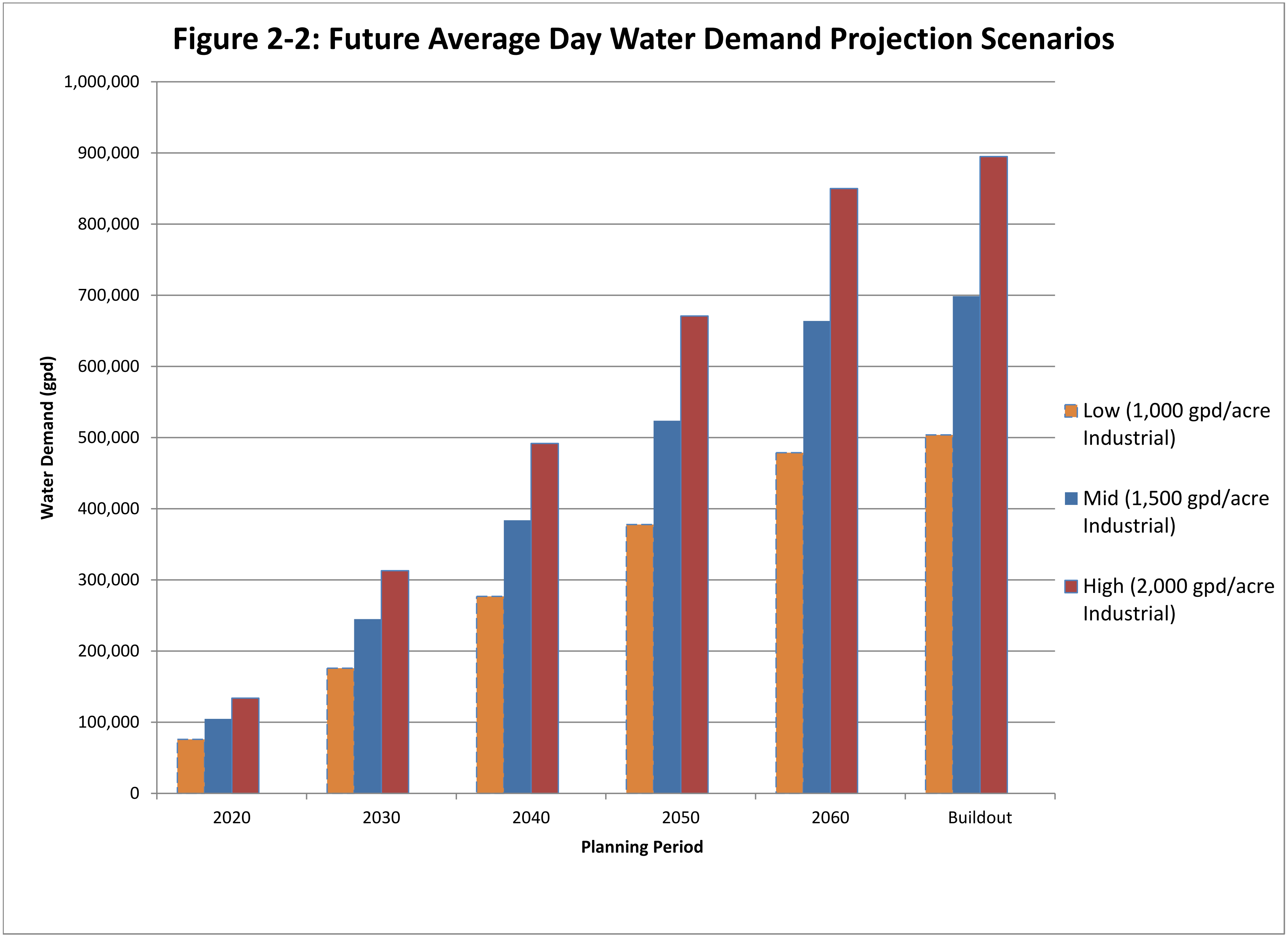
Figure 2-2: Future Average Day Water Demand Projection Scenarios
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Water Demand (gpd)
2020
2030
2040
2050
2060
Buildout
Planning Period
Low (1,000 gpd/acre Industrial)
Mid (1,500 gpd/acre Industrial)
High (2,000 gpd/acre Industrial)

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Section 3

Evaluation of Existing Water Infrastructure within Eno EDD

CDM Smith performed a preliminary hydraulic evaluation of the existing water infrastructure within the Eno EDD to determine what improvements, if any, would be needed to provide the infrastructure backbone needed to support anticipated growth. This section describes the evaluation and associated conclusions.

3.1 Existing Infrastructure

The City's water distribution system currently extends into the Eno EDD. This area is served from the City's High Pressure Zone (hydraulic gradient of 700 feet). The primary piping in this area consists of a 16-inch diameter ductile iron transmission pipe along US Hwy 70 and 6-inch diameter distribution pipes in the Mobile Acres 2 development, as shown in **Figure 3-1**. Per the City's as-built drawings, approximately 2,300 feet of the transmission pipe along US Hwy 70 near the Durham County and Orange County border is 12-inch instead of 16-inch diameter, as shown on the figure.

3.2 Water Distribution System Evaluation

City's water distribution system hydraulic model, which was previously developed using WaterGEMS software, was used to evaluate the adequacy of the existing system to support the Eno EDD projected demands.

3.2.1 Model Verification

Prior to modeling the additional Eno EDD demand, field data was collected to verify the model's accuracy in the Eno EDD area. Two hydrant flow tests were conducted in May 2013. The field test data and locations of the two tests are shown on **Figure 3-2**. The City's Finley Pump Station, located near Neal Road and Finley Street, provides emergency fire flow pumping support to the High Pressure Zone in the western portion of the system, which includes the portion of the system in Orange County. However, the hydrant tests were conducted with the Finley pumps off. Similar operational and demand conditions were simulated in the hydraulic model and results compared with the field test data. For both tests, the static pressures simulated in the model were within 1 psi of the static pressures observed in the field and residual pressures simulated in the model were within 7 psi of the field data. Therefore, the hydraulic model was considered accurate for the purposes of evaluating the future Eno EDD water demands.

3.2.2 Model Set-Up and Evaluation Criteria

The Eno EDD water demand projections calculated using the unit demand factors discussed in Section 2 are for an average day demand. When evaluating an existing water distribution system or designing new distribution pipes, peak demand conditions must be considered. These are typically peak hour demands or requirements for fire protection.

Maximum day demands were calculated by applying a factor of 1.5 to the average day demands. This factor is based on previous hydraulic evaluations performed for the City's water distribution system. The fire flow requirements for the City of Durham for various land use types are as follows:

- 1,500 gallons per minute (gpm) for residential
- 2,000 gpm for offices, hotels with sprinklers, townhomes, institutional, and multifamily apartments
- 2,500 gpm for commercial with sprinklers, hotels without sprinklers
- 3,000 gpm for commercial without sprinklers, industrial with sprinklers
- 3,500 gpm for industrial without sprinklers

The City does not always provide the full fire flow, but may instead have the developer provide additional on-site fire suppression systems to meet these requirements for large commercial or industrial buildings.

Hydraulic simulations were run for the existing system under maximum day demand conditions, both with and without the additional Eno EDD projected demand. An extended period simulation was run to examine the variation in demand, pressure, and other system conditions over the course of a maximum demand day. Fire flow simulations were also run to determine the maximum available fire flow.

Based on the hydraulic model provided by the City, the existing maximum day demand on the US Hwy 70 transmission main within Orange County is approximately 27,000 gpd. A maximum day demand to average day demand peaking factor of 1.5 was assumed for the Eno EDD demand projections, resulting in an additional maximum day demand of 756,000 gpd for the low scenario and 1,343,000 gpd for the high scenario, as shown in **Table 3-1**. A description of how the water demands for the Eno EDD area were developed can be found in Section 2. The hydraulic model provided by the City includes a single system-wide diurnal pattern applied to all modeled demands. This same diurnal pattern was also applied to the Eno EDD demand, resulting in the peak hour demands given in Table 3-1.

Table 3-1. Summary of Demand along US Hwy 70 Transmission Main in Orange County

	Low Scenario		High Scenario	
	MDD[1] (gpd)	PHD[2] (gpd)	MDD[1] (gpd)	PHD[2] (gpd)
Existing Orange County	27,000	38,000	27,000	38,000
Eno EDD (Build Out)	756,000	1,058,000	1,343,000	1,880,000
Total	783,000	1,096,000	1,370,000	1,918,000

1. MDD = Maximum Day Demand; MDD:ADD peaking factor = 1.5 per existing hydraulic model
2. PHD = Peak Hour Demand; PHD:MDD peaking factor = 1.4 per existing hydraulic model

For the hydraulic simulations, the entire Eno EDD demand for the build-out planning period was added near the western end of the Eno EDD on the 16-inch transmission main near the intersection of US Hwy 70 and Mt Hermon Church Road. This represents a worst-case scenario for head loss in the transmission main.

Evaluation of the capacity of the existing water distribution system within the Eno EDD was made based on the following guidelines:

- **Minimum Pressure** –minimum pressures greater than 30 psi during peak hour demand conditions are generally recommended.
- **Velocity** – for transmission mains, a maximum design velocity of 10 feet per section (fps) is recommended, with velocities less than 5 fps as the desirable range (per AWWA Manual M32).
- **Headloss** – maximum design headloss of 2 to 3 feet per 1,000 feet of pipe is recommended for transmission mains 16-inches in diameter and greater (per AWWA Manual M32).
- **Fire Flow** – a fire flow of 3,500 gpm, while maintaining a residual pressure of 20 psi, is recommended during maximum day demand conditions for industrial customers without sprinklers.

3.2.3 Hydraulic Capacity Analysis

Results of the hydraulic simulation with the Low Scenario and High Scenario Eno EDD demand were compared with the existing system hydraulic simulation results. **Table 3-2** presents results for minimum pressure at three locations along the existing US Hwy 70 transmission main. For the Low Scenario, minimum pressures during peak demand conditions are lower than existing pressures by approximately 9 psi, but are still above 60 psi. For the High Scenario, minimum pressures are more than 30 psi lower than existing pressures. However, minimum pressure is still greater than 30 psi.

Table 3-2. Minimum Pressure along Existing Water Transmission Main in Eno EDD

Location	Minimum Pressure[1] (psi)		
	Existing	Low Scenario	High Scenario
US 70 & Eno Trailer Park Rd (highest elevation)	71	63	40
US 70 approx. 700 feet east of Groucho Rd (lowest elevation)	98	89	64
End of 16-inch pipe - US 70 near power substation	87	78	51

1) Values based on minimum pressure estimated during a peak hour demand condition.

Table 3-3 presents results for velocity, headloss, and fire flow along the existing US Hwy 70 transmission main within the Eno EDD. The available fire flow is reported at the far western end of the modeled transmission main near the power substation.

For the Low Scenario, all three system parameters fall within the recommended ranges discussed in the previous section. For the High Scenario, maximum system headloss is greater than the design range of 2 to 3 ft per 1,000 ft of pipe. The available fire flow is also slightly lower than 3,500 gpm.

Table 3-3. Velocity, Headloss, and Fire Flow along Existing Water Transmission Main in Eno EDD

System Parameter	Existing	L3ow Scenario	High Scenario
Maximum Velocity (fps)	< 1	< 3	< 4
Maximum Headloss (ft/1,000 ft)	< 1	< 2	< 4
Fire Flow (gpm)	> 3,500	> 3,500	3,200

3.2.4 Summary

Based on the hydraulic modeling results, the existing water distribution system and US Hwy 70 water transmission main have adequate capacity to serve the Eno EDD Low Scenario demand through the build-out planning period.

For the High Scenario, the hydraulic analysis indicated reduced pressures and higher headloss resulting from increased build-out demand in the Eno EDD. Improvements within the City's water distribution system may be needed to increase transmission capacity to the Eno EDD area for the High Scenario. However, these improvements would not be needed until the Eno EDD is near build-out.

The existing US Hwy 70 transmission main was constructed in the late 1980's and is approximately 25 years old. This pipe was assumed to be in good internal condition for the purposes of the hydraulic modeling. As development of the Eno EDD occurs and demands increase in the future, the City may want to verify the condition of the transmission main by performing C factor testing or other condition assessment to make sure deterioration has not occurred and the pipeline is still adequate to support development.

The location and size of water distribution infrastructure connecting to the existing transmission main to serve development within the Eno EDD should be evaluated as more specific development information is available.

Section 4

Proposed Wastewater Collection System within the Eno EDD

CDM Smith performed an evaluation to develop a conceptual layout of the recommended wastewater collection and conveyance infrastructure backbone within the Eno EDD. This section describes the evaluation and associated conclusions.

4.1 Existing Wastewater Collection System

Most of the existing development within the Eno EDD is served by private septic systems, with the exception of a small mobile home park at Hillsborough Road and Duke Forest Mobile Home Lane which maintains a small private pump station that pumps to the City's wastewater collection system on Hillsborough Road at the Durham County border. To meet the goals of the project, a wastewater infrastructure backbone is required to serve the Eno EDD and discharge into the City's wastewater collection system.

4.2 Eno EDD Physical Features

As discussed in Section 1.2, the Eno EDD is located within Orange County, and borders Durham County to the east. Several physical features within the Eno EDD area were considered for a wastewater collection system when evaluating the project area. The features described below are shown on **Figure 4-1**.

4.2.1 Roadways

Two major roadways pass through the Eno EDD. US Hwy 70 runs east-to-west through the project area and isolates several parcels to the north from the majority of the parcels to its south. I-85 enters the Eno EDD at its interchange with US Hwy 70 and continues west, isolating a grouping of parcels to the north from the majority of the parcels to the south.

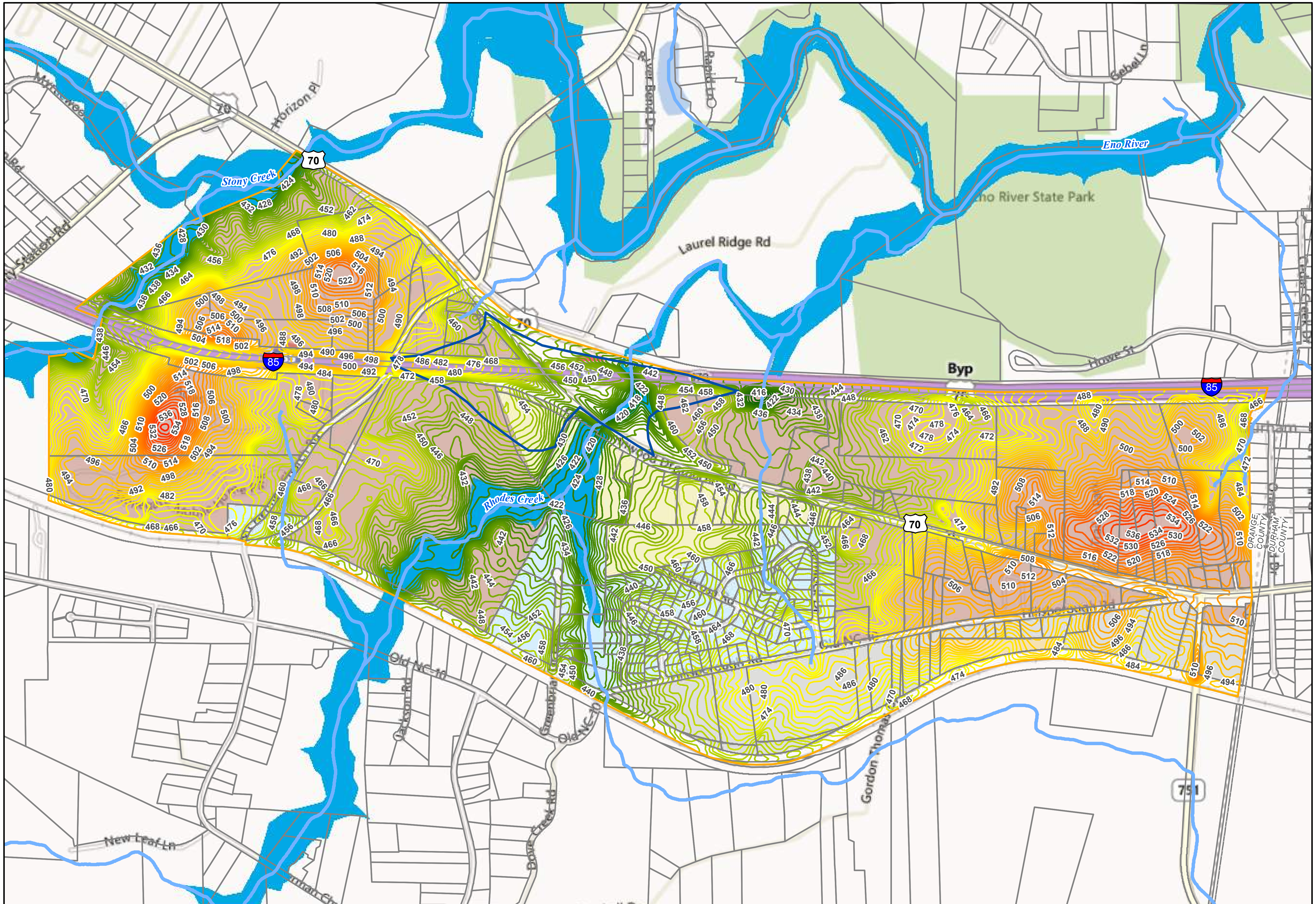
During preliminary analyses, it was identified that NCDOT is planning future improvements to the US Hwy 70/I-85 interchange, which are expected to include new on and off ramps. These improvements will require property acquisition around the interchange, which will increase the area unavailable for future development. Design of the interchange has not been completed as of the time of this report, however preliminary designs have been developed and were made available to CDM Smith by the County. The largest proposed right-of-way (ROW) area shown on the interchange improvement alternatives was used to identify the area in which proposed wastewater infrastructure could not be located, as shown on Figure 4-1.

In general this evaluation assumed that wastewater infrastructure could be located within most road ROWs, with the exception of I-85 and the new I-85 and US Hwy 70 interchange. It was also assumed that a crossing of US Hwy 70 or I-85 would have to be performed using trenchless methodologies.

4.2.2 Hydrography

The Eno EDD is located within the Upper Falls Lake watershed, just south of the Eno River and has eight streams that flow into and through the project area. Of those streams, four are located in areas where they are not anticipated to impact the wastewater infrastructure to be proposed as part of this project, such as the section of Stony Creek located along the western most border of the project area, as shown on Figure 4-1. Based on a GIS desktop analysis, the remaining four streams appeared to be located in areas that could impact the proposed wastewater infrastructure. CDM Smith performed a field visit to evaluate the streams to determine the level of impacts that would result from construction of new wastewater infrastructure. It was determined during the field visit that two of the streams are ephemeral, only conveying stormwater during rainfall events, and would therefore not result in permitable environmental impacts. Rhodes Creek, which is located in the center of the project area and flows north through the I-85 and US Hwy 70 interchange, is a perennial stream and would require environmental permits in order to construct proposed infrastructure. **Figure 4-2** is a picture of the stream, looking downstream from the Old Autumnwood Drive bridge crossing. The stream is approximately 15 feet wide at this location and would require bypass pumping and coordination with regulatory agencies if a wastewater pipe were to be installed across it using open-cut installation method. Therefore, it was assumed for this evaluation that crossing Rhodes Creek would be performed using trenchless methodologies (e.g. bore-and-jack or horizontal direction drilling).

Figure 4-2. Old Autumnwood Drive at Rhodes Creek



Eno EDD

Physical Features

Figure 4-1

Legend

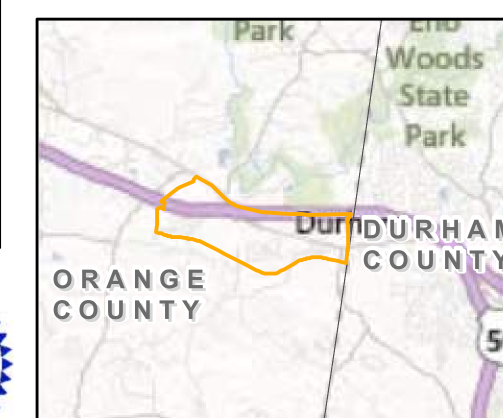
- Proposed DOT ROW for Improvements to 70/85 Interchange
- Stream
- Eno EDD Area
- Parcel Boundary

Contour Elevation

- 412 - 450 Ft
- 451 - 475 Ft
- 476 - 500 Ft
- 501 - 525 Ft
- 526 - 550 Ft
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,000 feet

N

CDM Smith

4.2.3 Topography

Ground elevations within the project area vary widely, ranging in elevation from 540 feet to 420 feet, a difference of 120 feet. Two predominant ridges run north and south within the Eno EDD. The westernmost ridge is located between Stony Creek and Rhodes Creek, just west of the I-85/US Hwy 70 interchange. The easternmost ridge is located just west of the boundary with Durham County. An elevation profile, shown on **Figure 4-3**, reflects the fluctuations within the Eno EDD. Elevation changes influence the ability to convey wastewater using gravity, versus being pumped. Consideration should be taken during design as to the long term cost and maintenance required for a very deep gravity sewer versus a shallow force main, associated with a pump station.

