City of Pearland

Water Model Update

April 2007

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Executive Summary

The objective of this study is to update recommendations for improvements to the City's water system as required to meet projected future water demands. A computer model of the City's water system has been used to achieve this objective. The existing water demands were evaluated, and future demands projected for modeling scenarios up to eighteen years in the future. Using the 2002 water master plan model as a starting point, the model was updated and used to evaluate the water system under existing and future demand conditions. Recommendations are made to address existing system deficiencies and future growth requirements, including, but not limited to additional water supplies, storage, booster pumps, pipelines, system operations, and variations in imported water supply sources.

WATER PRODUCTION AND CONSUMPTION

The City water supply is provided by a network of local groundwater wells and imported water from adjacent cities. The City's total water production in 2006 was approximately 2,950 MG with an average day demand of approximately 7.2 mgd. According to the City's population estimates, the City's population has increased three-fold in the last 15 years. Assuming the same growth trends, water demands in the City will increase by three times in the next eighteen years to approximately 31.3 mgd in 2025 as shown in **Table ES-1**.

Table ES- 1
Demand Projections

Year	Average Day (mgd)	Maximum Day (mgd)
2006	7.2	13.7
2010	13.0	24.7
2015	20.3	38.6
2020	25.7	48.9
2025	31.3	59.4

EXISTING WATER FACILITIES

The current City water facilities include groundwater wells, storage tanks, booster pumps, pipelines, and imported water connections. **Table ES-2** summarizes the City's existing water distribution system infrastructure.

Table ES- 2
City of Pearland Existing Water Distribution System Facilities

Facility Type	Number
City Wells	11
MUD Wells	4
Imported Water Connections	2
Booster Pump Stations	15
Storage Reservoirs	24
Pipelines (all sizes)	302 miles

The City currently obtains its water from 11 operating groundwater wells and 2 imported water connections. Four additional Municipal Utility District (MUD) wells are located in an unincorporated Extra Territorial Jurisdiction (ETJ) area at the southern perimeter of the City. These wells are expected to connect to the City water distribution system by 2015.

The City has twenty four storage tanks, consisting of ground storage tanks and elevated storage tanks at sixteen different sites. The total storage volume excluding MUD tanks is approximately 13.9 MG.

HYDRAULIC MODELING

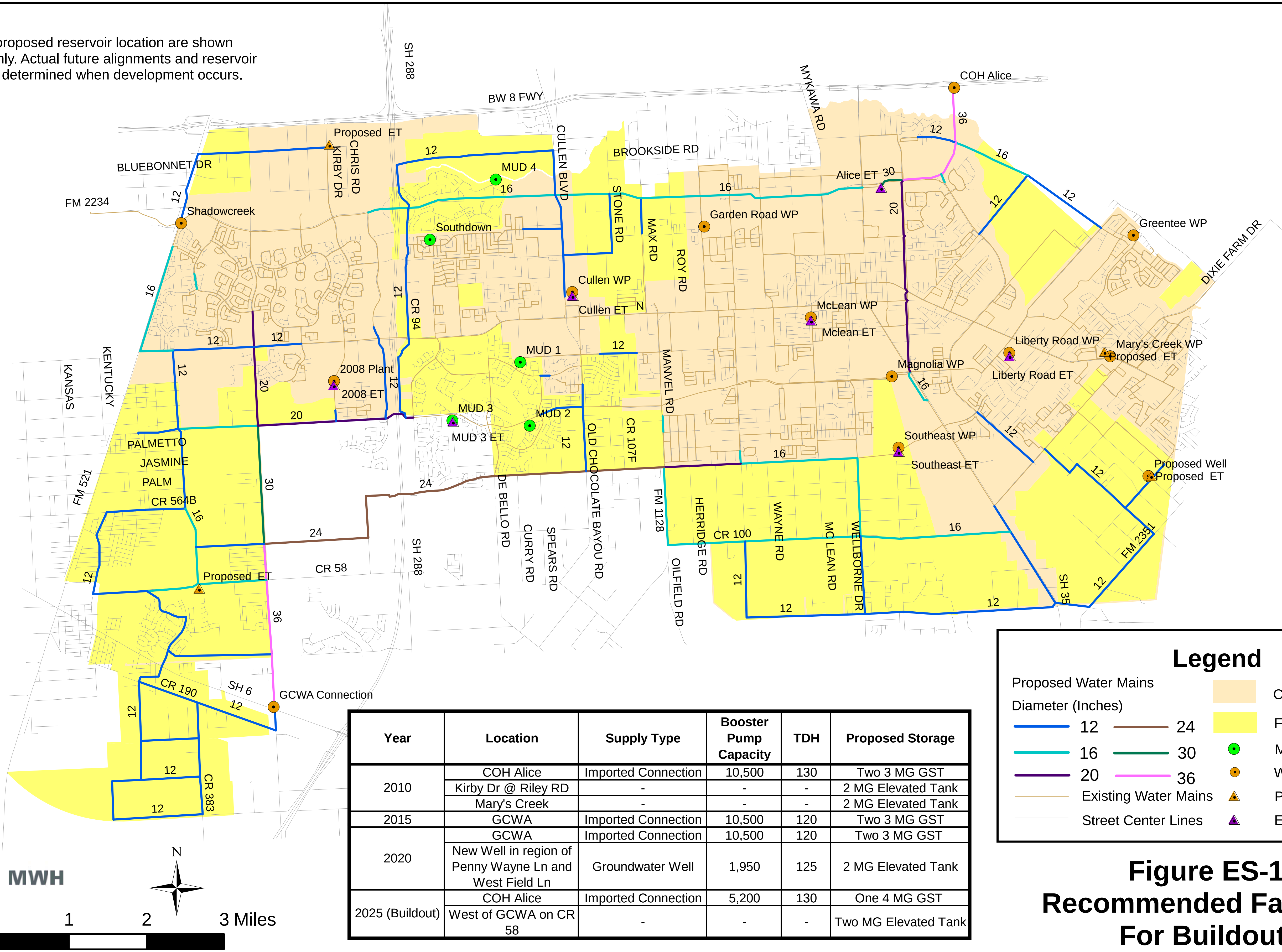
An existing computer model of the City's water distribution system was updated for this project. Current GIS files detailing the City's water distribution system infrastructure were used to add new pipelines and facilities that had been installed since the completion of the 2002 water system master plan. After the existing model was updated, the model was validated based on actual field data. Validation is the process of comparing model data to field data to verify model accuracy. In the validation, pressures at each supply source were no greater than 7.1 percent (3.8 psi) off from average field pressure at any one source during the month of September, 2006.

SYSTEM EVALUATION

The water system is evaluated for its ability to meet supplies under 2010, 2015, 2020 and 2025 (build-out) demands. Supply and storage capacities are compared with recommended supply and storage criteria. Recommendations for additional supplies and storage are made to address the deficiencies. The hydraulic model is used to evaluate system pressures and pipeline velocities, and to make recommendations for the sizing of future pipelines and facilities. **Table ES-3** lists the recommended facilities and **Table ES-4** lists the length of recommended new pipelines. The approximate locations for these pipelines and facilities are shown in **Figure ES-1**.

Notes:

1. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.



Year	Location	Supply Type	Booster Pump Capacity	TDH	Proposed Storage
2010	COH Alice	Imported Connection	10,500	130	Two 3 MG GST
	Kirby Dr @ Riley RD	-	-	-	2 MG Elevated Tank
	Mary's Creek	-	-	-	2 MG Elevated Tank
2015	GCWA	Imported Connection	10,500	120	Two 3 MG GST
2020	GCWA	Imported Connection	10,500	120	Two 3 MG GST
	New Well in region of Penny Wayne Ln and West Field Ln	Groundwater Well	1,950	125	2 MG Elevated Tank
2025 (Buildout)	COH Alice	Imported Connection	5,200	130	One 4 MG GST
	West of GCWA on CR 58	-	-	-	Two MG Elevated Tank

Legend

Proposed Water Mains Diameter (Inches)

- 12
- 16
- 20
- 24
- 30
- 36
- Existing Water Mains
- Street Center Lines
- City_Limits
- Future Development
- MUD Wells
- Water Plants
- Proposed Elevated Tank
- Existing Elevated Tank

MWH

Figure ES-1 Recommended Facilities For Buildout

Table ES- 3
Recommended Water Facilities

Facility Location	Description	Year
COH Alice	15 mgd imported connection, 10 MG ground storage, booster pump station	Two phases: 2010 (10 mgd) and 2025 (5 mgd)
Near Kirby Drive and Riley Road	2 MG elevated tank	2010
Mary's Creek WP	2 MG elevated tank	2010
GCWA	20 mgd imported connection, 12 MG ground storage, booster pump station	Two phases: 2015 and 2020
Near Penny Wayne Ln and West Field Drive	Groundwater well, 0.6 MG ground storage, booster pump station, 2 MG elevated tank	2015
West of GCWA on CR58	2 MG elevated tank	2025

Table ES- 4
Approximate Length of Recommended Pipelines

Year	Pipeline Diameter						Total (ft)
	12-inch	16-inch	20-inch	24-inch	30-inch	36-inch	
2010	29,500	3,500	15,600	0	1,700	2,700	53,000
2015	67,000	78,000	10,800	30,500	0	11,000	197,300
2020	70,300	10,000	0	0	0	0	80,300
2025	101,900	15,600	0	0	0	0	117,500
Total (ft)	**268,700**	**107,100**	**26,400**	**30,500**	**1,700**	**13,700**	**448,100**

Section 1
Introduction

This report discusses the effects of additional and modified developments on the City of Pearland's water distribution system master plan. This section provides an overview of the project and an outline of the report.

PROJECT BACKGROUND AND STUDY AREA

The City of Pearland, Texas (City) has a population of approximately 80,500 with annex in 2007, and provides water service to this population. The City water supply is provided by a network of local groundwater wells and imported water from adjacent cities. In 2002, Montgomery Watson Harza (MWH) completed the City's water master plan, identifying additional facilities needed to meet future demands under projected land use and population conditions through build-out. Since completion of the master plan, new developments have warranted an additional study to evaluate current and projected water distribution system infrastructure requirements.

The study area for this project included all areas within City limits. Also included were multiple Extra Territorial Jurisdiction (ETJ) areas on the perimeter of the City, primarily on the City's southern border. The study area for this project is identical to that of the 2002 water master plan.

OBJECTIVE AND SCOPE OF WORK

The objective of this study is to update recommendations for improvements to the City's water system as required to meet projected future water demands. A computer model of the City's water system is used to achieve this objective. The existing water demands are evaluated, and future demands projected for modeling scenarios up to eighteen years in the future. Using the 2002 water master plan model as a starting point, the model is updated and used to evaluate the water system under existing and future demand conditions. Recommendations are made to address existing system deficiencies and future growth requirements, including, but not limited to additional water supplies, storage, booster pumps, pipelines, system operations, and variations in imported water supply sources.

The scope of work for this study includes the following tasks:

- Collection and review available information
- Model creation / update of all existing water facilities (i.e. storage tanks, groundwater wells, water plants, imported water sources) and proposed 288/518 groundwater well
- Model creation / update of all existing pipelines 12-inches in diameter and greater
- Model creation / update of existing pipelines 8 to 10-inches in diameter when needed for looping
- Demand allocation - four model run years: 2010 (base), 2015, 2020, 2025 (buildout)

- Evaluate the water system based on current and future water demands, 288/518 well addition, and source water addition scenario variations
- Review and recommend improvements to meet future growth and correct deficiencies
- Report production
- Project management and meetings
- Quality assurance and quality control

DATA SOURCES

In preparation for this study, City staff provided information necessary to develop the water model and future water distribution system demands. Additionally, material was obtained from other sources, including the United States Geological Survey (USGS) and the City of Pearland website. Pertinent materials included water system maps, City maps, planning and development information, historical records, and detailed facility information. Meetings were held with City staff during the course of the study to review and verify project data.

AUTHORIZATION

This report has been developed in accordance with an agreement between the City and MWH dated October 13, 2006.

HYDRAULIC MODEL ANALYSIS REPORT OUTLINE

This report consists of the following sections:

- Section 2 discusses the study area population, land use and development, existing water demand and production, and demand projections within the City to the year 2025.
- Section 3 focuses on model creation and calibration, and planning criteria.
- Section 4 discusses the existing water facilities.
- Section 5 describes the evaluation of the existing and future systems, recommendations and conclusions.

ABBREVIATIONS

To conserve space and improve readability, abbreviations have been used in this report. Each abbreviation has been spelled out in the text the first time it is used. Subsequent usage of the term is usually identified by its abbreviation. The abbreviations used are shown in **Table 1-1**.

