Sewer Master Plan

February 2016

Prepared by:

Bowen Collins & Associates, Inc.
CONSULTING ENGINEERS

Prepared for:

OREM

SEWER MASTER PLAN

February 2016

Prepared for:

Prepared by:

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CHAPTER 1
INTRODUCTION

INTRODUCTION

Orem City has retained Bowen Collins & Associates (BC&A) to prepare a master plan for the City's wastewater collection system. The purpose of this sewer master plan report is to identify recommended improvements that will resolve existing and projected future deficiencies in the wastewater collection system throughout the City's service area. The results of this study will be incorporated into a Rate Study that will be used to establish wastewater user rates for the City.

SCOPE OF SERVICES

The general scope of this project involved a thorough analysis of the City's sewer collection system and its ability to meet the present and future wastewater needs of its residents. As part of the Sewer Master Plan, BC&A completed the following tasks.

Task 1: Collected information as needed to develop the sewer master plan based on the City's general plan and existing facilities.

Task 2: Updated population projections and estimated growth in sewer flow to evaluate future growth needs.

Task 3: Developed a hydraulic computer model of the Orem City collection system to evaluate existing and projected future system deficiencies. This included calibrating the model using data from the City's existing GIS database and water meter data from the City.

Task 4: Identified existing operating deficiencies.

Task 5: Identified projected future operating deficiencies.

Task 6: Evaluated alternative improvements for resolving deficiencies identified in Tasks 4 and 5. This included evaluating alternatives looking at diversion locations and reuse opportunities.

Task 7: Developed a comprehensive capital facilities plan incorporating all required improvements identified for the collection system.

Task 8: Documented results of the previous tasks in a report with additional memoranda as needed. As part of this task, BC&A also made presentations to the City's public advisory committee and City Council in meetings throughout the project.

In association with the master planning process, BC&A performed several additional evaluations relative to the Orem City sewer system. The results of these evaluations are contained in technical memoranda attached at the end of this report. This included the following:

- A struvite evaluation at the wastewater reclamation facility
- An evaluation of maintenance and manpower requirements in the City

In conjunction with the master plan, a rate study was also completed by BC&A's financial subconsultant, Lewis Young Robertson & Burningham. The results of their activities are documented in a separate report.

This document is a working document. Some of the recommended improvements identified in this report are based on the assumption that development and/or potential annexation will occur in a certain manner. If future growth or development patterns change significantly from those assumed and documented in this report, the recommendations may need to be revised. The status of development should be reviewed at least every five years. This report and the associated recommendations should also be updated every five years.

ACKNOWLEDGMENTS

The BC&A team wishes to thank the Public Works Advisory Committee as well as the following individuals from Orem City for their cooperation and assistance in working with us in preparing this report:

Chris Tschirki	Public Works Director
Neal Winterton	Water Resources Division Manager
Joseph Jamison	GIS Specialist / Sewer Collection Project Manager
Lawrence Burton	Water Reclamation Section Manager
Tom Phelps	Information Technology

PROJECT STAFF

The project work was performed by the BC&A's team members listed below. Team member's roles on the project are also listed. The project was completed in BC&As' Draper, Utah office. Questions may be addressed to Keith Larson, Project Manager at (801) 495-2224.

Mike Collins	Principle in Charge
Keith Larson	Project Manager
Andrew McKinnon	Project Engineer
Aaron Anderson	Staff Engineer, Sewer Modeling
Mike Hilbert	Clerical

CHAPTER 2
EXISTING SYSTEM FEATURES

INTRODUCTION

As part of this Master Plan, BC&A has assembled an inventory of existing infrastructure within the sewer collection system. The purpose of this chapter is to present a summary of the inventory of Orem City's existing sewer collection system that can be used as a reference for future studies.

SERVICE AREA

The Orem City sewer system service area as shown in Figure 2-1 is approximately 20 square miles and is bordered by the following: Mount Timpanogos to the east, Utah Lake and Vineyard to the west, Lindon City to the north, and Provo City to the south and east. The service area generally follows the corporate boundaries of the City; however, there are some areas that deviate from this general conclusion as a result of topography limitations and historic development patterns. This includes areas of Lindon City (to the north) and the Town of Vineyard (to the west) that are served by the Orem City collection system. There are also small areas at the south end of Orem City that flow to the Provo City wastewater treatment plant. There are even a few small areas of Orem City's collection system that flow through parts of Lindon's collection system on their way to Orem's treatment plant. The areas where each of these situations apply are identified on Figure 2-1.

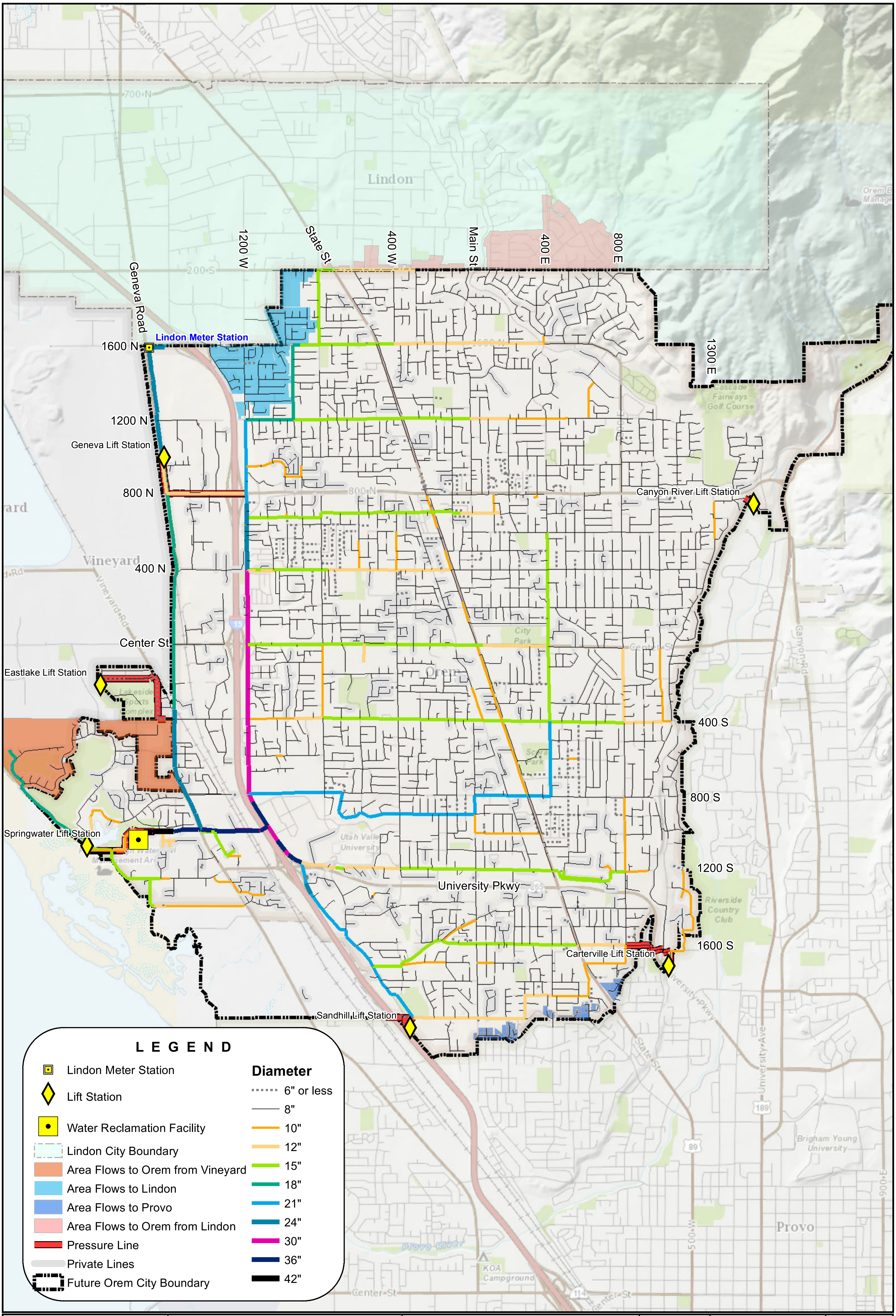
Wastewater from the City's collection system service area is treated at the Orem City Water Reclamation Facility. Additionally, the reclamation facility treats all of Lindon City's existing wastewater, most of which is metered at the Lindon Meter Station indicated in Figure 2-1. In 2014, the total population served by the reclamation facility included approximately 90,000 permanent residents in Orem City with an additional 10,000 permanent residents from Lindon City. In addition to permanent residents, the City also serves the Utah Valley University student and faculty population along with many other commercial, industrial, and institutional entities. The east side of the City is largely residential and is mostly built out. The west side of the City includes significant commercial/industrial, with some large areas still available for future development.

TOPOGRAPHY

The topography of the City generally slopes from northeast to southwest with the City's treatment plant located at the southwest edge of the City (next to Utah Lake). Most of the City collection system flows by gravity to the treatment plant, but a few areas do require lift stations (6 total). All of the wastewater flow from Lindon must be pumped through the City's largest lift station on Genene Road.

COLLECTION SYSTEM

Major attributes of the various components of the collection system are summarized in the following sections.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS

OREM CITY
SEWER MASTER PLAN

EXISTING COLLECTION SYSTEM

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 2-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 2-1.mxd amckinnon 6/26/2014

Sewer Collection Pipes

There are about 1.5 million feet (286 miles) of sewer pipe and over 6,400 manholes in the Orem City Sewer System that are cataloged in the GIS database. Table 2-1 contains a summary of the sewer pipes for the Orem City sewer collection system. As can be seen in the table, 80 percent of the pipe in the system is 8 inches in diameter. This represents the vast network of small collection mains in neighborhoods throughout the City.

Table 2-1
Sewer Collection System Sizes and Lengths

Diameter	Length (ft)	Length (mi)	Percentage
4*	3,982	0.75	0.3%
6	64,888	12.29	4.3%
8	1,193,295	226.00	78.9%
10	59,253	11.22	3.9%
12	43,472	8.23	2.9%
15	74,131	14.04	4.9%
18	18,182	3.44	1.2%
21	24,777	4.69	1.6%
24	12,040	2.28	0.8%
27	834	0.16	0.1%
30	9,495	1.80	0.6%
33	2,209	0.42	0.1%
36	3,169	0.60	0.2%
42	2,493	0.47	0.2%
Total	**1,512,219**	**286.41**	**100.0%**

*Service laterals are not included in the collection system lengths.

Table 2-2 provides a summary of the pipeline materials used in the City's wastewater collection system. As indicated in the table, concrete pipe is the most common pipe material in the system. There is also a large portion of the system where pipeline material is unknown. Given the age of the areas where pipeline material is unknown, it is suspected that most of this pipe is also concrete. In the end, as much as 80 percent of the collection system may be concrete pipe.

The high percentage of concrete pipe in the City collection system may create some challenges in the future. While concrete is generally a durable, long lasting material, it is extremely susceptible to corrosion associated with hydrogen sulfide gas. As part of the City's long term maintenance plans, it will likely need to perform extensive rehabilitation to protect its existing concrete pipelines from hydrogen sulfide related corrosion. This is discussed in greater detail in subsequent chapters of this report.

Because of its resistance to hydrogen sulfide related corrosion, PVC is now the preferred material of construction for most new sewer mains. As the City continues to rehabilitate and replace older existing lines, it is anticipated that the percentage of PVC will gradually increase.

Table 2-2
Sewer Collection System Materials

Pipe Material	Percentage
Concrete	42.1%
Unknown	39.6%
PVC	15.8%
Other*	2.5%

*Clay, ADS, cast iron, resin liners

Diversions

The City has a single diversion near UVU and I-15 that uses an overflow weir to send excess flow through a parallel pipe underneath I-15 and the UTA and Union Pacific railroad tracks. The overflow is not used under dry weather flow conditions, but may function during wet weather to prevent surcharging conditions. In addition to this diversion, there are a number of manholes in the City that have potential overflow pipes that are primarily used for flushing lines and maintenance. These overflow diversions are discussed more in Chapter 4.

Sewer Lift Stations

There are 6 sewer lift stations in the Orem City sewer collection system that are owned and operated by Orem City. The City's lift stations range in capacity from 300 to 1,200 GPM. Where possible, pump curves and as built drawings were collected for each lift station and are included in Appendix A. A summary of the lift station data is listed in Table 2-3.

Table 2-3
Summary of Sewer Lift Stations

Name	Address	Capacity (gpm)*	Wet Well Volume (cf)	Power (HP)	No. Pumps
Carterville Lift Station	1720 S 1030 E	500	350	40	2
Geneva Lift Station - to Geneva Road	1002 N Geneva Rd	833	1,851	10	2
Geneva Lift Station - to 1200 West	1002 N Geneva Rd	1,187		75	2
Springwater Lift Station	2100 W 1000 S	850	300	23	2
Eastlake Lift Station	1991 W 180 S	300	175	15	2
Canyon River Lift Station	155 N 1550 E	300	280	25	2
Sandhill Lift Station	2082 S Sandhill Rd	300	211	10	2

*each lift station is also equipped with a variable frequency drive to reduce pump cycles and limit stagnation.

Note that the Geneva Lift station can discharge to two different gravity mains (1200 West and Geneva Road) that flow to the City's reclamation facility. For normal dry weather flow, the City normally discharges to Geneva Road. However, for wet weather conditions, inflow from Lindon can significantly exceed normal dry weather flows. For these conditions, the City may pump to 1200 West using a separate set of pumps and force main.

OREM CITY WATER RECLAMATION FACILITY

The Orem City Water Reclamation Facility (WRF) is located at 1797 West 1000 South and was first constructed in 1958. The WRF includes a pretreatment headworks that screens the raw influent prior to pumping it to the main treatment plant for secondary treatment. The secondary treatment process includes primary clarifiers, aerobic and anaerobic digesters, secondary clarifiers, and dissolved air flotation. Solids handling facilities at the WRF include gravity thickeners, an oxidation ditch, return and waste activated sludge, and a belt press. Effluent is treated with ultraviolet disinfection prior to discharging to the Powell Slough toward Utah Lake. The WRF has a peak month, average day capacity of 13.5 mgd, with a peak hydraulic capacity of 21.6 mgd.

These capacities are based upon cursory review of data provided by City personnel. It is recommended that a Facility Study for the entire treatment process be completed. The Facility Study will provide a comprehensive look at the entire treatment process, and would identify cost effective alternatives for meeting the future needs of Orem City.

CHAPTER 3
FUTURE GROWTH AND FLOW PROJECTIONS

INTRODUCTION

Before attempting to hydraulically model and evaluate the City's sewer collection facilities, one must first have an accurate understanding of wastewater flows. This includes an estimate of both the quantity and distribution of existing and future flows. The purpose of this chapter is to summarize the results, assumptions, and process of calculating both existing and future wastewater flows.

There are three major components of wastewater flow: domestic wastewater, infiltration, and inflow. Each of these is discussed in detail in this chapter.

DOMESTIC WASTEWATER

Domestic wastewater includes all wastewater produced by system customers, including both residential and commercial customers. There are several methods that can be used to estimate domestic wastewater flow. This study develops domestic wastewater flow projections based on both full time residential population and employment population. The methodology of this study can be summarized as follows:

1. Define the service area.
2. Divide the service area into a number of smaller sub-areas using geographical information system (GIS) mapping.
3. Project residential population for each sub-area based on existing and projected patterns of development.
4. Project employment and other non-residential populations for each sub-area based on existing and projected patterns of development.
5. Adjust projections as required to accommodate areas of special growth consideration including "planned development" zones (PD Zones), Utah Valley University, University Mall Redevelopment, and the Southwest Annexation Area.
6. Estimate the domestic wastewater contribution of each factor (residential and non-residential) based on a statistical analysis of existing levels of development and historic water use in each sub-area.
7. Convert projections of residential and non-residential development to wastewater flow rates based on their historic contributions.

Each step of this process is summarized in the sections below.

STUDY AREA

The study area for this analysis is generally the same as the City's municipal boundary as shown in Figure 3-1 with additional flow inputs from Lindon City (which are conveyed to the City's treatment facility via Geneva Road) and Vineyard City. It is expected that the sewer collection system will continue to expand to provide service to new development within the City, but that services will not extend much beyond the City's current corporate boundaries and the small collection areas in Vineyard and Lindon currently served by the City's collection system. Orem City's collection system will eventually serve all areas in Vineyard south of 400 South.

TRAFFIC ANALYSIS ZONES

Division of the service area into smaller sub-areas is important for two reasons. First, it increases the accuracy of the population and flow projections by examining land use and development patterns at a smaller scale. Second, it yields projections that are distributed spatially across the service area, an important requirement for future modeling efforts.

For this study, sub-areas were defined based on Traffic Analysis Zones (TAZ). A TAZ is the smallest geographic unit used for residential and non-residential population projections developed by the Mountainland Association of Governments (MAG). Non-residential population data includes employees, retail, industrial, and other non-residents. TAZ boundaries are established on an arbitrary basis by MAG for travel demand modeling.

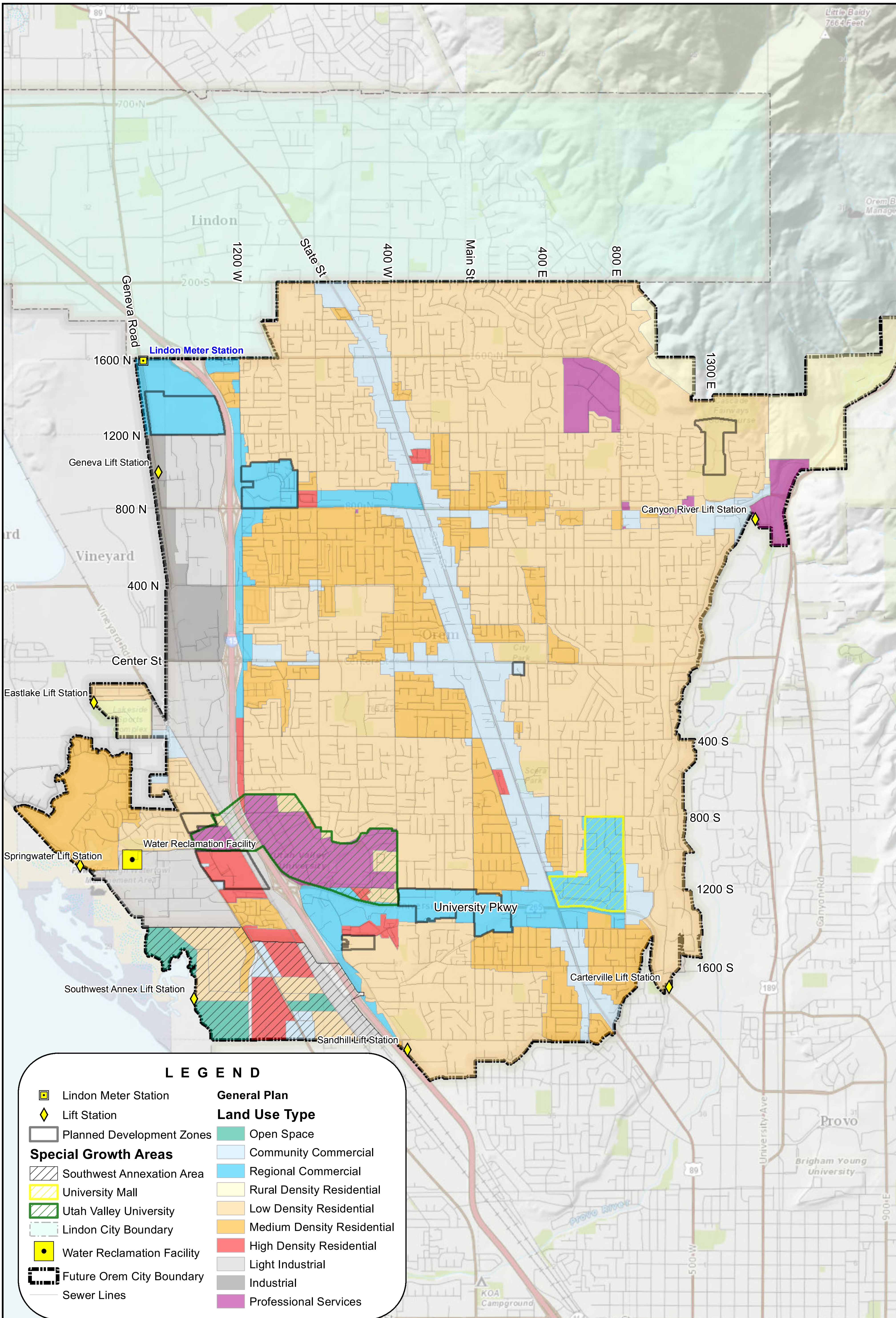
TAZ boundaries were used for this analysis because population projections have already been developed from census data for TAZ areas by MAG. The projections are provided every 5-years starting in 2010 and continuing to 2040. TAZ boundaries were also used because they are small enough to give an adequate distribution of flow across the service area for use in modeling. The TAZ boundaries used in this analysis are shown on Figure 3-2. As can be seen in the figure, TAZ boundaries are not always consistent with the City's service area boundaries. If a TAZ was only partially in the study area boundary, then the percentage inside the boundary was determined. MAG projections were multiplied by this percentage to determine the portion of the TAZ projection within the study area boundary.

