JULY 2007

COLLECTION SYSTEM MASTER PLAN

FINAL REPORT

Preserving Bend's Water Environment

MWH

City of Bend
Collection System Master Plan

June 2007

Prepared by

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In Association with Crane & Merseth

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ABBREVIATIONS

ABBREVIATIONS

To conserve space and facilitate readability, the following abbreviations have been used in this report:

AACE – American Association of Cost Engineers
AAGR – Average Annual Growth Rate
BOD_5 – Biochemical Oxygen Demand
City – City of Bend
CIP – Capital Improvement Program
CSMP – Collection System Master Plan
d/D – ratio of flow depth to pipe diameter
DEQ – Oregon Department of Environmental Quality
EDU – Equivalent dwelling unit
fps – feet per second
GIS – Geographic Information System
gpad – gallons per day per acre
gpd – gallons per day
gpm – gallons per minute
I/I – Infiltration and Inflow
mgd – million gallons per day
MMDWF – Maximum Month Dry Weather Flow
MMWWF – Maximum Month Wet Weather Flow
NPDES – National Pollution Discharge Elimination System
NPW – Net Present Worth
O&M – Operation and Maintenance
OAR – Oregon Administrative Rules
RCP – Reinforced Concrete Pipe
PF – Peaking Factor
PW – Present Worth
RDII – Rainfall Derived Infiltration and Inflow
SE - Southeast
SSO – Sanitary Sewer Overflow
TM – Technical Memorandum
TSS – Total Suspended Solids
UAR – Urban Reserve Area
UGB – Urban Growth Boundary
WRF – Water Reclamation Facility

SECTION 1

INTRODUCTION

The City of Bend (City) sanitary sewer collection system was constructed in the early 1980's. The system provided gravity sanitary sewer service to much of the developed city. In addition to the core system of gravity sewers, a trunk line was constructed approximately five miles long that transported wastewater to the new wastewater treatment plant. The collection system on the west side of the Deschutes River flows to the Westside Pump Station where the wastewater is pumped across the Deschutes River to the gravity system on the east side of the river.

The City has grown from a population of 17,300 in 1980 to 70,330 in 2005. Over this period the wastewater collection system has been expanded as areas were developed. These expansions have been connected to the original core system. Much of this sanitary sewer expansion has incorporated either pump stations to avoid deep sewer construction or use of pressure sewer systems which can also be constructed in much shallower trenches. All new sewers were oriented to discharge to the core area and ultimately flow through the plant interceptor to the Water Reclamation Facility (WRF). This has created two major issues that, unless corrected will cause problems with future sanitary sewer service.

First, because of this flow pattern recent residential and commercial growth has overloaded the original gravity system which was not designed to handle flows of this magnitude. Second, the inordinate use of shallow sewers and pump stations to serve many of the subdivisions north and south of the City's core area has increased the system maintenance requirements. This increased maintenance has increased operating cost which will ultimately cause user service fees to escalate more rapidly then service with a more gravity oriented system.

Due to the extraordinary growth the City has experienced, major revisions to the system must be made. These revisions are required to accommodate growth on the City's periphery with gravity service and relieve the capacity deficiencies in the core area system. Some of the issues that need to be resolved include:

- The plant interceptor is reaching capacity and will not be able to carry future wastewater flows generated by the growing system
- Many of the sewers in the existing core system are already at capacity
- Many of the service areas that are being served by pump stations have created a barrier to system development on the expanding periphery of the City. This will cause new developments to pump raw sewage around the existing, hydraulically-limited pressure systems
- The Westside pump station and collection system is limited in its capacity to serve the developing areas on the west side of the City
- The large number of pump stations have become an Operations and Maintenance (O&M) burden on City staff resulting in increased O&M costs

These issues are the primary focus of the 2006 Collection System Master Plan (CSMP). This plan has been done in three tasks:

- Task 1 – Model Development. During this task the current and future service areas of the City were divided into drainage basins and sub-basins for analysis. The existing HYDRA model was updated to a new dynamic model using InfoSWMM. This model was calibrated by a flow monitoring program. This new model was used to evaluate system capacity under existing flows as well as in a variety of planning scenarios. One of the outcomes of Task 1 was the identification of capacity limitations that currently exist in the system as well as the new limitations that will occur as the City population grows to build-out densities.

- Task 2 – North and Southeast (SE) Interceptor Concept Planning. A preliminary report for each interceptor was developed providing an alternative alignment for each interceptor. This work demonstrated that with the construction of these two interceptors many of the capacity limitations in the existing system can be mitigated.

- Task 3 – Master Plan Development. The planning criteria developed earlier was updated and confirmed in a variety of workshops with the City and an expert panel. Updated wastewater flows that will be generated by future development throughout the planned service area were developed and various scenarios for service were developed. An evaluation of the scenarios was performed to identify the major system components necessary to provide adequate capacity in the future. This analysis provided recommendations for capital improvements that include upgrades and removal of pump stations, correction of system capacity deficiencies and construction of new interceptors.

The results are documented in this Master Plan Report and a Study Area Plan for each of nine study areas. The detailed analysis performed on each task throughout the project has been documented in a Technical Memorandum (TM).

PURPOSE AND NEED

The City of Bend is the provider of wastewater collection and treatment service within the City of Bend Urban Growth Boundary (UGB). The 2006 Collection System Master Plan was developed in cooperation with the City of Bend Public Works Department to develop a; 1) roadmap for providing service to all existing users, and 2) existing developed areas that have not yet been connected to the system and 3) for new development. This includes areas outside the UGB but within the Urban Reserve Area (UAR). The key principles that the plan is based on are:

- Protect the public health and maintain the existing quality of the water environment within and around the City of Bend
- Provide ongoing system capacity and reliability while minimizing the risk of Sanitary Sewer Overflows (SSOs)
- Provide planning for expansion based on the approved General Plan
- Expand the existing system using a phased approach as capacity and/or service is needed

- Provide service to existing developed areas that currently are not provided with sanitary service
- Provide cost-effective service to new development
- Develop a long-term plan for sanitary service within the existing UGB and UAR service areas

The results and recommendations of the Master Plan are summarized in this 2006 Collection System Master Plan Report. In addition to this Master Plan Report, nine Study Area Plans were developed to provide a detailed summary of the plans for providing sanitary service to each parcel. This includes a plan for local gravity sewers, recommendations on the long-term operation of each pump station, and the correction of current and long-term system capacity deficiencies.