Table 1-1
Abbreviations

Abbreviation	Explanation
acre-ft/yr	acre-feet per year
ADD	Average Day Demand
ADP	Average Day Production
asl	above sea level
AWWA	American Water Works Association
City	City of Pearland, Texas
DU	dwelling unit
DU/acre	dwelling unit per acre
EPS	Extended Period Simulation
ETJ	Extra Territorial Jurisdiction
fps	feet per second
gpad	gallons per acre per day
gpd	gallons per day
gpm	gallons per minute
HGL	Hydraulic Grade Line
hp	horsepower
HWL	High Water Level
MDD	Maximum Day Demand
MDP	Maximum Day Production
MG	Million Gallons
MG/yr	million gallons per year
mgd	million gallons per day
MUD	Municipal Utility District
PHD	Peak Hour Demand
psi	pounds per square inch
SCADA	Supervisory Control and Data Acquisition
sf	square feet
TDH	Total Dynamic Head
USGS	United States Geological Survey
WDF	Water Duty Factor

Section 2
Historical Demand and Demand Projections

This section provides an analysis of historical water demand and production, along with a discussion of future water demand projections based on new developments. Peaking factors for maximum day and peak hour water uses were based on the previous master plan and verified for current use. A comparison of water currently available through water supply sources against existing and future demands is made to determine water production facility needs through buildout.

STUDY AREA

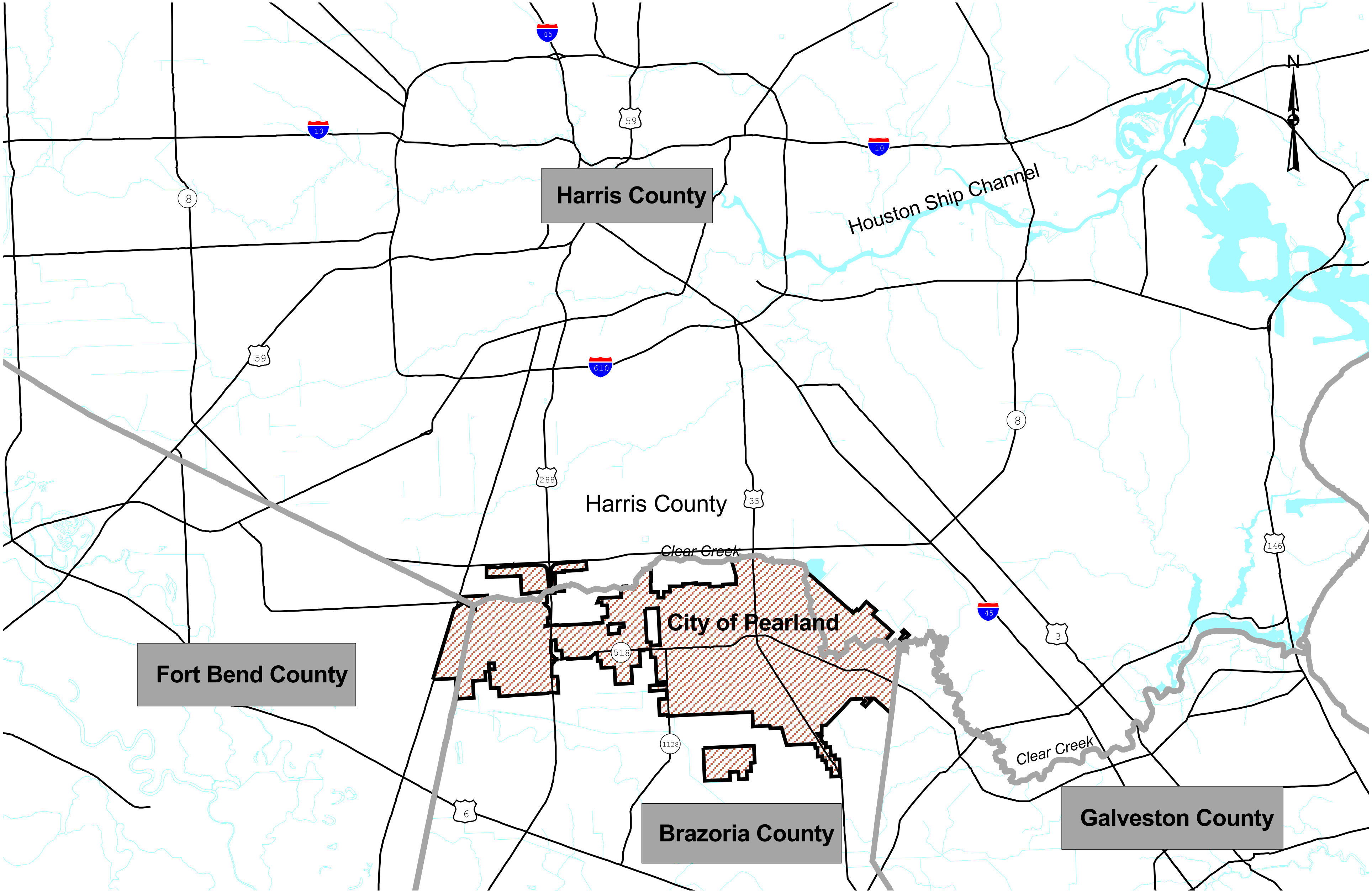
The City of Pearland is a suburb located near the heart of the Houston Metroplex, covering approximately 72.3 square miles including Extra Territorial Jurisdiction (ETJ) in northern Brazoria County. The ETJ is the unincorporated land within five miles of Pearland's boundary that is not within the city limits or ETJ of another city. It is the territory where Pearland alone is authorized to annex land. ETJ gives a municipality the right to apply its zoning and sub-division ordinances to nearby properties that are not within the municipality and not incorporated in another municipality. The City is located approximately 18 miles south of downtown Houston and approximately 40 miles northwest of Galveston. Three Texas State highways cross through City borders: State Highway 288, State Highway 35, and FM 518. The northern boundary of the City lies along Beltway 8, Houston's second loop. A map of the City and vicinity is shown in **Figure 2-1**.

The study area consists of predominantly flat, gentle terrain that slopes to the east. Elevations range from approximately 30 feet above sea level (asl) near the southeast corner of the City to 70 feet asl in the vicinity of the City's northwest boundary.

The City provides water service to local customers only. The service area consists of residential, commercial, and industrial developments, as well as open space such as community parks, golf courses and cemeteries. Commercial use areas are concentrated along State Highway 288 and FM 518. Industrial use areas are concentrated in the eastern and southeastern sections of the City, primarily along State Highway 35. Two major new developments are located at the northwest and northeast corners of the City.

POPULATION

The City has a population of approximately 80,500 (2007 City estimate) with annex in 2007. According to the City's population estimates, the City's population has increased three-fold in the last 15 years.



MWH
MONTGOMERY WATSON HARZA

City of Pearland Water Model Update

Figure 2-1
City of Pearland

LAND USE AND DEVELOPMENT

Information on existing and planned land use was provided by the Water Master Plan (MWH, August 2002) and various City departments.

Future land use in this study and in previous reports is based on information provided by the City in the form of land use planning documents, existing infrastructure maps, existing master plans, and as-builts and construction documents. **Figure 2-2** details land use projections and growth timing estimates used as the basis for developing future hydraulic modeling scenarios.

For the development analysis in this study, the City's 19 land use types were considered as the following: Parks; Public/Semi-public; Retail, Offices, and Services; Village District; Business Commercial; Low Density Residential; Medium Density Residential; Mixed Use Business Park; Offices; B-15,000 sf Lots (Suburban Residential); Garden/O'Day Mixed Use District; High Density Residential; Industrial; Light Industrial; A-1/2 Ac. Lots (Suburban Residential); Business Park; C-12,000 sf Lots (Suburban Residential); Cullen Mixed Use District; and D-12,000 sf Lots (Suburban Residential). The land use information provided by the City was combined with the Water Duty Factors (WDFs) listed in **Table 2-1** to give projected demands for future developments. Water duty factors (WDF) are the projected water use per area of each land use type, and the listed WDFs are taken from the 2002 master plan. The WDF methodology was used to determine future demands for specific planning regions and future developments. The total projected max day buildout demand using this methodology is approximately 59.4 MGD. For verification purposes the max day buildout demand in previous master plan (2002) was 65 mgd.

Table 2-1
Water Duty Factors for Demand Projections

Land Use Type	Land Use Category	Assumed Average Day Water Duty Factor (gpm/acre)
Parks	Residential	0.48
Public/Semi-public	Commercial	0.34
Retail, Offices, and Services	Commercial	0.34
Village District	Multi-unit	2.95
Business Commercial	Commercial	0.34
Low Density Residential	Residential	0.48
Medium Density Residential	Residential	0.48
Mixed Use Business Park	Commercial	0.34
Offices	Commercial	0.34
B-15,000 sf Lots	Residential	0.48
Garden/O'Day Mixed Use District	Commercial	0.34
High Density Residential	Multi-unit	2.95
Industrial	Commercial	0.34
Light Industrial	Commercial	0.34
A-1/2 Ac. Lots	Residential	0.48
Business Park	Commercial	0.34
C-12,000 sf Lots	Residential	0.48
Cullen Mixed Use District	Commercial	0.34
D-12,000 sf Lots	Residential	0.48

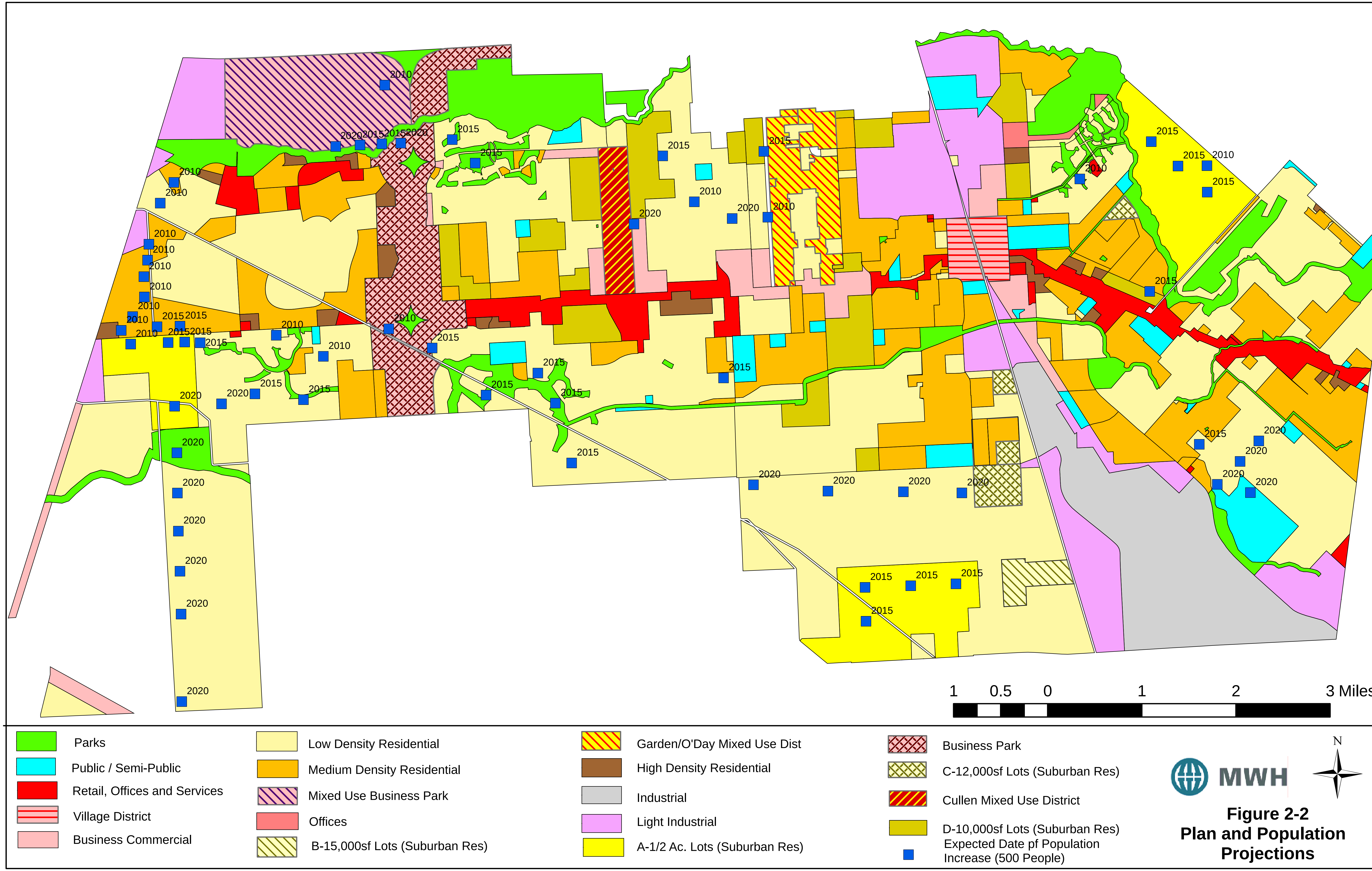


Figure 2-2
Plan and Population Projections

EXISTING WATER PRODUCTION AND DEMANDS

An evaluation of the historical quantity of water produced and a projection of future water requirements is given in this subsection. The water demand projections are based on land development projections presented previously.