OREM CITY RESIDENTIAL AND NON-RESIDENTIAL POPULATIONS

Population projections for the City have been developed using the City's General Plan, population projections from the Governor's Office of Management and Budget (GOMB) and Mountainlands Association of Government. Residential and non-residential projections were developed for two periods: Present to 2040, and 2040 to 2060. The methodology varies slightly for each period.

Projections from Present to 2040

The population projections, from present to 2040, were initially taken from the MAG Population Projection Report, 2011 Baseline. The MAG projections were then adjusted with input from City personnel for the special areas of consideration noted above and for key "planned development" zones (PD Zones). PD Zones are identified separately because of the relatively wide variability in



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OREM CITY
SEWER MASTER PLAN

OREM CITY GENERAL PLAN & SPECIAL GROWTH AREAS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 3-1

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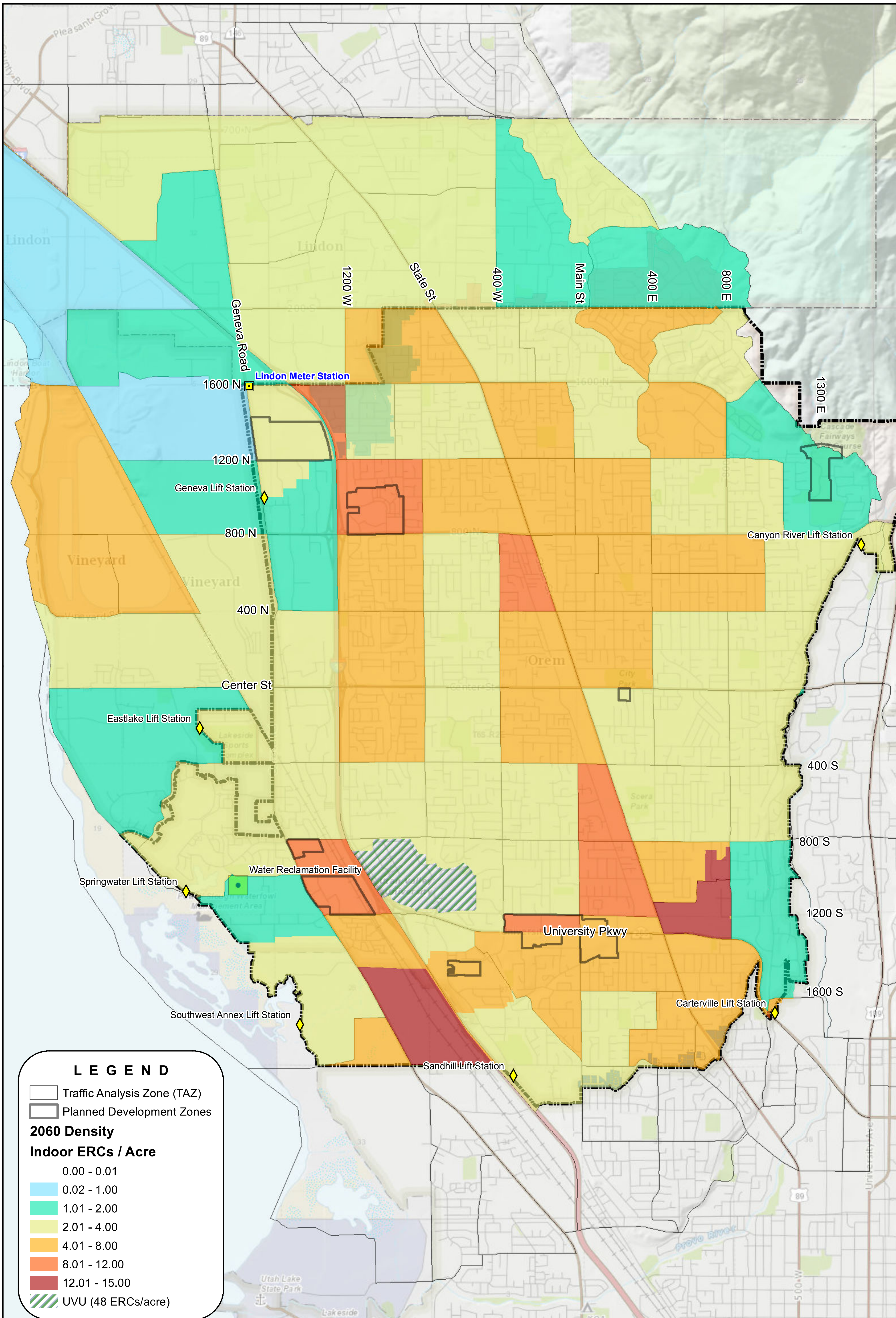

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OREM CITY
SEWER MASTER PLAN

2060 DEVELOPMENT DENSITY
INDOOR ERCS PER ACRE

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO.
3-2

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 3-2 - Development Density.mxd amckinnon 4/20/2015 types of development that may be incorporated into a PD Zone (including commercial, industrial, mixed use development, student housing). In general, PD Zones are intended to be consistent with the underlying General Plan designation, but may include other development types in the zone in accordance with City and developer interests for the site.

The modified MAG projections were used to estimate where growth will occur in the City. MAG will be updating its projections in the near future, but for the purpose of this study, the distributions used from the 2011 baseline were considered adequate with modifications by City personnel to reflect City estimates. Residential and non-residential populations were treated separately and independently for these projections.

The Southwest Annexation Area was treated somewhat independently for these projections. This area of the City has its own planning documents that have defined buildout wastewater production. An equivalent residential population for this area was developed for this area using the wastewater projections from the August 2015 "Sanitary Sewer Impact Fee Facilities Plan and Impact Fee Analysis" prepared by Lewis Young Robertson and Burningham. This area is shown to be completly built out by the year 2027.

Projections from 2040 to 2060 - Residential

The detailed MAG projections only extend to 2040. Because this does not cover the full planning window of this sewer master plan, growth beyond the year 2040 needed to be examined and incorporated into this study. A buildout estimate of growth was estimated for each area of the City by extrapolating the population from 2040 to 2060 using the final growth rate in the MAG projections for all areas with a positive growth rate (some areas have a negative growth rate associated with declining population). This estimate was compared to the overall GOMB projection for total City population at 2060 and adjustments were made within the special areas of consideration or PD Zones so that the 2060 population distribution matched the 2060 GOMB residential population estimate. Figure 3-2 shows an estimate of equivalent residential connections per acre in 2060 using an average household size of 3.34 persons/household (2008 – 2012 estimate for Orem City).

Projections from 2040 to 2060 – Nonresidential

For non-residential growth, a buildout estimate of growth was estimated by extrapolating from 2040 to 2060 using the final growth rate in the MAG projections for all areas with a positive growth rate. No other adjustments were made for non-residential growth.

Projections for UVU – Nonresidential

Because Utah Valley University (UVU) makes up a significant portion of City-wide wastewater production, and has a significant potential for growth, projections for UVU were treated separately from other nonresidential projections. Based on UVU's current Master Building Plan, the square footage of buildings on the UVU campus is estimated to approximately double to accommodate future student populations in Orem City. As a result, wastewater production for the campus will also likely double in the future. Projections for UVU assume funding for expansion projects on campus will be uniform through 2060 so that a student population of approximately 53,000 students is reached in 2060. It should be noted that the student population has been used to project wastewater growth for UVU rather than building square footage because an accurate estimate of the existing building square footage was not available during this study. With either approach, the estimated wastewater is anticipated to double within the planning window.

The results of the residential and non-residential projections described above are summarized in Tables 3-1 and 3-2.

Table 3-1
Residential Population Projections

Year	Orem[1] Residential Population	Lindon Residential Population	Vineyard[2] Residential Population	Southwest[3] Annexation Population	Total Residential Population
2010	88,328	10,134	69	0	98,531
2013	91,466	10,595	90	0	102,151
2020	99,227	11,753	223	1,219	112,422
2030	103,321	12,459	526	5.611	121,917
2040	112,288	13,721	727	5,611	132,347
2050	118,900	14,600	788	5,611	139,899
2060	123,600	15,900	806	5,611	145,917

[1]A small portion of the Orem City service area contributes wastewater to Provo City. This area was neglected for Table 3-1.
[2]The estimated service area population from Vineyard City includes all areas in Vineyard south of 400 South and is based on the residential population distribution derived from Mountainland Association of Governments Traffic Analysis Zones.
[3]The residential population indicated for the Southwest Annexation area was calculated based on a build-out flow of 334,646 gpd of wastewater production and the total number of approved ERUs as identified in the area's updated planning documents. For simplicity, all wastewater from the Southwest Annexation Area is being represented as residential.

Table 3-2
Non-Residential Population Projections

Year	Orem[1] Non-Residential Population	Lindon Non-Residential Population	Vineyard[2] Non-Residential Population	Total Non-Residential Population (except UVU)	Total[3] UVU Student Population
2010	130,371	28,225	26	158,622	23,963
2013	135,022	29,509	34	164,565	26,307
2020	146,643	36,584	51	183,278	36,279
2030	155,318	42,121	115	197,554	41,967
2040	161,309	46,158	121	207,588	45,516
2050	164,401	51,487	128	216,016	49,065
2060	167,552	57,431	134	225,117	52,614

[1]A small portion of the Orem City service area contributes wastewater to Provo City. This area was neglected for Table 3-1.
[2]The estimated service area population from Vineyard City includes all areas in Vineyard south of 400 South and is based on the residential population distribution derived from Mountainland Association of Governments Traffic Analysis Zones.
[3]The student population indicated is based on a uniform growth rate through 2060.

DOMESTIC WASTEWATER FLOW PROJECTIONS

The process of using residential and non-residential population data to develop domestic wastewater flow rates was completed by relating the residential and nonresidential indoor water use to wastewater flow rates.

An analysis of indoor water usage for residents, nonresidents, and UVU was developed for Orem City using indoor water meter records. Based on the water meter records, non-residential indoor water use which consists of retail, employment, industrial, and other water uses was equal to approximately 24% of total indoor water use in the City. Based on this data, it was possible to estimate the contribution of wastewater by residential, non-residential, and student populations. Based on the residential and non-residential population data, indoor water meter data, and total influent at the City's wastewater treatment plant, an estimate of per capita domestic wastewater for each user type was developed as summarized in Table 3-3.

Table 3-3
Contribution of Wastewater by User Type

Component	Wastewater Contribution (gpcd)
Residential Population	59.6
Non-Resident Population	11.7
Student Population	31.3

Total domestic wastewater contributions can therefore be estimated by multiplying the projected residential, non-residential, and student populations by their respective per capita wastewater contribution as summarized in Table 3-4.

Table 3-4
Projected Total Domestic Wastewater Flows

Year	Residential Domestic Wastewater Flow (mgd)	Non-Residential Domestic Wastewater Flow (mgd)	UVU Domestic Wastewater Flow (mgd)	Total Domestic Wastewater Flow (mgd)
2013	6.09	1.93	0.83	8.85
2020	6.71	2.14	1.14	9.99
2030	7.27	2.31	1.32	10.90
2040	7.90	2.43	1.43	11.76
2050	8.34	2.53	1.54	12.41
2060	8.70	2.64	1.65	12.99

Water Conservation

It should be noted that the results in the tables above do not include any reduction in future wastewater production associated with conservation. The City currently has a water conservation goal to reduce its per capita water usage (as measured in the year 2000) by 25 percent by the year 2025. A reduction in wastewater flow associated with this projected future conservation was not included for two reasons. First, the projections have been based on recent water use data that already reflects some conservation since the year 2000. Second, the water conservation goal of the City includes consideration of both indoor and outdoor water use. Past history would suggest that the majority of conservation will occur through the reduction of outdoor water use. As a result, the effects of water conservation on indoor water use will likely be relatively small. Because of these two reasons, additional conservation in the future was conservatively ignored for modeling purposes in this study. However, it is possible that, as the City continues to reduce water use through conservation, there may be some effect on indoor water use and domestic sewer flows. This could potentially delay some projected future system deficiencies and associated system improvements. System flow monitoring will be a valuable tool to track changes in domestic sewer production over time and further assess the effects of indoor conservation.

WASTEWATER FLOW DISTRIBUTION

Table 3-4 summarizes total wastewater projections for the City service area as a whole. For hydraulic modeling purposes, these flows must be distributed throughout the service area. For existing conditions, flows were distributed based on winter water use records. The City GIS system includes historic water use records for each meter in the City system. Winter water reads for each meter were attached to the nearest trunkline manhole in the model to calculate the portion of total domestic wastewater flow associated with each manhole.

To distribute future flows, growth was evaluated by TAZ. The total increase in flow for each TAZ was calculated as described in the sections above. The growth was then distributed to the nearest trunkline manhole within each TAZ. In the case of UVU, increases in flow were assigned to a single manhole because most of the projected expansion will not necessarily require new collection system pipes.

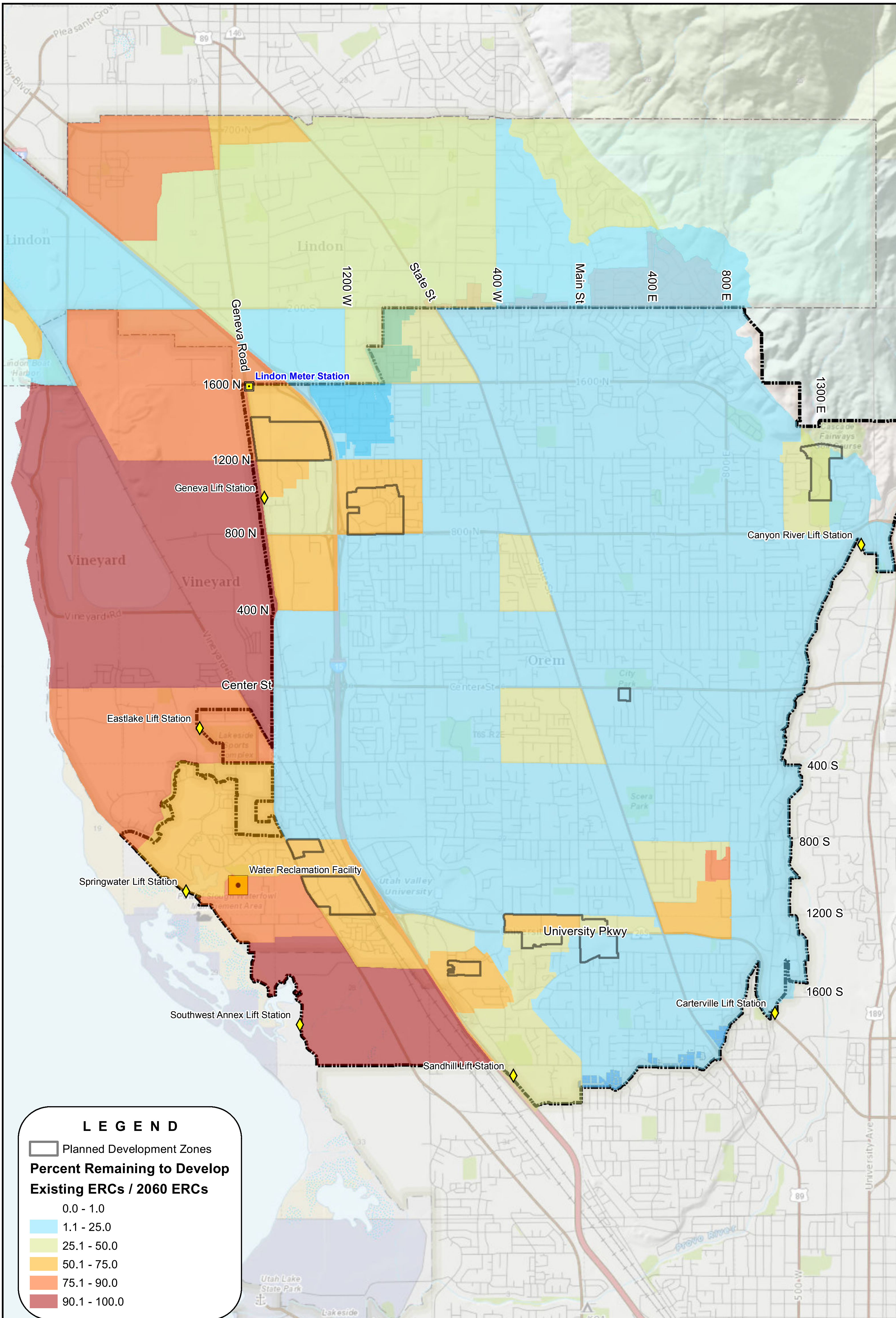
Figures 3-3 shows the potential for growth in Orem based on the estimated percentage of remaining development compared to 2060 in equivalent residential connections.

INFILTRATION

Beyond domestic wastewater contributions, the second component of wastewater flow that must be considered is infiltration. Infiltration is defined as water that enters into the sewer system which is not directly or indirectly related to either domestic wastewater or to a specific storm event. This flow can enter as a result of open pipe joints, cracks in pipes, pipes poorly connected at manholes, leaky lateral connections, roots, etc. Infiltration is generally a function of groundwater levels. Groundwater levels in the service area fluctuate depending on climate and season. Infiltration rates will correspondingly change seasonally but will generally be constant during a single 24-hour period. Temporary increases in the amount of water that enters the system after a storm because of an increase in ground water will be considered as inflow (as discussed in a subsequent section).

Factors that can affect infiltration include pipe age, material, and number and condition of lateral connections. Age can contribute to infiltration in two ways. First, older pipes are more likely to be in poor condition. Cracks, separated joints, and other defects can contribute significantly to increased infiltration. Second, older pipes do not have the benefit of improvements in construction techniques that have occurred over time. Gasketed pipe joints, rubber boots at manholes and laterals, and other improvements have contributed greatly to reducing system infiltration over time.

