THE CITY OF FREDERICK

2006 WATER MASTER PLAN

MARCH 2009

DAYTON & KNIGHT LTD.
Consulting Engineers

453.1

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THE CITY OF FREDERICK
2006 WATER MASTER PLAN

Submitted to:

The City of Frederick
111 Airport Drive East
Frederick, MD 21701

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March 2009

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Dayton & Knight Ltd.
CONSULTING ENGINEERS

#210 - 889 Harbourside Drive, North Vancouver
British Columbia, Canada V7P 3S1
Telephone: 604-990-4800 • Fax: 604-990-4805
E-mail: dkeng@dayton-knight.com

"LETTER OF TRANSMITTAL"

March 24, 2009

Mr. Gene Walzl, P.E.
Water and Sewer Engineer
The City of Frederick
140 West Patrick Street
Frederick, MD 21701

Dear Mr. Walzl:

RE: The City of Frederick
2006 Water Master Plan

Dayton & Knight Ltd. has completed the update to the 2000 Water Master Plan that will guide the supply and distribution of water to the City of Frederick through 2040. The opportunity to assist you with this planning study is much appreciated.

Respectfully submitted,

Dayton & Knight Ltd.

Jack Lee, P.Eng.
Project Manager

Sean Brophy, P.Eng.
Water Treatment Specialist

Joel McAllister, P.Eng.
Water Modeler

Reviewed by:

Harlan Kelly, P.E., P.Eng.

JM/hh
453.1
Encls.

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THE CITY OF FREDERICK
2006 WATER MASTER PLAN

TABLE OF CONTENTS

TITLE PAGE

LETTER OF TRANSMITTAL

TABLE OF CONTENTS

ABBREVIATIONS AND DEFINITIONS

1.0 EXECUTIVE SUMMARY 1

- 1.1 Existing Water System 1
- 1.2 Water Demand Projections 1
- 1.3 Hydraulic Modeling 3

2.0 INTRODUCTION 1

- 2.1 Background 1
- 2.2 Consultant Team 1
- 2.3 Study Progression 2
- 2.4 Project Review 4
- 2.5 Acknowledgments 4

3.0 EXISTING WATER SYSTEM 1

- 3.1 General Description 1
- 3.2 Water Supply Sources 1
  - 3.2.1 Linganore Source 2
  - 3.2.2 Monocacy Source 3
  - 3.2.3 Mountain Source 4
  - 3.2.4 Wells 6
- 3.3 Water Treatment Plants 7
  - 3.3.1 Linganore Water Treatment Plant 8
  - 3.3.2 Monocacy Water Treatment Plant 9

TABLE OF CONTENTS (cont'd.)

3.3.3 Lester Dingle Water Treatment Plant 10
3.3.4 Fishing Creek Water Treatment Plant....11
3.3.5 Zenon Water Treatment Plant....12
3.4 Water Storage Tanks....12
3.4.1 Linden Tank....13
3.4.2 Vernon Avenue Tank....14
3.4.3 South Carroll Street Tank....15
3.4.4 Bowers Road Tank....15
3.4.5 Butterfly Lane Tank....16
3.4.6 Whittier Tank....17
3.5 Water Pumping Stations....18
3.5.1 Route 40 West Pumping Station....18
3.5.2 Lester Dingle Pumping Station....19
3.5.3 Whittier Pumping Station....19

4.0 WATER DEMAND PROJECTIONS....1

4.1 Population Projection....1
4.2 Average and Maximum Day Demands....1
4.3 Peaking Factor....3
4.4 Projected Water Demands Versus Available Supply....4
4.5 Feasibility of Interconnecting Other Areas....6

5.0 HYDRAULIC MODELING....1

5.1 Introduction....1
5.2 Model Development....2
5.3 Model Calibration....2
5.3.1 Hydrant Testing....2
5.3.2 Field Procedure....3
5.3.3 Calibration Results....3
5.3.4 Extended Period Simulations....4
5.3.5 Diurnal Pattern....4
5.3.6 Calibration....5
5.4 Design Criteria....5
5.4.1 Service Pressures....6
5.4.2 Fire Protection and Storage....6
5.5 System Analysis....7
5.5.1 Existing (2005)....7
5.5.2 Future....13
5.6 Transient Analysis....15
5.6.1 Zone 462....15
5.6.2 Zone 595 (Western)....17

TABLE OF CONTENTS (cont'd.)

5.6.3 Zone 595 (Whittier) 17
5.7 Future Finished Water Storage Sites 17
5.7.1 Zone 462 18
5.7.2 Zone 595 19
5.8 Water Quality 19

APPENDICES

A Information and Documents Used for Study
B Existing Upgrades
C Future Upgrades

LIST OF TABLES

3-1 Allowable Water Withdrawals 3-2
4-1 Summary Of Water Demands 4-2
4-2 Projected Water Demands 4-6
4-3 Water Supply Impacts 4-7
5-1 Design Service Pressure Criteria 5-6
5-2 Recommended Existing and Available Fire Flows During Maximum Day Scenario 5-9
5-3 Recommended System Improvements 5-11
5-4 Recommended Future System Improvements 5-13

LIST OF FIGURES

3-1 Existing Water Supply and Distribution System ....*after* 3-1
4-1 Population Projections ....*after* 4-1
4-2 Population Growth and Per Capita Water Demands (1990 - 2005) ....*after* 4-2
4-3 Water Demand Records (1991 - 2005) ....*after* 4-3
4-4 Projected Water Demand 2006-2040 PRWSA Growth Scenario ....*after* 4-6
5-1 City of Frederick Dirunal Demand Pattern 5-5
5-2 Water Service Boundaries ....*after* 5-6
5-3 2006 Peak Hour Scenario Low Pressure Junctions ....*after* 5-8
5-4 Fire Node Locations ....*after* 5-10
5-5 Recommended Immediate Improvements 2007-2009 ....*after* 5-10
5-6 Recommended Future Improvements 2010 and Beyond ....*after* 5-12
5-7 Zone 462 Pressure Surge Results with Tanks at 460' HGL ....*after* 5-14

TABLE OF CONTENTS (cont'd.)

5-8 Zone 462 Pressure Surge Results with Tanks Full .....*after* 5-15
5-9 Zone 595 (Western High Zone) Pressure Surge Results.....*after* 5-16
5-10 Zone 595 (Whittier High Zone) Pressure Surge Results.....*after* 5-16
5-11 Storage Requirements for Pressure Zones .....*after* 5-17
5-12 Amber Tank Siting Options.....*after* 5-17
5-13 Water Quality Simulation Chlorine Residual Analysis
Simulated Chlorine < 1.0 ppm.....*after* 5-19
5-14 Water Quality Simulation Chlorine Residual Analysis
Simulated Chlorine < 0.75 ppm.....*after* 5-19

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

ABBREVIATIONS AND DEFINITIONS

ABBREVIATIONS

ACH	aluminum chorohydrate
ADD	average day demand
AIM	Asset Information Management
ATS	Automatic Transfer Switch
CAA	Clean Air Act
CFS	cubic foot per second
CMMS	Computer Maintenance Management System
CMU	concrete masonry unit
CPU	computer processing unit
D&K	Dayton & Knight Ltd.
D/DBPR	disinfectant/disinfection by-product rule
DI	ductile iron
DPW	Department of Public Works
ENRc	Engineering News Record construction McGraw-Hill index
EPA	Environmental Protection Agency
EPS	extended period simulation
ERCRA	Emergency Response and Community Right to Know Act
ERP	effective radiated power
ESWTR	Enhanced Surface Water Treatment Rule
FET	Field Effect Transistors
fps	feet per second
FSK	Frequency Shift Keying
ft	feet
GIS	Geographical Information System
gpcpd	gallons per capita per day
gpm	gallons per minute
GWUDI	Groundwater under direct influence of surface waters
GWR	groundwater rule
HAA_5	sum of five regulated Haloacetic Acids
HGL	hydraulic grade line

HMI	Human Machine Interface
HMIS	Hazardous Materials Identification System
HP	horsepower
I/O	input/output
IDSE	initial distribution system evaluation
LAN	Local Area Network
LLA	Lake Linganore Association
LT1ESWTR	long term 1 enhanced Surface Water Treatment Rule (USEPA)
LT2ESWTR	long term 2 enhanced Surface Water Treatment Rule (USEPA)
Mbps	mega bits per second
MCC	Motor Control Center
MCL	maximum contaminant levels
MDD	maximum day demand
MDE	Maryland Department of Environment
MG	million gallons
MGD	million gallons per day
MRDL	maximum residual disinfectant levels
MSDS	Material Safety Data Sheet
NAAQS	National Ambient Air Quality Standards
NTU	nephelometric turbidity unit
OSHA	Occupational Safety and Health Administration
PDM	Pulse Duration Modulation
PHA	Process Hazard Analysis
PLC	Programmable Logic Controller
POE	Point of Entry
POU	Point of Use
PRWSA	Potomac River Water Supply Agreement
psi	pounds per square inch
PSM	Process Safety Management
PWS	public water system
RAA	running annual average
RAS	remote access server
RF	Radio Frequency
RMP	Risk Management Program
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SMP	standard monitoring plan
SQL	Structural Query Language
SSS	system specific study
SWTR	Surface Water Treatment Rule
TCP/IP	transport control protocol/internet protocol
TDH	total dynamic head
THM	trihalomethane
TTHM	total trihalomethane
TVSS	transient voltage surge suppressor
TWL	top water level

UPS	uninterruptible power supply
USEPA	United States Environmental Protection Agency
UV	ultraviolet
UVT	ultraviolet transmittance
VSAT™	Vulnerability Self-Assessment Tool
VSLIchip	very large scale integrated chip
WAN	Wide Area Network
WAUP	Water Appropriation and Use Permit
WMPU	2000 Water Master Plan (Chester Report)
WMPV	2000 Water and Sewer Master Plan Update (Chester Report)
WRA	Whitman, Requardt and Associates
WTP	water treatment plant
WWTP	wastewater treatment plant

DEFINITIONS

Average Day	The average water consumption/demand during a year.
Maximum Day	The day of highest water consumption/demand during a year.
Maximum Month	Average flow during month of highest water consumption/demand during a year.
Peak Week	Average flow during week of highest water consumption/demand during a year.
Peaking Factor	Ratio of maximum day demand divided by the average day demand for a given year.

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

1.0 EXECUTIVE SUMMARY

The City of Frederick's water supply and distribution system presently services about 58,000 people. Due to changes in planning and availability of water from various sources, the City has decided to update the 2000 Water Master Plan.

1.1 Existing Water System

Figure 3-1 illustrates the City's existing water supply and distribution system. There are four supply sources, four water treatment plants (the potable Zenon membrane plant is not being used), six distribution storage tanks and three pumping stations. There are two major pressure zones, with the lower Zone 462 to the east and the higher Zone 595 to the west.

1.2 Water Demand Projections

The average day per capita demand has declined from a high of 137.9 gpcpd in 1992 to a low of 100.0 gpcpd in 2005. The City's peaking factor (ratio of maximum day demand to average day demand) from 1960 to 2001 is 1.30. The 15 year average peaking factor from 1991 to 2005 is 1.34. A peaking factor of 1.60 is used by the County for the Potomac water supply design and 1.60 is also used for this study.

The City's existing adequate safe yield, under the MDE Monocacy Conset Order, from the various sources are:

- Lake Linganore WTP 6.0 MGD
- Monocacy WTP 2.0 MGD
- Lester Dingle WTP 1.7 MGD
- Wells 3, 4 and 7 0.68 MGD

10.38 MGD

The City has recently signed the Potomac River Water Supply Agreement (PRWSA) with Frederick County which secures additional water supply to the City. The County's schedule for Potomac water combined with the City's sources are summarized as follows for maximum day:

Year	City Sources (MGD)	County Potomac (MGD)	Total (MGD)	Population that could be Serviced
Existing	10.38	-	10.38	64,875
2009	8.38	8.00	16.38	102,375
2015	8.38	12.00	20.38	127,375

Originally, the population projections selected by the City for this study were those in the Expanding Horizons growth scenario from the 2004 Comprehensive Plan. However, it is understood that the City has subsequently decided to use the projected demands listed in the PRWSA.

Based on the demands listed in the PRWSA, population estimates were developed. It is anticipated that the population by 2030 will be 90,000. Using the same growth rate the projected population will be 108,000 by 2040.

The City will require additional water supply by 2033 for a 1.60 peaking factor with the City's existing sources and the new Potomac Supply. If water reuse options are considered, the peaking factor may with their use be reduced.

1.3 Hydraulic Modeling

The H_2OMAP software by MWHSoft was used to undertake steady state, extended period simulation and water quality simulations. Hydrant flow and pressure testing was done to field calibrate the computer model. Transient analysis was also conducted using the H_2OSURGE software by MWHSoft.

System deficiencies were identified with recommended immediate improvements (2007 to 2009) and recommended future improvements (2010 and beyond) to upgrade the City's system. The recommended improvements are detailed in Tables 5-3 and 5-4 respectively.

The transient analysis indicates that there are no abnormal high pressures in the City's distribution system due to normal day-to-day pump operation. However, analysis indicates that there may be transient issues during a power failure at the Monocacy WTP under specific background conditions.

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

2.0 INTRODUCTION

2.1 Background

The City of Frederick is located in Frederick County, Maryland. The City, founded in 1745, owns and operates a potable water supply and distribution system which includes four potable water treatment plants and a portable Zenon membrane plant that presently serves a population of about 58,000 people (year 2005). For comparison, the County operates 18 potable water treatment plants that serve about 44,000 people.

Chester Engineers completed a Water and Sewer Master Plan Update in 2000 (WMPU) for the City. Significant changes have since occurred including the availability of water from existing supplies, the development of new supplies from wells and the completion of an update to the City's Comprehensive Plan in 2003. The City has also signed the Potomac River Water Supply Agreement with Frederick County on March 3, 2006 which will be the next water source for the City.

2.2 Consultant Team

Three consultants were selected by the City in July 2005 to submit engineering proposals for a Comprehensive Update to the City of Frederick 2000 Water Master Plan. Proposals were received by the City on July 29, 2005 and interviews with the three consultant teams

were held on August 18, 2005. The City Council awarded the assignment to Dayton & Knight Ltd. on September 14, 2005.

The Dayton & Knight Ltd. team members consist of:

Dayton & Knight Ltd. (Prime Consultant)	Jack Lee, P.Eng. (Principal-in-Charge)
	Sean Brophy, P.Eng. (Water Supply/Treatment Specialist)
	Harlan G. Kelly, P.E., P.Eng. (QA/QC)
	Joel McAllister, P.Eng. (Water Modeling Engineer)
	Gerson Neiva, P.Eng. (Water Treatment Engineer)
	Victor Wong, P.Eng. (SCADA Specialist)
	Brano Jutric (Electrical/Mechanical Engineer)
	Dena Vergamini, C.Tech. (Water Quality Technologist)
ADTEK Engineers Inc. (Structural Engineering Sub-consultant)	Tee Pecora, P.E. (Principal Structural Engineer)
	Jeffrey Miller, P.E. (Structural Engineer)
CORRPRO Companies Inc. (Corrosion Engineering Sub-consultant)	Walter Young, P.E. (Principal Corrosion Engineer)

2.3 Study Progression

The study started in September 2005 with the review of information received from the City. A meeting was held on October 3 and 4, 2005 with the Dayton & Knight Ltd. team and City staff to review concerns and key issues for the following:

a) Project Reviews
b) Water Demand Projections
c) Hydraulic Modeling

d) Condition and Performance of Overall System

e) Reliability and Vulnerability Assessment

f) Water Supply

g) Water Treatment

h) SCADA and Data Security Management

Hydrant flow/pressure testing in the field was undertaken during October 6 and 7, 2005 with assistance from City staff. The data collected were used to calibrate the City's water model.

Site reconnaissance of the City's water facilities was undertaken by Dayton & Knight Ltd.'s technical team members during November 15 to 28, 2005. A condition assessment was done at the same time (except for the watermains and structural issues) and a Critical Concerns list provided to the City on December 6, 2005 for inclusion in the 2006 infrastructure budget.

A conference call was held with City staff on February 24, 2006 to review Dayton & Knight Ltd.'s drafts of various technical memos. Comments received were incorporated in the revisions.

Progress meetings were held with MDE on March 21, 2006 and with the City on March 22, 2006.

A second meeting was held with the County on April 12, 2006 to review their schedule on the Potomac Water Supply construction.

A workshop with the City's Mayor and Board was undertaken on April 12, 2006.

Five excavations were undertaken on June 12, 13 and 14, 2006 to remove pipe sections for corrosion evaluation. The City provided 16 coupons taken from previous work for this assessment.

Training sessions with City staff on the use of the computer model were held from April 10-12, 2006.

A first draft of the report was submitted on November14, 2006 and was reviewed with City staff on December 5 and 6, 2006.

Dayton & Knight Ltd. was informed on January 4, 2007 that the projected population growth was not as high as originally envisioned. A second draft of the report was issued on March 22, 2007 with a revised projected population. The recommendations, schedule of improvements and costs in the first draft were revised for the second draft.

The City met with Dayton & Knight on October 25, 2007 to review the population projections and projected water demands. Dayton & Knight were instructed to use the demands and populations stated in the Potomac River Water Supply Agreement (PRWSA) for the final draft of the report. The recommendations, schedule of improvements, and costs from the second draft were revised for the final draft based on the projections stated in the PRWSA.

2.4 Project Review

Available information for review provided by the City for this Study are referenced in Appendix A. The documents were categorized, reviewed and discussed with City staff in order for the study team to be fully knowledgeable of the infrastructure, capacities and operation of the water system.

2.5 Acknowledgments

The Dayton & Knight Ltd. team wish to thank the following for their input and guidance:

The City of Frederick

- Gene Walzl, P.E., Water & Sewer Engineer
- Zack Kershner, P.E., Deputy Director - Engineering
- Tom Davis, P.E., Past Deputy Director - Operations
- Paul Lee, P.E., Past Director of Engineering
- Fred Eisenhart, Past Director of Public Works
- Randy Connatser, Past Deputy Director of Public Works
- Marc Stachowski – Manager – Land Development & Construction
- Keith Brown, Water Superintendent
- Craig Lambert, Water Plant Superintendent
- Mark Curry – Past Water Plant Assistant Superintendent
- Joe Adkins, Chief of Comprehensive Planning
- Becky Marinaro, Past CIP Manager
- Dan Seal, City Chemist
- Janice Dorcus, Office Manager

Frederick County

- Mike Marschner
- Kevin Demosky, P.E.
- Rodney Winebrenner, P.E.

Maryland Department of Environment

- John Grace, P.E.
- Barry O'Brien, P.E.
- Patrick Hammond, P.E.

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

3.0 EXISTING WATER SYSTEM

3.1 General Description

The City's water supply and distribution system is illustrated in Figure 3-1. There are four supply sources, four water treatment plants and a portable Zenon membrane plant, six distribution storage tanks and three pumping stations. The water distribution system consists of lower and upper (two) major pressure zones. Zone 462, the lower zone, services most of the City to the east, and Zone 595, the upper zone, services the two areas to the west. A new pumped zone was created in 2006 to the northwest corner of the City with the construction of the Whittier Pumping Station. This zone will service 45 single family homes and 75 multi-family condominium units. It is understood that another pumped only zone, fed by the proposed Birdseye Pumping Station, will be constructed near the Bowers Road Tank to service 38 single family homes.

The City currently has two interconnections with the County. There are some County developments (Waterside and Spring Ridge subdivisions) that use the City's distribution system to convey County water to the developments. The City also has one permanent connection at Evergreen Point.

3.2 Water Supply Sources

The City's four water sources are:

- Mountain Source (Fishing Creek and Tuscarora Creek)
- Linganore Source
- Monocacy Source
- Wells (presently not considered)

Allowable water withdrawals by the City for these sources are summarized in Table 3-1.

TABLE 3-1
ALLOWABLE WATER WITHDRAWALS

Water Sources	Safe Yield (MGD)	Flow By (MGD)	Permitted by the MDE	
			Avg. Day (MGD)	Max Month (MGD)
Linganore Reservoir	6.000	4.50	6.000	9.000
Monocacy River	2.000	26.20	5.700	8.500
Fishing Creek Reservoir	0.890	0.50	1.900	3.800
Tuscarora Creek	0.000	0.20	0.800	1.000
Well Nos. 3, 4, and 7	0.680	-	0.565	0.680
TOTAL	**9.570**		**14.965**	**22.980**

Source: City of Frederick Department of Engineering – from 2004 Annual Water Report, adjusted to include Well Nos. 3 and 7.
NOTE: Tuscarora Creek is no longer in use. Monocacy River safe yield is actually 0.00; however, the City is currently operating under a consent order from MDE that allows a 2.0 MGD withdrawal under low flow conditions.

Safe yield capacity is the quantity of water that can be withdrawn regularly and permanently under the worst drought of record (1966).

3.2.1 Linganore Source

The Linganore source is located to the southeast of the City with the water supplied from Lake Linganore. Lake Linganore was created with the damming of Linganore Creek in 1972 by the Lake Linganore Association as a recreational lake, for the Lake Linganore Planned Unit Development. The Lake Linganore Dam was constructed in accordance with a November 1, 1968 agreement between the County and the Lake Linganore Association. The Lake Linganore Association owns and operates the lake. The County

also draws water directly from the lake and treats the water with their own water treatment plant located near the dam.

Photo 3-1 – Lake Linganore

Linganore Creek is a third order stream and a major tributary of the Monocacy River. The Linganore WTP's intake withdraws water directly from Linganore Creek at about 1-1/2 miles downstream from the Lake Linganore Dam. The catchment area at the intake is approximately 85 square miles (54,000 acres).

The Linganore Dam is earth filled and is about 750 feet long and 62.5 feet high at its maximum section. The storage volume at the time of construction was about 854 million gallons.

3.2.2 Monocacy Source

The Monocacy River is a second order stream and the largest tributary in Maryland to the Potomac River, which discharges to Chesapeake Bay and the Atlantic Ocean.

The Monocacy source is located to the east of the City consisting of an intake from the Monocacy River. Fort Detrick also has a river intake adjacent to the City's Monocacy

intake. The catchment area upstream of the City's Monocacy intake is about 700 square miles (448,000 acres) consisting of various land use with over 60% being pasture and cropland.

Photo 3-2 – Monocacy River Intake

Water from the Monocacy River is treated at the Monocacy Water Treatment Plant.

3.2.3 Mountain Source

Two mountain sources are located to the northwest of the City and consist of Fishing Creek and Tuscarora Creek. Fishing Creek was developed as a source in 1897 and was the second source of water for the City after the original Tuscarora source was developed in 1870. Tuscarora Creek has low flows during the summer along with turbidity issues and is no longer used by the City. Fishing Creek flows into Fishing Creek Reservoir where the water is impounded. The Fishing Creek Dam was constructed in 1925 to increase system storage. The original construction provided about 60 MG of water. The dam and spillway was raised by five feet in 1933 to increase the storage to 77 MG. To comply with dam safety requirements, the dam was modified and the spillway lowered in 1981 resulting in a storage capacity of 56 MG. The City currently estimates the available storage at about 50 MG.

Photo 3-3 – Overflow at Fishing Creek Reservoir

The dam is an earth embankment about 580 feet long and about 49 feet high. There is a concrete core extending the entire length of the dam.

The intake is located in the lake and has screen gates at depths of 10 feet and 25 feet.

The Fishing Creek watershed is mostly within the City's forest area at the intersection of Gambrill Park Road and Mountaindale Road.

Water from the mountain source is pre-treated at the Fishing Creek reservoir with additional treatment at the Lester Dingle Water Treatment Plant.

3.2.4 Wells

Photo 3-4 – Well No. 4

Photo 3-5 – Zenon Membrane Plant

The City has three available wells in Fredericktowne Village Park, which were granted Water Appropriation and Use Permits in 2003 (Well No. 4) and 2005 (Well Nos. 3 and

7). These were drilled in response to the water shortage crisis. The wells were not used due to operational issues and water quality issues. The well water was originally to be treated by a portable Zenon membrane plant. During the initial phase of this study, the Zenon membrane plant was to be relocated to the Monocacy WTP. A pipeline was built between the wells and the Monocacy WTP with the objective of treating the well water with the relocated Zenon membrane plant. The City subsequently decided not to relocate the Zenon membrane plant. The well water is to be conveyed to the Monocacy WTP for treatment. The Monocacy WTP is to be modified to treat the well water and to treat the Monocacy River water. The Zenon membrane plant has since been disassembled.

3.3 Water Treatment Plants

The City's five water treatment plants are:

- Linganore Water Treatment Plant
- Monocacy Water Treatment Plant
- Lester Dingle Water Treatment Plant
- Fishing Creek Water Treatment Plant
- Zenon Membrane Plant (decommissioned)

3.3.1 Linganore Water Treatment Plant

Photo 3-6 – Linganore Water Treatment Plant

The Linganore Water Treatment Plant is located at the end of Plant Road, east of Linganore Road and treats the water from Linganore Creek. The original treatment plant was built in 1932 with three filters and three additional filters were added in 1954. The treatment plant was further upgraded in 1993 to include flocculation and sedimentation. The rated capacity of the Linganore Water Treatment Plant is 6.0 MGD.

Creek water is gravity conveyed through a 24-inch pipe to a traveling screen and then to a 14 ft. x 12 ft. suction well. Water is pumped from the suction well (three pumps) into a 6 MG pre-sedimentation pond. The water then travels by gravity into the head of the plant for treatment. The treatment process consists of corrosion control, coagulation, flocculation, sedimentation, filtration and disinfection. There are two flash mix tanks for the addition of alum and chlorine. Carbon lime and polymers are also added at the flash mix tanks to improve the treatment processes if required.

3.3.2 Monocacy Water Treatment Plant

Photo 3-7 – Monocacy Water Treatment Plant

The Monocacy Water Treatment Plant treats the water from the Monocacy River and is located on North Market Street, southwest of Liberty Road and adjacent to the Fort Detrick Water Treatment Plant. The facility was built in 1960 and was expanded from 2.0 MGD to 3.0 MGD capacity in 1988.

Water from the Monocacy River is diverted into a 30-inch diameter intake pipe that is gravity conveyed to a wet well. The water is then pumped into the head of the plant for treatment. The treatment process is similar to the Linganore WTP and consists of corrosion control, fluoridation, coagulation, flocculation, sedimentation, filtration and disinfection. Gas chlorine (for pre-disinfection) and powder aluminum sulphate and polymers as coagulants are added prior to the rapid mixer.

3.3.3 Lester Dingle Water Treatment Plant

Photo 3-8 – Lester Dingle Water Treatment Plant

The Lester Dingle Water Treatment Plant treats the water from the mountain source and is located on Christopher's Crossing Road, near the intersection of Whittier Drive. The plant was built in 1986 and had a 3.0 MGD capacity. The current capacity is 1.7 MGD.

The facility consists of five pressure filters. Each pressure filter is 10 feet in diameter and has two layers of filter media; 12 inches of anthracite and 24 inches of sand.

The water into the treatment plant is conveyed by a 12-inch diameter supply main from the Fishing Creek Reservoir.

3.3.4 Fishing Creek Water Treatment Plant

Photo 3-9 – Fishing Creek Water Treatment Plant

The Fishing Creek plant is a small building located immediately downstream of the dam and houses a control room and rooms for storage of chemicals. Lime, fluoride and gas chlorine are added to the water from the Fishing Creek reservoir.

Chemically treated water is then provided to the 11 houses connected to the supply main between the dam and the Lester Dingle plant.

3.3.5 Zenon Water Treatment Plant

Photo 3-10 – Zenon Water Treatment Plant

The potable Zenon Water Treatment Plant is located at Fredericktowne Village Park, at the south end of Schifferstadt Boulevard to treat the well water. It was constructed with the intent of relocating to the Monocacy Water Treatment Plant. The portable Zenon ultrafiltration membrane plant has a capacity of 1.0 MGD and is expandable to 3.0 MGD.

The potable Zenon plant was disassembled in 2006.

3.4 Water Storage Tanks

The City has six water storage tanks as follows:

Zone 462

- Linden Tank (2,000,000 gal)

- Vernon Avenue Tank (1,000,000 gal)
- South Carroll Street Tank (1,000,000 gal)

Zone 595

- Bowers Road Tank (1,000,000 gal)
- Butterfly Lane Tank (750,000 gal)
- Whittier Tank (1,000,000 gal)

The total storage volume is 6,750,000 gallons.

3.4.1 Linden Tank

Linden Tank has a top water level of 462 ft. It is fed from the pumps at Monocacy and Linganore water treatment plants. It has an internal diameter of 104 feet and a depth of 32 feet.

The Linden Tank is a dome roof tank of wire-wound, circular, prestressed-concrete construction. According to the drawings supplied, the tank was built in the early 1980's and has a capacity of 2,000,000 gallons. There is also a concrete valve vault on the tank site.

Photo 3-11 - Linden Tank (2,000,000 gal)

3.4.2 Vernon Avenue Tank

Vernon Avenue Tank is a one million gallon elevated storage tank with a top water level of 472 feet. It is also fed from the pumps at Monocacy and Linganore water treatment plants.

The Vernon Avenue Tank is welded steel construction built in 1960 by Pittsburgh-Des Moines Steel Company. The 76 ft-0 inches diameter by approximately 35 ft-0 inches tall tank is supported on ten 2 ft-8 inches diameter columns with a 10 ft-0 inches diameter riser in the center. The columns and riser bear on reinforced concrete foundations with the riser foundation containing a valve vault.

Photo 3-12 - Vernon Avenue Tank (1,000,000 gal)

3.4.3 South Carroll Street Tank

South Carroll Street Tank is a one million gallon elevated storage tank with a top water level of 460 feet. It is fed from the pumps at Monocacy and Linganore water treatment plants.

The Carroll Street Tank is welded steel construction built in 1948 by Chicago Bridge and Iron Company. The 71 ft-6 inches diameter by approximately 35 ft-0 inches tall tank is supported on ten 4 ft-0 inches diameter columns with an 8 ft-0 inches diameter riser in the center. The columns and riser bear on reinforced concrete foundations with a separate reinforced concrete valve vault on the site.

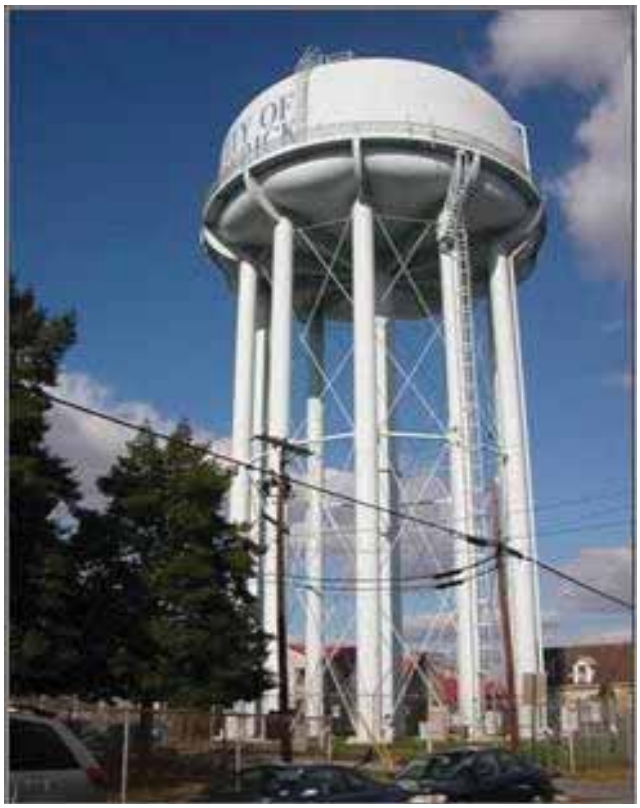


Photo 3-13 - South Carroll St. Tank (1,000,000 gal)

3.4.4 Bowers Road Tank

Bowers Road Tank is located at the westernmost extent of the City's distribution system. The tank has a top water level of 595 feet and is fed from the Route 40 booster station. The tank has an internal diameter of 85 feet and a depth of 24 feet.

The Bowers Road Tank is a dome roof tank of wire-wound, circular, pre-stressed concrete construction. According to the drawings supplied, the tank was built in the late 1980's or early 1990's and has a capacity of 1,000,000 gallons. There is also a concrete valve vault at the tank site.

Photo 3-14 - Bowers Road Tank (1,000,000 gal)

3.4.5 Butterfly Lane Tank

Butterfly Lane Tank is a 750,000 gallon elevated storage tank with a top water level of 595 feet and is fed from the Route 40 booster station.

The Butterfly Lane Tank is welded steel construction built in 1973 by Pittsburgh-Des Moines Steel Company. The 59 ft-0 inches diameter by approximately 40 ft-0 inches tall

tank is supported on seven 3 ft-0 inches diameter columns with a 6 ft-0 inches diameter riser in the center. The columns and riser bear on reinforced concrete foundations with the riser foundation containing a valve vault. There is also a separate valve vault on the site just south of the tank.

Photo 3-15 - Butterfly Lane Tank (750,000 gal)

3.4.6 Whittier Tank

Whittier Tank has a top water level of 595 feet. It is fed from the Lester Dingle booster station. It has an internal diameter of 60 feet and a depth of 48 feet.

The Whittier Tank is a dome roof tank of wire-wound, circular, prestressed-concrete construction. According to the drawings supplied, the tank was built in the early 1990's and has a capacity of 1,000,000 gallons. There is also a concrete valve vault at the tank site.

Photo 3-16 - Whittier Tank (1,000,000 gal)

3.5 Water Pumping Stations

The City has three pumping stations:

- Route 40 West Pumping Station
- Lester Dingle Pumping Station
- Whittier Booster Pumping Station

3.5.1 Route 40 West Pumping Station

The Route 40 Booster Station (or the Western High Zone Booster) was constructed in 1969 and upgraded in 1987. The booster station contains two 100 HP pumps and one 40 HP pump. The 100 HP pumps each have a rated capacity of 1390 gpm at 160 ft TDH and the 40 HP pump has a rated capacity of 750 gpm at 160 ft TDH.

The pump station is controlled by the levels in Bower's Road and Butterfly Lane tanks. Bower's Road tank is the lead tank.