4.3 Design Criteria

4.3.1 Priority Service Areas

The Eno EDD consists of 290 parcels covering approximately 796 acres within the County. Attempting to provide sanitary sewer service to each individual parcel would prove both inefficient and uneconomical. Instead, several areas were identified as priority service areas.

Priority service areas were identified based on input from County staff, development potential, and geographical location within the Eno EDD. As such, priority service areas included larger parcels near the Eno EDD boundaries and areas dense with parcels zoned for future industrial use. Three main priority service areas were identified, as shown on **Figure 4-4**.

> **Priority Service Area 1** – Area 1 consists of the parcels bounded by I-85 to the north, US Hwy 70 to the west and south, and Durham County to the east. The parcels within this area are zoned for future Industrial use. The parcels range in size from 1 acre to 40 acres. A single 40 acre parcel offers the potential opportunity for development as a large industrial customer.
>
> **Priority Service Area 2** – Area 2 includes the parcels south of US Hwy 70, along the eastern portion of the Eno EDD. Specifically, it includes those parcels zoned for future Commercial and Industrial use. While most of these parcels are less than 10 acres in size, their proximity to US Hwy 70 offers an attractive development location for potential customers.
>
> **Priority Service Area 3** – This area includes several large parcels in excess of 50 acres. The area is located south of I-85 and west of Rhodes Creek and is bisected by Mt. Herman Church Road. The size of these parcels and proximity to the I-85/US Hwy 70 interchange make them ideal for large industrial customers.

While they are not considered in a priority service area, it is important to note the parcels located north of I-85 and south of US Hwy 70 along the western edge of the Eno EDD. These parcels are all zoned for future Industrial use and possess the potential to attract large developers. However, to connect these parcels to the proposed wastewater system, a pipe would have to be installed underneath I-85. For the purposes of this report, it was assumed that future developers in this area would install such a pipe under I-85 to connect into the Eno EDD wastewater system.

4.4 Proposed Wastewater System

4.4.1 Peaking Factor

A peaking factor was applied to the average flows for design of wastewater collection system infrastructure. The peaking factor accounts for typical diurnal variations in wastewater flow and also infiltration/inflow into the collection system. A peaking factor of 4 is typical of new residential development within the City. However, industrial flows typically do not have high peaking factors since it is typically a constant discharge whereas there is greater fluctuation for residential development since people tend to use most of their water early in the morning and late in the afternoon. Therefore, a peaking factor of 2.5 was applied to the wastewater flow projections within the Eno EDD area. This peaking factor was chosen as the minimum allowable by the North Carolina Department of Environment and Natural Resources (NCDENR) for permitting new sewer pipes and pump stations.

4.4.2 Gravity Sewer

With the identification of the priority service areas, CDM Smith evaluated gravity sewer alignment alternatives to collect wastewater from these areas. Utilizing a combination of input from County staff as well as analysis of the physical features described previously, preliminary pipe alignments were derived. The goal of these alignments was to connect the priority service areas to a central collection location utilizing gravity flow. **Figure 4-5** shows the preliminary pipe alignments within the Eno EDD.

4.4.2.1 Pipe Depth Analysis

Pipe depths can vary widely along a given alignment and, in turn, will affect associated costs. Applicable regulations and standards should be the starting point when determining overall pipe depths. As a beginning point, the regulations and standards to consider are the minimum required depth of cover and minimum pipe slope.

The City's specifications for sewer construction require a minimum depth of cover between the existing grade and the crown of the pipe of 4 feet. Additionally, the City's standards specify the minimum slope required. The following are the minimum slope requirements for the pipe diameters proposed for this project:

- 8 inch – 0.50% slope
- 12 inch – 0.22% slope

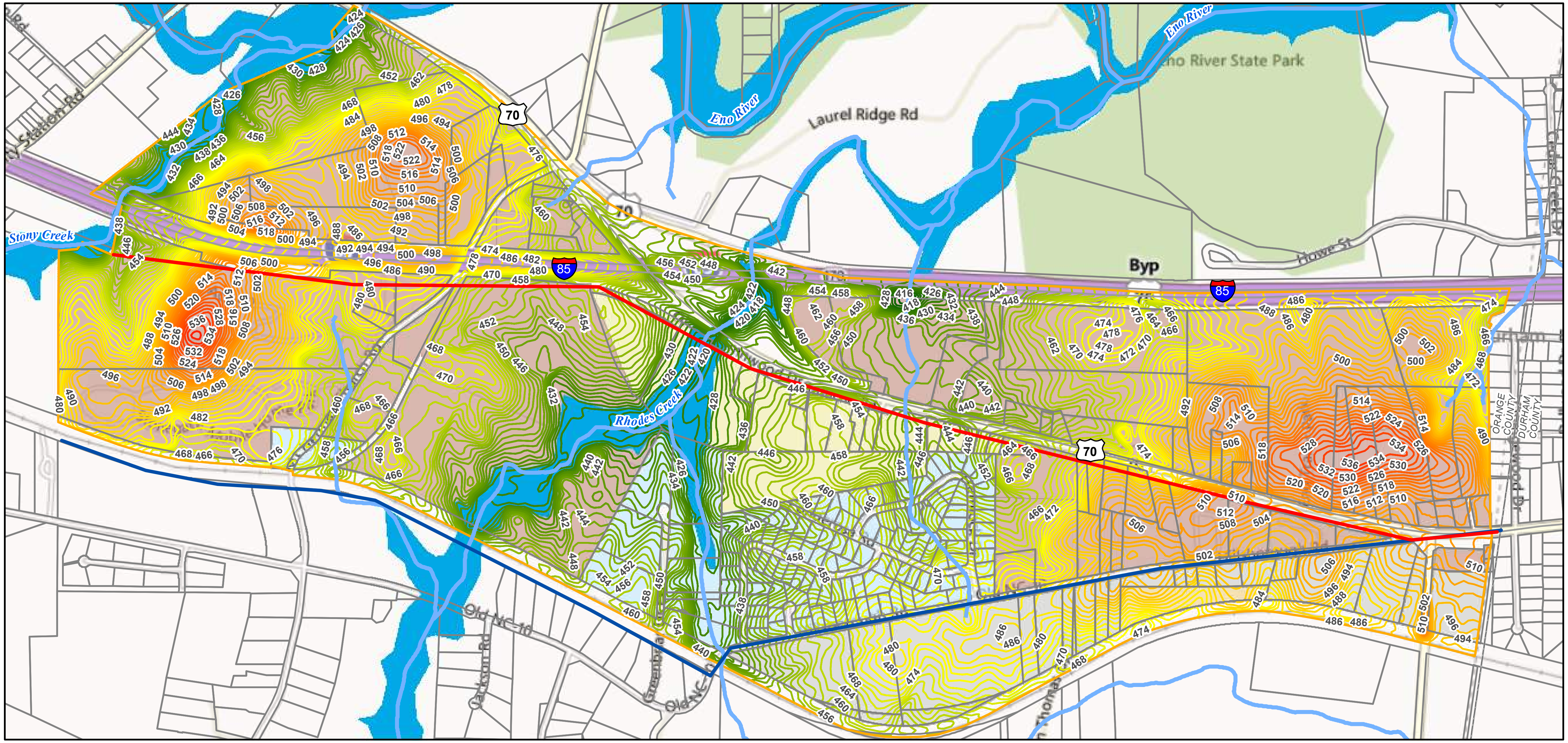
At a minimum, the pipe must meet the minimum depth of cover and slope requirements along the entire pipe alignment. As such, pipe depths are dictated by these parameters. However, other factors also affect pipe depths and must be considered in the evaluation. These factors are described below.

Topography – Topographic variations along a pipe alignment will affect the pipes depth. As stated above, a pipes minimum slope must be met regardless of a rise in ground elevation. Therefore, the pipe will continue to drop in depth, even while the elevation rises, thus leading to a deeper pipe along the elevation rise. Additionally, at a point along the alignment where the ground elevation drops, the slope of the pipe must increase accordingly so as to maintain the minimum depth of cover. Similarly, this can lead to a deeper pipe.

Eno EDD

Elevation Profile

Figure 4-3



Legend

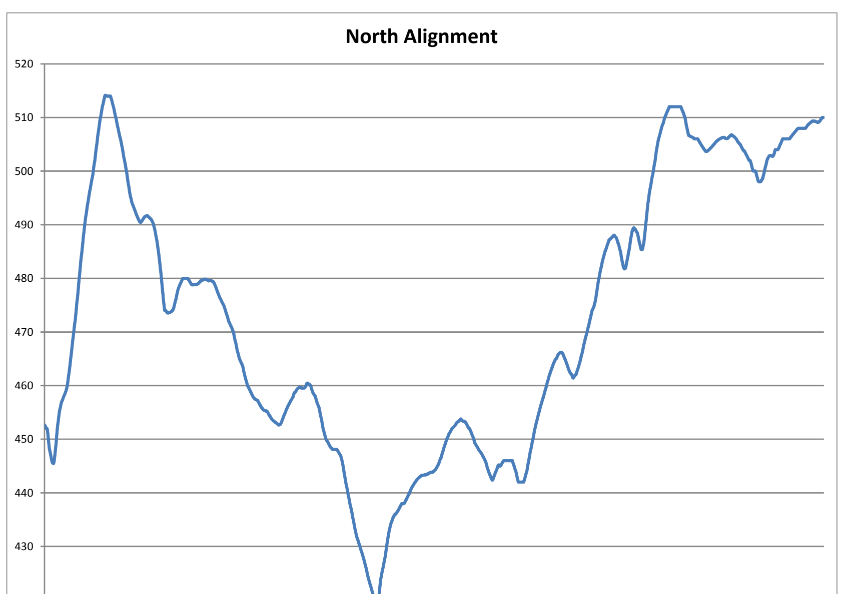
- North Alignment
- South Alignment
- Stream
- Eno EDD Area
- Parcel Boundary

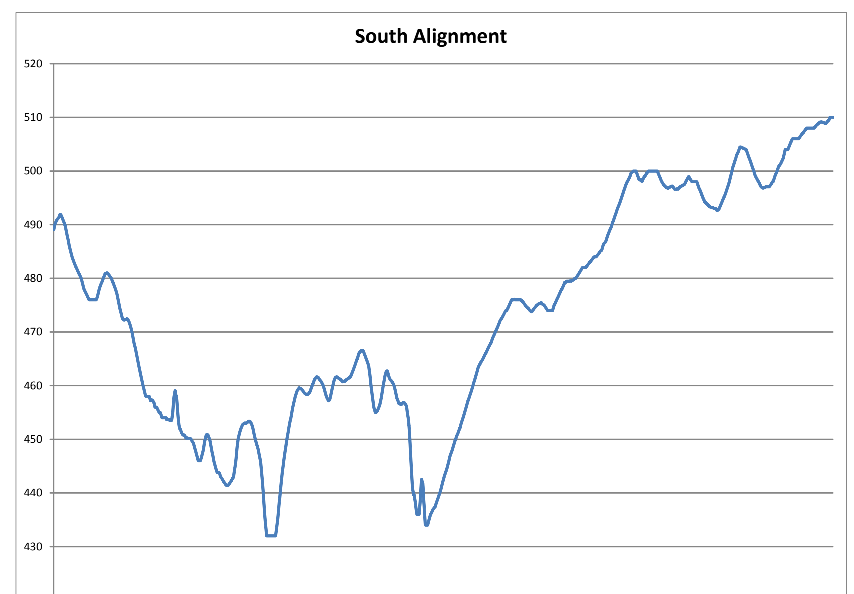
Contour Elevation

- 412 - 450 Ft
- 451 - 475 Ft
- 476 - 500 Ft
- 501 - 525 Ft
- 526 - 550 Ft
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space

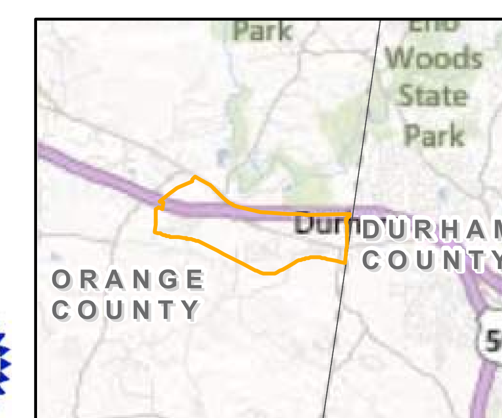




0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,000 feet

N

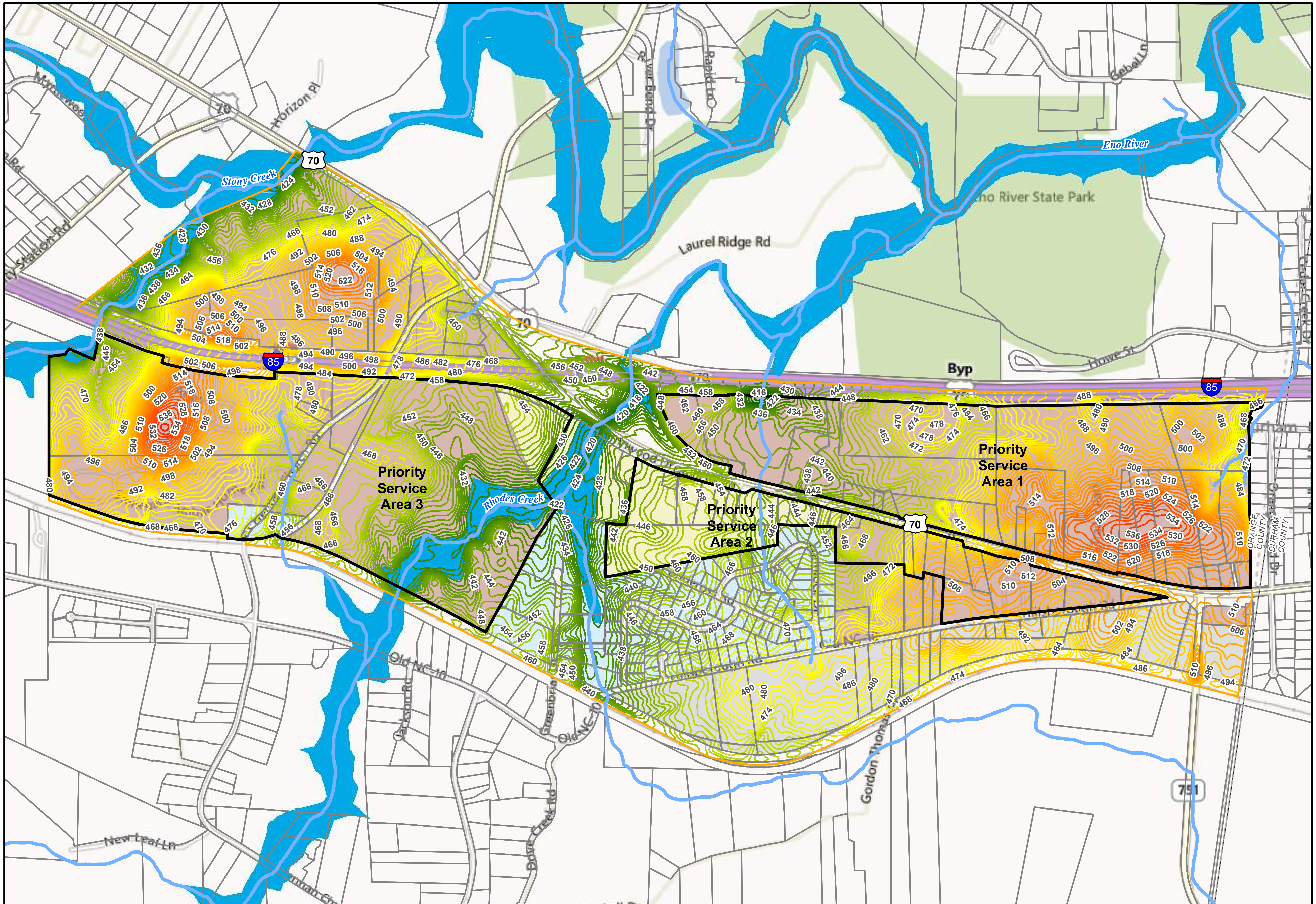


CDM Smith

Eno EDD

Priority Service Areas

Figure 4-4



Legend

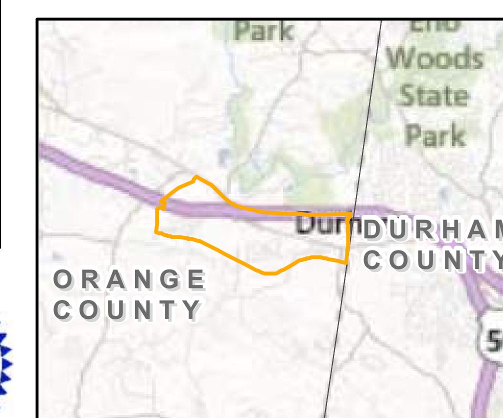
- Priority Service Area
- Stream
- Eno EDD Area
- Parcel Boundary

Contour Elevation

- 412 - 450 Ft
- 451 - 475 Ft
- 476 - 500 Ft
- 501 - 525 Ft
- 526 - 550 Ft
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



Feet
0 500 1,000 2,000 3,000 4,000 5,000
1 inch = 1,000 feet

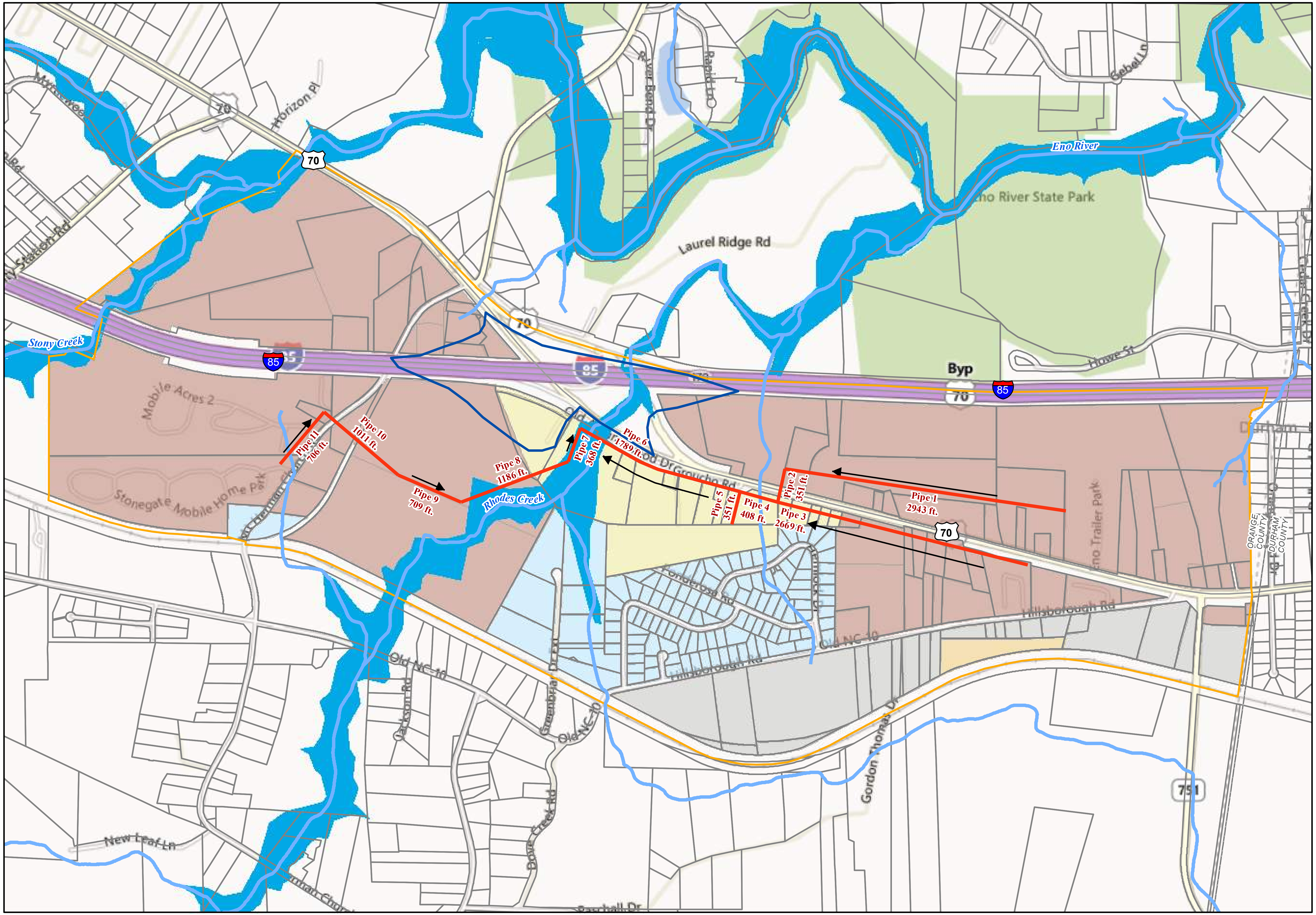
N

CDM Smith

Eno EDD

Gravity Sewer System Pipe Alignments

Figure 4-5

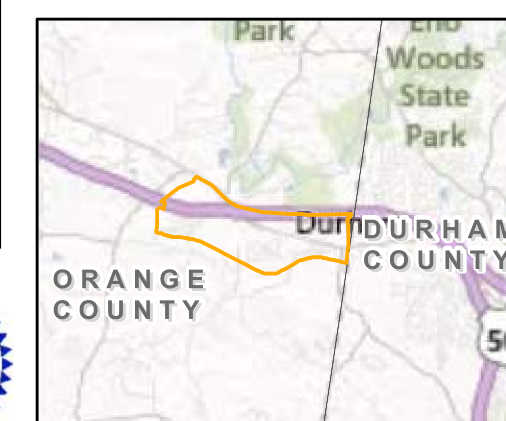


Legend

- Proposed Gravity Sewer
- Flow Direction
- Proposed DOT ROW for Improvements to 70/85 Interchange
- Stream
- Eno EDD Area
- Parcel Boundary
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



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1 inch = 1,000 feet

N

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As previously discussed, the topography throughout the Eno EDD is highly variable. Along each individual pipe, these variations led to depths of cover greater than the required minimum.