The City obtains its water from a local network of groundwater wells and imported water from adjacent cities. **Table 2-2** lists annual production rates in million gallons per year (MG/yr) for City sources from 2004 through 2006.

Table 2-2
Annual Water Production
All values are in MG/yr.

Supply Source	2004	2005	2006
Alice	3	178	276
Cullen	325	318	290
Garden Road	404	199	162
Green Tee	37	45	40
Liberty	268	164	233
Magnolia	307	423	122
Mary's Creek / 518	386	374	220
McLean	92	69	89
Old City Hall	43	106	120
Shadow Creek	284	757	1,025
Southdown	0	0	138
Southeast	0	87	334
Total Annual Production	2,148	2,719	3,049

Peaking Factor

The peaking factor established for converting average annual demand to maximum day demand is 1.9. The peaking factor used in the 2002 Water Master Plan is used for hydraulic modeling performed for this study. The maximum day peaking factor used in the Water Master Plan was calculated based on historical monthly water production data provided by the City.

Diurnal Curve

The hourly water demand pattern is a diurnal curve, in which the water demand for each hour of the day can be expressed as a ratio to the daily water demand. The diurnal demand pattern from the 2002 Water Master Plan prepared by MWH is used in this study. The demand pattern was taken from a similar city where residential land use is predominant (Austin, Texas). The curve, shown in **Figure 2-3**, illustrates the water demand coefficient at 30 minute intervals.

The curve is imported to the model as the water demand pattern assigned to each loaded node, representing a multiplier against daily demand flows. The peak hour of this diurnal curve is found to occur at approximately 8:30 pm, and represents a factor of 1.7 times the daily flow.

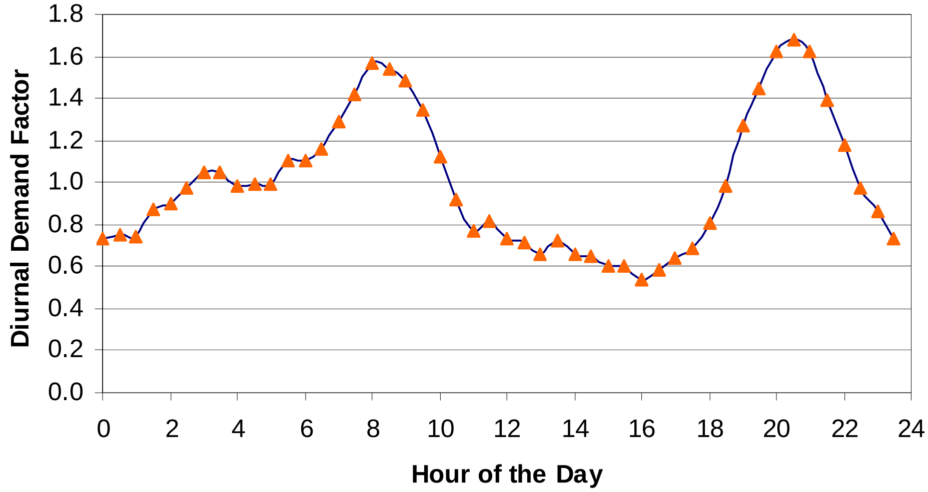


Figure 2-3
Daily Water Demand Pattern used in Water Modeling

FUTURE WATER DEMANDS

Future demands are based on the amount of future development and historical growth trends of water use. For future demands, it is assumed that current users will continue to use water at the current rate. As discussed earlier, the WDF in **Table 2-1** are used to determine the future demand for different scenarios. The land use data provided by the City is used to calculate the demands for 2010, 2015 2020 and 2025. Based on direction from the City, buildout is assumed to occur in 2025. The areas for each scenario year are identified from land use data and multiplied by the WDFs listed in **Table 2-1** to calculate the water demand for each year. The curves, shown in **Figure 2-4** and data in **Table 2-3**, illustrate the average day and maximum day water demand for the future years selected for analysis.

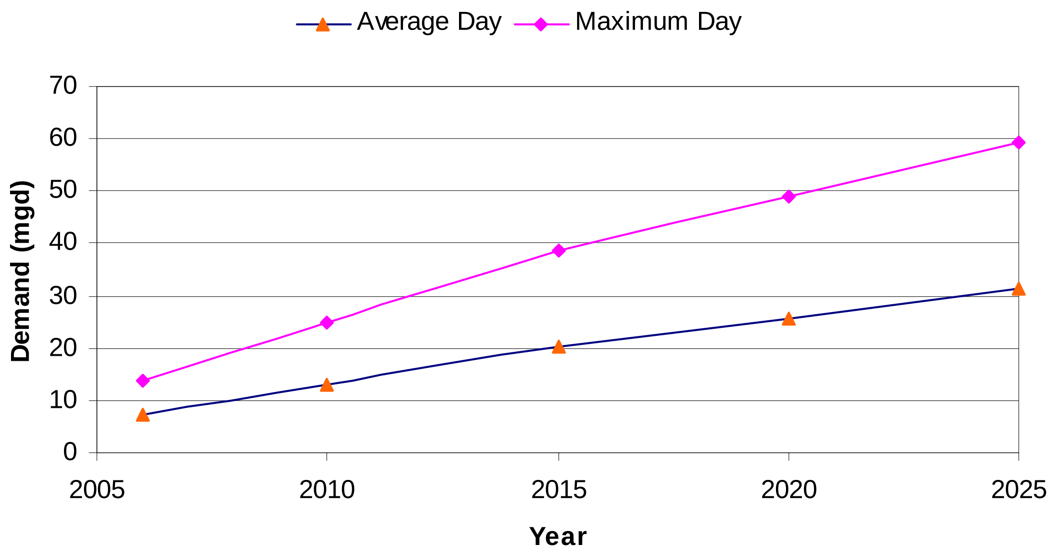


Figure 2-4
Demand Projections

Table 2-3
Demand Projections

Year	Average Day (mgd)	Maximum Day (mgd)
2006	7.2	13.7
2010	13.0	24.7
2015	20.3	38.6
2020	25.7	48.9
2025	31.3	59.4

Section 3
Model Development and Calibration

The modeling methodology follows a logical progression of events including data acquisition, model construction, demand allocation, model calibration and system evaluation. The first four activities are described in this section. The system evaluation is presented in Section 5.

MODEL UPDATE

H_2OMAP Water GIS Version 6.0 is used in creating the system model. A previous model of the City's water distribution system was created using an earlier version of H_2OMAP Water for the August 2002 water master plan prepared by MWH. The 2002 model is used as a base for creating the new model for this study. Current GIS files of City streets, water pipelines, meter boxes, and other system infrastructure are used to update the 2002 model. The hydraulic analysis model is developed to contain all of the City's pipelines of twelve inches in diameter or greater, eight to ten inch diameter pipelines needed for looping, and facilities. In this model, main active pipelines, booster pumps, storage reservoirs and imported water connections are modeled.

Computer Model

H_2OMAP Water GIS Version 6.0, a hydraulic and water quality modeling software package, is used to model the City's existing and future water distribution systems. This software provides the capability of keeping track of water distribution system information such as pipeline material, date of pipe installation, and pressure zone.

H_2OMAP represents the state-of-the-art in GIS-based water supply and distribution systems analysis. The program provides scores of cutting edge simulation capabilities for performing a wide variety of essential modeling tasks in record time. MWH Soft H_2OMAP User Manual Section 4 provides a comprehensive description of the theory and methodology behind the hydraulic and water quality modules used by H_2OMAP. H_2OMAP utilizes an enhanced version of the EPANET analysis engine as developed and distributed by the U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory (EPANET 2000).

Data Collection

At the outset of the study, available data is gathered for the water distribution system's physical facilities. The data provided by City staff included pipeline locations and diameters; tank locations, elevations, diameters and volumes; well locations and depths; well pump design operating points and operational controls; booster pump locations, operating points and operational controls; and imported water supply connection locations.

Data is also gathered on historical and projected populations, water production, and historical and projected land use maps of the City to be used in the development of water production determinations and water demand allocations.

Additional data gathered during the course of the study with the assistance of City staff includes a summary of projects currently under construction or scheduled for construction within the next two years.

Model Construction

The pipeline network from the 2002 water master plan is used as the base map for the model created for this study. The City provided current GIS files detailing streets, water system infrastructure, zoning, and boundaries of the City and ETJ. These GIS files along with base map from the 2002 model were moved, when necessary, to the NAD83 datum, Texas State Plane - South Central coordinate system.

The base map from the 2002 model is used as the basis for identifying the location of all pipelines. Pipeline locations in the base map are verified by comparing base map data with data from current GIS files of City water system infrastructure. Any new pipelines constructed after 2002 and represented in current GIS files are added to the model. All transmission and distribution pipelines twelve inches in diameter and larger are modeled. Pipelines of eight to ten inches are included where necessary for looping. A separate pipeline is defined wherever two or more pipelines intersect, and wherever a pipeline changes size. Model inputs for pipelines include pipeline length, diameter, and roughness. The pipeline length is automatically calculated in H_2OMAP.

Junctions are defined at the intersection of two or more pipelines, or at the location where any pipeline changes size. Junction input information included elevation and demand. Junctions are added in areas where water demand from new developments prompted expansion of the water distribution network.

Storage tanks are modeled as cylindrical tanks and input with their locations determined from record maps and City-provided GIS files. Tank elevations and diameters are left unchanged from the 2002 model. Storage facilities constructed after 2002 are input using detailed facility information provided by City staff.

Each supply well is modeled as a fixed-head reservoir feeding a ground storage tank. Well flow capacity is modeled upstream of the ground storage tank and represented in one of two ways: a pump with a design flow equivalent to the nominal capacity of the well; or a flow control valve with a setting equal to the nominal capacity of the well. If an elevated tank exists at a supply well, the elevated tank is connected to the supply source at a node directly downstream of a supply well booster pump or flow control valve.

Demand Allocation

Demands are allocated based on areas of influence with respect to "demand" junctions. The system model consists of 1,555 pipes and 1,145 junctions. The distribution system arrangement and the locations of the junctions are evaluated with respect to determining which junctions would become demand junctions. Demand junctions are nodes to which a portion of the total system demand has been allocated, based on their areas of influence. Every area of the City is divided into demand polygons, and each demand polygon contains one demand junction.

Demand junctions are selected based on proximity to other junctions, and whether or not the junction is part of a water supply facility. The City model includes 1,068 demand junctions, or approximately 93 percent of the total number of nodes.

After selection of demand junctions, Thiessen polygons are created around the demand junctions. Based on the location of the demand nodes and the land use projections provided by the City, the land use file is divided into separate polygons such that each demand node was assigned an area surrounded by an individual polygon. Total water demand within that area is then assigned to the demand node.

Existing demands are distributed using City water production data for 2005. From the information collected, the consumption rate is estimated for each demand junction.

MODEL VALIDATION

Verification of the hydraulic model is performed using water distribution system pressure data from September and October 2006. The City provided daily pressure monitoring data for each water supply source for the two month period. To evaluate the model, a 24-hour extended-period simulation (EPS) under current average day demand conditions is performed. For validation purposes, current average day water demand for the City is distributed to existing demand nodes under the assumption that the demand at each node is equivalent. Each supply source is set with controls and settings used for typical operations seen in September 2006. The model is run and the average model pressure for each run is compared with average and maximum pressures for September and October 2006 as provided by the City. These results are used to determine if the model is providing reasonable values for pressure.

The pressure at the nodes directly downstream of each water supply facility is compared to field pressure data. The results of the comparison are detailed in **Table 3-1**.

Table 3-1
Model Verification Pressure Data

Water Plant Name	Model Pressure (psi)	Field Pressure (psi)			
		September 2006		October 2006	
		Average Pressure	Maximum Pressure	Average Pressure	Maximum Pressure
Garden Road	57	55	58	55	58
Shadow Creek	59	57	67	54	64
Cullen	58	56	57	57	57
McLean	57	54	59	55	56
Old City Hall	57	54	55	55	56
Alice	58	54	56	36	58
Magnolia	57	54	57	54	57
Southeast	58	56	57	56	58
Liberty	58	54	57	56	57
Mary’s Creek	59	56	60	48	58
Green Tee	59	57	63	56	63

A comparison of field data versus modeled data indicated that the model output is reasonable. The model pressure is not greater than 7.1 percent (3.8 psi) off from average pressure at any one water plant during the month of September, with the greatest discrepancy observed at the Alice Water Plant. The data for the month of October does not include pressure data for the final thirteen days of the month. The model results are in the range of the field data, therefore the results were validated.