3.5.2 Lester Dingle Pumping Station

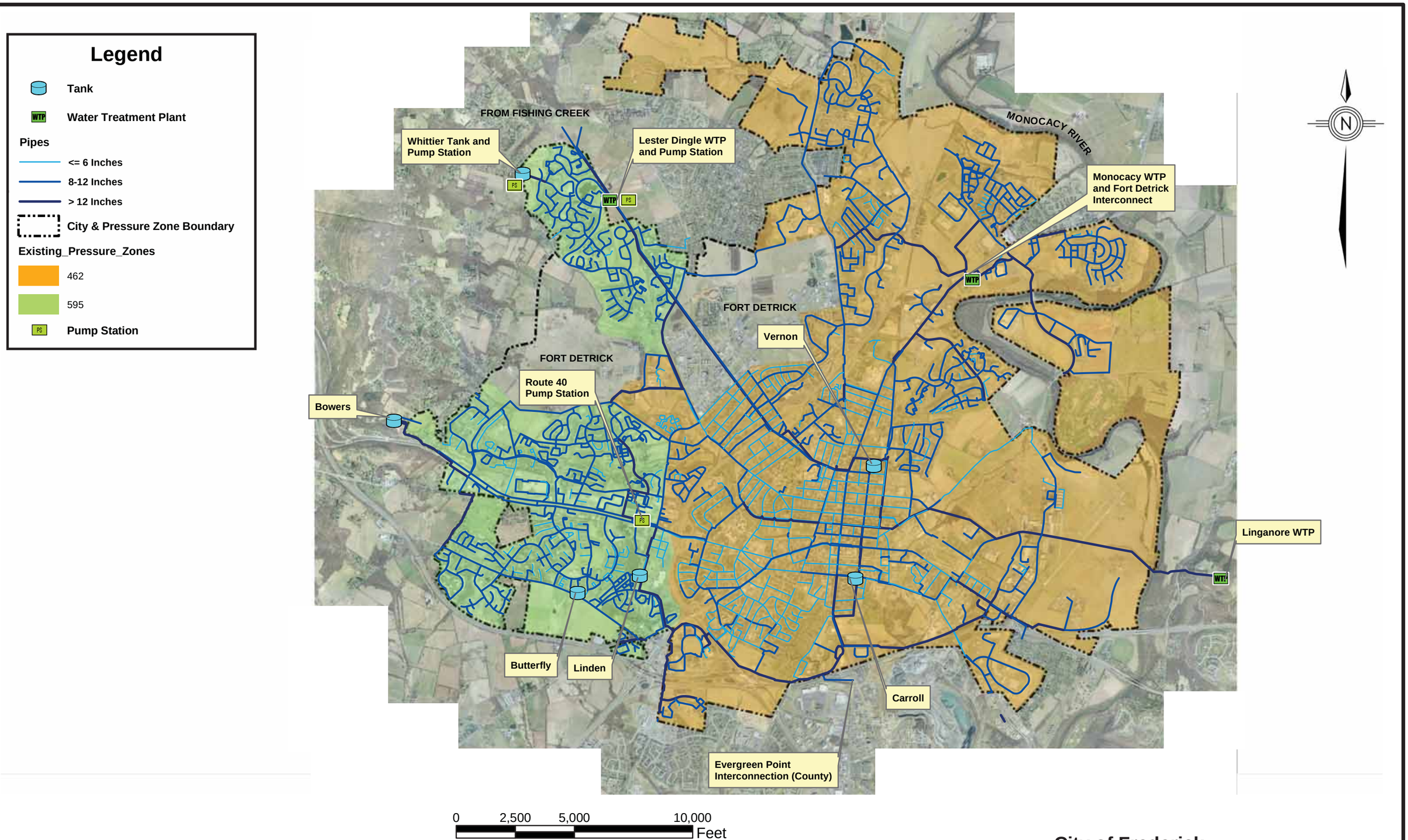
The Lester Dingle booster station was constructed in 1990. The booster station contains two 100 HP pumps. The 100 HP pumps each have a rated capacity of 1100 gpm at 175 ft TDH.

The pump station is controlled by the levels in the Whittier Tank.

3.5.3 Whittier Pumping Station

The Whittier Pumping Station was constructed in 2005/06 and will service the higher areas above the existing Whittier Tank. Initially, the station will service approximately 45 single family and 75 multi-family homes. Both domestic service and fire protection will be provided. Low flows will be provided through the use of a hydropneumatic tank.

The pumping station was designed to be upgraded to pump to a Zone 730 tank.



453-1 FIGURE 3-1.mxd 1:1 07-03-06

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: JM
FILE No. 453.1

City of Frederick
2006 Water Master Plan
Existing Water Supply and Distribution System

Figure 3-1

4.0 WATER DEMAND PROJECTIONS

4.1 Population Projection

Population projections were initially based on HNTB's 2004 Comprehensive Plan's Expanding Horizon Growth Scenario. The following populations were forecasted:

Growth Scenario	Year 2030	Year 2000	Population Increase
Expanding Horizon	104,000	52,800	51,200

After a teleconference with the City on January 4, 2007 and meetings with the City on January 30, 2007 and October 25, 2007, it was decided that the City could not feasibly serve the Expanding Horizons growth scenario with public water and sanitary sewer. Therefore, the PRWSA service area was adopted for this study.

Figure 4-1 illustrates the projected populations based on the demands listed in the PRWSA.

4.2 Average and Maximum Day Demands

The City's water usage records from 1991 to 2005 were reviewed. The average day, maximum day and population are summarized in Table 4-1 along with the annual per capita water demands.

TABLE 4-1
SUMMARY OF WATER DEMANDS

Year	Average Day (MG)	Maximum Day (MG)	Date of Maximum Day	Population	Average Day Per Capita Water Demand* (gpcpd)
1991	5.481	7.749	July 21	41,296	132.7
1992	5.851	7.401	Oct. 8	42,436	137.9
1993	5.928	8.246	Aug. 30	43,607	135.9
1994	6.090	9.167	June 6	44,811	135.9
1995	6.112	8.004	Aug. 3	46,049	132.7
1996	6.108	7.870	Apr. 23	47,320	129.1
1997	6.463	8.526	July 31	48,627	132.9
1998	6.511	8.385	June 16	49,969	130.3
1999	6.646	9.256	June 9	51,349	129.4
2000	6.210	7.915	July 31	52,767	117.7
2001	6.800	8.292	Aug. 8	53,797	126.4
2002	6.811	8.969	July 9	54,847	124.2
2003	6.324	8.161	Mar. 31	55,918	113.1
2004	6.255	8.626	May 4	57,009	109.7
2005	5.815	8.253	July 30	58,122	100.0

*NOTE – The Average Day Per Capita Demand includes non-residential demands.

The City advises that the 2005 maximum day of 8.643 MG was the result of hydrant flushing in the Whittier area to restore chlorine residuals and the Lester Dingle WTP being placed back on-line. The low chlorine residuals were due to the Lester Dingle WTP being off-line. Large quantities of water were used to flush the WTP and the Fishing Creek Supply Main. We consider this event not representative and therefore the second highest water usage day of 8.253 MGD on May 11, 2005 was used as the maximum day for 2005.

Figure 4-2 illustrates the City's population and the per capita demand from year 1991 to year 2005. The population growth rate over the 15 year period is about 2.3% with 41,296 people in 1991 and increasing to 58,122 in year 2005. Of interest is that the per capita water usage has been declining from a high of 137.9 gpcpd in 1992 to a low of 100.0 gpcpd in 2005. This reduction is mainly due to the City's leak reduction program during the past three years.

4.3 Peaking Factor

The peaking factor is used to determine future maximum day demands based on historic average day flows. Maximum day demand is used to determine future tank storage requirements, water treatment plant design capacities and sizing of watermains. Maximum day demand is also used as a base scenario when running fire flow simulations.

The peaking factor is the ratio of maximum day demand divided by the average day demand for a given year. Figure 4-3 illustrates the average day demands, maximum day demands and the peaking factors from 1991 to 2005.

The 15 year average peaking factor from 1991 to 2005 is 1.34 and the 20 year average peaking factor is 1.33 (year 1986 to 2005).

The City's peaking factor for years 1960 to 2001 is 1.30. The trend is that the peaking factor is increasing at a slow rate.

The Water Allocation Ordinance stipulates the following peaking factors:

- 1.30 to be in effect to November 1, 2004
- 1.35 to be used during the interim until the Potomac source is available
- 1.40 to be used once the Potomac source is on-line

This compares with a 1.60 peaking factor used by the County for their design of the Potomac water supply system.

The City's 1965 Water Report used a peaking factor of 1.50 and the 2000 Chester Report used 1.32 for year 2020. Our opinion is that the 1.32 ratio used in the 2000 Chester Report is low.

The City currently has a heavy industrial component, which tends to lower the peaking factor when compared to similar communities with a large residential population. The anticipated trend is that the traditional heavy industries will be replaced by bio-tech firms. The City's growth is anticipated to be more residential, which will increase the peaking factor due to domestic and lawn sprinkling demands. Industrial peak demands are normally not as high as residential peaks. The impact of bio-tech growth and the corresponding loss of heavy industry on peak water demand is unknown.

A peaking factor of 1.60 was used for this Study instead of 1.42 for the following reasons:

1. The trend is that the peaking factor is increasing (1.38 in year 2004 and 1.42 in year 2005). This is likely due to the City's aggressive leak detection program which is reducing the per capita water consumption and hence the lower daily average demand.

2. The County is using a 1.60 peaking factor for the Potomac supply design. It would be desirable for the City and the County to use the same design criteria to avoid confusion especially if the two will be sharing information on the water models, as required in the Potomac River Water Supply Agreement.

3. The 1.60 peaking factor will be a more conservative approach that will provide a safety factor for the scheduling of infrastructure improvements in the future. If water reuse is provided in future, the peaking factor will be reduced.

4.4 Projected Water Demands Versus Available Supply

The City's existing allowable supply from the various sources is summarized as follows:

- Lake Linganore water treatment plant (Safe Yield) 6.0 MGD
- Monocacy water treatment plant (MDE Consent Order) 2.0 MGD
- Lester Dingle water treatment plant 0.89 MGD
- Wells 3, 4 and 7 (Safe Yield) 0.68 MGD

TOTAL 9.57 MGD

The County has indicated the following schedule for water from the Potomac:

	Maximum Day		
Date	City Sources (MGD)	County-Potomac (MGD)	Total (MGD)
Existing	9.57	-	9.57
2009	7.57*	8.00	15.57
2015	7.57*	12.00**	19.57

*NOTE: The 2002 Consent Order CO-02-01-WS which permits the City to withdraw 2.0 MGD from the Monocacy River when the river flows are below the 26.2 MGD flow by requirements has been set to expire on December 31, 2006. We are assuming that MDE will extend this Consent Order until sufficient water is available from the County's Potomac source. The adequate safe yield from the Monocacy will be zero by year 2009.

**NOTE: The Potomac River Water Supply Agreement between the City and the County identifies that the 12.0 MGD ultimate need value is subject to adjustment when supporting documentation is developed for the next increase in the Water Appropriation and Use Permit.

Table 4-2 summarizes the City's projected maximum day demands (assuming a 1.60 peaking factor on all future demands) through 2040 for both residential and non-residential demands.

TABLE 4-2
PROJECTED WATER DEMANDS

Year	Residential Population	Maximum Day Demand		
		Residential Demand (MGD)	Non-Residential Demand (MGD)	Total Demand (MGD)
2005	58,000	5.10	3.16	8.26
2010	62,456	5.97	4.10	10.07
2015	68,434	6.93	5.10	12.03
2020	74,984	7.98	6.20	14.18
2025	82,162	9.13	7.40	16.53
2030	90,026	10.39	8.72	19.10
2035	98,643	11.76	10.16	21.92
2040	108,085	13.28	11.74	25.02

Figure 4-4 illustrates the projected maximum day demand to year 2040 for a 1.40 and for a 1.60 peaking factor for the PRWSA growth scenario along with the City's projected adequate safe yield.

The City will need additional water supply by the year 2031 for a 1.60 peaking factor. The City will not need additional water supply until beyond the year 2040 for a 1.40 peaking factor.

4.5 Feasibility of Interconnecting Other Areas

The feasibility of interconnecting areas outside of the City boundaries such as Clover Hill and the Walkersville system was evaluated.

Clover Hill currently has a population of approximately 3,400 people and Walkersville currently has a population of approximately 5,600 people.

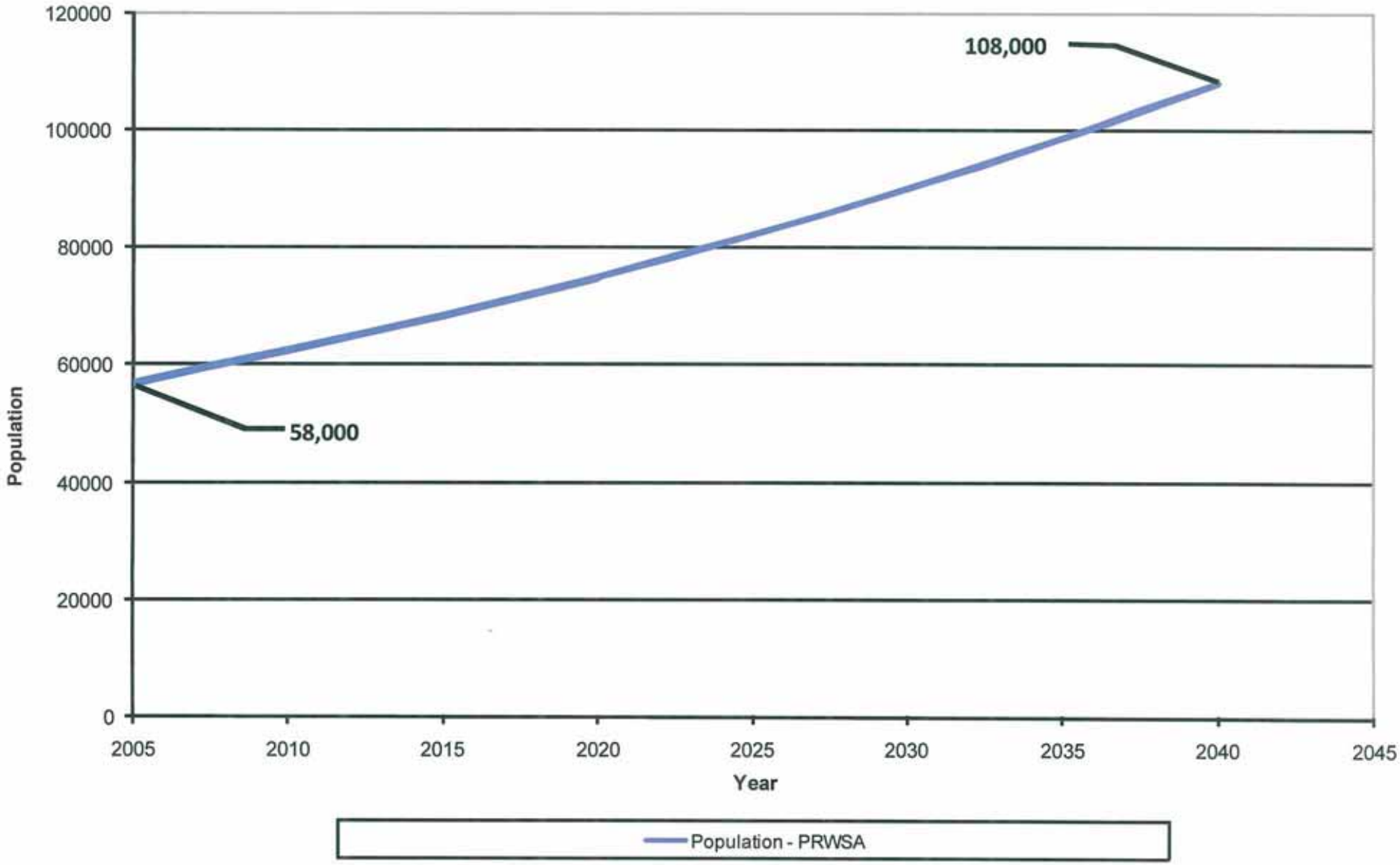
The addition of either of these communities would have the effect of fast-tracking the improvements identified in this report. Additional considerations such as storage, HGL, and the distribution network within each community would have to be taken into account before City water could be provided.

For the water supply, the impacts are shown in Table 4-3 below. For this analysis it was assumed that both Walkersville and Clover Hill have a population growth of 2% per year, and that the Maximum Day to Average Day Peaking Factor was 1.60.

TABLE 4-3
WATER SUPPLY IMPACTS

Year at Which Demand Exceeds 19.57 MGD (Current City Sources Plus Potomac Supply @ 12.0 MGD)			
Without Walkersville and Clover Hill	With Walkersville Only	With Clover Hill Only	With Walkersville and Clover Hill
2031	2026	2028	2023

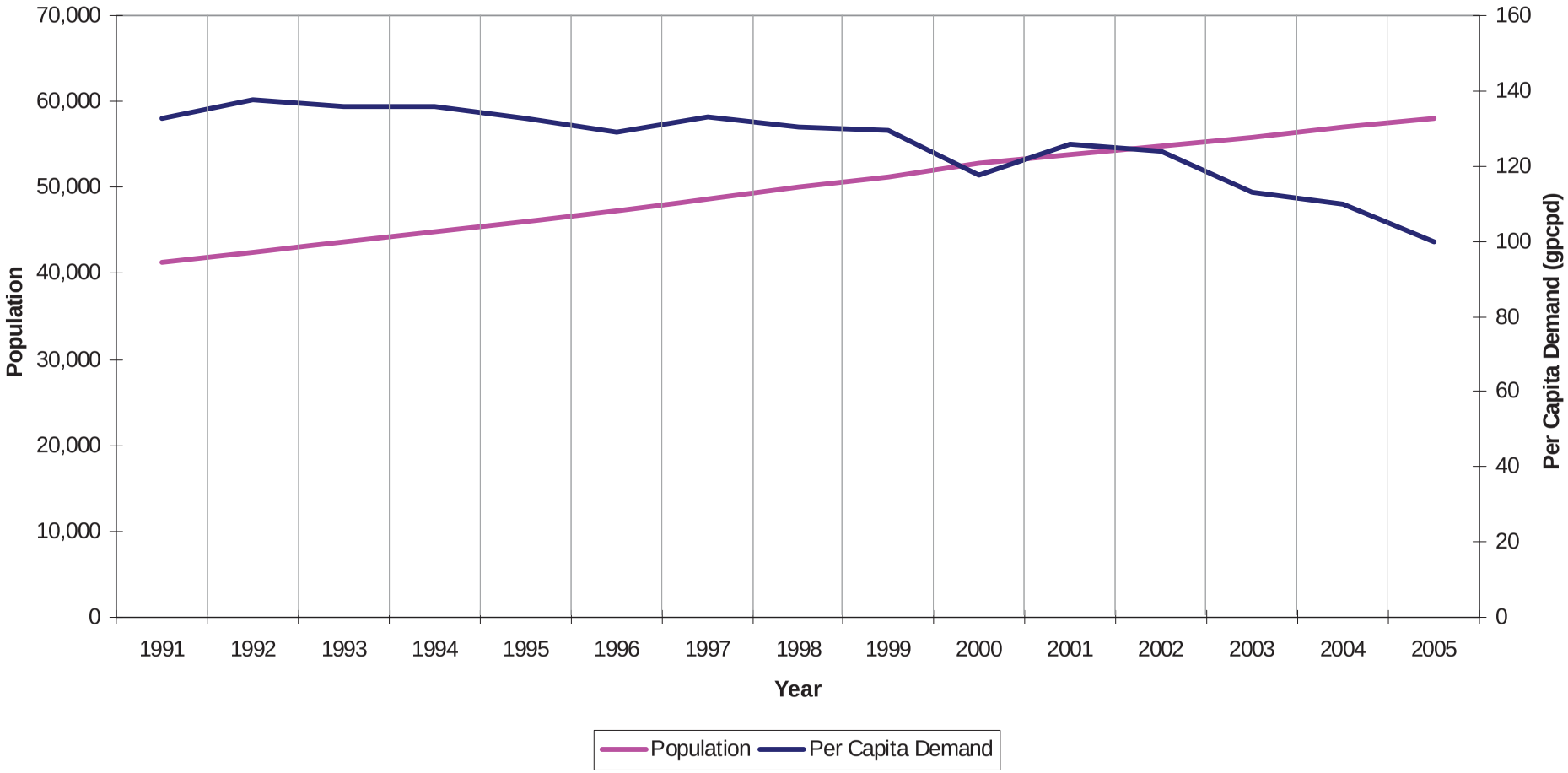
Servicing by the City is feasible for both areas. Improvements identified in this report should be reviewed prior to their design in order to confirm sizes.



CITY OF FREDERICK
2006 WATER MASTER PLAN
POPULATION PROJECTIONS

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: JM
DWG. No: 453.1

FIGURE 4-1



CITY OF FREDERICK

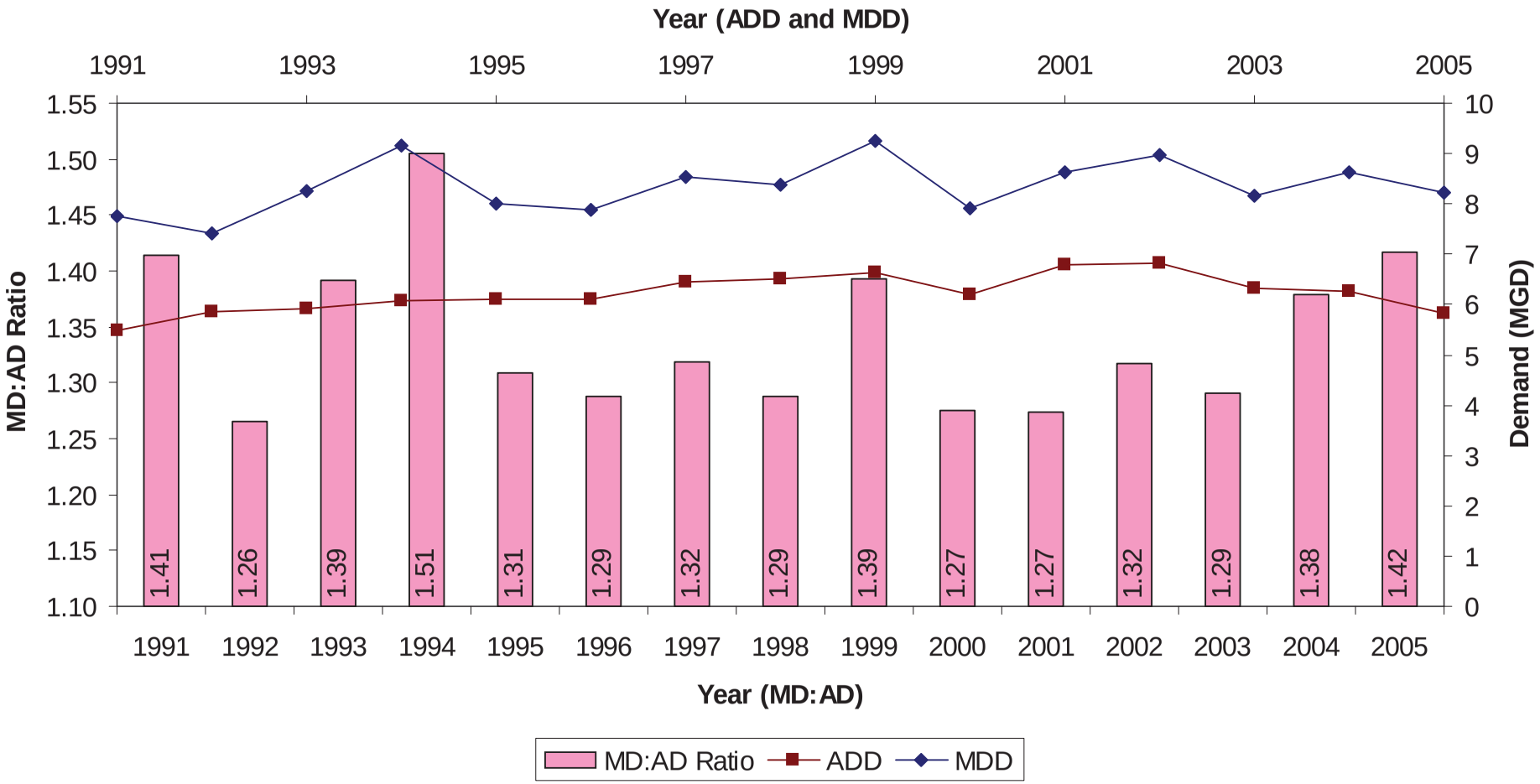
COMPREHENSIVE UPDATE TO THE 2000 WATER MASTER PLAN

POPULATION GROWTH AND PER CAPITA WATER DEMANDS (1990 - 2005)

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: LW / CWW
DWG. No: 453.1

FIGURE 4-2

FILE: P:\PRODWGS\FREDERICK\453-1\FIGURE 4_1 to 5.dwg 06-11-15 chong



CITY OF FREDERICK

COMPREHENSIVE UPDATE TO THE 2000 WATER MASTER PLAN

WATER DEMAND RECORDS (1991 - 2005)

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: CWW
DWG. No: 453.1

FIGURE 4-3

FILE: P:\PRODWGS\FREDERICK\453-1\FIGURE 4_1 to 5.dwg 06-11-15 chong

CITY OF FREDERICK
2006 WATER MASTER PLAN
PROJECTED WATER DEMAND 2006-2040
PRWSA GROWTH SCENARIO

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: JM
DWG. No: 453.1

FIGURE 4-4

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

5.0 HYDRAULIC MODELING

5.1 Introduction

As a portion of the work involved in the Comprehensive Update to the 2000 Water Master Plan, the City of Frederick retained Dayton & Knight Ltd. to create and calibrate a new water distribution model in H_2OMAP. This model was to include steady state, extended period simulation (EPS), transient analysis, and a water quality simulation.

In 2000, an EPANET model was created for the analysis of the distribution system for the 2000 Water Master Plan Update. This model was converted to CYBERNET (Haestad Methods) in 2002 to integrate with Frederick County's model. The City has since purchased H_2OMAP and has converted the CYBERNET model to this format.

This new H_2OMAP model was calibrated and used for analysis of the distribution system for the 2006 Water Master Plan Update. Further, the City will use this calibrated model for capital works planning, fire flow analysis, and subdivision approvals. There has been a need to calibrate the model to confirm that the "C" values, demand assignments, and pump curves are correct. A calibrated water model is a critical tool to assist in analyzing any water supply and distribution system.

5.2 Model Development

A computer model of the City's water system was developed using the H_2OMAP software with data from the City's existing water model and background information provided by the City. The details of the water development are provided in a separate technical report "Water Model Development & Calibration – Completion Report".

5.3 Model Calibration

Water model calibration is an important step in developing a water model. Calibration allows the modeler to have greater confidence in the results of the model, as these have been verified in the field.

5.3.1 Hydrant Testing

Hydrant flow tests were conducted over two days from October 6-7, 2005.

The procedure used to collect data for model calibration was multi-pressure monitoring, and is outlined as follows:

- Four high-resolution pressure loggers (± 0.2% of full scale) were installed on pre-determined pressure hydrants and one adjacent to the flow hydrant.
- A single 2½-inch pitot gauge complete with diffuser was installed on a pre-determined flow hydrant port to achieve full hydrant flow. This is shown in Photo 5-1.
- City crew monitored flow and supervised drainage.
- Flow rates were recorded from the flow gauge. This flow is later compared to the recorded flow in the data logger to ensure accuracy of the instrument.
- Pressure loggers were removed, stopped and downloaded into a computer program. From this recorded data, static and residual pressures were later retrieved.

Photo 5-1 - Pitot Gauge On Flow Hydrant

5.3.2 Field Procedure

The field calibration undertaken for this project used the flow and pressure data collected and compared these test results to modeled results. Typically, computer and field results should agree to within 10-15%.

Storage tank levels were recorded during the flow testing, and these levels were then used to determine if booster pumps were on or off based on the booster set points. A review of the tank levels during the testing indicated if the tanks were filling or draining.

5.3.3 Calibration Results

A review of the water treatment plant production records indicated that the demand for these days was 70% of Maximum Day and 65% of Maximum Day for October 6 and 7, 2005, respectively. The background demands were set accordingly in the model.

A series of steady state analysis were undertaken for each of the flow tests. Correlation of field pressures and the model predicted pressures was excellent. Generally, all of the field pressures were within 10% of the modeled pressures, although there were a few that were between 10% to 15%.

A more in-depth analysis of the calibration is provided in the Water Model Completion Report.

5.3.4 Extended Period Simulations

Extended period simulation (EPS) diurnal patterns were developed based on information collected by the City on May 31, 2006. During this period the City took readings of tank levels, pump status, and water treatment plant discharge flows and pressures on an hourly basis. These data were used to develop the diurnal demand pattern and calibrate the EPS model.

5.3.5 Diurnal Pattern

The daily diurnal pattern used in the EPS model was determined through the analysis of the data provided by the City, and is shown graphically in Figure 5-1.

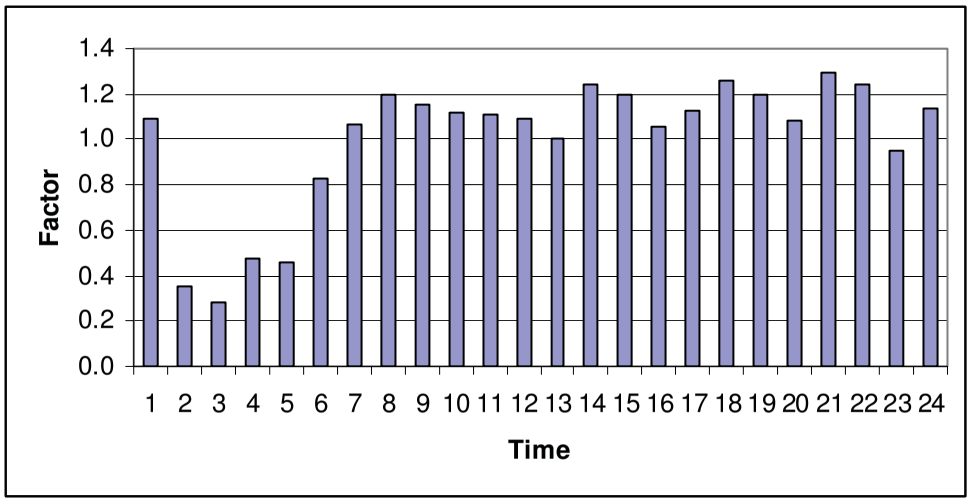


Figure 5-1- City Of Frederick Dirunal Demand Pattern

5.3.6 Calibration

The EPS was run using the diurnal time (1hour) steps illustrated in Figure 5-1.

Available pump data were input to the model. This information consisted of a combination of data in the existing model and rated pump capacity as recorded from the pump nameplates. Pump controls were entered as provided by the City.

Modeled tank levels were compared to measured tank levels during the duration of the data recording period. With the exception of Vernon Tank, the correlation between modeled and recorded data was excellent.

5.4 Design Criteria

The design criteria used for this analysis included a review of minimum service pressures and available fire flows as described under this section.

5.4.1 Service Pressures

Service pressures were based on the same criteria as those set out in the 2000 Water Master Plan Update. These are the same criteria as those from Frederick County's Design Manual for Water and Sewer Facilities. The criteria are shown in Table 5-1.

TABLE 5-1
DESIGN SERVICE PRESSURE CRITERIA

Condition	Pressure (psi)
Minimum Peak Demand Pressure	35
Maximum Allowable Pressure	112
Minimum Fire Hydrant Pressure (Residual)	20

For the purpose of developing service areas, the minimum pressure of 40 psi was selected for the following reasons:

- To allow for higher pressures in the upper storeys of houses
- To better allow for use of fire sprinklers

Figure 5-2 shows the proposed service limits based on the 40 psi minimum pressure criteria.

5.4.2 Fire Protection and Storage

Water distribution systems must be able to deliver large volumes of water for fire protection in addition to normal water demands.

Fire protection assumptions are:

1. Only one fire will be fought at any one time.
2. To ensure pumper trucks obtain adequate water supplies from hydrants, a minimum residual pressure of 20 psi on the street main is required during fires.

3. Fire flow is coincident with maximum day demand.

Reservoir storage volume was determined using the following criteria:

EQUATION 5-1

$$V = A + B + C$$

A = Fire storage

B = Balancing (25% of max day)

C = Emergency Storage (25% of A+B)

5.5 System Analysis

A system analysis was undertaken for existing infrastructure and demands. Average, peak hour, and maximum day plus fire flow scenarios were simulated.

5.5.1 Existing (2005)

1. Average Day

Existing average day pressures for demand nodes ranged from 40 psi to 88 psi in Zone 462. The lower pressures were along the Zone 462/595 boundary. In Zone 595, existing average day pressures ranged from 44 psi to 108 psi. The higher pressures were along the Zone 462/595 boundary.

2. Peak Hour

For design purposes, Frederick County uses an average day to peak hour peaking factor of 4.0. The City does not currently have the flow records to adequately define a peak

hourly peaking factor, so for the purposes of this Master Plan Update the County's design value was used.

For peak hour, pressures in Zone 462 ranged from 34 psi to 86 psi. Pressures in Zone 595 ranged from 36 psi to 104 psi. The locations of junctions not meeting the minimum pressure requirement of 35 psi are shown in Figure 5-3.

The low-pressure locations in the Linden Tank area are near the high point of land from Linden. These junctions do not service any properties – all properties in these locations are serviced form the Western High Zone.

The low-pressure junction near Bowers Tank is at a high point of land and does not service any properties. This will likely be serviced by the Birdseye booster station.

There are two general areas where low pressures occur that service residential properties. The low pressures that occur in the Amber Meadows area are near high-points of land. This area is also located relatively far from a tank. The low pressures that occur in the Yellow Springs/Old Farm area are in Zone 462, along the Zone 595 border. The pressures in this area fall below 35 psi under existing average day conditions if the Lester Dingle WTP is off-line.

3. Maximum Day Plus Fire Flow

The 2000 Water Master Plan Updated listed several locations of target fire flows. It is understood that these locations were developed based on the following:

- Information contained in the Insurance Services Organization (ISO) Commercial Risk Services 1992 letter report to the City.
- 1991 Water Master Plan Update.

- Estimates based upon consideration of the general character of the development in proximity to the test location.

These locations were reviewed prior to analysis, and were modeled with existing maximum day demands, with a required residual system pressure of 20 psi under fire flow conditions. For the fire flow analysis, all of the pumps in the Route 40 Pump Station were assumed to be running. One pump in the Lester Dingle Pump Station was assumed to be running. The computer simulation results are shown in the following Table 5-2. The shaded values identify system deficiencies.

