2012 Sanitary Sewer

Master Plan Update

December 2012

City of West Jordan
8000 South Redwood Road
West Jordan, Utah 84008

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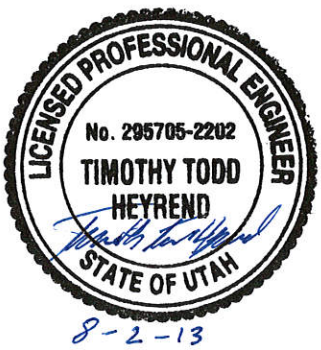

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EXECUTIVE SUMMARY

The City of West Jordan (City) has completed the 2012 Sanitary Sewer Master Plan (Plan) which evaluates the existing sewer capacity of all of the sewer lines in the City sewer system. Previous master plans studied the sewer trunk lines in arterial roads, groundwater infiltration, and provided survey and model data for the major roads. The 2012 Master Plan provides comprehensive survey and modeling data for each manhole and pipe throughout the City including individual neighborhoods. The Plan provides an estimate of future growth based on the City's Land Use Plan, and the required sewer capacity to meet the per capita wastewater demand for this growth. The location and size of new pipelines were studied, modeled, and mapped, as were improvements to the existing sewer system under the Capital Improvements Plan.

A Geographical Information System (GIS) based computer model (INFOSWMM) was used to evaluate the existing and future pipe collection systems. The computer model incorporates Global Positioning System (GPS) surveyed manhole and pipe elevation datum collected by the City for each manhole and pipe in the City's sewer system. The current West Jordan population density from census data, and the current land use map were used to evaluate sewer usage per person for existing residential areas and to project future sewer use in undeveloped areas. Water use records from water meters were used to estimate existing commercial and industrial sewer usage. The existing sewer model was calibrated by comparing observed flows in several locations throughout the City with model output data for each location, model flows calibrated to within +/- 5% of the observed flows.

EXISTING SYSTEM EVALUATION

The results of the existing system evaluation indicate that most of the system is currently functioning well. However, a few pipe lines have reached or are approaching capacity. The areas requiring improvements are highlighted in color on Figure ES-1. The observed deficiencies are as follows:

- The 12-inch pipeline on the south side of 7000 South from 2200 West to 1300 West has areas of over-capacity, which cause the 12-inch pipeline in Redwood Road to backup.
- The 1300 West 10-inch pipeline from 8300 South to 8050 South is at capacity, due in large part to infiltration from groundwater into the sewer laterals, pipes, connections, and manholes.
- Various other areas of the City show short segments of pipes that may be experiencing capacity problems. These localized areas need to be investigated further with field monitoring to confirm problem areas.

Infiltration (ground water) and inflow (surface storm water) entering the sewer system were studied by using metered flow data in 7000 S. from 3200 West to 1440 W., and at the end of the trunklines in 7000 S., 8050 S., and 9000 S. The results of the infiltration study show the highest infiltration areas located east of Redwood Road with an average of 1,005 gallons per acre day (gpad). Areas that contribute infiltration to the 7000 S trunklines are located near the canals from 3100 West to 2637 West with infiltration as high as 910 gpad. Infiltration in the 7000 S

trunkline from 2637 S to approximately Redwood Road measured an average rate of 175 gpad. East of Redwood Road, the infiltration rate was 980 gpad. An Infiltration Study completed in 1992 concurred that areas east of 1300 West and near the canals have high volumes of infiltration assumed to be 412 gallons per acre per day (GPAD).

High inflows were observed on Wednesday December 22, 2010 with 0.63 inches of rainfall. This storm contributed on average an additional 980,000 gallons per day (215 gpad) of total discharge for the system. A storm on October 23, 2010 measured 0.23 inches of rainfall and contributed on average an additional 130,000 gallons per day (29 gpad).

FUTURE SYSTEM EVALUATION

Build out lines were located in proposed roads from the Master Transportation Plan. Figure ES-2 shows proposed locations and sizes of future lines to serve the undeveloped areas. The build out population for the area served by West Jordan sanitary sewers is 175,000 people, as projected by the City of West Jordan Planning Department.

The existing pipe system with future new pipes, and removal of the diversion manholes in Old Bingham Highway and 9000 South, was subjected to future flows to determine which existing lines may need to be relieved. The buildout system model identified the lines that are undersized in capacity to convey buildout flows. New pipelines were then added to the model to increase line sizes, or add parallel lines. The results of the analysis showed significant capacity issues requiring pipe upsizing in the following locations:

- 7000 South from 2800 West to 1300 West, and the adjoining portion of Redwood Road,
- Center Park Drive to Jordan Landing Boulevard,
- 1300 West at 8300 South and along the 8050 South trunkline discharge,
- Wells Park Road and Bagley Park Road in the Industrial Park, and
- Old Bingham Highway from 4800 West to 9000 South,
- Various neighborhood and small diameter pipe locations in the City.

FUTURE IMPROVEMENTS AND CAPITAL IMPROVEMENT PLAN

To accommodate future growth, relief improvements need to be constructed in portions of the existing system. The recommended improvements are presented in Figure ES-3 and Table ES.1. The numbers on Figure ES-3 correspond to the projects listed in Table ES.1. The projects are prioritized for incorporation into a capital facilities plan. The percentage of each project that is attributed to existing development or future development, based on existing and future flows, is shown for capital facilities budgets and impact fee analysis. Project costs were based on recent sewer project bids received by the City of West Jordan.

Increased buildout flow projections were included for the Regional Airport expansion to the east with proposed commercial areas, and for future industries in the Bagley Industrial Park. In order to serve these areas, the improvements described below are recommended.

The Center Park Drive existing 8-inch pipeline is undersized and requires a 12-inch pipe and connection to the 7000 South trunkline, disconnecting from the Jordan Landing trunkline. The 7000 South pipeline requires an upsize to an 18-inch pipe to replace the existing 12-inch and 10-inch trunkline on the south side of the road from 3420 West to 2150 West, and then connecting to the existing 15-inch pipe on the north side of the road at 2150 West and upsizing this 15-inch trunkline to a 24-inch pipe to 1300 West. Further studies and options for the 7000 South trunkline can be conducted as the Airport businesses are constructed and utilization needs are better understood.

Pipeline upsizes at the Bagley industrial Park to a 12-inch pipe in Wells Park Road, 15-inch pipe in Hawley Park Drive and Axel Park roads, and 18-inch in portions of Bagley and Old Bingham Highway where the pipe has not already been upsized. Removal of the diversion manholes at the Old Bingham Highway and 9000 South in order to separate industrial flow from the residential neighborhood in the Wildflower subdivision. Small segments of 9000 South need to be upsized to accommodate the future flow from the industrial park.

The existing 8-inch pipeline in 1300 West requires upsizing due to the infiltration and inflow problems in this area, and for future development along 1300 West. A new pipe segment is needed at the Bingham Creek culvert to reroute the sewer pipe east instead of through the middle of the culvert wall, and to increase the existing pipe size in 8050 South

OTHER RECOMMENDATIONS

It is recommended that the City investigate the sources of inflow and infiltration to the piping distribution system. A study using field monitoring, CCTV, and field inspection of each lateral, pipe, and manhole in the areas where infiltration is shown to exist may reveal areas where pipes or manholes can be repaired which can reduce large I&I flows.

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1 INTRODUCTION AND BACKGROUND

The City of West Jordan (City) sanitary sewer system consists of 292 miles of pipe, and 6,081 manholes. Wastewater is collected with a gravity drain pipe system and conveyed from the west side to the east side of the City with metered discharge points at 9000 South, 8050 South, 7800 South, and 7000 South. Major collection trunklines run west to east on 9000 South, 7800 South, and 7000 South. Additional collector trunklines on the west side of the City are located in the New Bingham Highway and the Old Bingham Highway, these pipes discharge into the 7800 South trunk line. Each major discharge is connected to a regional trunk line that flows south to north along the Jordan River and into the South Valley Water Reclamation Facility (SVWRF) located at 7495 South 1300 West, West Jordan. The City is a member owner agency of the SVWRF and has purchased capacity up to 18.5 million gallons per day (mgd). The City currently discharges at a weekly average rate of 8.5 mgd (5,903 gpm), with a weekly peak day – daily average discharge rate on Sunday of 9.6 mgd (6,670 gpm) and a maximum instantaneous peak hour flow on Thanksgiving Day at noon of 15.2 mgd (10,555 gpm).

The majority of the east side of the City consists of established neighborhoods, commercial, and industrial areas. Heavy and light industrial sectors are located in the south west quadrant of the City, and the west side of the City beyond 4800 W is experiencing continuing residential and commercial growth with large swaths of land yet to be developed. The previous Sanitary Sewer Master Plan from 2003 studied the major trunklines and large problem areas in the City. This study provides a detailed in depth evaluation of every existing pipeline in the City, incorporating flows from neighborhood sewers and routing these to the collector and major collector pipes. This study presents findings for inflow and infiltration completed by visual inspection and flow monitoring. Future infrastructure requirements are shown throughout the City, along major trunklines, and in particular on the west side where development is yet to occur.

This Sanitary Sewer Master Plan study is divided into the following tasks: 1) Update the Sanitary Sewer Model in INFOSWMM to include all pipes and manholes and accurate flows from each connection, 2) Evaluate the existing system (2011-2012) to determine current capacity and system deficiencies, 3) Evaluate the existing system under future loads to show the need for existing system improvements that are necessary through buildout, as part of an overall Capital Facilities Plan, and 4) Evaluate the need and location for new facilities to accommodate future new growth and development on the west side and interior of the City.

A sophisticated computer modeling software (INFOSWMM by Innovyze) running in a Geographic Information System (GIS) based environment is used in conjunction with the City's General Land Use Plan to simulate current and future sanitary sewer system capacity.

2 LAND USE PLANNING AND POPULATION

2.1 EXISTING POPULATION ESTIMATES AND LAND USE

The City's most current GIS parcel data, aerial photographs, and March 2012 Land Use Map (Figure 2.1) were used to identify residential, commercial, industrial, and light industrial areas of the City. The wastewater flows from these areas were then individually assigned to the wastewater model, see section 5.3. The population estimate used information from the United States Census Data 2010 and the Governor's Office of Planning and Budget for residential dwelling unit densities and occupancy rates (capita per dwelling unit). The current citywide residential dwelling units per acre is 1.51. Average residential Occupancy Rate per type of structure from US Census Data is listed in Table 2.1. Table 2.2 presents current density ranges for each zoning classification. The City population for 2010 from the United States Census was 103,712, and the June 30, 2011 population was 106,286. Table 2.3 shows density ranges for the performance based overlay district, which allows increases in density when a developer adds amenities such as extra open space, playgrounds, or upgrades to building facades.

Table 2.1. 2010 Residential Occupancy Rate.

Units in Structure	Households	Population	People per Household
1	24,716	90,089	3.64
2 to 4	674	1,546	2.29
5 or more	3,961	9,404	2.37
Mobile	794	2,591	3.26
Total	30,145	103,630	3.438

Table 2.2. Residential Density Ranges.