PLANNING AND EVALUATION CRITERIA

Planning criteria are used in the evaluation of both the existing and future system hydraulic models. A list is developed of typical planning criteria used in systems of similar water purveyors, local codes, engineering judgment, common accepted industry standards, and input from City staff. The “industry standards” are typically ranges of acceptable values for the criteria in questions and therefore, they were utilized more as a check to confirm that the values being developed are reasonable. A list of planning criteria used in the evaluation of the City’s water distribution system is shown in **Table 3-2**.

Table 3-2
Summary of Planning Criteria

Description	Planning Criteria
Peaking Factors:	
Maximum Day Demand	1.9 x Average Day Demand
Peak Hour Demand	1.7 x Maximum Day Demand
Minimum System Pressure	35 psi, with a goal of 50 psi on transmission pipelines
Maximum System Pressure	80 psi, with a goal of 65 psi
Maximum Water Velocity Pipeline	8 fps
Storage Capacities:	
Operational Storage	25% of Max Day Demand
Fire Storage	1.00 MG (4 hours @ 4000 gpm)
Emergency Storage	Average Day Demand

There are three primary evaluation criteria: 1) acceptable pressure, 2) maximum acceptable pipeline velocities, and 3) adequacy of storage volumes for operational, emergency and fire flow requirements. It is understood that the State of Texas has a requirement of a minimum of 100 gallons of ground storage and 100 gallons of elevated storage for each service connection, but since the number of future service connections is unknown, the alternative storage planning criteria of 25% of maximum day demand, 1.00 MG fire, or 100% of average day demand was proposed. The above listed capacities are considered reasonable for a system of this size. Storage planning should be reviewed in the future for conformance with connection requirements and City’s import water risks.

Section 4
Water System Facilities

This section describes the existing system facilities and provides an overview of the existing system operations, including pressure zones and normal system operations. The current City facilities modeled include wells, booster pumps, storage reservoirs, pipelines, and pressure regulating stations. Each set of facilities is discussed in detail below, following the description of the system's normal operating procedures.

SUMMARY OF FACILITIES

The existing system consists of eleven groundwater wells within City limits, three additional Municipal Utility District (MUD) groundwater wells located in the ETJ area, and a number of other facilities as shown in **Table 4-1**. **Figure 4-1** depicts an overview of the facility locations within the City, and provides a layout of the City's water distribution system pipelines.

Table 4-1
City of Pearland Existing Water Distribution System Facilities

Facility Type	Number
City Wells	11
MUD Wells	4
Imported Water Connections	2
Booster Pump Stations	15
Storage Reservoirs	24
Pipelines (all sizes)	302 miles

A computer hydraulic model is developed to model the existing system, to identify areas for future system additions and improvements, and to evaluate alternative future system improvements. The methodology of model construction is presented in Section 3, and a detailed description of the investigations and analyses is presented in Section 5 of this report. All existing facilities are modeled according to the City's water system maps, with additional detailed facility information provided by City staff.

ELEVATIONS

Elevations within the City vary by approximately 40 feet, with the highest point at approximately 70 feet above sea level (asl) at the northwest perimeter, and the lowest point at approximately 30 feet asl at the southeast perimeter.

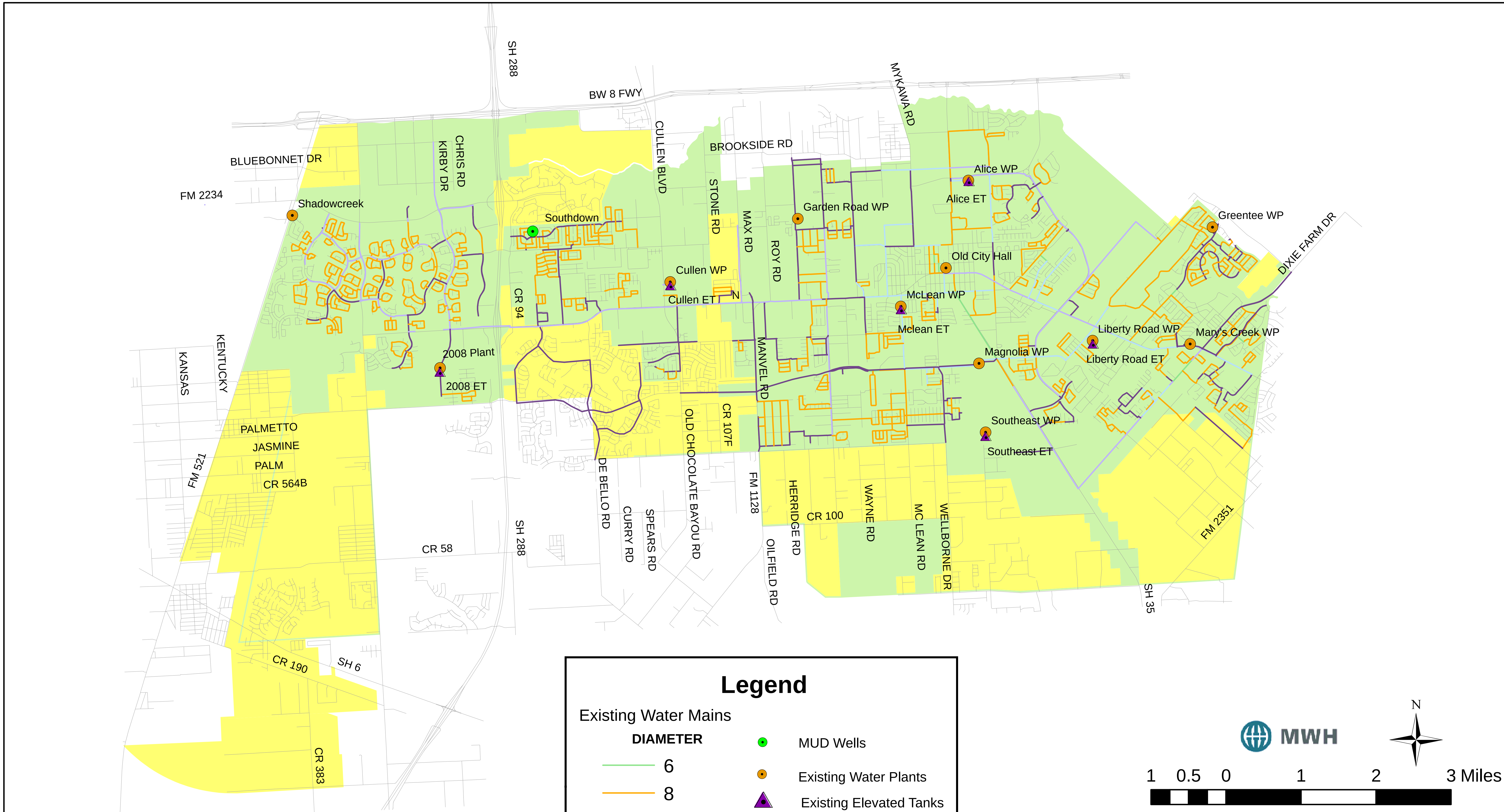


Figure 4-1
Existing Water Distribution System and Facilities

GROUNDWATER WELLS

There are fourteen operating groundwater wells (referred to herein as wells) within City and ETJ limits. A summary of the physical and operational data of the wells currently in service is presented in **Table 4-2**. All wells and surface water connections pump into storage reservoirs.

Table 4-2
Supply Source Summary

Well Name	Location	Capacity (gpm)	Connection Year
City Wells			
Alice	Alice Rd. & N. Main St.	913	Existing, to be abandoned between 2010 and 2015
Cullen	Freedom Dr. & Old Chocolate Bayou Rd.	1,300	Existing
Garden Road	Garden Rd. & Butler Rd.	1,380	Existing
Liberty	Liberty Dr. & E. Broadway	1,580	Existing
Magnolia	Magnolia St. & S. Main St.	1,050	Existing
Mary's Creek (518)	Woodcreek Dr. & E. Broadway	750	Existing
McLean	McLean Rd. & Apple Springs Dr.	650	Existing
Old City Hall	N. Texas Ave. & W. Broadway	560	Existing, to be abandoned between 2010 and 2015
Southeast	Wells Dr. & Keis Rd.	1,800	Existing
288 Well	Harris Ave. & Milam Lane	1,300	Existing
(Southdown)	Southdown Dr. & E. Brompton Dr.	972	Existing
MUD Wells			
MUD 1	Shelby Dr. & Clarestone Dr.	972	Existing, to be connected between 2010 and 2015
MUD 2	Vinecrest Dr. & Summerfield Dr.	972	Existing, to be connected between 2010 and 2015
MUD 3	CR 922 & Southfork Dr.	2,083	Existing, to be connected between 2010 and 2015
MUD 4	Hickory Field Lane	1,200	Existing, to be connected between 2010 and 2015
Surface Water Connections			
Green Tee	Scarsdale Blvd. & Bogey Way	69	Existing
Shadow Creek	Shadow Creek Pkwy. & Almeda Rd.	4,200	Existing
TOTAL		**20,779**	

IMPORTED WATER SUPPLIES

The water supply provided by City and MUD wells is supplemented by imported water supplies. The City of Houston, Texas currently provides Pearland with 6 MGD via an imported supply connection at the Shadow Creek water plants. An imported connection of 100,000 gpd is also located at the Green Tee water plant, as shown in Table 4-2. Two future imported supply sources were evaluated during hydraulic modeling. An additional supply from the City of Houston via a connection at the Alice water plant was evaluated, as well as an imported water supply from the Gulf Coast Water Authority (GCWA) near the southwest corner of the City. The volume imported from each source was varied during modeling scenarios to evaluate impacts on water distribution system infrastructure requirements.

STORAGE RESERVOIRS

There are twenty four storage reservoirs within the City's water distribution system and MUD, and sixteen different storage reservoir sites. The City's storage reservoirs consist of ground storage tanks (GST) and elevated storage tanks (ET). **Table 4-3** provides a summary of storage tank information. Storage reservoir locations are shown in **Figure 4-1**.

Tank dimensions provided in **Table 4-3** are the dimensions input into the hydraulic model and do not represent actual field conditions. There are two ground storage tanks at both the Alice water plant and the Shadow Creek water plant. For modeling purposes, the combined storage capacity of the two ground storage tanks at each water plant has been represented in the form of a single tank. Elevation data for elevated tanks is given assuming that the bottom of each elevated tank is at a height 100 feet above the local ground elevation.

Table 4-3
Storage Facility Summary

Description	Volume (MG)	Diameter (feet)	Height (feet)	Bottom Elevation (feet asl)	Overflow Elevation (feet asl)
Ground Storage Tanks					
Alice (Tank – 1)	0.5	55	28	48	76
Alice (Tank – 2)	0.5	55	28	48	76
Cullen	0.60	65	24	53	77
Garden Road	0.46	55	26	50	76
Green Tee	0.21	39	24	35	59
Liberty	0.46	55	26	46	72
Magnolia	0.46	55	26	50	76
Mary's Creek (518)	0.46	50	28	31	59
McLean	0.46	39	34	51	85
Old City Hall	0.33	39	24	50	74
Shadow Creek (Tank – 1)	1.6	91	33	61	94
Shadow Creek (Tank – 2)	1.6	91	33	61	94
Southeast	1.00	83	25	47	72
288 Well (2008)	1.00	83	25	59	84
Southdown	0.50	55	28	48	76
MUD 1	0.50	55	28	56	84
MUD 2	1.20	55	68	56	124
MUD 3	1.24	55	70	60	130
MUD 4	0.50	55	28	52	80
Subtotal Ground Storage	**13.5**				
Elevated Storage Tanks					
Alice	0.50	42	48	148	196
Cullen	1.00	60	48	153	201
Liberty	0.50	42	48	146	194
McLean	0.50	42	48	151	199
Southeast	1.00	60	48	147	195
288 Well (2008)	1.00	60	48	153	201
MUD 3	0.70	60	33	160	193
Subtotal Elevated Storage	**5.20**				
Total Storage Volume	**18.7**				

In general, ground storage tanks are served by groundwater wells, and water is pumped via booster pump from these tanks into the water system. Elevated storage tanks are served by booster pumps, and water flows via gravity into the water system from elevated tanks.

BOOSTER PUMPS

There are 41 booster pumps at fifteen booster pump stations within the City and ETJ area. Booster pumps are located downstream of the storage reservoirs to lift the reservoir water to distribution system pressure. **Table 4-4** provides a summary of booster pump information.