Areas of Service – The contributing area of each pipe must also be considered in pipe depth analysis. A sewer trunk pipe must be at a low enough elevation to be able to serve parcels in the contributing area via gravity. Parcels with lower elevations in the contributing area can push the sewer trunk pipe deeper.

The evaluation of the proposed gravity system infrastructure did not include an analysis of pipe depths required to serve individual parcels. Instead, ground profiles were generated along five paths extending beyond the proposed alignments. Each path represents a possible branch line from the main pipe and was chosen to provide significant coverage within the Eno EDD. Depths of the pipes along the main alignments were adjusted to be able to serve parcels along or near these paths. It is assumed that these paths are representative of areas around them, and therefore their effect on pipe depths is considered to be representative. The five service area paths used for the analysis are shown on **Figure 4-6**.

Critical Crossings – At points along a pipe alignment, physical features might be encountered that require the gravity pipe to be installed at a deeper elevation to avoid conflicts. Utility conflicts, such as those encountered at a large road intersection, can also dictate overall pipe depth. Within the Eno EDD, several of these critical crossings will be encountered. As discussed in Section 4.2.2, GIS data indicated several creeks and streams within the Eno EDD. Upon field verification, Rhodes Creek was the only waterway found to be flowing with water. As shown on Figure 4-1, Rhodes Creek bisects the Eno EDD near its center, separating parcels on its east from those on its west. The only way to connect the parcels together to a central location would be to cross the creek. Preliminary evaluation of pipe alignments indicated the need to cross the creek near its intersection with US Hwy 70. Due to the size of the creek, it was determined a trenchless crossing would be recommended, as opposed to installing an aerial sewer or open-cutting the stream. As such, crossing underneath the creek pushes the depth of downstream pipes deeper.

US Hwy 70 and I-85 are major thoroughfares through Durham and Orange Counties. As shown on Figure 4-1, both roads pass through the Eno EDD at different locations. Where it passes through the Eno EDD, US Hwy 70 isolates a large number of future industrial parcels to its north. In an effort to serve these parcels, it was determined that US Hwy 70 would need to be crossed. Although only a 2-lane road at the proposed crossing location, US Hwy 70 is a NCDOT regulated road, and therefore open-cutting the road for pipe installation would become difficult from a permitting standpoint. It was determined that the road would be crossed using a trenchless technology. Similar to crossing Rhodes Creek, installation of a pipe underneath a NCDOT highway will likely require additional cover beyond the 4 feet required by the City, thus causing the depth of downstream pipes to increase.

Each factor was accounted for during preliminary analysis to determine pipe depths. It is noted that while the minimum slopes were used as a starting point, the abovementioned factors dictated the slopes used for depth analysis. The minimum, maximum and average depths of cover along each pipe alignment are summarized in **Table 4-1**. Depths of cover were rounded to the nearest 0.5 feet.

Table 4-1. Depth of Cover

Gravity Pipe	Depth of Cover (ft)		
	Minimum	Maximum	Average
Pipe 1	4.0	16.0	8.5
Pipe 2	11.0	15.5	13.5
Pipe 3	4.0	15.5	8.0
Pipe 4	10.5	17.0	13.0
Pipe 5	4.0	14.5	8.5
Pipe 6	4.0	24.0	14.0
Pipe 7	4.5	10.0	7.0
Pipe 8	4.0	16.0	8.5
Pipe 9	4.5	11.5	8.5
Pipe 10	9.5	19.5	14.5
Pipe 11	4.0	20.0	10.0

4.4.2.2 Pipe Capacity

As discussed in Section 2, wastewater flows for the Eno EDD parcels were determined based on future land use. As stated above, a peaking factor of 2.5 was applied to each flow scenario (low, mid, and high) and planning period (2020 through build out). NCDENR's minimum design criteria for gravity sewers was used as a starting point of analysis. Under these guidelines, sewers are to be designed to flow half full at the average daily flow. However, this approach does not take into account peak flows and could result in sanitary sewer overflows (SSOs). CDM Smith discussed with NCDENR staff and agreed that a more appropriate design criteria is to assume the pipe flows approximately 75 percent full during peak flow conditions.

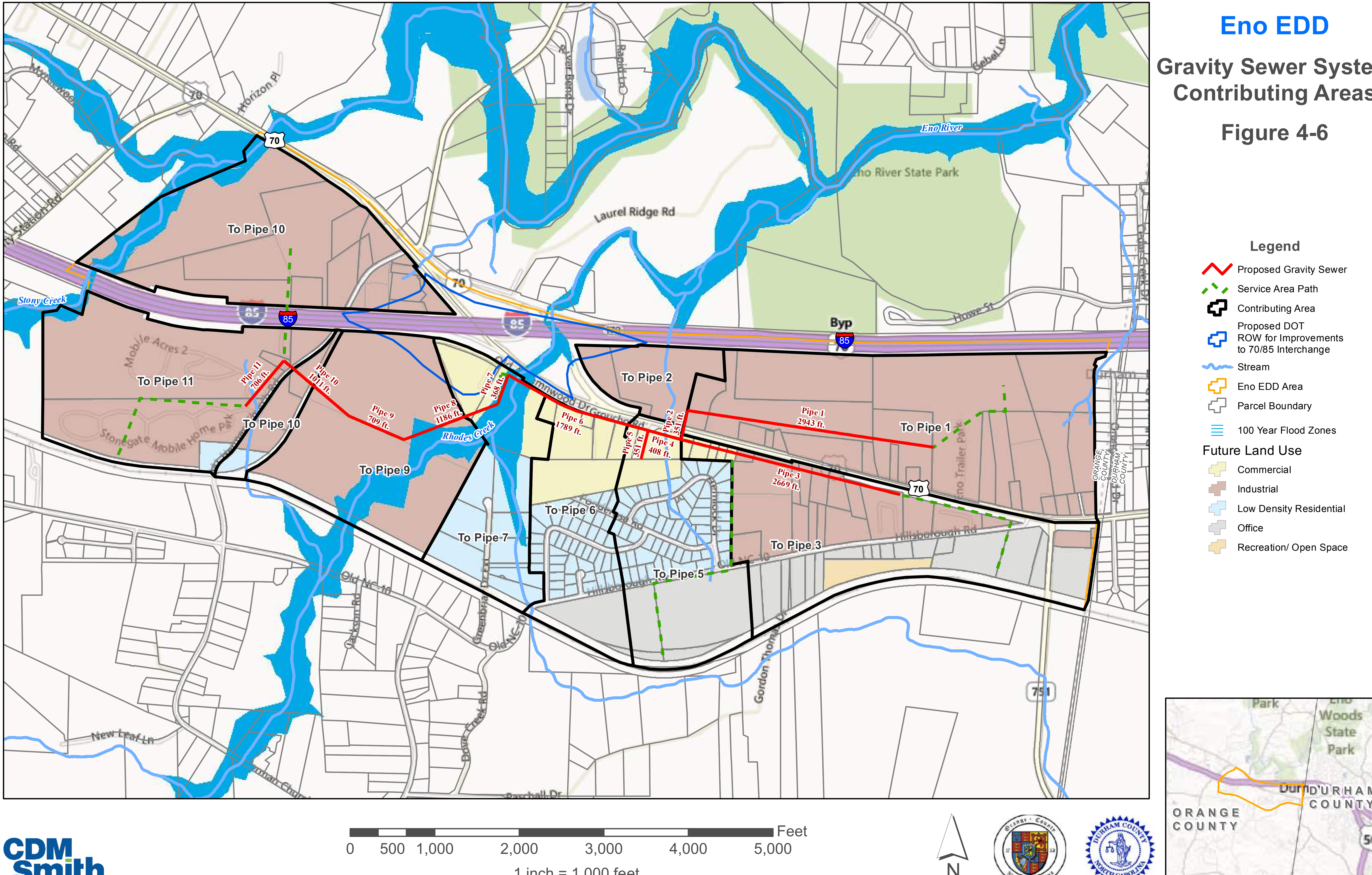
Analysis accounted for pipe slopes, as the slope of a pipe affects the pipes carrying capacity. A pipe with a minimum slope will convey less flow than a pipe of the same diameter with a greater slope. As discussed in Section 4.4.2.1, physical factors along each alignment were used to determine the slope necessary to maintain minimum cover. For the purposes of this report, the average slope along each pipe alignment was used when determining the pipes carrying capacity.

Based on topography within the Eno EDD and the alignments shown on Figure 4-5, each parcel was assigned to a discharge pipe. For the purposes of this report, the sum of the parcels discharging to a given pipe will be referred to as the contributing area. Once the contributing area for each pipe was defined, total flow to the pipe was determined. The contributing areas associated with each pipe are shown on Figure 4-6. In addition to flows from the associated contributing area, analysis also accounted for flows from upstream pipes. The total flow is considered to be the summation of a contributing areas flow and flow from upstream pipes. Total flows were determined for both the low scenario and high scenario. Flow direction in the pipes is indicated by flow arrows on Figure 4-5.

Eno EDD

Gravity Sewer System Contributing Areas

Figure 4-6



CDM Smith

The total flows determined for each pipe were then compared to the pipes carrying capacity to determine the necessary diameter. **Table 4-2** summarizes the total flow (low scenario and high scenario) and pipe diameter necessary for each gravity pipe within the Eno EDD based on the average slope for each pipe. Also shown in the table is the length for each pipe segment. Total flows were rounded to the nearest 5,000 gpd. It should be noted that the City of Durham does not stock or install 10 inch diameter gravity sewer pipe. Therefore, any pipe that was determined to have a diameter of 10 inches was upsized to a 12 inch diameter in Table 4-2.

Table 4-2. Pipe Diameters

Gravity Pipe Segment[1]	Low Scenario		High Scenario		Pipe Length (feet)
	Total Flow[2] (gpd)	Pipe Diameter (inches)	Total Flow[2] (gpd)	Pipe Diameter (inches)	
Pipe 1	215,000	8	435,000	8	2,943
Pipe 2	260,000	8	515,000	12	351
Pipe 3	120,000	8	195,000	8	2,669
Pipe 4	380,000	8	710,000	12	408
Pipe 5	65,000	8	65,000	8	351
Pipe 6	500,000	8	835,000	12	1,789
Pipe 7	505,000	12	955,000	12	368
Pipe 8	450,000	8	900,000	12	1,186
Pipe 9	450,000	8	900,000	12	709
Pipe 10	310,000	8	620,000	12	1,011
Pipe 11	145,000	8	285,000	8	706
				Total =	12,491

Notes:
1) Refer to Figure 4-5 for the location of the individual pipe segments.
2) Total Flow includes the contributing area flow plus any flow from upstream pipes.

4.4.3 Eno EDD Pump Station

CDM Smith considered two main factors for the Eno EDD pump station as part of this evaluation, (1) location and (2) capacity. The following provides a description of the evaluation performed for both.

4.4.3.1 Pump Station Location

Preliminary analysis of proposed pipe alignments included determining a central location for construction of a pump station. Topographical low spots throughout the Eno EDD were analyzed as potential pump station locations. The highest concentration of low spots follows Rhodes Creek. Per the City design standards, pump stations may not be constructed within a Federal Emergency Management Agency (FEMA) 100-year floodplain. Additionally, the pump station should not be constructed within the proposed NCDOT ROW associated with US Hwy 70/I-85 improvements. An area west of Rhodes Creek just south of US Hwy 70 was found to meet these criteria. The Eno EDD pump station is shown on **Figure 4-7** in relation to Rhodes Creek and US Hwy 70. This location should provide sufficient space between the proposed NCDOT ROW and the 100-year floodplain. Additionally, the proximity to US Hwy 70 simplifies the process of connecting gravity pipes to the pump station. US Hwy 70 also acts as an ideal corridor for construction of the associated force main. The pump station is anticipated to be a wet-well style utilizing submersible wastewater pumps operated in a lead/lag configuration.

The overall depth of the pump station is dictated by the connecting depth of gravity pipes. Sufficient depth below the lowest invert must also be provided for operating depth and pump submergence requirements. Based on preliminary evaluations, it is anticipated that the wet well will be approximately 25 feet to 30 feet deep.

4.4.3.2 Pump Station Capacity

The pump station will need to have sufficient capacity to convey Eno EDD wastewater flows to the City's sewer system. However, wastewater flows within the Eno EDD are projected to increase by 670% between 2020 and build-out. It would be infeasible and uneconomical to design a pump station to handle such a wide range of flows. Additionally, the 50 year time period between 2020 and build-out will require multiple pump replacements and could also require replacement/rehab of the pump station structure. Given these circumstances, it was determined that the pump station should be designed for an intermediate point between 2020 and build-out. For the purposes of this report, a 30 year period was assumed to be an appropriate period for capacity analysis. This period was selected based on the assumption that the pumps will have approximately a 15-year servie life. After the first 15-years, they would be replaced. After the next 15 years the pump station would need to be upgraded anyways to accommodate larger future flows. Based on this time period, the projected maximum day flow used for this pump station is 1.2 million gallons per day (mgd).

A duplex pump station could be designed to operate in a lead/lag mode to allow smaller capacity pumps to be utilized. This would provide the flexibility for a single pump to handle flows anticipated shortly after completion while allowing both pumps to handle flows near the end of their service life. While it is anticipated pumps will be replaced at their end of their service life, flows may dictate that the pump station wet-well also be upsized at the end of the 30 year period.

4.4.4 Force Main

In this section, the portion of the force main from the pump station to the City boundary is discussed. A description of the alignment and characteristics for the force main within the City of Durham can be found in Section 5.

A force main would be constructed to convey wastewater from the pump station into the City's sewer system, as shown on Figure 4-7. The force main would follow US Hwy 70 from the proposed pump station location into Durham County, which is approximately 7,000 feet long. Due to narrow ROW along US Hwy 70 through the Eno EDD, it is possible that one lane of traffic may need to be shut down during force main construction.

A preliminary hydraulic evaluation of the force main indicates that the following diameters would provide adequate capacity for existing and build-out planning periods.

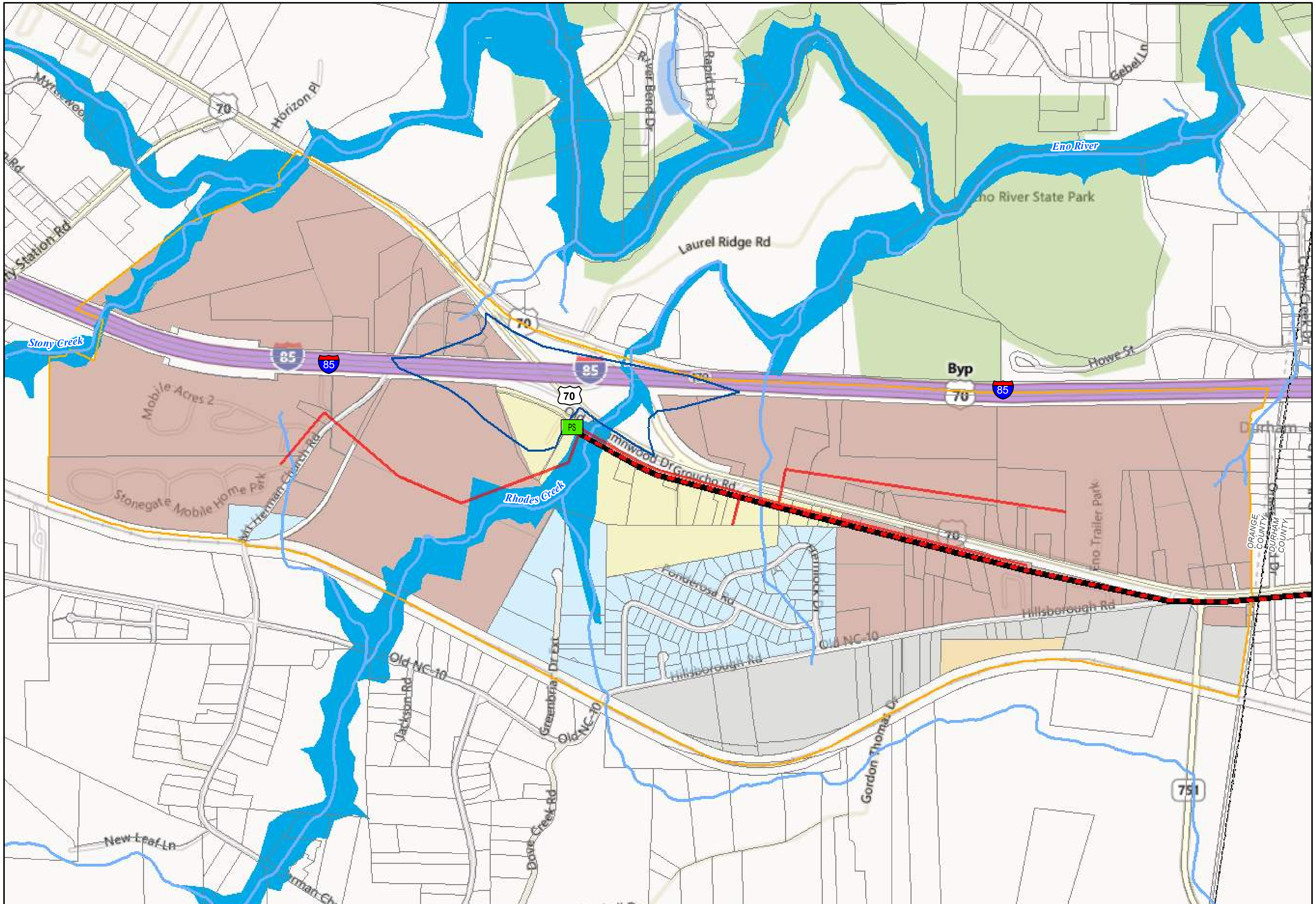
- Low Scenario: 8 inch diameter
- High Scenario: 12 inch diameter

For both scenarios, the force main velocity would be greater than 2 fps, but less than 5 fps and the headloss would be less than 5 feet per 1,000 feet of pipe; both of which are the industry standard design criterion.