Infiltration in the collection system was identified primarily through temporary flow monitoring conducted by Orem City personnel over a number of years. Infiltration in the collection system was identified by subtracting domestic flow developed using indoor water use records from the total average flow at flow monitors in the City. To account for seasonal fluctuations in infiltration, the highest average monthly flow over the last 5-years was used as the planning criteria for calibrating the existing condition model. Calibration of the hydraulic model is discussed in further detail in Chapter 4. The total infiltration included in the model for existing conditions is 0.94 mgd. For the City's entire collection system, this equates to approximately 356 gallons per day per inch-diameter mile. For comparison, the American Society of Civil Engineers (ASCE) recommends an allowable infiltration rate for new construction of no more than 500 gpd/in-dia/mile. This would suggest that Orem City has relatively low infiltration for its relative age. This conforms to anecdotal information reported by Orem City personnel and may be the result of the topography and soil characteristics of the Orem bench that result in relatively large depths to ground water. For projecting future infiltration, the existing City-wide infiltration rate (infiltration/domestic flow = 11.7%) was applied to future growth uniformly.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS

OREM CITY
SEWER MASTER PLAN

AREAS OF POTENTIAL GROWTH

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 3-3

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Table 3-5 shows projected domestic flows and infiltration through 2060 based on the assumptions above.

Table 3-5
Dry Weather Sewer Flow Rates (mgd)

Year	Projected Domestic Sewer Flows	Estimated Infiltration	Estimated Dry Weather Sewer Flows
2013	8.85	0.94	9.79
2020	9.99	1.10	11.09
2030	10.90	1.42	12.32
2040	11.76	1.51	13.27
2050	12.41	1.57	13.98
2060	12.99	1.63	14.62

INFLOW

The third and final component of wastewater flow that must be considered for wastewater master planning is inflow. Inflow is defined as any water that enters into the sewer system which is directly or indirectly related to a storm event. It can come directly from storm runoff through improper connections to the storm water system, missing or leaky manhole covers, roof drains connected to the system, etc. Storm events can also cause the ground water to raise temporarily, which can cause an increase in flow in the sewer system through the same mechanisms that result in groundwater infiltration during dry weather (cracked pipes, leaky laterals, etc.). Any temporary increase in sewer flow due to raising levels of ground water as a result of snowmelt or rain is considered inflow.

Figure 3-4 shows the flows at the City's wastewater treatment plant 3 days before and after a severe storm event that occurred on September 7, 2013 in Orem City. The storm caused flooding at numerous locations in the City and exceeded the 1 percent probable storm (100-year storm). Resulting inflow at the treatment plant increased flows by at least 150 percent for a short period. It is assumed that many collection system pipes were affected similarly. From this data, it is clear that the City's system does have potential for significant inflow. However, it is not possible to accurately estimate the magnitude and distribution of inflow events for individual pipes without a significant amount of flow monitor and rain gauge data. As a result, inflow has not been included directly in projected flows, but it will be important for the City to include adequate hydraulic capacity in its collection and treatment system to account for inflow events.

WATER RECLAMATION FACILITY CAPACITY

Based on the growth projections through build-out for the Orem City sewer service area, Figure 3-5 summarizes projected flow into the Orem City Water Reclamation Facility. As shown in the figure, average day capacity of the plant is not expected to be exceeded until after 2040. Peak hour sewer flows are more difficult to project because they can be significantly affected by groundwater conditions and inflow events. Based on the best available data, peak hour flows are also not expected to exceed the peak hydraulic capacity of the plant until after 2040. It is recommended

Figure 3-4
Inflow at Wastewater Treatment Plant
for September 7, 2013

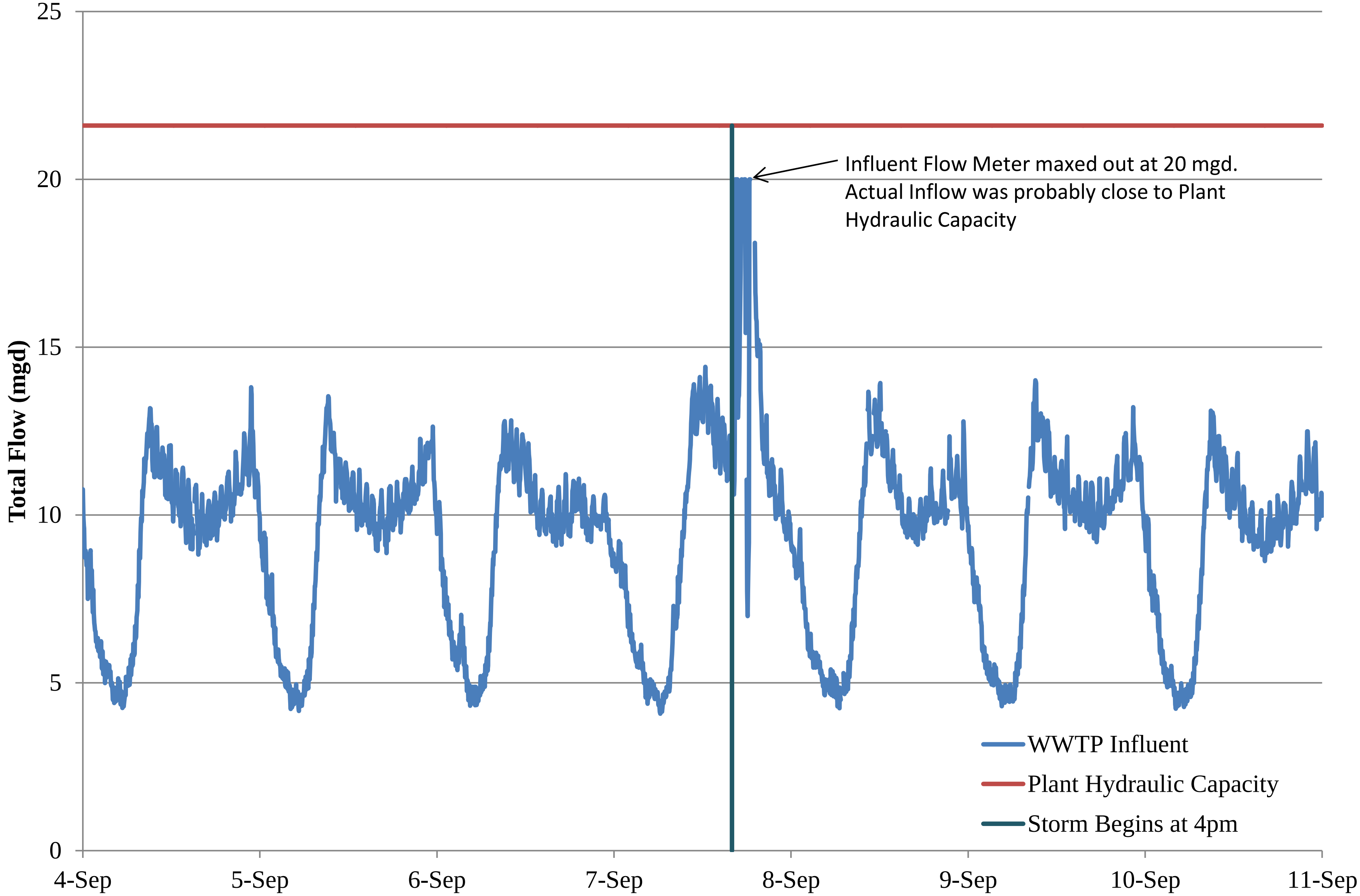
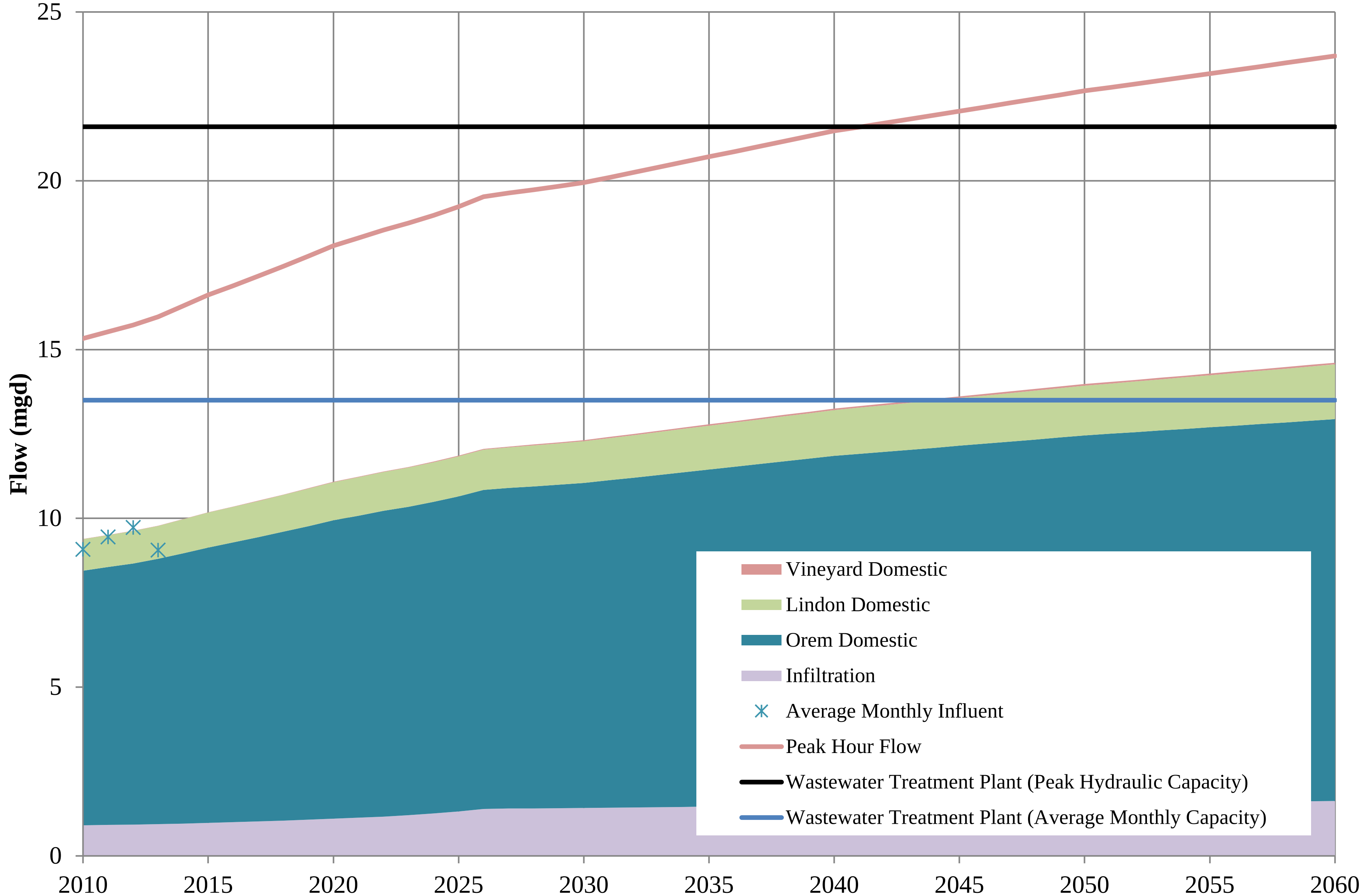


Figure 3-5
Future Wastewater Production to Orem City
Wastewater Treatment Plant



that Orem City continue to monitor and evaluate peak flows relative to plant capacity. However, based on current data, it is not expected that expansion of the plant will be an issue anytime in the near future.

CHAPTER 4
HYDRAULIC MODELING

INTRODUCTION

A critical component in identifying required areas in the Orem City collection system where pipes have capacity deficiencies is the development of a hydraulic computer model. An extended period simulation (EPS) hydraulic model was developed using Innovyze's InfoSWMM software. The purpose of this chapter is to present a summary of the methodology used to develop this model.

GEOMETRIC MODEL DATA

There are two major types of data required to develop a hydraulic model of a sewer system: geometric data and flow data. Geometric data consists of information on the location and size of system facilities including pipes, manholes, and lift stations. It also includes the physical characteristics of the facilities including pipe roughness, invert elevations at manholes, pump settings in lift stations, and a description of any diversions present. This information is generally collected from system inventory data or through direct field measurement. The following sections describe how geometric data was assembled for use in the hydraulic model.

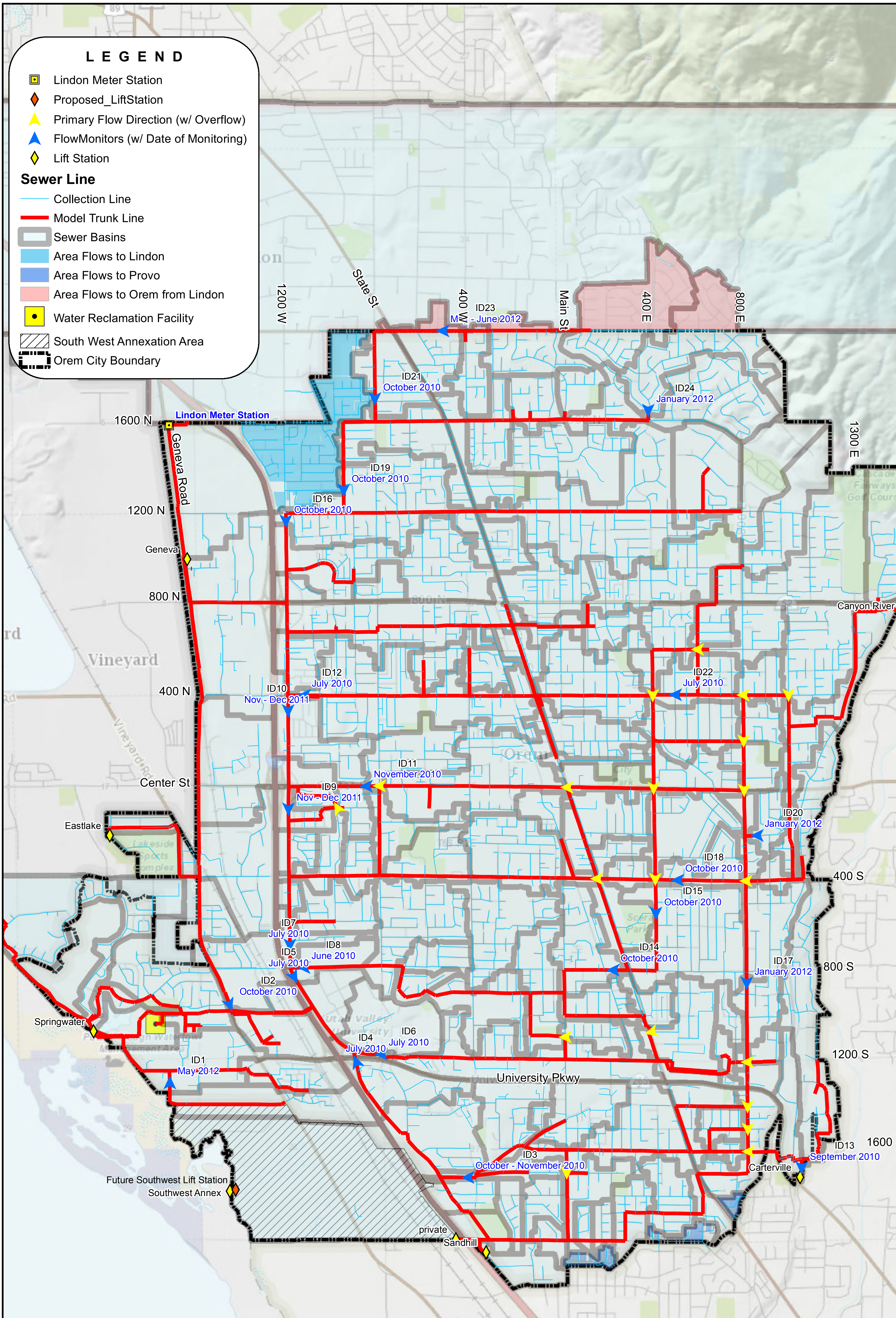
Pipeline and Manhole Locations

Orem City has spent considerable time assembling a GIS inventory of its existing sewer facilities. That database includes information on the location and size of manholes and pipelines in the Orem City collection system. Based on direction from City personnel, pipeline and manhole data was taken directly from the City's GIS database for use in the model. In some areas where manholes did not have reliable invert information, invert elevations were interpolated based on inverts upstream and downstream of areas without information. Areas with interpolated inverts have been documented in the hydraulic model.

Modeled Pipelines

It was not deemed necessary to model all of the sewer pipes in the Orem City sewer system. As smaller pipes are added to the model, the more refined the analysis becomes, but this requires additional time, effort, and expense (including higher annual software maintenance costs for hydraulic modeling). Hence, it is important to consider the required accuracy and available budget when selecting the sewer lines to model.

To optimize the level of effort, it was decided to include in the model all sewer pipes with a diameter of 10 inches or larger and 8-inch pipes serving areas greater than 200 acres as shown in Figure 4-1. As service areas decrease in relative size (less than 200 acres), State minimum slope requirements result in capacities that exceed the potential wastewater production for typical residential densities in Orem City. As a result, modeling pipes that are serving areas smaller than this size will not add any additional meaningful results to the analysis. It is possible that higher density developments may require additional 8-inch pipes to be modeled in the future.



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OREM CITY
SEWER MASTER PLAN

MODEL TRUNK LINES & FLOW MONITORS

NORTH:

SCALE: 0 1,250 2,500 Feet

FIGURE NO. 4-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 4-1 - Trunk Lines.mxd amckinnon 11/7/2014

However, for the purpose of this study, the pipes identified for modeling were considered adequate for assessing potential hydraulic deficiencies. The final selection of sewer lines included in this model was reviewed and approved by Orem City personnel.

Pipe Flow Coefficients

Pipe flow coefficients used throughout the hydraulic model were assigned a Manning's roughness coefficient of 0.013. This is approximately equal to the roughness coefficient of concrete and clay pipe. While there are other materials in the system with lower published roughness coefficients (e.g. PVC), 0.013 was used throughout the system as a conservative approach for estimating pipe capacity. In addition, most collection pipes can develop thin layers of bacteria and solids (a slime layer) that result in relatively uniform roughness coefficients despite varying materials.

Sediment and Debris

Because of the transportable nature of grease and debris in a sewer collection system, it is not possible to identify the exact location and quantity of grease or debris accumulation in the system for any specific point in time. Similarly, the build-up and erosion rates of sediment in sanitary sewer systems are not always well understood. As a result, the detailed modeling of sediment, grease, and debris on a system wide basis is not feasible because of continually changing conditions. Therefore, no sediment was included in the various runs of the hydraulic model. Instead, the design and evaluation criteria for the Orem City collection system is based on "clean" pipes, with an allowance for capacity lost to the accumulation of sediment (see Chapter 5).

It should be noted that the hydraulic modeling software used to simulate the operation of the Orem City wastewater collection system does have the ability to set sediment depth in pipes. Therefore, if the City does collect detailed sediment data for a given section of pipe, the sediment may be added to the model and its effects evaluated. However, it should be emphasized that any sediment levels defined today will change in the future as flow conditions change.

Lift Stations

Orem City has 6 lift stations in its collection system. Where pump curves were available, associated pump performance criteria were input into the model. Pump curves at other locations were estimated based on the required lift and flow capacity of the lift station as reported by City personnel.