TABLE 5-2
RECOMMENDED EXISTING AND AVAILABLE FIRE FLOWS DURING MAXIMUM DAY SCENARIO

Junction ID	Location	Recommended Fire Flow (gpm)	Available Fire Flow (gpm)
3-PR4	Hillcrest Center	5,000	5,800
J-1681	Ballenger Creek Center	2,650	7,700
J-1696	Schifferstadt Boulevard and East 16th Street	2,000	6,300
J-2011	North Amber Business Park	5,000	4,760
J-2289	Route 15 N Loop	2,000	2,900
J-2694	Wyngate Drive and North Place	2,800	2,000
J-279	Bailes Lane and East Patrick Street	3,500	10,000
J-2849	Carroll Parkway and Kline Boulevard	5,000	2,085
J-2859	Frederick Fairgrounds	5,000	5,340
J-2880	South Jefferson Street and Scholl's Lane	3,500	1,740
J-2888	Rosemont Avenue and Military Road	1,750	3,250
J-289	East Patrick Street and North Wisner Street	5,900	9,000
J-294	Opossumtown Pike and Community College Dr.	3,000	3,600
J-3006	West Patrick Street and South Jefferson Street	2,250	1,925
J-3039	Frederick Memorial Hospital	5,000	11,300
J-336	North Crossing Subdivision	2,000	3,150
J-352	Montevue Lane and Shookstown Road	2,250	6,600
J-4050	Whittier Subdivision	2,000	7,100
J-4333	Taskers Chance Subdivision	4,000	10,000
J-4470	Golden Mile Market Place	5,000	8,200
J-4755	Old Farm Road and Yellow Springs Road	3,000	2,200
J-4842	Mill Pond and Five Shillings Drive	1,000	2,500

Junction ID	Location	Recommended Fire Flow (gpm)	Available Fire Flow (gpm)
J-599	Westpointe Plaza	5,000	8,700
J-620	Hayward Road and Thomas Johnson Drive	3,500	3,900
J-7103	West 7th Street and Taney Avenue	5,000	5,900
J-7108	Wheyfield Drive	2,000	4,300
J-7111	Wormans Mill Subdivision	4,000	2,370
J-7123	Monocacy Boulevard and East South Street	3,000	12,000
J-7186	Walter Martz Road	1,000	3,375
J-817	Crumland Farms Development	3,000	1,470
J-822	Rockledge Plaza	6,000	6,000
J-823	Monocacy Meadows	2,000	9,200
J-847	Overlook Subdivision	4,000	2,600

As shown above, there are 9 junctions that do not meet the fire flow criteria. These junctions are as follows:

- J-2011
- J-2694
- J-2849
- J-2880
- J-3006
- J-7111
- J-817
- J-847
- J-4755

The fire flow junctions are also shown graphically in Figure 5-4.

4. Upgrades to System

The 2000 Water Master Plan Update had several recommendations to improve the distribution system and meeting targeted fire flows. These have been reviewed and revised.

Table 5-3 lists the required improvements recommended to the existing distribution system. These are shown graphically in Figure 5-5. Unless otherwise specified, all proposed mains are assumed to be in parallel with existing mains. These improvements are shown in greater detail in Appendix B.

TABLE 5-3
RECOMMENDED SYSTEM IMPROVEMENTS

Item	Recommended Improvements	Reason	Source
E-1	Construct 750,000 gallon elevated tank in the Amber Meadows area.	Improve Fire Flows Alleviate Low Pressure	D&K
E-2	Construct approximately 1,650 feet of 12-inch diameter main on Patrick Street between Monroe Street and Monocacy Blvd.	Improve Fire Flows	2000 WMPU
E-3	Construct approximately 3,900 feet of 16-inch diameter main on Patrick Street between South Carroll Street and Jefferson Street.	Improve Fire Flows	2000 WMPU
E-4	Construct approximately 3,450 feet of 16-inch diameter main on West 2nd Street between Grove Blvd and North Bentz Street.	Improve Fire Flows	2000 WMPU
E-5	Construct approximately 1,500 feet of 12-inch main on Carroll Parkway between Frederick High School and Fairview Avenue.	Improve Fire Flows	2000 WMPU
E-6	Install check valve at watermain connecting Zone 595 at Opossumtown Pike to allow for water to flow from Zone 462 to Zone 595 when required.	Improve Fire Flows	D&K
E-7	Replace approximately 400 feet of existing 6-inch watermain on Wyngate Drive between Norva Ave and North Place with an 8-inch watermain.	Improve Fire Flows	2000 WMPU
E-8	Construct approximately 1,200 feet of 12-inch main on Key Parkway between Willowdale Drive and McCain Drive.	Alleviate Low Pressure	2000 WMPU
E-9	Construct approximately 1,200 feet of 12-inch main on Key Parkway from McCain Drive west to the termination of the existing 12-inch watermain on Key Parkway.	Alleviate Low Pressure	D&K
E-10	Construct approximately 1,900 feet of 12-inch main on Key Parkway between Waverly Drive and Old Camp Road.	Alleviate Low Pressure	2000 WMPU
E-11	Construct approximately 1,000 feet of 12-inch main on Old Camp Road from Route 40 to Key Parkway.	Alleviate Low Pressure	D&K
E-12	Construct approximately 250 feet of 12-inch connecting main across Route 40 on Old Camp Road.	Alleviate Low Pressure	2000 WMPU
E-13	Construct approximately 3,500 feet of 12-inch main on Shookstown Road between Willowdale Drive and Old Camp Road. It is understood that this is currently under design.	Alleviate Low Pressure	2000 WMPU

TABLE 5-3 (cont'd.)
RECOMMENDED SYSTEM IMPROVEMENTS

Item	Recommended Improvements	Reason	Source
E-14	Construct approximately 2,250 feet of 12-inch main on West Patrick Street from Klein Blvd. to Baughman's Lane.	Alleviate Low Pressure	D&K
E-15	Construct approximately 5,500 feet of 16-inch watermain along Yellow Springs Road and Montvue Lane from the termination of the existing 16-inch watermain on Yellow Springs Road to Shookstown Road to interconnect the two 595' HGL pressure zones.	Provide redundancy between pressure zones	D&K
E-16	Construct approximately 1,900 feet of 12-inch watermain on Butterfly Lane between Himes Avenue and Jefferson Pike.	Alleviate Low Pressure	2000 WMPU
E-17	Construct approximately 2,200 feet of 20-inch main from new Amber Tank south along Thomas Johnson Drive to the existing 20-inch main.	Alleviate Low Pressure	D&K
E-18	Construct approximately 31,700 feet of 18-inch main from Fishing Creek Reservoir to the Lester Dingle Treatment Plant.	Alleviate Low Pressure Replace Aging Main Ease of Operation	D&K
E-19	Change valving in the Old Farm/Yellow Springs Road area so that this location is serviced through Zone 595.	Alleviate Low Pressure	D&K

5.5.2 Future

Model runs for predicted demands for 2030 were undertaken to size new infrastructure and improvements. Model runs for 2010, 2015, 2020, and 2025 were also undertaken to refine the timing of the infrastructure identified for 2030.

1. Upgrades to System

The upgrades to the system are shown in Table 5-4. These upgrades were determined based on the demands outlined in the PRWSA. The timing listed in the table is approximate based on the assumption that the developments listed in the PRWSA will be in place by 2030. Figure 5-6 shows the recommended improvements. These improvements are also shown in greater detail in Appendix C.

TABLE 5-4
RECOMMENDED FUTURE SYSTEM IMPROVEMENTS

Item	Description	Year	Source
F-1	Construct approximately 3,100 feet of 20-inch watermain along Reich's Ford connecting the Potomac supply to the City's 16-inch on Monocacy Boulevard.	2010	PRWSA
F-2	Construct approximately 1,600 feet of 16-inch watermain along Reich's Ford from Monocacy Blvd to East South Street.	2010	PRWSA
F-3	Construct approximately 250 feet of 12-inch watermain along an existing 8-inch on Oppossumtown Pike north of Christopher's Crossing Road to remove 8-inch bottleneck.	2010	D&K/2000 WMPU
F-4	Construct approximately 5,000 feet of 18-inch watermain from Lester Dingle Booster Station along Lakeside Drive north to Rocky Springs Road (ROW required for 2,400 feet of this main) to Rocky Springs Road, then east to Yellow Springs Road.	2015	D&K/2000 WMPU
F-5	Construct approximately 3,100 feet of 12-inch watermain from Yellow Springs Road and Rocky Springs Road north along Yellow Springs Road to the extent of the future City boundary.	2015	
F-6	Construct approximately 2,500 feet of 16-inch watermain along Linden Avenue from Poplar Street north to West Patrick Street, then west to the Route 40 Booster Station.	2015	D&K
F-7	Construct approximately 600 feet of 12-inch main on Hayward Road to Loop main to Opossumtown Pike.	2015	2000 WMPU
F-8	Construct approximately 700 feet of 20-inch main to remove existing 8-inch bottleneck on 20-inch main at Thomas Johnson Drive.		
F-9	Construct approximately 9,000 feet of 12-inch watermain from the Amber Tank north along Thomas Johnson Drive to McClellan Drive, north to Willow Drive, west along Willowbrook Road, and north along Bloomfield Road to the extent of the new development.	2020	D&K/2000 WMPU
F-10	Construct approximately 16,600 feet of 24-inch watermain from the existing 18-inch along Schley Ave and Blueridge Ave west to Rosemont Ave, then north along Rosemont Ave/Yellow Springs Road, then west to Lester Dingle Booster. Approximatly 2,300 feet of this main will be along currently undeveloped land, and a ROW will be required.	2020	D&K/2000 WMPU
F-11	Construct approximately 8,600 feet of 12-inch watermain from Yellow Springs and Walter Martz Road east and north along Walter Martz Road to Wittenburg Drive.	2020	
F-12	Construct approximately 6,300 feet of 12-inch watermain from the new 20-inch near Amber Tank east across Route 15 to Trading Lane, then along Trading Lane to Route 26.	2025	D&K/2000 WMPU
F-13	Construct approximately 8,500 feet of 16-inch watermain along an existing 4-inch watermain from County Lane northeast along Gas House Pike to the east side of Monocacy River.	2025	D&K/2000 WMPU
F-14	Construct new 1.0 MG Zone 462 tank.	2025	D&K
F-15	Construct new 0.75 MG Zone595 tank.	2025	D&K

5.6 Transient Analysis

As part of this study, a transient analysis was undertaken. Assumptions used include:

- To simplify the analysis, the wave speed was set at 4000 fps for all pipes. Wave speed is a function of the fluid, pipe material, diameter, wall thickness, and type of restraint. For example, the wave speed in ductile iron pipe can range from 3460 fps for 24 inch PC 250 pipe to 4400 fps for 4 inch PC 350 pipe. A flow velocity of 4000 fps was used for this analysis, as it is the typical wave speed for an 8 to 10 inch ductile iron pipe.
- The system was assumed not to have any surge protection devices (surge tanks, PRV, air/vacuum valves, etc.). The locations of these devices were unknown at the time of this study and this more conservative approach was taken.
- Each pressure zone was modeled for a single major surge event. This event was to have the pumps in the zone stop suddenly, simulating a loss of power. The pumps were modeled to be shut down over a 10 second interval.

5.6.1 Zone 462

Zone 462 was modeled with a simulated power failure at the both Linganore and Monocacy treatment plants causing the pumps to shut down over a 10-second period. This simulation predicted negative pressures and high pressure spikes in several locations throughout the system, typically at the end of dead end mains and/or in small diameter (less than 6-inch) pipes. For this analysis, power failure of the Monocacy pumps have the greatest impact in terms of surge pressures on the system. Results discussed below are for a power failure at the Monocacy WTP.

A graph showing the pressure during the surge event is shown in Figure 5-7 for the junction with the highest pressure surge range in the system. This junction is at the end of a 3-inch watermain at the end of Pinecroft Court in the Amber Meadows area.

The Monocacy and Linganore treatment plants do not have a surge relief valve such as those installed in the Lester Dingle and Route 40 pumping stations. With this valve installed, the surges in the system are significantly reduced. Figure 5-7 shows the effect of a surge anticipating relief valve on the same junction at the end of Pinecroft Court.

The analysis assumed a 10 second shut down period for the pumps. This actual shut down period for the pumps is dependant on the pump and system characteristics. The higher the pump inertia (the resistance the pump has to acceleration or deceleration), the longer it will take for the pump to stop spinning, thus helping to control transients. Inertia is constant for a particular pump and motor combination. Also, the type of system the pump is pumping into will affect shut down time. A pump that conveys low flows into a high-head system will shut down faster than a pump that pumps high flows into a low-head system.

The degree of surging within the system is highly dependant on the initial tank levels when the surge occurs. The results discussed above are for a surge event with the tanks at an HGL of approximately 460 feet. The simulation predicts that if the surge event occurred when all the tanks are full, the high pressure spikes are eliminated, as shown in Figure 5-8.

It was noted that many of the junctions simulated that are subject to pressure surges are located in the northern portions of Zone 462, away from existing tanks. Once the Amber Tank is constructed, many of these surges will be attenuated. It is predicted that, with the construction of the tank, there are no pressure surges in the zone above 130 psi if modeled using the same criteria as above (tanks at 465 ft HGL). However, low pressures are still predicted if no surge anticipating relief valve is installed.

We recommend the City install a surge anticipating relief valve in the Monocacy WTP.

5.6.2 Zone 595 (Western)

Zone 595 (Western High Zone) was modeled with a simulated power failure at the Route 40 Pump Station causing the pumps to shut down over a 10-second period. This simulation did not result in any pressures less than 20 psi. This location was at the intersection of Andover Lane and Deerfield Place. A graph showing the pressure during the surge event is shown in Figure 5-9.

5.6.3 Zone 595 (Whittier)

Zone 595 (Whittier) was modeled with a simulated power failure at the Lester Dingle Pump Station causing the pumps to shut down over a 10-second period. Simulated surge pressures ranged from a minimum of 36 psi to a maximum of 116 psi. The greatest range in pressures was 50 psi, at the end of an 8-inch dead end pipe on Carroll Creek View Crescent in a relatively new subdivision. A graph showing the pressure during the surge event at this location is shown in Figure 5-10.

5.7 Future Finished Water Storage Sites

Currently, the City has an available storage of 6.75 MG of finished water. Globally, this would be sufficient through to 2030; however, the spatial development and the alleviation of current low-pressure areas will require the storage to be constructed sooner than this date.

Dayton & Knight created the pressure zones based on contour data. The 2000 Water Master Plan Update states 35 psi as the minimum pressure. However, for this Water Master Plan Update, 40 psi was used as the minimum pressure at ground level as a safety factor to allow for reduced pressure in the upper floor of two storey homes and to allow for variance to cut and fill requirements for future site grading.

It is understood that the City will not allow further development outside of Zone 595 other than the developments already approved. Whittier Pumping Station is adequate to supply a pumped-only zone for the approved development only. It is also understood that the Birdseye development, near Bowers Tank, will be serviced by a small booster station. Both of these booster stations will require peak balancing and fire storage to come from the adjacent tanks.

Demands for each zone were analyzed to determine a storage tank construction schedule. This is shown graphically in Figure 5-11.

Possible locations for the proposed storage tanks were analyzed. Tanks are required in all three pressure zones during the course of the master plan horizon. Each zone's storage requirements are outlined in the following sections.

5.7.1 Zone 462

This is the City's lowest and largest pressure zone. As shown in Figure 5-11, the required storage by 2040 is 5.70 MG. The existing storage volume is 4.0 MGD.

Hydraulic modeling indicates the largest need for the storage tank is in the northern portion of the City, near the Amber Meadows area. This area has pressures that fall below the minimum pressure value of 35 psi and reduced fire flows because of the distance from a storage tank.

Topography limits the type of reservoir to an elevated tank with a volume of 750,000 gallons. A review of the City's existing tanks indicates that the height from the ground to the TWL is approximately 130 feet to 140 feet. Therefore the required ground elevation will be at least 325 feet. Additional criteria to consider are the distance to the nearest trunk main and the available land.

Three possible sites are shown on Figure 5-12. These sites were chosen based on:

- They are currently unoccupied (except for a baseball field at Site A).
- They are in close proximity to the 20-inch main from the Monocacy WTP.

We recommend that the City review these sites and begin property negotiations with the owner(s). The preferred site would be Site C, as it is:

- Unoccupied
- Second highest point of land
- Upstream of the existing 8-inch bottleneck in the 20-inch main from the Monocacy Treatment Plant

The improvements identified in this study assume Site C is the site for the new Amber Tank.

In the future (2028), a new tank will be required to meet the pressure zones storage requirements. We recommend that this tank be 1 MG and be installed at the northern extent of development on Bloomfield road.

5.7.2 Zone 595

By 2040, 3.40 MG of storage will be required in Zone 595. Currently, there are 2.75 MG of storage.

It is proposed that a new 750,000 gallon tank be installed adjacent to Yellow Springs Road, approximately 2,900 feet north of Walter Martz Road.

5.8 Water Quality

Water quality modeling is a dynamic process by which the computer model will attempt to predict the movement of a dissolved substance (constituent) moving throughout the

distribution system over time. This type of model requires a calibrated EPS model. For this preliminary water quality simulation chlorine was the chemical modeled, as the City already has a chlorine monitoring program in place.

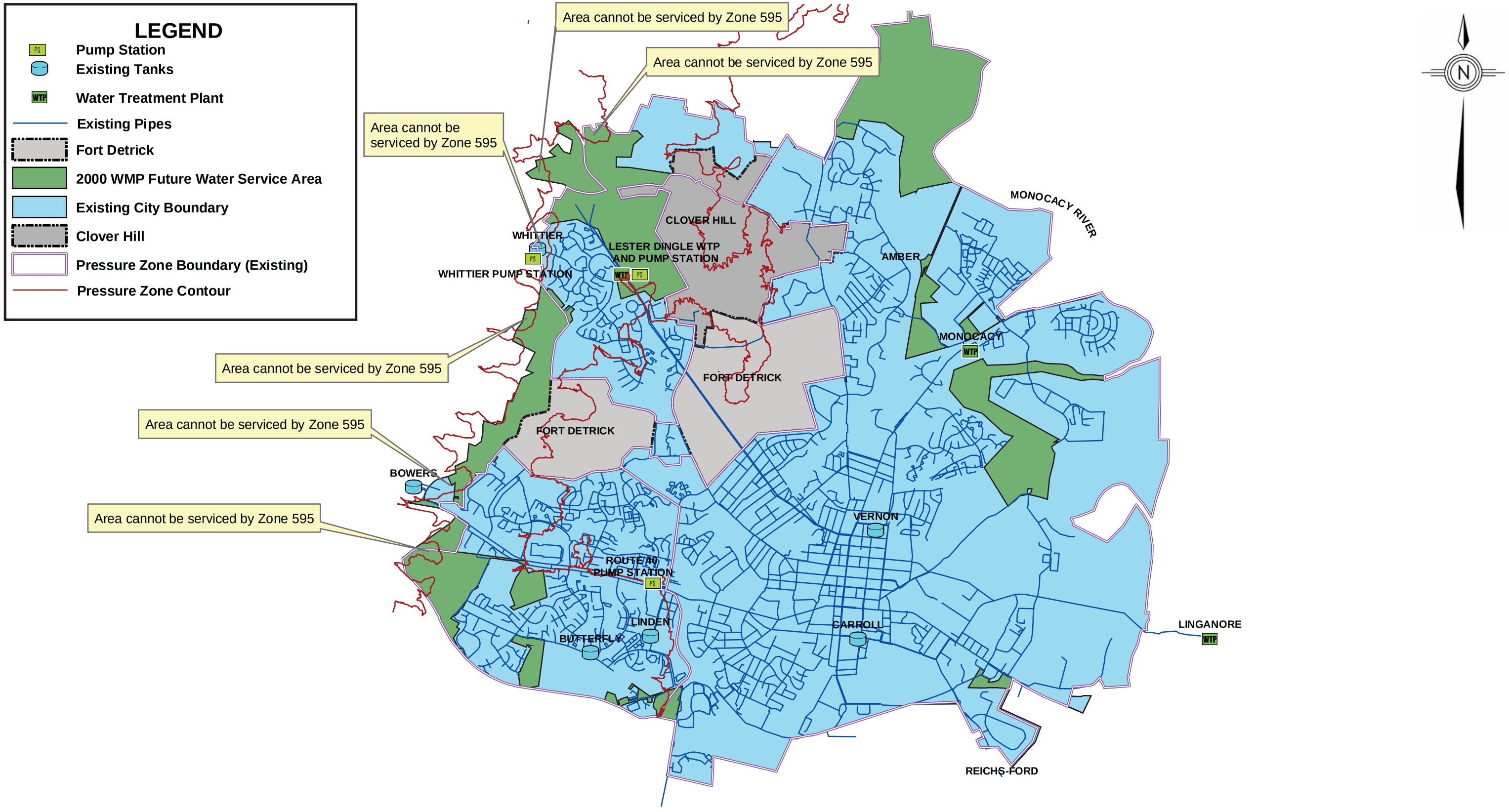
The City's standard is to maintain minimum residual chlorine of 1.0 ppm. This standard is typical of a municipal water distribution system, and is well above prescribed standards. The US EPA requires that the residual chlorine be at least 0.2 ppm at the point of entry into the distribution system (e.g. treatment plants) and that a detectable residual be maintained throughout the distribution system.

In order to determine areas which may be subject to low residual chlorine concentrations, separate scenarios were run to determine which areas do not meet the City's standard, and which areas do not meet the US EPA requirements.

Figure 5-13 shows the areas that are modeled do not meet the City's target 1.0 ppm residual chlorine concentration. The areas not meeting the target concentrations can be categorized into:

- End of dead end pipes
- Western High Zone
- Locations furthest from a chlorine source

It should be noted that although these locations do not meet the City target of 1.0 ppm residual chlorine, they all have a predicted detectable residual. Figure 5-14 shows the junctions where the predicted residual chlorine is less than 0.75 ppm. These locations are all on dead end pipes or in low-demand areas. The model does not predict any residual chlorine concentrations less than 0.5 ppm.



0 2,500 5,000 10,000 Feet

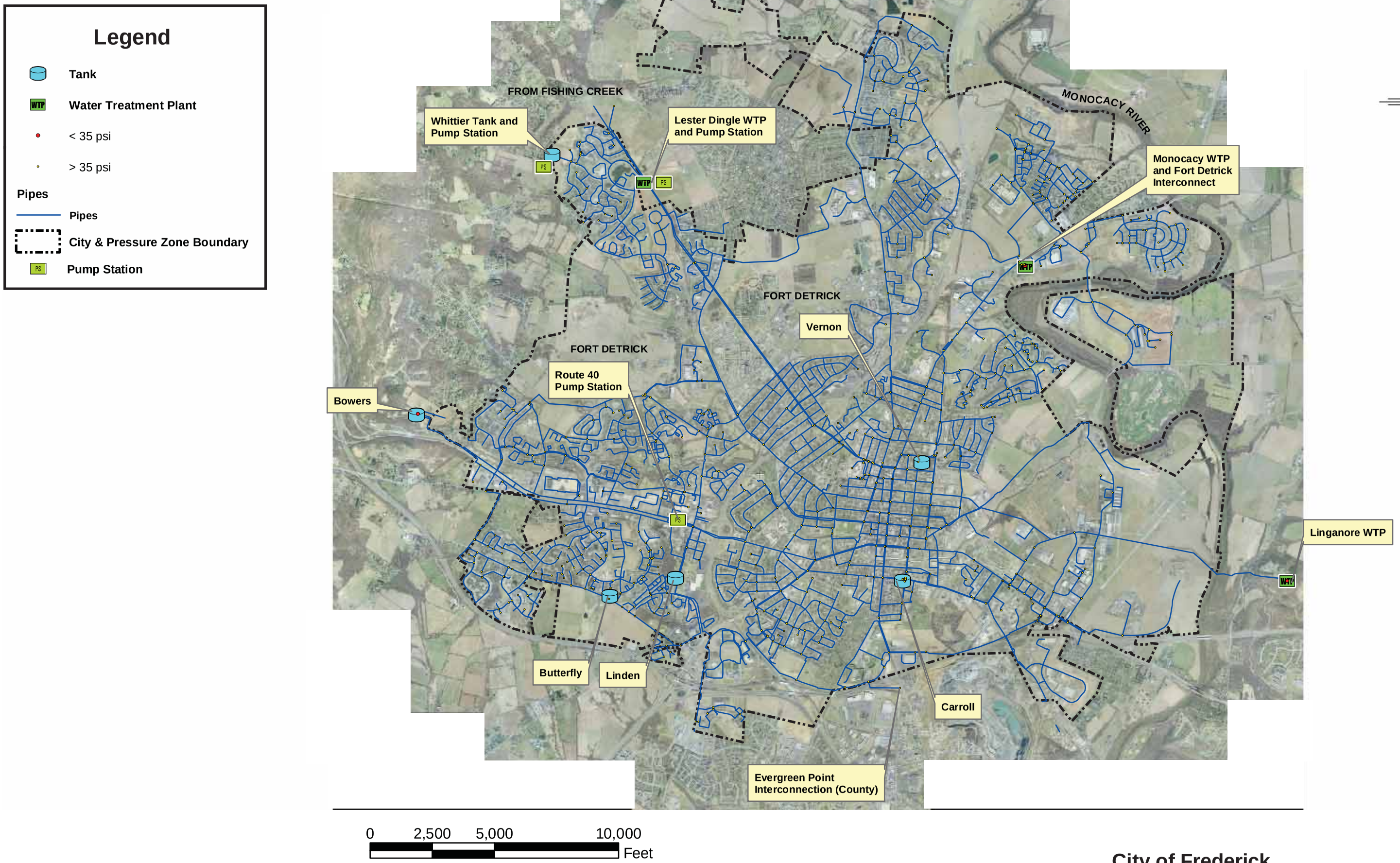
453-1 FIGURE Boundary Nov 07.mxd 1:1 07-11-26

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: JM
FILE No. 453.1

City of Frederick
2006 Water Master Plan

Water Service Boundaries

Figure 5-2



453-1 FIGURE 5-3.mxd 1:1 21-08-08

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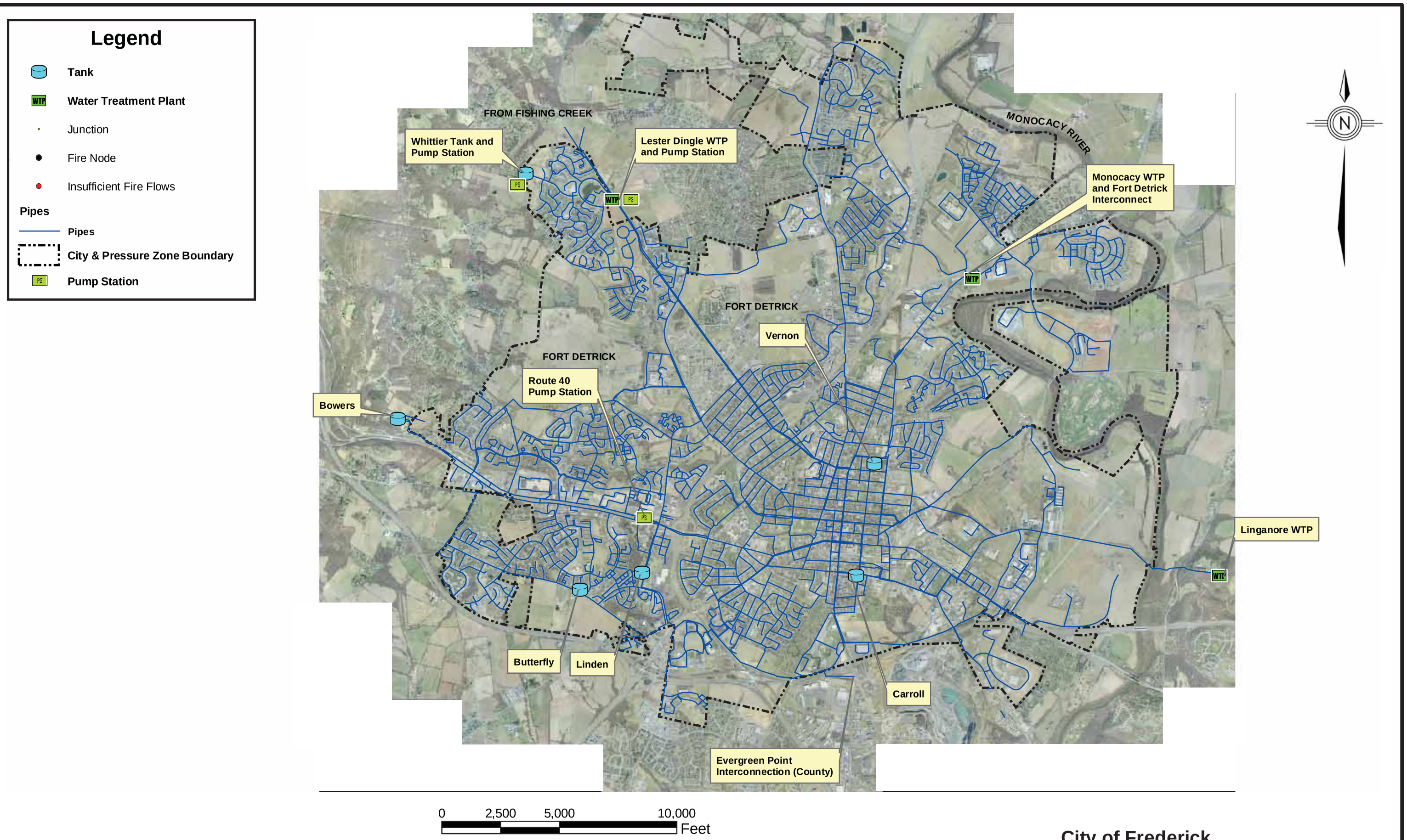
FILE No. 453.1

City of Frederick
2006 Water Master Plan
2006 Peak Hour Scenario Low Pressure Junctions

Figure 5-3



City of Frederick
2006 Water Master Plan
Fire Node Locations

Figure 5-4

453-1 FIGURE 5-4.mxd 1:1 21-08-08

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CONSULTING ENGINEERS
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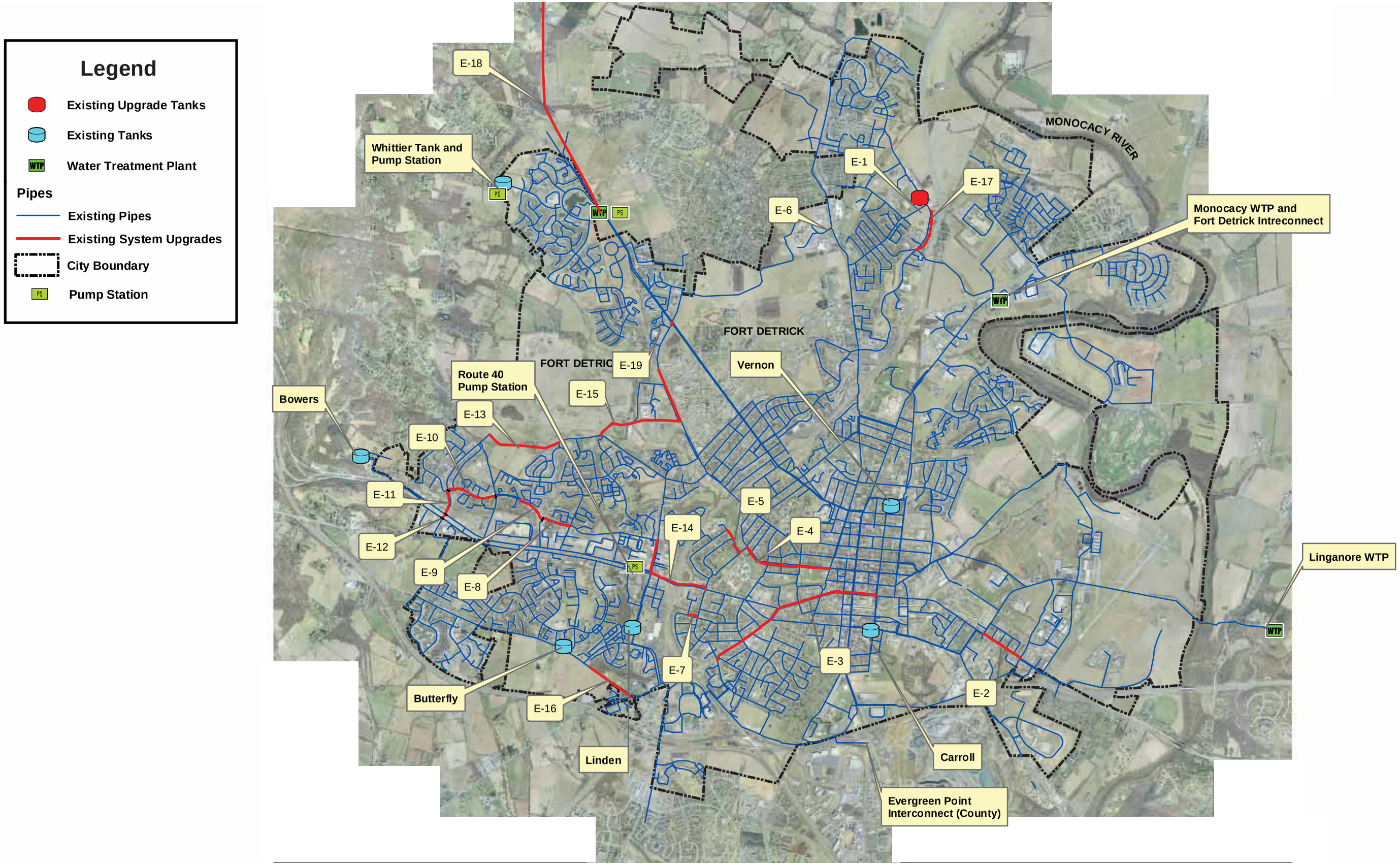
FILE No. 453.1