Density Designation	Current Density Range (dwelling units per acre)
Very Low Density	Up to 2.0
Low Density	1 to 3
Medium Density	3.1 to 5.0
High Density	5.1 to 10
Very High Density	10.1 and up

Table 2.3. Residential Density for the Performance Based Overlay District.

Density Designation	Density Range (Dwelling Units Per Acre)
Very Low Density	Up to 2.0
Low Density	1 to 3.5
Medium Density	3.1 to 7.6
High Density	5.1 to 14.1
Mixed Use	0-25

2.2 FUTURE POPULATION ESTIMATES & LAND USE

Future population estimates and subsequent wastewater demands were projected for ultimate build-out using the City's recently approved March 2012 Land Use Map zoning designations (Figure 2.1). The City anticipates that the current annual growth rate of 0.98% will remain relatively consistent over the next 3-5 years. The ultimate build-out population is based on the City of West Jordan Planning Department estimates of residential dwelling unit densities and occupancy rates (capita per dwelling unit), and is approximately 175,000 residents.

2.3 EXISTING FACILITIES DRY WEATHER FLOW GENERATION

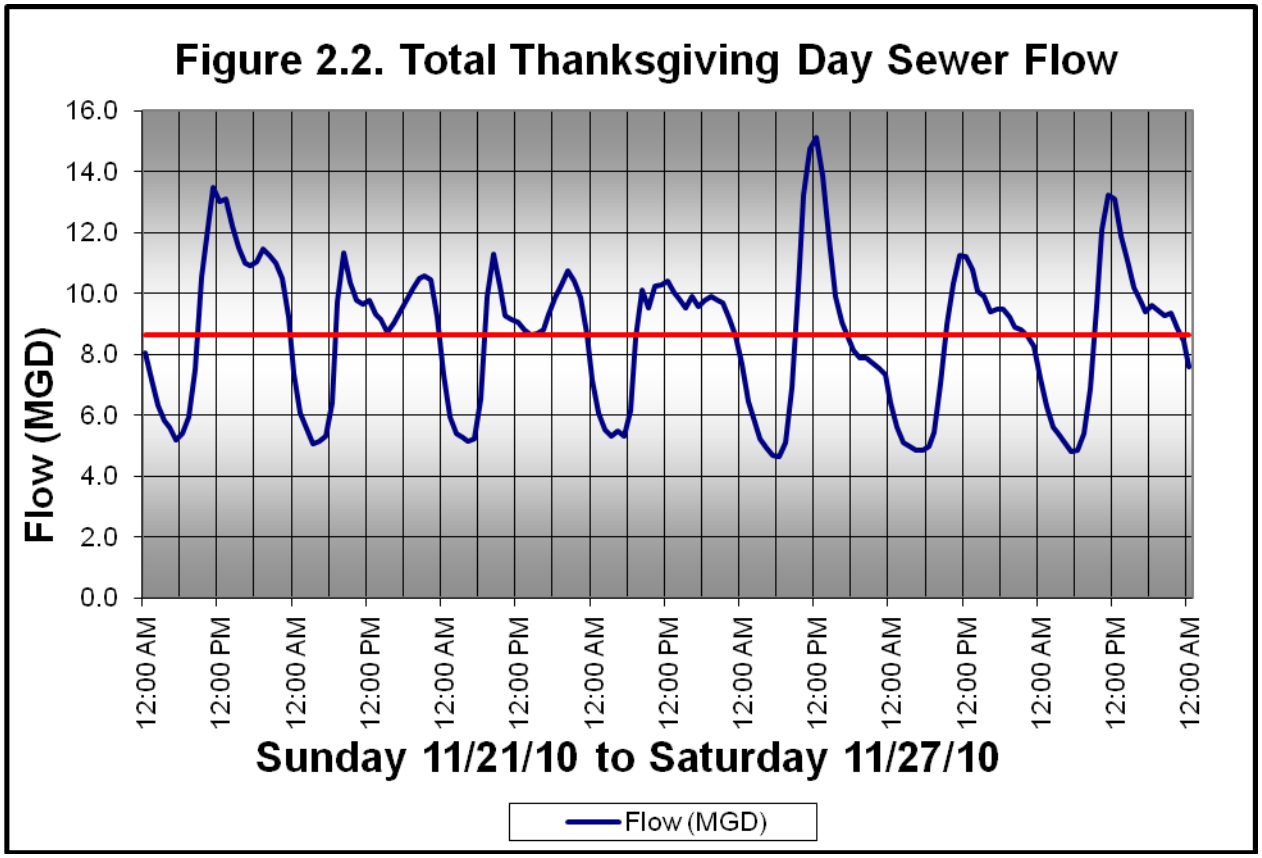
A sanitary sewer system receives two flow components: dry weather flow (DWF) and wet weather flow (WWF). Wet weather flow is described in Chapter 4. The dry weather flow component (baseflow) is flow generated from routine water usage by residential, commercial, business and industrial users. Baseflow typically varies throughout the day with weekday residential peak flows occurring in the morning, between 7 a.m. and 10 a.m., and in the evening between 5 p.m. and 8 p.m. The heaviest residential use is seen on Saturday and Sunday. Commercial baseflow typically starts at 8:00 a.m. and peaks from 11:00 to 2:00 and again from 4:30 to 8:30. Industrial and light industrial flows can have sporadic evening peaks, but generally have base flows during the work day with afternoon peaks. A more detailed discussion of residential, commercial, and industrial dry weather flows is presented below.

2.3.1 Existing Residential Dry Weather Flow

Existing residential dry weather flow is best measured by using winter water meter records. Average 2009 winter monthly residential water use per connection from metering data provided by the City was 6,792 gallons per month, and total City water use per day during the winter months, including commercial and industrial uses, as measured from Jordan Valley Water Conservancy District was 7.9 mgd. Using a population of 103,630 in 2010 from Table 2.1, with 30,145 households and 3.438 people per house (Table 2.1), the average residential water use was calculated at 66 gallons per person per day (gppd). This correlates well with several studies of water use. The American Water Works Association lists the average per person daily water use at 69.3 gallons, and provides a breakdown of how the water is used. Interestingly, 13.7% is lost in water leaks (www.awwa.org). The Utah Division of Water Resources published the average per capita winter water use as 62.2 gallons per day (gpcd), with Salt Lake City averaging 60.7 gpcd and Orem averaging 62.4 gpcd (UDWRe Water Use Study 2010).

Nearly all of the water used in homes is sent to the sewer system, resulting in average weekday residential sewer demands of approximately 66 gppd, and 250 gallons per connection per day for a typical home with 3.8 people, the average occupants of a single family dwelling.

Residential weekend flows tend to peak on Saturday and Sunday during late morning to early afternoon. Total average daily sanitary sewer flow generated within the City is approximately 8.5 million gallons per day (mgd) during regular weekly flows, and 9.2 mgd average on the weekend. The highest peak flows occur on the Christmas Day and Thanksgiving Day holidays with a maximum peak instantaneous flow of 15.2 mgd, although the average daily flow for Thanksgiving Day is only 8.52 mgd, see Figure 2.2 for 2010 Thanksgiving Day flows.



2.3.2 Existing Commercial and Light Industrial Dry Weather Flow

Existing commercial and light industrial dry weather flows were calculated based on water meter usage. Light industrial and Industrial areas were entered into the model at 100% of indoor water meter records. The commercial center wastewater flows were entered using 80% of the indoor water meter consumption, in order to bring the model into calibration with observed flows. A table of commercial water meter records is included in Appendix A. Commercial business baseflow peaks between 10 a.m. and 2 p.m., with restaurant flows increasing during the mid morning and evenings. Light Industrial users discharge predominantly during the weekdays between 7:00 a.m. and 6:00 p.m. and taper off over the weekend (see Appendix B Sewer Flows for South Bagley and Old Bingham Highway 5250 West).

Large Industrial users tend to maintain a base 24 hour sewer discharge with afternoon peaks during the week, and sporadic sharp spikes during equipment cleaning, equipment maintenance and shift changes. The largest Industrial sanitary sewer users in West Jordan are Fairchild

Semiconductor (455,000 gallons per day (gpd)), Dannon Yogurt (277,000 gpd), and Otto & Sons Meat Packing plant (53,000 gpd). The sewer discharge for these large users was based on actual water meter readings or on monitored output flow, and specific discharge patterns were developed in the computer model to obtain precise hourly discharge amounts into the sewer system.

2.4 LAND USE BASED FUTURE DRY WEATHER FLOW GENERATION

2.4.1 Future Residential Dry Weather Flow

In order to create a future residential wastewater flow rate from each undeveloped land area in the City, the people per household, as based on the land use type, were multiplied by the maximum dwelling units per acre, and by 95 gppd to provide an average maximum residential sewer use per acre. The peak sewer use of 95 gppd represents the peak day discharge currently seen on Thanksgiving Day, and is also recommended by the State of Utah Division of Water Quality for future planning. The sewer use per acre was multiplied in GIS by the undeveloped land size to create a future wastewater discharge per land use type see Table 2.4. These discharges were then assigned to a specific future - sewer pipe in the model. This method of flow distribution provides accurate, site specific, future wastewater discharge estimates.

Table 2.4. Future Flow for Residential, Commercial, and Industrial Areas.

Land Use	Low Dwelling Units per Acre (du/ac)	High Dwelling Units per Acre (du/ac)	People per House (pph)	Gallons per Capita per Day (gcd)	Residential Future Sewer Use per Parcel (gpd)	Commercial Sewer Use (gpd per Acre)	Residential Sewer use for future Development (gpd/Acre)
Very Low Density Residential	1	2	3.78	95	359		711
Low Density Residential	2	3.5	3.78	95	359		1,079
Medium Density Residential	4.51	7.6	3.78	95	359		1,797
High Density Residential	9	14.1	2.64	95	251		3,536
Very High Density Residential	12	24	2.64	95	251		6,017
Mixed Use	0	25	2.64	95	251	2,450	6,270
Town Center	14	30	2.25	95	214	1,225	6,270
Neighborhood Commercial						850	
Community Commercial						850	
Regional Commercial						850	
Light Industrial						1,230	

Commercial Flow Source: ASCE Gravity Sanitary Sewer Design and Construction: industrial design example from California lists Large Industrial and Hospital wastewater flow on 96 acres at 2,450 gallons per acre day (gad). West Jordan future Light Industrial lots are assigned half of this amount as many of the current light industrial lots are small businesses with minor discharges.

Mixed Use Residential = 25 du/ac*2.64pph*95 gcd = 6,270 gal/acre/day

2.4.2 Future Commercial and Light Industrial Dry Weather Flow

Future commercial and light industrial wastewater discharges in undeveloped portions of the City are difficult to forecast because each type of commercial or light industry consumes and discharges different amounts of water. If the number of future employees per acre is known, an employee head count with an assigned water use per employee of 30 gallons per person per day can be used.

The ASCE Gravity Sanitary Sewer Design and Construction Manual presented a sewer use study of a California industrial and hospital site encompassing over 96 acres with a wastewater flow rate of 2,450 gallons per acre day (gpad). The West Jordan flows in light industrial areas were assigned 1,225 gpad as many of these vacant light industrial lots in West Jordan are smaller than one acre, and typically use water and sewer for a small number of employees and minor facility use.