Potential Diversion

The City has one diversion in its collection system near UVU and I-15 where flow can be diverted into a parallel sewer main underneath the freeway and railroad tracks. In addition, there are a number of manholes that have two potential flow directions based on the available invert information provided by the City. In all cases, there is a primary flow direction where all flow is conveyed under typical conditions with a potential "overflow" direction primarily used for flushing lines and system maintenance. Table 4-1 lists the location of these potential diversions along with their primary flow directions which are also shown in Figure 4-1. These potential diversions were identified so that the hydraulic model would correctly simulate the proper flow path for wastewater through the collection system.

Table 4-1
Manholes with Potential Overflow Directions

Manhole ID	Location	Main Flow Direction
17-0171	600 E 600 North (Overflow manhole to the south. All flow goes west).	West
26-0028	400 S 400 East (Overflow manhole to the west. All flow goes south).	South
17-0063	800 E 400 North (Overflow manhole to the south. All flow goes west).	West
17-0072	1000 E 400 North (Overflow manhole to the west. All flow goes south).	South
17-0089	200 N 800 East (Overflow manhole to the west. All flow goes south).	South
19-0086	1000 W 100 South (Overflow manhole to the west. All flow goes northwest).	Northwest
20-0173	800 W Center Street (Overflow manhole to the south. All flow goes west).	West
21-0136	400 E Center Street West (Overflow manhole to the west. All flow goes south).	South
21-0164	Center Street & State Street (Overflow manhole to the south. All flow goes west).	West
26-0154	400 S State Street West (Overflow manhole to the south. All flow goes west).	West
27-0033	800 E 400 South (Overflow manhole to the south. All flow goes west).	West
31-0028	1100 S Main Street (Overflow manhole to the south. All flow goes west).	West
31-0124	1070 S State Street (Overflow manhole to the north. All flow goes west).	West
32-0026	1200 S 800 East (Overflow manhole to the south. All flow goes west).	West
34-0110	1700 S Main Street (This is an overflow manhole to the North. All the flow goes to the south).	South
35-0021	1600 S 800 East (Overflow manhole to the south. All flow goes west).	West
35-0024	1500 S 800 East (Overflow manhole to the west. All flow goes south).	South
35-0026	1400 S 800 East (Overflow manhole to the west. All flow goes south).	South
22-0093	800 E Center St (Overflow manhole to the west. All flow goes south).	South
16-0139	400 North 400 E. (Overflow manhole to the west. All flow goes south).	South

FLOW DATA

Once all required geometric data was collected and a physical model of the system was developed, flow data was obtained to model the system hydraulics. Three types of flow information were required for hydraulic modeling: total magnitude of flow, timing of flow, and distribution of flow across the City service area. Each of these flow characteristics is discussed below.

Total Flow

Flow projections for the Orem City service area were presented in detail in Chapter 3. Total flow for modeling scenarios examined here are summarized in Table 4-2.

Table 4-2
Hydraulic Modeling Scenario Total Daily Flow Volumes (mgd)

Scenario	Existing	2060
Dry Weather Flow/Infiltration	9.79	14.62

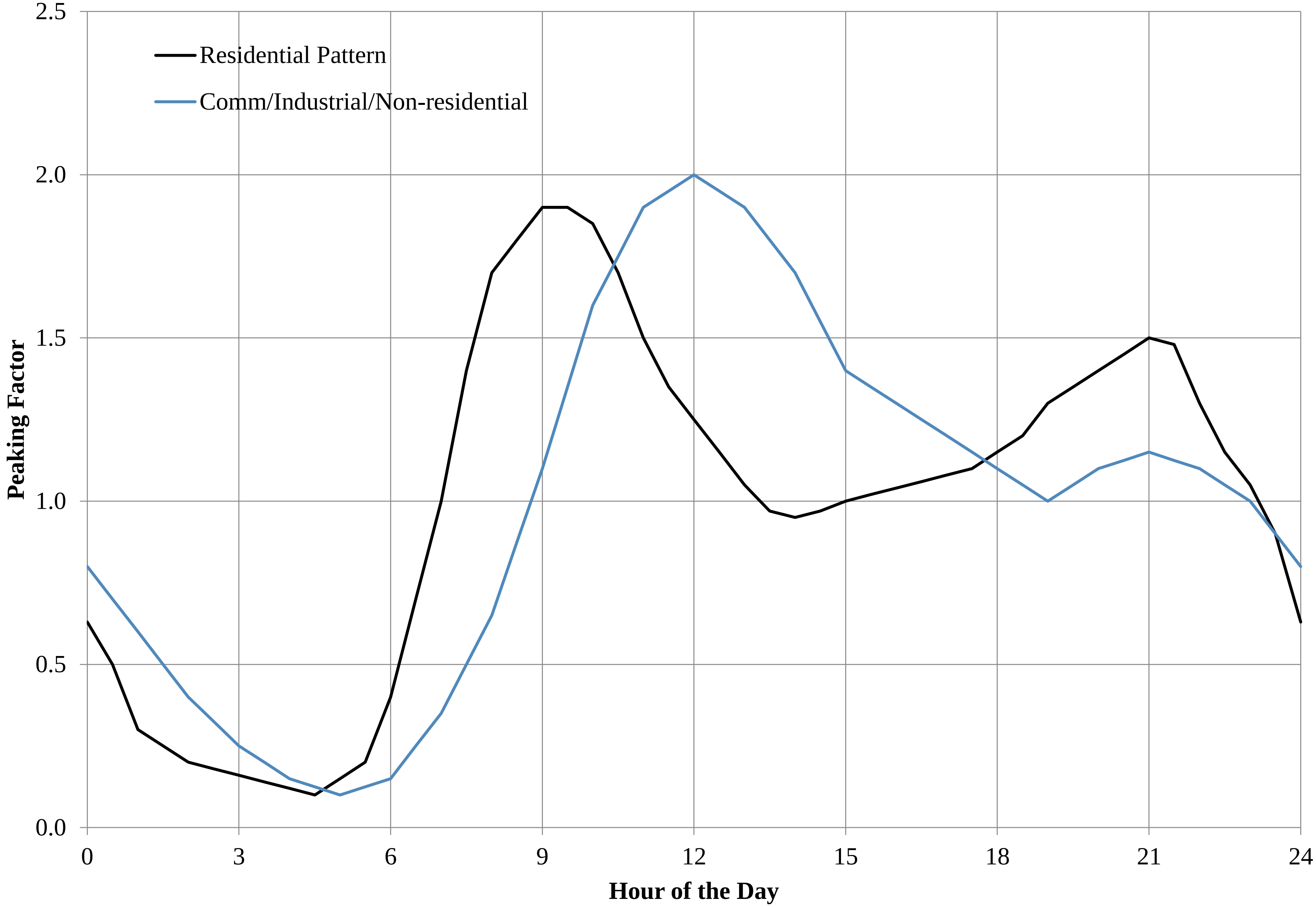
Timing of Flow

It will be noted that the volumes shown in Table 4-2 represent total flow over a 24-hour period. Since sanitary sewer flows vary throughout the day with varying indoor water demands, of much greater importance for the purposes of modeling collection system capacity is the calculation of peak flows that occur during the day. To predict the magnitude and timing of peak flows in the model, it is important to understand how flow varies throughout the day. This is different for each component of wastewater flow.

Domestic Wastewater – The pattern of fluctuating domestic water use is often referred to as a diurnal pattern. These patterns vary depending on the type of user. For example, the typical diurnal pattern for residential weekday wastewater production is shown in Figure 4-2. This figure was developed by dividing measured flows from predominantly residential neighborhoods by each neighborhood's average daily flow, essentially normalizing flow measurements so they can be compared against each other. As can be seen in the figure, peak residential wastewater production typically occurs around 9 a.m. as residents prepare for the work day, with a smaller peak occurring around 9 p.m. as residents clean up and prepare for bed. The average residential pattern shown in Figure 4-2 is the pattern used in the hydraulic model to predict flow for "residential" sewer flows. Figure 4-2 also includes a commercial/industrial diurnal pattern. While industrial flow patterns will largely be dependent on the type of industry, no flow monitoring data was available that could identify a strictly industrial flow pattern in the City. The commercial/industrial pattern shown in Figure 4-2 was developed using flow monitoring on Geneva Road near University Parkway.

Infiltration – As discussed in Chapter 3, infiltration may vary on a seasonal basis but does not generally vary on a daily basis. Thus, it has been assumed that infiltration remains constant throughout the day in the collection system model.

Figure 4-2
Diurnal Patterns in Orem City



Inflow – For this study, inflow has not been modeled directly because of the wide variability in storm events and inflow response possible in the City. For design purposes, Orem City has included a capacity allowance in its design criteria to account for inflow into its collection system.

Table 4-3 shows the peaking factors used for each hour that represent the patterns used in the hydraulic model.

Table 4-3
Hydraulic Model Diurnal Patterns

Hour	Residential	Commercial
0	0.63	0.8
1	0.3	0.6
2	0.2	0.4
3	0.16	0.25
4	0.12	0.15
5	0.15	0.1
6	0.4	0.15
7	1	0.35
8	1.7	0.65
9	1.9	1.1
10	1.85	1.6
11	1.5	1.9
12	1.25	2
13	1.07	1.9
14	0.95	1.7
15	1	1.4
16	1.04	1.3
17	1.08	1.2
18	1.15	1.1
19	1.3	1
20	1.4	1.1
21	1.5	1.15
22	1.3	1.1
23	1.05	1
24	0.63	0.8

Based on the diurnal patterns used above, peak flows simulated in the model are summarized in Table 4-4.

Table 4-4
Hydraulic Modeling Scenario Peak Hour Flows* (mgd)

Scenario	Existing	2060
Dry Weather Flow	17.02	24.92

*Peak hour WWTP inflow from extended period simulation which accounts for attenuation in the collection system.

Distribution of Flow

With flow magnitude and timing estimated, the final step in developing flow data for the model is distributing it spatially across the City:

Domestic Wastewater – Existing domestic sewer flows included in the hydraulic model were distributed based on winter water use data. Winter water meter data collected across the City was assigned to the nearest manhole assuming that the sewer connections from the various water meters would flow to the same manhole. Metered demands which have some inherent inaccuracies with underreporting were factored up to match the estimated domestic production for the City as measured at the City's wastewater treatment plant. Future growth of domestic sewer flow was distributed in the same manner based on growth as projected by TAZ (described in Chapter 3).

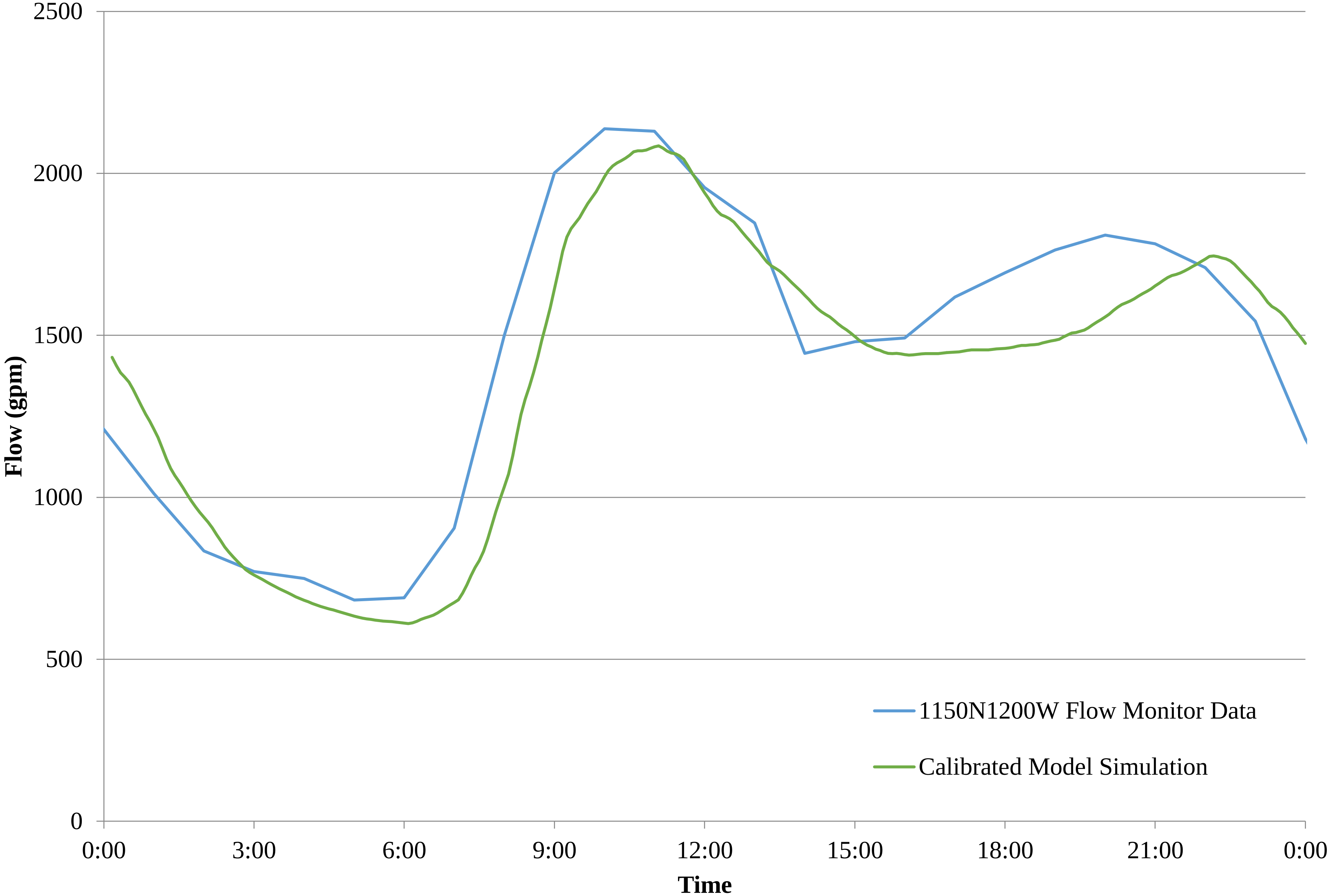
Infiltration – Existing infiltration was distributed using flow monitoring data collected by Orem City. Because infiltration likely varied significantly over the wide range of dates when flow monitoring was collected, each flow monitoring site was compared to treatment plant data for the period of collection and a seasonally adjusted estimate of infiltration was developed for each flow monitoring site. The seasonally adjusted estimate was then distributed into the tributary area for the flow monitor sites.

CALIBRATION

The process of model calibration involves adjusting or modifying certain model parameters in order to better match the actual conditions of the sewer system. Calibration of the model was performed using available historical flow meter data from various locations throughout Orem City. A comparison of model results against the historic flow monitoring results appears to indicate that, in general, the model is reproducing system conditions within a reasonable level of accuracy. However, model adjustments were made where possible in order to better match the historic monitoring results. Final results for one sample flow monitoring location are shown in Figure 4-3. As is the case with all model results of this type, model results produce a slightly smoother curve than the actual flow monitoring results.

It should be understood that the hydraulic model developed for this study relies on the available geometric and flow monitoring data provided by Orem City. As additional pipelines are surveyed or new flow measurement data is collected, the hydraulic model should be updated and recalibrated to reflect the updated conditions. Orem City should continue to update this hydraulic model based on new survey information at least once a year to ensure it reflects current conditions.

Figure 4-3
Simulated Model Results vs Observed Flow at Sample Flow Monitor (ID16)



CHAPTER 5
SYSTEM EVALUATION

With the development and calibration of a hydraulic sewer model, it is possible to simulate sewer system operating conditions for both present and future conditions. The purpose of this chapter is to evaluate hydraulic performance of the collection system and identify potential hydraulic deficiencies.

EVALUATION CRITERIA

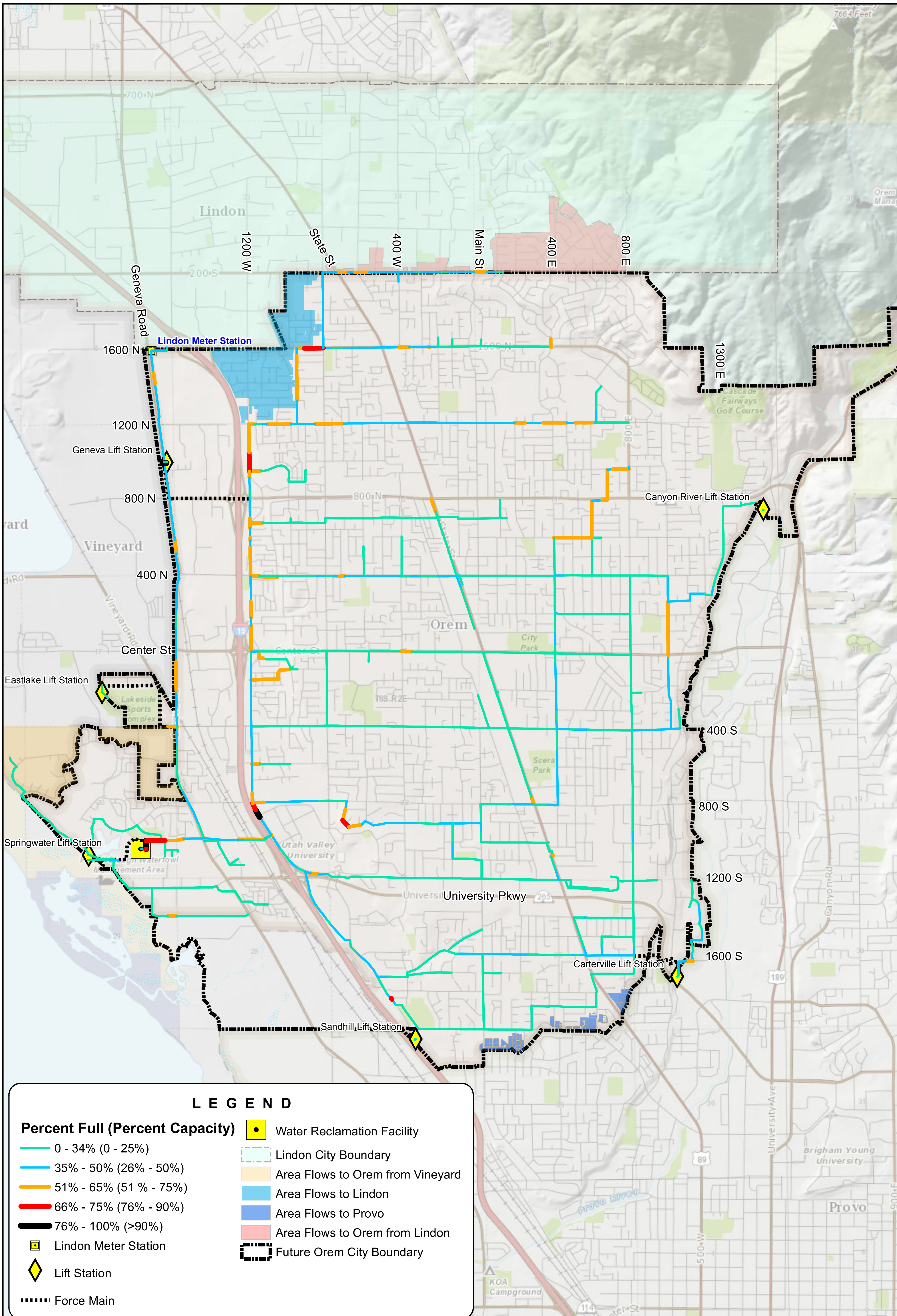
In defining what constitutes a hydraulic deficiency, it is important to consider the assumptions made in estimating sewer flows in the model. As described in Chapters 3 and 4, the sewer flow included in the model is composed of two parts: domestic sewer flow and infiltration. This means that the model represents dry weather conditions only and does not include wastewater flows associated with inflow. Additionally, estimates of domestic wastewater flows and infiltration are based on available historic data. Because these estimates are based on average values and a limited data set, actual flows will fluctuate and may be greater than the model estimates. For example, infiltration during extremely wet years could be more than estimated in the model (e.g. 1983 was a statewide historically wet year that led to high infiltration and flooding in many areas, but this year is outside the historical flow records available at the plant). The criteria established for identifying deficiencies should be sufficiently conservative to account for inflow in the system and occasional domestic and infiltration flows higher than those estimated in the model. The following criteria have been established to identify capacity deficiencies in the system:

- **Pipeline Capacity –** The most important deficiency to eliminate in the sewer system is inadequate capacity. For this master plan, it was decided to define a capacity deficiency as any point where the dry weather peak hour flow in the pipe is greater than 75 percent of the pipe's full flow capacity, which occurs when flow exceeds a depth of approximately 65 percent of the pipe's diameter. The remaining 25 percent of pipe hydraulic capacity was reserved for inflow and/or unaccounted for fluctuations in domestic flow and infiltration. In cases where short segments of relatively flat pipes exist, a maximum allowable depth of 65 percent of pipe diameter is used to define a pipe deficiency. A manning's roughness value of 0.013 was used for all collection pipes to conservatively calculate capacity.