Eno EDD

Proposed Wastewater System

Figure 4-7

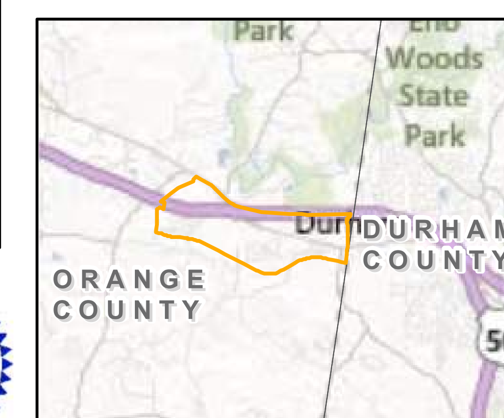


Legend

- PS Pump Station
- Proposed Gravity Sewer
- Proposed Force Main
- Proposed DOT ROW for Improvements to 70/85 Interchange
- Stream
- Eno EDD Area
- Parcel Boundary
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,000 feet

N

CDM Smith

aSection 5

Conveyance to City of Durham's Wastewater Collection System

CDM Smith performed an evaluation of various alternatives for where the wastewater flow generated within the Eno EDD could be discharged into the City's wastewater collection and conveyance system. This section describes the evaluation and associated conclusions.

5.1 Eno EDD Force Main Discharge Alternatives

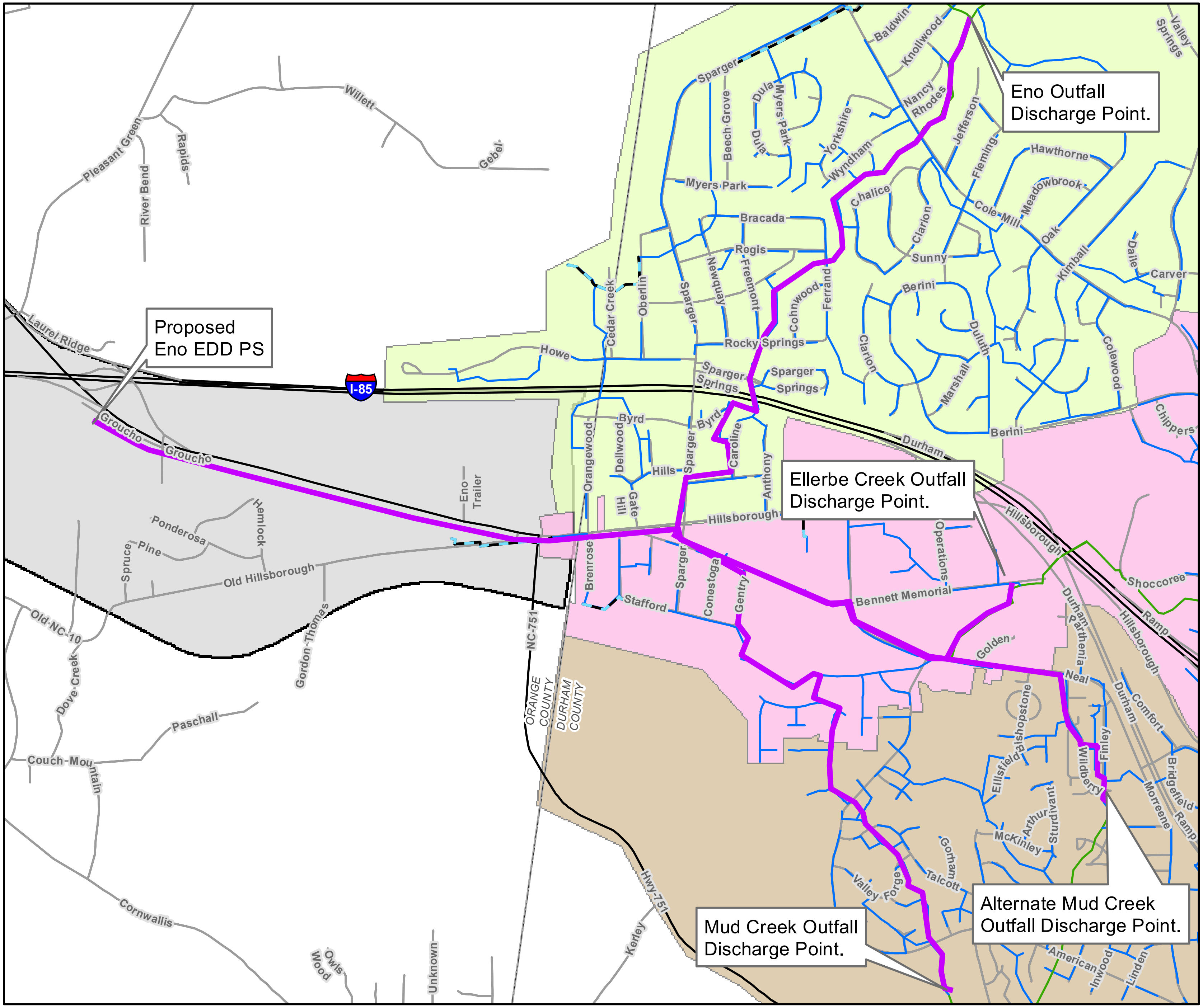
5.1.1 Alternative Discharge Locations

Discharge of the proposed Eno EDD force main to either the City's Eno outfall (within the Eno Basin), Ellerbe Creek outfall (within the North Durham Basin), or Mud Creek outfall (within the Farrington Basin) was considered. Flow from both the Eno Outfall and Ellerbe Creek outfall is conveyed to the North Durham WRF. Flow from the Mud Creek outfall is conveyed to the South Durham WRF. The existing gravity sewer pipe located near the Orange County and Durham County border, nearest the proposed force main from Eno EDD, is 8-inches in diameter. An 8-inch pipe does not have adequate capacity to handle the projected build-out flow from the Eno EDD area. Therefore, the proposed force main was extended in each basin to a point where there was sufficient capacity to convey the Eno EDD flow. However, this location does not mean that there will not be negative impacts to the City's wastewater collection and conveyance system further downstream of the discharge point. **Figure 5-1** shows four alternative discharge locations, which are described below. The force main routing shown on Figure 5-1 is approximate and will be further evaluated during design to determine feasibility and final optimal routing.

Eno Outfall – The Eno outfall force main alternative discharges to the 12-inch gravity sewer upstream of the Rivermont pump station. The preliminary force main route follows the existing 8-inch sewer easement, with a total length of approximately 19,100 feet.

Ellerbe Creek Outfall – The Ellerbe Creek outfall force main alternative discharges to the 12-inch gravity sewer near Bennett Memorial Road, just west of Interstate 85. The preliminary force main route follows Bennett Memorial Road, Neal Road, and an existing 8-inch sewer easement, with a total length of approximately 15,000 feet.

Mud Creek Outfall – Two discharge options were identified for the Mud Creek outfall. Alternative 1 discharges to the 10-inch gravity sewer west of NC Highway 751 and east of Constitution Drive. The preliminary force main route follows an existing 8-inch sewer easement, with a total length of approximately 18,200 feet. Alternative 2 discharges to the 10-inch gravity sewer at the end of Finley Street. The preliminary force main route follows Bennett Memorial Road, Neal Road, and Wildberry Lane, with a total length of approximately 17,300 feet.



Eno EDD

Force Main Discharge Alternatives

Figure 5-1

Legend

- Eno EDD Force Main Alignment Option
- Existing Force Main

Gravity Sewer

- Less than or Equal to 8 inch
- 10 - 12 inch
- 14 - 16 inch
- 18 - 21 inch
- Greater than or Equal to 24 inch

Wastewater Basin

- Eno
- Farrington
- Lick
- Ellerbe
- Eno EDD Area

0 1,000 2,000 4,000 6,000 Feet

1 inch = 2,000 feet

N

CDM Smith

The general topography along the proposed force main routes increases in elevation between the proposed Eno EDD pump station and the Orange County and Durham County border to a high point near Hillsborough Road and Bennett Memorial Road. From that point the elevation generally decreases along each of the proposed force main routes to the respective gravity sewer discharge points.

5.1.2 Interbasin Transfer Considerations

Wastewater flow from the Eno and Ellerbe Creek outfalls are conveyed to the North Durham WRF, which discharges to the Neuse River basin. Wastewater flow from the Mud Creek outfall is conveyed to the South Durham WRF, which discharges to the Cape Fear River basin. Since the City's primary water source is from the Neuse River basin, discharge through the South Durham WRF is subject to North Carolina Interbasin Transfer (IBT) requirements. However, the City has grandfathered IBT flows of greater than 20 million gallons per day. City staff indicated that the relatively small flow from the Eno EDD would be covered under the existing IBT amount. Therefore, IBT considerations were not a factor in selecting the Eno EDD force main discharge location.

5.2 Hydraulic Model Set-Up

Hydraulic modeling of the Eno outfall, Ellerbe Creek outfall, and Mud Creek outfall was performed to evaluate the capacity of the existing wastewater collection system to support the Eno EDD projected flows. The following sections describe the flows and wastewater infrastructure simulated in the hydraulic models.

5.2.1 Estimated Peak Hour Design Flows from Eno EDD

A peaking factor of 2.5 was applied to the projected wastewater flows within the Eno EDD area to simulate peak design conditions for capacity analysis, as discussed in Section 4.4. A summary of average and peak flows within the Eno EDD is given in **Table 5-1** for the low, mid and high scenarios, discussed in Section 2. Peak flows simulated within the existing Eno, Ellerbe Creek, and Mud Creek outfalls are also presented in Table 5-1 and discussed in the following sections.

Table 5-1. Summary of Peak Flows for Hydraulic Modeling

	Low Scenario		Mid Scenario		High Scenario	
	ADWF[1] (mgd)	Peak Flow[2] (mgd)	ADWF[1] (mgd)	Peak Flow[2] (mgd)	ADWF[1] (mgd)	Peak Flow[2] (mgd)
Eno EDD (Build Out)	0.402	1.01	0.558	1.40	0.715	1.79
Eno Outfall (Existing)[3]	3.23	12.93	3.23	12.93	3.23	12.93
Ellerbe Creek Outfall (Existing)[3]	3.85	15.39	3.85	15.39	3.85	15.39
Mud Creek Outfall (Existing)[3]	0.64	2.56	0.64	2.56	0.64	2.56

1. ADWF = Average Dry Weather Flow
2. Peak Flow estimated assuming 2.5 peaking factor for Eno EDD area; 4.0 peaking factor for existing wastewater flows.
3. Existing flows at the downstream end of the outfall.

5.2.2 Eno and Ellerbe Creek Outfall Model Set-Up

Hydraulic models of the Eno outfall and Ellerbe Creek outfall were created by CDM Smith based on existing GIS data. The Eno outfall model includes approximately 10 miles of 10-inch through 42-inch diameter trunk sewer extending from Hillsborough Road to the Eno pump station. The model also includes the Rivermont pump station and 12-inch diameter force main. The hydraulic model does not include the Eno pump station and force main since it was assumed that the pump station and force main would have adequate capacity to convey peak Eno EDD flows to the North Durham WRF, per the direction of the City. The Ellerbe Creek outfall model includes approximately 12 miles of 10-inch through 42-inch diameter trunk sewer from the intersection of Neal Road and American Drive through the North Durham WRF. The modeled pipes in each outfall are shown in **Figure 5-2**. In both models, manhole rim and invert data from the GIS was used to establish pipe slope; however this data was noted by the City to contain potential inaccuracies. More accurate pipe slope data is not available at this time.

Existing flow meter data was used to estimate average dry weather flows in each model. Since a detailed model of the system that considers inflow and infiltration (I/I) was unavailable, a consistent approach was applied to compare alternatives. A peaking factor of 4 was used to represent peak flows for comparison. A peaking factor of 4 was chosen as a typical residential peaking factor used by the City in past evaluations as well as being an industry standard peaking factor that accounts for a reasonable level of I/I. It should be noted that higher peaking factors have been measured in some parts of the City's collection system, but more detailed evaluation of the Eno and Ellerbe Creek outfalls was not available. Table 5-1 shows the average and peak flows modeled at the downstream end of each outfall.

The Eno and Ellerbe Creek outfall models were intended to be screening-level tools and were not fully calibrated to flow monitoring data. It was assumed that the GIS attributes used to build the model are sufficiently accurate at this stage of the project. A dry weather flow balance was performed and the balanced flows, with peaking factors applied, were loaded into the models.

5.2.3 Mud Creek Outfall Model Set-Up

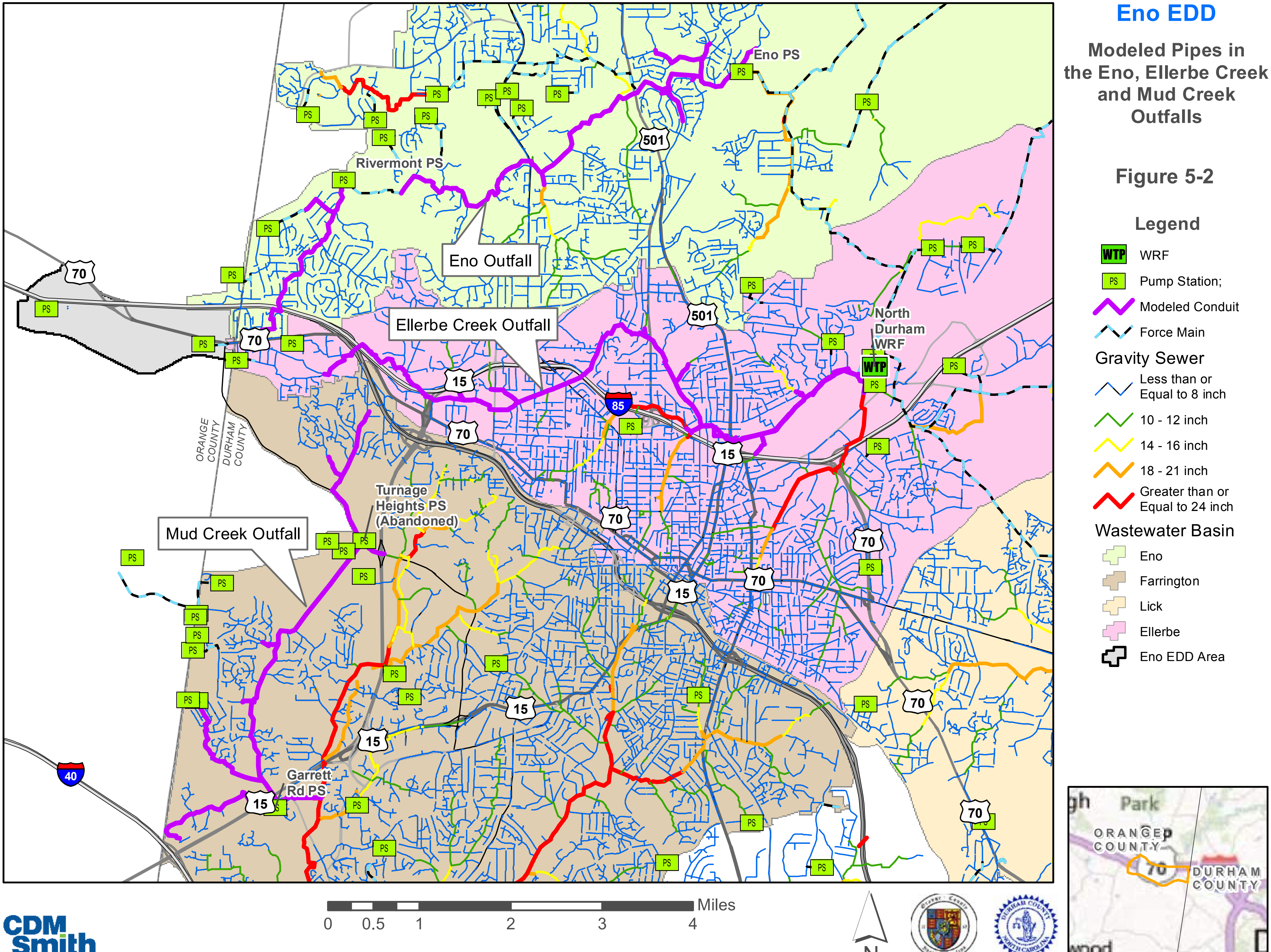
The existing hydraulic model of the South Durham WRF basin, developed by others, was used as the basis for this capacity analysis. The City is planning to abandon the Turnage Heights pump station, which currently pumps flow downstream of the proposed Eno EDD force main discharge to the NHO subbasin. This flow will instead be rerouted by gravity through the Mud Creek Outfall into the BMP subbasin and down to the Garrett Road pump station. Therefore, the existing hydraulic model was modified to reflect this planned project. The capacity analysis was performed using a portion of the South Durham WRF basin model. The modeled pipes include trunk sewer in the THP and BMP subbasins from the two alternate proposed Eno EDD force main discharge points downstream to the Garrett Road pump station. The modeled pipes are shown in Figure 5-2. Per the City, it was assumed that the existing pipes downstream of the Garrett Road pump station have adequate capacity to convey peak Eno EDD flows to the South Durham WRF.

Although the existing model includes wet weather flow simulations, peak flow conditions for this analysis were simulated by applying a peaking factor of 4.0 to the modeled dry weather flow, the same as in the Eno and Ellerbe Creek outfalls, to facilitate comparison with the Eno and Ellerbe Creek outfall analysis. Table 5-1 lists the average and peak flows modeled at the downstream end of the Mud Creek outfall.

Eno EDD

Modeled Pipes in the Eno, Ellerbe Creek and Mud Creek Outfalls

Figure 5-2



CDM Smith

5.3 Capacity Analysis

Hydraulic simulations were run for the existing system under peak flow conditions both with and without the additional Eno EDD peak flows. The model results are discussed, by outfall, in the following sections. Figures showing the percent of pipe capacity used for gravity sewer (calculated by comparing the depth of flow in the sewer to the diameter of the pipe) and locations of model-predicted SSOs for each scenario are located in **Appendix A**. The SSO volumes presented in the following sections assume constant loading of peak flow to the collection system over a 24-hour period, which is not likely to occur with a normal storm event. Therefore, the magnitude of the predicted overflow should only be used for comparison between scenarios.

5.3.1 Eno Outfall

Without any additional flow from the Eno EDD, the Eno outfall already has limited capacity to convey peak flows from within the Eno basin. During peak flow conditions, most of the trunk sewer pipes between Guess Road and the Eno pump station are flowing at 100 percent capacity and several SSOs are predicted. Percent of the pipe capacity used and locations of overflows are shown in **Figure A-1** in Appendix A.

With Eno EDD low scenario flow added to the Eno outfall, additional overflows and pipe capacity restrictions are predicted between the Eno EDD force main discharge and the Rivermont pump station (**Figure A-2**). Therefore, the Eno outfall was eliminated as an option for the Eno EDD force main discharge.

5.3.2 Ellerbe Creek Outfall

Without additional flow from the Eno EDD, one SSO of 0.34 mgd is predicted during peak flow conditions along the Ellerbe Creek outfall near North Duke Street. The majority of the trunk sewer pipes upstream of the overflow location are predicted to be between 50 and 75 percent full (**Figure A-3**).

With Eno EDD low scenario flow added at the proposed Eno EDD force main discharge location near Neal Road, a new SSO of 0.30 mgd is predicted at the location where the trunk sewer reduces to an 8-inch diameter pipe near Cole Mill Road. An increase of the existing SSO from 0.34 to 0.98 mgd is also predicted (**Figure A-4**). The addition of the Eno EDD flow increases the total SSO volume by approximately 1 mgd. This is similar to the peak flow being added by the Eno EDD project. An additional simulation was performed by moving the Eno EDD force main discharge downstream to an 18-inch pipe at the Hillandale Golf Course. While this eliminates the SSO near Cole Mill Road, the existing SSO near North Duke Street increased from 0.34 to 1.28 mgd (**Figure A-5**). This increase in SSO volume is also similar to the peak flow being added by the Eno EDD project.

Since the existing system has limited capacity and most of the peak flow volume from the Eno EDD area is resulting in additional downstream overflows, the Ellerbe Creek outfall was eliminated as an option for the Eno EDD force main discharge.

5.3.3 Mud Creek Outfall

Without additional flow from the Eno EDD, most of the modeled trunk sewer pipes are flowing at 50 percent capacity or less during peak flow conditions. Some sections of pipe are between 50 and 75 percent full, however, no surcharge is predicted (**Figure A-6**).

With Eno EDD low scenario flow added at the proposed Eno EDD force main discharge location east of Constitution Drive, an SSO of 0.48 mgd is predicted along the 12-inch trunk sewer upstream of the proposed gravity sewer near the current Turnage Heights pump station location (**Figure A-7**). The downstream 18-inch trunk sewers are predicted to be between 50 and 75 percent full (not accounting for flow lost to the upstream overflow).