2.4.3 Future Industrial Dry Weather Flow

The West Jordan large industrial users were assigned future flows of 50,000 gallons per day (gpd) at Otto & Sons meat packing plant, 200,000 gpd at Jordan Valley Hospital, and 500,000 gpd for Dannon Yogurt and Fairchild Semi-Conductor. One undeveloped area of West Jordan's industrial sector, west of Prosperity Road, was assigned a future flow for heavy industry of 200,000 gpd to prepare for at least one large industrial user in the future.

A summary of the population and baseflow projections for the Existing 2012 Land Use, and Ultimate Build-Out are presented in Table 2.5.

Table 2.5. Existing and Buildout Average Dry Weather Base Flows for Residential, Commercial, and Industrial Areas.

Planning Year	Population	Residential Flow (mgd)	Commercial Flow (mgd)	Light & Heavy Industrial Flow (mgd)	Total WWTP Flow (mgd)
Existing 2010	103,630	6.72	1.41	0.91	9.04
Build-Out	175,000	16.6	3.39	2.02	22.01

mgd= million gallons per day.

3 COLLECTION SYSTEM FACILITIES

3.1 COLLECTION SYSTEM

The City's collection system service area is approximately 7.5 square miles and services 24,543 connections, of which there are 23,276 residential, and 1,177 commercial connections. The collection system contains 292 miles of pipeline ranging in diameter from 8 inches to 36 inches, 6,081 manholes, and three private pump stations. The collection system conveys flow from the west side of the City at the base of the Oquirrh Mountains by gravity to the eastern City boundary on the west side of the Jordan River. The pipelines in the original areas of the City are constructed primarily of vitrified clay pipe (VCP) and some concrete pipe. Pipelines in roads and subdivisions built after the late 1970s are constructed primarily of plastic pipe. The primary trunk sewer, which transports wastewater to the South Valley Water Reclamation Facility treatment plant at 7495 South 1300 West, is a 48" diameter pipeline running south to north on the west side of the Jordan River bottoms. City trunklines with discharge meters at the primary trunk sewer are located at 7000 South, 7800 South, 8050 South, and 9000 South. Future metering locations are proposed at 7700 South for the Gardner Village commercial center, and at 8800 South, which will combine a local area discharge with the re-located current 9000 South meter.

There are three separate diversion structures currently in the collection system that transfer wastewater between the major sewers: 1) Old Bingham Highway and 4800 West, diverts flow out of Old Bingham Highway to 4800 West; 2) 9000 South and 4800 West, diverts flow out of 4800 West to 9000 South; and 3) 9000 South and Old Bingham Highway, diverts flow to 9000 South. These diversions were installed to relieve wastewater flow in the Old Bingham Highway from 4800 West to 4100 West. With the construction of a new pipeline for Dannon that runs north and ties into the new Bingham Highway east of the Copper Hills Youth Center, this relief is no longer needed. A future capital project is proposed to upsize the pipeline in the Old Bingham Highway and to remove all diversion structures as they plug easily and require weekly inspections and cleaning.

3.2 PUMP STATIONS

The City does not currently operate or maintain any public pump stations, as the only City pump station at 1220 West 8660 South was removed in 2011 and replaced with a gravity flow sewer system in 1220 West. There are however, three existing private pump stations located at 1) Navigator Park on Airport Road and 6800 South, 2) the former 84 Lumber site on Airport Road and 6600 South, and 3) Spring Hollow Subdivision at Triumph and 7000 South. The City plans to build a gravity sewer flow pipe system in Airport road and connect it to the newly constructed sewer pipe across the South Valley Regional Airport to eliminate private pumping stations 1 and 2 described above. The Spring Hollow lift station will remain in place indefinitely as the discharge outfall is lower than the trunk line pipe at the east end of the City.

4 FLOW MONITORING

4.1 INTRODUCTION

As part of the hydraulic modeling calibration effort, temporary flow meters were installed to measure dry weather and wet weather flows in the collection system. Monitored flow was recorded every fifteen minutes using the City of West Jordan's Flo-Dar meters. These records of actual collection system flows where then correlated with the flows in the hydraulic model. The City has permanent flow meters to record the discharges to South Valley Water Reclamation Facility (SVWRF) at 7000 South, 7800 South, 8050 South and 9000 South trunklines. These flow meters are located at the east end of the City trunklines and also accumulate flow data every 15 minutes. Additional flow monitors were placed in strategic locations throughout the City to obtain localized flow information. Flow monitoring results at the City's permanent meters and temporary meter locations are discussed below.

4.2 COLLECTION SYSTEM FLOW MONITORING

A total of six temporary flow meters were installed throughout the collection system during 2010 and 2011. These monitors are in addition to the four permanent monitors located at the east end of the City's trunklines. During flow monitoring, pipeline flow (cfs), depth, and velocity data were collected at each flow meter in 15-minute intervals using Flo-Dar® meters. The monitors were left in place for periods over one week in order to capture the differences in weekday and weekend flows. Flow monitoring data was compared to data from the hydraulic model for calibration.

The location of the flow meters divided the collection system into five representative uses or differentiations in trunklines. Appendix B contains graphs of the results of each monitoring station. Table 4.1 presents the location of the flow meters and targeted sewer areas. Flow monitoring occurred during dry weather and is used as the base flow. It should be noted that modeled flow for the 7800 South 4300 West 24-inch trunkline (Appendix B) compared closely to actual monitored flow, and the flow confirms residential daily sewer use of 66 gallons per person per day, as presented in section 2.3.1. This pipe flow does not contain any contributions from groundwater infiltration or rainfall inflow (see section 4.3 for further discussions of inflow and infiltration), which is important for a baseline residential flow for incorporation into the model, and to predict infiltration and inflow rates above the base flow.

4.2.1 Overall Flow Monitoring Results

The average daily flow for the Year 2010 began at 7.8 mgd, increased after the summer to 8.3 mgd, and increased in November to 8.5 mgd. For the Year 2011, the average daily flow ranged from 8.5 mgd on dry weather weeks to 8.7 mgd on wet weather weeks. Weekend flows were typically higher than weekday flows at 9.2 mgd, with peak flows at 12.5 mgd, Thanksgiving Day having the highest flows of the year with a peak instantaneous flow of 15.2 mgd.

Table 4.1. Existing and Buildout Flow Monitoring:
A Comparison of Measured Average and Peak Flows for Residential, Commercial, and Industrial Areas to Modeled Flow.

Meter Location	Primary Land Use and Trunkline Delineation	Average Flow Observed (mgd)	Max Flow & Peaking Factor	Dates	Average Sewer Model Flow (mgd)	Model Max Flow, & Peaking Factor	Model Average Flow Percent Accuracy	Future Average and Max Flow Model Estimates (mgd)
Bagley Park Road and Old Bingham Highway	Industrial Segment prior to Old Bingham Highway	0.12	0.31 PF 2.58	Jan. 26 – Feb 4 2011	0.11	Max 0.21 PF 1.9	92%	Avg. 0.81 Max 2.1
5250 West Old Bingham Highway 18”	Industrial Area with Meat Packing Plant	0.18	0.42 PF 2.33	Jan. 26 – Feb 4 2011	0.19	Max 0.35 PF 1.84	106%	Avg. 0.91 Max 2.5
9000 South 2450 West 15” trunkline	Residential & Fairchild Semiconductor	1.17	1.59 PF 1.36	Aug 11 2010	0.96	Max 1.55 PF 1.61	82%	Avg. 1.97 Max 3.04
7800 South 4300 West 24” trunkline	Residential & Airport Road Light Industrial	1.25	2.22 PF 1.78	Jan 13 – Jan 18 2012	1.3	Max 2.1 PF 1.62	104%	Avg. 5.1 Max 8.2
4100 W. New Bingham Highway 24” trunkline	West side Residential, Industrial, and Light Industrial areas	1.35	1.98 PF 1.47	Jan 13 – Jan 20 2012	1.19	Max 1.89 PF 1.58	88%	Avg. 4.5 Max 7.1
Old Bingham Hwy 7900 S	Mixed Use High Density, Residential, and Light Industrial	0.18	0.31 PF 1.72	8/21/2010	0.35	Max 0.55 PF 1.57	190%	Avg. 1.0 Max 1.62

4.3 INFLOW AND INFILTRATION

4.3.1 Infiltration

Infiltration occurs when existing sewer lines undergo material and joint degradation and deterioration as well as when sewer lines are poorly designed and constructed. (Figure 4.1). Infiltration is groundwater entering the pipes or manholes through cracks, breaks, lids, faulty seals, plant root instructions, improperly aligned or seated joints and manhole walls. Because infiltration is directly influenced by groundwater fluctuations, the volume of infiltration entering a sewer system is generally expected to fluctuate from season to season with typically larger volumes anticipated in the spring and smaller volumes anticipated in the winter. Irrigation canals also raise the height of the groundwater table in the surrounding areas, and contribute to increased infiltration in localized areas down gradient of the canals.