453-1 FIGURE 5-5.mxd 1:1 21-08-08

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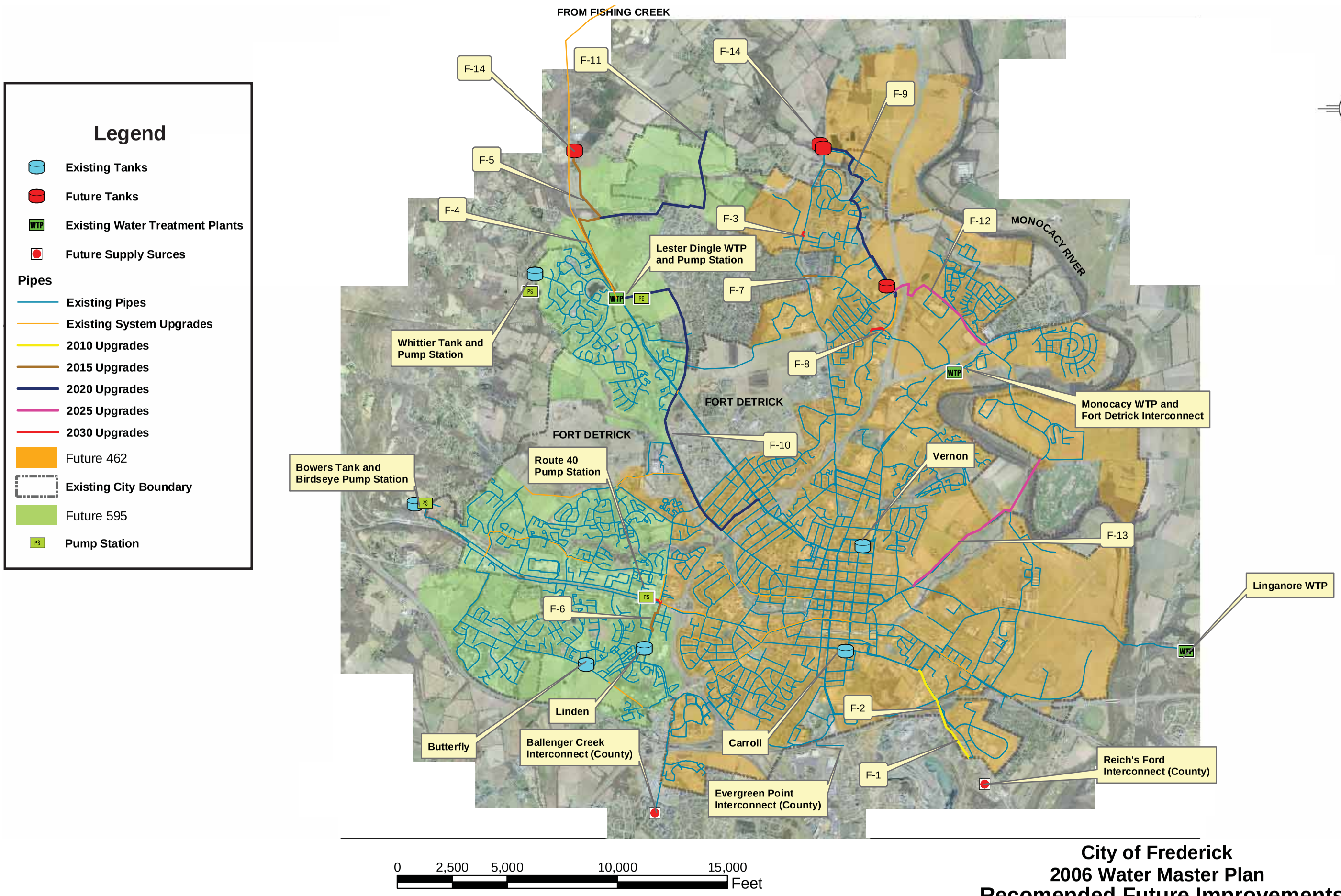
FILE No. 453.1

City of Frederick
2006 Water Master Plan
Recommended Immediate Improvements
2007-2009

Figure 5-5



City of Frederick
2006 Water Master Plan
Recomended Future Improvements
2010 and Beyond

Figure 5-6

453-1 FIGURE 5-6.mxd 1:1 21-08-08

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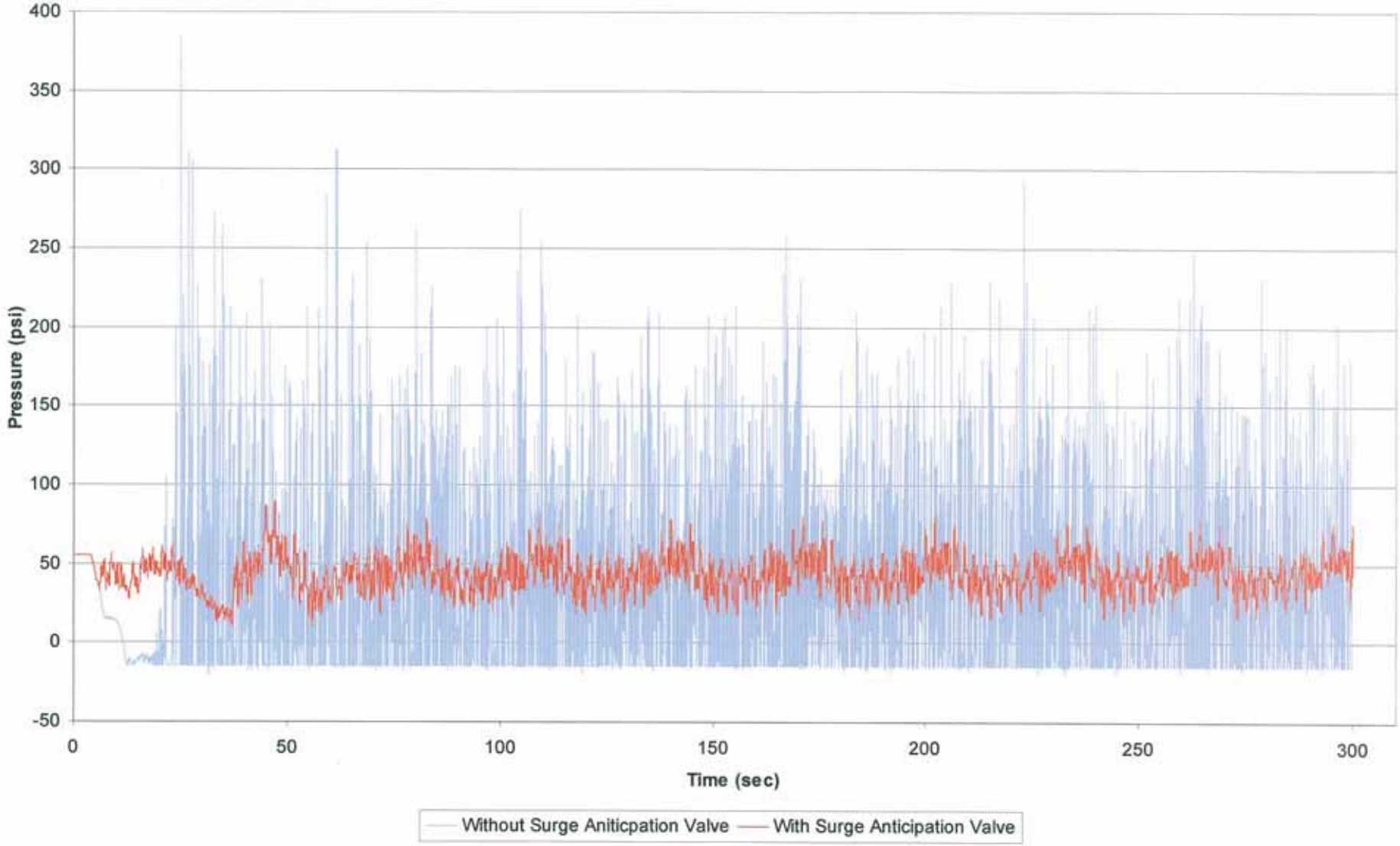


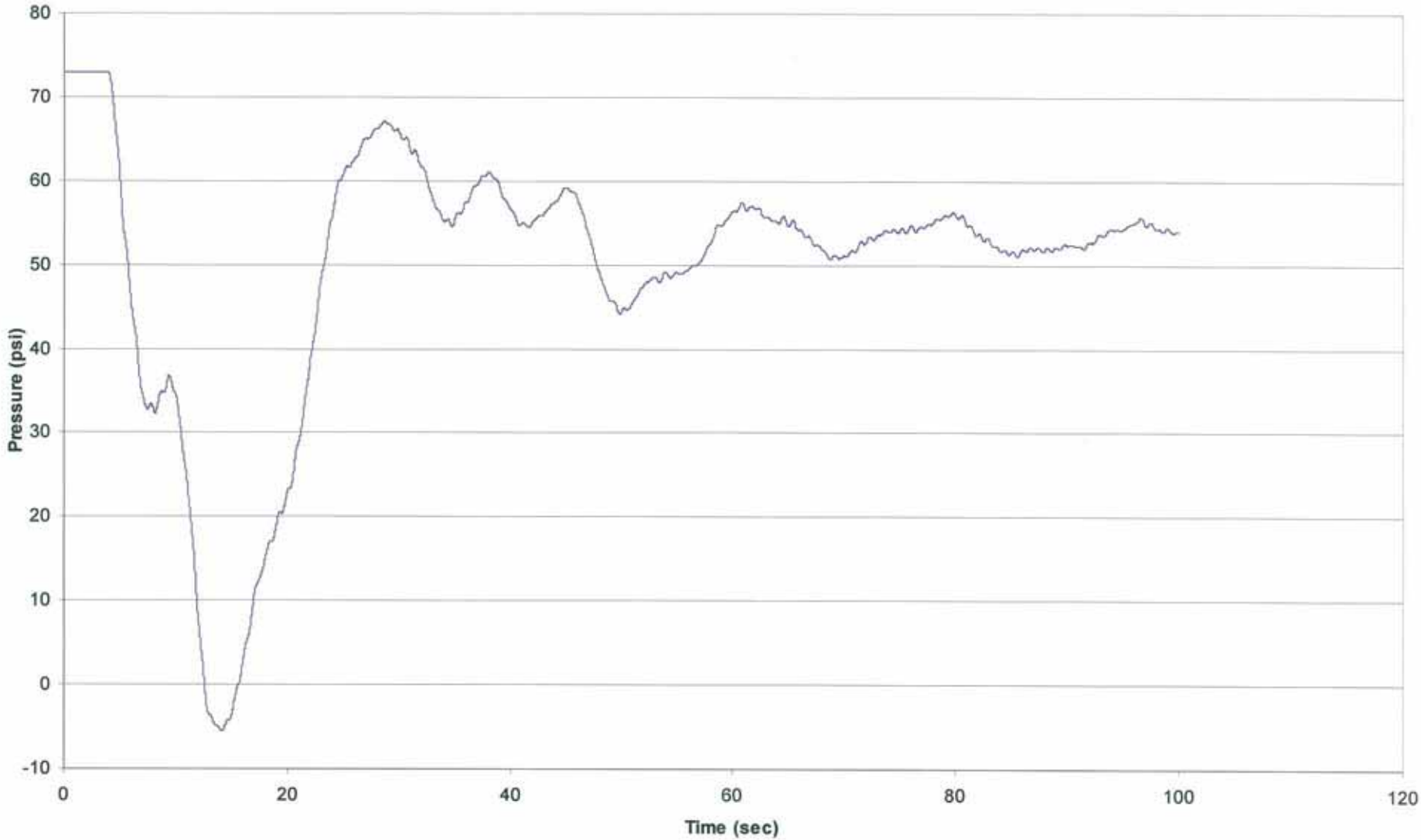
CITY OF FREDERICK

2006 WATER MASTER PLAN

ZONE 462 PRESSURE SURGE RESULTS WITH TANKS AT 460' HGL

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: CMW
DWG. No: 453.1

FIGURE 5-7



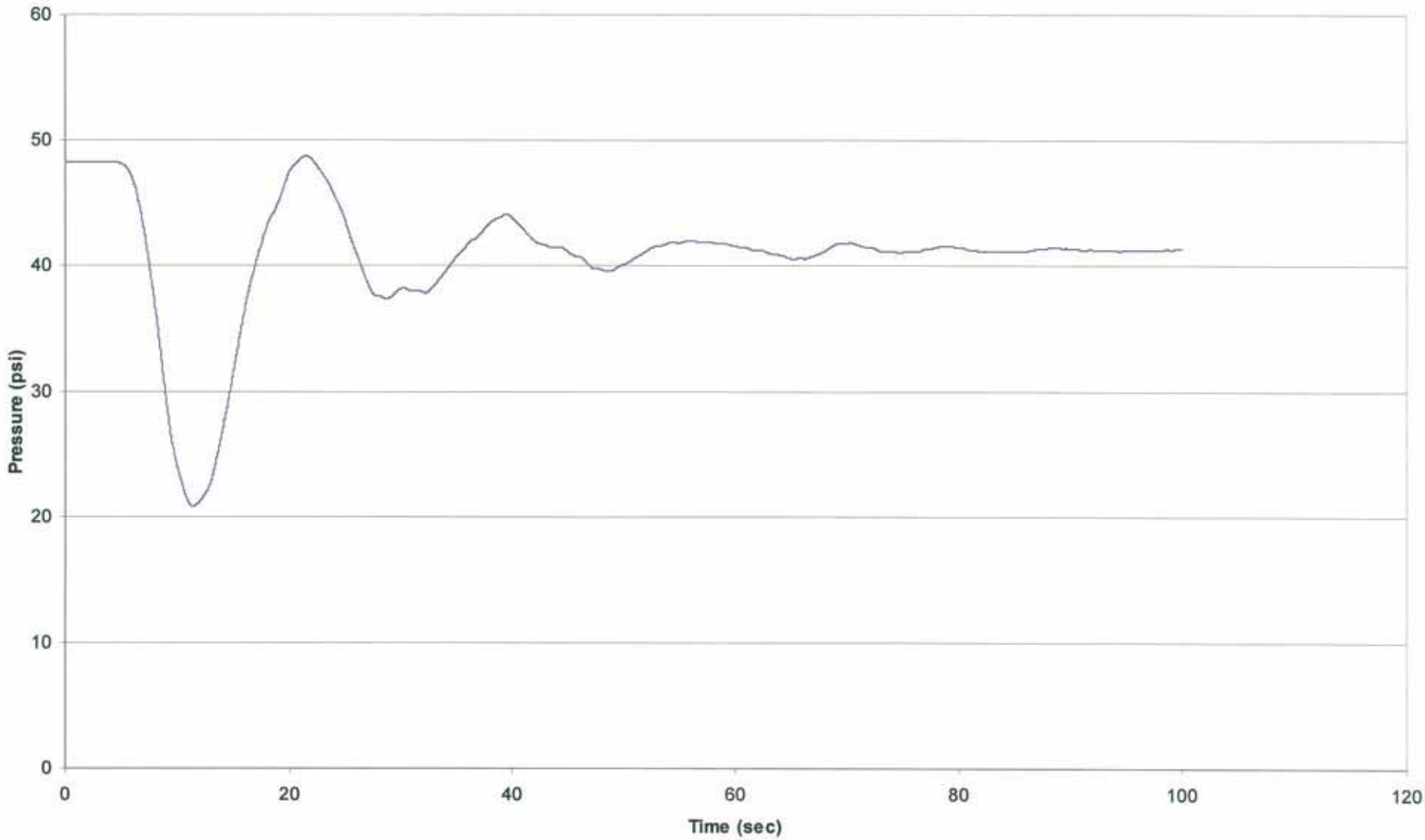
CITY OF FREDERICK

2006 WATER MASTER PLAN

ZONE 462 PRESSURE SURGE RESULTS WITH TANKS FULL

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: CWW
DWG. No: 453.1

FIGURE 5-8



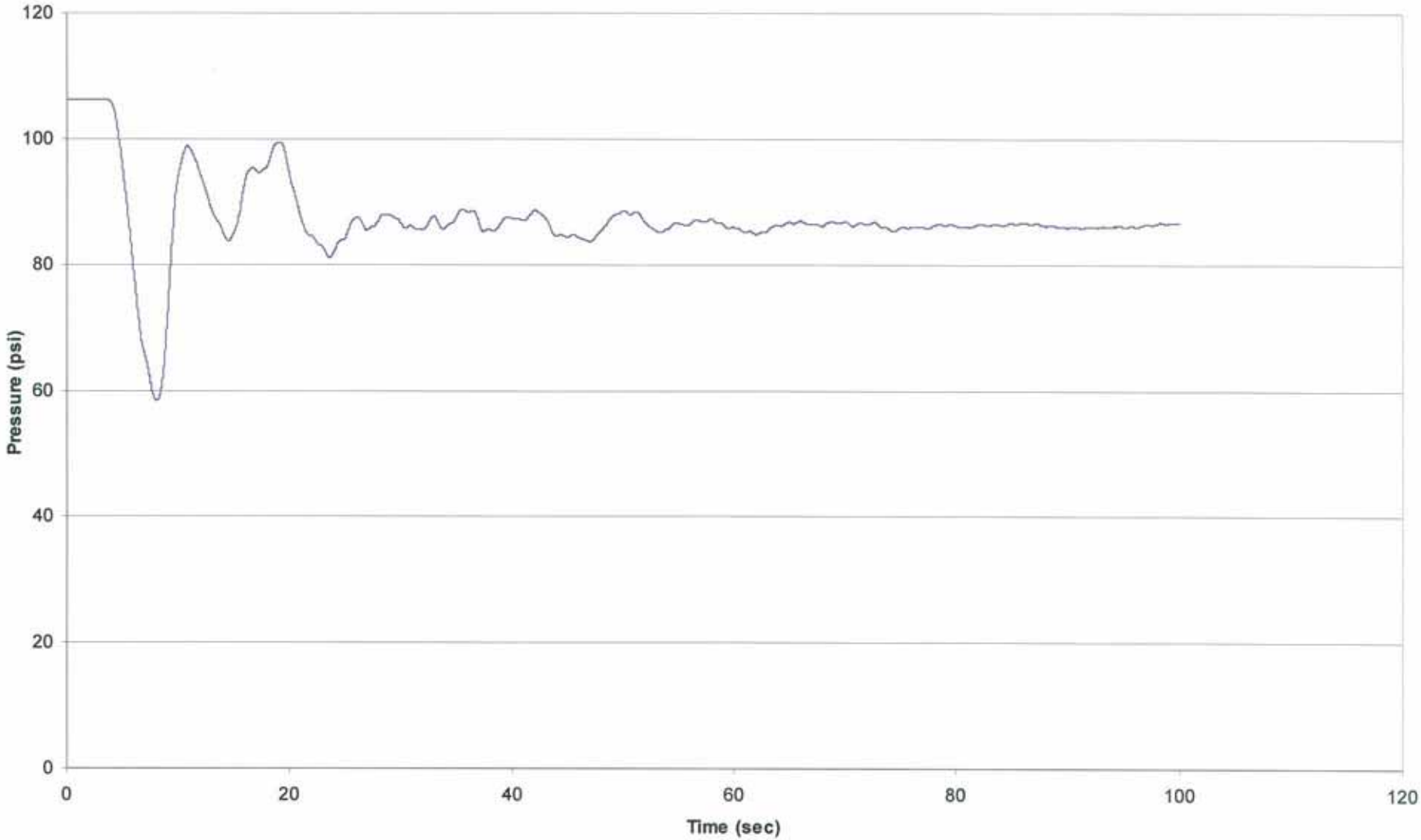
CITY OF FREDERICK

2006 WATER MASTER PLAN

ZONE 595 (WESTERN HIGH ZONE) PRESSURE SURGE RESULTS

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: CWW
DWG. No: 453.1

FIGURE 5-9



CITY OF FREDERICK

2006 WATER MASTER PLAN

ZONE 595 (WHITTIER HIGH ZONE) PRESSURE SURGE RESULTS

Dayton & Knight Ltd.
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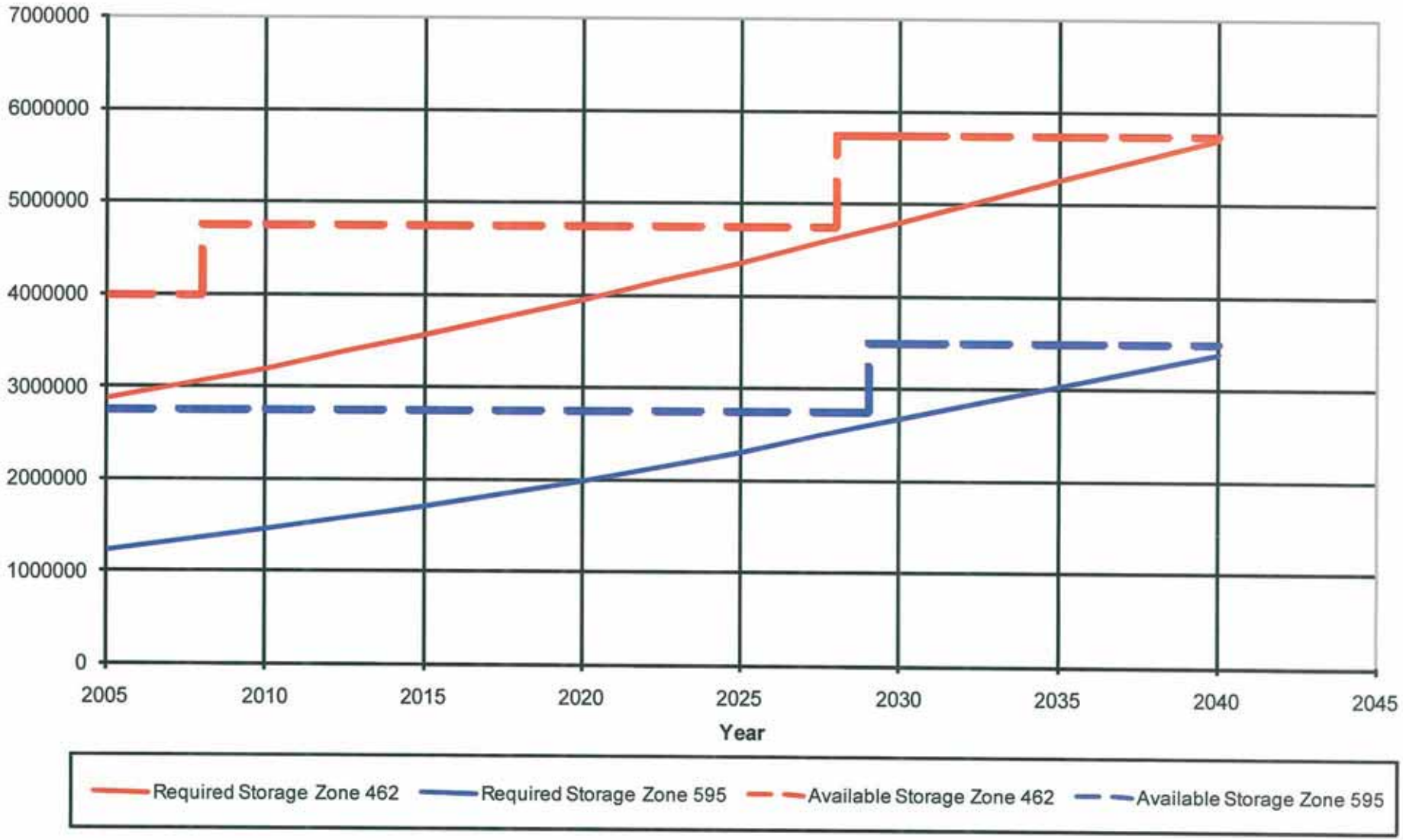
DWG. No: 453.1

FIGURE 5-10



CITY OF FREDERICK
2006 WATER MASTER PLAN
STORAGE REQUIREMENTS FOR PRESSURE ZONES

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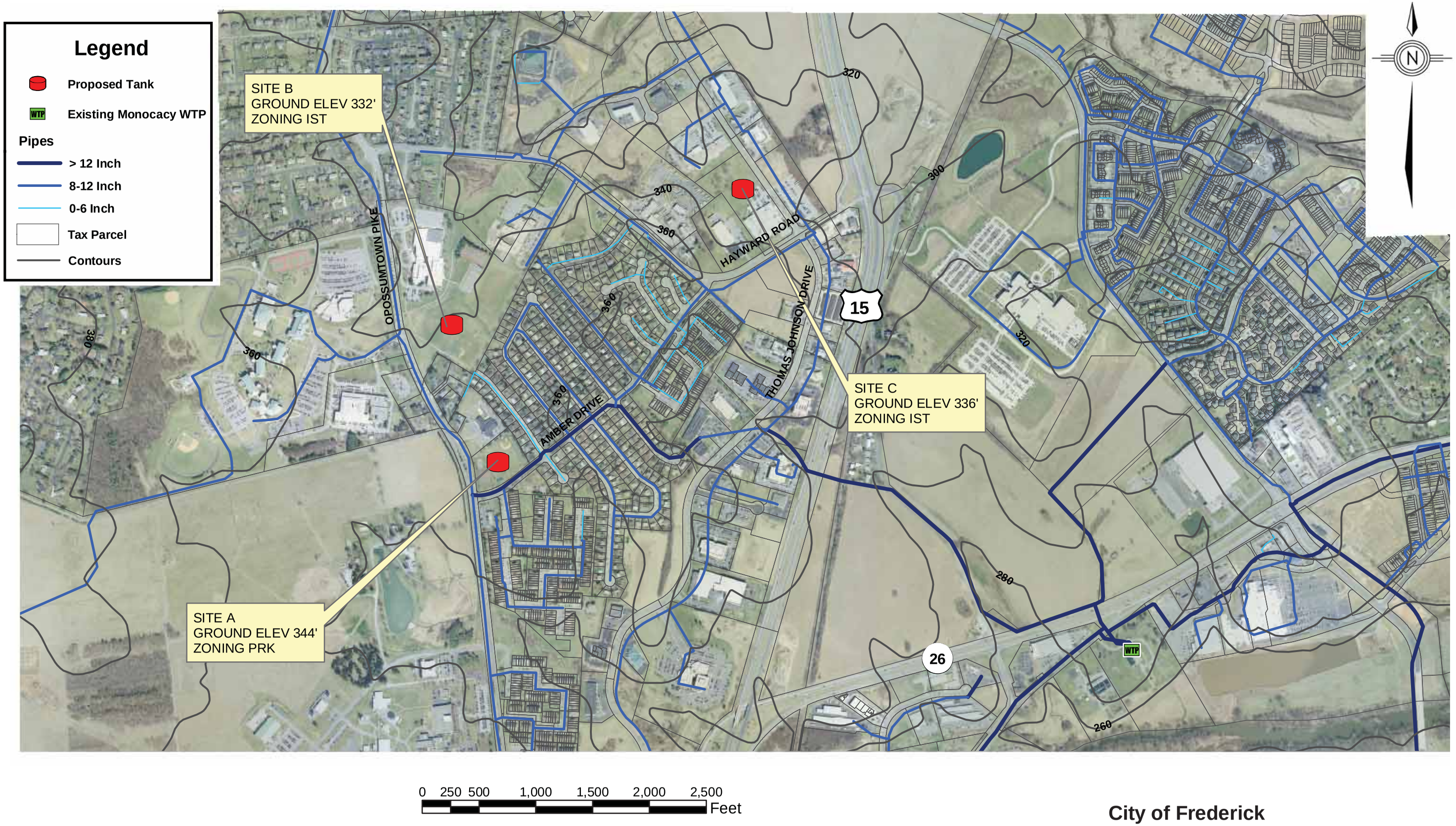
DRAWN BY: CMW
DWG. No: 453.1

FIGURE 5-11



453-1 FIGURE 5-12.mxd 1:1 21-08-08

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FILE No. 453.1

City of Frederick
2006 Water Master Plan
Amber Tank Siting Options

Figure 5-12

Legend

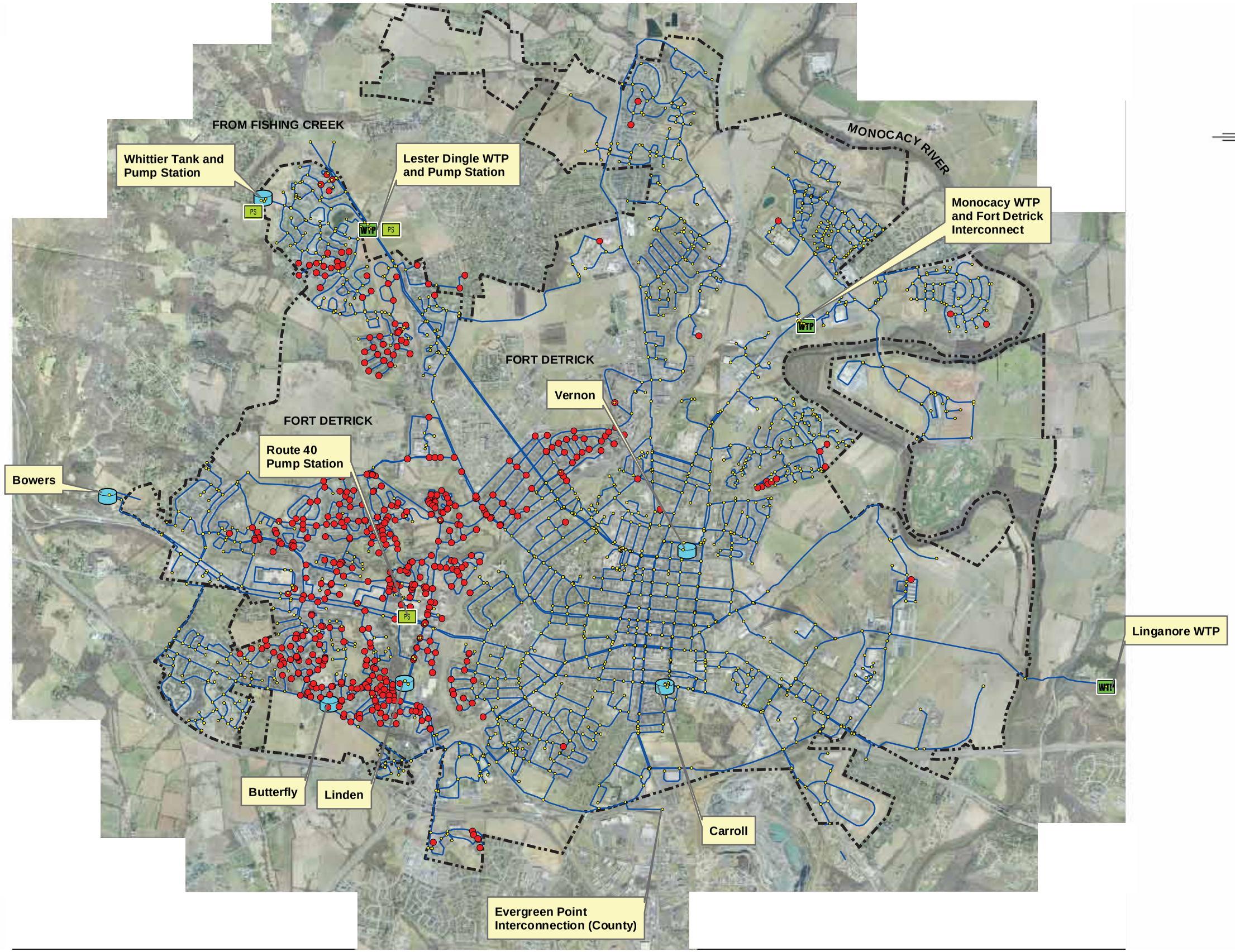
- Tank
- Water Treatment Plant

Pipes

- Pipes
- City & Pressure Zone Boundary

Chlorine Concentration

- < 1.0 ppm
- > 1.0 ppm
- Pump Station



0 2,500 5,000 10,000 Feet

City of Frederick
2006 Water Master Plan
Water Qualtiy Simulation Chlorine Residual Analysis
Simulated Chlorine < 1.0 ppm

453-1 FIGURE 5-13.mxd 1:1 21-08-08

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CONSULTING ENGINEERS
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FILE No. 453.1

Figure 5-13

Legend

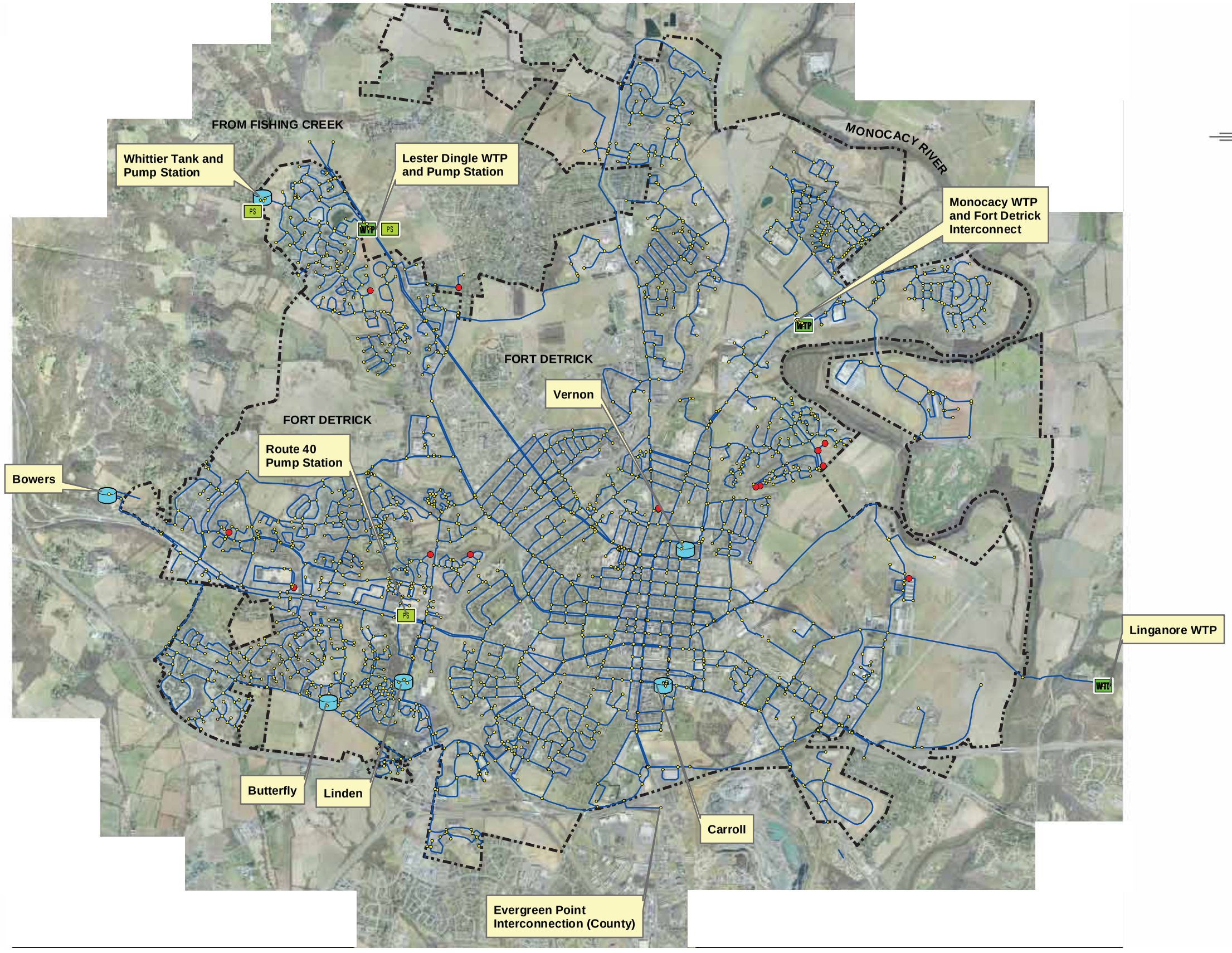
- Tank
- Water Treatment Plant

Pipes

- Pipes
- City & Pressure Zone Boundary

Chlorine Concentration

- < 0.75 ppm
- > 0.75 ppm
- Pump Station



0 2,500 5,000 10,000 Feet

City of Frederick
2006 Water Master Plan
Water Qualtiy Simulation Chlorine Residual Analysis
Simulated Chlorine < 0.75 ppm