With Eno EDD mid scenario flow added at the proposed Eno EDD force main discharge location east of Constitution Drive, an additional SSO is predicted along the 10-inch gravity sewer just downstream of the force main discharge (**Figure A-8**). The downstream 18-inch trunk sewers are predicted to be between 50 and 75 percent full (not accounting for flow lost to the upstream overflow). With the Eno EDD high scenario flow, several more overflows are predicted in the vicinity of the force main discharge (**Figure A-9**).

For all three scenarios with Eno EDD peak flow (low, mid and high scenario), the modeled flow to the Garrett Road pump station is within the existing capacity of 3.1 mgd. However, once pipe improvements are made to convey all peak flows to the pump station without SSOs, the pumps may need to be upgraded. The City has indicated that an additional pump is expected to be added at the Garrett Road pump station as part of the Turnage Heights pump station removal project.

Discharge of the Eno EDD force main to the Mud Creek outfall was selected as the preferred alternative since this outfall is the only proposed discharge location with some existing capacity for additional peak flow. However, discharge of the Eno EDD flow to the Mud Creek outfall will likely require further capacity improvements to the City's collection system to convey Eno EDD flows.

5.4 Additional Hydraulic Considerations

The preferred Eno EDD force main route discharges into the Mud Creek outfall. The Eno EDD pump station would generally pump uphill through the force main from an elevation of approximately 420 feet at the pump station to a high point in the force main of approximately 520 feet near Hillsborough Road and Bennett Memorial Road. From that point, the force main would slope downhill to the proposed discharge into the existing gravity sewer, at an elevation of approximately 360 feet. Since the discharge point is at a lower elevation than the pump station, the downhill section of the force main may not flow under pressure at some pumping rates during normal operations. In addition, a partial vacuum condition can be created at the high point when the force main drains after pumps shut off. This type of force main profile is also susceptible to high pressure surge due to pump shutdown or power failure. Since the pipe is not flowing full at all times, corrosion can also be an issue.

Due to potential hydraulic concerns in the downhill section of the force main, a gravity sewer option for this section should be considered. The proposed Eno EDD force main would extend from the Eno EDD pumps to the high point near Hillsborough Road and Bennett Memorial Road. From that point, gravity sewer could be constructed to convey Eno EDD flow to the 10-inch gravity sewer in the Mud Creek outfall east of Constitution Drive. While the gravity sewer option would be more expensive, it would avoid the hydraulic issues discussed above. Costs for the proposed Eno EDD infrastructure are presented in Section 6.

Section 6

Engineers Opinion of Probable Construction Cost

CDM Smith was tasked with developing an opinion of probable cost for the proposed Eno EDD wastewater collection and conveyance system. The estimate relies on the use of historical data from comparable work, estimating guides, handbooks, and costing curves as provided by CDM Constructors Inc.

6.1 Construction Cost Assumptions

The construction costs presented in this study are based on unit costs that have been developed as described in the aforementioned text. The unit construction costs include some of the direct and indirect costs incidental to work associated with each respective cost item with the remaining costs assumed to be accounted for in the contingency. The direct costs include materials, labor, equipment, and a mark-up for overhead and profit. The indirect costs generally include permit fees, North Carolina sales tax, and a mark-up for general conditions expenses, insurance and bonding costs. These indirect costs generally tabulate to an amount equal to 5-10% of the direct costs of each respective cost item.

The unit costs do not include compensation for change orders, engineering (including design, construction contract administration, construction observation, and start-up), finance or funding agency administration, legal services, land acquisition (including, but not limited to, temporary and permanent easements), or any other costs associated with the project that will not specifically be included in the contractor's scope. However, some of these are accounted for in the contingencies discussed below.

Contingencies

In most construction budgets, there is an allowance for construction contingencies or unexpected costs occurring during construction. The amount of contingency is based on historical experience, the expected difficulty of a particular construction project, and the stage of design. This contingency amount may be included within each cost item or the construction contingency may be included as a distinct cost item. The following contingencies are reflected in the cost estimate.

- Mobilization/Demobilization – 5%: Accounts for contractor costs associated with mobilizing to the project site to begin construction, and demobilizing from the site upon completion of construction. 5% is a typical estimate for mobilization/demobilization costs and is used throughout the industry.
- Contractor OH&P – 10%: Accounts for contractor mark-ups to cover their overhead and profit. 10% is an industry standard to account for OH&P.
- Contingency – 25%: Allows for unknowns associated with early stages of design. Being in the conceptual level, 25% is standard. This number will decrease as the project moves into design.
- Engineering, Permitting, and Administration – 20%: Accounts for costs associated to design the project, coordinate and obtain applicable permits, and produce reports and figures for the project. Since the fee is not known, 20% has been assumed.

6.2 Projecting Unit Costs to Future Values

Costs presented in this report are based on the October 2013 Engineering News-Record Construction Cost Index (ENRCCI), which has a value of 9666.

Index values can be used to estimate future construction costs based on the probable construction costs presented in this report by applying the following relationship:

$$\text{Current Cost} = \frac{\text{Construction Cost Index Value at Time of Construction}}{\text{Construction Cost Index Value (Nov. 2013)}} * \text{Estimated Cost (Nov. 2013)}$$

where, "Current Cost" represents the estimated cost of the work at the mid-point of construction for any given project and in similar fashion, the "Construction Cost Index Value at Time of Construction" shall represent the value of the ENRCCI at the mid-point of construction for any given project.

An example calculation of updating construction costs to present day or "current" cost for a given project is shown below:

Current Construction Cost (mid-point of construction June 2015) = (9990/9666) x $1,000,000.00 = $1,033,519.55

based on:

Probable construction cost in November 2013 = $1,000,000;

Value of ENRCCI (November 2013) = 9666;

Assumed Value of ENRCCI (June 2015) = 9990

It should be noted, however, that updating probable construction costs into present day costs for periods of greater than three to five years is speculative and can result in gross inaccuracies, as the current inflation rates of construction costs fluctuate constantly.

6.3 Opinion of Probable Construction Cost

Based on CDM Smith's analysis, presented in earlier sections, the following proposed infrastructure improvements are necessary for each scenario:

- Low Scenario
  - Approximately 12,500 feet of gravity sewer pipe
    - 12,123 feet of 8 inch
    - 368 feet of 12 inch
  - A 0.7 mgd pump station sized to handle 30 year flows
  - Approximately 18,300 feet of conveyance to the City of Durham's sewer system
    - Approximately 7,000 feet of 8 inch force main
    - Approximately 11,300 feet of 12 inch gravity sewer pipe
- High Scenario
  - Approximately 12,500 feet of gravity sewer pipe

    - 6,669 feet of 8 inch
    - 5,822 feet of 12 inch
- A 1.2 mgd pump station sized to handle 30 year flows
- Approximately 18,300 feet of conveyance to the City of Durham's sewer system
    - Approximately 7,000 feet of 12 inch force main
    - Approximately 11,300 feet of 18 inch gravity sewer pipe

An opinion of probable cost (OPCC) was developed for infrastructure proposed under each scenario. These costs are presented below in **Table 6-1** and **Table 6-2**. Assumptions made when developing the estimate are included in the table. Refer to Section 4.4.3 for an explanation of why the Eno EDD pump station was sized for 30 year flows.

Table 6-3 and **Table 6-4** have been provided below to show costs broken down, for each scenario, by their geographic location. The contingencies and mark-ups have been allocated into the individual costs, instead of to the subtotals. The system components and associated costs, for each scenario, are reflected on **Figure 6-1** and **Figure 6-2**, respectively. This information has been provided so that individual project components can be removed and a revised total project cost developed without having to recalculate the contingency amounts.

Table 6-1. Opinion of Probable Construction Cost - Low Scenario

Associated System	Description	Unit	Quantity	Cost Estimate
Eno EDD Gravity System	Gravity Sewer - 8 inch DIP	Lf	12,123	$ 702,000[1]
	Jack & Bore	Lf	120[2]	$ 60,000
	Gravity Sewer - 12 inch DIP	Lf	368	$ 21,000[1]
	Gravity Sewer Manhole[3]	Ea	45	$ 270,000
Eno EDD Conveyance System to Durham Sewer System	Pump Station[4]	mgd	0.7	$ 486,000
	8 inch Force Main[4]	Lf	7,000	$ 315,000
	8 inch Jack & Bore	Lf	160[5]	$ 80,000
	12 inch Gravity Sewer	Lf	11,300	$ 757,000[6]
	12 inch Jack & Bore	Lf	100	$ 94,000
	Gravity Sewer Manhole[3]	Ea	38	$ 228,000
	Traffic Control[7]	Lf	8,000	$ 180,000
	Pavement Replacement	Sy	1,000	$ 42,000
			Subtotal	**$ 3,235,000**
			5% Mobilization/Demobilization	$ 160,000
			Subtotal	**$ 3,400,000**
			10% Contractor OH&P	$ 340,000
			Subtotal	**$ 3,740,000**
			25% Contingency	$ 940,000
			Subtotal	**$ 4,680,000**
			20% Engineering, Permitting, and Administration	$ 940,000
			TOTAL	**$ 5,620,000**

Notes:

1) Cost reflects various depths of cover. Not shown in table for clarity.
2) Jack & Bore costs reflect two (2) 60-ft bores. See Note 11.
3) Gravity sewer manhole spacing of 300 feet.
4) Pump station sized for 30 year flows.
5) Jack & Bore costs reflect one (1) 100-ft bore and one (1) 60-ft bore. See Note 11.
6) Cost assumes 15 feet of cover.
7) Traffic control required during installation of force main along Hwy 70.
8) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
9) Cost does not reflect pump replacement by 2035.
10) Cost does not reflect land acquisition.
11) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

Table 6-2. Opinion of Probable Construction Cost - High Scenario

Associated System	Description	Unit	Quantity	Cost Estimate
Eno EDD Gravity System	Gravity Sewer - 8 inch DIP	Lf	6,669	$ 358,000[1]
	Jack & Bore	Lf	120[2]	$ 78,000
	Gravity Sewer - 12 inch DIP	Lf	5,822	$ 420,000[1]
	Gravity Sewer Manhole[3]	Ea	45	$ 270,000
Eno EDD Conveyance System to Durham Sewer System	Pump Station[4]	mgd	1.2	$ 540,000
	12 inch Force Main[4]	Lf	7,000	$ 378,000
	12 inch Jack & Bore	Lf	160[5]	$ 104,000
	18 inch Gravity Sewer	Lf	11,300	$ 1,220,000[6]
	18 inch Jack & Bore	Lf	100	$ 125,000
	Gravity Sewer Manhole[3]	Ea	38	$ 228,000
	Traffic Control[7]	Lf	8,000	$ 180,000
	Pavement Replacement	Sy	1,000	$ 42,000
			Subtotal	**$ 3,943,000**
			5% Mobilization/Demobilization	$ 200,000
			Subtotal	**$ 4,140,000**
			10% Contractor OH&P	$ 414,000
			Subtotal	**$ 4,550,000**
			25% Contingency	$ 1,140,000
			Subtotal	**$ 5,690,000**
			20% Engineering, Permitting, and Administration	$ 1,140,000
			TOTAL	**$ 6,830,000**

Notes:

1) Cost reflects various depths of cover. Not shown in table for clarity.
2) Jack & Bore costs reflect two (2) 60-ft bores. See Note 11.
3) Gravity sewer manhole spacing of 300 feet.
4) Pump station sized for 30 year flows.
5) Jack & Bore costs reflect one (1) 100-ft bore and one (1) 60-ft bore. See Note 11.
6) Cost assumes 15 feet of cover.
7) Traffic control required during installation of force main along Hwy 70.
8) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
9) Cost does not reflect pump replacement by 2035.
10) Cost does not reflect land acquisition.
11) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

Table 6-3. Individual Component Costs - Low Scenario

System Component[1]	Description	Cost Estimate[2]
Pipe 1	Gravity Sewer - 8 inch DIP	$ 378,000
Pipe 2	Gravity Sewer - 8 inch DIP	$ 112,000[3]
Pipe 3	Gravity Sewer - 8 inch DIP	$ 329,000
Pipe 4	Gravity Sewer - 8 inch DIP	$ 65,000
Pipe 5	Gravity Sewer - 8 inch DIP	$ 52,000
Pipe 6	Gravity Sewer - 8 inch DIP	$ 340,000[3]
Pipe 7	Gravity Sewer - 12 inch DIP	$ 58,000
Pipe 8	Gravity Sewer - 8 inch DIP	$ 146,000
Pipe 9	Gravity Sewer - 8 inch DIP	$ 99,000
Pipe 10	Gravity Sewer - 8 inch DIP	$ 146,000
Pipe 11	Gravity Sewer - 8 inch DIP	$ 105,000
Pump Station	0.7 mgd Capacity[4]	$ 842,000
Conveyance Line	7,000 LF of 8 inch Force Main	$ 1,075,000[3]
	11,300 LF of 12 inch Gravity	$ 1,873,000[3,5]
	TOTAL	**$ 5,620,000**

Notes:

1) Component names refer to Figure 6-1.
2) Estimates are total allocated costs and include:
   a. 5% Mobilization
   b. 10% Contractor OH&P
   c. 25% Contingency
   d. 20% Engineering, Permitting, and Administration
3) Cost reflects Jack & Bore. See Note 12.
4) Pump station sized for 30 year flows.
5) Cost assumes 15 feet of cover.
6) Gravity sewer costs reflect various depths of cover and manhole costs. Not shown in table for clarity.
7) Gravity sewer manhole spacing of 300 feet.
8) Traffic control required during installation of force main along Hwy 70.
9) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
10) Cost does not reflect pump replacement by 2035.
11) Cost does not reflect land acquisition.
12) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Pipe 2 - Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

Table 6-4. Individual Component Costs - High Scenario

System Component[1]	Description	Cost Estimate[2]
Pipe 1	Gravity Sewer - 8 inch DIP	$ 376,000
Pipe 2	Gravity Sewer - 12 inch DIP	$ 132,000[3]
Pipe 3	Gravity Sewer - 8 inch DIP	$ 328,000
Pipe 4	Gravity Sewer - 12 inch DIP	$ 72,000
Pipe 5	Gravity Sewer - 8 inch DIP	$ 51,000
Pipe 6	Gravity Sewer - 12 inch DIP	$ 392,000[3]
Pipe 7	Gravity Sewer - 12 inch DIP	$ 58,000
Pipe 8	Gravity Sewer - 12 inch DIP	$ 165,000
Pipe 9	Gravity Sewer - 12 inch DIP	$ 110,000
Pipe 10	Gravity Sewer - 12 inch DIP	$ 161,000
Pipe 11	Gravity Sewer - 8 inch DIP	$ 104,000
Pump Station	1.2 mgd Capacity[4]	$ 936,000
Conveyance Line	7,000 LF of 12 inch Force Main	$ 1,220,000[3]
	11,300 LF of 18 inch Gravity	$ 2,725,000[3,5]
	TOTAL	**$ 6,830,000**

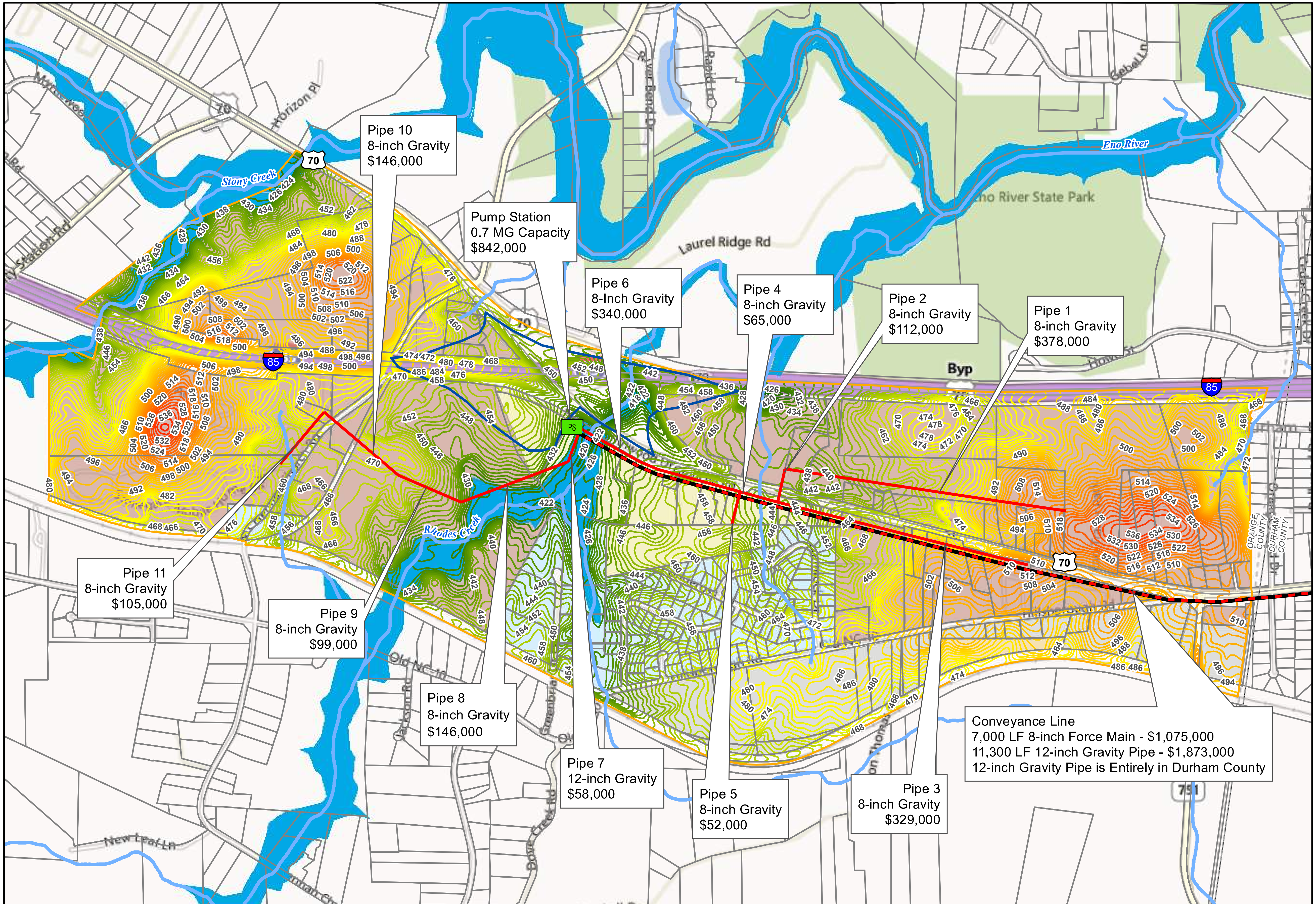
Notes:

1) Component names refer to Figure 6-2.
2) Estimates are total allocated costs and include:
   a. 5% Mobilization
   b. 10% Contractor OH&P
   c. 25% Contingency
   d. 20% Engineering, Permitting, and Administration
3) Cost reflects Jack & Bore. See Note 12.
4) Pump station sized for 30 year flows.
5) Cost assumes 15 feet of cover.
6) Gravity sewer costs reflect various depths of cover and manhole costs. Not shown in table for clarity.
7) Gravity sewer manhole spacing of 300 feet.
8) Traffic control required during installation of force main along Hwy 70.
9) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
10) Cost does not reflect pump replacement by 2035.
11) Cost does not reflect land acquisition.
12) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Pipe 2 - Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

Eno EDD

Allocated Component Costs- Low Scenario

Figure 6-1



Legend

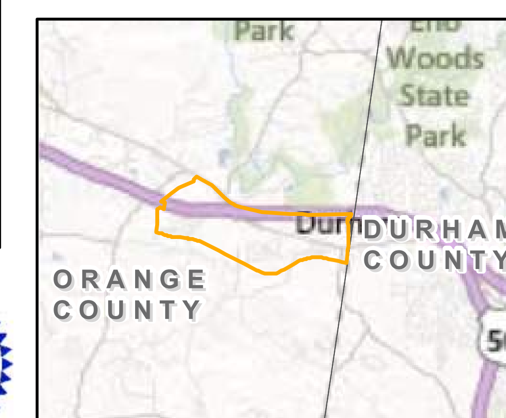
- Pump Station
- Proposed Force Main
- Proposed Gravity Sewer
- Proposed DOT ROW for Improvements to 70/85 Interchange
- Stream
- Eno EDD Area
- Parcel Boundary

Contour Elevation

- 412 - 450 Ft
- 451 - 475 Ft
- 476 - 500 Ft
- 501 - 525 Ft
- 526 - 550 Ft
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,000 feet