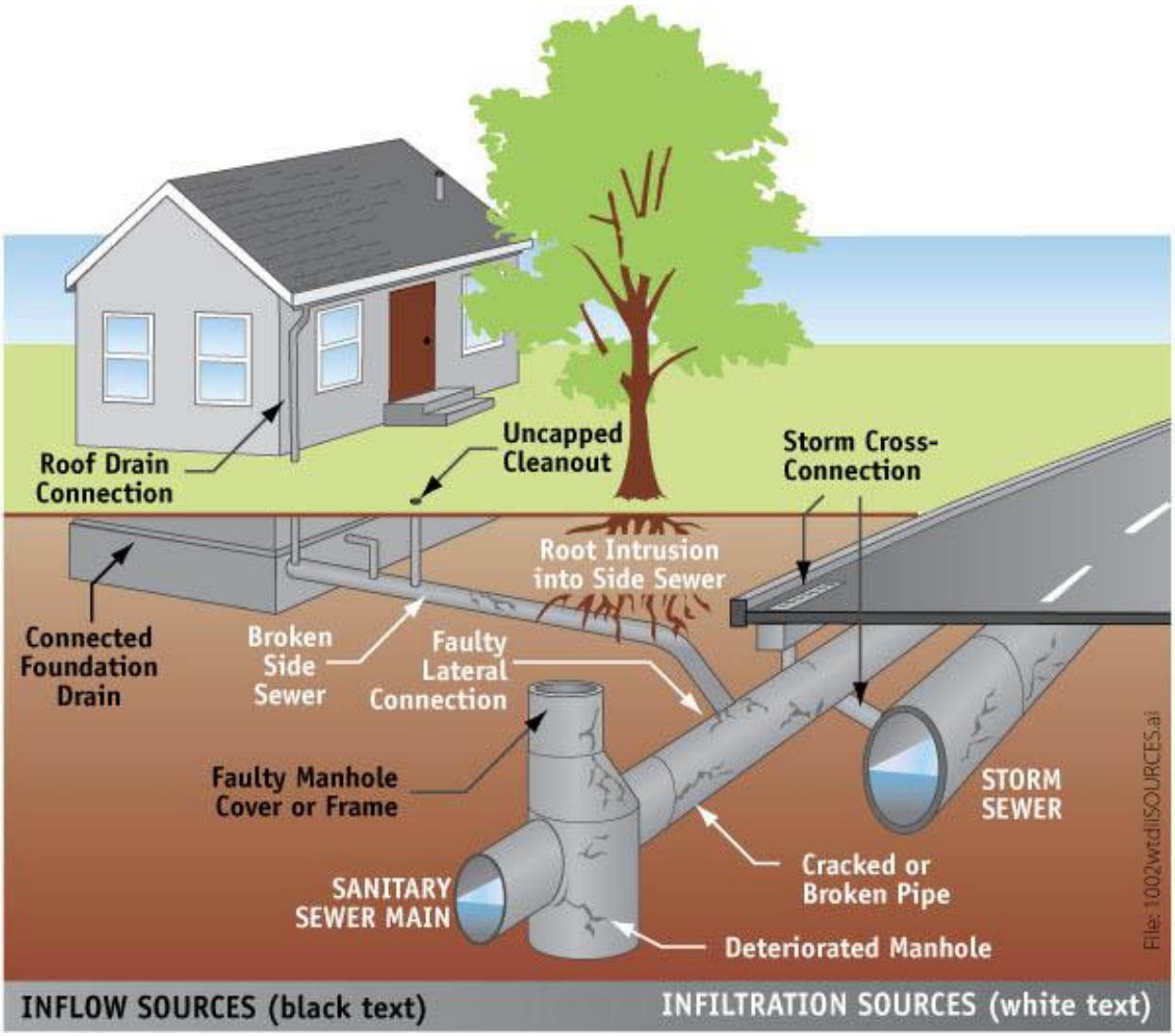


Image Courtesy of King County Website

Figure 4.1: Inflow and Infiltration Sources

4.3.2 Inflow

Inflow is extraneous water discharged into a sewer system from sources such as sump pumps, roof leaders, cellar/foundation drains, surface drains, drains from springs and swampy areas, manhole covers, catch basins, cross-connections from storm drains, cooling water discharges, leaking tide gates, and other inlets. Inflow differs from infiltration in that it is the result of direct connections of extraneous flow sources into the collection system and, generally, is not linked to fluctuations in the groundwater table.

4.3.3 Inflow and Infiltration Effects

Extraneous water from infiltration and inflow (I&I) sources reduces the capacity and capability of sewer systems and treatment facilities to transport and treat domestic and industrial wastewaters. The adverse effects of I&I in the collection system are that they increase both the flow volume and peak flows in the system, causing it to operate at or above its capacity. Because of the additional flow volume, costly pipe size increases may be necessary in the future as the reserved pipe capacity for future growth is used for infiltration and inflow. Excess flows contribute to increased wear of the system and are costly as the City pays a fee for each gallon discharged to the South Valley Water Reclamation Facility for treatment, currently $1.30 per 1000 gallons based on 8.5 mgd, or $4,000,000 annually. Excess I&I water is treated at SVWRF with additional treatment systems that would not be necessary if I&I water were prevented from entering the municipal system. If too much I&I enters the collection system, sanitary sewer overflows may occur.

4.4 INFILTRATION STUDY

Infiltration rates into the sewer system vary in the City based on the groundwater table depth and proximity to irrigation canals. Five major irrigation canals run south to north and either pass through or terminate in the eastern half of the City of West Jordan. The pipelines where low infiltration occurs are generally located west of 4000 West as the groundwater table is deeper and canals are not present. West Jordan also receives groundwater recharge flow from a secondary recharge area located on the east side of the Oquirrh Mountain Range. Due to the slope of the land from west to east, groundwater is conveyed west from the Oquirrh Mountains to the Jordan River, creating higher groundwater levels in the eastern portion of the City. Recent video footage of the 1300 West sewer pipe shows significant flow increases and in some cases pipe submersion due to infiltration from 9400 South to 8600 South. Potholing at 8680 South and 1250 West in May 2011 showed the groundwater elevation at 9 feet below the ground surface, submerging the majority of the sewer system in this area under the groundwater. Wastewater operations personnel reported in 2011 that visual observations of the 1300 West Sewer trunkline show the pipe at capacity for most of the length due to groundwater infiltration.

4.4.1 Historical Infiltration and Inflow Studies and Results

A 1992 infiltration study, *City of West Jordan Sewer System Infiltration Study, CRS, 1992*, concluded that "most infiltration occurring within the City of West Jordan is situated east of 2200 West; with the bulk of infiltration actually occurring east of 1700 West. At several

locations throughout the City, existing sanitary sewer lines either pass near or beneath these irrigation canals. During the heavy irrigation season, leakage from these canals completely saturates the surrounding soils." Manholes experiencing infiltration next to the canals were located at 7962 South 3800 West, 6939 South 2200 West, 7269 South 2944 West, 8435 South 2700 West, and 7800 south 3725 West. Infiltration above 120 gallons per minute was observed in manholes in the areas of 1300 West, 1500 West, and Redwood Road. Since this study, the Redwood road trunk line pipe was lined with a continuous pvc liner to reduce infiltration; however, older neighborhood pipes and lateral connections still contribute infiltration water to the trunkline.

The City's 2003 Sanitary Sewer Master Plan, *2003 Sanitary Sewer Model & Capital Facilities Plan, JUB, 2003*, incorporated infiltration into the pipes in Redwood Road and 1300 West at a rate of 412 gallons per acre per day (gpad). The report indicated that during monitoring, the flow meters registered one significant storm event that contributed a relatively small amount of inflow and infiltration to the system. Estimates of inflow were 0 gpad on the West side of the City to 70 gpad on the east side.

4.4.2 Current Infiltration Study and Results

The City conducted an infiltration study out of necessity to bring the sewer model into calibration, as it was observed that the sewer discharge rates from residences were significantly less in the model than what was observed at the trunkline meters for 7000 south and 8050 South. Both inflow and infiltration were observed in the flow monitoring graphs from SVWRF and from the observations of City personnel. Therefore, flow data was collected to quantify infiltration rates.

Infiltration volume is typically measured as the low point of the daily wastewater flow graph, minus the known flows during that time period. In 2010 the City experienced one of the wettest years on record, which saturated the soils and led to increased infiltration. Appendix C shows graphs of West Jordan Sewer Meters for each of the four major trunklines for a dry weather week in August 23, during the years 2009, 2010, 2011, and 2012, with full irrigation canals. These yearly comparisons show that the most infiltration occurred in 2011, after record precipitation in 2010 led to increases in groundwater recharge from the Oquirrh Mountains. The graphs show that 7000 South and 8050 South trunklines are affected the most by higher levels of groundwater; 9000 South has moderate levels of infiltration; and 7800 South is influenced the least from infiltration. Figure 3.1 shows the manholes where infiltration was applied to the model, actual locations where infiltration is present need to be investigated.

Increases in dry weather infiltration were also observed when comparing sewer flows with the irrigation canals full on October 8, 2010 (8.363 mgd) to October 22nd 2010 (7.988 mgd), when the irrigation flows were reduced and the ground was not as saturated (Table 4.2). These results show that the canals likely contribute 375,000 gallons per day in infiltration to the sewer flows.

Table 4.2. Observed Flow Results and Infiltration Rates

Meter	Dry Weather Flow Daily Average Dec 12 2010	Dry Weather Flow Daily Average Dec 26 2010	Wet Weather Flow Daily Average Dec 19 2010	Dry Weather Flow Daily Average Oct 22 2010	Irrigation Season Dry Weather Flow Daily Average Oct 8 2010	Wet Weather Flow Daily Average Oct 30	Dry Weather Flow Daily Average Nov 15 2011	Irrigation Season Dry Weather Flow Daily Average Aug 23 2011	Wet Weather Flow Daily Average Nov 1 2011
7000 South	2.669	2.804	2.719	2.435	2.518	2.612	2.396	2.663	2.525
7800 South	4.193	3.938	4.325	3.624	3.912	4.155	4.017	4.238	4.368
8050 South	0.455	0.45	0.45	0.444	0.476	0.469	0.524	0.744	0.551
9000 South	1.57	1.586	1.596	1.485	1.457	1.565	1.488	1.572	1.39
Total	8.887	8.778	9.090	7.988	8.363	8.801	8.425	9.217	8.834

Note: All flows are in Millions of Gallons per Day

In order to further define the areas contributing infiltration to the 7000 South trunkline, flow monitors were placed in 7000 S from 3200 West to 1450 West, on both pipelines. Appendix C presents the field monitoring graphs along 7000 South in 2012. Differences in the calibrated model flow without infiltration, and based on the number of residences and water meter use records, were compared to field measured flows to calculate the amount of infiltration in each segment of the trunklines in 7000 South, 8050 South and 9000 South, see Table 4.3.

Table 4.3. Calculated Infiltration Assigned to 7000 South, 8050 South, and 9000 South

Location	Modeled Average Dry Weather Flow Without Infiltration (mgd)	Actual Average Dry Weather Flow (mgd)	Assigned Infiltration (gpad)
7000 S west of 3200 W	0.33	0.36	0
7000 S between 3100 W 15” Pipe west of Utah Lake Canal	0.42	0.38	0
7000 S between 3100 W 15” Pipe east of Utah Lake Canal	0.42	0.473	865
7000 S 2637 W 10” Pipe North Side	0.07	0.23	865
7000 S 2637 W 12” Pipe South Side	0.58	1.21	910
7000 S 2300 W 10” Pipe North Side	0.08	0.35	215
7000 S 2300 W 12” Pipe South Side	0.68	1.33	160
7000 S 2160 W 12” Combined Pipe	0.84	1.11	190
7000 S 1550 W 12” Pipe South Side	1.16	1.53	145
7000 S 1400 W 15” Pipe North Side	0.094	0.2	980
8050 S areas east of Redwood Road	0.27	0.75	1030
9000 S areas east of canal at 2300 W	1.42	1.7	635

Gpad = gallons per acre per day. MGD = millions of gallons per day

The results of the infiltration study as represented in Table 4.3 and on the graphs in Appendix C show the highest infiltration areas located east of Redwood Road with an average of 1,005 gallons per acre day (gpad). Areas that contribute infiltration to the 7000 S trunklines are located near the canals from 3100 West to 2637 West with infiltration as high as 910 gpad. Infiltration continues along the 7000 S trunkline from 2637 S to approximately Redwood Road at an average rate of 175 gpad. East of Redwood Road, the infiltration rate is 980 gpad. End of pipe infiltration results show 37% of the 7000 South trunkline flow is from infiltration. In the 8050 South trunkline and areas by the canals on the 7000 S trunkline, the model shows as much as 64% of the flow is attributed to infiltration during 2011, when comparing calculated sewer flows based on water meter records to actual flows. The 9000 South end of the trunkline results show that 16.5% of the flow is from infiltration. The 7800 South trunkline infiltration results were not quantified as part of the study; however, they are projected to be less than 200 gpad based on the amount of commercial areas with shallow sewer pipes that contribute to the trunkline.