Table 4-4
Booster Pump Summary

Station Name	Number of Pumps	Capacity (gpm)	Total Dynamic Head (feet)
Alice	3	887 (all pumps)	151 (all pumps)
Cullen	3	1,500 (all pumps)	148 (all pumps)
Garden Road	3	987 (all pumps)	148 (1 pump); 116 (2 pumps)
Green Tee	2	590 (all pumps)	150 (all pumps)
Liberty	3	1,032 (all pumps)	150 (all pumps)
Magnolia	3	1,170 (1 pump); 975 (2 pumps)	148 (1 pump); 150 (2 pumps)
Mary's Creek (518)	3	1,000 (1 pump); 742 (2 pumps)	152 (all pumps)
McLean	2	480 (all pumps)	150 (all pumps)
Old City Hall	2	380 (all pumps)	150 (all pumps)
Shadow Creek	5	2,000 (3 pumps); 1,000 (2 pumps)	148 (all pumps)
Southeast	3	1,500 (all pumps)	148 (all pumps)
MUD 1	2	1,500 (all pumps)	148 (all pumps)
MUD 2	2	1,500 (all pumps)	148 (all pumps)
MUD 3	3	1,500 (all pumps)	148 (all pumps)
MUD 4 (Southdown)	2	1,500 (all pumps)	150 (all pumps)

PIPELINES

City pipelines range between 4 and 30-inches in diameter. All pipelines 12-inches in diameter or greater were included in the hydraulic model developed for this study. Pipelines with a diameter of 8 or 10-inches were included to complete loops where necessary. Water mains in the hydraulic model represent approximately 74 percent of the total water main in the system by length.

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Section 5
Water System Evaluation

The purpose of this section is to describe the evaluation of the City's existing and future water distribution system. The water system was evaluated using the hydraulic model and planning criteria described in Section 3 and demand projections described in Section 2. Water sources, node pressures, pipelines velocities, fire flow, storage tank volumes and booster pump capacities are investigated. Facilities needed to solve existing deficiencies and meet future demands through year 2025 are recommended in this section. Details of infrastructure requirements for intermediate demand conditions (2010, 2015 and 2020) are also provided.

WATER DEMANDS

The City of Pearland's water system was evaluated for adequate supply, system pressures, storage and booster pump capacity to deliver sufficient water under existing and future demand scenarios. Existing and future demands from Section 2 are summarized in **Table 5-1** below. The future demands are based on projected demands for years 2010, 2015, 2020 and 2025 respectively. The buildout scenario is estimated to occur in year 2025.

Table 5-1
Water Demands

Year	Average Day Demand (mgd)	Maximum Day Demand (mgd)
Existing	7.2	13.7
2010	13.0	24.7
2015	20.3	38.6
2020	25.7	48.9
2025 (Buildout)	31.3	59.4

SUPPLY EVALUATION

Under typical conditions, the total capacity of water supplies should be equal to or greater than MDD. Demands above MDD are typically supplied from storage. For system planning, it is assumed that the total capacity of supplies should total MDD with the largest groundwater well out of service for reliability purposes.

The City's existing groundwater well capacity totals 16.4 mgd, plus the existing imported connection at Shadow Creek with a capacity of 6 mgd. There are three MUD wells currently in operation but not connected to the City water system; these wells have a total capacity of 5.8 mgd and are expected to connect to the water system before 2015. One well located at 518 and 288 with a capacity of 2.1 mgd is currently under construction. Two wells, Alice and Old City Hall, are expected to be abandoned between 2010 and 2015.

Table 5-2 lists the existing and future supply capacities for each year. Historically the City's main water source has been groundwater wells, however, the majority of future sources will be from imported water connections. The three major point sources for imported water supply are:

- City of Houston connections at Shadow Creek (Shadow Creek)
- City of Houston Connections at Alice (COH Alice)
- Gulf Coast Water connection southwest corner of the City (GCWA)

The major points sources listed above will be phased into service as identified in **Table 5-3**. These assumed water source capacities are based on projected supply capacities included in the scope of work for this study.

Table 5-2
Imported Water Source Capacity

Year	Water Source Capacity (mgd)		
	Shadowcreek	COH Alice	GCWA
2010	6	10	0
2015	6	10	10
2020	6	10	20
2025 (Build-out)	6	15	20

As shown in **Table 5-2 and Figure 5-1**, by increasing the capacities of the imported sources to the values shown in **Table 5-3**, there will be sufficient water sources to meet the projected maximum day demands. However, due to insufficient system pressures in the southeast portion of the system, a groundwater well with a capacity of 1.9 mgd is recommended for the southeast portion of the system in the general region of CR 253 and Penny Wayne Lane to improve system pressures. Though the supply calculation does not show that an additional well is necessary, the well is needed to maintain level in the recommended elevated tank in the region. Alternatively, pipelines could be constructed to deliver water to the proposed elevated tank, but this will require significant distances of pipeline, leading to low pipeline velocities.

STORAGE CAPACITY EVALUATION

The existing storage capacity contains 17 ground storage and 7 elevated tanks. The total storage volume excluding MUD tanks is approximately 13.9 MG. The proposed recommendations of the reservoir evaluation are summarized in this section. The storage evaluation is performed for each intermediate years and buildout scenario. The total required storage is a combination of three components:

- Operational storage
- Fire flow storage
- Emergency storage

As described earlier in Section 3, the recommended operational storage is 25 percent of MDD. Fire flow storage should provide sufficient water for four hours at 4,000 gpm (0.96 MG). Emergency storage is recommended as 100 percent of ADD. The required storage is compared with the actual available storage for the entire system. A summary of required and available storage volumes for each scenarios are presented in **Table 5-4 and Figure 5-2**.

Table 5-3
Supply Capacity Evaluation

Year	ADD (mgd)	MDD (mgd)	Required Supplies (mgd)	Existing Supply with Largest Well Out of Service (mgd)	Largest Existing Well (mgd)	Supply Currently Under Construction (mgd)	Abandoned Supplies (mgd)	MUD Supplies with Largest Well Out of Service (mgd)	Largest MUD Well (mgd)	Total Existing Supplies (mgd)	Additional Supplies Required (mgd)	Recommended Supplies (mgd)	Total with Recommendations (mgd)
Existing	7.2	13.7	13.7	19.3	2.6	0.0	0.0	0.0	0.0	19.3	0.0	0	19.3
2010	13.0	24.8	24.8	19.3	2.6	2.1	0.0	0.0	0.0	21.4	3.3	10	31.4
2015	20.3	38.6	38.6	19.3	2.6	2.1	-2.1	4.5	3.0	26.4	12.1	10	49.2
2020	25.7	48.9	48.9	19.3	2.6	2.1	-2.1	4.5	3.0	26.4	22.4	11.9	59.2
2025 (Buildout)	31.3	59.4	59.4	19.3	2.6	2.1	-2.1	4.5	3.0	26.4	33.0	5	64.2

Table 5-4
Storage Capacity Evaluation

Year	ADD (mgd)	MDD (mgd)	Total Required Storage (MG)	Existing Storage (MG)	Storage Currently Under Construction (MG)	Abandoned Storage (MG)	MUD Storage (MG)	Total Existing Storage (MG)	Additional Storage Required (MG)	Recommended Storage (MG)	Total with Recommendations (MG)
Existing	7.2	13.7	11.6	12.6	0.0	0.0	0.0	12.6	0.0	0	12.6
2010	13.0	24.8	20.2	12.6	2.0	0.0	0.0	14.6	5.4	10	24.6
2015	20.3	38.6	30.9	12.6	2.0	-1.3	4.1	17.5	13.4	6	33.5
2020	25.7	48.9	38.9	12.6	2.0	-1.3	4.1	17.5	21.4	8.6	42.1
2025 (Buildout)	31.3	59.4	47.1	12.6	2.0	-1.3	4.1	17.5	29.6	6	48.1

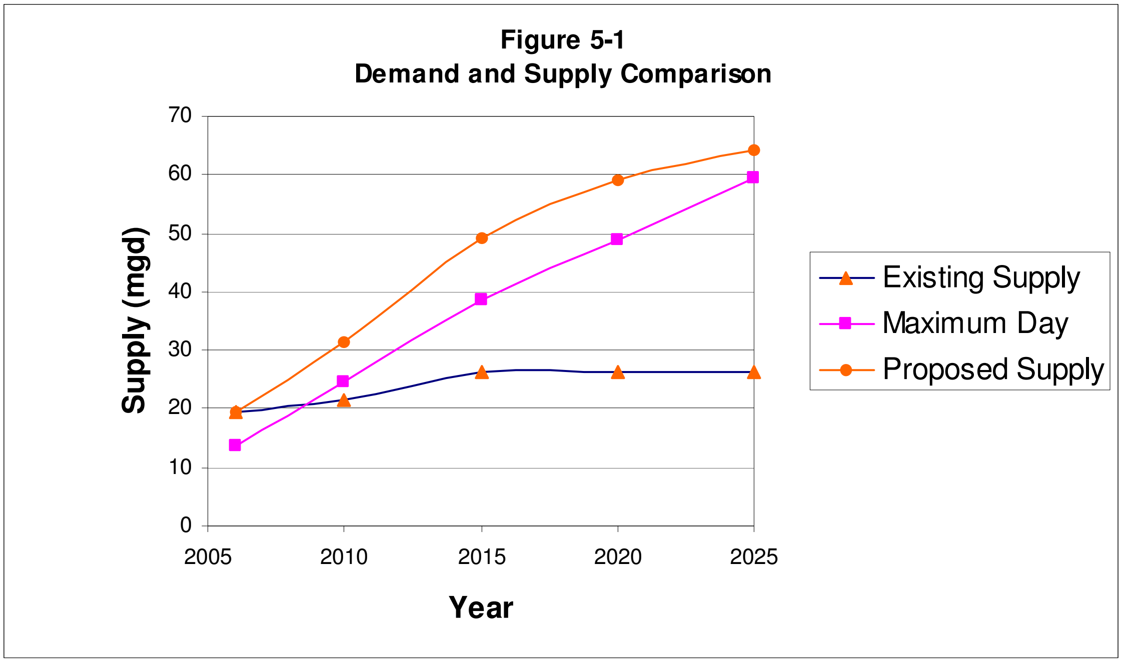


Figure 5-1
Demand and Supply Comparison
Supply (mgd)
70
60
50
40
30
20
10
0
2005
2010
2015
2020
2025
Year
Existing Supply
Maximum Day
Proposed Supply

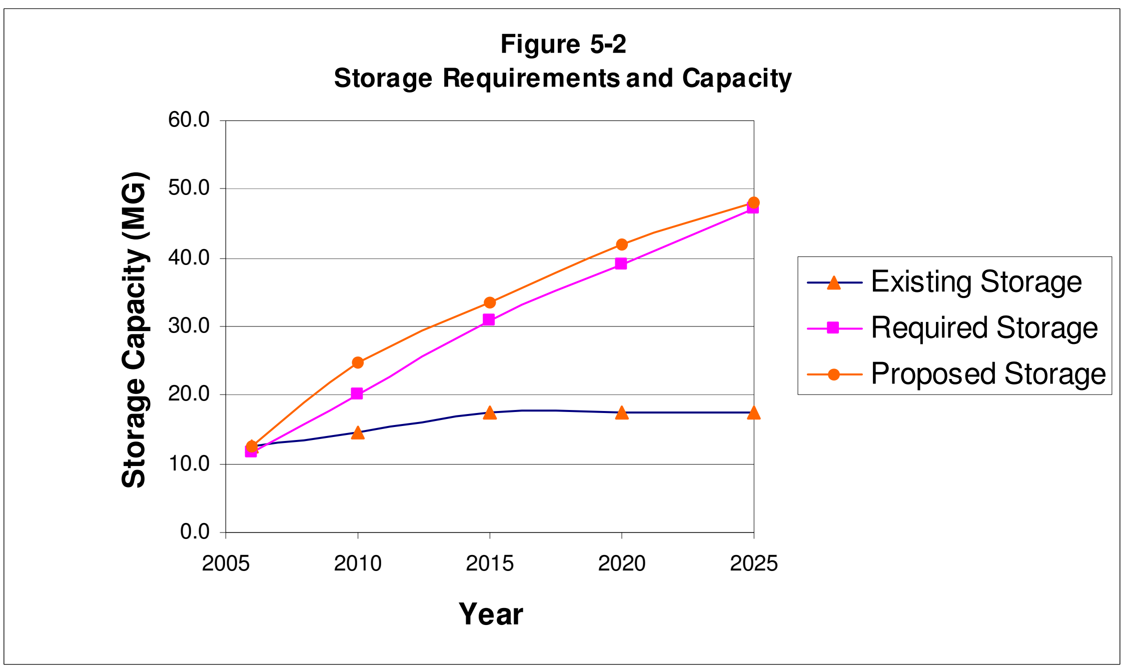


Figure 5-2
Storage Requirements and Capacity
Storage Capacity (MG)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
2005
2010
2015
2020
2025
Year
Existing Storage
Required Storage
Proposed Storage

Based on the storage requirements shown in **Table 5-4**, recommendations for additional storage are listed in **Table 5-5**. Ground storage tanks are recommended with the installation of the imported water connections. For each connection, two 3 MG tanks are recommended at the installation of the connection, with additional reservoirs as the capacity of the connection is increased. Four elevated tanks are recommended for the City. The elevated tank at Mary's Creek and in the region of Riley Road and Kirby Drive (Shadow Creek) are recommended for 2010; the storage calculation does not show that the capacity of the elevated tanks are required, however, due to low pressures and pressure fluctuations at high demands, it is recommended that both elevated tanks be installed as soon as possible. The ground storage tank and elevated tank in the region of Penny Wayne Lane and West Field Lane is to be constructed in conjunction with the proposed groundwater well at the same location.