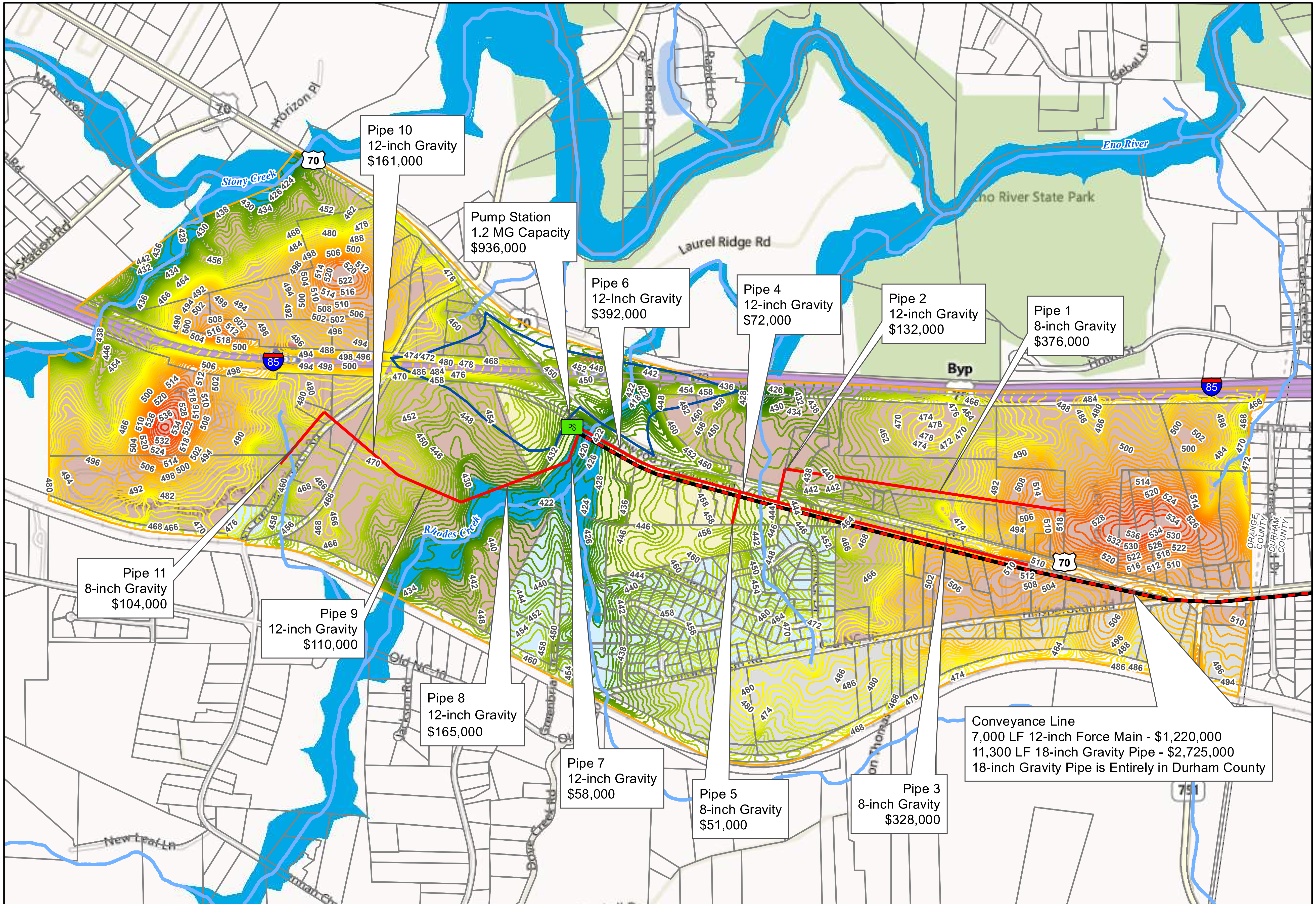
N

CDM Smith

Eno EDD

Allocated Component Costs-High Scenario

Figure 6-2



Legend

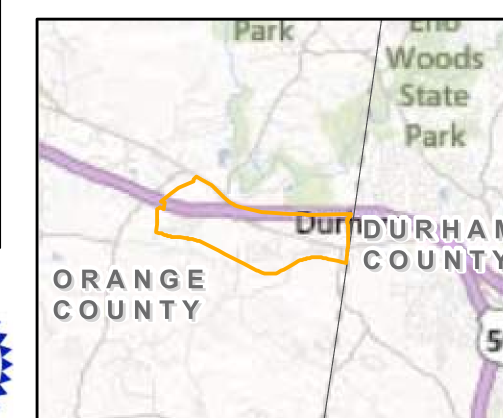
- PS Pump Station
- Proposed Force Main
- Proposed Gravity Sewer
- Proposed DOT ROW for Improvements to 70/85 Interchange
- Stream
- Eno EDD Area
- Parcel Boundary

Contour Elevation

- 412 - 450 Ft
- 451 - 475 Ft
- 476 - 500 Ft
- 501 - 525 Ft
- 526 - 550 Ft
- 100 Year Flood Zones

Future Land Use

- Commercial
- Industrial
- Low Density Residential
- Office
- Recreation/ Open Space



0 500 1,000 2,000 3,000 4,000 5,000 Feet

1 inch = 1,000 feet

N

CDM Smith

Section 7

Permit Requirements

Several regulatory permits and approvals will be needed from state, federal, and local authorities. The following is a discussion of the anticipated permit and approval requirements, the agency or authority responsible for issuing each approval, and the activity that triggers the need for each approval.

7.1 Environmental Assessment

The North Carolina State Environmental Policy Act (SEPA) requires that an environmental document (Environmental Assessment (EA) or Environmental Impact Statement (EIS)) be prepared for projects that involve an expenditure of public funds; action by the state (such as a permit); and a potential effect upon natural resources, natural beauty, or historical or cultural elements of the state's common heritage. An EA/EIS provides an evaluation of the likely short- and long-term effects associated with the project and the mitigation measures that are proposed to minimize or avoid these effects. NCDENR has established minimum criteria that are used to identify projects for which an environmental document is not required. For pump stations and force mains, the rule states that an EA/EIS is not required for pump stations/force mains with design flows of less than 1,750 gpm (2.52 mgd). In relation to gravity sewers, the rule states that an EA/EIS is not required for gravity sewers that are less than 3 miles in length or less than 18 inches in diameter.

Projected flows to the Eno EDD pump station and associated force main are not sufficient enough to require an EA/EIS, as flows are less than the minimum 1,750 gpm (2.52 mgd), even at buildout conditions. However, the gravity sewer system could potentially lead to the need for an EA/EIS. Preliminary evaluation of infrastructure needs within the Eno EDD estimate approximately 2.3 miles of 8- and 12-inch gravity sewer. Additionally, as discussed in Section 5.4, due to potential hydraulic concerns in the downhill section of the force main, a gravity sewer option could be considered. Based on preliminary analysis of this conveyance option, approximately 1.5 miles of gravity sewer up to 18-inches in diameter could be necessary. When considering this alternative to provide gravity sewer for the downhill section of the force main, then an EA/EIS could be required. As the project infrastructure necessary becomes more defined, the need for an EA/EIS will be reevaluated.

The review process for an EA/EIS is typically takes 6 months.

7.2 Authorization to Construct

A Pump Stations, Force Mains, and Gravity Sewers (PSFMGSA) construction permit is also needed from NCDENR Division of Water Resources (DWR) to install the new facilities. The plans and specifications must be prepared in accordance with 15A North Carloina Administrative Code (NCAC) 2T and meet minimum design criteria for set forth in the guidelines, as well as meeting good engineering practices. The review is estimated to take 2 to 3 months with the submittal occurring towards the end of the final design phase.

7.3 Nationwide Permit/Water Quality Certification

A Section 404 Nationwide Permit is required for the discharge of dredged or fill material into waters of the United States (including stream crossings), which also triggers the need for a NCDENR 401

Water Quality Certification. These two permits can be applied for simultaneously with a single application and may be required due to construction/disturbance of wetlands or existing streams. The 404 Nationwide Permit Number 12 for Utility Line Applications will be issued by the U.S. Army Corps of Engineers. NCDENR DWR reviews the project information to ensure that the water quality of the state is not degraded as a result of the project and will issue the 401 Water Quality Certification. The review process for these two permits should take approximately 2 months.

Preliminary analysis of the proposed Eno EDD gravity sewer alignment indicates three stream crossings. As discussed in Section 4, site visits showed only one stream to be flowing with water, and it is anticipated this stream will be crossed using trenchless technology. However, the remaining streams, in addition to any streams along the alignment not indicated on GIS data, will need to be identified and confirmed by NCDENR DWR to determine if permitting is required. Additionally, wetland impacts are not known at this time. Once the final alignment is determined, the need for the Nationwide Permit and/or Water Quality Certification will be reevaluated.

7.4 Sediment and Erosion Control Plan

A Sediment and Erosion Control Plan will be submitted to the NCDENR Division of Land Resources – Land Quality Section for review. The plan must be submitted, since more than 1 acre of land will be disturbed. The typical review time for this permit is approximately 1 month. With approval of the Sediment and Erosion Control Plan, the City will also receive approval for coverage under the NPDES Stormwater General Permit for Construction Activities, which requires weekly monitoring of sediment and erosion control during construction. The project must also comply with the requirements of the Division of Land Resources' Self Inspection Program, which requires inspection after completion of each phase of construction. These two monitoring programs have been combined and can be recorded on one form.

7.5 Falls Lake Nutrient Management Strategy

The Eno EDD project area is located within the Falls Lake watershed. As such, the project must adhere to the Falls Lake Rules. Falls Lake Nutrient Management Strategy rules were adopted in January 2011. These rules are intended to restore and maintain water quality in the Falls Lake watershed. The rules require 50-foot buffers on surface waters in the watershed. Surface waters subject to the rules include those that appear on a soil survey map, USGS topographic map, or other map approved by the Geographic Information Coordinating Council or the NC Environmental Management Commission (NCEMC). The rules also require stormwater management plans to control nitrogen and phosphorus for new development of 12,000 square feet or more, which may apply to the pump station. Authorization of compliance will be reviewed by DWR as part of the 401 Water Quality Certification process.

7.6 Building Standards Permit

Based on preliminary analysis, a building is not expected to be required at the pump station site. However, if it is determined during design that an on-site building is required/desired, then a building permit for various trade work associated with the building (electrical, mechanical, site work, etc.) will be required. The selected contractor(s) for the work will be required to apply and pay for these permits. The design team will assist with these reviews and approvals during the design and construction phases.

7.7 Air Quality Registration

Current NCAC (NCAC 02Q .0903 EMERGENCY GENERATORS) requires emergency diesel-engine-driven generators be registered/permitted with the Division of Air Quality only when fuel use exceeds 322,000 gallons per year. The need for an emergency generator will be determined during design. If an emergency generator is included in design, fuel usage will be estimated to determine if registration is required. A generator can be registered at any time prior to installation. Once the forms are submitted, the registration review process is expected to take less than a month.

7.8 NC DOT

Preliminary evaluation assumed the installation of proposed gravity and force main infrastructure within NCDOT ROW. Additionally, trenchless crossing of Hwy-70 and SR-751 were assumed in the analysis. As such, an encroachment agreement will have to be obtained from the NCDOT, once alignments are finalized. NCDOT may also require a Driveway Permit be obtained if a new site associated with the project connects to a NCDOT road.

As discussed in Section 4, initial analysis of potential pump station locations took into account NCDOT plans for future improvements to the I-85/US Hwy 70 interchange. Selecting a location for the pump station should include coordination with NCDOT to verify adjustments/updates to the proposed interchange plans, so as to avoid placing the pump station within future NCDOT ROW.

7.9 Railroad

Preliminary alignments of the force main proposed crossing the Norfolk Southern-owned railroad in Durham County. Applicable permits and applications will need to be coordinated with Norfolk Southern to allow for the trenchless crossing of the railroad. A Right-of-Entry permit is required for temporary access to the railroad right-of-way for surveying and geotechnical borings. An Encroachment permit is required for construction of the water main within Norfolk Southern's right-of-way. The crossing must be designed per Norfolk Southern's Design and Construction Standard Specifications. The application for an Encroachment permit must include the Norfolk Southern Facility (Utility) Encroachment application form, plan and profile drawings, and a permit fee.

7.10 Miscellaneous Coordination

In addition to the permit requirements outlined in this section, coordination with other entities must also occur.

Site visits indicated numerous utilities along sections of the proposed alignment. Utilities observed include gas pipeline and high voltage energy transmission lines. It is anticipated that these utilities, along with others not observed during field visits, will need to be crossed, or will conflict in some way, along the proposed alignment. These utility conflicts should be examined further during design and contact/coordination with the appropriate entity be made.

The presence of threatened or endangered species was not evaluated during preliminary analysis. However, with proposed alignments crossing undeveloped land, or running near large power easements, an analysis should be done to determine the presence of such species in conjunction with the 404/401 permitting.

Section 8

Conclusions and Recommendations

The purpose of this section is to present a summary of the conclusions presented in Sections 1 through 7 of this report and discuss options for project implementation.

8.1 Conclusions

The primary objective of this project is for the City and County to collaborate to construct the backbone of a water and sewer system within the Eno EDD that will promote an effective growth pattern in Orange County with respect to location and phasing. In order to develop the backbone system, CDM Smith has performed an evaluation of the Eno EDD to develop projected water and wastewater flows, determine what infrastructure will be needed to create the backbone, determine where the generated wastewater will be discharged in the City's sewer system, identify potential permitting needs, and develop conceptual opinions on probable cost.

The water demands and wastewater flows developed for the Eno EDD are summarized in **Table 8-1**. It can be seen from the table that the projected average water demands vary from 76,000 gpd in year 2020 under the Low scenario to 895,000 gpd by build-out under the High scenario. The projected average wastewater flows vary from 60,000 gpd in year 2020 under the Low scenario to 715,000 gpd by build-out under the High scenario.

Table 8-1. Summary of Average Day Water Demand and Wastewater Flow Projections by Planning Period

Projections[1,2]	Planning Period Flows[3] (gpd)					
	2020	2030	2040	2050	2060	Build-out
Low Water	76,000	176,000	277,000	378,000	479,000	504,000
Mid Water	105,000	245,000	384,000	524,000	664,000	699,000
High Water	134,000	313,000	492,000	671,000	850,000	895,000
Low Wastewater	60,000	141,000	221,000	302,000	382,000	402,000
Mid Wastewater	84,000	195,000	307,000	419,000	530,000	558,000
High Wastewater	107,000	250,000	393,000	536,000	679,000	715,000

Notes:
1) The Low, Mid, and High projections differ based on the assumed unit water demand factor for industrial development. The Low projection assumed 1,000 gpd/acre, the Mid projection 1,500 gpd/acre, and the High projection 2,000 gpd/acre.
2) The wastewater projections are based on an assumed water return rate of 80 percent.
3) The percentage of growth between planning periods was provided by Orange County.

The Eno EDD currently has a 16-inch diameter waterline installed in the project area. Based on a hydraulic model analysis, the existing water main has sufficient capacity to meet the near-term and build-out demands for the Low and Mid scenarios. There are some minor flow and headloss deficiencies for the High flow scenario under build-out conditions, however it would be anticipated that improvements implemented in the City's system by the time build-out were to occur may address the minor deficiencies. Therefore, no additional water distribution infrastructure is recommended.

The only municipal wastewater infrastructure within the Eno EDD is a small pump station near the eastern most boundary of the project area that conveys a small amount of flow to the City. Therefore, a wastewater collection and conveyance system backbone is required within the Eno EDD. Recommended collection system infrastructure and associated conceptual opinions of probable cost were developed for the Low and High wastewater flow scenarios. **Tables 8-2** and **8-3** present the recommended infrastructure and associated cost for the Low and High flow scenarios, respectively.

In order to construct the recommended infrastructure, a number of regulatory permits will be required. In an effort to minimize environmental impacts and associated permitting efforts, trenchless construction methodologies were assumed for stream and roadway crossings. The potential need for an EA/EIS could be required as a result of the amount of infrastructure included in the project, but is not a certainty. If the gravity sewer and force main proposed to parallel US Hwy 70 cannot be installed within the NCDOT road ROW, the need for an alternative alignment and/or easement acquisition could be required, which would lengthen the project schedule and impact project cost. This would need to be addressed early in the design phase to minimize impacts.

8.2 Cost Reduction Options

It is recognized that the costs presented in either Table 8-2 or Table 8-3 would be a significant investment for the County and that immediately funding the project in its entirety will be a challenge. Therefore, the following options to potentially reduce project cost and/or phase the improvements were identified and are presented below.

- Construct only the pump station and force main. Collection system infrastructure could be constructed by developers on an as-needed basis, or by the County if additional funding becomes available.

- Construct the pump station, force main, and only the most critical collection system infrastructure. The collection system piping recommended for this option includes gravity pipes 2, 4, and 6, as identified on Figure 6-1. Constructing these gravity pipes would prevent developers from having to impact Rhodes Creek and US Hwy 70, both of which will have permitting challenges.

- Construct the force main from the proposed pump station to a manhole in the City's wastewater collection system near the Eno EDD boundary, as opposed to all the way to the recommended location in the South Durham Basin, described in Section 5. This option would temporarily reduce the amount of force main and gravity sewer pipe by approximately 11,000 feet. It is expected that this alternative discharge point will only have sufficient capacity to receive wastewater flows in the near-term, and that the additional force main would be needed in the future. The force main and pump station would still be designed to handle future flows so that when the discharge point into the City's wastewater system needs to be relocated to the recommended location in the South Durham Basin, the existing force main would only have to be extended (i.e. not upgraded). Additional modeling and engineering evaluation will be required to determine where and how much wastewater flow can be discharged to the alternative location in the City's system.

Table 8-2. Opinion of Probable Construction Cost – Low Wastewater Flow Scenario

Associated System	Description	Unit	Quantity	Cost Estimate
Eno EDD Gravity System	Gravity Sewer - 8-inch DIP	Lf	12,123	$ 702,000[1]
	Jack & Bore	Lf	120[2]	$ 60,000
	Gravity Sewer - 12-inch DIP	Lf	368	$ 21,000[1]
	Gravity Sewer Manhole[3]	Ea	45	$ 270,000
Eno EDD Conveyance System to Durham Sewer System	Pump Station[4]	MGD	0.7	$ 486,000
	8-inch Force Main[4]	Lf	7,000	$ 315,000
	8-inch Jack & Bore	Lf	160[5]	$ 80,000
	12-inch Gravity Sewer	Lf	11,300	$ 757,000[6]
	12-inch Jack & Bore	Lf	100	$ 94,000
	Gravity Sewer Manhole[3]	Ea	38	$ 228,000
	Traffic Control[7]	Lf	8,000	$ 180,000
	Pavement Replacement	Sy	1,000	$ 42,000
			Subtotal	**$ 3,235,000**
			5% Mobilization	$ 160,000
			Subtotal	**$ 3,400,000**
			10% Contractor OH&P	$ 340,000
			Subtotal	**$ 3,740,000**
			25% Contingency	$ 940,000
			Subtotal	**$ 4,680,000**
			20% Engineering, Permitting, and Administration	$ 940,000
			TOTAL	**$ 5,620,000**

Notes:

1) Cost reflects various depths of cover. Not shown in table for clarity.
2) Jack & Bore costs reflect two (2) 60-ft bores. See Note 11.
3) Gravity sewer manhole spacing of 300 feet.
4) Pump station sized for 30 year flows.
5) Jack & Bore costs reflect one (1) 100-ft bore and one (1) 60-ft bore. See Note 11.
6) Cost assumes 15 feet of cover.
7) Traffic control required during installation of force main along Hwy 70.
8) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
9) Cost does not reflect pump replacement by 2035.
10) Cost does not reflect land acquisition.
11) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

Table 8-3. Opinion of Probable Construction Cost – High Wastewater Flow Scenario

Associated System	Description	Unit	Quantity	Cost Estimate
Eno EDD Gravity System	Gravity Sewer - 8-inch DIP	Lf	6,669	$ 358,000[1]
	Jack & Bore	Lf	120[2]	$ 78,000
	Gravity Sewer - 12-inch DIP	Lf	5,822	$ 420,000[1]
	Gravity Sewer Manhole[3]	Ea	45	$ 270,000
Eno EDD Conveyance System to Durham Sewer System	Pump Station[4]	MGD	1.2	$ 540,000
	12-inch Force Main[4]	Lf	7,000	$ 378,000
	12-inch Jack & Bore	Lf	160[5]	$ 104,000
	18-inch Gravity Sewer	Lf	11,300	$ 1,220,000[6]
	18-inch Jack & Bore	Lf	100	$ 125,000
	Gravity Sewer Manhole[3]	Ea	38	$ 228,000
	Traffic Control[7]	Lf	8,000	$ 180,000
	Pavement Replacement	Sy	1,000	$ 42,000
			Subtotal	**$ 3,943,000**
			5% Mobilization/Demobilization	$ 200,000
			Subtotal	**$ 4,140,000**
			10% Contractor OH&P	$ 414,000
			Subtotal	**$ 4,550,000**
			25% Contingency	$ 1,140,000
			Subtotal	**$ 5,690,000**
			20% Engineering, Permitting, and Administration	$ 1,140,000
			TOTAL	**$ 6,830,000**

Notes:

1) Cost reflects various depths of cover. Not shown in table for clarity.
2) Jack & Bore costs reflect two (2) 60-ft bores. See Note 11.
3) Gravity sewer manhole spacing of 300 feet.
4) Pump station sized for 30 year flows.
5) Jack & Bore costs reflect one (1) 100-ft bore and one (1) 60-ft bore. See Note 11.
6) Cost assumes 15 feet of cover.
7) Traffic control required during installation of force main along Hwy 70.
8) Eno EDD gravity sewer system was sized based on high flow scenario with a peaking factor of 2.5
9) Cost does not reflect pump replacement by 2035.
10) Cost does not reflect land acquisition.
11) Jack & Bores were assumed for:
    - 60-ft bore under Hwy 70 (Eno EDD Gravity System)
    - 60-ft bore under stream crossing near pump station (Eno EDD Gravity System & Conveyance System)
    - 100-ft bore under SR 751 along force main route (Eno EDD Conveyance System)
    - 100-ft bore under railroad along force main route (Eno EDD Conveyance System)

- Construct the pump station and force main to convey only near-term wastewater flows, with the understanding that both will need to be upgraded in the future. This option will cost significantly more money for the County over the lifetime of the project, but have a lower initial capital cost. Additional modeling and engineering evaluation will be required to determine where and how much wastewater flow can be discharged in the City's system and what the required infrastructure will be.