CONSISTENCY WITH CITY GENERAL PLAN

This CSMP considers areas within the Urban Growth Boundary (City limits) of Bend plus the unincorporated areas within the City's Urban Reserve Area (UAR). All planning has been consistent with the City's adopted General Plan. This is noted as the 1998 General Plan with amendments made since that time. A copy of the current General Plan is available on the City's Community Development web site.

The population projection used in this plan is based on the formal planning document that was developed in a concerted effort between the City, Deschutes County and the State of Oregon. This document is the Deschutes County Coordinated Population Forecast – 2000–2025 (Population Forecast). This study was completed on August 24, 2004. A copy of this document is available on the Deschutes County Community Development Department web site.

CONSISTENCY WITH DEQ PLANNING GUIDELINES

These documents were written to meet the Oregon Department of Environmental Quality (DEQ) Nine-Point Scope of Work outlined in Guidelines for Preparation of Facilities Plans and Environmental Reviews for Community Wastewater Projects. Environmental review was not performed this study. Environmental review will be done as the projects are developed and the determination to use State Revolving Loan Funding is made.

COLLECTION SYSTEM MASTER PLAN ORGANIZATION

A complete set of the CSMP documents includes the Executive Summary, the CSMP report, nine Study Area Plans and the supporting Technical Memoranda (TMs). These are available in both electronic format on CD-ROM and as printed reports. The Executive Summary is intended to provide the reader with an "easy to read" overview of the key planning issues, decisions and the implementation program. The CSMP is the formal document that summarizes the planning that was done and outlines the implementation program. The Study Area Plans provide usable guides that can be used to provide sanitary service to unsewered areas. The report is structured into three areas shown in ***Figure 1-1*** and described below:

PLANNING BASIS

Section 1
Introduction

Section 2
Basis of Planning

TM 1A
Information Summary

North Interceptor
Preliminary Evaluation

SE Interceptor
Preliminary Evaluation

TM-3A
Alternative Development Workshop

TM 3-1
Planning Assumptions Summary

TM 3-2
Potential UAR WW Service Areas

TM 3-4
Planning Study Areas

TM 3-5
Population Projections

TM 3-6
Cost Criteria

Section 3
Modeling and Capacity Analysis

TM 1B
Sub-basin Delineation

TM 1C
Flow Development Methodology

TM 1D/1E
Model Calibration

TM 3-3
Updated Sub-basin Delineation

TM 3-7
Hydraulic Evaluation of Existing System

THE PLAN

Section 4
Capacity Improvement Projects

Study Area 1 Master Plan
Study Area 2 Master Plan
Study Area 3 Master Plan
Study Area 4 Master Plan
Study Area 5 Master Plan
Study Area 6 Master Plan
Study Area 7 Master Plan
Study Area 8 Master Plan
Study Area 9 Master Plan

Section 5
Pump Station Master Plan

TM 3-8
Pump Station Master Plan

Section 6
Interceptor Master Plan

TM 3-9
Interceptor Evaluations

IMPLEMENTATION

Section 7
Long-Term Conveyance Plan

TM 3-10
Long-term Conveyance Plan

Section 8
Capital Improvement Program

Figure 1-1
CITY OF BEND
COLLECTION SYSTEM MASTER PLAN ORGANIZATION

- Planning Basis – provides an overview of the criteria used in the planning process. This includes the planning assumptions, cost criteria, the population projections and the results of system modeling.
- The Plan – documents the results of the planning process in the nine Study Area Plans, a Pump Station Master Plan and the Interceptor Master Plan.
- Implementation – provides a summary of the recommended implementation program, including the Capital Improvement Program (CIP).

The supporting TMs are listed below and are also shown in ***Figure 1-1*** under the report chapters that the specific TM provides the supporting information and analysis. Each TM developed during the planning process is listed below by project task:

Task 1

TM 1A – Information Summary
TM 1B – Sub-basin Delineation
TM 1C – Flow Development Methodology
TM 1D/1E – Model Calibration

Task 2

System Limitations
North Interceptor Preliminary Evaluation
SE Interceptor Preliminary Evaluation

Task 3

TM-3A – Alternative Development Workshop
TM 3-1 – Planning Assumptions Summary
TM 3-2 – Potential UAR WW Service Areas
TM 3-3 – Updated Sub-basin Delineation
TM 3-4 – Planning Study Areas
TM 3-5 – Population Projections
TM 3-6 – Cost Criteria
TM 3-7 – Hydraulic Evaluation of Existing System
TM 3-8 – Pump Station Master Plan
TM 3-9 – Interceptor Evaluations
TM 3-10 – Long-term Conveyance Plan

Some of the key elements of the master planning effort are described below.

Use of Geographic Information System Technology

The master planning work made extensive use of Geographic Information Systems (GIS) technology for several purposes. GIS mapping was developed to consolidate land use information from multiple sources and create a digital compilation of land uses for use in estimating wastewater flows in the service area. GIS was also used to develop the physical data on the existing collection system for use with the hydraulic model, as well as to generate the study area boundaries and analyze flows. Finally, GIS was used to display model results and to generate the graphics used in the master plan documents.

Flow Monitoring

This master plan included a flow monitoring program that included the installation of 22 temporary flow monitors for a period of 10 days. The flow information gathered during this period of time was used to develop the diurnal curves used in the modeling of the system and for model calibration. This flow monitoring was performed in early February 2005 and provided the base flow data used for planning.

Hydraulic Modeling

A major part of the master planning work was the development of a new hydraulic model of the City collection system. A "fully dynamic" model called InfoSWMM was selected for this purpose. This type of model provides very accurate simulations of flows in the system, takes into account the effects of backwater and flow travel times from different areas and simulates the affect of pump stations on flows in the system. The model is linked to a comprehensive GIS interface that provides the basis for the development of flows for the various scenarios that were modeled during planning.

REPORT ORGANIZATION

This Master Plan Report includes seven sections, which are described below.

Section 1, Introduction, presents the background, objectives and scope of the Master Plan and describes the key elements of the study.

Section 2, Basis of Planning, presents the definition of the Master Plan study area, land use projections, population projections and the basis for developing capital costs. This chapter also provides a description of the existing system.

Section 3, Modeling and Capacity Analysis, presents a summary of the InfoSWMM model and how it was used to evaluate alternative scenarios in the development of the recommended plan.

Section 4, Capacity Improvement Area Plan Projects, presents a summary of the capacity upgrades required in the existing gravity sewer system to provide adequate capacity through system build-out.