Table 5-5
Summary of Proposed Storage Reservoir and Facility Improvements

Facility Type	Number of Tanks	Capacity of Tanks (MG, each)	Location	Year
Ground Storage	2	3	COH Alice	2010
Elevated Tank	1	2	Mary's Creek	2010
Elevated Tank	1	2	In region of Riley Rd & Kirby Dr	2010
Ground Storage	2	3	GCWA	2015
Ground Storage	1	0.6	In region of Penny Wayne Ln & West Field Ln	2020
Elevated Tank	1	2	In region of Penny Wayne Ln & West Field Ln	2020
Ground Storage	2	3	GCWA	2020
Ground Storage	1	4	COH Alice	2025
Elevated Tank	1	2	Off CR 58	2025
Total	**12**	**21.6**		

BOOSTER PUMP CAPACITY RECOMMENDATIONS

Booster pumps will be constructed with each of the imported water connections and new groundwater wells. In general, booster pumps need to be sized to meet Peak Hour Demand. Based on the diurnal curve shown in Section 2, since PHD is approximately 1.7 times MDD, the total booster pump capacity recommended is 1.7 times the capacity of the supply, plus a standby pump. Recommended booster pump capacities are shown in Table 5-6.

Table 5-6
Booster Pump Capacity Recommendations

Supply Type	Booster Pump Capacity (gpm), not including standby	TDH (ft)	Location	Year
Groundwater Well	1,950	125	New Well in region of Penny Wayne Ln and West Field Ln	2020
Imported Connection	10,500	130	COH Alice	2010
Imported Connection	5,200	130	COH Alice	2025
Imported Connection	10,500	120	GCWA	2015
Imported Connection	10,500	120	GCWA	2020

TRANSMISSION PIPELINE EVALUATION

For each of the years in the planning horizon, the required transmission pipelines to serve the City have been identified as described below.

Evaluation Methodology

The required transmission pipelines required for the City are identified by using the hydraulic model developed as described in Section 3. Pipelines to serve each region currently not served by the City are created on an approximate one mile grid basis and inserted into the model. The buildout system was developed first to determine the ultimate infrastructure needed by the City to serve water demands. Though the minimum pressure requirement is 35 psi, the pipelines are sized so that minimum pressures on the transmission pipelines during PHD are approximately 50 psi. Where the pressures are insufficient, future pipelines were upsized or new pipelines are recommended so that the pressures provided are in the requisite range. Where pipeline velocities are unusually low, the pipelines are downsized, with a minimum pipeline diameter of 12-inches for transmission pipelines.

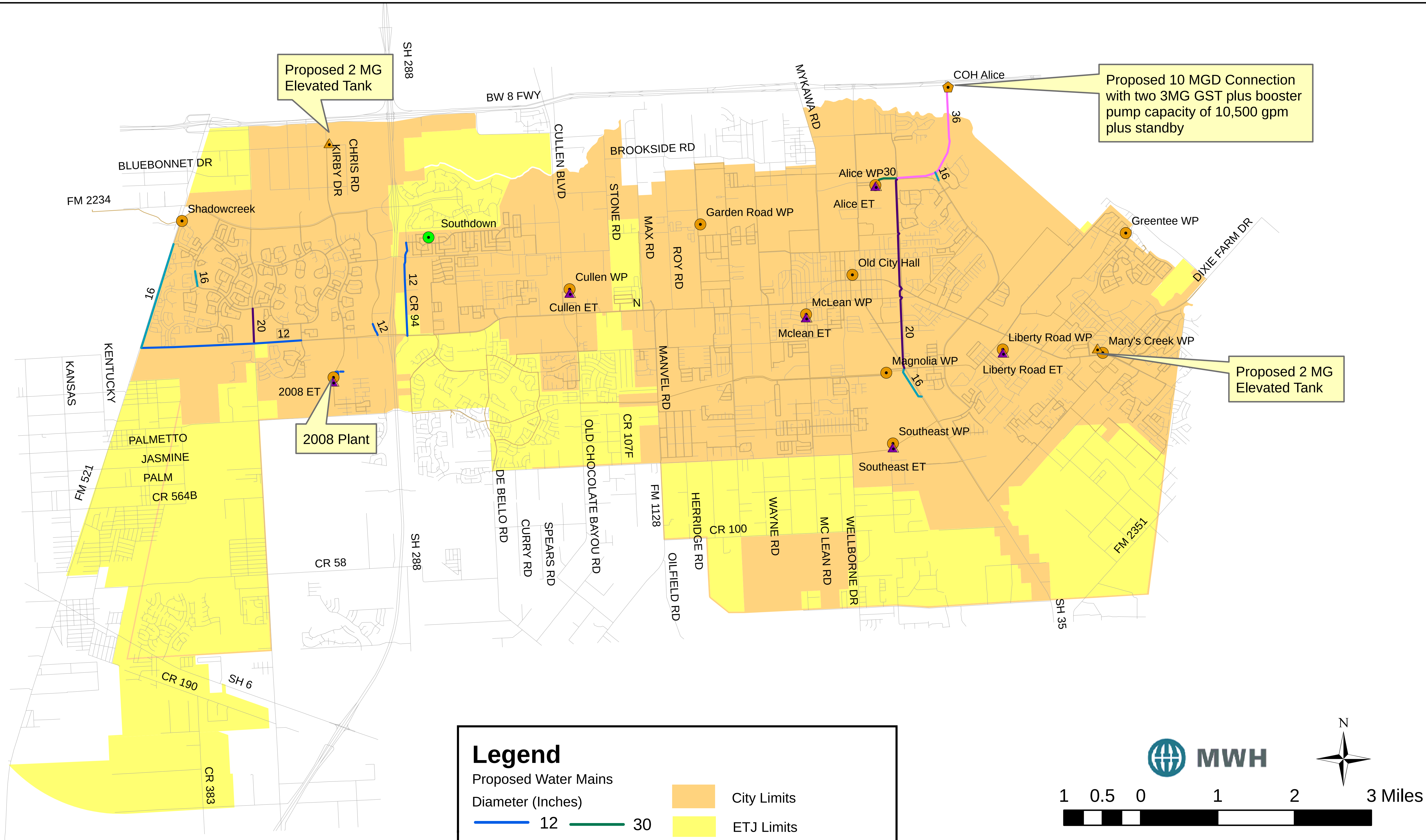
Once the buildout pipelines are sized, the expected year of connection was added for each demand junction in the model. The system is modeled for each intermediate year to determine the date each of the future facilities will be required. Pipelines are not downsized for intermediate years since it is assumed that the City would not construct a smaller pipeline in one year and parallel that pipeline with a larger one a few years later.

Pipelines Required for 2010

Pipelines required for 2010 and purposes of the pipeline are shown in **Table 5-7**. In general, pipeline improvements are recommended to loop key sections of the transmission main network and increase the system's ability to distribute increased supply from the COH Alice connection within the network. **Figure 5-3** shows the proposed pipelines and facilities required to meet projected 2010 demands.

Table 5-7
Summary of Proposed Pipeline Improvements - 2010 Scenario

Pipeline Alignment			Diameter (inches)	Approximate Length (feet)	Purpose of Pipeline
From	To	Along			
Broadway Street	Mooring Pointer Dr	FM 521	12	7,500	Looping of transmission pipelines
Half Moon Bay	FM 521	Broadway Street	12	14,800	Looping of transmission pipelines
Broadway Street	Trinity Bay	Kingsley Dr	20	2,400	Looping of transmission pipelines
Arcadia Bay Dr	In North Direction	Trinity Bay Dr	16	1,000	Looping of transmission pipelines
Broadway Street	In North Direction	Business Center Dr	12	800	Looping of transmission pipelines
Broadway Street	Lambeth Dr	CR 94	12	6,400	Looping of transmission pipelines
Old Alvin Rd	Alice	McHard Rd	30	1,700	Connection to COH Alice
Old Alvin Rd	Pearland Pkwy	McHard Rd	36	2,700	Connection to COH Alice
McHard Rd	In Southeast Direction	Pearland Pkwy	16	600	Connection to COH Alice
McHard Rd	COH Alice	Pearland Pkwy	36	6,000	Connection to COH Alice
McHard Rd	Magnolia St	Old Alvin Rd	20	13,200	Transmission of water from COH Alice to the south
Magnolia St	South of Magnolia Street	S Main Street	16	2,500	Transmission of water from COH Alice to the south



Notes:

1. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.

Figure 5-3
Water System Projects to Meet 2010 Demand

Pipelines and Facilities Required for 2015

Pipelines required for 2015 and purposes of the pipeline are shown in **Table 5-8**. **Figure 5-4** shows the proposed pipelines and facilities required to meet projected 2015 demands.

Table 5-8
Summary of Proposed Pipeline Improvements – 2015 Scenario

Pipeline Alignment			Diameter (inches)	Approximate Length (feet)	Purpose of Pipeline
From	To	Along			
GCWA Connection	Jasper Dr	CR 48	36	11,000	Connection to GCWA
CR 48	SH 288	Big Island Dr	24	13,200	Transmission of water from GCWA to the east
SH 288	Manvel Rd	Bailey Rd	24	17,300	Transmission of water from GCWA to the east
Bailey Rd	CR 100	FM 1128	16	5,300	Looping of transmission pipelines
FM1128	Veterans Dr	CR100	16	13,100	Looping of transmission pipelines
CR 100	Hastings Cannon Rd	Harkey Rd	12	5,200	Looping of transmission pipelines
Harkey Rd	Pearland Sites Rd	Hastings Cannon Rd	12	8,100	Looping of transmission pipelines
CR 100	Hastings Cannon Rd	Pearland Sites Rd	12	5,300	Looping of transmission pipelines
Bailey Rd	CR 100	Veterans Dr	16	5,300	Looping of transmission pipelines
Manvel Rd	CR 94	Kincade Rd, Southfork Rd & CR 59	12	17,400	Looping of transmission pipelines
CR 389	Glen Cullen Ln	CR 91	12	2,500	Looping of transmission pipelines
Foxden Dr	Old Chocolate Bayou Rd	Northfork Dr	8	2,500	Looping of transmission pipelines
Lakecrest Ln	Bailey Rd	Old Chocolate Bayou Rd	12	5,900	Looping of transmission pipelines
Morgan Rd	Bagnolirose Ln	Northfork Dr	12	600	Looping of transmission pipelines
CR 94	CR 48	CR 59	20	10,800	Looping of transmission pipelines
Carson Ave	CR 59	In South Direction	12	800	Looping of transmission pipelines
North of McHard Rd	Lambeth Dr	SH 288 & Country Place Pkwy	12	5,700	Looping of transmission pipelines
SHH 288	Cullen Blvd	Kilnar Rd	12	4,900	Looping of transmission pipelines
Kilnar Rd	Brookside Dr	Cullen Blvd	12	3,000	Looping of transmission pipelines
Brookside Dr	Cliff Stone Rd	Mar Rd	12	2,400	Looping of transmission pipelines
Pearland Pkwy	Country Club Dr	City Limit (northeast)	16	11,500	Looping of transmission pipelines
Pearland Pkwy	City Limit	Future Street	12	5,200	Looping of transmission pipelines
N. Main St	Business Center Dr	McHard Rd, Brookside Dr, CR 106 A & Shadowcreek Pkwy	16	42,800	Looping of transmission pipelines