- **Lift Station Capacity –** A lift station capacity deficiency is defined as anytime dry weather peak hour flows exceed 85 percent of the lift station's primary pumping capacity. This criterion is a little less conservative that the capacity criterion for pipeline because all lift stations are required to have at least one backup pump in case of mechanical failure or significant inflow from wet weather events. Lift stations also have storage wet wells that can accommodate higher than expected flows for short durations.

EXISTING SYSTEM ANALYSIS

Figure 5-1 displays the hydraulic capacity of the sewer system under existing peak hour flow conditions. Pipes in the figure are color coded to show the ratio of maximum depth in the pipe to



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OREM CITY
SEWER MASTER PLAN

PEAK FLOW TO CAPACITY FOR EXISTING CONDITIONS

NORTH:

SCALE:

FIGURE NO.
5-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 5-1 - Existing Capacity.mxd aanderson 10/27/2014 the pipe's full depth. Based on peak flow and pipe capacities alone, there are a few isolated deficiencies scattered throughout the system. These deficiencies are generally due to pipes being laid on a flat slope, which decreases the full flow capacity.

Short sections of flat pipe often do not represent a significant operational or maintenance issue for the system. The results shown in Figure 5-1 represent the maximum flow depth at any point along the length of the pipe. As long as the neighboring pipes have sufficient capacity, the extra depth caused by the flat slope will not result in surcharging problems for the system. Deficiencies observed in the existing system do not appear to pose a significant surcharge risk at this time, but will require monitoring as sewer flows continue to increase. No lift station deficiencies were observed in the existing sewer system.

Carterville Lift Station Infiltration

In general, Orem City has relatively low infiltration rates from groundwater intrusion into sewer collection pipes. The Carterville Lift Station service area appears to be a possible exception to these relatively low infiltration rates. Initial comparisons of metered water use and measured flows through the Carterville Lift Station indicate that a significant portion of flow is attributable to infiltration. Because this amount of infiltration seems unreasonably high, it is possible that there are errors in either the metered water usage for the homes which flow to the lift station or the flow measurement performed on the lift station itself. This considered, it is recommended that the City carry out additional flow monitoring tests both upstream and downstream of the lift station to determine if excessive infiltration is fact an issue that needs to be addressed.

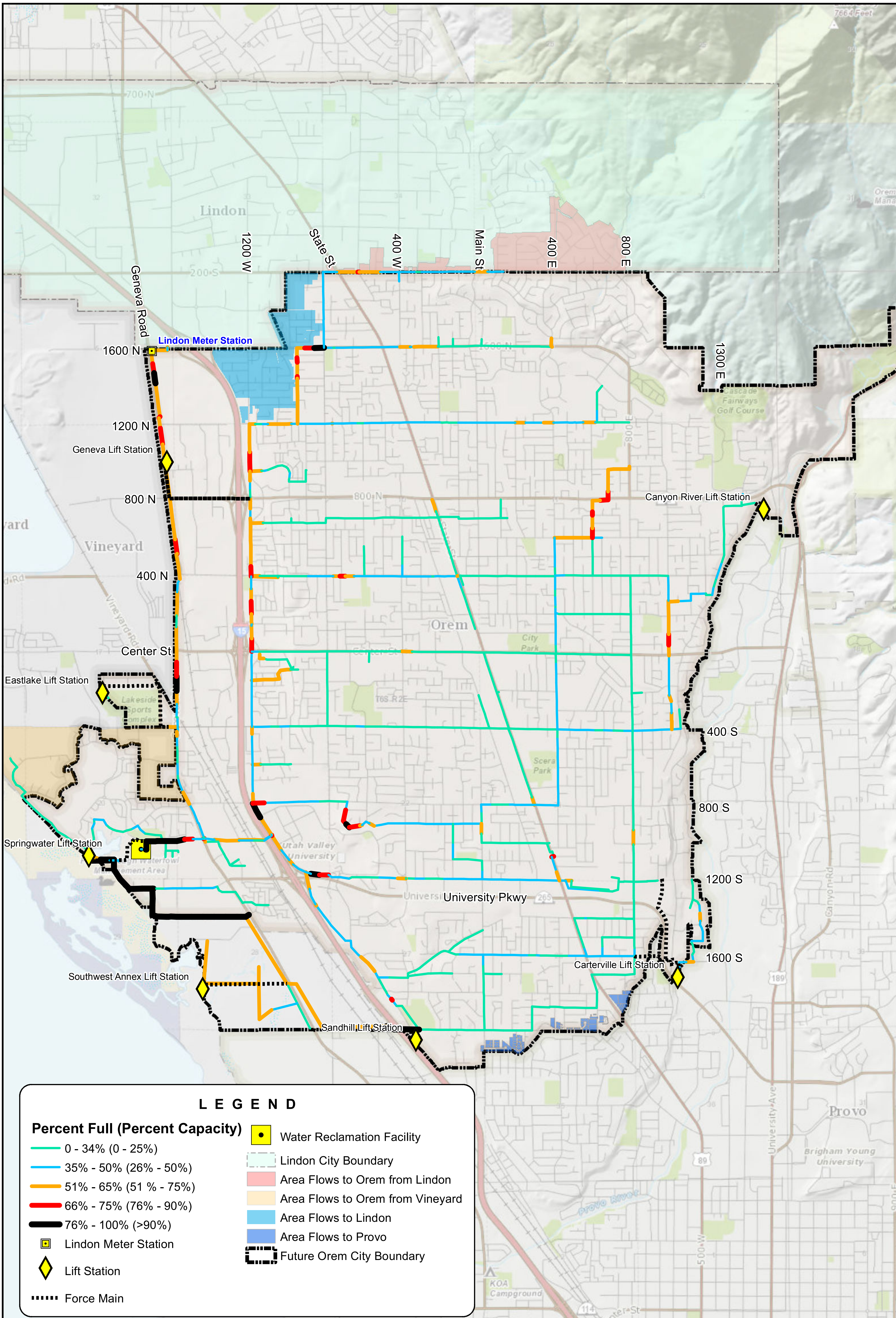
No pipe capacity deficiencies were identified as a result of what has been identified as potentially excessive infiltration at the Carterville Lift Station. However, this represents an area where Orem City could potentially reduce operation and maintenance costs if infiltration is indeed confirmed to exist at the Carterville lift station and can be reduced through sewer line rehabilitation projects.

FUTURE SYSTEM ANALYSIS

Figure 5-2 shows the hydraulic performance as calculated by the hydraulic model for sewer flows at projected conditions in 2060 if no improvements are made to the existing system. These results assume that sewer flows associated with future development will flow to the nearest manhole in the existing system. While the majority of the system under 2060 conditions has ample capacity, some significant deficiencies have been observed in the model results.

Pipeline Deficiencies

As shown in Figure 5-2, model results for the sewer collection system at 2060 show isolated pipeline capacity deficiencies which are mostly a result of pipes laid with shallow slopes. Only some of these simulated deficiencies require an improvement project as discussed below.



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OREM CITY
SEWER MASTER PLAN

PEAK FLOW TO CAPACITY FOR BUILDOUT CONDITIONS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 5-2

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1600 North 800 West

Model simulations have indicated that a growth related deficiency will occur in a segment of pipe on 1600 North, downstream of the intersection of 1600 North and 800 West. Based on the current projections and distribution of flows in the model, it is anticipated that this section of pipe will become deficient by approximately the year 2030. This timing is subject to change based on the actual growth patterns in future years.

College Drive/1200 West at 800 South

The section of pipe downstream of the manhole at 1200 West and 800 South is projected to become deficient within the next 6-8 years. GIS data for manhole inverts provided by Orem City indicate an adverse slope in a portion of this deficient pipe. This could be an error in the survey data, and it is recommended that the invert elevations be verified before finalizing any plans for a capital project.

925 South 725 West

Hydraulic model results indicate a potentially deficient section of pipe along 925 South and 725 West. It is estimated that this length of pipe will exceed its available capacity by the year 2030.

Chambery Collection Line

The existing sewer line which conveys wastewater from the Chambery housing development to the Springwater Lift Station is expected to see a significant increase in flow as a result of projected development. Future model results indicate that there will be capacity deficiencies along the entire reach of pipe from Chambery to the Springwater Lift Station. Depending on growth in the area, it is estimated that the available capacity in this pipe will be exceeded within the next 5-10 years.

College Drive near 1200 South

Orem City would like to relocate the outfall of the Carterville Lift Station to 1200 South because of aging infrastructure and concerns about the existing force main's location under University Parkway and between existing homes. As a result of this relocation, a deficiency has been projected at buildout in the pipe along College Drive near University Parkway and I-15. This deficiency appears to be the result of a transition from a steep slope to a flat slope as the 12 inch line runs into the large transmission line near 1-15 and University Parkway. This location will primarily be a concern for surcharging under wet weather conditions.

Lift Station Deficiencies

Table 5-1 summarizes the projected 2060 flow to the lift stations in Orem City.

Table 5-1
Summary of Sewer Lift Stations

Name	Capacity (gpm)	Existing Dry Weather Peak Flow (gpm)	2060 Dry Weather Peak Flow (gpm)*
Carterville Lift Station	500	220	250
Geneva Lift Station	1,987	790	***2,540***
Springwater Lift Station	850	180	***1,320***
Eastlake Lift Station	300	20	70
Canyon River Lift Station	300	2	3
Sandhill Lift Station	300	10	40

*italicized bold text indicates a deficiency.

Geneva Road Lift Station

Primarily due to growth from Lindon City, 2060 model results indicate future deficiencies in the Geneva Lift Station. The lift station at Geneva Road and 800 North is currently equipped with 4 pumps. The pumps include a primary and backup 10 horsepower pump with a capacity of 800 gpm (833 gpm @ 22’) that discharges into Geneva Road. When peak flows exceed the capacity of these pumps (such as under wet weather conditions), excess flow can be pumped through a primary and backup 75 horsepower pump with a capacity of 1,190 gpm that discharge to 1200 West. The current combined capacity of Geneva Lift Station is 1,990 gpm. At buildout, peak hour flows are predicted to reach approximately 2,540 gpm, exceeding the current pumping capacity of the lift station. However, the force mains to Geneva Road and 1200 West will have sufficient capacity at buildout. Therefore, it should be possible to achieve the needed capacity at the Geneva Road Lift Station through a relatively inexpensive upgrade to the lift station pumps.

Springwater Lift Station

The Springwater Lift Station has two challenges. First, as a result of projected development, flow routed through the Springwater Lift Station is expected to increase substantially. The primary and backup pump at the Springwater Lift Station are 20 horsepower with a capacity of 850 gpm. With predicted peak hour flows reaching as high as 1,320 gpm, the Springwater Lift Station will require a significant pump upgrade. A second challenge at the lift station is its condition. Orem City personnel have indicated that the lift station and force main are both approaching the end of their service life and need to be replaced in order to meet the needs of existing and future users. As a result, replacement of this lift station will be a high priority for the City.

Orem City Water Reclamation Facility

WRF Inlet

Model results for the sewer system under existing flows indicate capacity issues in a couple of sections of the large inlet pipe to the WRF. These deficiencies currently do not appear to create the potential for surcharging. However, as can be seen in Figure 5-2, the model simulation results at 2060 suggest that the deficiencies will spread to other connected sections of pipe, extending east from the WRF outfall toward East Shore High School. Building additional capacity through this portion of the system will be required at some point in the future.

Plant Capacity

Growth projections in the Orem City sewer service area are predicted to produce flows into the WRF which could exceed both the average monthly capacity and peak flow capacity of the plant (see Chap. 3, Figure 3-5). However, existing capacity appears to be adequate through at least 2040 and no immediate capacity needs at the plant have been identified. It should be noted that these predictions are based on existing patterns of wastewater flow. It is recommended that the City carry out a more extensive evaluation of plant capacity in the years to come to better identify the timing of any potential expansion improvements at the WRF.

CHAPTER 6
SYSTEM IMPROVEMENTS

The hydraulic model results have identified potential deficiencies in the sewer system under existing and future conditions. This chapter covers system improvements intended to solve deficiencies as the City continues to grow. Once the detailed design of sewer facilities commences, the design capacity of these pipelines or lift stations should be based on projected build-out flows. Improvements are organized in this chapter by type and location of improvement. The priority of each project has been based on the predicted timing of when the improvement will be needed.

COLLECTION SYSTEM CAPACITY IMPROVEMENTS

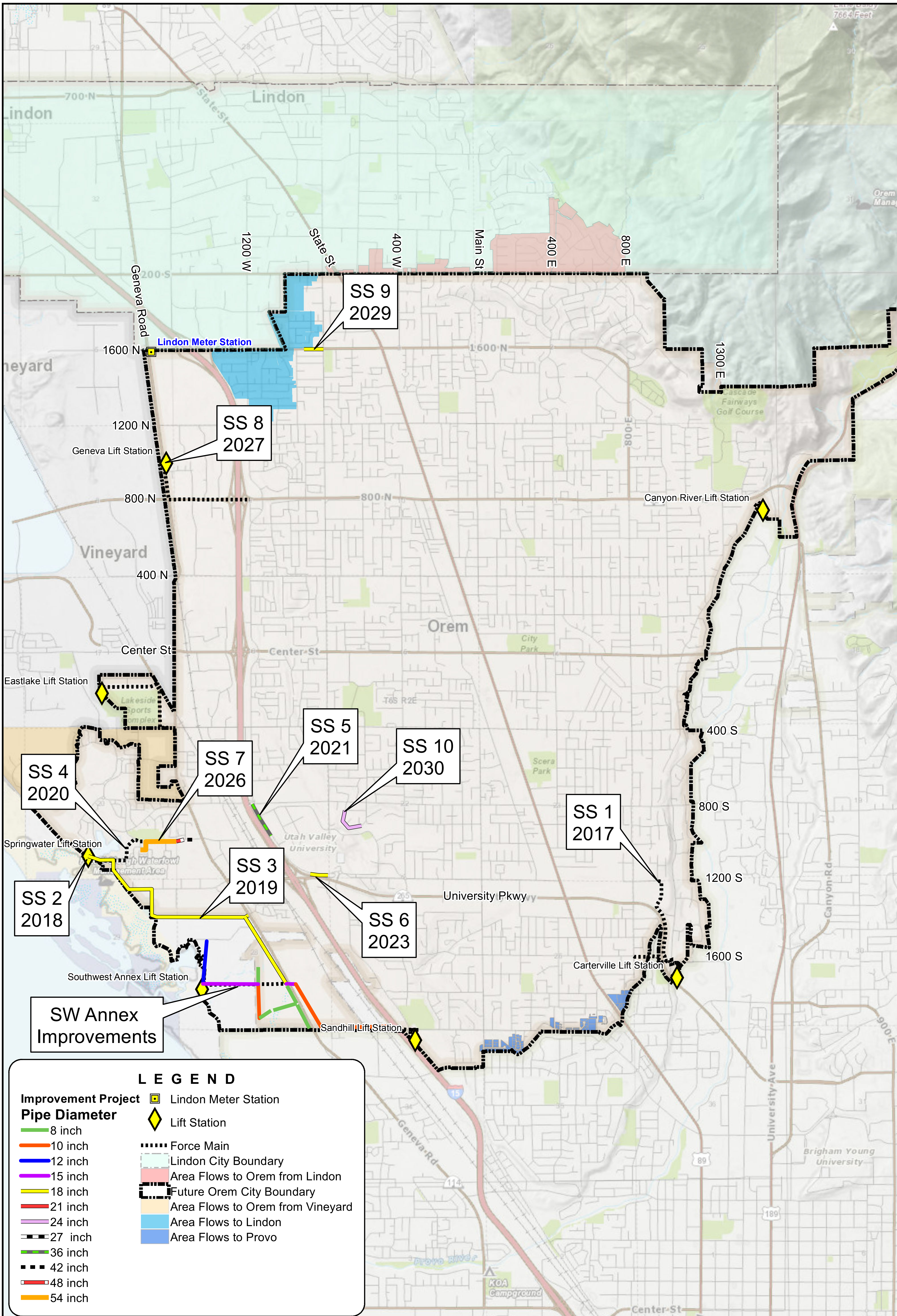
A number of collection system improvements have been identified to resolve hydraulic deficiencies related to existing or projected sewer flows as shown in Figure 6-1. Many of these projects are not needed for many years. All of the projects, regardless of timing, are discussed below and have been shown in the figure.

SS 1. Carterville Force Main Relocation

Although there do not appear to be any pipe capacity deficiencies in the Carterville Lift Station service area as a result of future growth, there are some age related deficiencies that require attention. The current alignment of the Carterville force main goes north out of the lift station then west under University Parkway. The line passes underneath several residential properties and ties into the collection system at 800 East and 1600 South. The line is also relatively old and the City is concerned with the condition of the pipe. In order to avoid potential problems with this line, Orem City has expressed the desire to abandon the existing pipe and relocate it to 925 East 1200 South, running the new line north along the east side of University Parkway and along 1000 East. Another viable outfall location for the force main was evaluated at University Parkway and 800 East. The City will have the option during design to select whichever location best suites the needs of the system.