453-1 FIGURE 5-14.mxd 1:1 21-08-08

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Figure 5-14

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

APPENDIX A

INFORMATION AND DOCUMENTS USED FOR STUDY

THE City OF Frederick

Information and Documents

Used For Study

	Date	Title	Author	Format
1	Jan-06	City of Frederick, Ground Water Treatment Plant Drawings (General Process Drawing (P-0.1), Process Control Diagram (P-0.2), Treatment Building Process Plan (P-1.1), Finnished Water Pump Room Plan and Elevations (P-2.2)	WATEK Engineering Corporation	Hardcopy (SB has originals)
2	Nov-05	Monocacy Water Treatment Plant Vulnerability Assessment - Draft	City	email
3	Nov-05	Linganore Water Treatment Plant Vulnerability Assessment - Draft	City	email
4	Nov-05	Mountain Water Supply Vulnerability Assessment - Draft	City	email
5	Nov-05	City Wide Map showing approximate Well Locations	City	Hardcopy
6	Nov-05	Well 4 Ultra-filtration Plant Vulnerability Assessment - Draft	City	email
7	2004-2005	Water System Actual Operation Cost for FY04 and FY05 (3 pages)	City	hardcopy and excel
8	2004-2005	Infrastructure Assets Data Collection	City	hardcopy (example)
9	2003-2005	Leak Detection Reports for past two and one-half years (outsourced data)	Fluid Pinpointing Services Inc.	Hardcopy
10	2000-2005	Average and Maximum Day Consumption	City	Hardcopy
11	Aug-05	Bailenger Creek Water Transmission System P/N #360023	City - Water NOW Team	Hardcopy
12	Aug-05	Monocacy River Water Appropriation and Use Permit renewal P/N #360022	City - Water NOW Team	Hardcopy
13	Aug-05	Additional GroundWater P/N #360022	City - Water NOW Team	Hardcopy
14	Aug-05	Patrick Street Water MainReplacement P/N #360024	City - Water NOW Team	Hardcopy
15	Aug-05	New Water Supply Project #360022	City - Water NOW Team	Hardcopy
16	Aug-05	Letter to City regarding Fort Detrick Water Plant	Maryland Department of the Environment	Hardcopy
17	Jul-05	Whittier Booster Pump Station P/N #370006	City - Water NOW Team	Hardcopy
18	Jul-05	Wellfield Development Well #3 & 7	City - Water NOW Team	Hardcopy
19	Jul-05	Water Treatment Plant, Prevention Program Manual and Risk Management	City	Hardcopy
20	Jun-05	Letter to County regarding New Design Filtration Plant	Maryland Department of the Environment	Hardcopy
21	Apr-05	Memo - Comments on a Request for Qualifications for Water Master Plan	Maryland Department of the Environment	Hardcopy
22	Apr-05	Land Management Code, Draft	City	Hardcopy
23	Apr-05	Executive Summary - Water NOW Team	City - Water NOW Team	Hardcopy
24	Mar-05	Wells 3 and 7 Water Appropriation and Use Permit, As-built information, Pump Test Results, Well Abandonment Report	Maryland Department of the Environment	Hardcopy
25	Feb-05	Letter to City regarding Reducing Water Leaks in the City's System	Maryland Department of the Environment	Hardcopy
26	2005	Water Supply Capacity Management Plans - 2005 Guidance Document	Maryland Department of the Environment	Hardcopy
27	Aug-04	Water Resources Development & Optimization Project	Malcolm Pirnie	Hardcopy
28	Jun-04	Summary of Elected and Appointed Officials	City	Hardcopy
29	Apr-04	Letter to MDE regarding corrected slides	City	Hardcopy
30	Apr-04	Letter to MDE regarding Updated Leak Reduction Graph	City	Hardcopy
31	Mar-04	Letter to City Mayor commending repairs in aging infrastructure	Maryland Department of the Environment	Hardcopy
32	Mar-04	Slide Presentation MDE & City March 12, 2004 Kick-off Meeting (Leak Reduction)	City	Hardcopy
33	Mar-04	Letter regarding City Team Goals and slide presentation from meeting	City	Hardcopy
34	2004	City of Frederick, Maryland Comprehensive Plan Map	City	Hardcopy
35	2004	City of Frederick Comprehensive Plan	City	Hardcopy
36	2004	Potomac River Water Supply Agreement	Frederick County - Div. of Utilities and Solid Waste	Hardcopy

Information and Documents

Used For Study

	Date	Title	Author	Format
37	2004	2004 Annual Water Report	City of Frederick Planning Department	Hardcopy
38	2004	Top 100 and 300 Water Users	City	Hardcopy
39	Jul-03	Potomac River Water Appropriation and Use Permit (Frederick County)	Maryland Dept. of Environment	Hardcopy
40	May-03	New Design Water Transmission System - East County Pumping Station Drawings G-1, C-1 - C-6, M-1, M-2, E-1	Whitman, Requardt & Associates	Hardcopy
41	Sep-03	Briefing Package for MDE for Water Resources Development and Optimization (slides)	City	Hardcopy
42	Oct-03	Letter to City regarding Water Supply Program	Maryland Department of the Environment	Hardcopy
43	Nov-03	Letter to Maryland Dept. Env. Regarding Water Resources Development and Optimization	City	Hardcopy
44	Mar-03	Letter to City regarding March 17th Info Meeting	Maryland Dept. of Environment	Hardcopy
45	2003	Drought Analysis	Whitman, Requardt & Associates	Hardcopy
46	2003	Hydraulic Info	Whitman, Requardt & Associates	Hardcopy
47	2002	Strategic Interim Water Management Plan	City of Frederick Planning Department	Hardcopy
48	2002	City Testing Information (lead, copper, SDWA, Water Quality)	City	Hardcopy
49	Sep-02	Water Allocation Ordinance	City	Hardcopy
50	Jun-02	Consent Order - Monocacy River	State of Maryland - Dept. of Environment	Hardcopy
51	Dec-02	Lake Linganore Siltation & Capacity Report	Whitman, Requardt & Associates	Hardcopy
52	Oct-01	Public Protection Classification Results letter to Mayor Grimes	Insurance Services Office, INC.	Hardcopy
53	Feb-00	Water and Sewer Master Plan Update	Chester Engineers	Hardcopy
54	Sep-00	Evaluation of the 2,000,000 Gallon Concrete Ground Storage Tank "Linden Avenue Tank"	Tank Industry Consultants	Hardcopy
55	Dec-99	Evaluation of the 750,000 Gallon Steel Elevated Water Tank "Butterfly Lane Tank"	Tank Industry Consultants	Hardcopy
56	Nov-98	Water Appropriation and Use Permits	Maryland Dept. of Environment	Hardcopy
57	Aug-98	Fishing Creek Dam Breach Analysis	McCrone Inc.	Hardcopy
58	Dec-81	Mountain Water Supply Improvements	Whitman, Requardt & Associates	Hardcopy
59	n/a	Water Distribution Maps in AutoCAD	City	Hardcopy
60	n/a	Birdseye View Booster Station Drawings	City	Hardcopy
61	n/a	Frederick County Water and Sewer Master Plan (Chapters 1 & 2)	City	Hardcopy
62	n/a	Source Water Assessments	Maryland Department of the Environment (Water Supply Program)	Hardcopy
63	n/a	Emergency Response Plan, Back-up Power Plan, Emergency Phone Listing, City Contacts Listing	City	Hardcopy
64	n/a	Dam Evacuation Notification	City	Hardcopy
65	n/a	List of Contractors (Pre-qualified Excavation Firms)	City	Hardcopy
66	n/a	Fishing Creek Optimization Presentation	City	Hardcopy
67	n/a	Leak Reduction Presentation	City	Hardcopy
68	n/a	Whittier Booster Pump Station Drawing (used to be called Dingle Pump Station)	City	Hardcopy
69	n/a	SCADA Pre-design Report	Whitman, Requardt & Associates	Hardcopy

Digital Format Only

70	Dec-05	City Water Model	City	Digital
71	Dec-05	SCADA System Files (programming files)	City	Digital
72	Jan-06	Water Leak Index Base Map 2001-2004	City	Digital
73	Nov-05	Map of all Wells	City	Autocad

Information and Documents

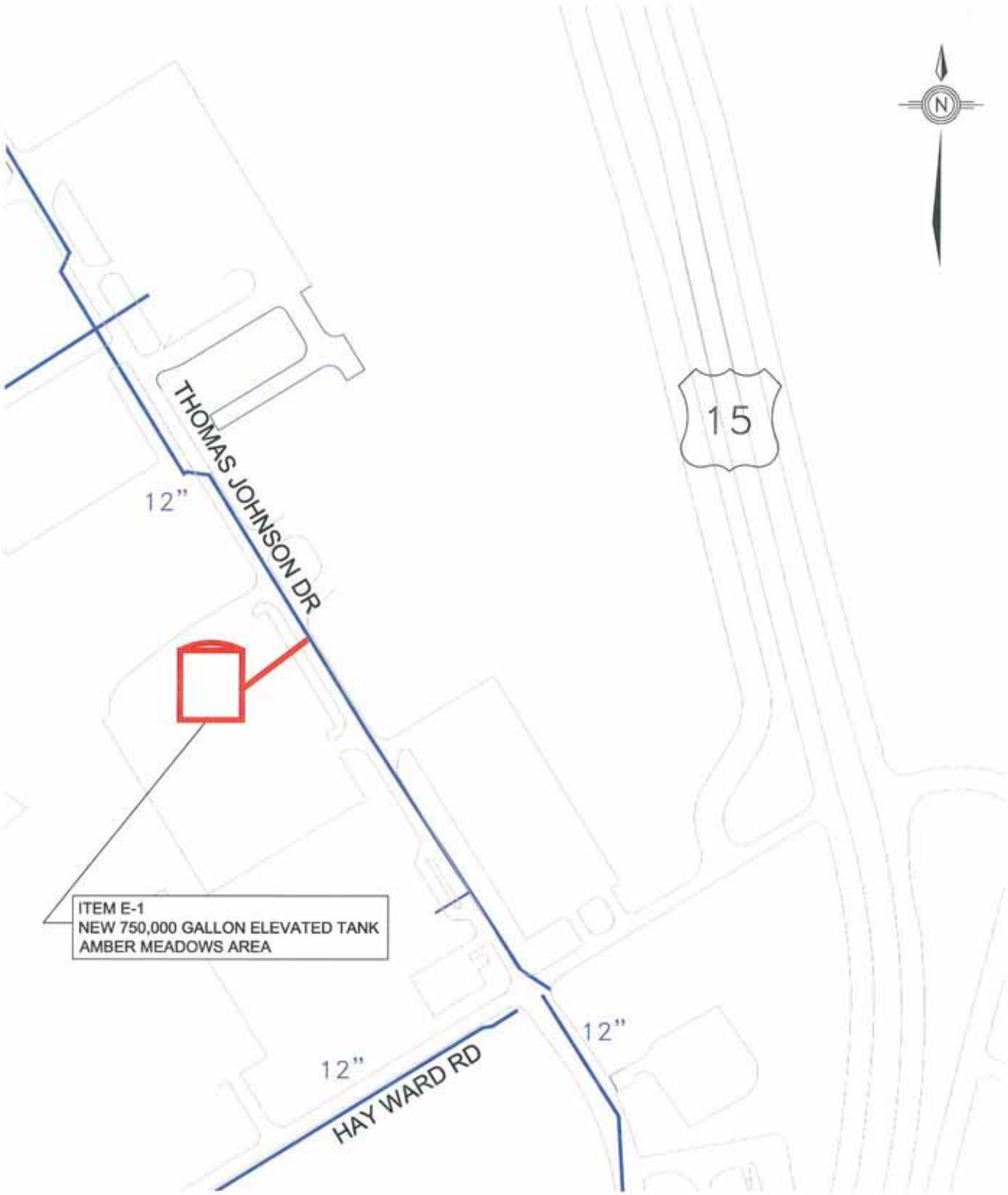
Used For Study

	Date	Title	Author	Format
	1999 - 2003	Demand Data 1999 - 2003, Avg. Day Analysis, 2002 Water Audit, Yearly Demand (2000		
	Dec-03	Dec 18, 2003 Board Meeting	City	pdf's
	Dec-03	Malcolm Pirnie / Mayor Workshop: agenda, cost & benefit summary, presentation outline, presentation, implementation steps, allocation growth chart (2004-2008)	Malcolm Pirnie	pdf's & excel
	Dec-03	Malcolm Pirnie Workshop / Meeting Visuals	Malcolm Pirnie	pdf's
74	Nov-02	Metering Data (Treatment Plant)	City	Digital
75	2002	H2OMAP Model	City	Digital
76	2001 - 2005	City Meter Records	City Finance	Excel
77	2001 - 2005	City Testing Information (lead, copper, SDWA, Water Quality)	City	Excel
78	2000	EPANET Model (2000)	City	Digital
79	1999 - 2002	Demand Curve Data files	Malcolm Pirnie	Excel
80	1960 - 2001	Daily Flows (data used to produce Appendix A in "Interim Water Plan"	US Geological Survey http://nwis.waterdata.usgs.gov/md/nwis/discharge/?site_no=01643000&agency_cd=USGS	Web Link
81	1929 to 2004	Monocacy River Streamflow records	US Geological Survey http://nwis.waterdata.usgs.gov/md/nwis/discharge/?site_no=01643000&agency_cd=USGS	Web Link
	1998	Fishing Creek Reservoir Dam Breach Analysis	McCrone, Inc.	pdf
	1982-1997	Tuscarora and Fishing Creek Withdrawal Report	City	excel
	n/a	Fishing Creek Planimetry Data	City	excel
	n/a	Safe Yield Analysis by City	City	pdf's
82	n/a	City of Frederick MrSID Mosaic	City	Digital
83	n/a	TAZ Data	City	Digital
84	n/a	Route 40 Pump Station Plans	City	Digital
85	n/a	Tuscarora Creek Rechlorination Station Drawings	City	Digital
86	n/a	Daily Flows 1990 - 2005	City	Excel
87	n/a	Zenon Plant Relocation Drawings (70%)	City	Digital
88	n/a	Cleaning and Lining Program Maps	City	Digital
89	n/a	Malcolm Pirnie Final Report (Task 5)	Malcolm Pirnie	Digital
	n/a	Stella Model, Task Summaries 1 through 5	City	
	n/a	Stella Model	City (80047794155)	Digital (JL has original)

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

APPENDIX B

EXISTING UPGRADES



0 125 250 375 500

1"=250'

CITY OF FREDERICK

2006 WATER MASTER PLAN

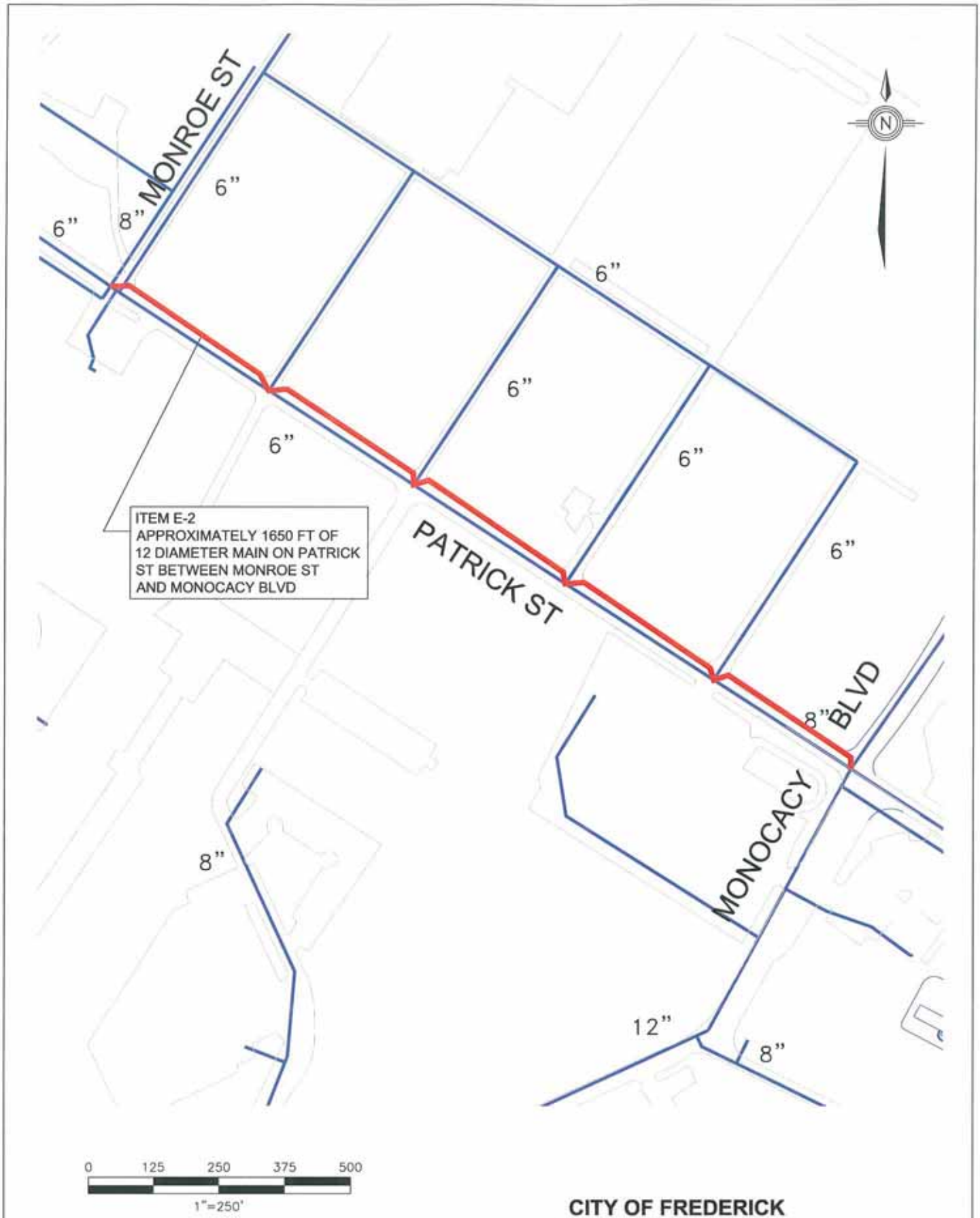
EXISTING UPGRADE E-1

AMBER MEADOWS 750,000 GALLON TANK

453-1 Water Improvements 1:1 07-01-05

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-1

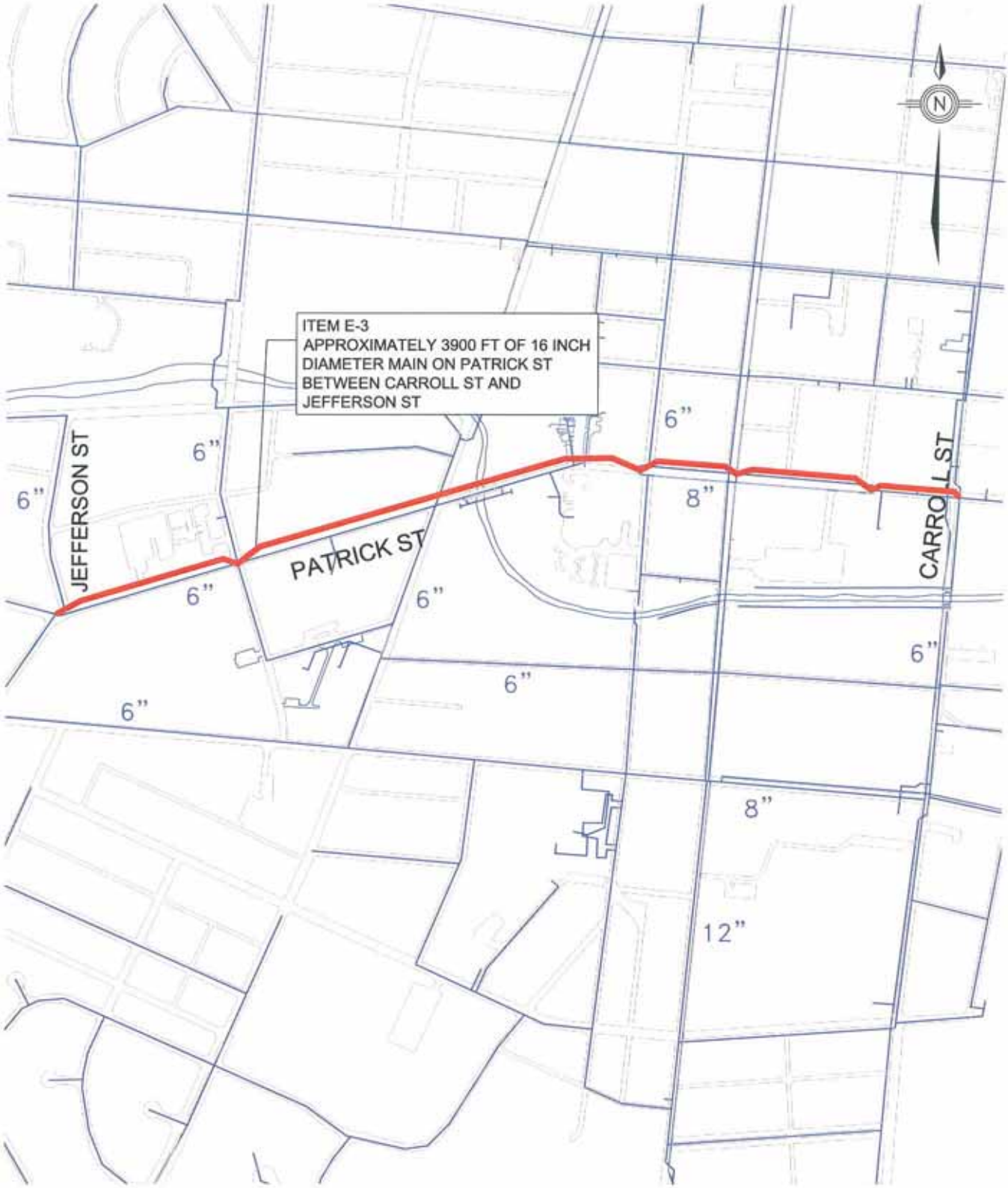


CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-2
12 INCH MAIN ON PATRICK STREET

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-2



0 300 600 900 1200

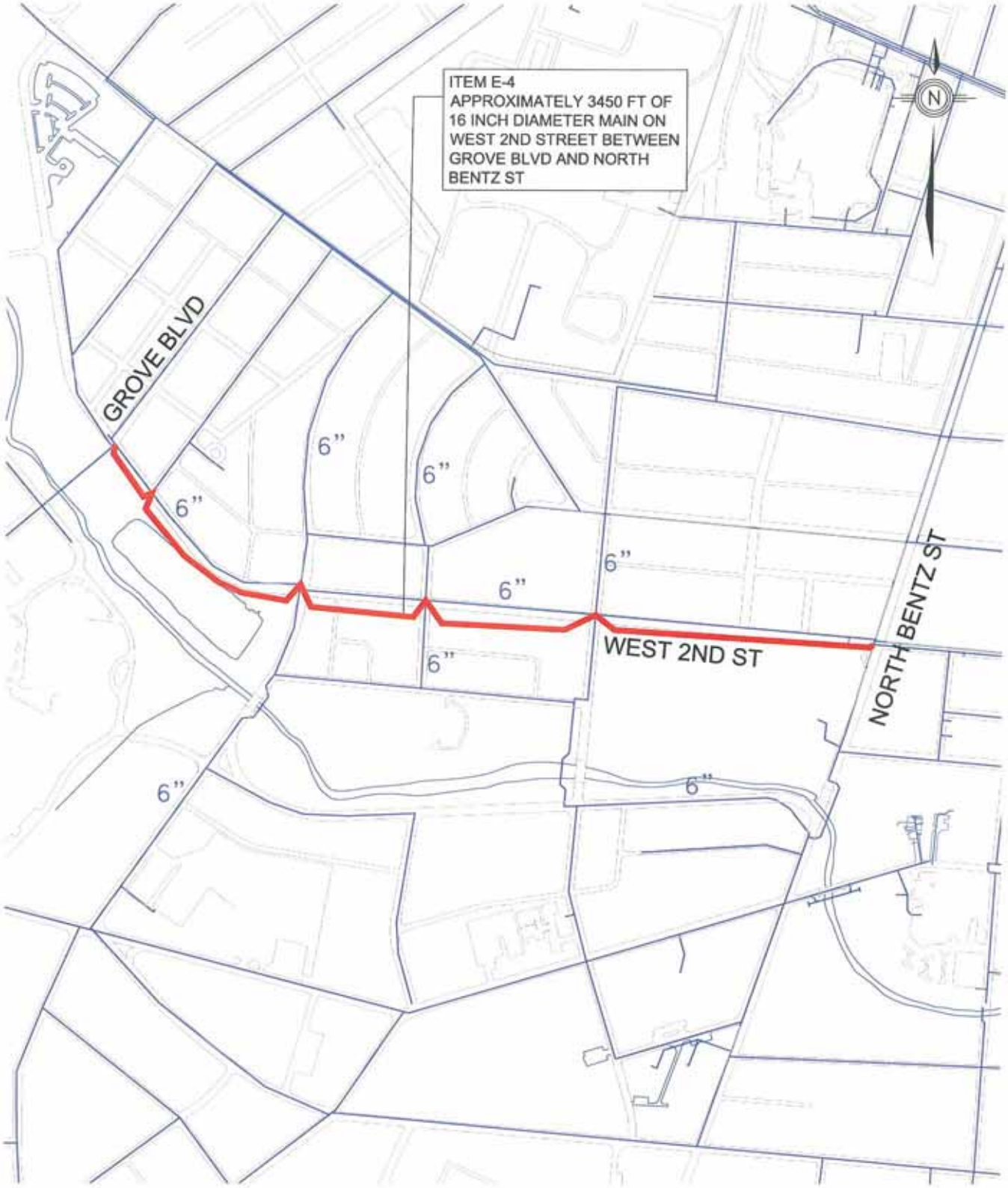
1"=600'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-3
16 INCH MAIN ON PATRICK STREET

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-3



0 300 600 900 1200

1"=600'

CITY OF FREDERICK

2006 WATER MASTER PLAN

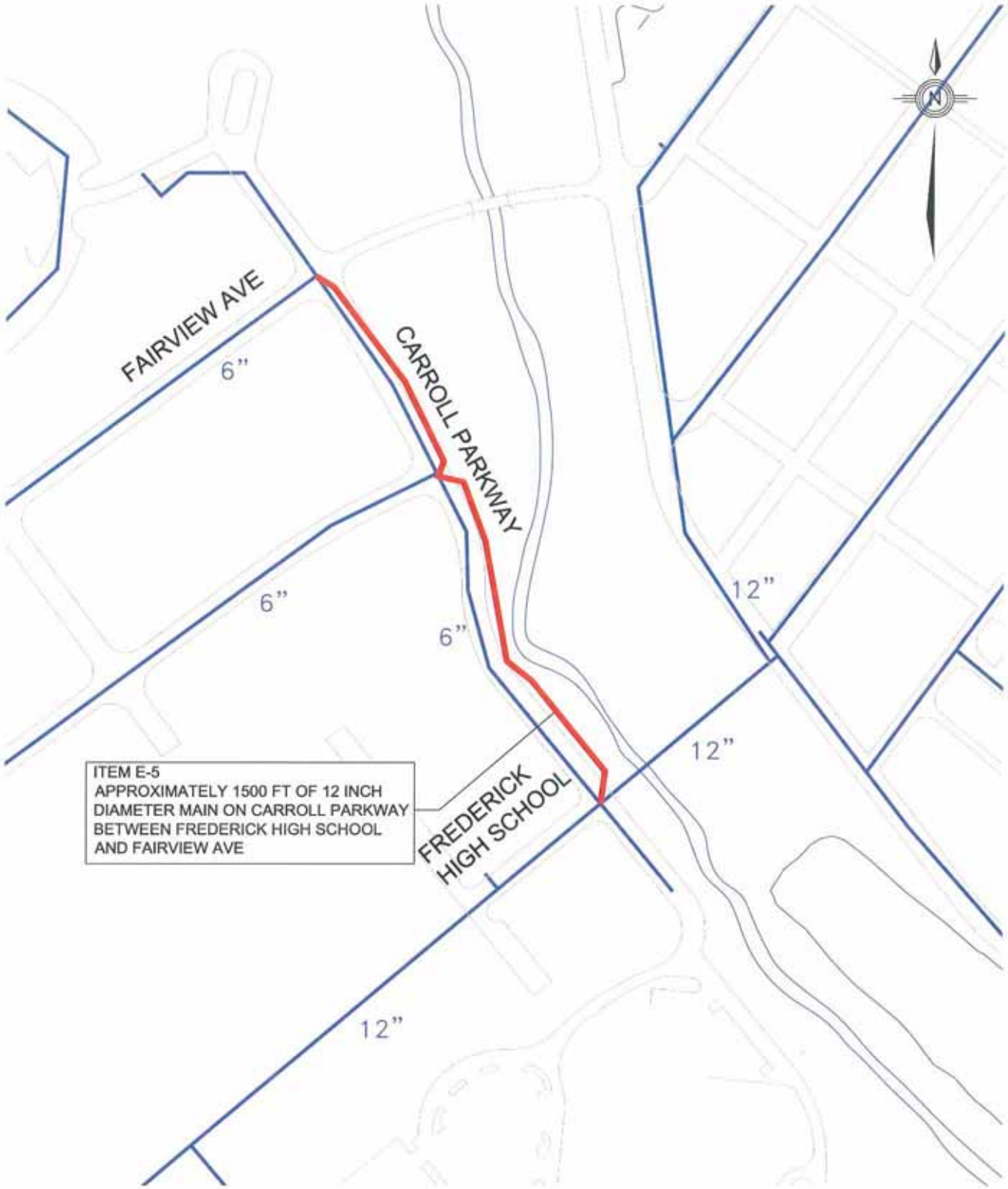
EXISTING UPGRADE E-4

16 INCH MAIN ON WEST 2ND STREET

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-4



0 125 250 375 500

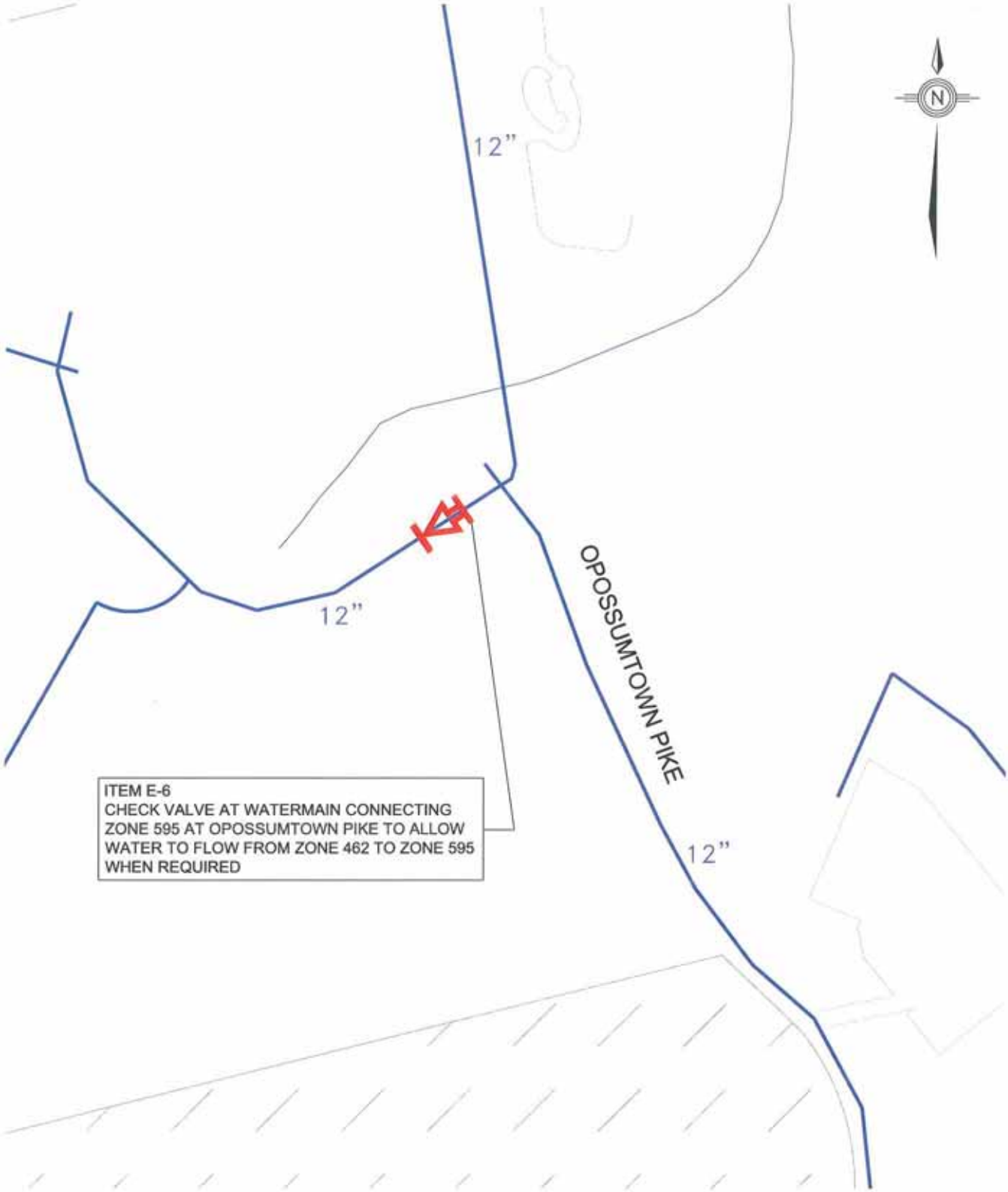
1"=250'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-5
12 INCH MAIN ON CARROLL PARKWAY