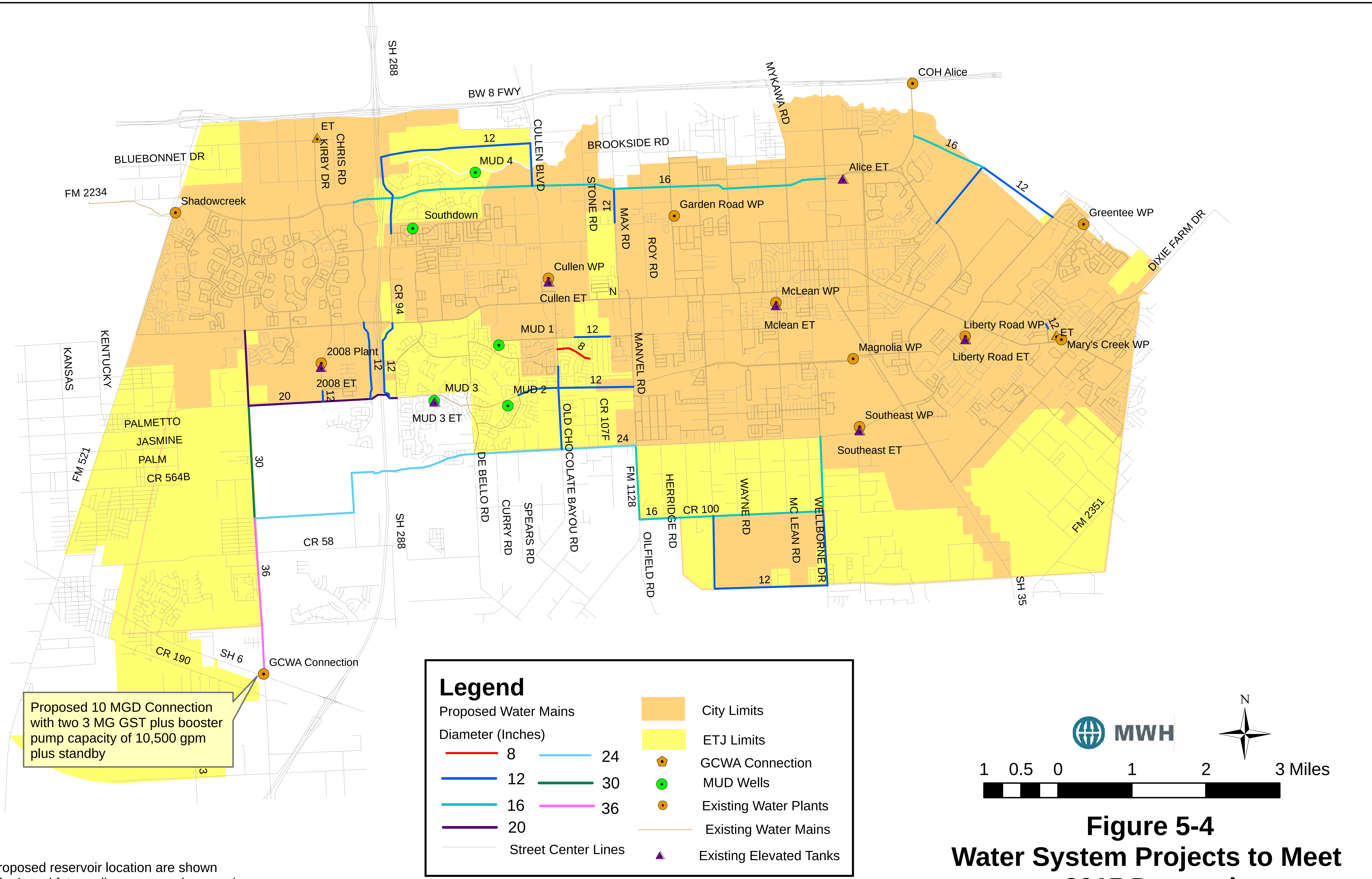


Figure 5-4
Water System Projects to Meet 2015 Demand

Notes:

1. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.

Pipelines and Facilities Required for 2020

Pipelines required for 2020 and purposes of the pipeline are shown in **Table 5-9**. **Figure 5-5** shows the proposed pipelines and facilities required to meet projected 2020 demands.

Table 5-9
Summary of Proposed Pipeline Improvements – 2020 Scenario

Pipeline Alignment			Diameter (inches)	Approximate Length (feet)	Purpose of Pipeline
From	To	Along			
Miscellaneous, see Figure 5-3, southwest portion of City in ETJ	Miscellaneous, see Figure 5-3, southwest portion of City in ETJ	Future Street, Savannah Pkwy, Croix Rd, Ladonia St, Rose Ln, CR 564B, & Doreen St	12	28,200	Looping of transmission pipelines
Brazoria County Border	CR 48	Croix Rd	16	10,000	Looping of transmission pipelines
Kirby Dr	Almeda Rd	Riley Rd	12	8,800	Looping of transmission pipelines
Riley Rd	Shadow Creek Connection	Almeda Rd	12	4,700	Transmission of water from Shadow Creek to the north
Brookside Rd	Hughes Ranch Rd	Stone Rd	12	4,000	Looping of transmission pipelines
Stone Rd	Cullen Blvd	Hughes Ranch Rd	12	3,300	Looping of transmission pipelines
Brookside Rd	Cullen WP	Cullen Blvd	12	7,000	Transmission of water from Cullen WP to the north
Cullen Blvd	Norfolk Dr	Hawk Rd	12	2,700	Looping of transmission pipelines
Dixie Farm Rd	CR 130	CR 127	12	7,600	Looping of transmission pipelines
CR 131	CR 127	CR 130	12	4,000	Looping of transmission pipelines

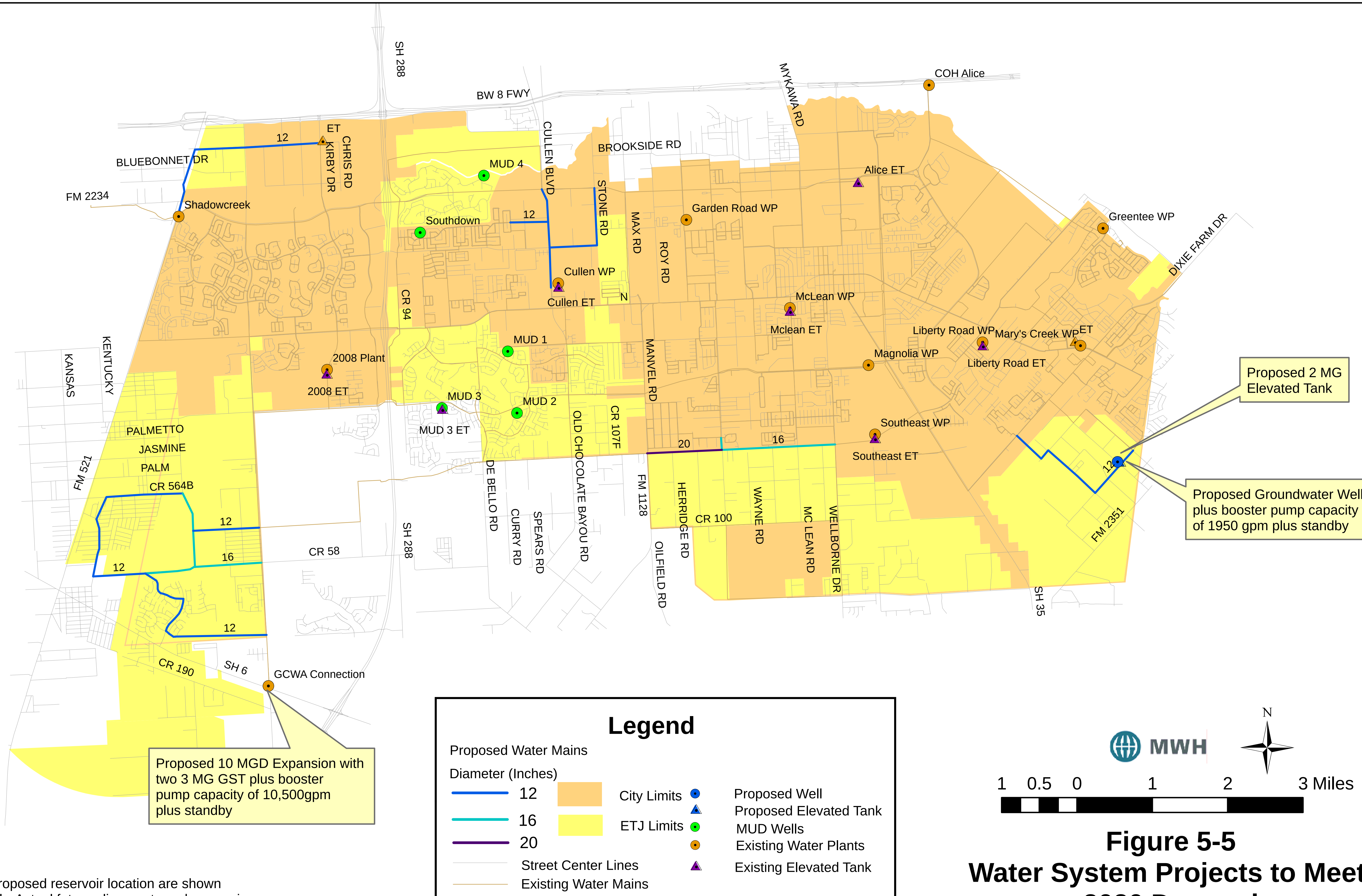


Figure 5-5
Water System Projects to Meet 2020 Demand

Notes:

1. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.

Pipelines and Facilities Required for 2025 (Buildout)

Pipelines required for 2025 and purposes of the pipeline are shown in **Table 5-10**. **Figure 5-6** shows the proposed pipelines and facilities required to meet projected 2025 demands. Pressure contours for the buildout condition are shown in **Figure 5-7** and pressure contours are shown in **Figure 5-8**.

Table 5-10
Summary of Proposed Pipeline Improvements – 2025 Scenario

Pipeline Alignment			Diameter (inches)	Approximate Length (feet)	Purpose of Pipeline
From	To	Along			
GCWA	CR 190	CR 48	36	1,700	Transmission of water from GCWA to the south
Miscellaneous, see Figure 5-4, southeast portion of City	Miscellaneous, see Figure 5-4, southeast portion of City	Hastings Cannon Rd, Telephone Rd, Hastings Rd, Dixie-Friendswood Rd, extension of Pearland Pkwy	12	46,300	Looping of transmission pipelines
CR 564	Orchard Mill Ln	CR 59	16	5,400	Looping of transmission pipelines
CR 564	Wood	Dallas Rd	12	2,800	Looping of transmission pipelines
CR 564	Wood	3rd	8	2,700	Looping of transmission pipelines
CR 564B	Extension of CR 518	CR 564 & extension of CR 564	12	10,800	Looping of transmission pipelines
Oiler Dr	Dixie Farm Rd	Live Oak	12	5,100	Looping of transmission pipelines
Pearland Pkwy	Glaston Bury	Hickory Creek	12	2,700	Looping of transmission pipelines
CR 130	FM 2351	CR 127	12	2,600	Looping of transmission pipelines
CR 127	Main St	FM 2351	12	9,000	Looping of transmission pipelines
Main St	Pearland Sites Rd	Hastings Cannon Rd	12	13,100	Looping of transmission pipelines
Main St	Pearland Sites Rd	N Hastings Field Rd	16	10,200	Looping of transmission pipelines