SS 2. Springwater Lift Station

The Springwater Lift Station is in extremely poor condition and is quickly approaching the end of its useful life. As a result, replacement of the lift station is needed in the very near future. When the lift station is replaced, expansion of the lift station is also needed to accommodate projected future growth. The Springwater Lift Station is currently equipped with primary and backup 20 horsepower, 850 gpm pumps. While this provides more than enough capacity for existing flows, peak hour flows through the lift station are estimated to reach 1,320 gpm in the future. In order to accommodate the increase in flow, it is recommended that the Springwater Lift station be upgraded with 2 larger capacity pumps (1 primary and 1 backup) with a capacity of at least 1,575 gpm. This will allow the lift station to operate at or below 85% capacity at peak hour flows.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS	OREM CITY SEWER MASTER PLAN	FUTURE SYSTEM IMPROVEMENTS	NORTH:	SCALE: 0 1,500 3,000 Feet	FIGURE NO. 6-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 6-1 - System Improvements.mxd aanderson 2/17/2016

SS 3. 1400 South, Chambery to Springwater Lift Station

The capacity of the existing 10-inch line which runs along 1400 South will be exceeded as a result of increased flow from new development. In order to convey the total flow for this service area, additional capacity must be provided. Replacing the existing line with a new 18-inch sewer main will provide the necessary capacity through build-out. Orem City GIS data indicates that the existing sewer conduit just upstream of the Springwater Lift Station crosses underneath an existing pond. It is recommended that the City verify the alignment of this section of pipe and analyze the ability to replace it.

SS 4. Springwater Force Main

Model results for build-out sewer flows in Orem City indicate that peak hour flows through the existing 10-inch Springwater force main may exceed the recommended maximum velocity of 7 feet per second at buildout. In a pumped system, high velocities cause excessive head leading to high operating costs and can pose a high risk for transient damage after power failures. In order to reduce peak hour flow velocities while also maintaining minimum velocities through the sewer line, it is recommended to install a new parallel 6-inch force main from the lift station to the outfall near the Water Reclamation Facility.

SS 5. College Drive/1200 West and 800 South

As shown in Figures 5-1 and 5-2, the 550 foot section of pipe on College Drive downstream of the intersection of 1200 West and 800 South is shown as deficient under both existing and future flows. The primary factor contributing to this deficiency is an adverse slope caused by a low point at the manhole invert approximately 275 feet downstream from the manhole at 1200 West and 800 South. It is recommended that the elevation of the inverts along this alignment be resurveyed and checked against the existing Orem City GIS data.

If current model results are accurate, it is recommended that 1,260 feet of 30-inch and 33-inch line be replaced with 36-inch line. However, this pipe should be surveyed and model results updated prior to beginning this capital project.

SS 6. College Drive near 1200 South

As a result of future growth in Orem City, a deficiency is projected under buildout conditions in the 12-inch sewer conduit on College Dr. and 1200 South on the east side of I-15. The recommended improvement for this section of pipe is to replace 820 feet of 12-inch pipe with new 15- or 18-inch pipe. Surcharge concerns at this location will primarily be a concern under wet weather conditions. Because there are no nearby connections, some surcharging at this location may not pose any significant concern. These pipes should be monitored after the first phase of redevelopment at the University Mall to verify that this project is needed. This improvement project is covered in more detail in a technical memorandum regarding development at the University Mall attached as an appendix to this report.

SS 7. 1000 South/Orem Water Reclamation Facility

By 2060, wastewater flow through the pipe on 1000 South leading to the treatment plant will exceed 75 percent of the pipe's hydraulic capacity. The deficient section of pipe starts in the 36-inch section near East Shore High School and continues east to the WRF. One option to eliminate this deficiency is to replace approximately 275 feet of the existing 36-inch pipe with 42-inch pipe, and replace the remaining length of 36-inch/42-inch pipe with a 48-inch/54-inch pipe. Depending on the age and condition of the existing pipe, this option may or may not be cost effective. Another option is to construct a parallel sewer main which would take any flow which exceeds the capacity of the main sewer trunk line.

SS 8. Geneva Lift Station Pump Upgrade

To accommodate build-out flows, particularly from Lindon City, the lift station on Geneva Road at 1000 North will require a capacity upgrade. The Geneva lift station is currently equipped with 4 pumps; a primary and backup 10 horsepower 833 gpm pump and a primary and backup 75 horsepower 1,187 gpm pump. Flow into the lift station up to 833 gpm is routed to Geneva Road through the 10 horsepower pump(s). Any remaining flow is taken by the 75 horsepower pump and sent through a force main to 1200 West. Because the line on 1200 West has more capacity than the line on Geneva Road, it is recommended to upgrade the larger pumps and send the increase in flow due to growth to 1200 West. Upgrading the capacity of the larger pumps from 1,187 gpm to 2,200 gpm would provide sufficient lift station capacity through buildout. It should be noted that the existing lift station building was designed with future expansion in mind. As a result, upsizing of the pumps at this location should be able to be accomplished relatively inexpensively.

SS 9. 1600 North 800 West

At the intersection of 1600 North and 800 West, the existing sewer system consists of a 15-inch pipe on 800 West (north of the intersection) and a 15-inch pipe on 1600 North (east of the intersection) combining into a 15-inch pipe which flows west from the junction. Model results show a capacity deficiency in the section of pipe downstream of the intersection. Replacing 950 feet of 15-inch pipe with new 18-inch pipe would provide the necessary capacity to convey peak hour flows while maintaining surplus capacity for inflow events.

SS 10. 925 South 725 West

A 1,200-foot section of the existing 21-inch pipe along 925 South starting at 725 West is projected to have a capacity deficiency under peak hour build-out flows. Replacing this pipe with a new 24-inch pipe will provide adequate capacity for sewer flows through buildout.

Southwest Annexation Area

One of the largest areas of future growth in Orem is the Southwest Annexation area. It is estimated that the annex will approach full build-out by 2027. In order to convey wastewater flows to the nearby Water Reclamation Facility, Orem City has proposed the installation of approximately 18,500 feet of new sewer pipe and a new lift station located at the west end of the annex. The main transmission line will run along Geneva Road and tie into the existing sewer system at Geneva Road near Chambery Woods. For reference, these improvements have been shown on Figure 6-1. However, it should be noted that these improvements will all be built and paid for by developers in the area. As a result, none of these projects are included in this master plan.

OTHER COLLECTION SYSTEM IMPROVEMENTS

In addition to the capacity related projects identified in the master plan model, Orem City has compiled a list of additional condition related collection system improvements which are to be constructed within the next 15 years. Table 6-1 contains a summary of these projects.

Table 6-1
Additional Condition Related Collection System Projects

Project Description	Estimated Cost (2014 Dollars)
675 N. 1060 W. to 1200 W. – H2S Concern	$29,500
1720 S. 400 W. to Sand Hill Rd. – H2S Concern	$41,500
Eastwood Street – Replacement Project	$200,000
Westwood Street – Replacement Project	$250,000
Total	**$521,000**

This does not represent a comprehensive list of all condition related system needs, but is intended to highlight the most pressing needs. Additional rehabilitation and replacement needs are discussed in Chapter 7.

WATER RECLAMATION FACILITY IMPROVEMENTS

A comprehensive evaluation of the City's reclamation facility was not included in the scope of this master plan. However, Orem City has identified a series of Water Reclamation Facility improvement projects that they would like to include in the capital facilities plan. Table 6-2 provides a summary of these projects. Among the projects identified is "Struvite Elimination". A technical memorandum documenting issues with Struvite at the reclamation facility along with recommendations is included in Appendix B.

Table 6-2
Orem City Water Reclamation Facility CIP Projects

Project Description	Estimated Cost (2014 Dollars)
Replace headworks bar screens	$400,000
Replace grit washer	$200,000
Third press in solids handling	$500,000
Struvite elimination	$1,600,000
Concrete/membrane existing lagoons	$500,000
Replace back-up generator	$500,000
Replace existing solids presses	$1,000,000
Upgrade/expansion of aeration/grit basin on the headworks facility	$800,000
Sludge disposal options - solar, central county treatment disposal site	$5,000,000
Co-generation technology	$1,000,000
Total	**$11,500,000**

CHAPTER 7
CAPITAL IMPROVEMENT PLAN

Previous chapters of this report have identified improvements to resolve existing deficiencies and to accommodate wastewater flow from future growth. Providing an acceptable level of service requires consistent and continual system monitoring and evaluation, with updates being made when necessary. The purpose of this chapter is to assemble a 10-year capital improvement program to implement the recommended improvements. This will include recommendations regarding levels of funding for system rehabilitation, replacement, and capital improvement projects.

SYSTEM REHABILITATION AND REPLACEMENT

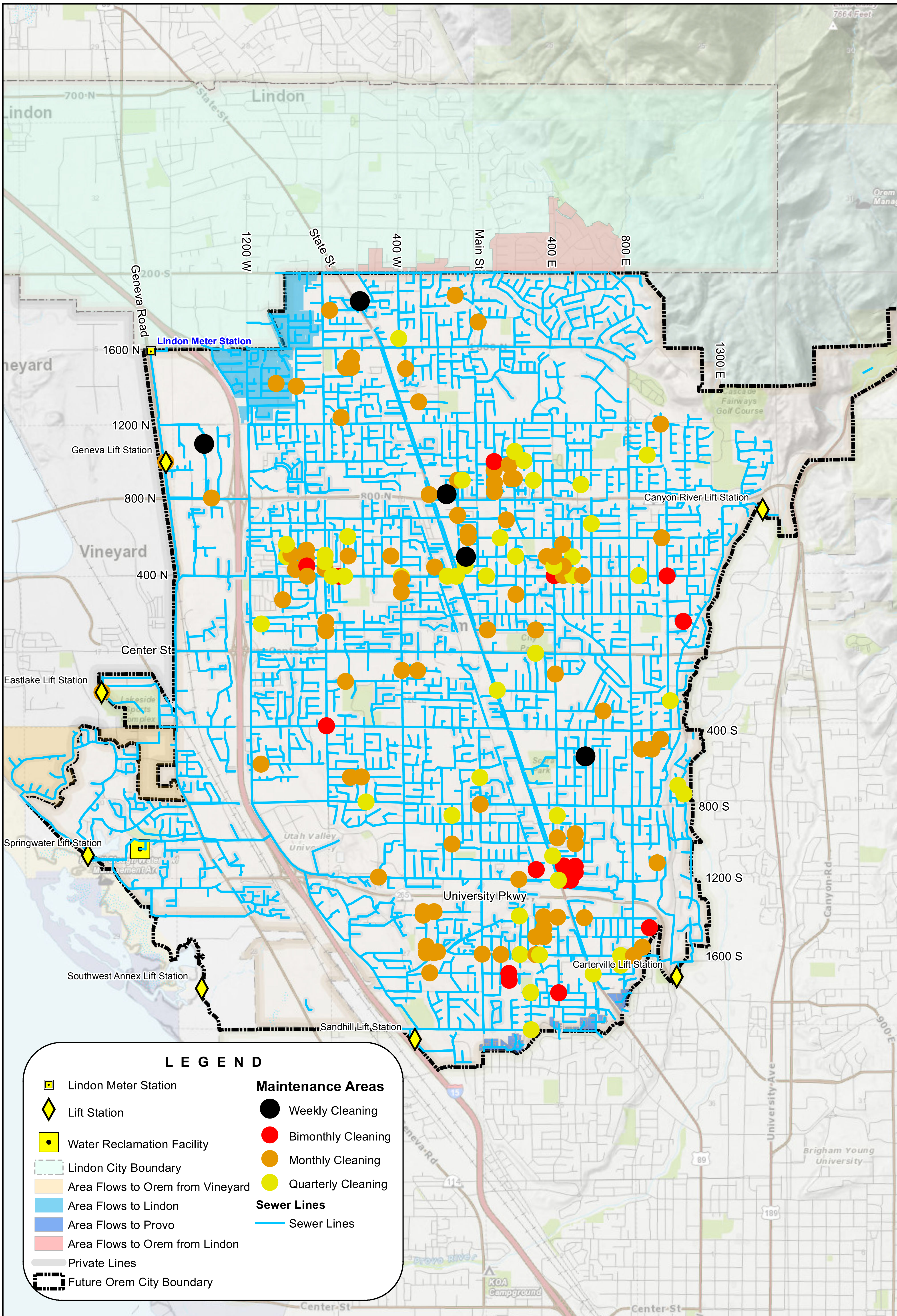
In order to assemble a 10-year capital improvement plan, it is not adequate to consider only capacity related improvements. It is also necessary to budget for the expected rehabilitation and replacement of system components. This section examines known areas of needed rehabilitation and replacement for inclusion in the capital improvement plan. This is not a comprehensive evaluation of existing maintenance procedures or system conditions, nor is it a complete asset management plan. Instead, it is a collection of general observations assembled during the master planning process relative to system rehabilitation and replacement.

Frequent Maintenance Areas

In an effort to improve the condition of the existing sewer system, Orem City has compiled a list of potential projects that could be completed to eliminate problems that require frequent maintenance by City staff (dated 2012). Areas requiring frequent maintenance are shown in Figure 7-1. A complete list of these maintenance projects can be found in Appendix C along with a breakdown of project priorities. Projects contained in the list include:

- Replacing deteriorated pipe
- Lining existing pipe (cast in place pipe)
- Pipe/manhole flushing
- Point repairs (such as at a joint)

A summary of the costs associated with these maintenance projects and the corresponding pay-back period is shown in Table 7-1 below.



Bowen Collins & Associates, Inc. CONSULTING ENGINEERS	OREM CITY SEWER MASTER PLAN	FREQUENT MAINTENANCE AREAS	NORTH:	SCALE: 0 1,500 3,000 Feet	FIGURE NO. 7-1

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 7-1 - Frequent Maintenance.mxd aanderson 2/17/2016

Table 7-1
Estimated Cost of Maintenance Projects & Corresponding

Return on Investment Time Frame	Estimated Cost of Maintenance Projects (2014 dollars)
Less than 10 years	$1,249,000
10 to 20 years	$1,018,000
20 to 40 years	$1,885,000
Greater than 40 years	$1,844,000
Total	**$5,996,000**

The return on investment time frame listed in Table 7-1 was developed by estimating the time and/or materials needed to perform maintenance for each facility requiring frequent maintenance. The annual cost associated with maintenance time and/or materials was then compared with the capital cost of eliminating the problem causing the need for frequent maintenance. The return on investment time frame reflects the number of years required before the capital cost of the improvement is paid back through reduced maintenance costs.

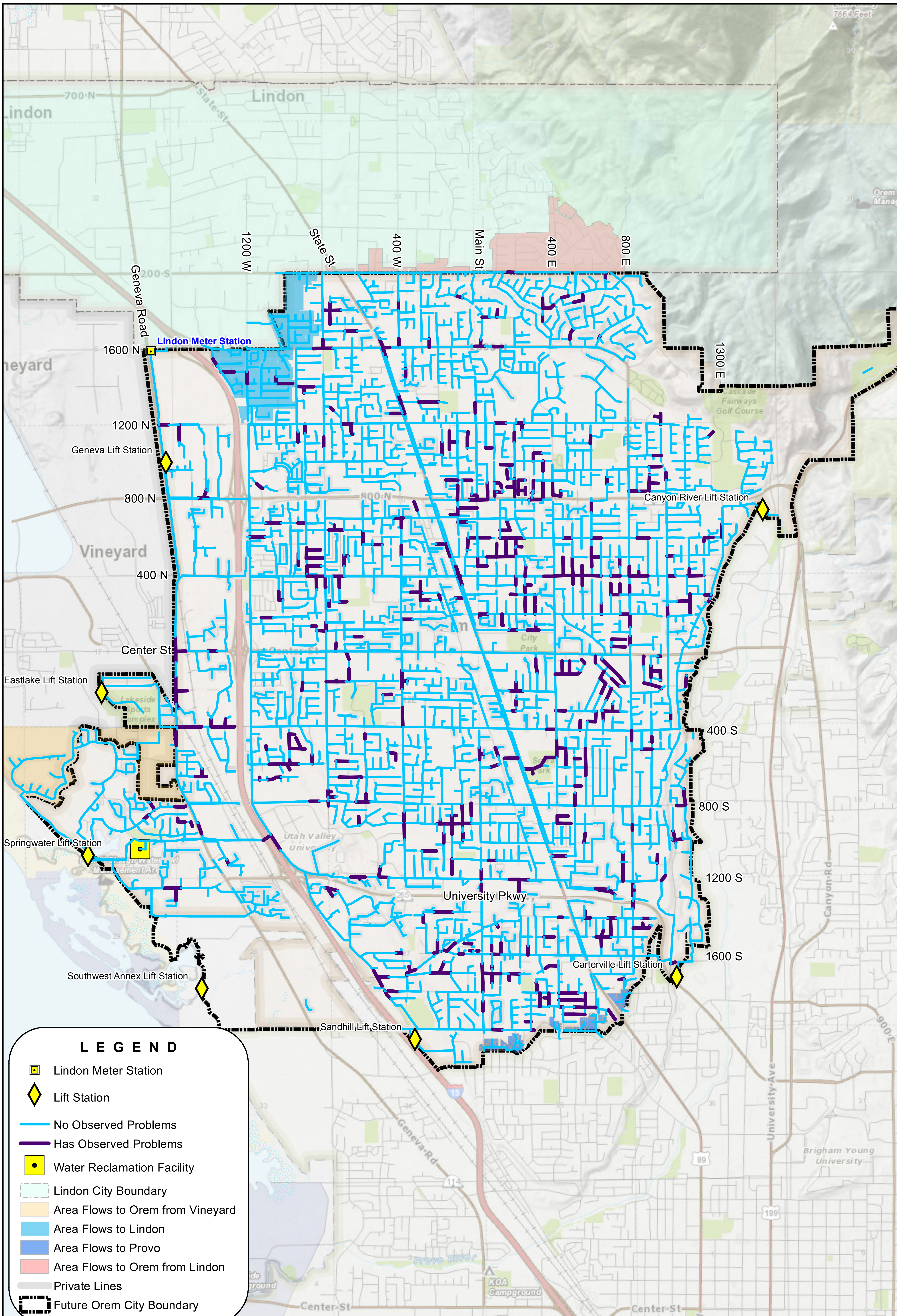
It is recommended that Orem City begin to complete the identified projects to eliminate frequent maintenance areas, starting with those that have the shortest return on investment. Even for those projects that have a longer return on investment, it is recommended that the City consider opportunities to complete some of these projects as opportunities arise. It is important to keep in mind that, as the system ages, these maintenance areas will continue to get worse and new areas will appear. Keeping up with maintenance projects and pipe replacement will help prevent the system from falling into disrepair and will reduce the amount that the City needs to spend in the long run.

Concrete Pipe Assessment and Rehabilitation

One major category of concern relative to sewer system rehabilitation and replacement is the corrosion of existing concrete pipe. Hydrogen sulfide gas in a sewer system can result in the formation of sulfuric acid (H_2SO_4) on pipe and manhole walls. Sulfuric acid can result in severe corrosion of ferrous metals and concrete. The top of a moist concrete pipe is a common area for the formation of sulfuric acid and corresponding corrosion. This is a significant concern for Orem because a large portion of the City's collection system is constructed of concrete pipe.

Orem City diligently inspects pipes on a regular basis to identify rehabilitation needs. Figure 7-2 identifies collection pipes in the City with observed deficiencies such as sulfuric acid related corrosion, breaks or cracks in the line, offset joints, bellies, roots, and infiltration. Some of these observed deficiencies can be eliminated with maintenance, but others require repair and replacement. It is recommended that the City continue to diligently perform preemptive pipe inspections to identify areas where corrosion may be occurring.