4.5 RAINFALL MONITORING

Inflow volume can be quantified by observing peak flow data during storm events and comparing this to monitoring data of the same area during dry weather. The City experienced unusually high precipitation amounts in 2010 with record breaking storm events. Changes in wastewater flows were monitored during storms by using the primary trunkline flow meters located at 7000 South, 7800 South, 8050 South, and 9000 South, see Table 4.4.

Table 4.4. Wet Weather Combined Inflow and Infiltration Monitoring Results.

Area	Rainfall (inches)	Daily Average Flow (MGD) without Rainfall Dec 12-18, 2010	Daily Average Flow (MGD) with Rainfall Dec 19-22, 2010	MGD Difference	Percent Difference
7000 South					
19-Dec	0.59	2.80	2.72	-0.08	0
20-Dec	0.36	2.79	2.75	-0.05	0
21-Dec	0.32	2.74	2.73	-0.01	0
22-Dec	0.63	2.74	2.87	0.13	4.7%
7800 South					
19-Dec	0.59	3.94	4.32	0.39	4.7%
20-Dec	0.36	4.02	4.37	0.35	8.7%
21-Dec	0.32	3.94	4.12	0.19	4.5%
22-Dec	0.63	3.95	4.52	0.58	14.4%
8050 South					
19-Dec	0.59	0.45	0.45	0.00	0
20-Dec	0.36	0.44	0.50	0.05	13.6%
21-Dec	0.32	0.44	0.49	0.05	11.4%
22-Dec	0.63	0.45	0.54	0.09	20%
9000 South					
19-Dec	0.59	1.59	1.60	0.01	0.6%
20-Dec	0.36	1.64	1.67	0.04	1.8%
21-Dec	0.32	1.64	1.61	-0.03	0
22-Dec	0.63	1.56	1.75	0.19	12.2%

Note: A 3.8% flow increase was observed on 7000 South during the October 2010 storm events

Table 4.4 data shows the difference of wet weather flow monitoring for each trunkline as calculated by subtracting monitored dry weather flow from wet weather flow. It was observed that 7000 South does not appear to have significant increases in flow; however, the results actual indicate that saturated soils in the area already contribute significant levels of infiltration and the extra inflow from rainfall is less pronounced. The 7800 South trunkline shows localized flow increases after a storm event. The data for the 8050 South trunkline show significant increases in flow during wet weather, while 9000 South increases are present, but less pronounced.

Dry weather monitoring curves from previous weeks were overlaid with wet weather flows to observe changes in the average flow and determine the amount of inflow proportional to the storm event, (see wet weather flow comparison graphs in Appendix D). Storm events occurred on October 23-26, 2010 with record setting precipitation of 0.84 inches on the 25th, according to the National Weather Service Forecast Office website for the Salt Lake City area, (see Table 4.5). Another series of storms occurred from December 19-22, 2010; and in November 2011.

High inflows (other than on the Christmas holiday) were observed on Wednesday December 22 with 0.63 inches of rainfall. This storm contributed on average an additional 980,000 gallons per day (215 gpad) of total discharge for the City when compared with Wednesday December 29, 2010. The storm on October 23, 2010 measured 0.23 inches of rainfall and contributed on average an additional 130,000 gallons per day (29 gpad) when compared to November 6, 2010, the closest Saturday without rainfall inflow.

Table 4.5. Rainfall Summary and Average Daily Total Flows

Date	Daily Rainfall Volume (inches)	Average Metered Flow (mgd)	Peak Metered Flow (mgd)		Date	Daily Rainfall Volume (inches)	Average Metered Flow (mgd)	Peak Metered Flow (mgd)
Th 10/21/2010	0	8.19	11.2		Tu 12/21/2010	0.32	8.95	10.75
Fr 10/22/2010	0	7.96	10.4		W 12/22/2010	0.63	9.68	11.78
Sa 10/23/2010	0.26	8.58	12.49		Th 12/24/2010	0	9.4	12.3
Su 10/24/2010	0.18	78th Meter Malfunction	78th Meter Malfunction		Fr 12/25/2010	0	9.46	14.64*
M 10/25/2010	0.84	78th Meter Malfunction	78th Meter Malfunction		W 12/29/2011	0	8.7	11.12
Tu 10/26/2010	0.32	78th Meter Malfunction	78th Meter Malfunction		Tu 11/1/2011	0.31	8.84	11.37
W 10/27/2010	0.03	8.65	11.67		Fr 11/4/2011	0.27	8.23	10.03
Th 10/28/2010	0	8.52	11.40		Sa 11/5/2011	0.24	9.15	13.18
Fr 10/29/2010	0	8.45	11.04		Sa 11/12/2011	0.18	8.65	12.66
Sa 10/30/2010	0.29	8.8	12.98		Su 11/13/2011	0.11	9.02	12.92
Su 10/31/2010	0	8.94	12.96		M 11/14/2011	0	8.52	11.6
Sa 11/6/2010	0	8.45	12.50		Fr 11/18/2011	0.30	8.22	10.95
Su 12/19/2010	0.59	9.09	13.17		M 11/21/2011	0.13	8.75	12.47
M 12/20/2010	0.36	9.23	11.54		T 11/22/2011	0	8.58	10.9

Note: All flow results are in million gallons per day (mgd)
*Christmas Day has the 2nd highest peak flow of the year at 14.64 mgd.
Thanksgiving has the highest peak flow at 15.2 mgd.

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5 COLLECTION SYSTEM MODELING

5.1 HYDRAULIC MODEL DEVELOPMENT

A computer model was developed to simulate the existing and future sanitary sewer system using Innovyze's INFOSWMMM sewer modeling software. Major trunkline data was incorporated from the 2003 master plan study. In addition, all sewer manholes in the entire City system were surveyed in 2010 to form a complete model. City personnel set up GPS equipment in a vehicle and hovered on top of each manhole to collect the GPS coordinate data. Pipe depths were hand measured by City Operations personnel and entered into the model. The sizes of the lines were taken from record drawings, existing City sanitary sewer base maps, and were field verified as needed.

The model includes all pipes within the City with a diameter of 8-inches or greater, and all associated manholes, diversion structures and lift stations. The pipeline length and diameter data, connectivity of upstream and downstream manholes, and existing or future status were included in the model database. The pipeline slopes in the hydraulic model are calculated based on invert elevations and pipe length. A Manning's "n" value of 0.013 was used for all pipes, based on a typical roughness value for a vitrified clay pipe. Figure 3.1 presents the City's collection system in the hydraulic model, which includes every existing pipe and pipe diameter sizes.

5.2 WASTEWATER FLOW COMPONENTS

A sanitary sewer collection system receives two flow components: dry weather flow (DWF) and wet weather flow (WWF). The dry weather flow component (or baseflow) is flow generated by routine water usage in the residential, commercial, business and industrial sectors of the City. The other component of dry weather flow is the contribution of dry weather groundwater infiltration into the collection system as described in section 4.3.

Stormwater inflow and trench infiltration comprise the wet weather flow component termed rainfall dependent inflow and infiltration (RDII). The RDII response in the collection system is seen immediately (as with inflow) or within hours after the rainfall event (as with infiltration). The groundwater infiltration effects on the collection system change during the irrigation season. A decrease in infiltration was observed from October 6th through the 21st monitoring data (see Appendix C) as the irrigation season ended.

5.3 DRY WEATHER BASE FLOW LOADING

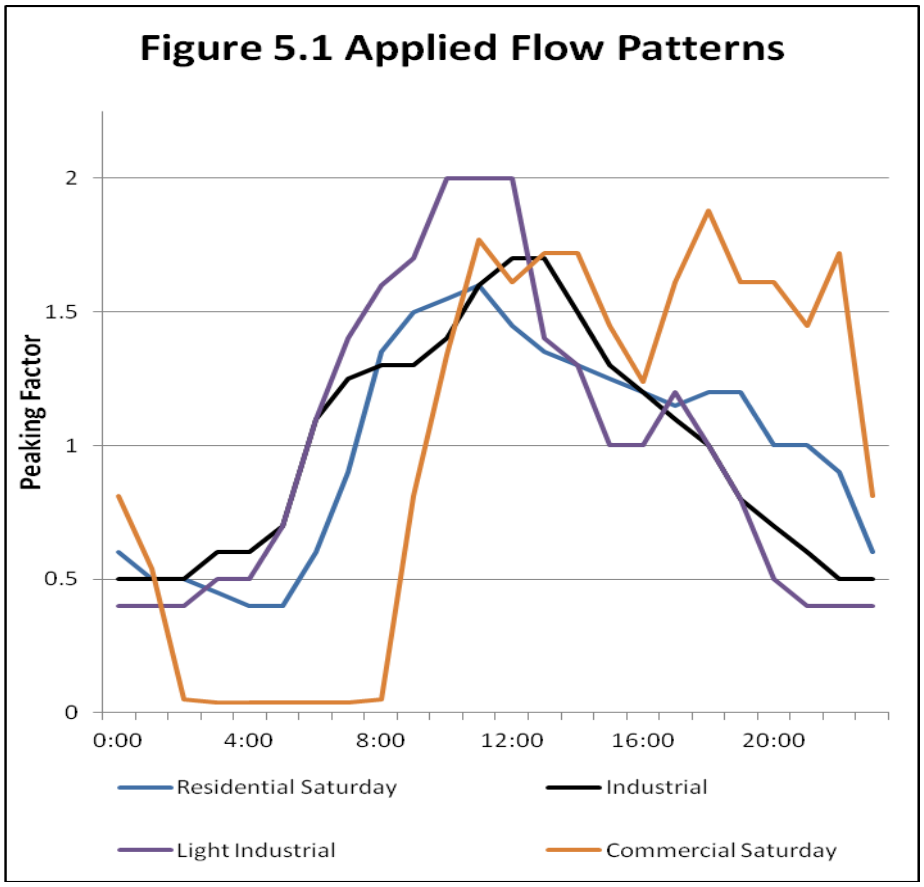
Land use and population estimates are the basis for developing the quantity of baseflow generated within the City. The type of land use in an area will affect the volume and characteristic of the baseflow being generated. Adequately estimating the quantity of this

wastewater is an important process in maintaining and sizing collection system facilities, both for existing conditions and future developments.

The INFOSWMM model uses a dry weather flow allocation subroutine to assign flows to each node based on the closest node to the demand. A GIS Citywide parcel layer was used with a GIS land use layer to assign demand flows from each parcel to the nodes based on the land use type, e.g. low density, medium density, commercial, high density, multi use, industrial, or light industrial. Approximately 25,000 separate dry weather demand loads were entered into the model. Actual meter use records of the commercial, industrial, and light industrial water usage were used to input flow into the model for existing flows, see section 2.3. Future flows were projected in the model based on land use per acre and multiplied by the number of acres and assigned to the closest future node, see section 2.4.

5.3.1 Diurnal Flow Patterns and Peaking Factors

Diurnal flow patterns were developed and refined in the model for each large industrial user, residential user, commercial, and light industrial user. Because the highest flows were governed by the residential users on Saturday and Sunday, the model was setup to mimic these high flow patterns, instead of a typical weekday pattern which was observed to be much lower in flow. The unit diurnal curve allows the INFOSWMMM software to quantify the flow throughout the day for the various types of land use activities, see Figure 5.1.