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-5



0 125 250 375 500

1"=250'

CITY OF FREDERICK

2006 WATER MASTER PLAN

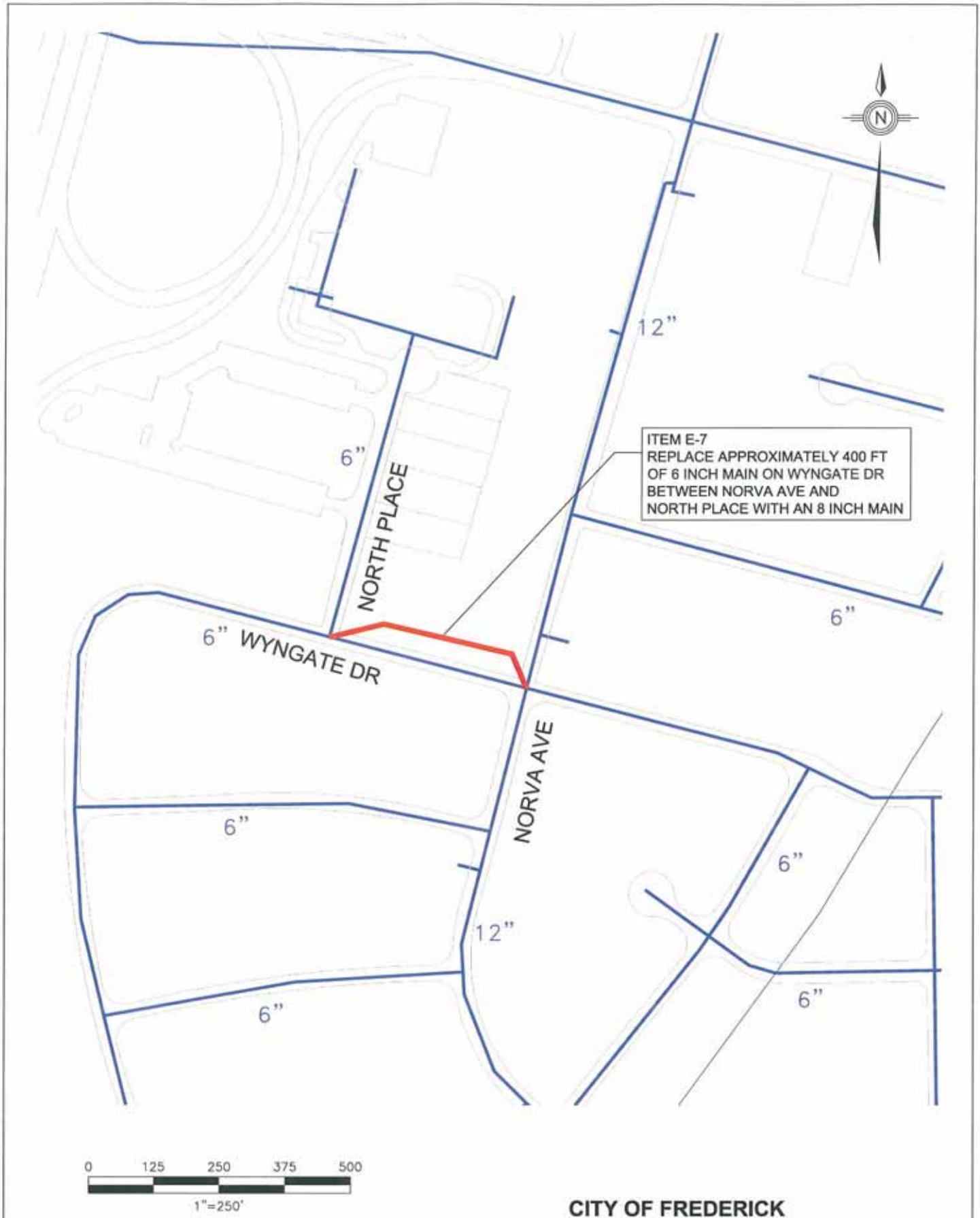
EXISTING UPGRADE E-6

CHECK VALVE AT OPOSSUMTOWN PIKE

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-6



CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-7
8 INCH MAIN ON WYNGATE DRIVE

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-7

0 125 250 375 500

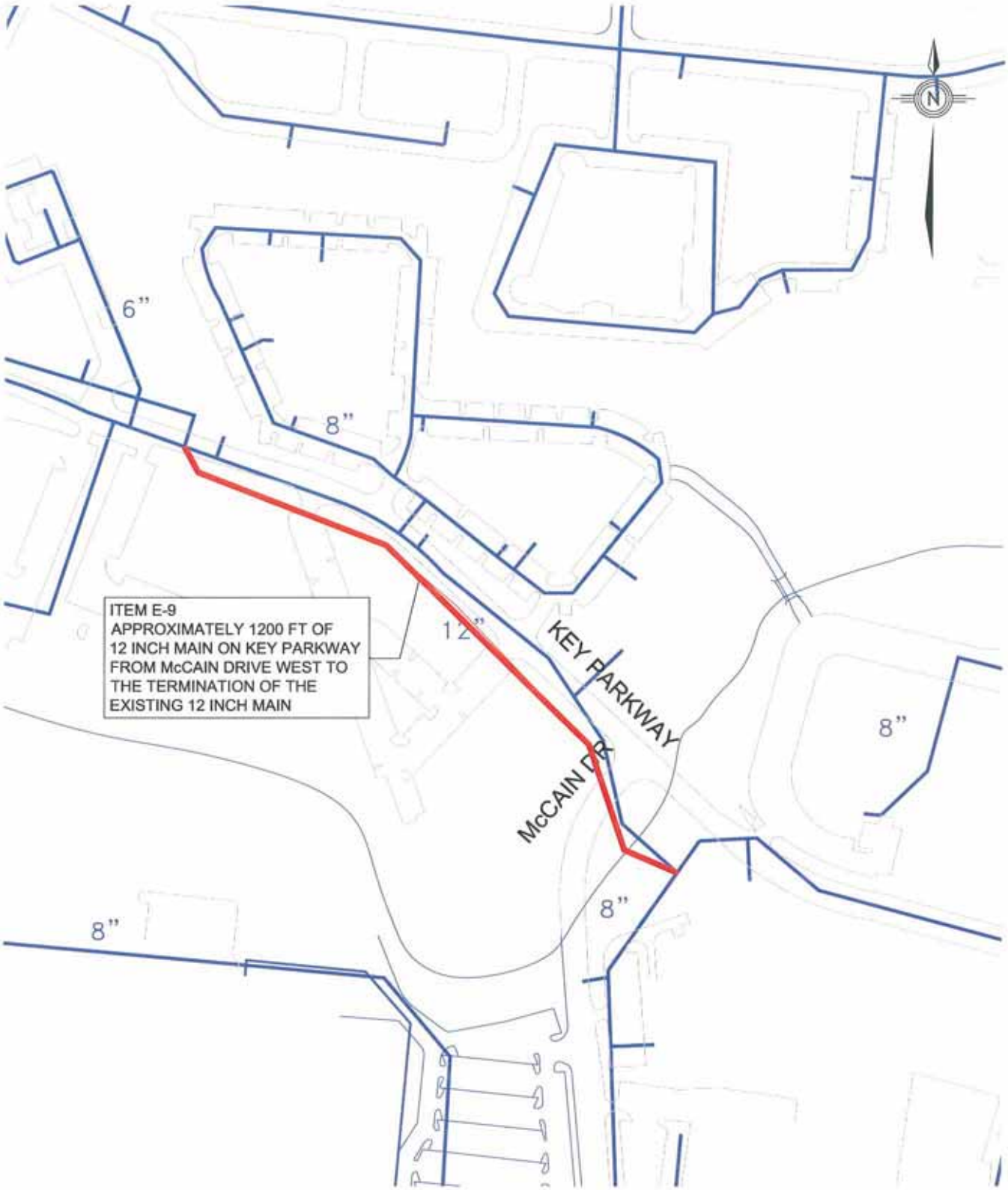
1"=250'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-8
12 INCH MAIN ON KEY PARKWAY

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-8



0 125 250 375 500

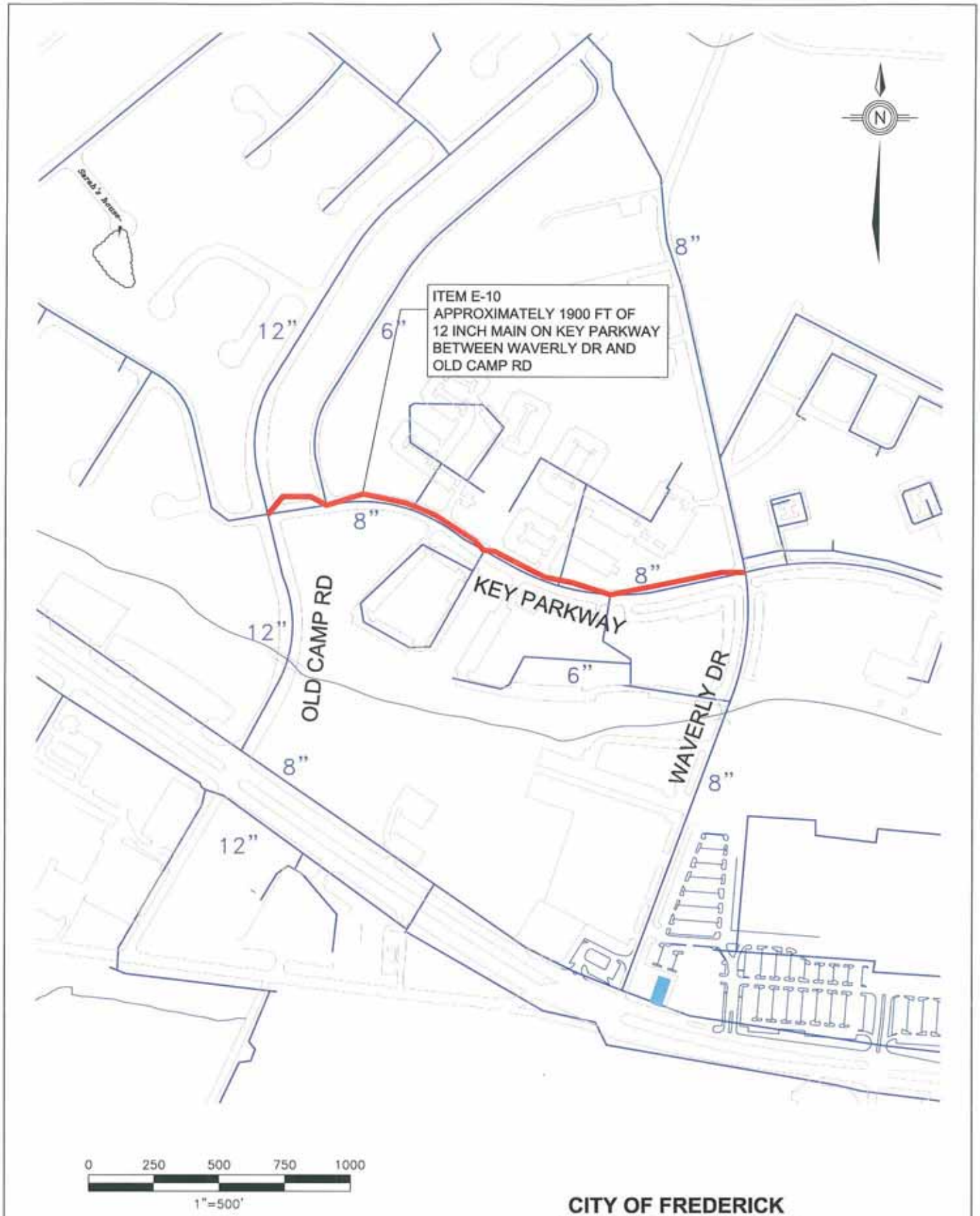
1"=250'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-9
12 INCH MAIN ON KEY PARKWAY

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-9

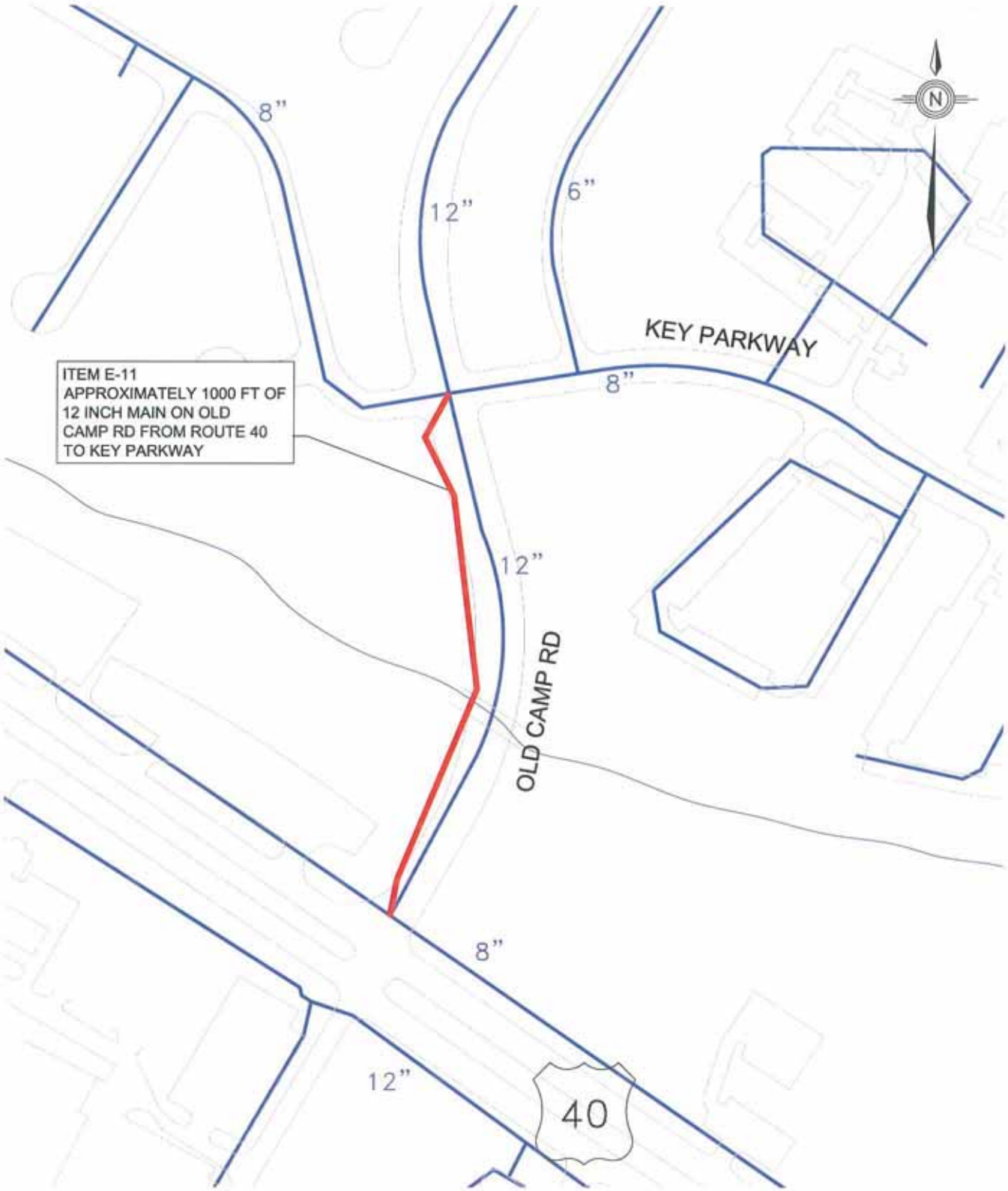


CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-10
12 INCH MAIN ON KEY PARKWAY

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-10



0 125 250 375 500

1"=250'

CITY OF FREDERICK

2006 WATER MASTER PLAN

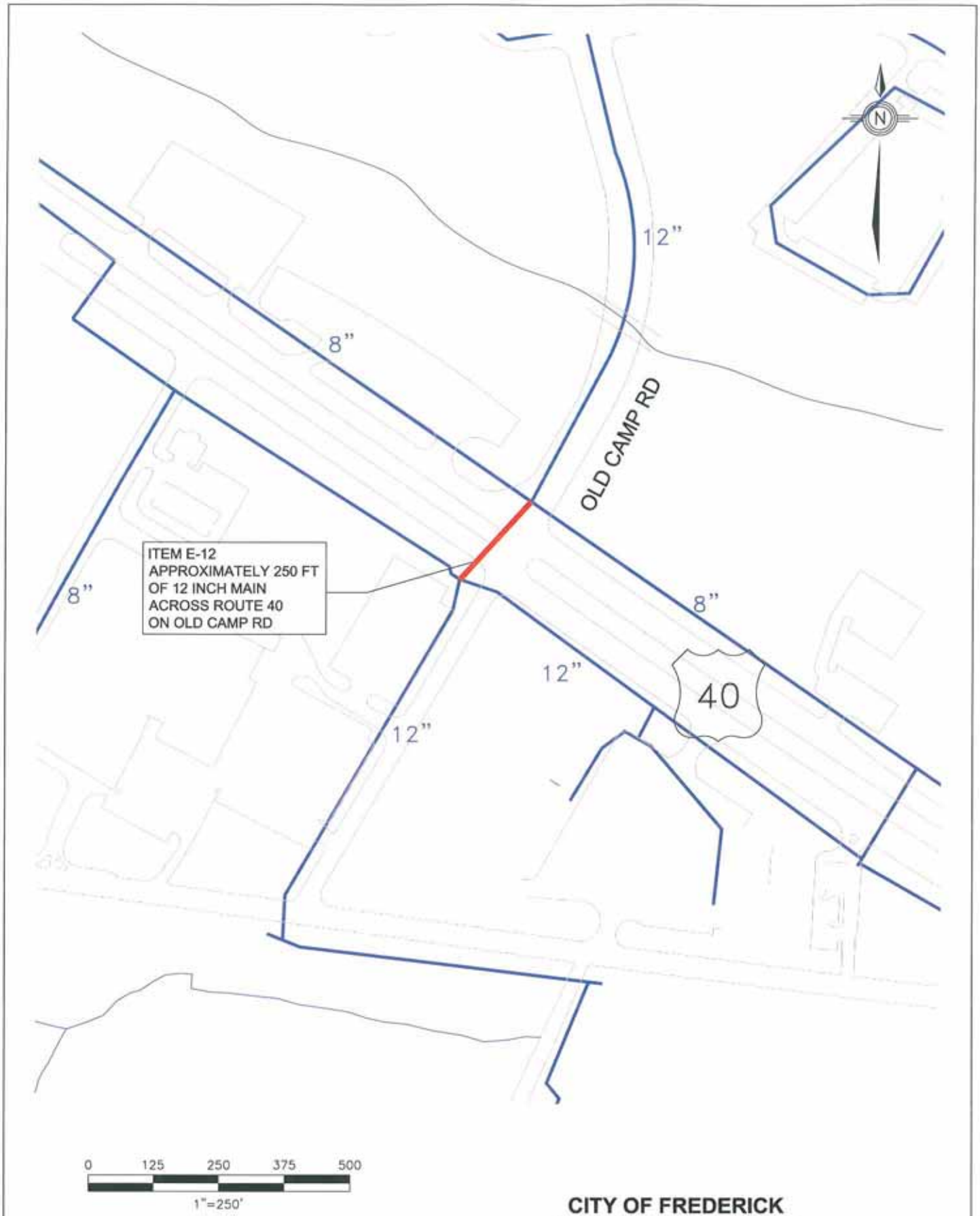
EXISTING UPGRADE E-11

12 INCH MAIN ON OLD CAMP ROAD

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-11

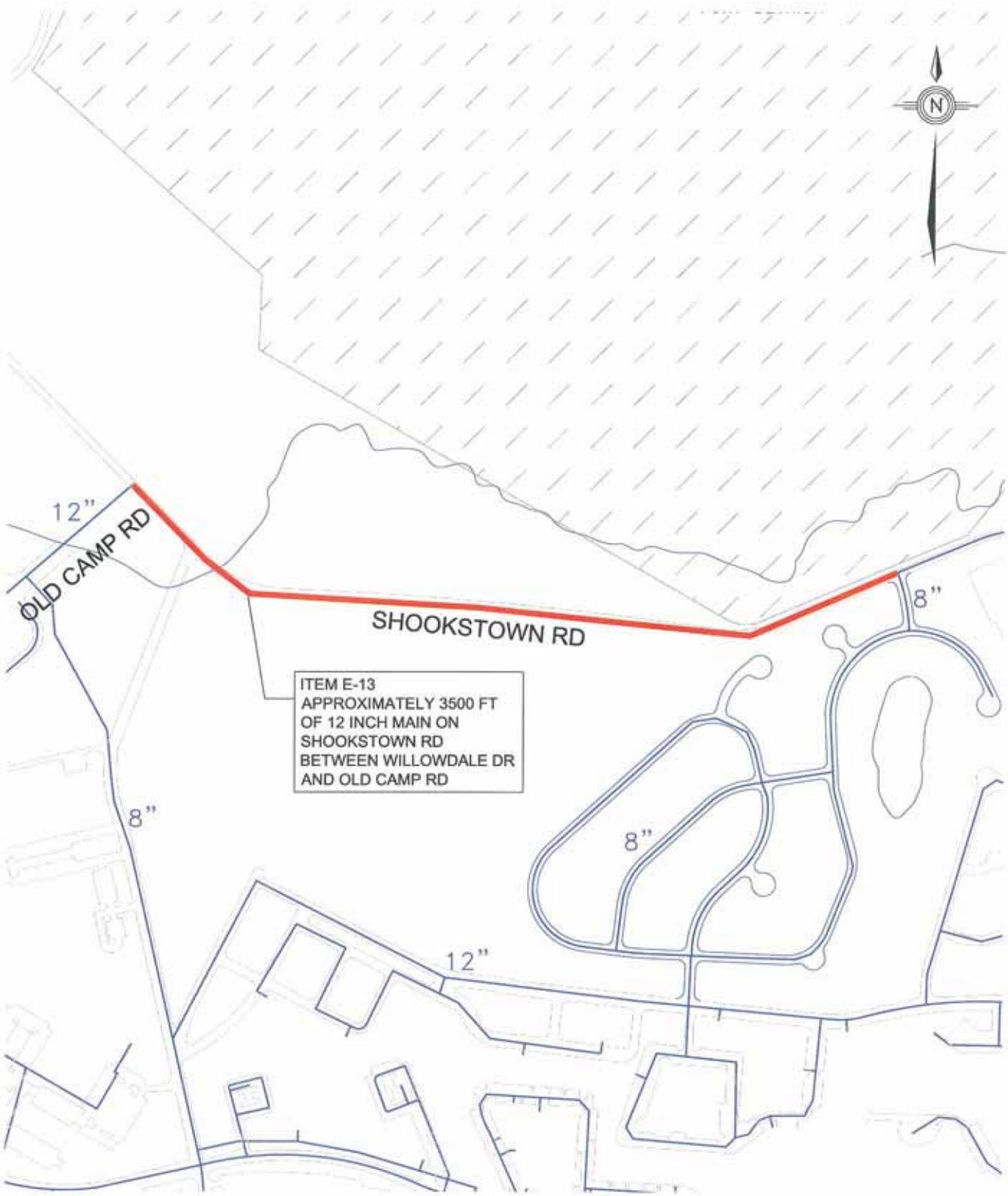


CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-11
12 INCH MAIN ON OLD CAMP ROAD

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-11



0 250 500 750 1000

1"=500'

CITY OF FREDERICK

2006 WATER MASTER PLAN

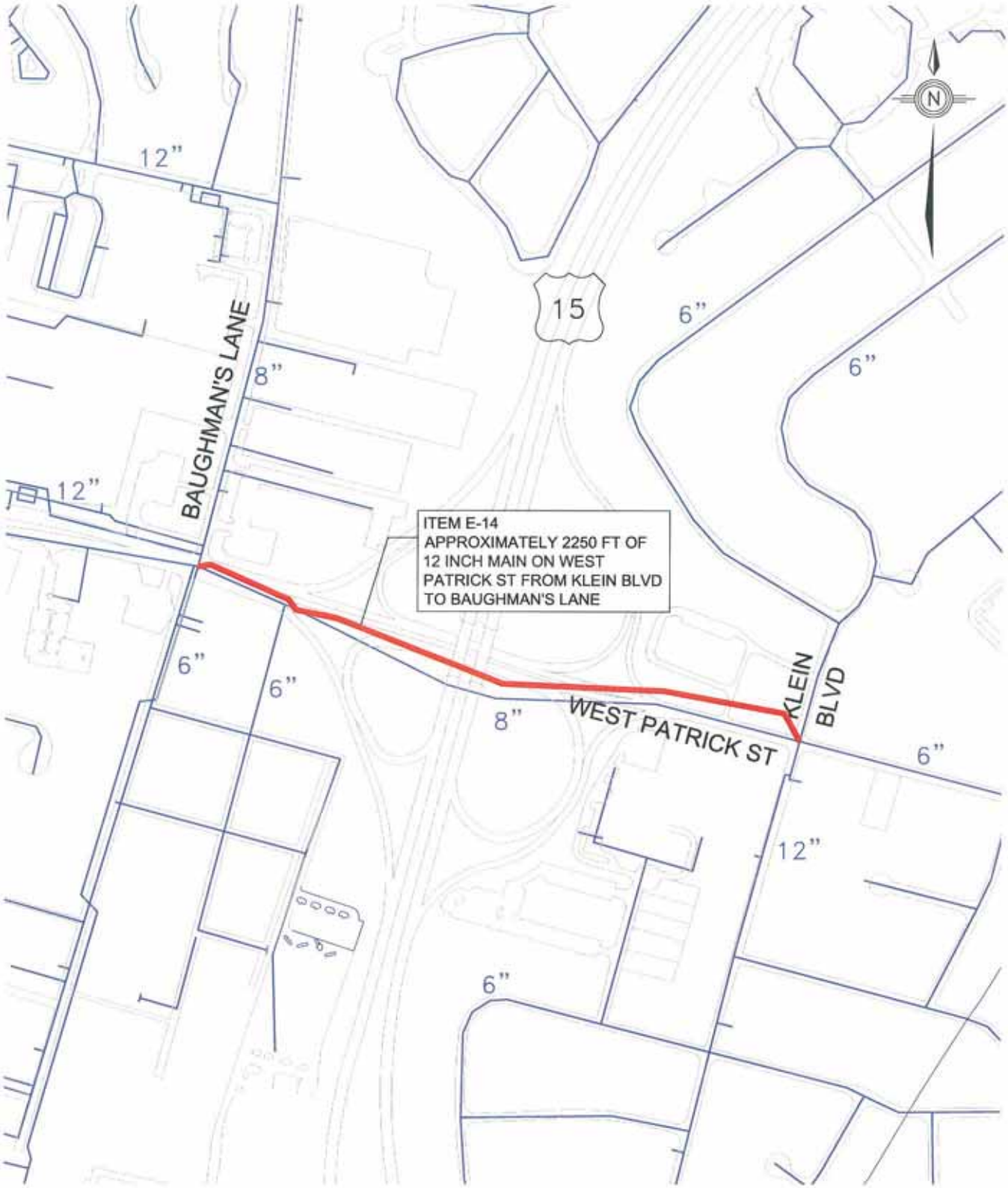
EXISTING UPGRADE E-13

12 INCH MAIN ON SHOOKSTOWN ROAD

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-13



0 250 500 750 1000

1"=500'

CITY OF FREDERICK

2006 WATER MASTER PLAN

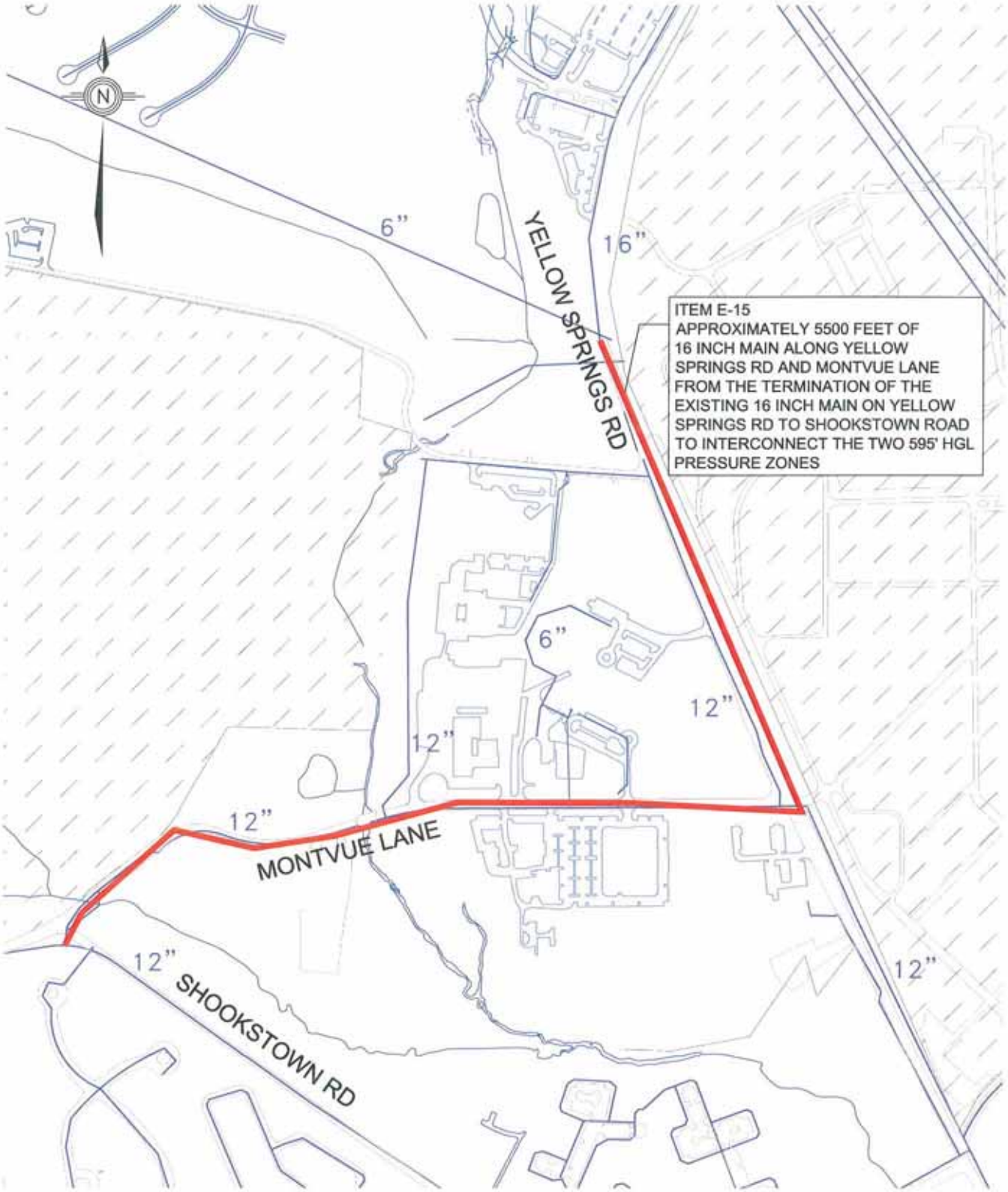
EXISTING UPGRADE E-14

12 INCH MAIN ON WEST PATRICK STREET

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-14



0 300 600 900 1200

1"=600'