8.3 Recommendations

The County has included approximately $1,500,000 in their Capital Improvement Program to fund design and construction of water and wastewater improvements in the Eno EDD. Based on the cost estimates presented in Tables 8-2 and 8-3, there is not currently enough funding available to construct the recommended wastewater infrastructure for either wastewater flow scenario. Therefore, the County will have to consider alternatives in order for this project to continue to move forward, possibly in addition to the cost reduction options presented in Section 8.2. Based on discussions with County and City staff, the following alternatives may be considered.

8.3.1 Alternatives

Alternative 1 – Design and Construction of Improvements

This alternative includes continuous design, permitting, bidding, and construction of the recommended improvements. In order for this alternative to move forward, Orange County will be required to reallocate funds to increase their available budget from $1,500,000 to the desired scenario estimate, presented in Tables 8-2 and 8-3. If design of the improvements were to begin in early 2014, construction would be estimated to start in early 2015.

Alternative 2 – Full Design of Improvements

This alternative includes development of a complete design package. Acquisition of any necessary permanent easements should also be included in this alternative. Permitting, bidding, and construction will be put on hold until additional funding can be secured. The permitting is put on hold because permit approvals have limited durations and could expire before construction funding is secured. This alternative will allow the County to make use of most of their currently available funds to keep the project moving forward so that once the additional funding is made available, the project can more quickly advance into permitting, bidding, and construction. Based on the cost presented in Table 8-2, the full design is expected to cost less than $1,130,000. The cost will be less since permitting would not be included in this phase.

Alternative 3 – Preliminary Design of Improvements

This alternative includes development of preliminary design documents, which are assumed to be around the 50 percent design stage. Final design, permitting, bidding, and construction will be put on hold until additional funding can be secured. This alternative will allow the County to make use of some of their available funding to keep the project moving forward so that once the additional funding is made available, the project can more quickly advance.

The preliminary design is expected to include an additional data collection effort, which would include survey and geotechnical investigation, followed by development of preliminary design drawings and key technical specifications. Additional work could also be included such as preliminary coordination with regulatory agencies and public outreach. Land acquisition for the proposed pump station could be performed. However, it may not be appropriate to acquire permanent easements, if any are required, based on the preliminary status of the design.

The cost to perform the preliminary design can be provided upon request, but can be assumed to be less than the $1,130,000 identified in Table 8-2 for full design and permitting.

Alternative 4 – Hold Project Indefinitely

This alternative puts the entire project on hold until additional funding can be secured by the County. This alternative will result in the longest schedule, as no upfront design work will have been completed. This alternative can also put the project at greater risk for significant changes as development and roadway modifications could impact the proposed alignments, which could in turn increase the cost of the project.

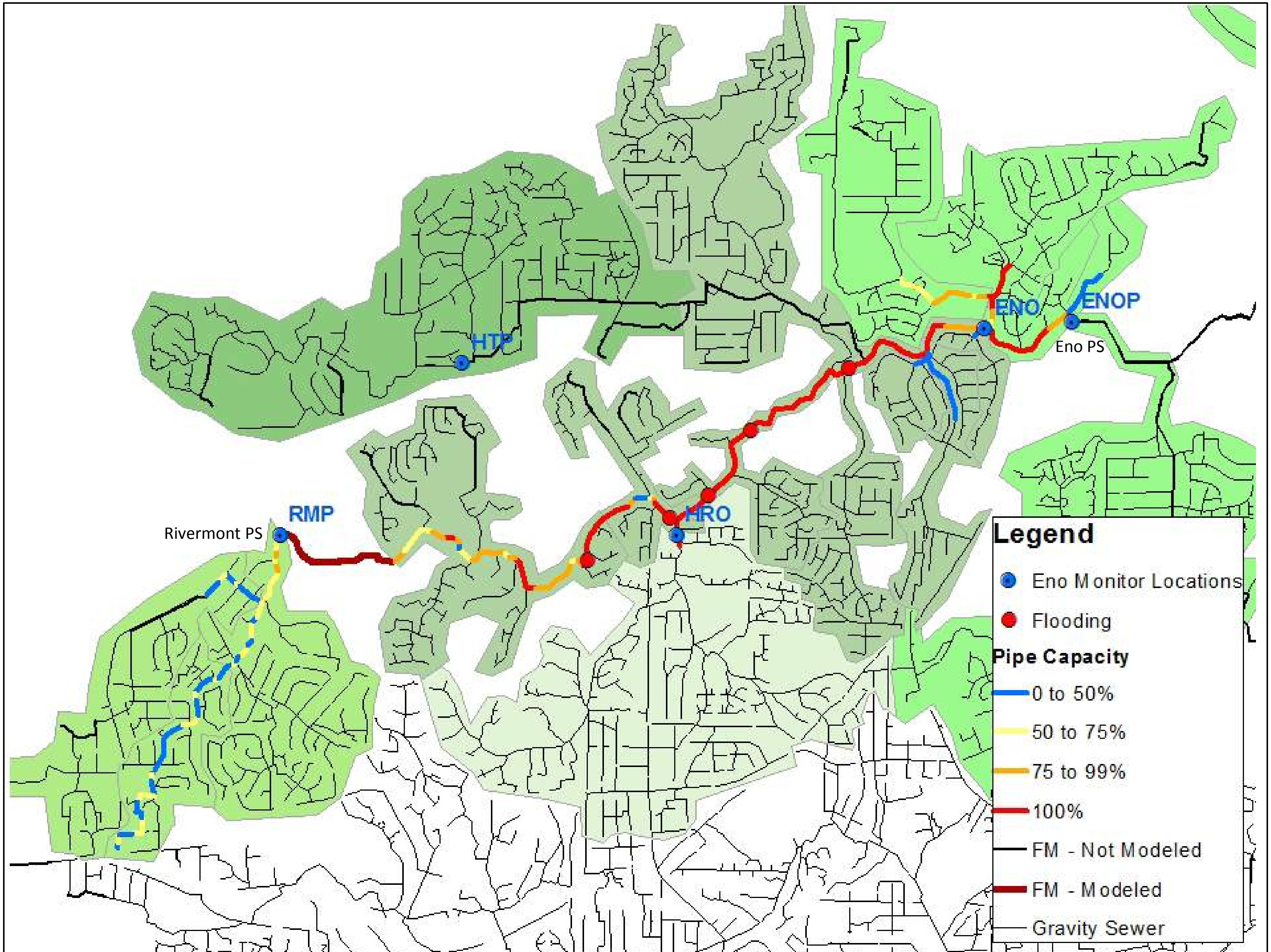
8.3.2 Recommendation

Based on the alternatives presented above, it is CDM Smith's recommendation that the County move forward with Alternative 2, which includes full design of the recommended improvements, but holding on the construction until additional funding can be secured. This alternative provides the following benefits:

- Avoids the need for an immediate reallocation of funds compared to Alternative 1.
- Allows the County to make use of the funds that are currently available for the project, compared to Alternative 4 and partially for Alternative 3.
- Allows the County to acquire the necessary easements, if any are required, compared to Alternatives 3 and 4.
- Allows the County to continue moving the project forward, compared to Alternative 4.
- Reduces the overall schedule compared to Alternatives 3 and 4.
- Allows the County to move immediately into permitting, bidding, and construction once the available funds are secured, compared to Alternatives 3 and 4. Being able to quickly implement the infrastructure will be much more attractive to potential developers.

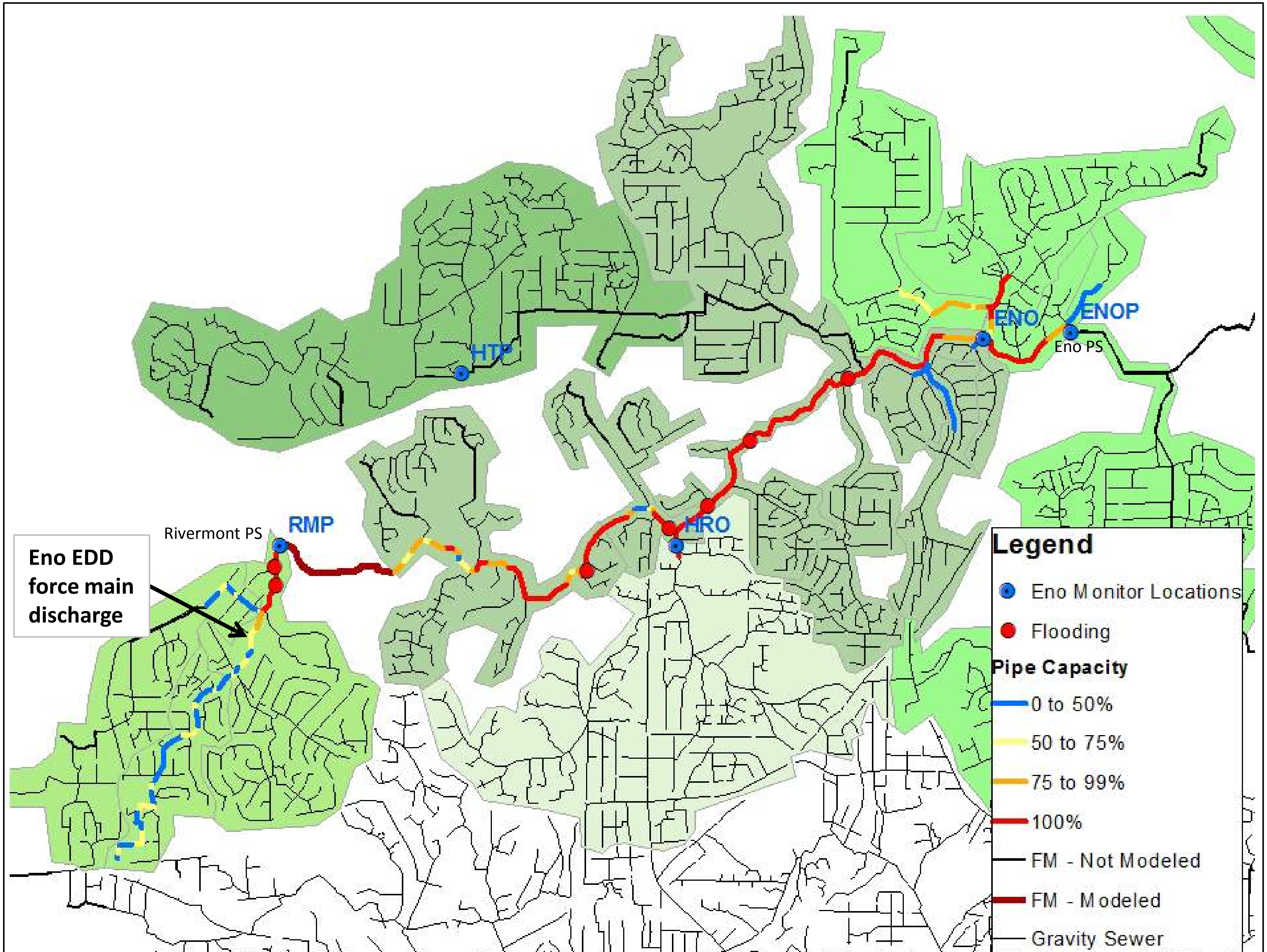
Appendix A

Capacity Analysis Figures



CDM Smith

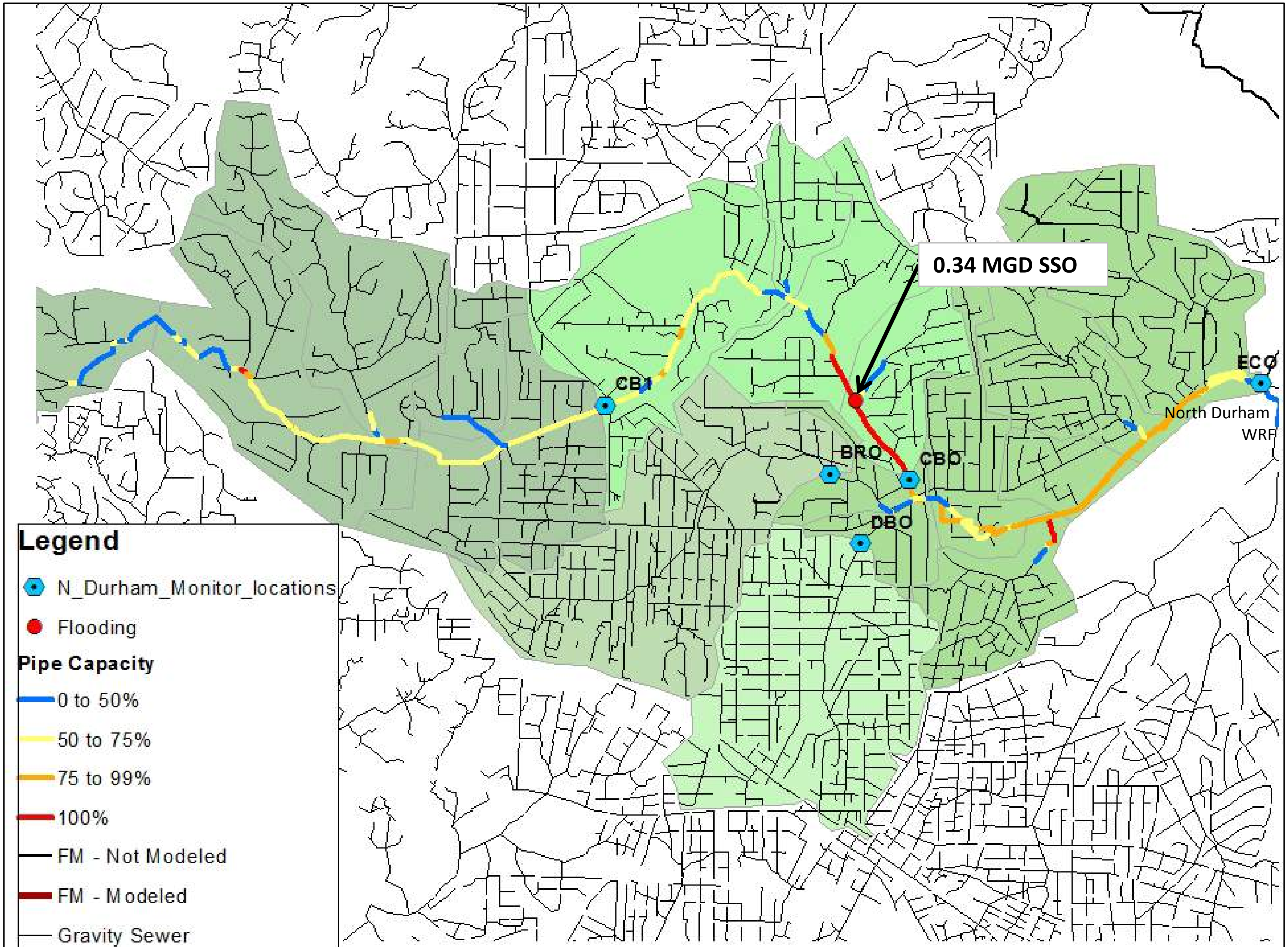
Figure A-1
ENO Outfall, Existing Peak Flow, No Eno EDD Flows Added



CDM Smith

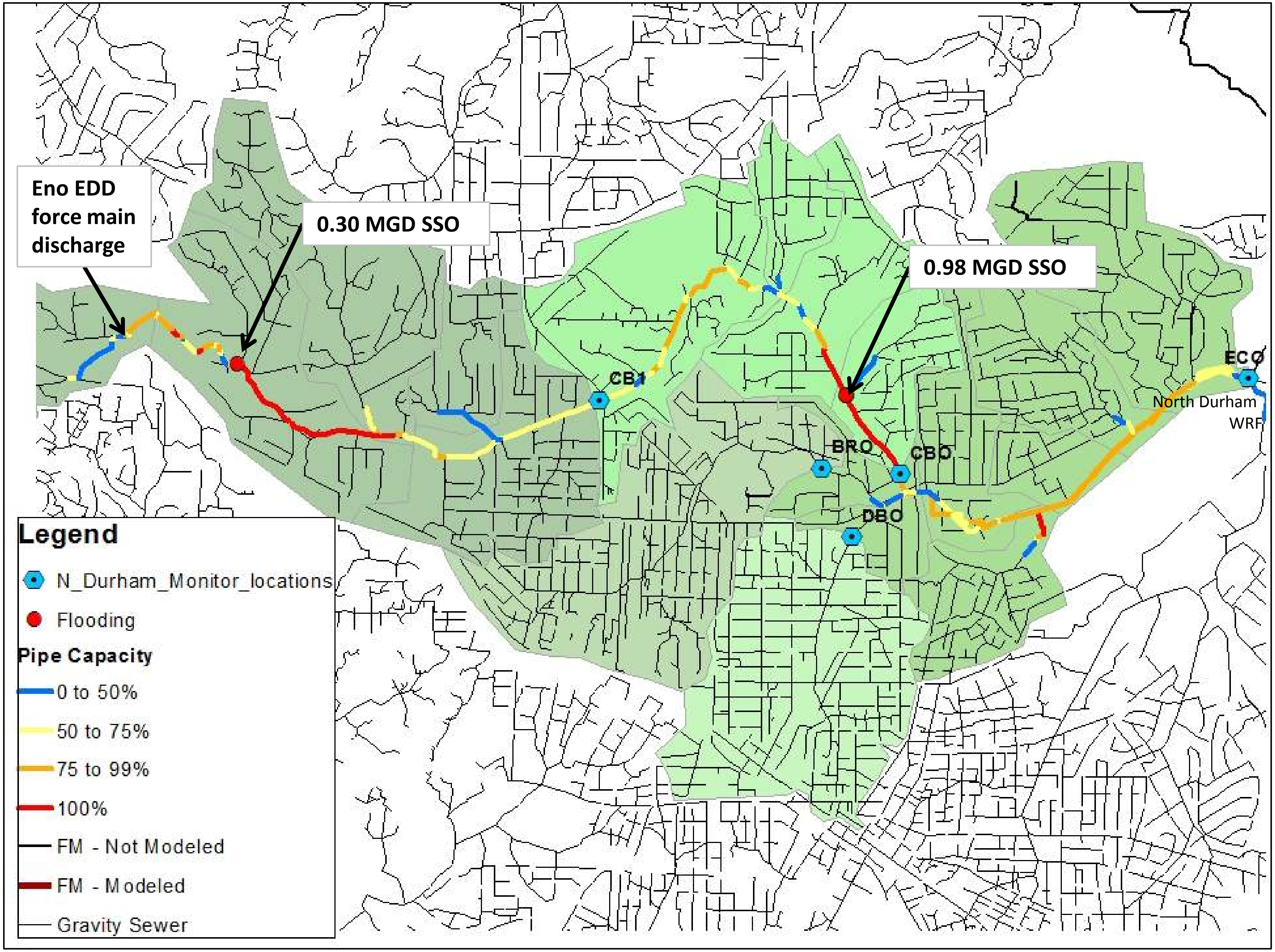
Figure A-2

ENO Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (Low Flow Scenario)