The system experiences higher weekend flows than weekday; therefore, the model was calibrated to the weekend flows. Various parts of the City have differing peaking rates. For instance, 7800 South west of 4300 West is mainly a residential system with early to mid morning and evening to late night peaks during the week, but less flow in the afternoon. When combined with the industrial flows from the New Bingham Highway, a constant flow is observed in the middle of the day from light industrial and commercial. 9000 South is heavily influenced by Fairchild semi-conductor peaks, which tend to have steady flows throughout the day and high flows in the afternoon. Peak flows occur at about 10:00 a.m. during the week, and between 11:00 a.m. to 12:00 p.m. on the weekend.

The peaking factor is defined as the daily peak flow divided by the daily average flow. The peaking factor ranges from 0.5 at 4:00 a.m. to 1.6 on a weekend to 1.77 on Thanksgiving Day, the highest peaking factor of the year. Table 5.1 and Figure 5.1 show the hourly flow patterns that are multiplied by the average demand to create hourly and peak flow values, correlating with actual metered flow data.

Table 5.1. Model Hourly Flow Patterns Multiplied by the Average Demand.

Time	Model Commercial Pattern	Model Industrial Pattern	Model Light Industrial Pattern	Normal Saturday Hourly Combined Flows (MGD)	Normal Saturday Combined Flows Pattern	Thanks-giving Hourly Combined Flows (MGD)	Thanks-giving Combined Flows Pattern
0:00	0.30	0.5	0.4	6.89	0.80	7.67	0.89
1:00	0.30	0.5	0.4	5.88	0.69	6.43	0.75
2:00	0.10	0.5	0.4	5.52	0.64	5.76	0.67
3:00	0.20	0.6	0.5	5.14	0.60	5.23	0.61
4:00	0.30	0.6	0.5	4.80	0.56	4.94	0.58
5:00	0.50	0.7	0.7	4.79	0.56	4.70	0.55
6:00	0.70	1.1	1.1	4.84	0.57	4.66	0.54
7:00	1.20	1.25	1.4	5.69	0.66	5.12	0.60
8:00	1.30	1.3	1.6	7.29	0.85	6.90	0.81
9:00	1.30	1.3	1.7	9.52	1.11	10.19	1.19
10:00	1.50	1.4	2.0	11.63	1.36	13.24	1.55
11:00	1.60	1.6	2.0	12.04	1.41	14.77	1.72
12:00	1.70	1.7	2.0	12.04	1.41	15.13	1.77
13:00	1.60	1.7	1.4	11.76	1.37	13.88	1.62
14:00	1.50	1.5	1.3	11.13	1.30	11.81	1.38
15:00	1.30	1.3	1.0	10.49	1.22	9.92	1.16
16:00	1.30	1.2	1.0	9.95	1.16	9.05	1.06
17:00	1.50	1.1	1.2	9.77	1.14	8.66	1.01
18:00	1.60	1	1.0	9.86	1.15	8.14	0.95
19:00	1.40	0.8	0.8	9.90	1.16	7.88	0.92
20:00	1.00	0.7	0.5	9.74	1.14	7.89	0.92
21:00	0.70	0.6	0.4	9.29	1.08	7.73	0.90
22:00	0.60	0.5	0.4	8.89	1.04	7.56	0.88
23:00	0.50	0.5	0.4	8.77	1.02	7.32	0.85

Mgd= millions of gallons per day

5.4 INFLOW AND INFILTRATION LOADING

Modeling the flow components of inflow and infiltration is accomplished by assigning I&I flows to each affected node. The age, materials, and condition of the collection system facilities will impact the quantity of inflow and infiltration. The INFOSWMM model was setup with several different scenarios as follows: existing dry weather flow, existing flow with rainfall added, future flow without rainfall, and future flow with rainfall. Groundwater infiltration was added to all of the scenarios to provide the maximum flow during existing and buildout conditions. As the groundwater table fluctuates during the irrigation season or after major rainfall events, a mounding effect is observed in the flow data. Thus, at different times, groundwater infiltration is a significant contributor to the collection system and uses up pipe capacity, see section 4.4.2.

It is important in the modeling process to calibrate to the highest groundwater mounding effect seen in the flow data to ensure that the model represents the worst-case scenario and that the potential impact of groundwater infiltration is not underestimated. A unique set of groundwater infiltration nodes was established in the model for the areas near canals and east of approximately 3200 West, see Figure 3.1 and Tables 4.3, 4.4, and 4.5. Rain events combine infiltration from the rising groundwater table and surface inflow from rainwater entering into the manholes. Inflow was assigned to the nodes that also have infiltration as they are generally the oldest and in the worst condition.

5.5 CALIBRATION

Model calibration is a crucial component of the hydraulic modeling effort. The model must be calibrated to flow metering data to ensure the most accurate results possible. The calibration process consists of calibrating to both dry and wet weather flow events.

5.5.1 Dry Weather Flow Calibration

Dry weather flow calibration ensures an accurate depiction of baseflow generated within the City, based on population estimates, diurnal curve patterns, and land use. Infiltration flow is included in the flows for dry weather calibration. Calibration involved adjusting the diurnal curves for each land use to match observed monitoring results. Table 5.2 summarizes the dry weather flow calibration. Dry weather flow calibration plots are provided in Appendices B and C. Average Model calibration results of the trunklines with actual flows show great accuracy of 96.3% to 101.5% for 7000 South, 8050 South, and 9000 South. 7800 South accuracy is 113%, likely due to a faulty trunkline meter, and fluctuations in business vacancy, the majority of which are located along the 7800 South trunkline. Local collector and trunkline pipes were monitored and calibrated for dry weather flow and the results were presented earlier in Table 4.1.

Table 5.2. A Comparison of Average Sewer Flow August 23, 2009-2012, Vs. Modeled Flow

Trunkline	Model	2009	2010	2011	2012
7000 South	2.7	1.9	2.1	2.6	1.9
7800 South	5.1	4.5	4.0	4.1	3.7
8050 South	0.69	0.55	0.61	0.68	0.69
9000 South	1.7	1.5	1.6	1.7	1.5

5.5.2 Wet Weather Flow Calibration

The model was calibrated using the information obtained from the flow monitoring results as discussed in Section 4. Table 5.3 summarizes the wet weather model flow calibration results when compared to the actual results as recorded at the discharge meter for each trunkline (see Appendix E). Calibration in 7000 South and 8050 South showed high levels of groundwater infiltration in this area, as seen by examining the minimum flows at the bottom of the flow curve at around 3:00 a.m. The majority of flows during this time will be from infiltration, as most residential, commercial, and light industrial activities are scarce at this hour. All of the major trunklines except 7800 South calibrated to within +/-3.5%. The 7800 South trunkline calibrated to within 18% due to less reliable business and light industrial sector flows and vacancies. However, if all of the businesses, light industrial, and industrial uses were employed at peak usage, the actual use would align with modeled flow. Therefore, the excess flow percentage in 7800 South is needed to accommodate the possible condition of full usage, and also provides a capacity buffer.

Table 5.3. Wet Weather Flow Calibration Summary.

Meter Location	Meter Flow (mgd)			Model Flow (mgd)			Average Flow Percent Error
	Average Flow	Minimum Flow	Maximum Flow	Average Flow	Minimum Flow	Maximum Flow	
7000 South	2.91	2.1	3.47	2.86	1.93	3.75	-1.72%
7800 South	4.33	1.93	6.97	5.10	2.22	7.91	17.8%
8050 South	0.74	0.61	0.90	0.73	0.57	0.88	-1.35%
9000 South	1.70	1.31	2.37	1.76	1.11	2.61	3.53%

mgd: million gallons per day

6 CAPACITY ANALYSIS

6.1 INTRODUCTION

Upon completion of the dry and wet weather flow calibration, a capacity analysis of the modeled collection system was performed. The capacity analysis identifies areas in the collection system where flow restrictions occur or where pipe capacity is insufficient to pass peak wet weather flows (PWWF) of the design storm. Pipes that do not have sufficient capacity to pass PWWF's can produce backwater effects in the collection system and potentially cause unwanted sanitary sewer overflows (SSO's). Maximum flow over full pipe flow or depth of flow over diameter of pipe (d/D) are accurate methods of predicting how much pipe capacity is remaining in the system, and if a pipe needs to be upgraded. A full pipe has a d/D value of 1.0, and has no reserve capacity, while a pipe flowing half full has a d/D value of 0.5, and has some reserve capacity. Table 6.1 provides the recommended d/D values and minimum pipe slopes.

Table 6.1. Design Slope Parameters

Pipe Diameter (inches)	Maximum Allowed depth/Diameter d/D	Minimum Pipe Slope
8	0.50	0.40 %
10	0.55	0.28 %
12	0.60	0.22 %
15	0.65	0.15 %
18	0.75	0.12 %
21	0.75	0.10 %
24	0.75	0.10 %
27	0.75	0.10 %
30	0.75	0.10 %
36	0.80	0.10 %

Ten State Standards allows for pipe slopes less than 0.10% (S=0.0010).
However, practical construction tolerances do not warrant lesser slopes.

6.2 COLLECTION SYSTEM PERFORMANCE

The City's collection system was analyzed using projected demand loads and inflow and infiltration additions. The capacity of the collection system was assessed for both the Existing 2012 land use condition and Buildout under the current West Jordan Land Use Plan. When flow in a pipeline reaches a depth-to-diameter (d/D) ratio of 0.75, the pipeline is considered under capacity. New sewers (parallel or replacement) are recommended to relieve these deficient pipelines.

The following scenarios were modeled to evaluate the system d/D capacity of every pipeline in the City:

- Existing pipe system Capacity analysis using current demands with Inflow and Infiltration (Figure 6.1);
- Existing pipe system Flows in cubic feet per second (cfs) using current demands with Inflow and Infiltration (Figure 6.2);
- Existing pipe system and demands with Inflow and Infiltration Capacity Analysis after removing the diversion manholes at 4800 West and Old Bingham Highway, 9000 South and 4800 West, and Old Bingham Highway and 9000 South, (Figure 6.3);
- Buildout system Capacity Analysis with the existing pipe system and future new pipes with future demands and Inflow and Infiltration (Figure 6.4);
- Buildout system Capacity Analysis after removal of the diversion manholes listed above using future demands with Inflow and Infiltration (Figure 6.5).

6.2.1 Existing System Capacity Analysis

The existing piping system capacity is generally adequate under current demand conditions; however, there are a few areas that need relief due to over-capacity or that are approaching over-capacity. Modeled system capacity, and calculated existing system flows for each pipe in the model are presented in Figures 6.1 and 6.2. The observed deficiencies are as follows:

- The 12-inch pipeline on the south side of 7000 South from 2200 West to 1300 West has areas of over-capacity, which cause the 12-inch pipeline in Redwood Road to backup.
- The 1300 West 10-inch pipeline from 8300 South to 8050 South is at capacity, due in large part to infiltration from groundwater into the sewer laterals, pipes, connections, and manholes.
- Various other areas of the City show short segments of pipes that may be experiencing capacity problems. These localized areas need to be investigated further with field monitoring to confirm problem areas.