CITY OF FREDERICK

2006 WATER MASTER PLAN

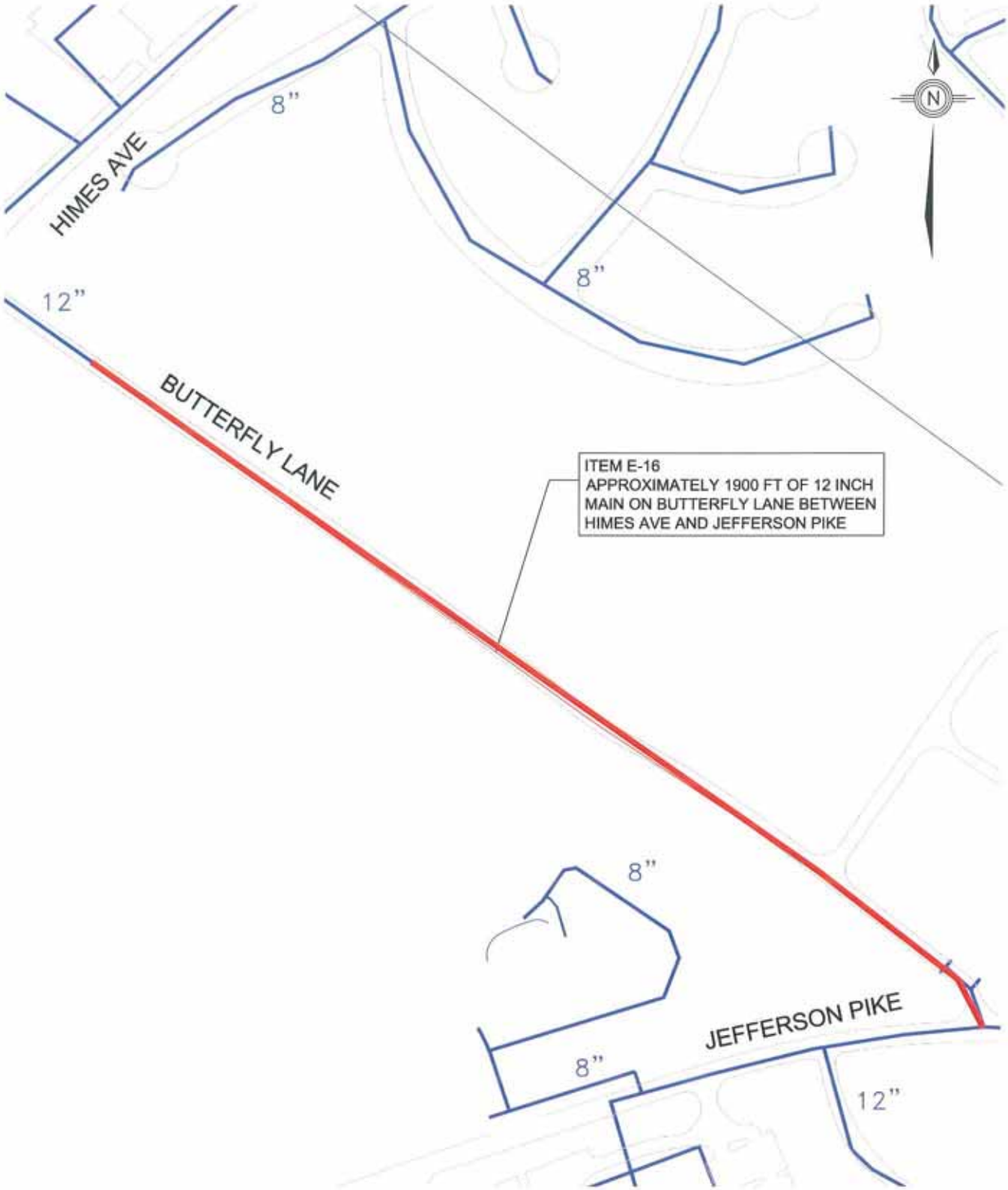
EXISTING UPGRADE E-15

YELLOW SPRINGS ROAD AND MONTVUE LANE

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-15



0 125 250 375 500

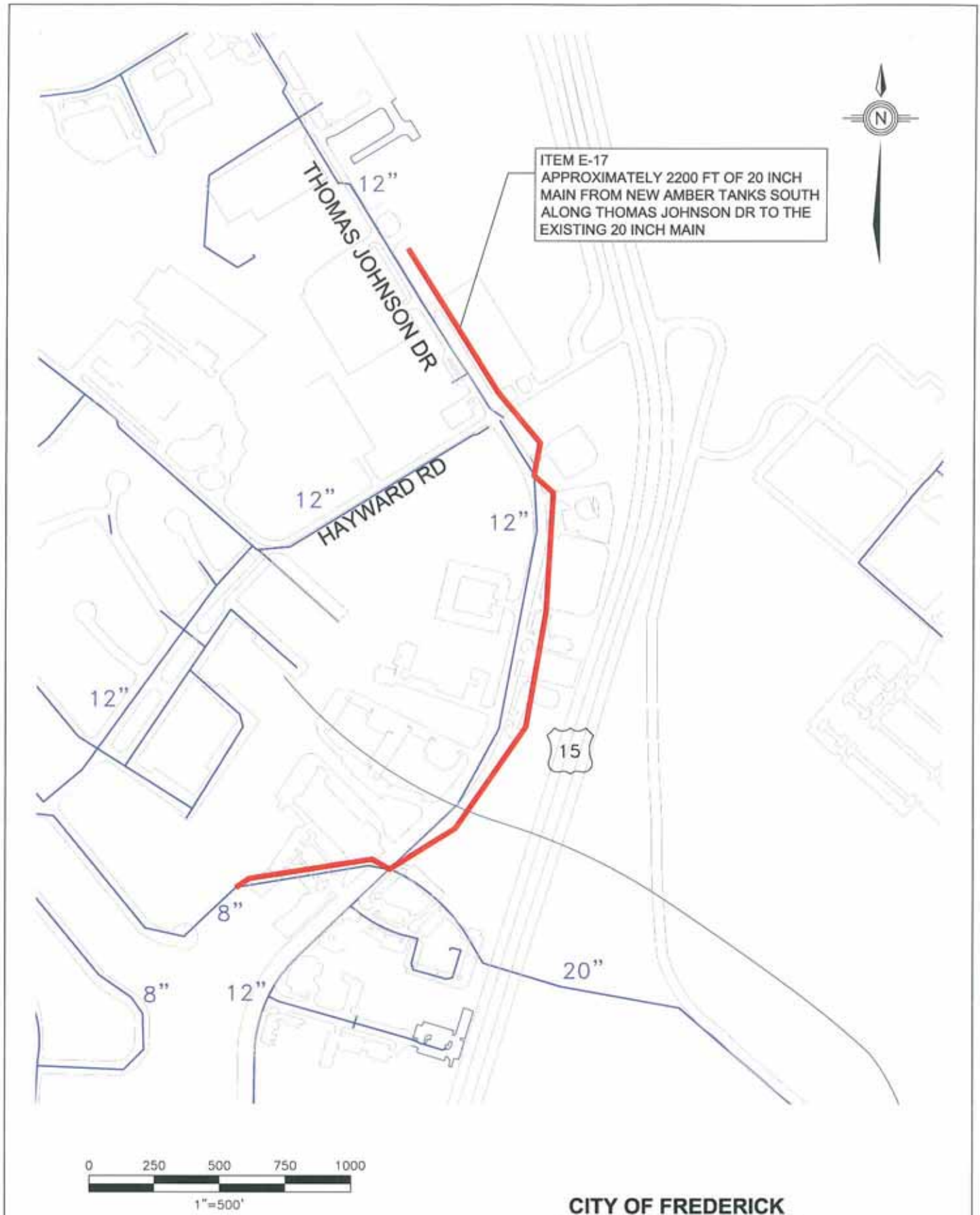
1"=250'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-16
12 INCH MAIN ON BUTTERFLY LANE

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-16

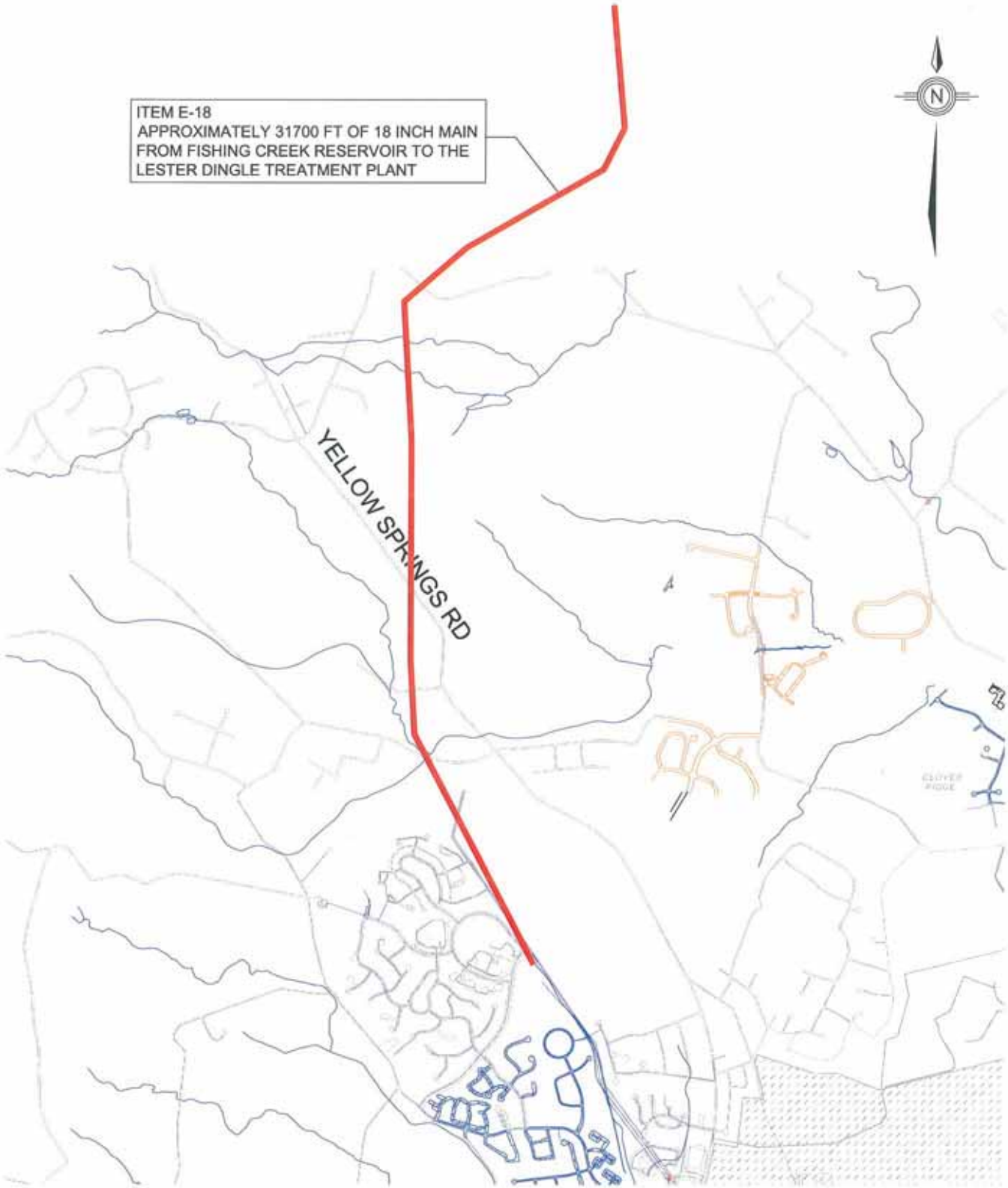


CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-17
20 INCH MAIN ON THOMAS JOHNSON DRIVE

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-17



0 1250 2500 3750 5000

1"=2500'

CITY OF FREDERICK

2006 WATER MASTER PLAN

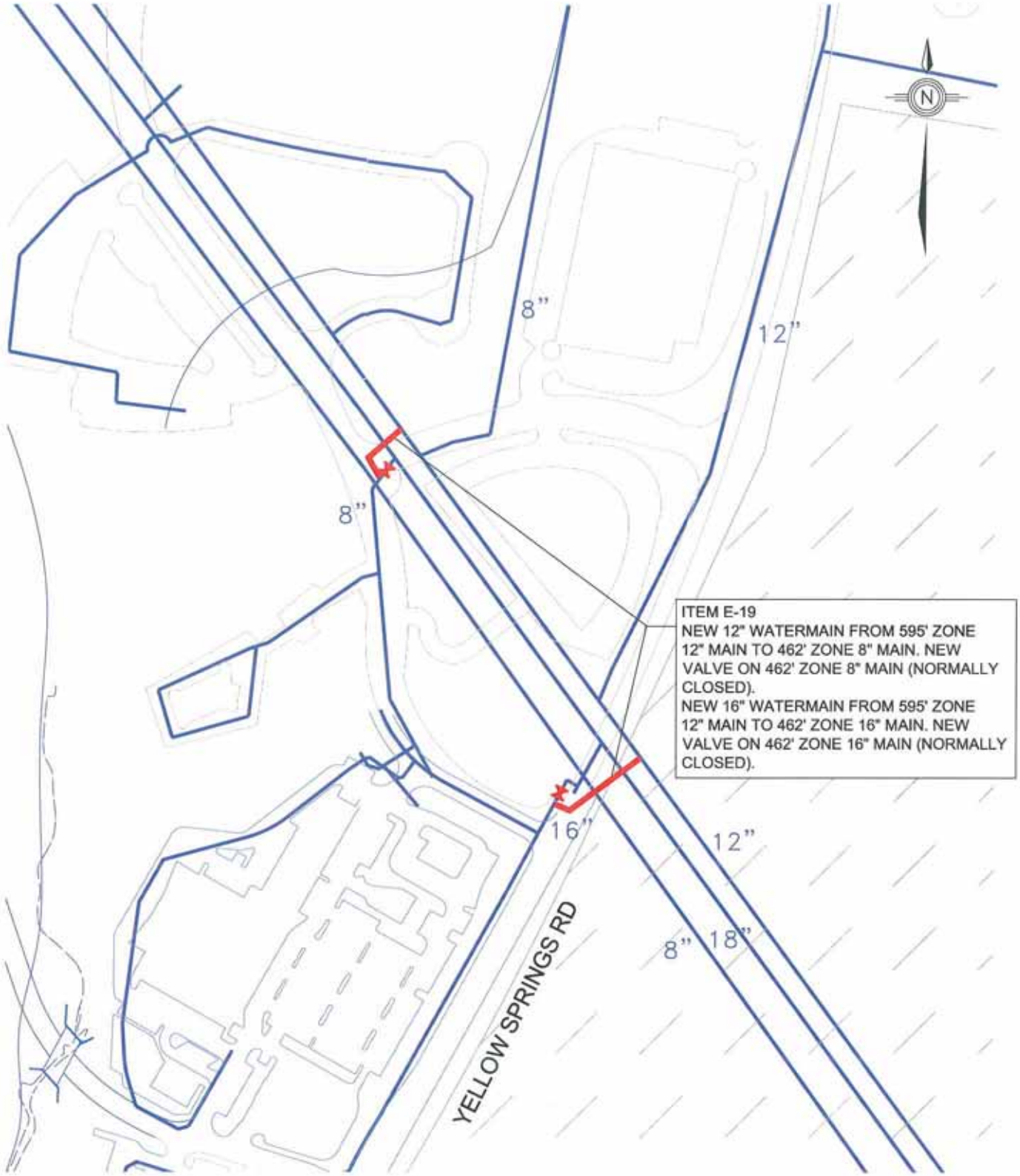
EXISTING UPGRADE E-18

FISHING CREEK RESERVOIR TO LESTER DINGLE WTP

453-1 Water Improvements 1:1 07-01-11

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-18



0 125 250 375 500

1"=250'

CITY OF FREDERICK
2006 WATER MASTER PLAN
EXISTING UPGRADE E-19
ZONE BOUNDARY CHANGE

453-1 Water Improvements 1:1 07-01-11

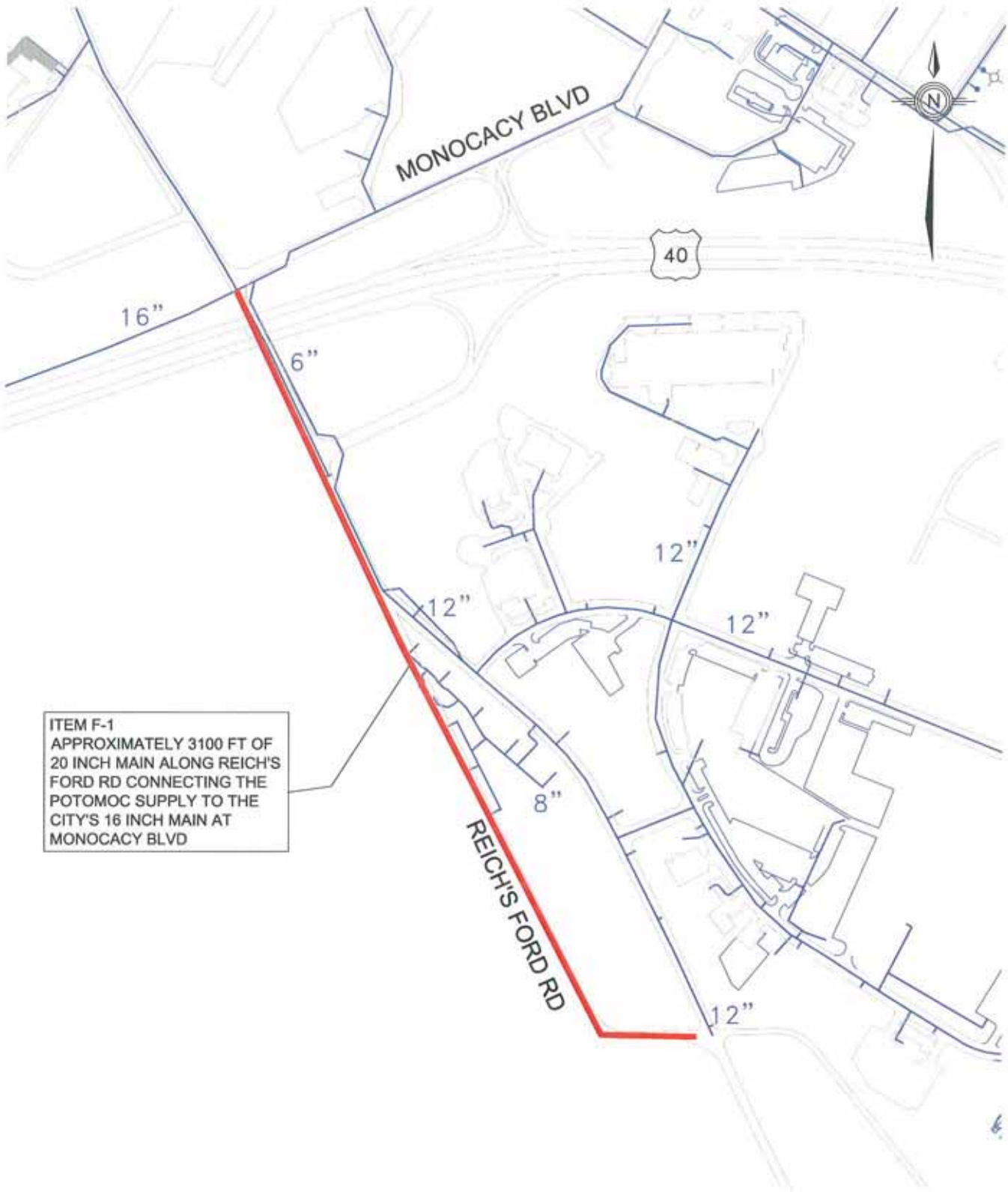
Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE E-19

THE CITY OF FREDERICK
2006 WATER MASTER PLAN

APPENDIX C

FUTURE UPGRADES



0 250 500 750 1000

1"=500'

CITY OF FREDERICK

2006 WATER MASTER PLAN

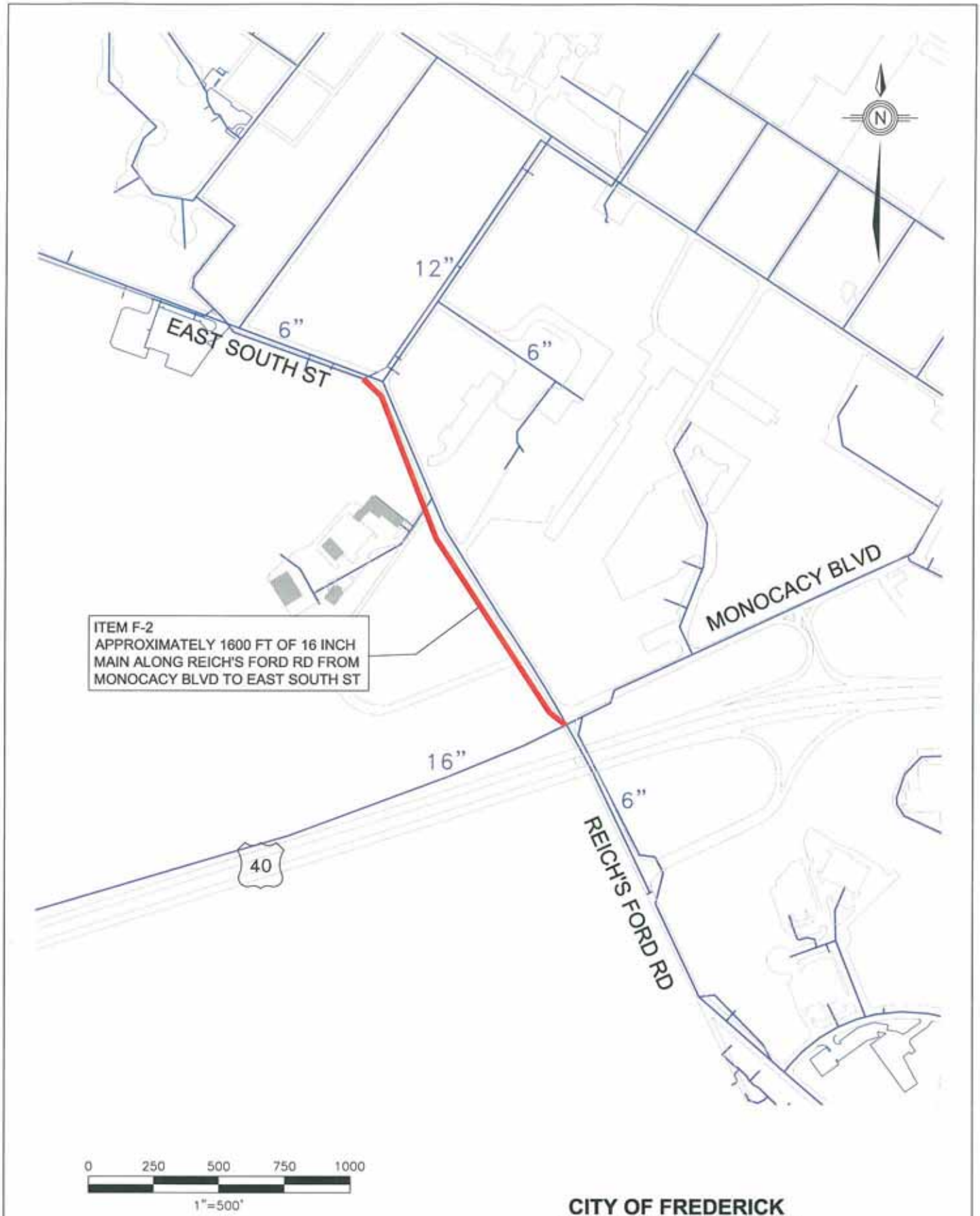
FUTURE UPGRADE F-1

20 INCH MAIN ALONG REICH'S FORD ROAD

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-1

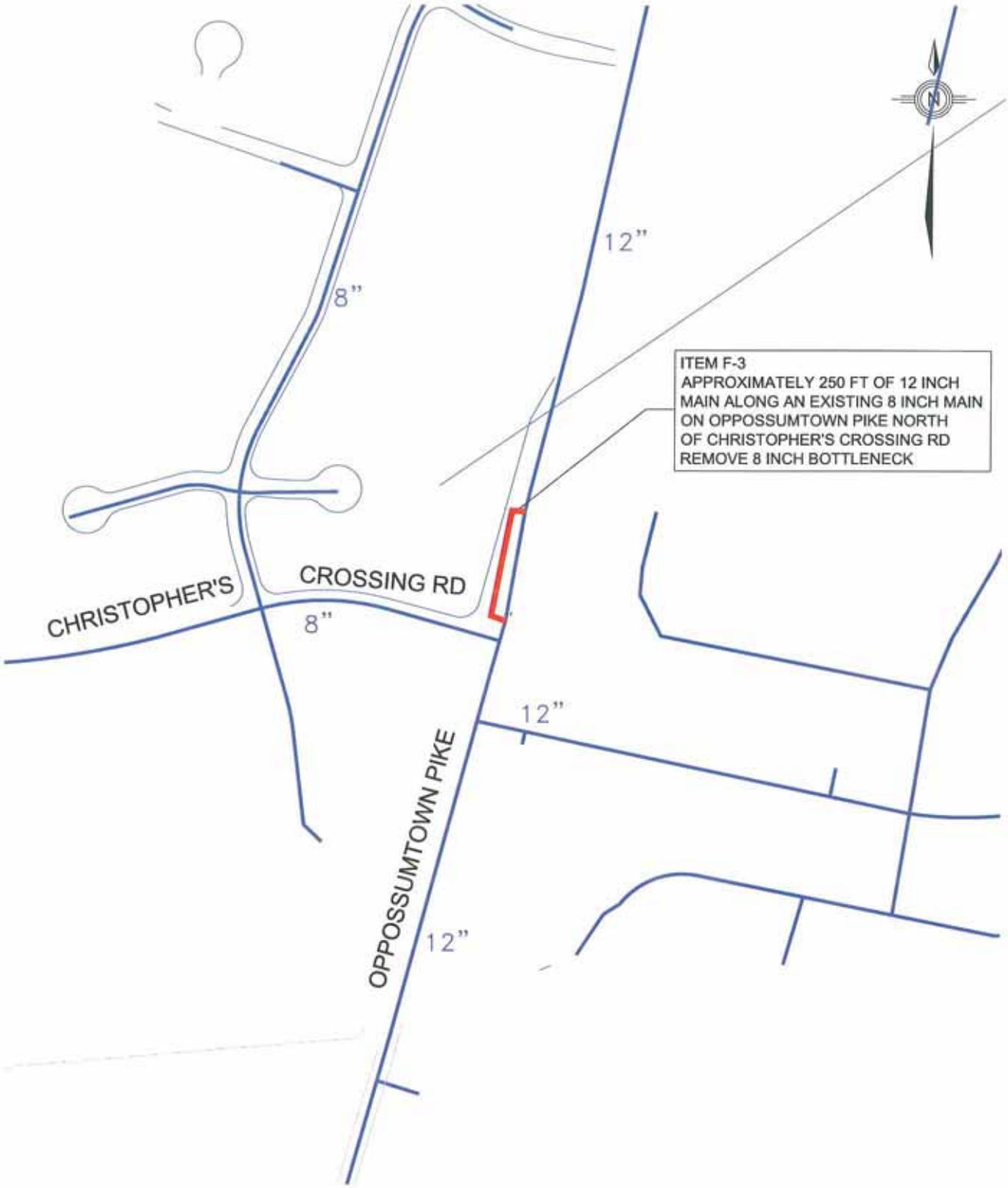


CITY OF FREDERICK
2006 WATER MASTER PLAN
FUTURE UPGRADE F-2
16 INCH MAIN ALONG REICH'S FORD ROAD

453-1 Water Improvements 1:1 07-01-06

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-2



0 125 250 375 500

1"=250'

CITY OF FREDERICK

2006 WATER MASTER PLAN

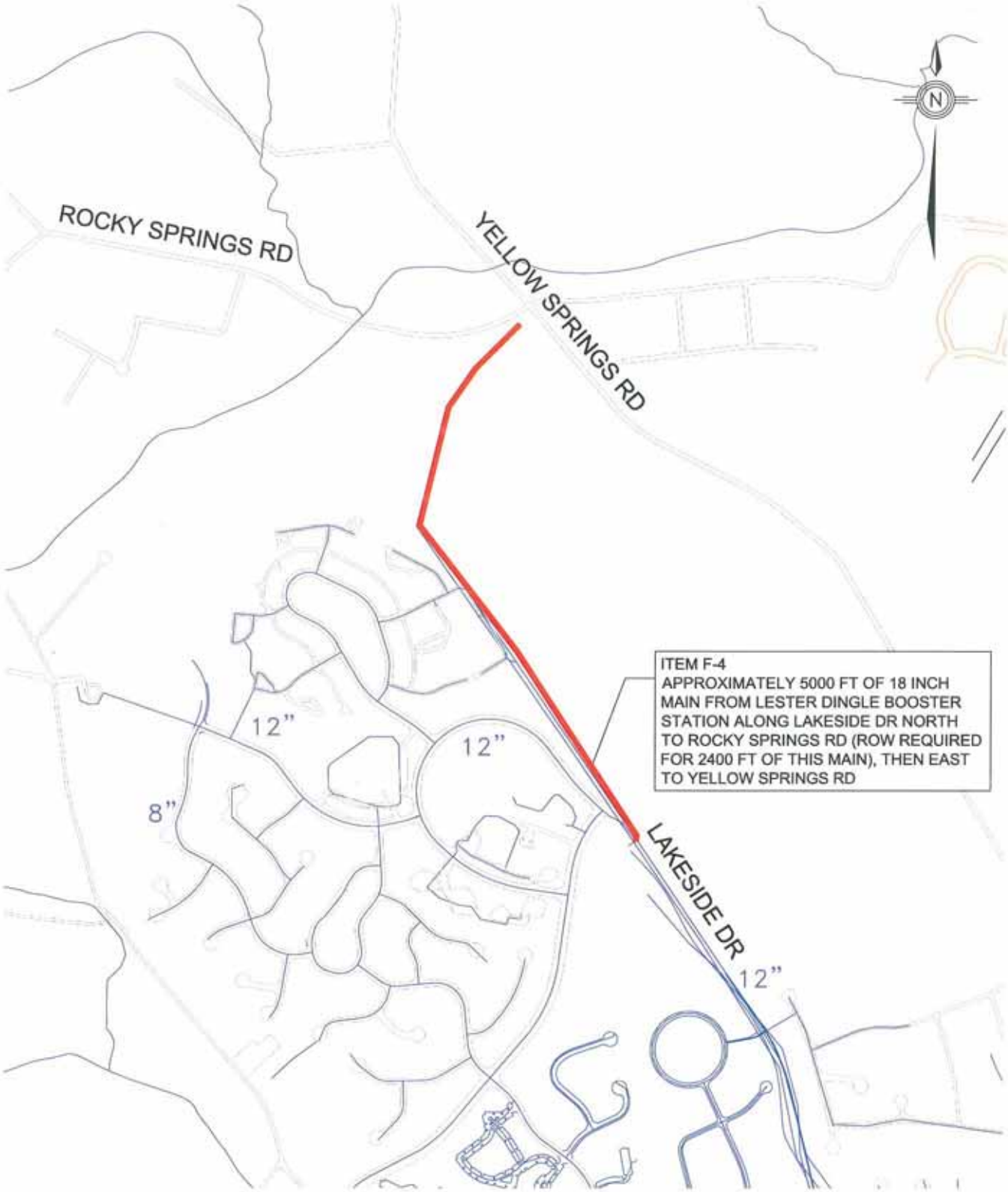
FUTURE UPGRADE F-3

12 INCH MAIN ON OPPOSSUMTOWN PIKE

453-1 Water Improvements 1:1 07-01-08

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-3



0 500 1000 1500 2000

1"=1000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

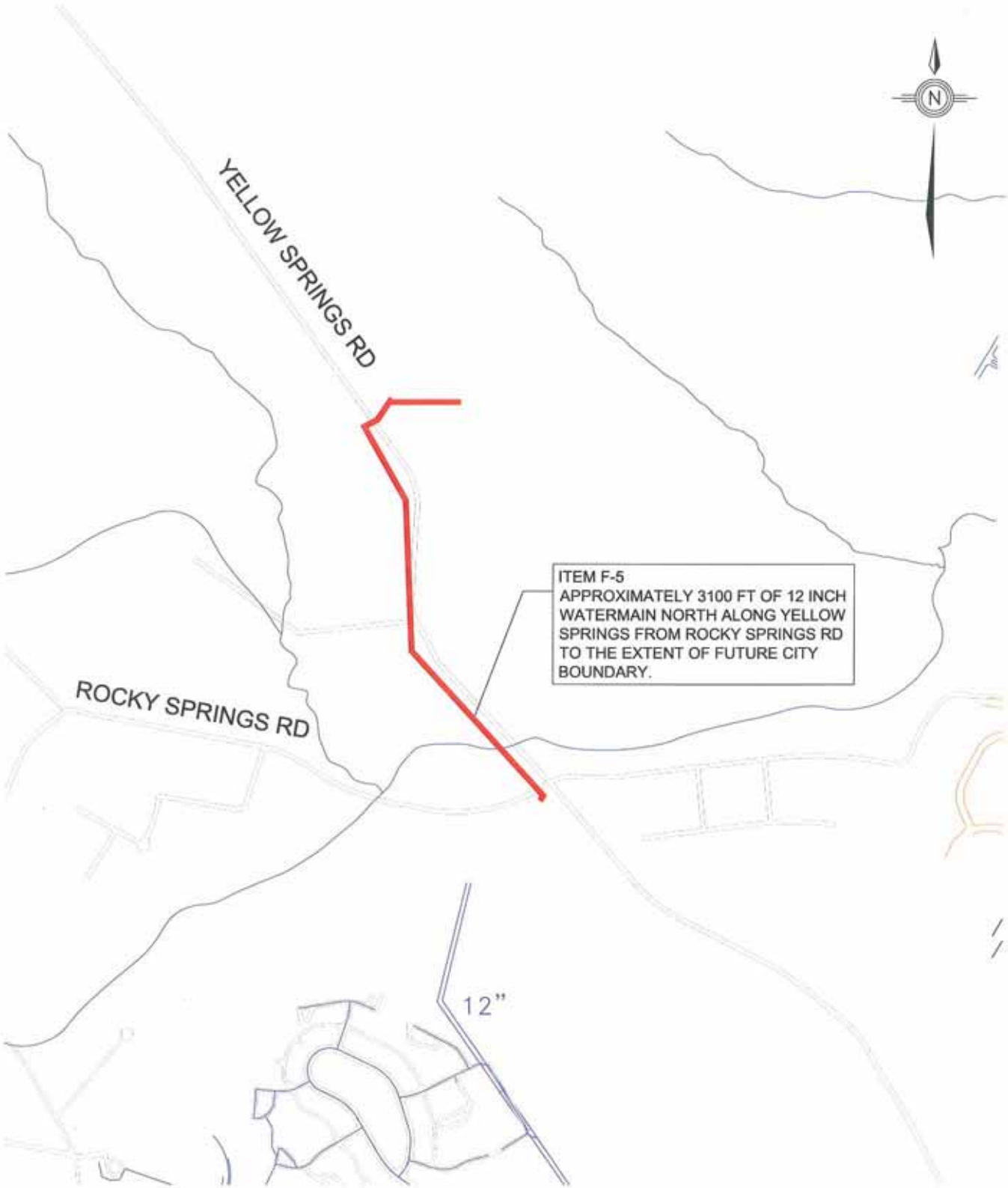
FUTURE UPGRADE F-4

LESTER DINGLE BOOSTER TO YELLOW SPRINGS ROAD

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-4



0 500 1000 1500 2000

1"=1000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

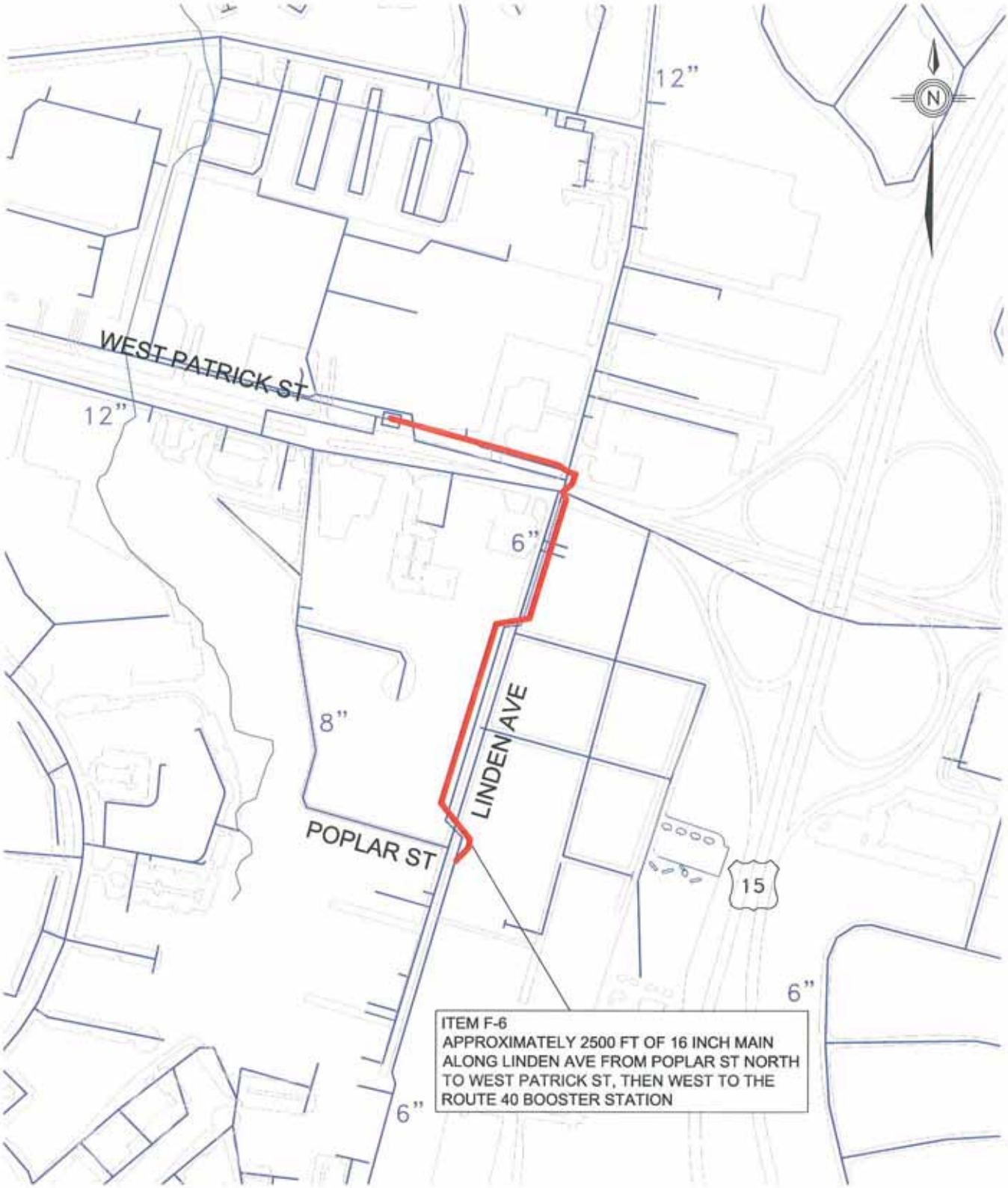
FUTURE UPGRADE F-5

YELLOW SPRINGS ROAD TO EXTENT OF NEW DEVELOPMENT

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-5



0 250 500 750 1000

1"=500'