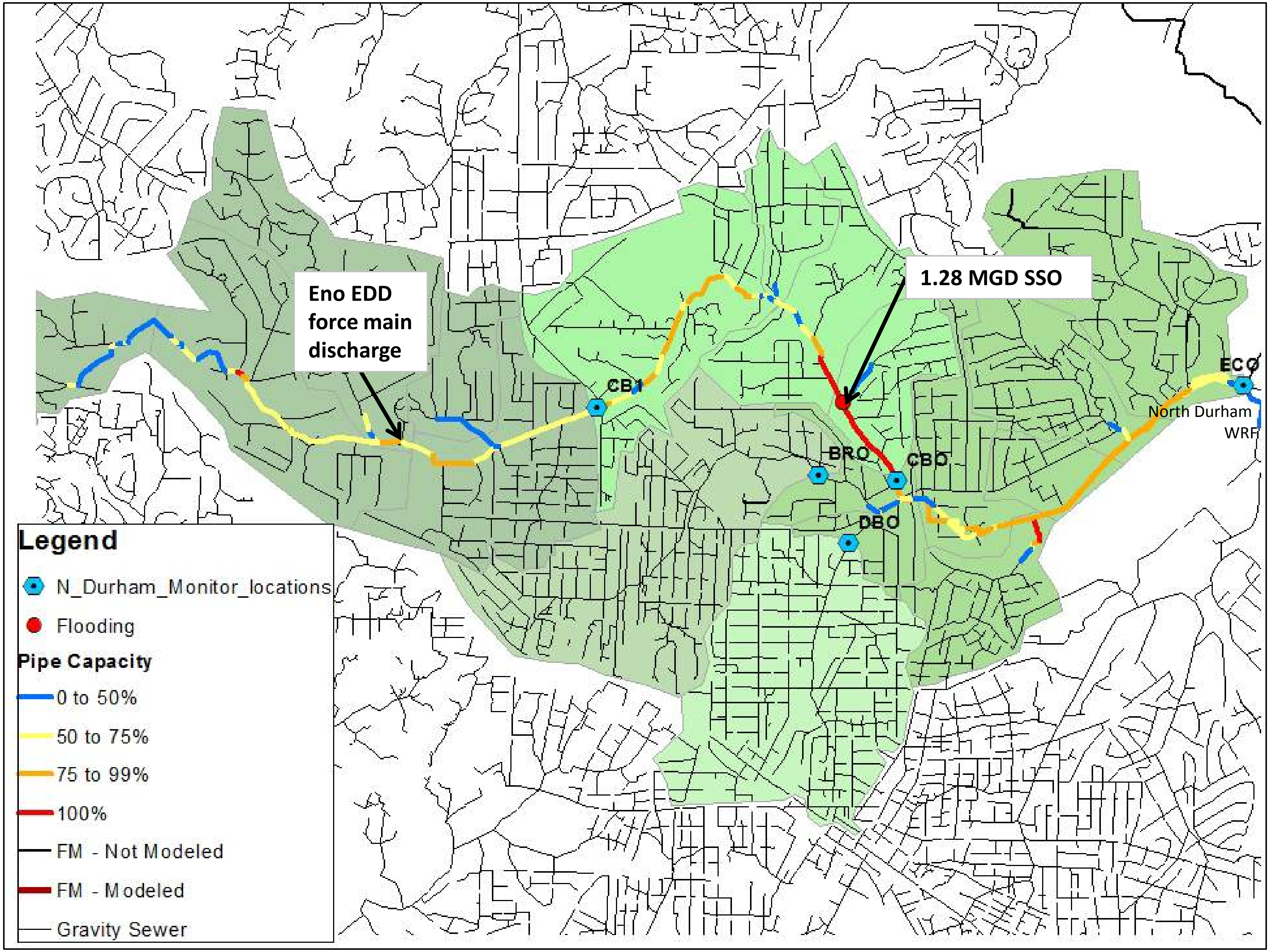
CDM Smith

Figure A-3
Ellerbe Creek Outfall, Existing Peak Flow, No Eno EDD Flows Added



CDM Smith

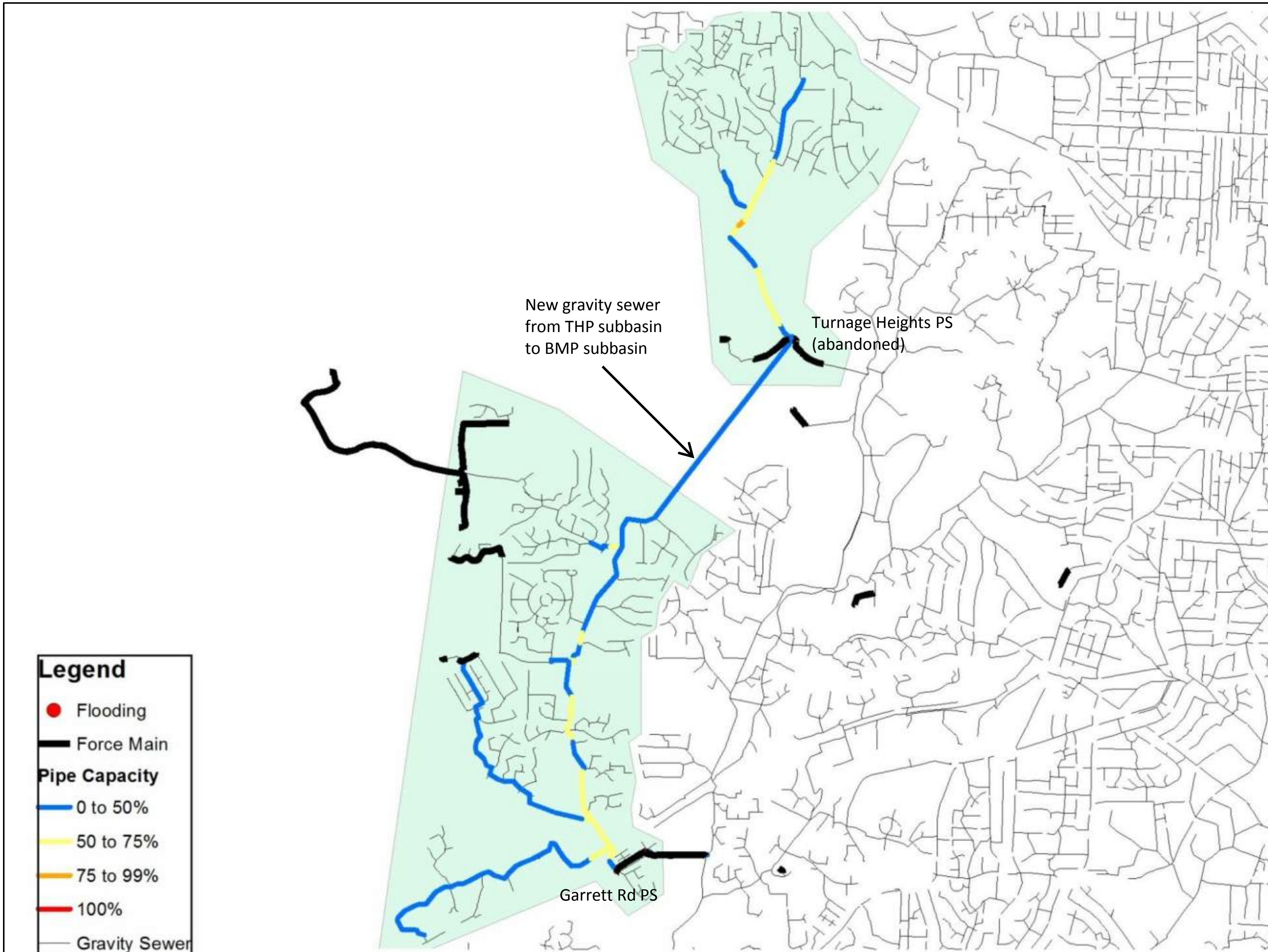
Figure A-4
Ellerbe Creek Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (Low Flow Scenario)



CDM Smith

Figure A-5

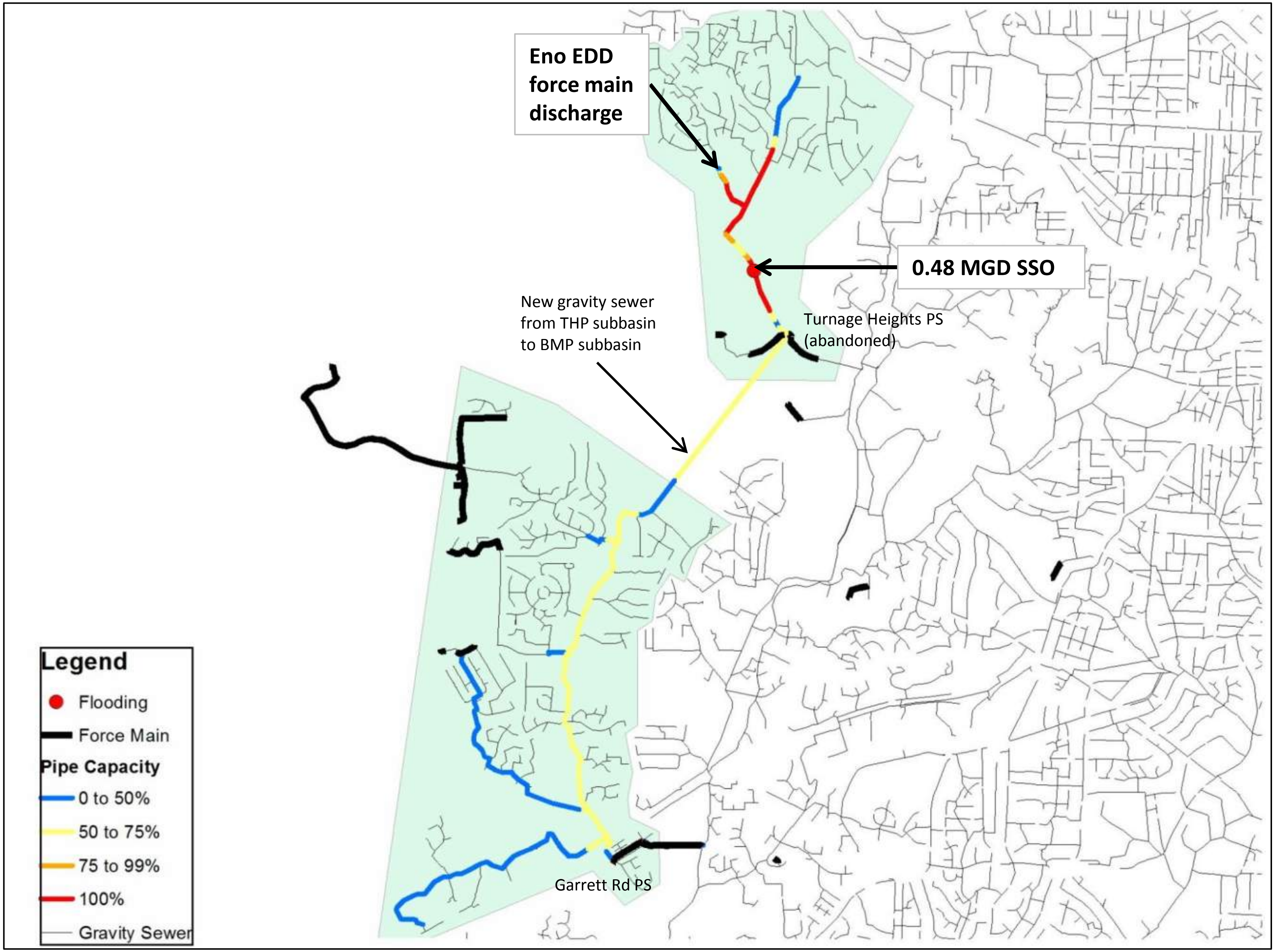
Ellerbe Creek Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (Low Flow Scenario), Alternate Force Main Discharge Location



CDM Smith

Figure A-6

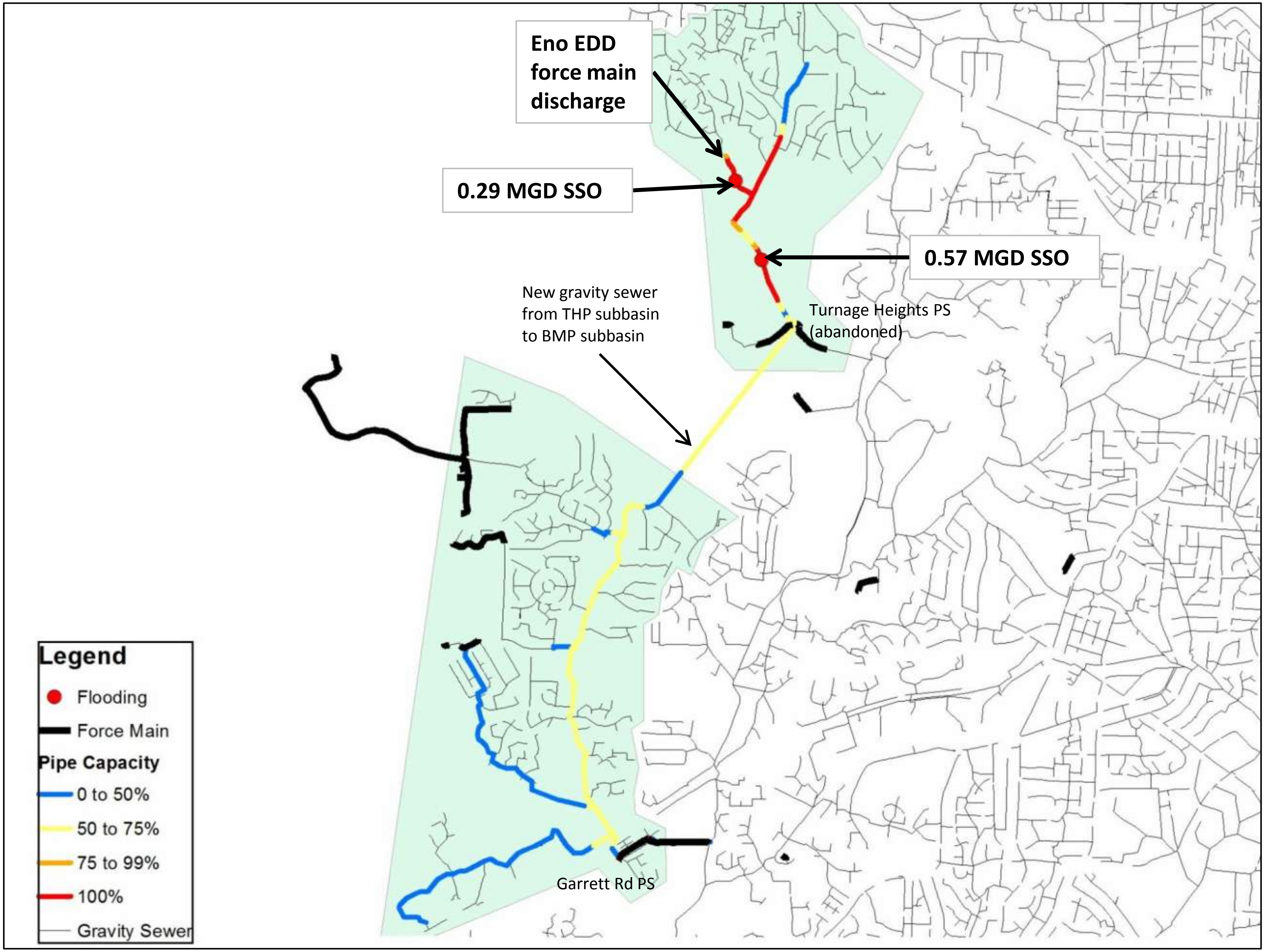
Mud Creek Outfall, Existing Peak Flow, No Eno EDD Flows Added



CDM Smith

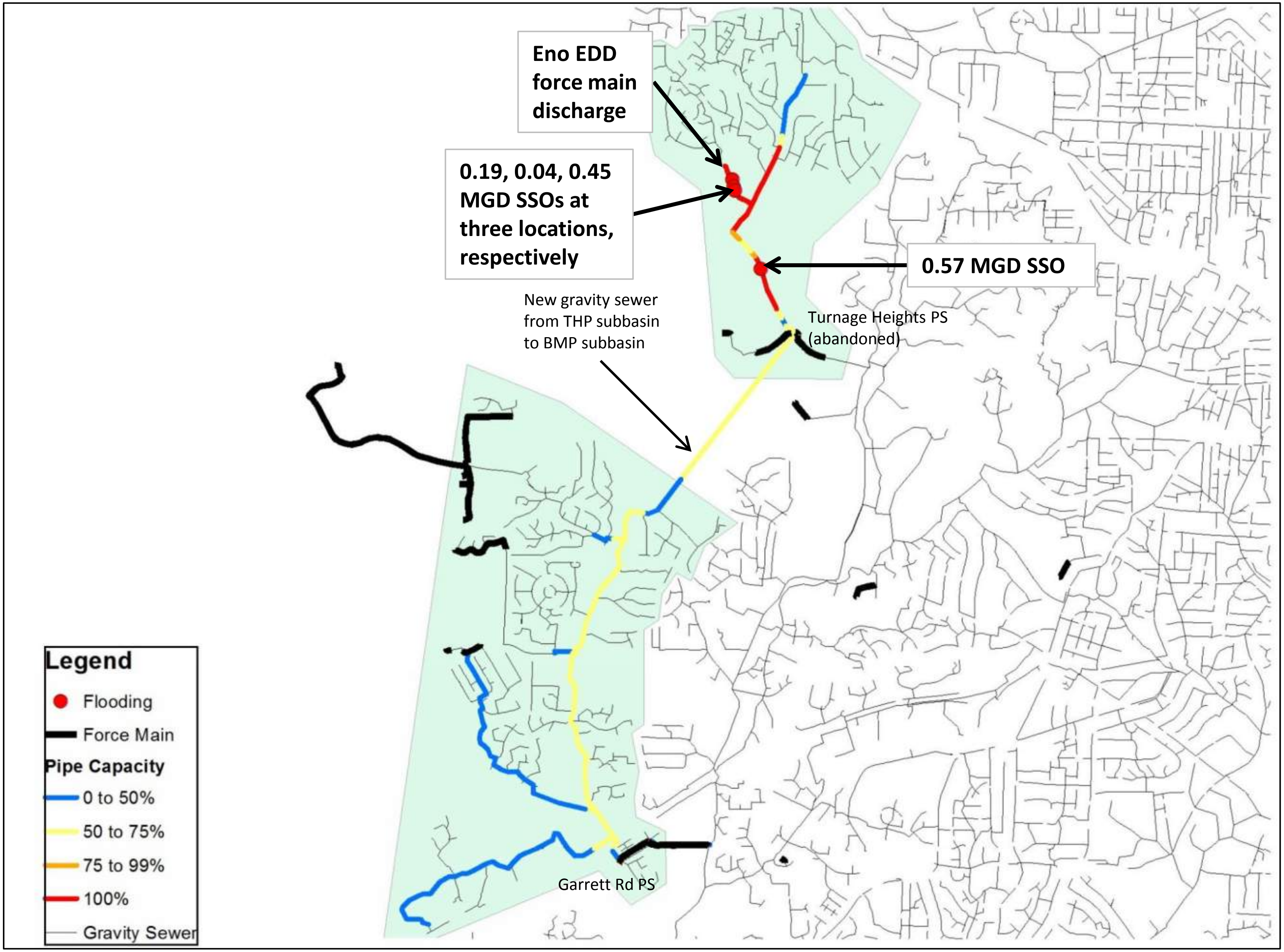
Figure A-7

Mud Creek Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (Low Flow Scenario)



CDM Smith

Figure A-8
Mud Creek Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (Mid Flow Scenario)



CDM Smith

Figure A-9
Mud Creek Outfall, Existing Peak Flow With Eno EDD Build Out Peak Flows Added (High Flow Scenario)