Section 5, Pump Station Master Plan, presents a summary of the pump station upgrades required to provide adequate system capacity through build-out and a summary of the pump stations that can be removed from service through the installation of new gravity sewers.

Section 6, Interceptor Master Plan, presents a summary of the new interceptors that are recommended in the plan.

Section 7, Capital Improvement Program, presents the phased implementation of the collection system improvements required to ensure adequate capacity as the City develops in the future.

The Appendices to this report, contained in separately bound volumes, includes copies of the TMs completed during the study and the Study Area Master Plans that document the proposed projects. A separately bound Executive Summary report has also been prepared for use by the City Council and staff and other community members who would like to have a better understanding of the City's master planning efforts.

PROJECT TEAM

The Master Plan was prepared under the guidance and direction of the City of Bend Public Works Department. The Master Plan was prepared by MWH Americas, Inc. with assistance from:

- Crane and Merseth Engineering and Surveying – Local sewer master plans, interceptor alternative evaluation and alignment plans, development of cost criteria and cost estimates
- SFE Global – Flow Monitoring

SECTION 2

BASIS OF PLANNING

INTRODUCTION

It is important to have a complete understanding of the existing collection system and the planning assumptions that were used during the planning process. The basis of planning establishes the background information from which the planning is done. This includes:

- Overview of Existing System
- Definition of the planning period
- Definition of the planning area
- Planning Design Criteria
- Population Projections
- Project Cost Estimating

Each of these issues is addressed in this section.

OVERVIEW OF EXISTING COLLECTION SYSTEM

The existing collection system provides service for portions of the areas within the existing city limits. The collection system collects and transports wastewater from the service area to the Water Reclamation Facility located northeast of the City. The collection system as of September 27, 2006 is shown in ***Figure 2-1***. This map is available on the City's Public Works web site.

COLLECTION SYSTEM CHARACTERISTICS

The existing collection system consists of a combination of gravity sewers, pressure sewers and pump stations. A gravity sewer is a line that flows by gravity in an open line. The segment of the gravity sewer is interconnected by a manhole to provide access to the sewer line for inspection and maintenance. Local sewers range in size from 6 to 8-inches in diameter. As these sewers combine, they become larger trunk sewers ranging in size from 10-inches up to 42-inches. Pressure sewers are lines that transport pumped flows and operate under pressure. These are either small local pressure lines providing service to local home sumps or larger lines serving area or regional pump stations. These generally range in size from 2-inches to 3-inches in diameter. Large pressure sewers are used as pump station force mains transporting flow between service basins. These pressure sewers range in size from 3-inches to 16-inches depending on the size of the pump station. A summary of the gravity and pressure sewers by size is shown in ***Table 2-1***.

There are 82 pump stations that are maintained by the City. Three of these pump stations, Murphy Road, Sawyer Park and Westside, are regional stations. Regional stations provide

Sewer Main Summary

Totals compiled September 27, 2006

Gravity Main

Size	Length (Feet)	Length (Miles)
6-Inch Main	60810.2	11.5
8-Inch Main	1430428.7	270.9
10-Inch Main	61811.9	11.7
12-Inch Main	48374.2	9.2
15-Inch Main	33102.4	6.3
16-Inch Main	3929.5	0.7
18-Inch Main	20007.5	3.8
20-Inch Main	3815.4	0.7
21-Inch Main	18568.3	3.5
24-Inch Main	11648.6	2.2
27-Inch Main	12168.0	2.3
30-Inch Main	4930.4	0.9
36-Inch Main	21135.3	4.0
42-Inch Main	8841.2	1.7
72-Inch Main	253.0	0.0
Total:	***1739824.5***	***329.51***

Pressure Main

Size	Length (Feet)	Length (Miles)
2-Inch Main	9378	1.78
3-Inch Main	94823	17.96
4-Inch Main	111121	21.05
6-Inch Main	111468	21.11
8-Inch Main	13522	2.56
12-Inch Main	487	0.09
16-Inch Main	3573	0.68
Juniper Main	116502	22.06
Total:	***460874***	***87.29***