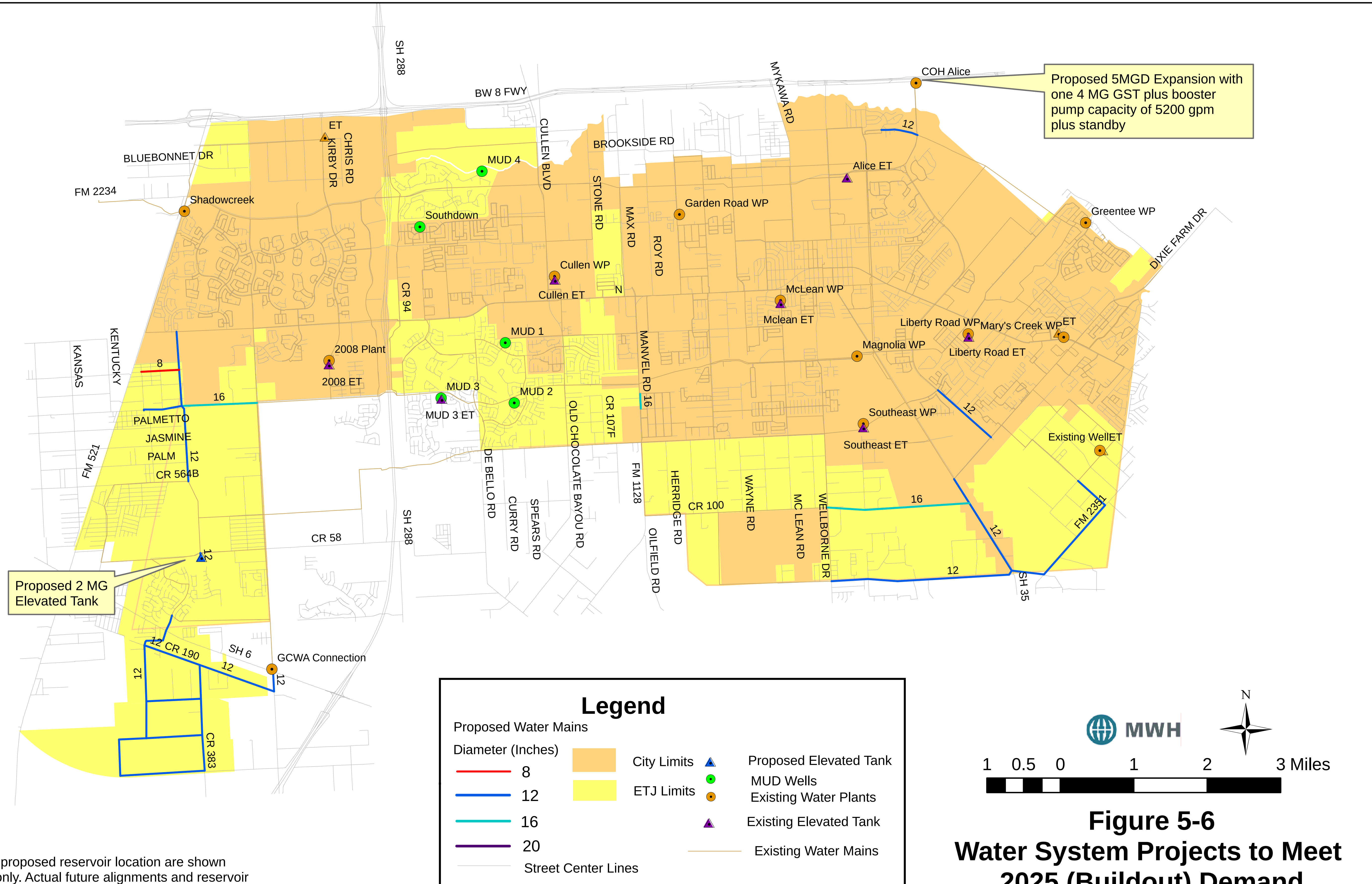
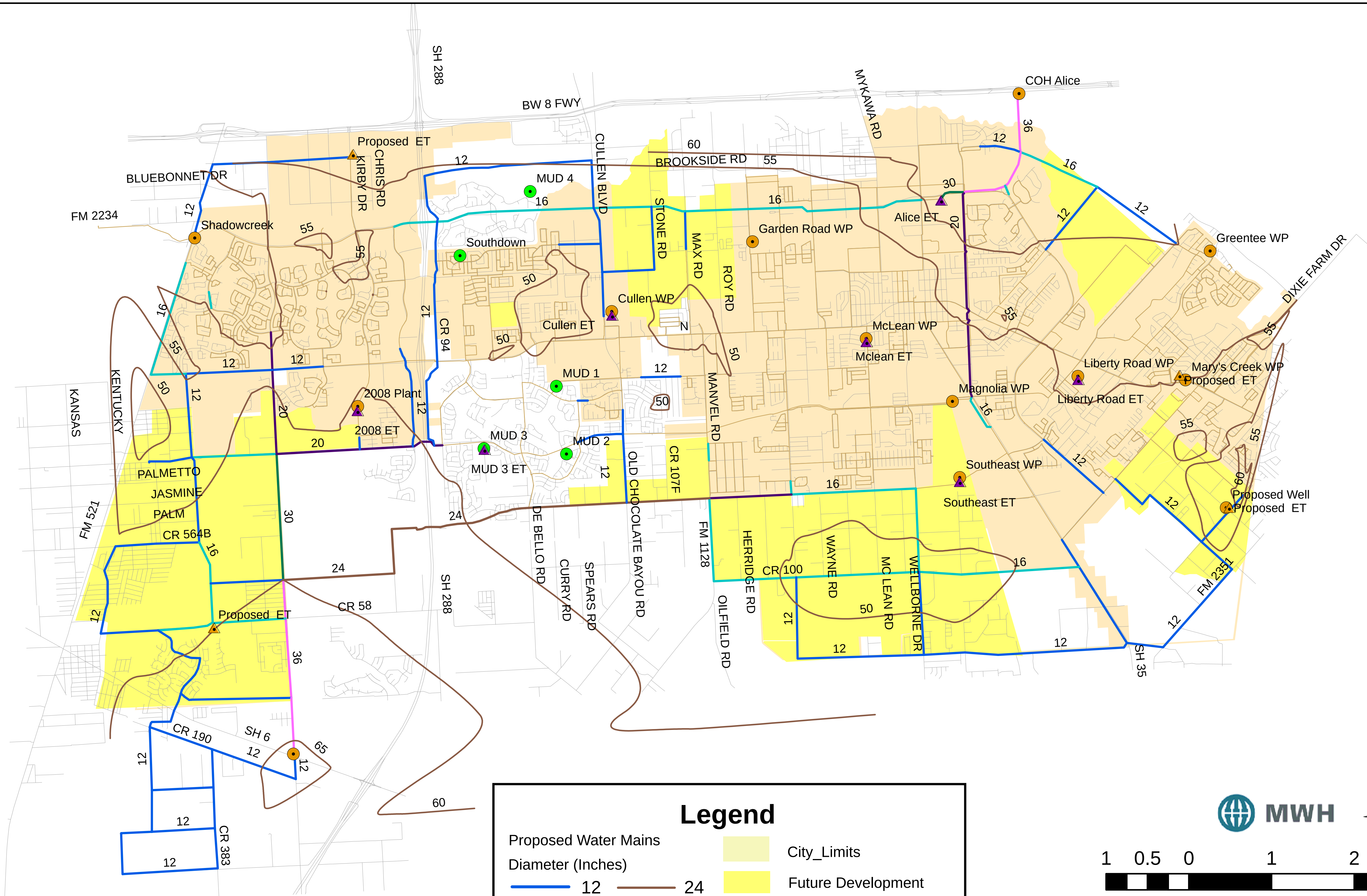


Figure 5-6
Water System Projects to Meet 2025 (Buildout) Demand

Notes:

1. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.



Legend

Proposed Water Mains Diameter (Inches)

12	24		City_Limits
16	30		Future Development
20	36		MUD Wells
Existing Water Mains			Water Plants
Street Center Lines			Proposed Elevated Tank
			Existing Elevated Tank

MWH

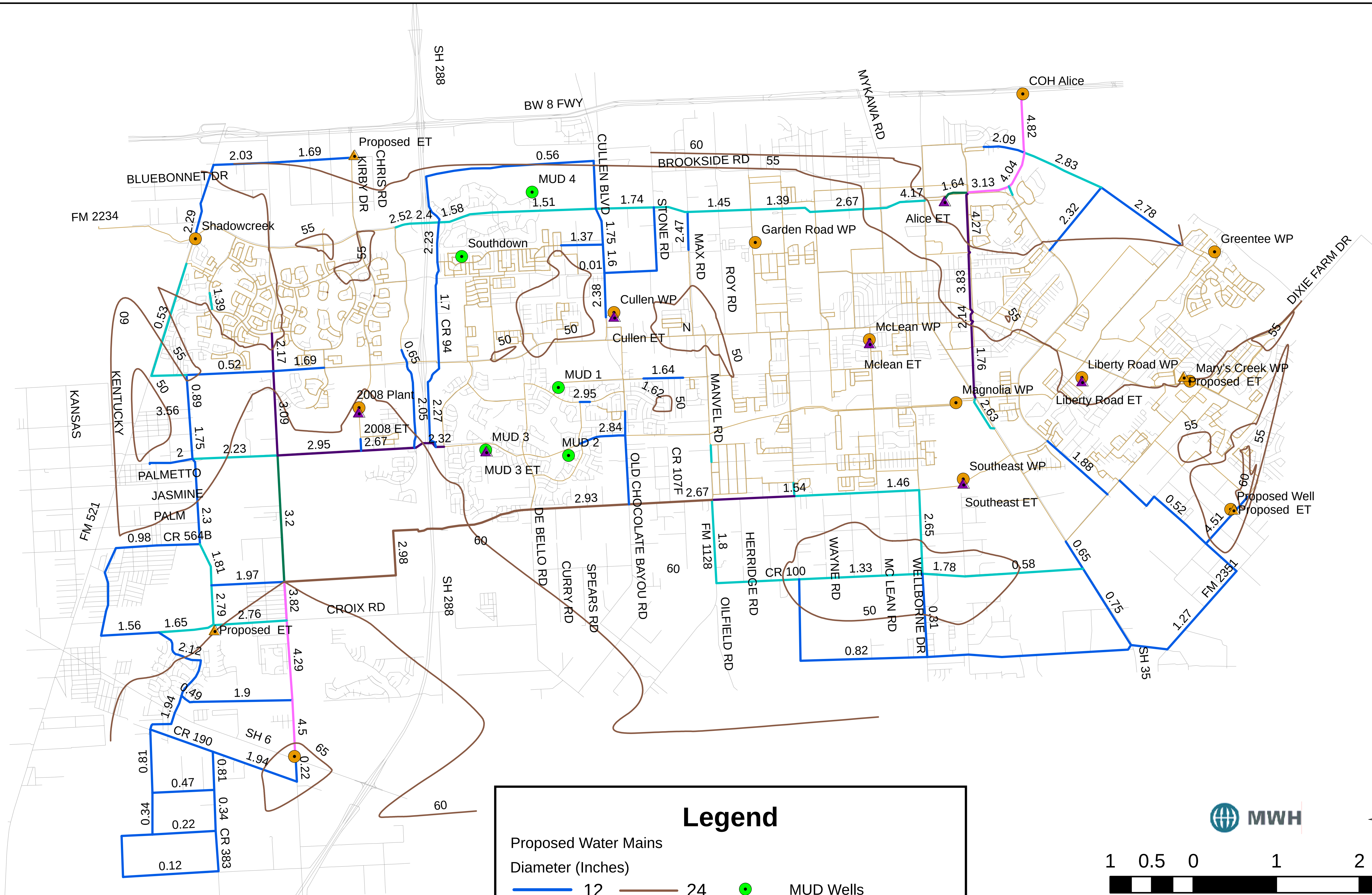
N

1 0.5 0 1 2 3 Miles

Notes:

1. Units for pressure are in psi
2. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.

Figure 5-7
Pressures at Peak Hour Demand Under Buildout Conditions



Legend

Proposed Water Mains

Diameter (Inches)

12	24	MUD Wells
16	30	Water Plants
20	36	Proposed Elevated Tank
Existing Water Mains		Existing Elevated Tank
Street Center Lines		

MWH

N

1 0.5 0 1 2 3 Miles

Notes:

1. Units for pressure are in psi and velocity are in fps.
2. Pipelines and proposed reservoir location are shown conceptually only. Actual future alignments and reservoir location will be determined when development occurs.

Figure 5-8
Pressures and Pipe Velocities Under Buildout Conditions

A summary of the proposed pipeline improvements is shown in **Table 5-11**.

Table 5-11
Length of Recommended Pipelines

Year	Pipeline Diameter						Total (ft)
	12-inch	16-inch	20-inch	24-inch	30-inch	36-inch	
2010	29,500	3,500	15,600	0	1,700	2,700	53,000
2015	67,000	78,000	10,800	30,500	0	11,000	197,300
2020	70,300	10,000	0	0	0	0	80,300
2025	100,200	15,600	0	0	0	1,700	117,500
Total (ft)	**267,000**	**107,100**	**26,400**	**30,500**	**1,700**	**15,400**	**448,100**

SENSITIVITY ANALYSIS

Using the hydraulic model, two sensitivity analyses are performed for the City's water system:

- Use of imported water connections only under ADD
- Modification of GCWA and COH Alice flow rates

Imported Water Sources Only at ADD

The hydraulic model is used to determine the feasibility of using only imported surface water connections under ADD. In this case, all groundwater wells are turned off. In this scenario, there is no significant modification to system pressures. At build-out, the imported supplies will provide approximately three-quarters of the total water supplies. Since ADD is just over half of MDD, there is sufficient imported water supplies to meet ADD without local groundwater sources. Thus, the hydraulic condition during MDD and during ADD with imported water sources only is very similar and shows similar pressure results.

Modification of Flows from Imported Sources

The sensitivity analysis requested by the City is to modify the flow rates from GCWA and COH Alice by up to 5 mgd to determine the effects of the change in flow rates on the buildout water system. No modifications are made to the build-out facility recommendations as shown in **Figure 5-7** and **Figure 5-8**.

Increasing the flow at COH Alice by 5 mgd (to 20 mgd) and reducing the flow at GCWA by 5 mgd (to 15 mgd) increases typical pressures in the eastern portion of the system by approximately 10 psi and reduces typical pressures in the western portion of the system by approximately 5 psi compared to **Figure 5-7**. During lower demand periods, the pressure at the COH Alice connection could be as high as 75 psi (compared to a high pressure of 70 psi) with the increase in supplies. It must be noted that the elevated tank at Alice will be completely full during parts of the day if COH Alice is flowing at 20 mgd.

Increasing the flow at GCWA by 5 mgd (to 25 mgd) and reducing the flow at COH Alice by 5 mgd (to 10 mgd) increases typical pressures in the western portion of the system by approximately 5 psi and reduces typical pressures in the eastern portion of the system by approximately 5 psi compared to **Figure 5-7**. During lower demand periods, the pressure at the GCWA connection could be as high as 75 psi (compared to a high pressure of 70 psi) with the increase in supplies. It must be noted that the proposed elevated tank near GCWA will be completely full during parts of the day if GCWA is flowing at 25 mgd.