Figure 7-3 identifies some areas of the system where H_2S corrosion may be more likely. This is the result of two factors:



Bowen Collins & Associates, Inc.
CONSULTING ENGINEERS

OREM CITY
SEWER MASTER PLAN

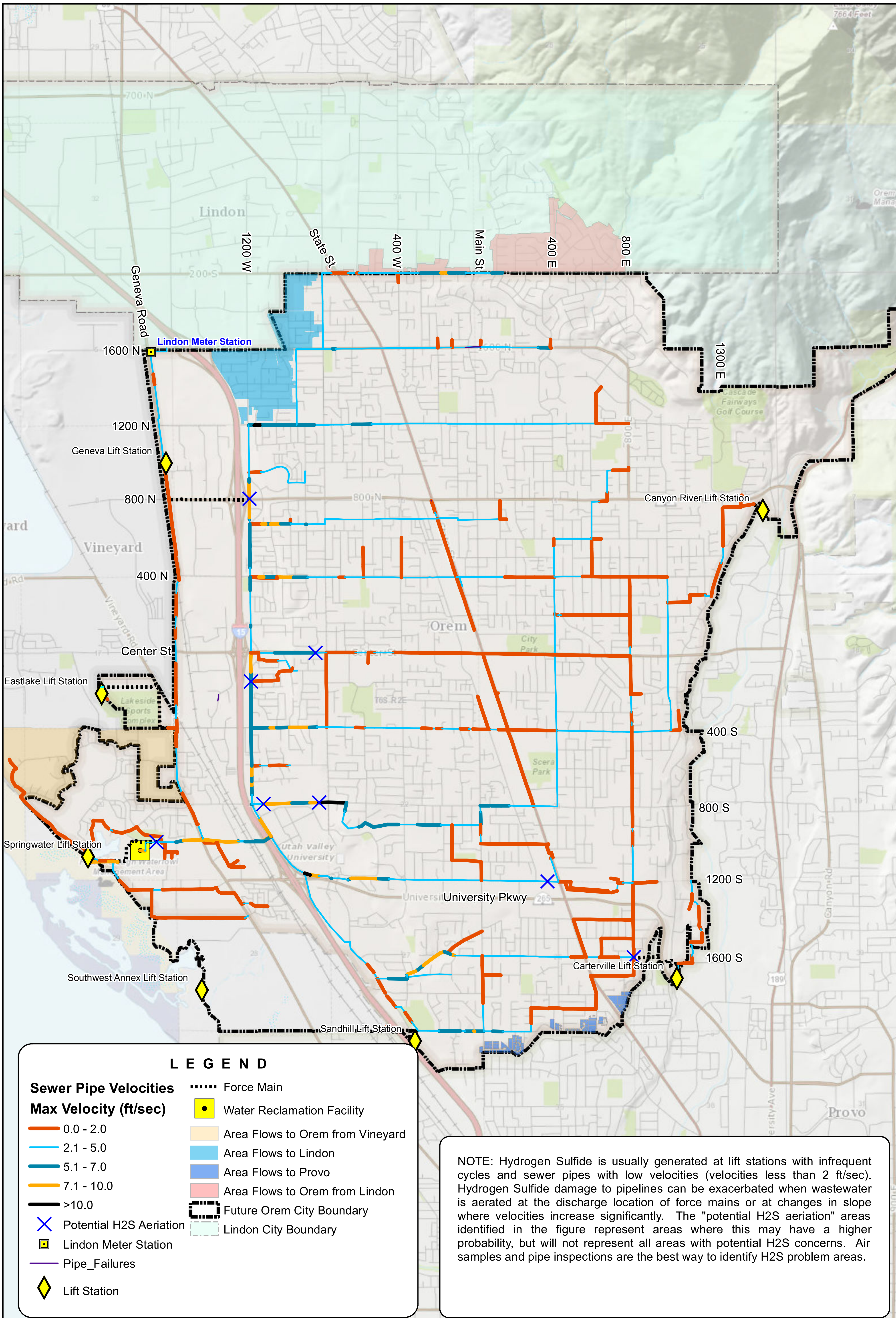
SEWER PIPES WITH OBSERVED STRUCTURAL ISSUES

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 7-2

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 7-2 - Observed Deficiency.mxd aanderson 2/17/2016



NOTE: Hydrogen Sulfide is usually generated at lift stations with infrequent cycles and sewer pipes with low velocities (velocities less than 2 ft/sec). Hydrogen Sulfide damage to pipelines can be exacerbated when wastewater is aerated at the discharge location of force mains or at changes in slope where velocities increase significantly. The "potential H2S aeration" areas identified in the figure represent areas where this may have a higher probability, but will not represent all areas with potential H2S concerns. Air samples and pipe inspections are the best way to identify H2S problem areas.

Bowen Collins & Associates, Inc.
CONSULTING ENGINEERS

OREM CITY
SEWER MASTER PLAN

PIPES WITH LOW VELOCITIES AND H2S AERATION CONCERN AREAS

NORTH:

SCALE: 0 1,500 3,000 Feet

FIGURE NO. 7-3

P:\Orem City\2013 Master Plans\4.0 GIS\4.1 Projects\SewerMap\Sewer-Figure 7-3 - H2S Potential Areas.mxd amckinnon 4/21/2015

- ***Hydraulic Conditions –*** H_2S formation is affected by hydraulic conditions in two ways. First, where velocities are low, there is more potential for the accumulation of a slime layer with the bacteria that create H_2S. As a general guideline, pipes with velocities less than 2 ft/sec have a higher probability of developing the anaerobic conditions that generate hydrogen sulfide. Second, where pipes have high velocities, there is a higher probability of aerating the wastewater and releasing the hydrogen sulfide gas that leads to damage of concrete pipe. Figure 7-3 indicates maximum flow velocities in sewer pipes for existing conditions. Of primary concern are those areas where long sections of low velocity flow are followed by a section with high velocity flow (the H_2S forms in the slow sections and is then released in the fast sections). Figure 7-3 identifies a few areas in the City where hydrogen sulfide could potentially be aerated because of significant changes in velocity. However, there are many other factors that can contribute to pipe deterioration including changes of use (e.g. construction of restaurants) and increases or decreases in flow from changing demographics.
- ***Force Main Discharge –*** Other areas of concern for hydrogen sulfide accumulation are at force main discharge locations. Because force mains flow full, very little corrosion will occur through the force main pipe. However, because they full, there is a larger hydrogen sulfide producing slime layer. As the pipes discharge into gravity mains and the flow is aerated, hydrogen sulfide gas can be released.

Where corrosion is observed, it is recommended that aggressive rehabilitation efforts be initiated to protect the pipeline from further damage. If the corrosion has not yet damaged the structural integrity of the pipeline, a cast-in-place pipe (CIPP) rehabilitation can often be done relatively inexpensively to protect the existing concrete and preserve the full design life of the pipe. If the corrosion has progressed to the point that the structural steel in the pipeline is compromised, a more expensive structural rehabilitation or complete replacement of the pipeline will be required.

Because hydrogen sulfide presents a major risk to the City's wastewater infrastructure, it is recommended that condition assessment of the City's existing infrastructure and prioritization of H2S related rehabilitation be an immediate priority. With the initial dollars that become available for this purpose, it is recommended that the City use its own forces and/or contract with outside inspection companies to perform a complete inspection and inventory of the City's existing pipelines. Using the information obtained through this inspection, the City can then develop an asset management plan to prioritize future rehabilitation activities.

System Rehabilitation and Replacement Priorities

Because funding is always limited, it is important to prioritize initial system rehabilitation efforts based on the potential consequence of a pipe not performing as designed. The following criteria may be helpful to Orem City personnel in identifying pipes that are most critical based on their relative importance in the collection system:

- Sewer Flow Rate – Flow rate in a sewer pipe is the single most important indicator of the importance of a pipe. Generally speaking, the higher the flow rate, the larger the area which a pipe serves. Bypass pumping costs, the risk if property damage, environmental and regulatory consequences, the cost of pipe replacement, and problems from sewage up in the system are all more severe for larger flow rates. In a worst case scenario, if a pipe collapses or becomes blocked and surcharging in the pipeline results in flows backing up into basements and streets, there is a much greater health hazard to the public with a high flow pipe.

- Road Type – It is much more difficult and costly to perform sewer line repairs on streets with dense traffic. Therefore, pipelines located in high traffic areas should be considered more critical than lower traffic areas. For example, the cost of pipe failure along 800 North or State Street would be much greater than an equivalent sized pipe located on a residential street.

- Pipe Depth – The depth of the pipe can have a significant impact on the cost of repairs and rehabilitation of sewer pipe. Extensions on backhoes, very wide trenches, dewatering, etc. make repairs and maintenance much more expensive and time consuming on deeper pipes. Repairing such pipes under an emergency situation would only be that more difficult. For this reason, deep pipelines should be prioritized over shallow pipelines when planning a repair or maintenance schedule.

CAPITAL IMPROVEMENTS BUDGET

Before establishing a 10-year capital improvement plan, it is necessary to determine how much funding will be set aside each year for capital improvements. One of the best ways to identify a recommended level of funding is to consider system service life. As with all utilities, each component of a sewer system has a finite service life. Therefore, it is necessary to continually spend money towards the rehabilitation or replacement of these components. If adequate funds are not set aside for regular system renewal, the collection system will fall into a state of disrepair and be incapable of providing the level of service that Orem City customers expect.

Orem City's sewer collection system is composed of about 1.5 million feet of pipe and over 6,400 manholes. The total cost to replace all of the pipes and lift stations in the Orem collection system would be approximately $380 million based on 2015 construction costs. In reality, it will not be necessary to completely replace the entire system as it ages because of rehabilitation technologies (e.g. slip lining, cast-in-place pipe, etc.). Rehabilitation costs are much lower than replacement costs (20% to 60% depending on pipe diameter). If Orem were able to rehabilitate the entire system rather than replace components, it would drastically reduce the "replacement value" to $90 million. Unfortunately, it is generally not possible to rehabilitate all system components due to either condition or capacity issues. Some pipes are beyond saving with rehabilitation, while others may require upsizing or correction of grade issues; all of these scenarios would require a replacement.

To account for the limitations on rehabilitation, BC&A recommends a renewal budget derived from a combination of rehabilitation and replacement using an approximate design life of 70 years. Table 7-2 shows a comparison of the required annual budget based on replacement, rehabilitation, and the recommended combination of both values.

Table 7-2
Recommended Sewer Collection System Renewal Budget

System Renewal	Annual Budget (2014 Dollars)*
Replacement of all system components	$5,700,000
Rehabilitation of all system components	$1,350,000
50% replacement 50% rehabilitation	**$3,525,000**

*1.5% of complete system "replacement" (ENR=9870)
which assumes an average 70 year life cycle for all system components (pipes, pump stations, etc.)

In addition to the collection system, a yearly budget should also be designated for the renewal of the Water Reclamation Facility. The total cost to replace the WRF would be approximately $80 million. Since the WRF incorporates several mechanical and electrical components, a shorter design life (50 years) was assumed. Table 7-3 shows the total recommended capital improvement budget for the sewer collection and treatment system.

Table 7-3
Recommended Total Sewer System Annual Capital Improvement Budget

Component	Value
Collection System	$3,525,000
Water Reclamation Facility	$1,600,000
Total	**$5,125,000**

In addition to system renewal requirements required for maintenance programs, there are also work force needs to operate and maintain facilities. Work force needs are discussed further in a technical memorandum in Appendix D.

10-YEAR CAPITAL IMPROVEMENT PLANS

Based on the City's identified project needs and recommended level of capital investment, BC&A has developed four potential capital improvement scenarios covering the next 10 years. These scenarios are shown in Figures 7-4 through 7-7 and detailed in Table 7-4 through 7-7. The process of developing the several scenarios was as follows

- **Identify the Revenue Available for CIP Based on Current Rates –** Each of the figures show the revenue that is projected to be available for capital improvement projects based on current rates. This represents the revenue the City would have available for capital improvements over the next 10 years if it does not make any changes to its existing rates. It will be noted that this revenue increases gradually over time as additional users join the system.

- **Identify the Recommended CIP Funding Level Based on System Value –** Each of the figures also show the recommended capital improvement project funding level for the wastewater system. This is the level of funding sufficient to perform maintenance related projects and system renewal as discussed previously. This level of funding increases over time to keep up with both system growth and inflation.
- **Develop a Transition Plan between the Current and Recommended Levels of Funding –** From the several figures, it is apparent that the projected revenue associated with existing rates will be woefully inadequate to implement the capital improvement projects needed in the City's wastewater system. At current rates, the City would not be able to keep up with system renewal projects and the level of service in the City's sewer collection and treatment system would begin to decline. Because of the dramatic difference between existing revenue and recommended CIP funding, a budget plan is needed to gradually transition between the two. The several scenarios look at different ways to reach the recommended level of funding:

  - **Scenario 1, 5-year Phase In (Figure 7-4, Table 7-4):** As a starting point, BC&A looked at the immediate needs of the City and identified a transition plan that would address all the most pressing needs while limiting annual rate increases. This resulted in the development of Scenario 1. This scenario includes transitioning to the recommended long-term level of funding over a period of 5 years. This scenario would allow the City to construct all of the recommended projects identified in the planning window and begin to implement additional maintenance and renewal projects.
  - **Scenario 2, 7-year Phase In (Figure 7-5, Table 7-5):** To minimize the required annual increases to the rates, BC&A also looked at slower implementation options. Scenario 2 includes a transition from current to recommended levels of funding over a period of 7 years. While this would reduce rate increases and would allow the City to complete all of its highest priority projects, it would require the City to postpone recommended maintenance and renewal projects. Over time, neglect to these areas will result in a reduced level of service and lead to more frequent and costly emergency repairs. Selection of Scenario 2 over Scenario 1 would result in the delay of $2.5 million in system maintenance improvements.
  - **Scenario 3, 10-year Phase In (Figure 7-6, Table 7-6):** This scenario is similar to Scenario 2, but would transition from current to recommended levels of funding over a period of 10 years. Selection of Scenario 3 over Scenario 1 would result in the delay of $5.9 million in system maintenance improvements.
  - **Scenario 4, Bonding (Figure 7-7, Table 7-7):** The previous three scenarios have looked at funding capital improvements on a pay as you go basis. As an alternative, the City could consider using bond funding as a way to accomplish more of the recommended projects without increasing rates as dramatically up front. Bond funding would also allow some of the costs incurred today to be paid for by future users that will benefit from the improvements. Scenario 4 includes funding all of the same projects as identified in Scenario 1, but uses bond funding to limit rate increases to levels slightly below those identified in Scenario 3. To accomplish this plan, the City would need to take out bonds of $4.5 million and

$7.5 million in 2018 and 2021 respectively. These would be used primarily to pay for collection system projects (e.g. Carterville Force Main Relocation, Springwater Lift Station, etc.) and treatment plant projects (Struvite Elimination, Headworks Replacement, etc.). Normal rate revenue could then be used for system maintenance and renewal.

Tables 7-4 through 7-7 list the improvement projects that could be completed within the next 10-years for Scenarios 1 through 4, respectively. Figures 7-4 through 7-7 show this same information graphically. For comparison purposes, Figure 7-4 includes the total level of funding for all four of the scenarios. System improvement projects have been grouped into the following major budget categories:

- **Collection System Capacity Improvements –** Collection system capacity improvements include projects needed to remedy existing deficiencies in the collection system or to increase capacity to accommodate future growth. Projects included within the next 10-years are those projects with existing deficiencies or deficiencies projected to occur within the next 10-years without improvements. Because these improvements are driven by projected growth, there is little flexibility in when they can be completed.
- **Water Reclamation Facility –** The overall capacity at the City's water reclamation facility (WRF) will be adequate for many years. However, there are a number of components at the WRF that will need to be upgraded or replaced within the next 10-years to continue to provide adequate service for the City. Projects to be included within the next 10-years were identified by City personnel. While there is some flexibility in the timing of these projects, unduly postponing their completion will lead to difficulty meeting treatment standards at the WRF.
- **Maintenance/H2S Related Projects –** Maintenance and H2S related projects include those projects identified above that are associated with frequent maintenance, observed condition issues, or H2S corrosion. There is significant flexibility in when these projects are completed. In the case of the frequent maintenance issues, the City could postpone all these projects indefinitely and just keep performing the maintenance. However, the sooner the projects are completed, the sooner the City will start realizing the savings associated with reduced maintenance costs. In the case of observed condition issues, the City might also postpone the improvements, but this will result in significant future expenditures. As discussed previously, maintenance issues will continue to surface as the system infrastructure ages, and the City will benefit by staying up to date on maintenance.
- **Vehicle (Fleet) Replacement –** City personnel have developed a schedule for vehicle replacement based on approximate use, depreciation, and reliability for maintenance vehicles in the City. Because the City has been behind on its replacement schedule over the last several years, the first two years of the recommended sewer budget include a larger proportion of total capital costs for vehicle replacement as the City replaces some of its vehicles that are already beyond their useful service life. However, these costs should decrease and then remain relatively constant as the City replaces vehicles at more regular intervals in the future.
- **Unplanned System Repairs –** Because the City cannot predict precisely when and where pipe failure may occur in the system, a budget item needs to be included in the

recommended capital fund plan that is dedicated to unplanned repairs. This money will then be available to address repairs to be performed when a deficiency is observed in the system. These likely would include point repairs that appear to be of an urgent nature in the system.

- **System Replacement/Renewal –** After accomplishing all of the specific improvements identified above, any remaining capital improvement budget would be dedicated to system replacement. System replacement costs will include identifying those areas of the City's collection system that appear to be aging and in need of repair or replacement. This budget item will include pipes identified via the City's inspection program that need lining or replacement.
- **SW Annex Improvements –** It will be noted that no costs have been shown in the plan for improvements associated with the Southwest Annex. These projects have been left out of the City's 10-year capital improvement budget because they will be funded and constructed by the annex developers.

Ultimately, selection of an implementation scenario has been left to the City's discretion. All of the scenarios will accomplish the City's most pressing capital improvement projects and will fund the system at the long-term recommended level of funding by the end of the 10-year planning window. Selection of a more or less aggressive implementation plan will ultimately depend on the City's desire to proactively invest in its system versus its tolerance for rate increases. In general, it is recommended that the City implement the transition as quickly as possible since system investment to protect existing assets has been consistently shown to reduce total long-term costs.