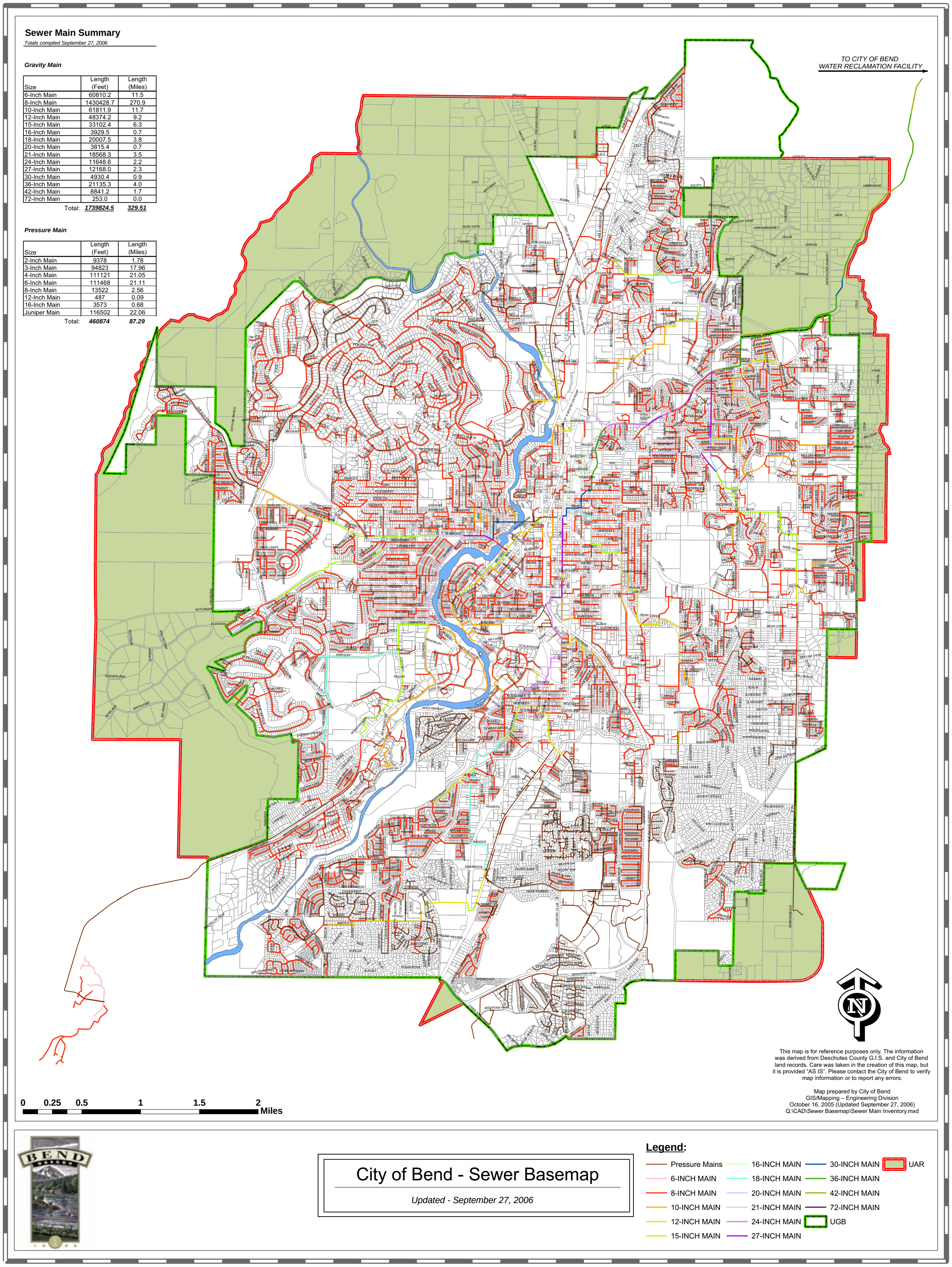


Figure 2-1 – Existing Collection System

Table 2-1
City of Bend
Collection System Components[1]

Line Size	Gravity Sewers		Pressure Sewers	
(in)	(feet)	(miles)	(feet)	(miles)
Juniper Utilities[2]	0	0	116502	22.06
2	0	0	9378	1.78
3	0	0	94823	17.96
4	0	0	111121	21.05
6	60810	11.52	111468	21.11
8	1430429	270.91	13522	2.56
10	61812	11.71	0	0.00
12	48374	9.16	487	0.09
15	33102	6.27	0	0
16	3930	0.74	3573	0.68
18	20008	3.79	0	0
20	3815	0.72	0	0
21	18568	3.52	0	0
24	11649	2.21	0	0
27	12168	2.30	0	0
30	4930	0.93	0	0
36	21135	4.00	0	0
42	8841	1.67	0	0
72	253	0.05	0	0
Total	1739824	329.51	460874	87.29

Notes:
1. Statistics as of September 27, 2006
2. Juniper Utilities contains various line sizes ranging from 2-inch to 4-inch

service to multiple developments. The rest of the stations are area stations serving a specific development. The pump stations are listed in ***Table 2-2***.

EXISTING SYSTEM VALUE

An estimate of the value of the existing collection system was developed. This estimate was done by assuming the no collection system exists and the system that is currently in place would be constructed. This value is estimated in 2006 dollars. The total estimated value of the existing system is $355M (million). This includes $295M for the gravity system, $36M for the pressure sewers and $23M for the pump stations. This demonstrates the value of this important asset to the City and the need to maintain this asset to ensure that maximum utilization of the system can be obtained.

The local sewers are typically installed by the developer when the land is developed. These sewers are usually 6-inch and 8-inch local gravity sewers. Of the total $295M value of the gravity system, $233M is local gravity sewers. This is 79% of the value of the gravity system. Most of the pump stations are also local with only three large stations being regional stations. The value of the local pump stations is $17M or 73% of the value of the pump stations.

Table 2-2
City of Bend
Pump Stations by Study Area

Study Area[1]	Pump Station	Capacity (gpm)	Study Area[1]	Pump Station	Capacity (gpm)
1	Shevlin Commons	118	7	DARNELL ESTATES	170
2	SHEVLIN MEADOWS	145	7	DESERT SKIES	95
2	WESTSIDE	6000	7	CAMDEN	125
2	WYNDEMERE	240	7	RIDGEWATER #1	125
2	AWBREY GLEN	900	7	RIDGEWATER #2	118
2	RIVERS EDGE	125	7	MURPHY	250
2	TUMALO HEIGHTS	195	7	FOXBOROUGH	260
2	RIMROCK #1	40	7	NOTTINGHAM #1	76
2	RIMROCK #2	40	7	NOTTINGHAM #2	56
2	RIMROCK #3	40	7	BLUE RIDGE	70
2	RIMROCK #4	40	7	THE PINES #1	60
3	WIDGI CREEK	450	7	THE PINES #2	60
3	SUNRISE VILLAGE #1	250	7	THE PINES #3	60
3	SHEVLIN	280	7	THE PINES #4	60
3	BACHELOR VILLAGE	125	7	THE PINES #5	60
3	TOUCHMARK	425	7	THE PINES #6	60
3	MAIN FIRE STATION	80	7	THE PINES #7	60
4	NORTH POINT	265	7	CROWN VILLA RV #1	80
4	NORTH WIND	270	7	CROWN VILLA RV #2	80
4	PHOENIX	228	7	QUAIL RIDGE #1	100
4	HIGHLANDS	250	7	QUAIL RIDGE #2	100
4	HOLIDAY INN	-	7	SUN MEADOWS	380
4	BOYD ACRES	65	7	SOUTH FIRE STATION	65
4	SUMMER MEADOWS	125	7	STONEHAVEN	250
5	EMPIRE VILLAGE	125	8	SOUTH VILLAGE	265
5	CANAL VIEW	120	8	OLD MILL	300
5	QUAIL CROSSING	265	8	WOODRIVER VILLAGE	240
5	MAJESTIC	265	8	TRI-PEAKS	120
5	SAWYER PARK	1000	8	DESCHUTES RIVER X-ING	148
5	ENCHANTMENT	150	8	PHEASANT RUN	125
5	DESCHUTES CO. JAIL	115	8	RIVER CANYON #1	320
5	NORTH FIRE STATION	80	8	RIVER CANYON #2	400
5	SERVICE	120	8	RIVER RIM	150
5	DESCHUTES BUSINESS	100	8	POPLAR PARK	180
5	EMPIRE	50	8	PINE RIDGE	180
5	GLENSHIRE	172	8	ASPEN RIDGE	-
5	RIVERHOUSE	400	9	RENWICK	40
6	DRAKE	650	9	HOLLOW PINES #1	140
6	PACIFIC	50	9	HOLLOW PINES #2	95
6	PIONEER	60	9	SUMMIT PARK	125
6	LINSTER	100			
6	UNDERWOOD	150			

Note 1: See Figure 2-4 for location of study areas

Assuming 95% of the force mains are part of local system, the total value of the local systems is $284M or 80% of the total system value. Therefore, the estimated value of the existing regional pump stations, trunk sewers and interceptors is estimated to be $71M.