CITY OF FREDERICK

2006 WATER MASTER PLAN

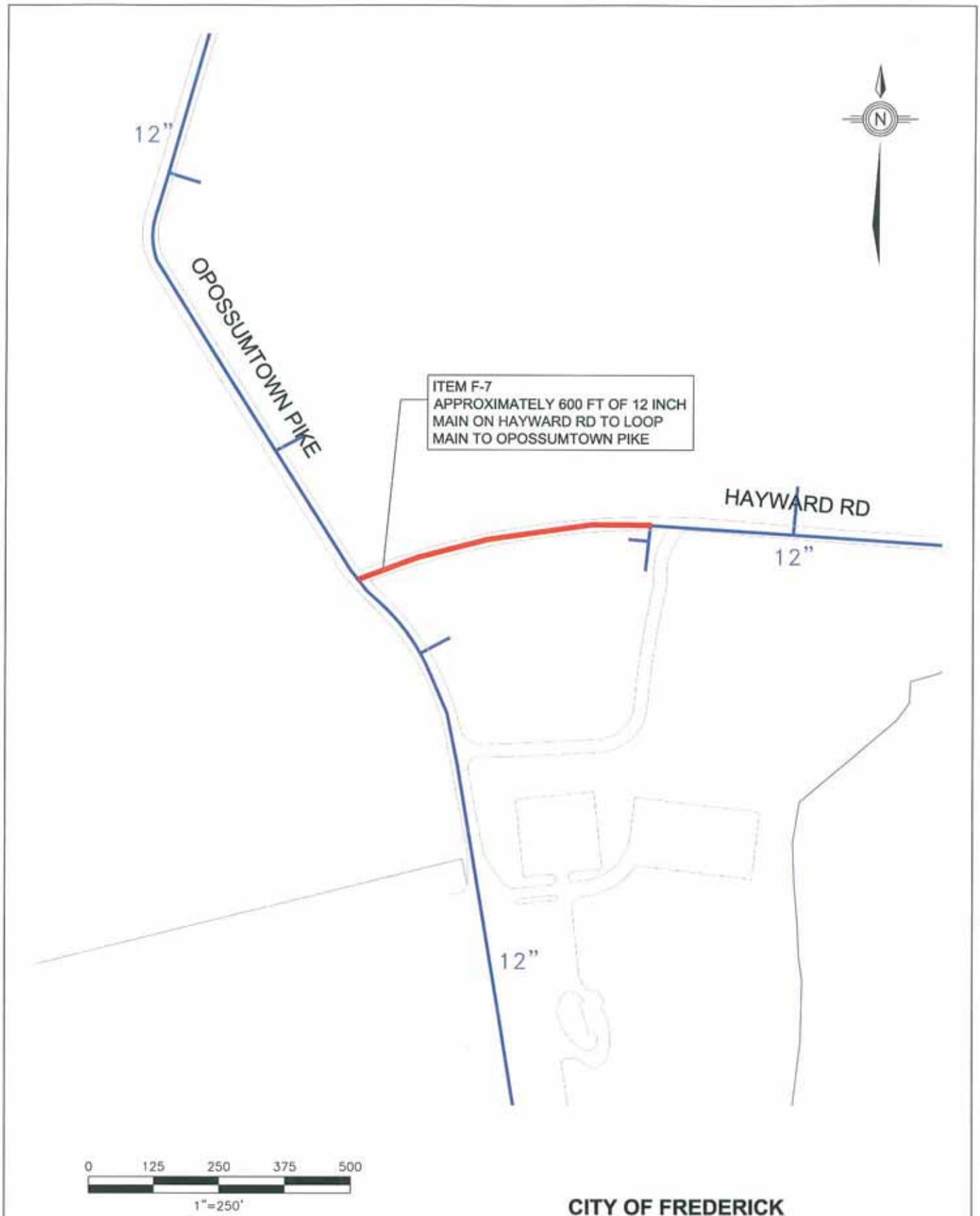
FUTURE UPGRADE F-6

16 INCH MAIN ALONG LINDEN AVENUE

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-6

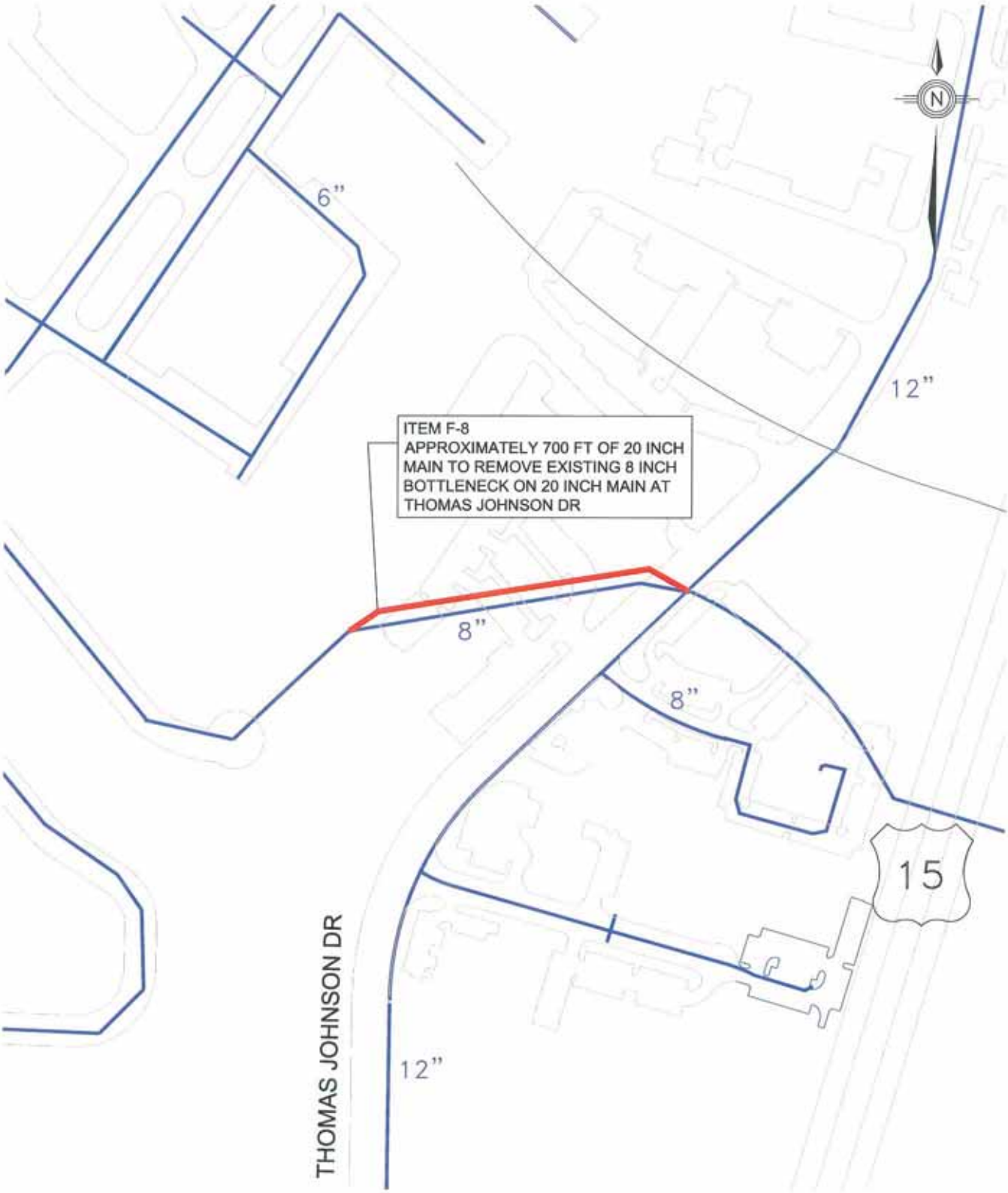


CITY OF FREDERICK
2006 WATER MASTER PLAN
FUTURE UPGRADE F-7
12 INCH MAIN ON HAYWARD ROAD

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-7



0 125 250 375 500

1"=250'

CITY OF FREDERICK

2006 WATER MASTER PLAN

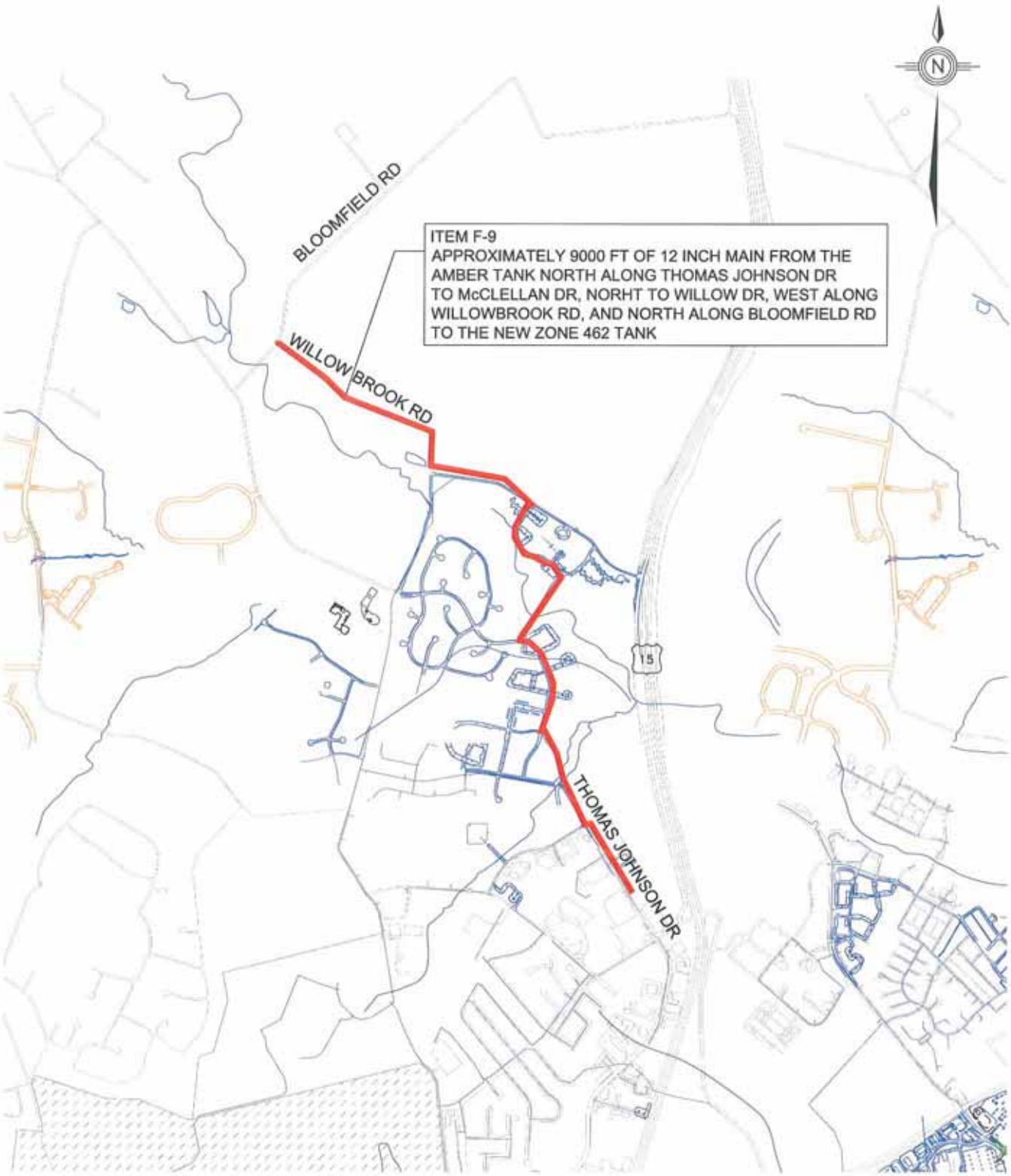
FUTURE UPGRADE F-8

20 INCH MAIN AT THOMAS JOHNSON DRIVE

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
CONSULTING ENGINEERS
DRAWN BY: MB
FILE No. 453.1

FIGURE F-8



0 1000 2000 3000 4000

1"=2000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

FUTURE UPGRADE F-9

AMBER TANK TO NEW ZONE 462 TANK

453-1 Water Improvements 1:1 07-01-09

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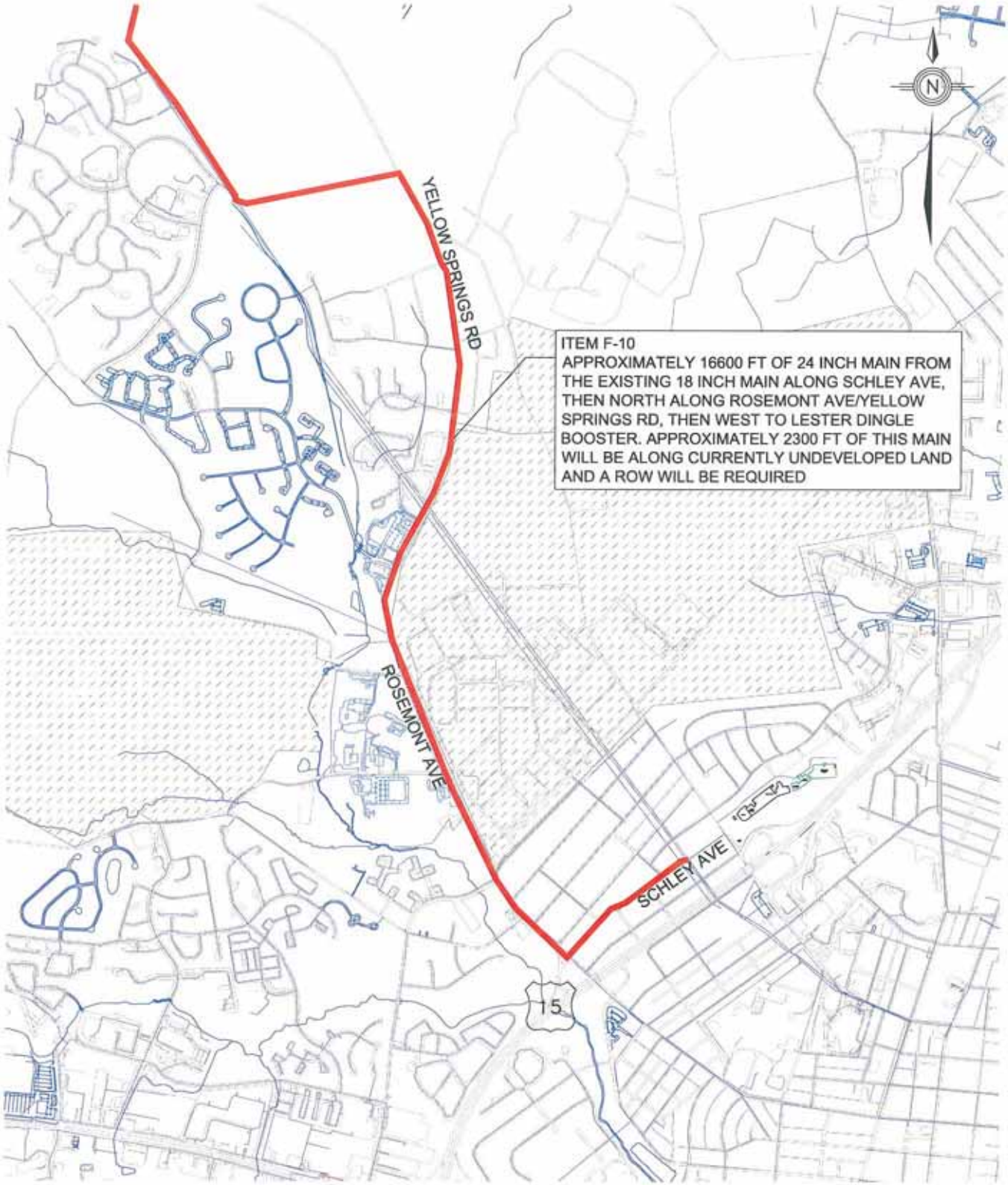
FIGURE F-9



0 1000 2000 3000 4000

1"=2000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

FUTURE UPGRADE F-10

SCHLEY AVENUE TO LESTER DINGLE BOOSTER

453-1 Water Improvements 1:1 07-01-09

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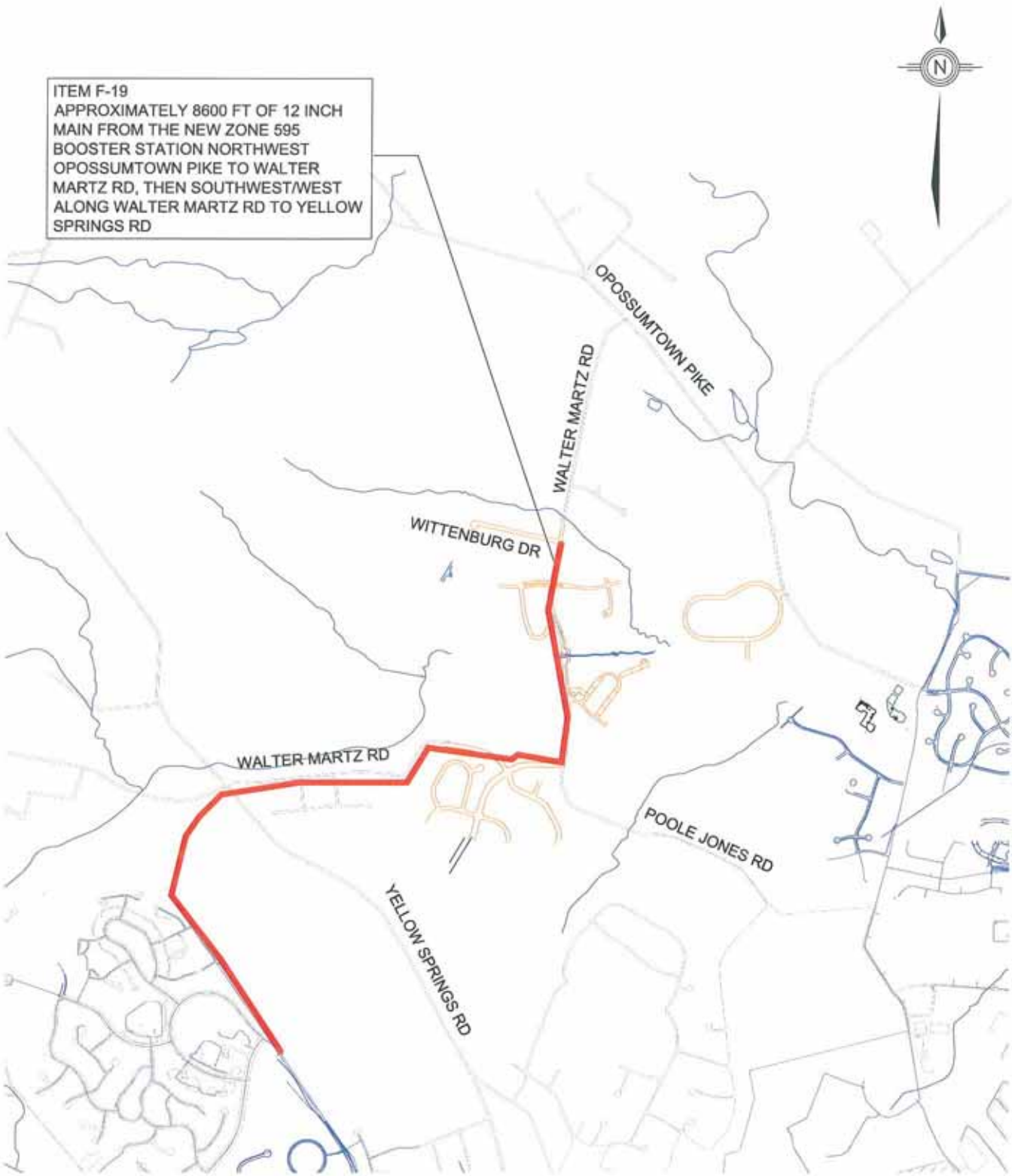
FIGURE F-10



0 1000 2000 3000 4000

1"=2000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

FUTURE UPGRADE F-11

YELLOW SPRINGS AND WALTER MARTZ ROAD TO WITTENBURG DRIVE

453-1 Water Improvements 1:1 07-01-09

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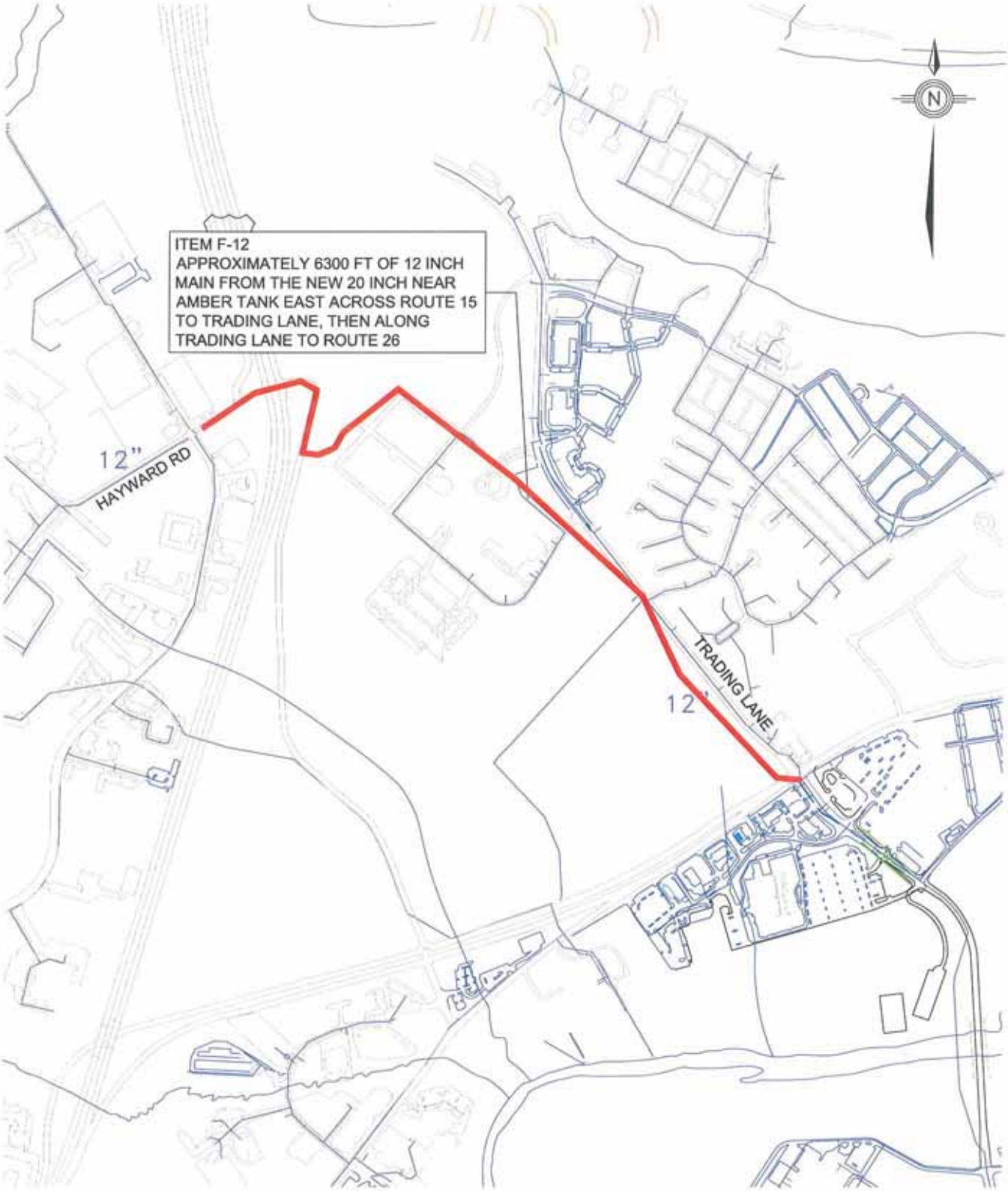
FILE No. 453.1

FIGURE F-11



0 500 1000 1500 2000

1"=1000'

CITY OF FREDERICK
2006 WATER MASTER PLAN
FUTURE UPGRADE F-12
NEW AMBER TANK TO ROUTE 26

453-1 Water Improvements 1:1 07-01-09

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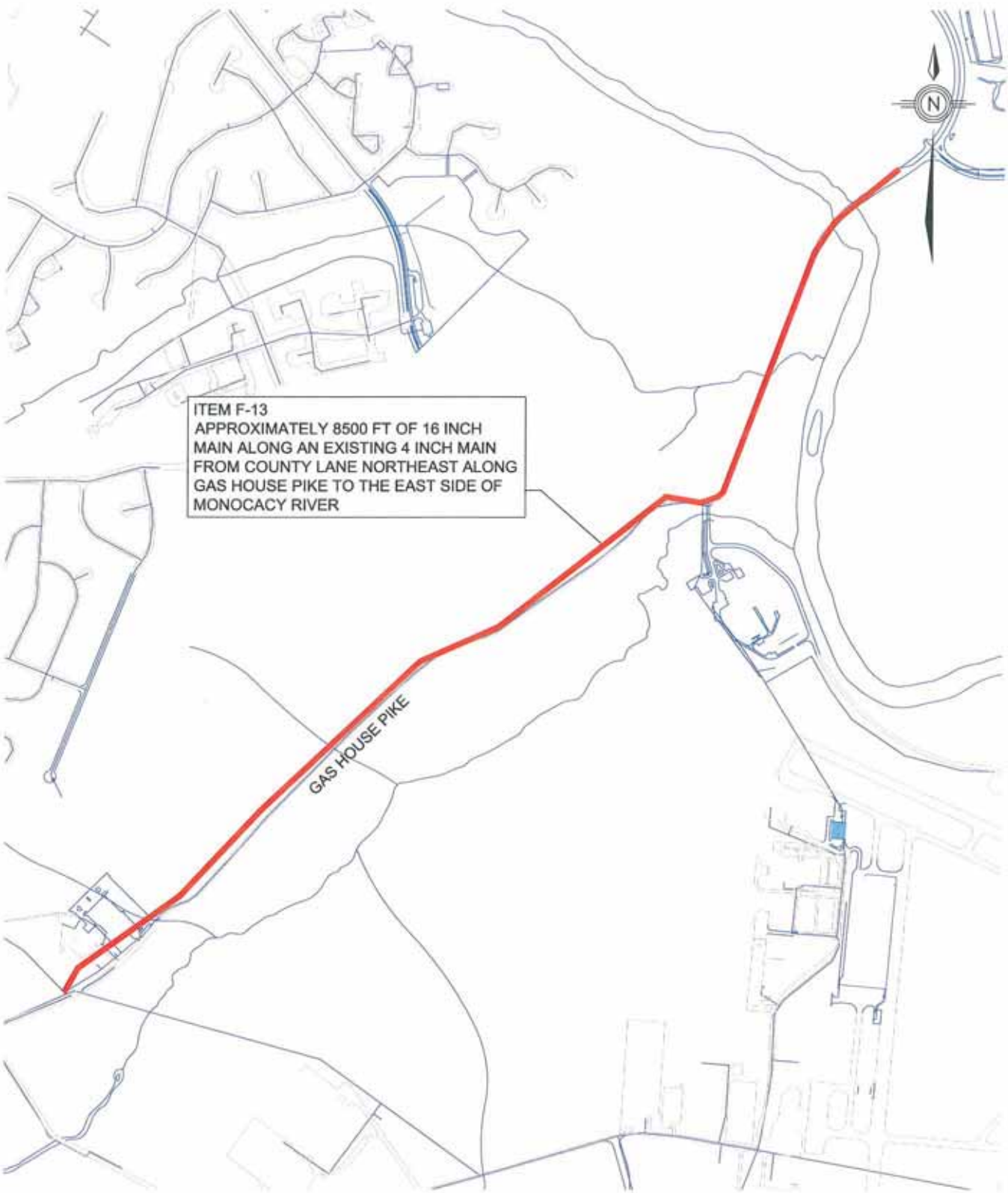
FILE No. 453.1

FIGURE F-12



0 500 1000 1500 2000

1"=1000'

CITY OF FREDERICK

2006 WATER MASTER PLAN

FUTURE UPGRADE F-13

16 INCH MAIN ALONG GAS HOUSE PIKE

453-1 Water Improvements 1:1 07-01-09

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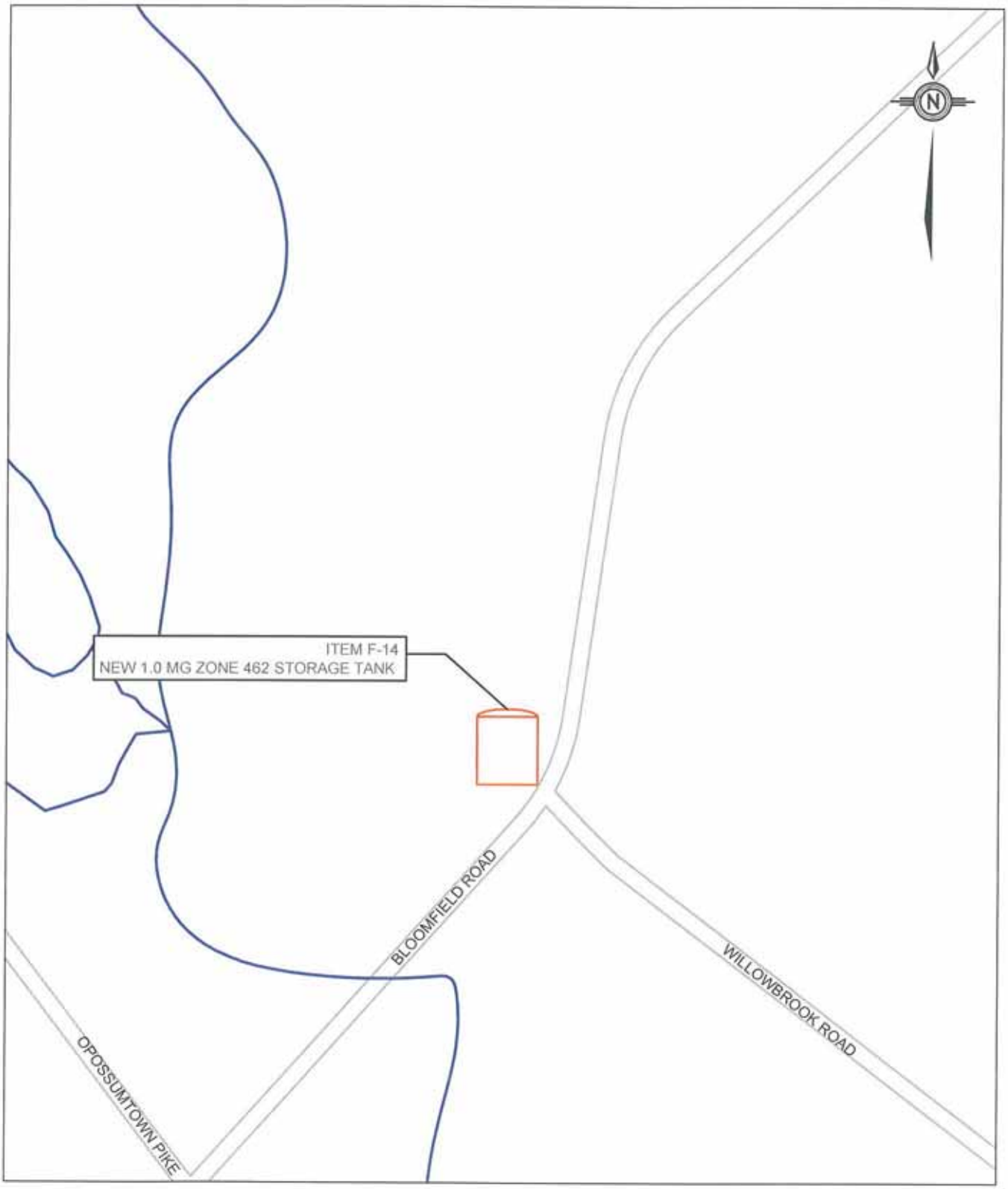
FILE No. 453.1

FIGURE F-13



0 125 250 375 500

1" =250'

City of Frederick
Comprehensive Update to the 2000
Water Master Plan

Future Upgrade F-14
1.0 MG ZONE 462 TANK

453-1 Water Improvements 1:1 07-01-09

Dayton & Knight Ltd.
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FILE No. 453.1

Figure F-14

0 125 250 375 500

1" =250'

City of Frederick
Comprehensive Update to the 2000 Water Master Plan

Future Upgrade F-15
0.75 MG ZONE 595 TANK

453-1 Water Improvements 1:1 07-01-09

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Figure F-15