6.2.2 Diversion Manhole Removal Analysis

Diversion manholes are problematic for operations as they need to be cleaned of debris buildup on a weekly basis. This requires a minimum of three personnel and traffic control as lanes are closed in 9000 South while the crew is working. The diversion manholes that are recommended for removal are located at 4800 West and Old Bingham Highway, 9000 South and 4800 West, and Old Bingham Highway and 9000 South. Diversion Manhole removal will take industrial flow out of the Wildflower subdivision from the connection at the Old Bingham Highway and 4800 West and keep the industrial flow in the Old Bingham Highway and 9000 South trunklines. The City has received odor complaints from the residents in Wildflower that are due to the industrial sewer flows through the neighborhood sewer pipe. Removal of the Diversion manhole at 9000 South and Old Bingham Highway will take flows out of the sewer pipe heading northeast and put all of the flow into 9000 South. This adjustment allows a more direct route of flow to 9000 South rather than sending flow to the pipe in 4000 West which has a flat slope.

Existing and future flows were modeled to determine the effects of removing the diversion manholes, see Figures 6.3, and 6.5. Table 6.2 presents the results of the study. Graphs of the flow model for existing flows with and without diversions to 4800 West, Old Bingham Highway, and 9000 South pipelines are presented in Appendix F. The model results of diversion manhole removal for existing flows and pipes show that the existing pipe system has the capacity for sending all of the current flows to the Old Bingham Highway and 9000 South. In the future, it is anticipated that additional industries will discharge much more sewer flow to the Old Bingham Highway and 9000 South. When this occurs, the 10-inch section of Old Bingham Highway will be inadequate and will need to be upsized. Also, sections of the 9000 South 12-inch trunkline will need to be upsized west of the Bangerter Highway, and at a flat portion of the pipe at 2300 West.

Table 6.2. Study for the elimination of Split Manholes on Old Bingham Highway and 4800 West and 9000 South 4800 West.

Pipeline	2012 Max Flow with Split Manhole (cfs)	Max 2012 d/D with Split Manhole	2012 Flow without Split Manhole (cfs)	Max 2012 d/D without Split Manhole	Max Future Flow with Split Manhole (cfs)	Max Future d/D with Split Manhole	Max Future Flow without Split Manhole (cfs)	Max Future d/D without Split Manhole
OBH 4800 W North 15” pipe	0.35	0.17	0	0	1.2	0.32	0	0
OBH 10” Pipe at Junction of 9000 S	0.36	0.33	0.7	0.33	1.5	0.51	2.7	0.8
9000 S 12” Pipe After OBH Junction	0.71	0.25	0.5	0.2	1.65	0.36	2.7	0.5

6.2.3 Future System Capacity Analysis

The sewer INFOSWMMM model was used to calculate future flows and assigned the flows to the appropriate pipes. New pipes were added to the western portion of the City in future road locations, and pipes were sized to accommodate the predicted flow from the City’s Land Use Map. Also, a new pipe was added in the Old Bingham Highway to accommodate flow from the transit oriented development northeast of the Jordan Valley Hospital, and new pipes were added to the east side of the airport to accommodate the airport’s future expansion plans. A capacity analysis was conducted of the current pipes with future demand flows, see Figure 6.4. The results

of the analysis showed significant capacity issues requiring pipe upsizing in the following locations:

- 7000 South from 3420 West to 1300 West, and the adjoining portion of Redwood Road,
- Center Park Drive to Jordan Landing Boulevard,
- 1300 West at 8300 South and along the 8050 South trunkline discharge,
- Wells Park Road and Bagley Park Road in the Industrial Park, and
- Old Bingham Highway from 4800 West to 9000 South,
- Various neighborhood and small diameter pipe locations in the City.

7 RECOMMENDED CAPITAL IMPROVEMENT PROGRAM

7.1 INTRODUCTION

The capacity analysis, described in Chapter 6, sets the foundation for the capital improvement program (CIP). The CIP focuses on alleviating the collection system capacity deficiencies. The intent of the CIP is to serve as a working document, which the City can follow to update the capacity deficient sections of the collection system.

7.2 CAPITAL IMPROVEMENT PROGRAM

When fully implemented, the CIP illuminates hydraulic capacity deficiencies in the collection system to convey peak wet weather flows (PWWF) to the wastewater treatment plant (WWTP). This section provides a discussion of the sewer replacement criteria, modeling assumptions, cost criteria and the recommended improvements included in the CIP.

7.2.1 CIP Criteria

7.2.1.1 Sewer Replacement Criteria

When additional capacity is required, existing sewers can be replaced or paralleled. For the purposes of this master plan update, it was assumed that a deficient existing sewer will be replaced with a larger diameter pipeline at the same slope as the existing pipeline, unless otherwise noted. The decision to replace or parallel the existing pipeline should be made during the predesign effort for each improvement. During the predesign effort, the existing sewer should be closed circuit televised (CCTV) to determine its structural condition. If severely deteriorated, the existing sewer should be replaced. If moderately deteriorated, the existing sewer can be rehabilitated by slip lining, pipe bursting, or inversion lining with a parallel sewer constructed to convey the excess flow. Except for pipe bursting, a rehabilitated sewer has less hydraulic capacity because of a reduction in cross-sectional area and this loss in existing capacity needs to be accounted for when sizing the parallel sewer. With pipe bursting, the existing pipe diameter can be increased by pulling a larger pipe through the existing pipe, causing it to burst. This system works well for trunklines as they typically have fewer lateral connections, and it requires very little road repair when compared to open trenching.

7.2.1.2 Modeling and Analysis Assumptions

The CIP is based on several assumptions:

- The hydraulic grade line is to be maintained below a depth to diameter ratio of 0.75 including inflow and infiltration flows.

- Water consumption was set at 95 gppd based on State Division of Water Quality Standards to provide a factor of safety in pipeline capacity for peak days.
- Groundwater infiltration and rainfall inflow values are the same as found in sections 4.4 and 4.5.
- Future residential, commercial, and industrial demands are based on the calculated loads per acre set forth in Table 2.4.

7.2.2 Planning Level Cost Criteria

The planning level capital cost estimate used in developing the CIP is based upon the unit costs presented in Appendix G for each project. These unit costs are from construction bids received for sanitary sewer projects in West Jordan within the last two years. The unit costs are for "typical" field conditions with construction in stable soil at an average depth of eleven feet to invert of pipe. The unit costs include pipe and pipe installation, manhole and appurtenances, excavation and backfill, pavement removal and replacement up to 4-inches thick, limited sheeting, dewatering and shoring, and contractor overhead and profit. To develop total CIP project costs, an additional 24.3 percent is added for engineering, administrative, legal fees, and municipal staff time.

7.3 RECCOMMENDED CAPITAL IMPROVEMENT PROGRAM AND PRIORITIZATION PLAN

The CIP needs to be phased in over time to provide the City with an affordable approach for implementation based on when the improvements are needed. The recommended improvements are presented in Figure 7.1 and Table 7.1. Each project is prioritized in Table 7.1 for incorporation into a capital facilities plan. Appendix G contains large project cost breakdown sheets that are listed by priority number. The major project improvements depend greatly on how the City develops in the future. Increased buildout flow projections were included for the Regional Airport expansion to the east with proposed commercial areas, and for future industries in the Bagley Industrial Park. Because of these additions, the improvements described below are recommended.

The Center Park Drive existing 8-inch pipeline is undersized and requires a 12-inch pipe and connection to the 7000 South trunkline, disconnecting from the Jordan Landing trunkline. The 7000 South pipeline requires an upsize to an 18-inch pipe to replace the existing 12-inch and 10-inch trunkline on the south side of the road from 3420 West to 2150 West, and then connecting to the existing 15-inch pipe on the north side of the road at 2150 West and upsizing this 15-inch trunkline to a 24-inch pipe to 1300 West. Further studies and options for the 7000 South trunkline can be conducted as the Airport businesses are constructed and utilization needs are better understood.

Pipeline upsizes at the Bagley Industrial Park to a 12-inch pipe in Wells Park Road, 15-inch pipe in Hawley Park Drive and Axel Park roads, and 18-inch in portions of Bagley and Old Bingham Highway where the pipe has not already been upsized. Removal of the diversion manholes at the Old Bingham Highway and 9000 South in order to separate industrial flow from the residential

neighborhood in the Wildflower subdivision. Small segments of 9000 South need to be upsized to accommodate the future flow from the industrial park.

The existing 8-inch pipeline in 1300 West pipe requires upsizing due to the infiltration and inflow problems in this area, and for future development along 1300 West. A new pipe segment is needed at the Bingham Creek culvert to reroute the sewer pipe east instead of through the middle of the culvert wall, and to increase the existing pipe size in 8050 South.

Figures 7.2 and 7.3 show the depth of flow over pipe diameter and the flow in cubic feet per second of each pipeline, once the recommended projects are completed. The figures show that adequate future capacity will be obtained with the proposed future system. These data can in no way predict all future flows to the system, and each trunkline will need to be re-examined as the undeveloped areas are built.

7.4 OTHER RECOMMENDATIONS

It is recommended that the City investigate the sources of inflow and infiltration to the piping distribution system. Because no less than three separate engineering studies have shown the presence of significant I&I in the trunklines, the presence of I&I is not likely to be refuted. The portion of the study that remains is detailed field monitoring, CCTV, and field inspection of each lateral, pipe, and manhole in the areas where infiltration is shown to exist. There may be areas where pipes or manholes can be repaired which can reduce large I&I flows.

Future updates to this study are necessary as developments and infrastructure projects are completed citywide, and to address proposed land use changes. A 5-year interval is recommended for updating this Master Plan.