SERVED VS. UNSERVED AREAS

There are currently many areas within the City that do not receive sewer service. The planning team gathered GIS data, financial data and sewer service data on the system in May 2005. This information was combined to determine the tax lots that were provided with sanitary service. Based on this information, statistics on each of the study areas were developed. There are areas within the City that have sewer service available, but the tax lots are not hooked up to the system. This is mostly due to the tax lot not being developed. To ensure that these tax lots were included in the analysis as not being connected to the system a specific terminology was developed to describe tax lots that are and are not connected. The terminology used to describe the receipt of sanitary service is:

- Served – A tax lot connected to the City sanitary system based on the financial records provided in May 2005.
- Unserved – A tax lot not connected to the City sanitary system. This is either a tax lot with no development on it or one that is developed, but sanitary service is not provided or is not connected to the system.
- Developed but Not Served – A tax lot not connected to the City sanitary system, but the tax lot has been developed. The sanitary service is most likely provided by a septic system. This classification is a sub-set of the unserved category.

The GIS database for the City in conjunction with the City's sewer billing data was used to determine whether each tax lot or parcel was receiving sanitary service or not. This information summarized by study area is shown in ***Table 2-3***. *This information is for parcels within the UGB only that are included in the City's sewer billing database as of May 2005.* Areas outside of the UGB are not included in this table because the City typically does not provide service to parcels outside the UGB.

In addition to the information on whether the parcel was served or not, it was determined if the unserved parcel was developed or not. This is shown in ***Table 2-3*** in the category of "Developed but Unserved" to show the number of parcels that are currently on septic tank.

This analysis shows some interesting statistics of the service area. These are:

- 53% of the parcels in the City do not receive sanitary sewer service on an acreage basis
- 33% of the parcels in the City do not receive sanitary service on a "number of parcels" basis
- 42% of the parcels that do not receive sanitary service are developed
- 14% of the parcels that are developed do not receive sanitary service

Table 2-3
2006 Collection System Master Plan
Study Area Characteristics
Served and Unserved Parcels[1]

Study Area[2]	Study Area (Acres)	Areas Within the UGB					
		Parcels Served		Parcels Not Served		Developed but Not Served	
		Number	Acres	Number	Acres	Number	Acres
1	1376	19	36	112	339	2	30
2	4927	4714	1970	1534	1423	135	45
3	3920	1948	824	1201	1418	400	166
4	4625	215	95	231	311	158	186
5	2186	1636	807	968	927	267	285
6	1218	2212	610	836	223	273	27.85
7	3941	1484	950	1955	1836	1475	938
8	3925	3061	1313	2217	1909	1013	727
9	3853	5256	1748	1147	1100	523	397
Total	**29,971**	**20,545**	**8,353**	**10,201**	**9488**	**4246**	**2802**

Notes:
1. Data based on May 2005 City of Bend Planning and Financial information.
2. See Figure 2-4 for location of study areas

These parcels are most likely currently being served by private septic tank systems. Most importantly, 53% of the acreage within the UGB does not receive sanitary sewer service. A system to provide service to these currently unserved parcels is provided in this master plan.

PLANNING PERIOD

The planning period for this study is from 2006 through 2030. The City has selected the year 2030 as the planning horizon for all of their planning efforts. This will allow for all of the City wide Master Plans that are being completed over the next few years to have the same planning horizon.

2030 PLANNING HORIZON

The planning horizon to be used in the Collection System Master Plan will be the year 2030. The population for the City of Bend UGB that is projected for 2030 is 119,009.

BUILD-OUT CONDITION

A build-out number of dwelling units was developed for the UGB or City Limits, the UAR and for each of the planning study areas. The build-out number of dwelling units was used to determine the sizing of area sewers, interceptors and pump stations. The build-out number of dwelling units was calculated assuming all parcels developed on a net acreage basis at the average zoning density for the specific land use type for each parcel.

PLANNING AREA

The planning area for this project will consist of the areas defined in the 1998 Bend Area General Plan, plus approved updates since that time (General Plan). The General Plan provides two areas for planning. The first area is bounded by the City Limits (or Urban Growth Boundary, UGB) and the second area is the Urban Reserve Area (UAR). The planning area provided by the General Plan is shown in ***Figure 2-2***. This figure summarizes the General Plan as of August 7, 2006. The study includes three areas in addition to the General Plan. These three areas are the planned development of: Juniper Ridge, Section 11 and a west side destination resort known as "Tetherow" inside UAR. Each of these planned developments are included in the Master Plan.

CITY LIMITS

The City Limits is shown in ***Figure 2-2*** as the area within the Urban Growth Boundary. The City provided information in GIS for the evaluation of each parcel (tax lot) within this area. This area is defined as the City Limits in the Master Plan.