Table 7-4
10-Year Capital Improvement Plan – Scenario 1, 5-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$500,000	$500,000	$1,518,214	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$14,786,000	$81,378	$638,416	$953,741	$2,323,666	$1,503,671	$1,898,541	$2,213,316	$2,918,362	$2,226,020	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$48,796,000**	**$2,339,818**	**$3,808,706**	**$4,748,215**	**$5,574,372**	**$6,435,555**	**$6,656,442**	**$6,884,902**	**$7,121,196**	**$7,365,592**	**$7,586,560**

Table 7-5
10-Year Capital Improvement Plan – Scenario 2, 7-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$500,000	$500,000	$1,518,214	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$12,528,000	$81,378	$112,604	$375,818	$1,802,622	$900,000	$1,600,000	$2,213,316	$2,918,362	$2,226,020	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$46,538,000**	**$2,339,818**	**$3,282,893**	**$4,170,292**	**$5,053,328**	**$5,831,885**	**$6,357,901**	**$6,884,902**	**$7,121,196**	**$7,365,592**	**$7,586,560**

Table 7-6
10-Year Capital Improvement Plan – Scenario 3, 10-Year Phase In Plan

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000	$934,210									
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000						$426,277				
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000							$999,887			
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000			$218,545							
WRF 4	Third press in solids handling	$500,000				$562,754						
WRF 5	Struvite elimination	$1,600,000			$1,748,363							
WRF 6	Concrete/membrane existing lagoons	$500,000						$597,026				
WRF 7	Replace back-up generator	$500,000						$597,026				
M 1	Frequent maintenance related projects	$5,996,000		$1,272,231	$655,199	$674,855	$695,101	$715,954	$737,432	$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000			$60,100							
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000			$65,564							
M 4	Eastwood Street - Replacement Project	$200,000									$260,955	
M 5	Westwood Street - Replacement Project	$250,000									$326,193	
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$412,604	$500,000	$1,611,624	$1,500,000	$2,000,000	$2,500,000	$3,000,000	$3,000,000	$3,000,000
System Replacement	Replace system as needed	$9,770,000	$81,378	$0	$294,364	$1,177,520	$300,000	$1,000,000	$1,600,000	$2,500,000	$2,000,000	$3,321,636
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$43,780,000**	**$2,339,818**	**$3,082,893**	**$3,870,292**	**$4,746,738**	**$5,231,885**	**$5,757,901**	**$6,271,586**	**$6,702,834**	**$7,139,571**	**$7,586,560**

Table 7-7
10-Year Capital Improvement Plan – Scenario 4, With Bonding

Project Identifier	Project Description	Estimated Total Cost (2106 Dollars)	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024	FY 2025	FY 2026
SS 1	Relocate Carterville Force Main to 1200 South	$667,000		$707,620								
SS 2	Replace Springwater Lift Station	$907,000		$962,236								
SS 3	Replace 6,850 feet of existing 10-inch line with 18-inch line in 1400 South (Chambery to Springwater)	$1,575,000					$1,825,857					
SS 4	Install 2,700 feet 6-inch force main parallel to existing 10-inch force main from Springwater Lift Station	$357,000					$413,861					
SS 5	Replace 1,260 feet of existing 27-inch/30-inch line with 36 inch line along College Drive at 800 South	$813,000					$942,490					
SS 6	Replace 820 feet of existing 12-inch pipe with 15-inch pipe along College Drive at 1200 South	$249,000									$324,889	
WRF 1	Replace screen washer	$100,000		$106,090								
WRF 2	Expand aeration basin in headworks	$400,000					$463,710					
WRF 3	Replace grit washer	$200,000		$212,180								
WRF 4	Third press in solids handling	$500,000					$579,637					
WRF 5	Struvite elimination	$1,600,000		$1,697,440								
WRF 6	Concrete/membrane existing lagoons	$500,000					$579,637					
WRF 7	Replace back-up generator	$500,000					$579,637					
M 1	Frequent maintenance related projects	$5,996,000	$617,588	$1,908,347			$2,085,302			$759,555	$782,342	$805,812
M 2	675 N. 1060 W. to 1200 W. - H2S Concern	$55,000		$58,350								
M 3	1720 S. 400 W. to Sand Hill Road - H2S Concern	$60,000		$63,654								
M 4	Eastwood Street - Replacement Project	$200,000						$238,810				
M 5	Westwood Street - Replacement Project	$250,000							$307,468			
M 6	H2S Rehabilitation Program	$14,665,000	$500,000	$518,448	$2,000,000	$2,000,000	$2,987,871	$1,900,000	$1,900,000	$1,900,000	$1,900,000	$1,900,000
System Replacement	Replace system as needed	$14,786,000	$398,000	$424,785	$956,959	$1,755,980	$850,825	$2,213,805	$2,662,862	$2,654,064	$2,760,746	$3,516,580
Repairs	Unplanned repair fund	$750,000	$77,250	$79,568	$81,955	$84,413	$86,946	$89,554	$92,241	$95,008	$97,858	$100,794
Fleet Replacement	Fleet maintenance and replacement	$3,666,000	$746,980	$504,780	$464,748	$410,469	$360,272	$332,064	$342,026	$348,271	$347,335	$358,318
	TOTAL	**$48,796,000**	**$2,339,818**	**$7,243,497**	**$3,503,661**	**$4,250,862**	**$11,756,043**	**$4,774,233**	**$5,304,597**	**$5,756,898**	**$6,213,169**	**$6,681,504**

Figure 7-4
Recommended Sewer Fund Expenditures, Scenario 1 - 5-year Phase In Plan

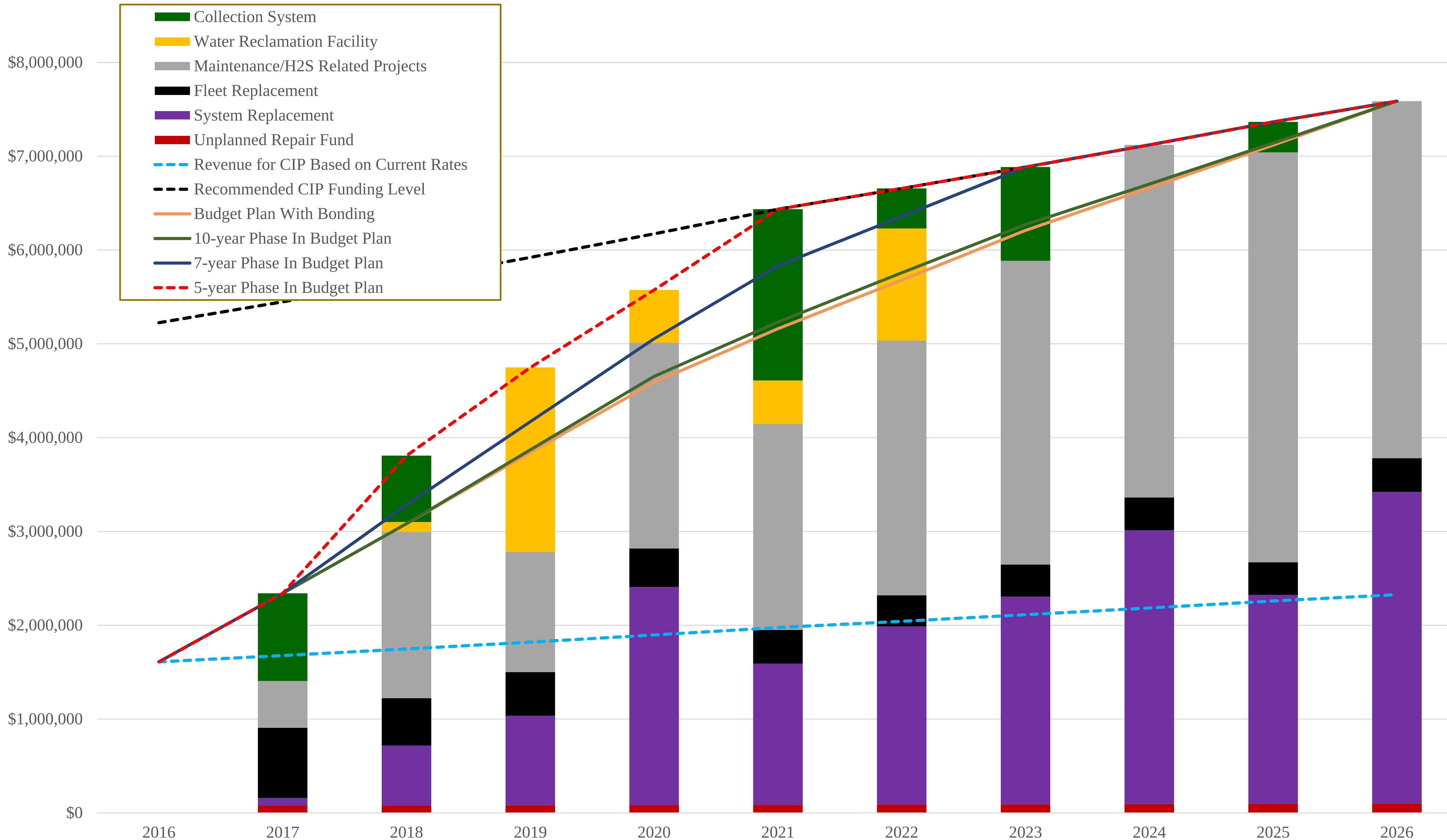


Figure 7-5
Recommended Sewer Fund Expenditures, Scenario 2 - 7-year Phase In Plan

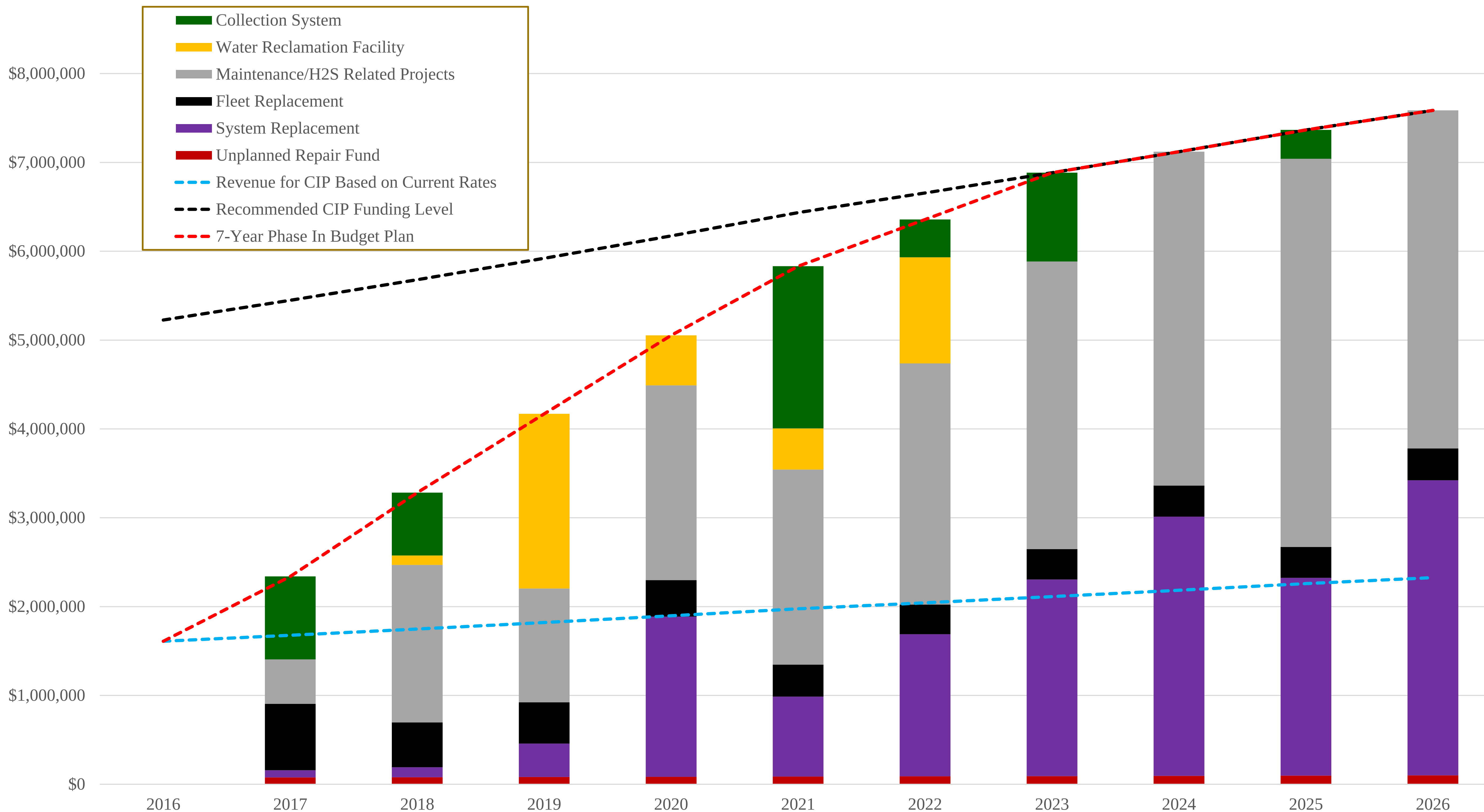


Figure 7-6
Recommended Sewer Fund Expenditures, Scenario 3 - 10-year Phase In Plan

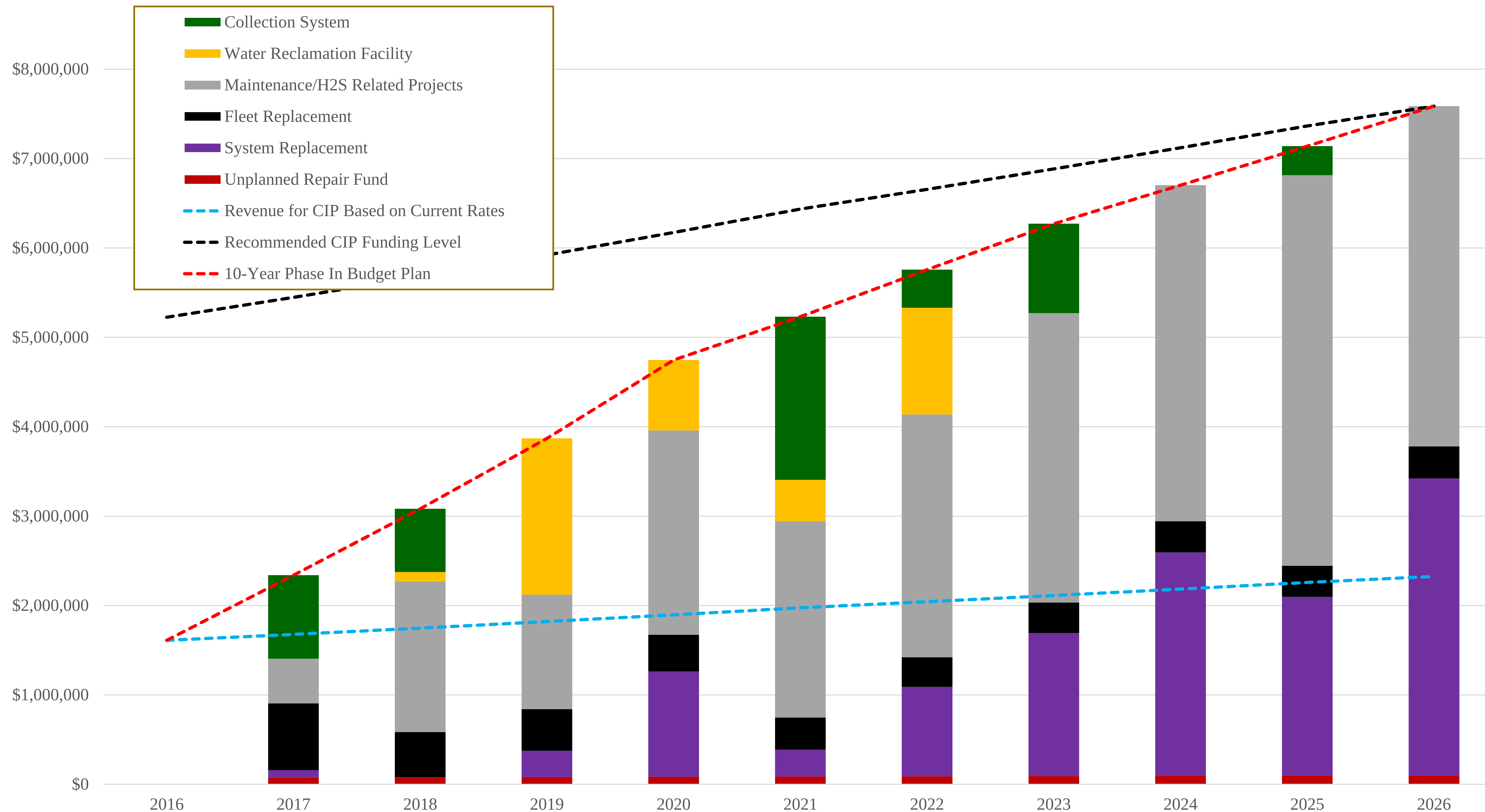
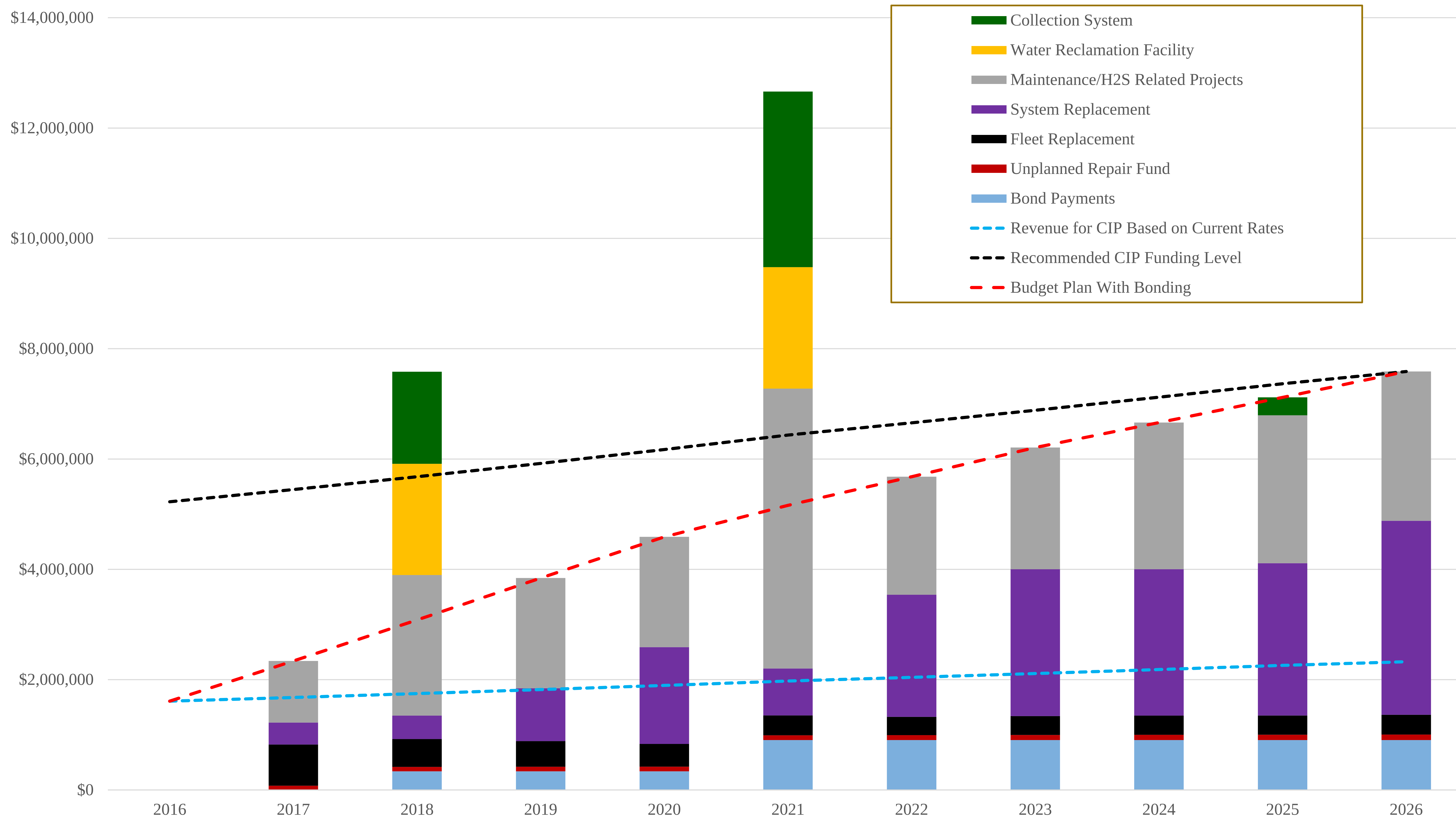


Figure 7-7
Recommended Sewer Fund Expenditures, Scenario 4 - With Bonding



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