APPENDIX A

Commercial Flows by Category

Industry Type	Thousands of Gallons used per month
Fast Food	49
Light Industrial	9
Office	9
Automotive Centers	4
Veterinary	20
Grocery	52
Retailers	6

APPENDIX B

Dry Weather Flow Calibration

APPENDIX C

Infiltration Study Graphs

APPENDIX D

Wet Weather Flow Calibration

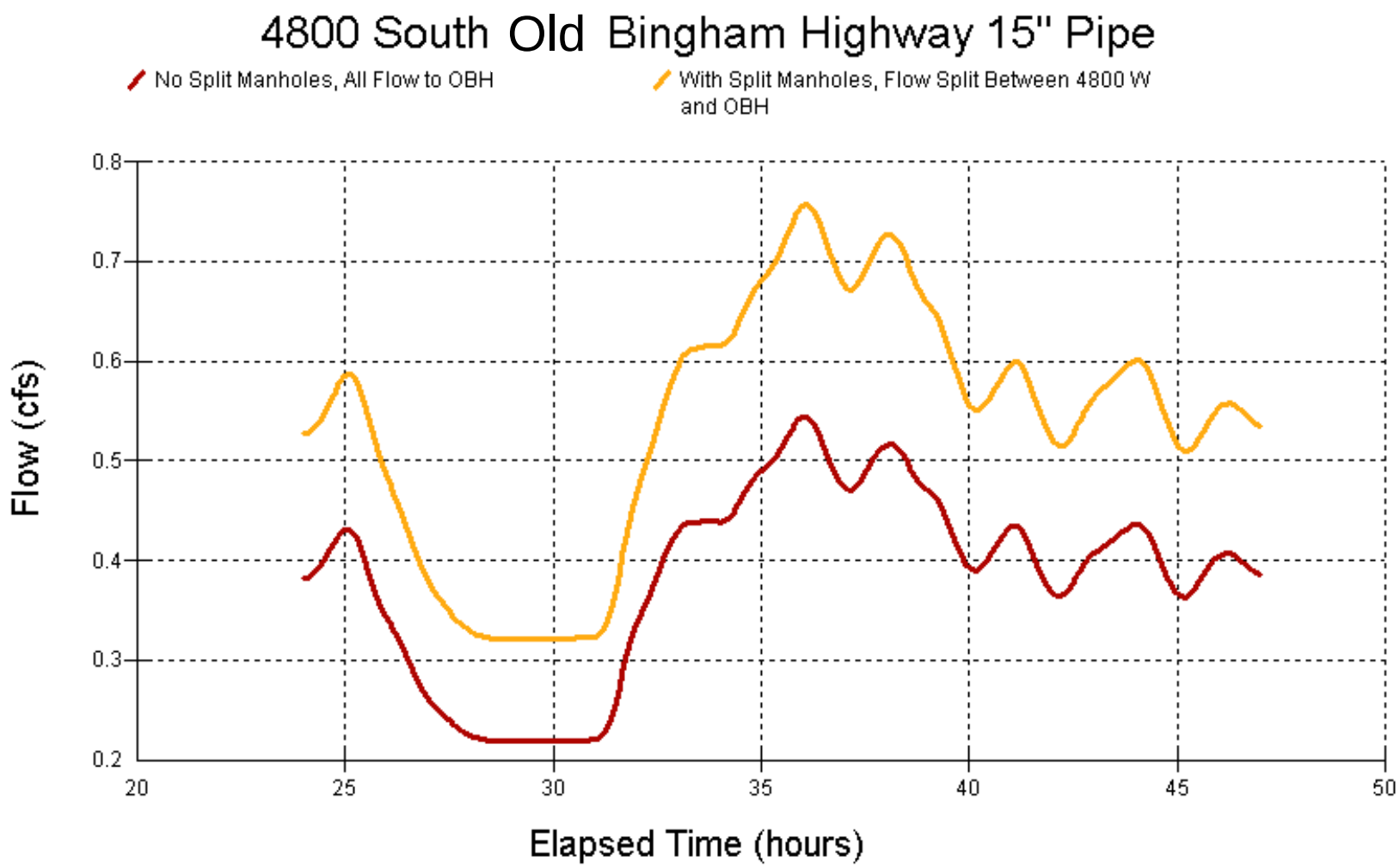
APPENDIX E

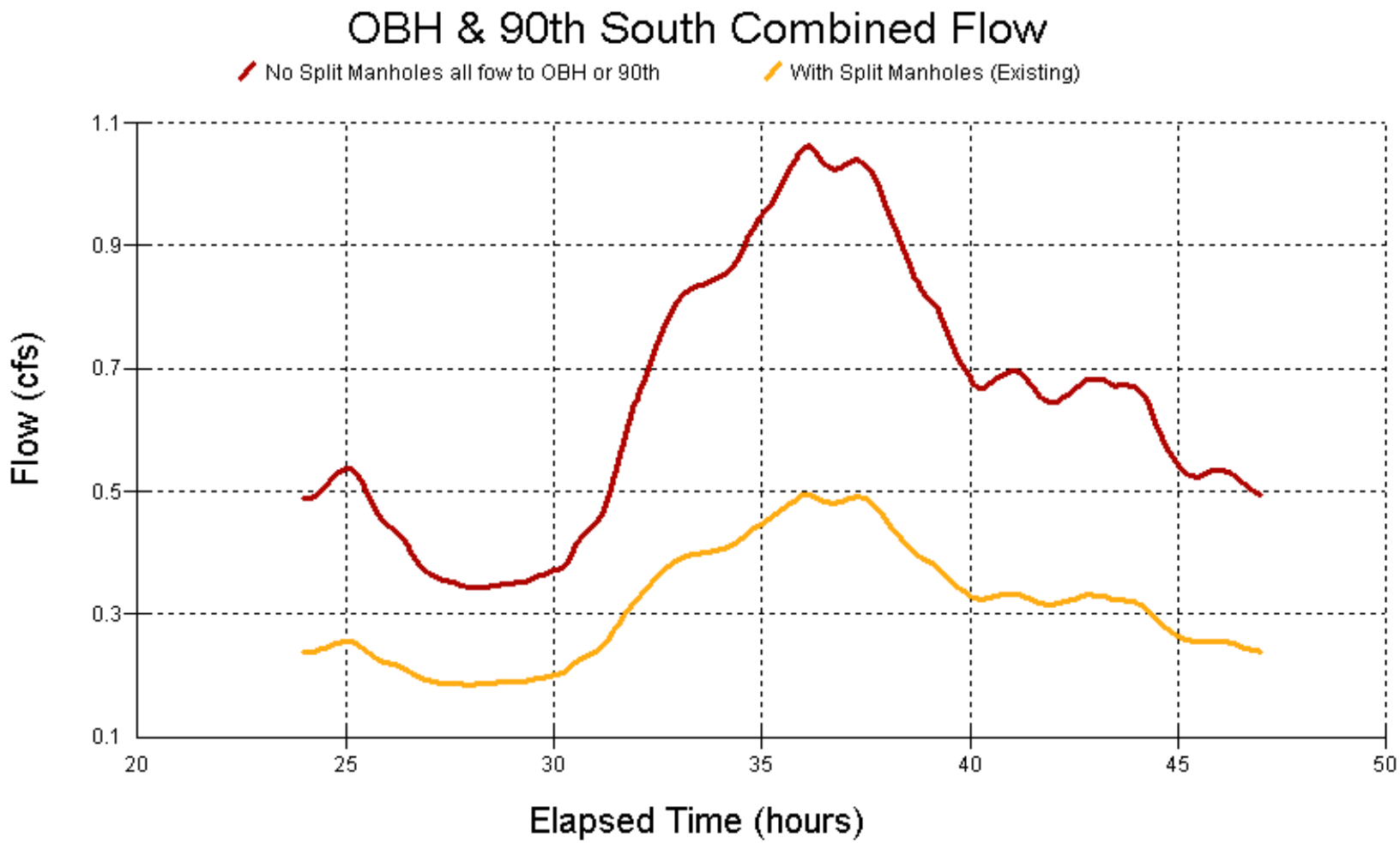
Model Calibration Graphs

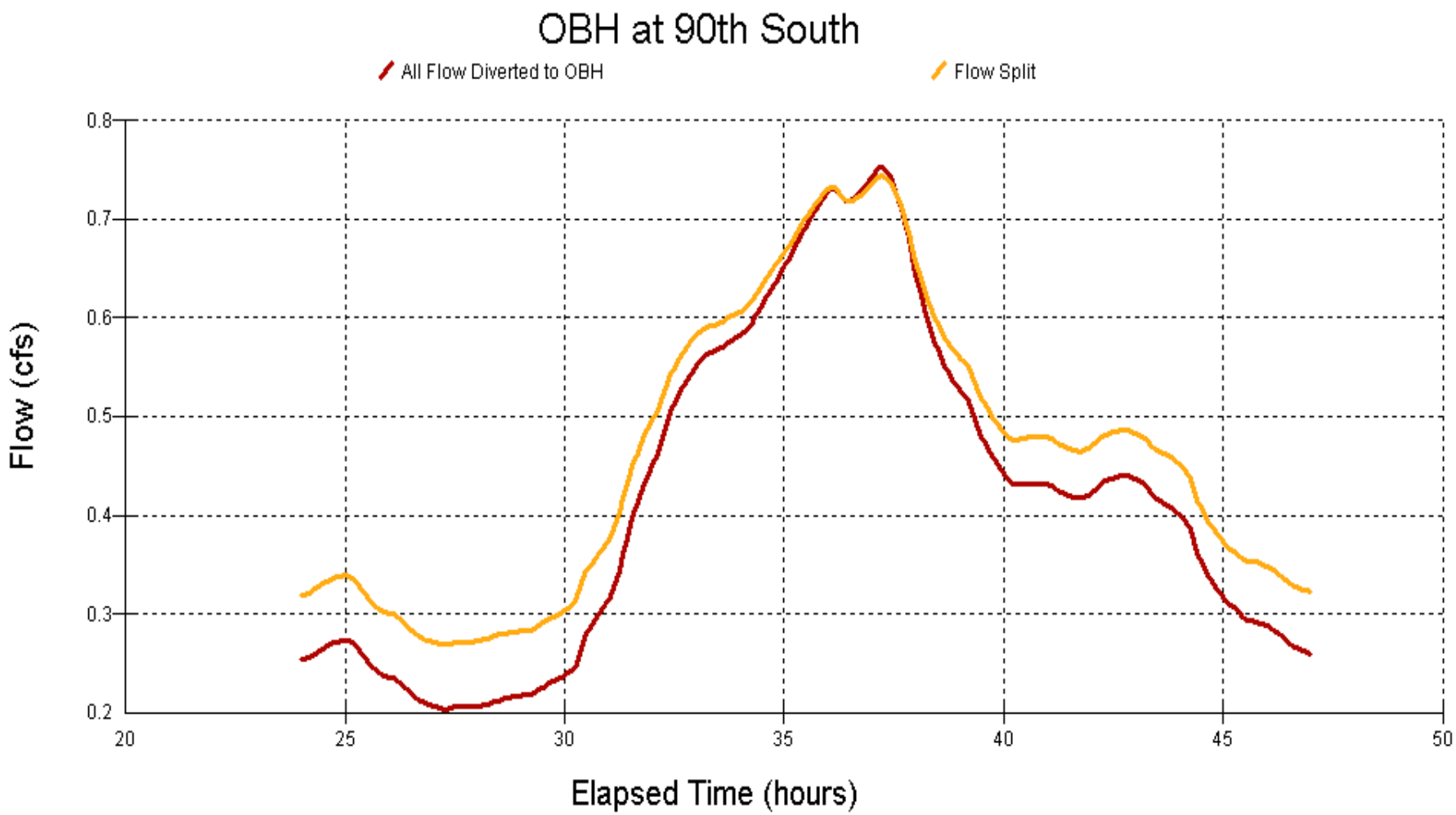
APPENDIX F

Diversion Manhole Study

Flow Graphs


4800 South Old Bingham Highway 15" Pipe
No Split Manholes, All Flow to OBH
With Split Manholes, Flow Split Between 4800 W and OBH
Flow (cfs)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
20
25
30
35
40
45
50
Elapsed Time (hours)


OBH & 90th South Combined Flow
No Split Manholes all fow to OBH or 90th
With Split Manholes (Existing)
Flow (cfs)
1.1
0.9
0.7
0.5
0.3
0.1
20
25
30
35
40
45
50
Elapsed Time (hours)


OBH at 90th South
All Flow Diverted to OBH
Flow Split
Flow (cfs)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
20
25
30
35
40
45
50
Elapsed Time (hours)

APPENDIX G

Capital Improvement Plan Projects and Costs