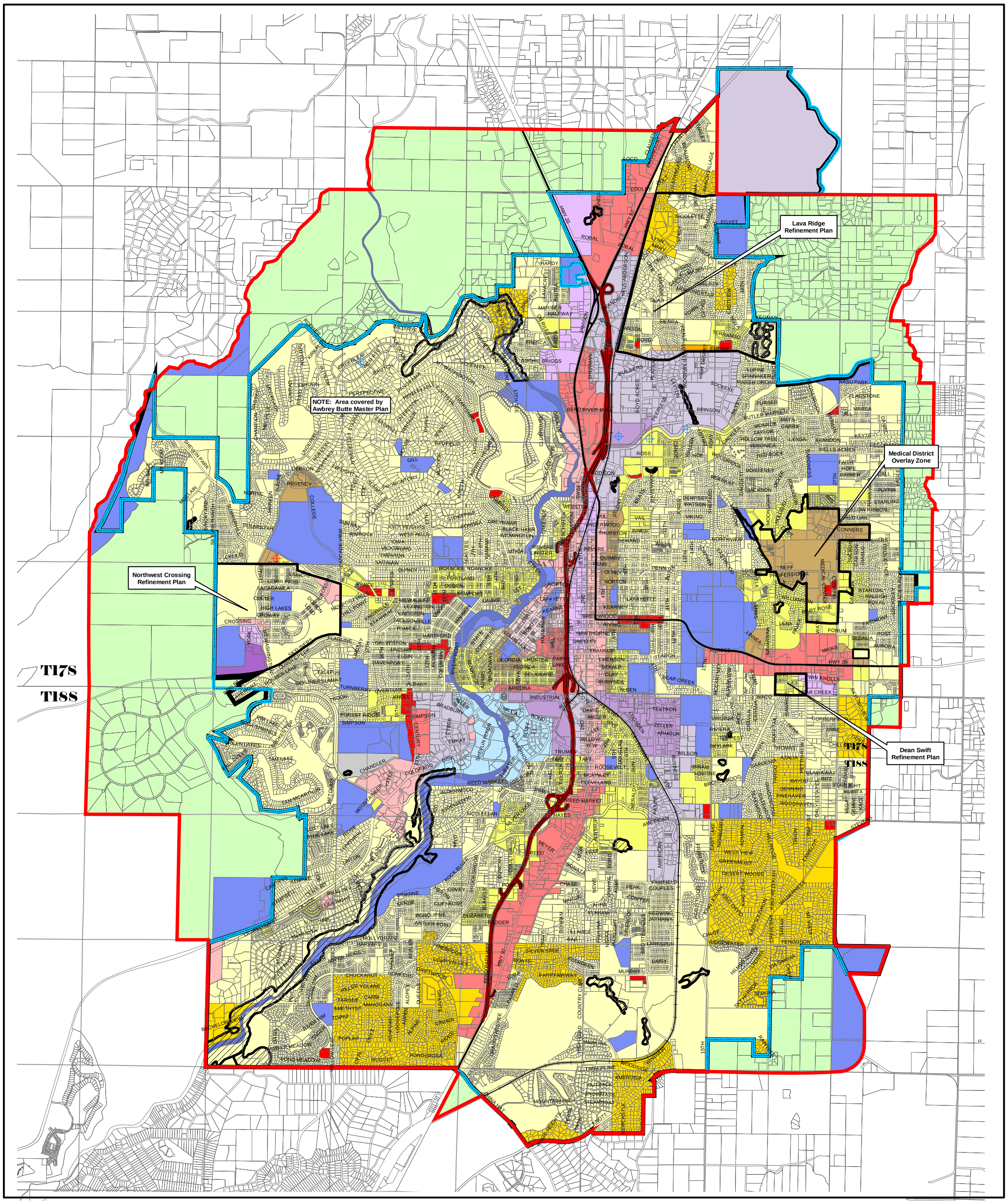
URBAN RESERVE AREA

The Urban Reserve Area is included in the General plan, and is outside the existing city limits. This area is defined as the area that the City can expand into in the future. It should be noted that the UAR defined in the 1998 General Plan has not been approved by the State of Oregon, but will be included in this planning process. (Inclusion of this area is necessary to define the alignment of the North Interceptor alternative.) It should also be noted that the City's Planning Department is currently evaluating the Urban Reserve Area and that this area may be modified in the next year.

JUNIPER RIDGE DEVELOPMENT

The Juniper Ridge Concept Plan specifies approximately 1500 acres on the north end of the City planned for light industrial, research and residential development. Phase 1 of the project will be approximately 500 acres slated for light industrial and research. Phase II includes over 1,000 acres of land that is planned for a mix of residential, commercial, industrial and institutional development. Part of this development is outside of the General Plan area but will be included in the planning area for the Master Plan. It is assumed that in addition to the 1,500 acre Juniper Ridge Development, adjacent lands bounded by US 97 on the west, Deschutes Market Road on the east and Deschutes Junction / Tumalo Road on the north will be included in a UGB expansion (per Jerry Mitchell – City of Bend Development Manager, April 6, 2006).

This area will be given a special zoning classification of EC. The unit flow values for this type of zoning classification have not be defined at this time, due to the preliminary nature of the area plan. Therefore, unit flow values that were used for this area was the industrial value of 700 gpd/acre based on total acres.



BEND URBAN AREA GENERAL PLAN

LEGEND

- City Limits
- Section Lines
- Railroads
- Urban Growth Boundary
- Parkway
- Areas of Special Interest
- Refinement Areas
- Urban Area Reserve
- Future Park
- Commercial Convenience

- CB- CENTRAL BUSINESS DISTRICT
- CC- COMMERCIAL CONVENIENCE
- CG- COMMERCIAL GENERAL
- CL- COMMERCIAL LIMITED
- IG- INDUSTRIAL GENERAL
- IL- INDUSTRIAL LIGHT
- IP- INDUSTRIAL PARK
- ME- MIXED EMPLOYMENT
- MR- MIXED RIVERFRONT

- PF- PUBLIC FACILITIES
- PO- PROFESSIONAL OFFICE
- PO/RM/RS
- RH- RESIDENTIAL URBAN HIGH DENSITY
- RL- RESIDENTIAL URBAN LOW DENSITY
- RM- RESIDENTIAL URBAN MEDIUM DENSITY
- RS- RESIDENTIAL URBAN STANDARD DENSITY
- SM- SURFACE MINING
- UAR- URBAN AREA RESERVE

0 1,300 2,600 5,200 Feet

DISCLAIMER: This map is for reference purposes only. The information was derived Deschutes County's G.I.S. and City of Bend land records. Care was taken in the creation of this map, but it is provided "AS IS". Please contact the City of Bend to verify map information or to report any errors.

Map prepared by City of Bend
Code Updated: August 7, 2006
v:\public maps\generalplan

Figure 2-2 – Bend Urban Area General Plan

SECTION 11

Section 11 is a 1-square mile area located on the southeast side of the City. This area is not currently in the UGB or UAR, but may be added to the UGB in the near future. For this reason, this area was included in the Collection System Master Plan. Section 11 is shown on the east side of the SE Planning Area in ***Figure 2-3***.

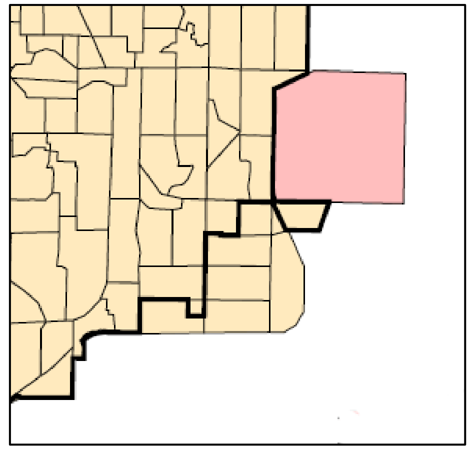


Figure 2-3 – Section 11

The City has developed preliminary planning information for this area. It is assumed that this area will contain a mixture of residential land use that includes 1713 single family dwellings at a density of 5 dwelling units (DU)/acre, 406 duplexes, triplexes or four-plexes at a density of 12 DU/acre and 517 apartments in 5 or more units at a density of 22 DU/acre for a total of 2636 DU. There will also be parks, schools and other commercial properties. The area is currently assumed to have a build-out population of 6327. This was the information used to develop flows for this area. There is currently no information on when this area is planned to be developed.

TETHEROW

There is currently a destination resort being planned on the west side of the City inside the UAR. The planning criteria for the parcels planned for this resort was used to develop flows for the Master Plan. The Tetherow resort property is planned to include approximately 706 acres of unique topography with rolling and undulating terrain. It was assumed that build-out of the Tetherow Destination Resort will occur over the next 10-20 years

The Thetherow resort sewerage system is expected to ultimately serve approximately 900 equivalent dwelling units or rooms and a projected population of 2000 people. Each equivalent dwelling unit is expected to contribute 300 gallons of sewerage a day, for an ultimate flow at project build-out of approximately 231,000 gallons per day.

City sewage collection system infrastructure, designed to serve the resort property, has been constructed in the bordering Broken Top Development. Eight-inch gravity sewers have been constructed to the eastern boundary of Broken Top Drive and in Skyliner Summit Phase 11. An 18-inch main has been constructed in Metolius Drive to the eastern boundary of the resort.

MASTER PLAN STUDY AREAS

The Planning Area has been divided into nine study areas. These Study Areas are shown in ***Figure 2-4***. The Master Plan includes a local plan of the trunk sewers required, pipe sizing, pipe depth and costs to eliminate deficiencies and provide sewer service within each of the Study Areas. Statistics for each study area are shown in ***Table 2-3***.

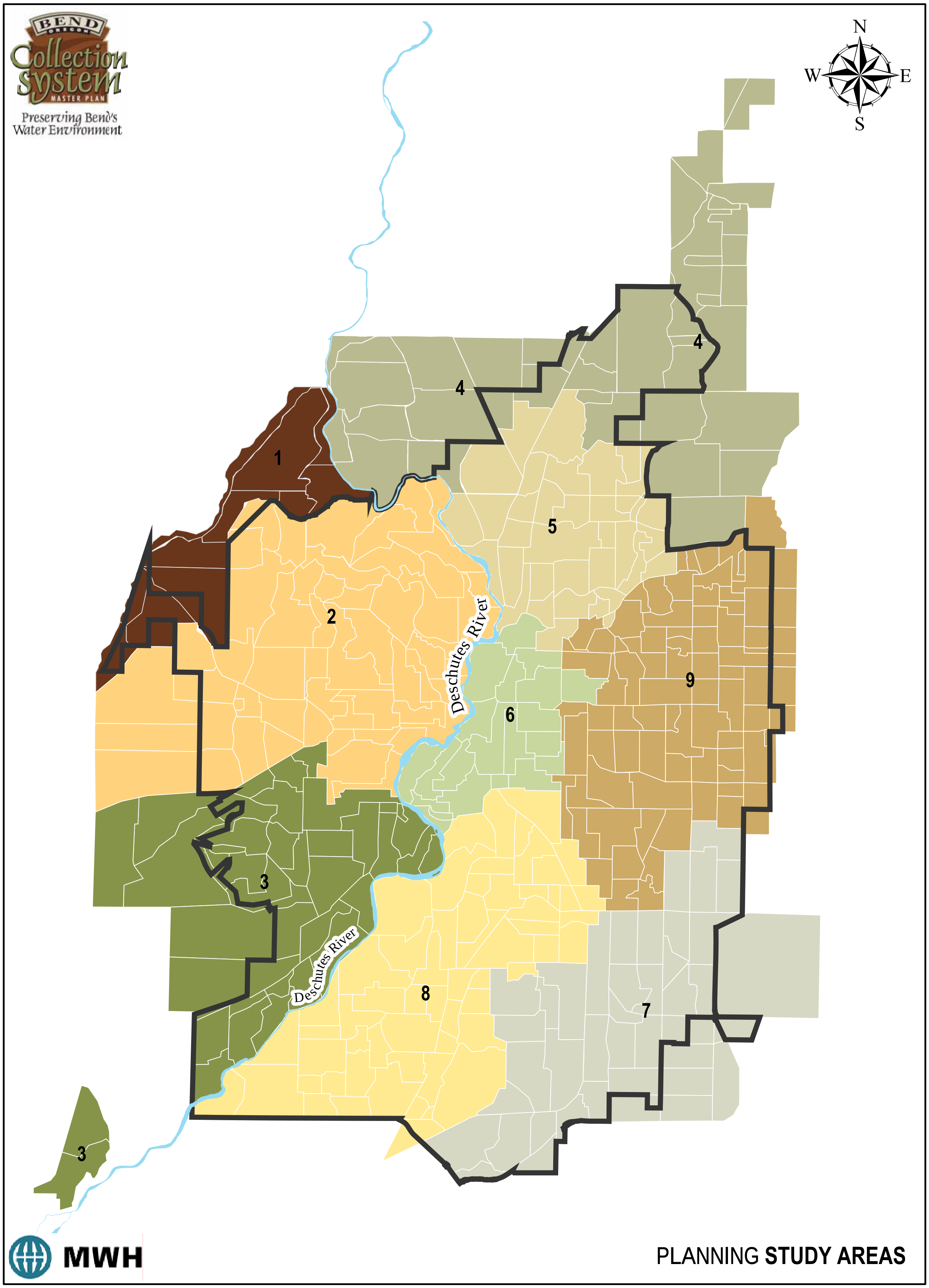


Figure 2-4 – Planning Study Areas

PLANNING DESIGN CRITERIA

Hydraulic design criteria were used to determine the capacity of the collection system gravity sewers, force mains and pump stations, as follows:

GRAVITY SEWER DRY WEATHER DESIGN CRITERIA

A friction value of 0.013 (n=0.013) was used for all gravity sewers to define flow conditions for all existing and future sewers.

The capacity of a gravity sewer is defined as the point where the ratio of flow depth to sewer diameter (d/D) is greater than or equal to 0.80. A second check of capacity is done to ensure that the flow to maximum pipe flow (q/Q) is less than or equal to 0.95. This check is important to determine if the depth criterion is exceeded due to a downstream condition or due to a local capacity limitation.

It should be noted that the d/D of 0.80 that is the maximum capacity of a gravity sewer under gravity or open-channel flow conditions. As the depth of flow in the gravity sewer gets greater than a d/D of 0.80, the velocity in the sewer is restricted by the greater headloss due to the increased wetted diameter.

GRAVITY SEWER WET WEATHER DESIGN CRITERIA

It has been observed in the past that there are periods of time during rain events that inflow into the system does occur. It is too conservative to use the design criteria of d/D = 0.8 for these periodic events. Therefore, under wet weather conditions, surcharge of the system will be accepted as long as there are no system overflows from either manholes or pump stations.

FORCE MAIN DESIGN CRITERIA

A friction value of 0.013 (n=0.013) was used for all force mains to define flow conditions for all existing and future pressure sewers. The maximum flow velocity that is allowed in a force main under operating conditions at the firm capacity of the pump station (redundant pump out of service) is 6 feet per second (fps). The maximum flow velocity shall not exceed 10 fps with all pumps in service.

PUMP STATION DESIGN CRITERIA

All pump stations must have a firm capacity to handle the flow developed under build-out conditions and peak wet weather design flow conditions. Therefore each pump station shall have available redundancy; i.e., only one pump should run if the pump station contains 2 pumps (2 out of three pumps may run in a 3 pump station and so on.)

FLOW FACTORS

Flows were developed by applying unit flow factors to the calculated number of DU’s on each parcel for residential properties based on the type of zoning of each parcel. For non-residential properties a specific unit flow factor was applied based on the specific type of land use.

RESIDENTIAL FLOW FACTORS

The number of dwelling units on a parcel or the parcel's acreage is multiplied by a flow factor (representative of the parcel's land use) to determine the wastewater flow from each parcel. For residential parcels, dwelling unit flow values of 200 gpd/DU for single-family and 180 gpd/DU for multi-family units is used.

NON-RESIDENTIAL FLOW FACTORS

For non-residential parcels, the database of winter-quarter average water consumption for Sewer Service codes SO and SM was evaluated to determine initial gpd/acre flow factors. The database was sorted using the LANDUSE field and then a flow factor calculated for each LANDUSE category by dividing the total average consumption by the total acreage. The results of these calculations are shown in ***Table 2-4***.

Table 2-4
City of Bend
Initial Non-Residential Flow Factors

Land Use	Flow Factor (gpd/acre)
Commercial	1,300
Industrial	700
Public	130
Other Improved	630

SEASONAL OCCUPANCY CALIBRATION FACTORS

The occupancy calibration factor was developed to provide a reduced flow for areas that have seasonal homes. These areas were identified by City staff when the calibration of the model was performed. The occupancy calibration factors were developed to obtain model calibration with the flow monitors that were placed in the system in early February 2005. The flow monitoring program is discussed in Section 3. Twenty-two flow monitors were placed in the system. Monitor No. 1 was in the main line to the treatment plant and was not specific to an area of the City. The other monitors and the corresponding occupancy calibration factors are shown in ***Table 2-5***.

It was initially assumed that there was 100% single family home occupancy and 80% multi-family home occupancy. The single family occupancy value was then only adjusted in areas of the City where it was indicated that a number of homes were seasonal. It was discovered that adjusting non-residential flow factors had negligible effect on the total flow from the monitor basins. As a result, the non-residential flow factors were not adjusted, so all flow adjustment was based upon the residential portion of the flow.

Table 2-5
Residential Unit Flow Factors for Seasonal Occupancy Levels

Monitor Number	Single Family Residential		Multi-Family Residential	
	Occupancy (%)	Flow Factor (gpd/DU)	Occupancy (%)	Flow Factor (gpd/DU)
2	100	200	80	180
3	100	200	80	180
4	85	200	80	180
5	100	200	80	180
6	100	200	80	180
7	100	200	80	180
8	100	200	80	180
9	50	200	80	180
10	100	200	80	180
11	100	200	80	180
12	100	180	80	170
13	100	200	80	180
14	100	200	80	180
15	100	180	80	170
16	100	200	80	180
17	100	200	80	180
18	100	200	80	180
19	100	200	80	180
20	70	200	80	180
21	100	170	80	180
22	100	200	100	180

SEASONAL PEAKING

The average flows developed on a parcel basis using the residential and non-residential flow factors provide a base flow for the system. The actual system limitations will occur during the summer peak condition. This condition occurs during the months of July, August, early September and sometimes during late December. This is due to an influx of tourism making use of the hotels/motels and commercial facilities in the City.

To determine a peaking factor for the summertime peak weekend, plant influent data for the years 1993 through 2004 were evaluated. The peaking factor typically ranges from 1.10 to 1.23 depending on the year. As a conservative measure, a summertime peak day peaking factor of 1.25 was applied to the wintertime weekday base flow to obtain the peak day flow.

DIURNAL CURVES

The system capacity is determined by the peak system flow. For the City, the peak flow is the diurnal flow peak on a weekend. A typical residential weekday and weekend residential diurnal curve was developed from the flow monitoring data taken in areas of the City that are predominately residential. In addition, a combination residential/commercial diurnal curve was developed to accommodate sub-basins within the City that consisted of a combined land use. These curves have been normalized (i.e., an average flow value of one over 24 hours) so their values can be used as multipliers on the base flow value being loaded into the model. The diurnal curve used for residential flows is shown in **Figure 2-5**.

INFILTRATION/INFLOW ALLOWANCE

The impact of wet weather flows was evaluated during modeling of the system. Each final alternative was evaluated under a wet weather event to ensure that no overflows would occur in the system. Wet weather flows can be highly variable, as was observed during the storm event on December 30, 2005. During this storm event, the existing system capacity was exceeded resulting in multiple overflows throughout the City and at the Water Reclamation Facility.

It is important to use a storm event that is not excessive. This will result in the system being sized for an event that will rarely occur. The Oregon Administrative Rules provide guidance for system wet weather capacity. This guidance is outlined in the Bacteria Standard and states that there must be capacity to provide for wet weather flows that are generated by a 5-year, 24-hour storm event. This type of storm is not typical on the east side of the Cascade Range. A more typical storm is a localized thunderstorm. For this reason, a few storms that occurred in the period between April and June of 2005 were evaluated. The April 23, 2005 storm shown in ***Figure 2-6*** is typical of one of these localized thunderstorms.

During this April 23, 2005 storm event, an additional total daily flow of 1-mgd was observed at the treatment plant. The plant flow reflected the intensity and duration of the storm. The peak occurred for a 2-hour period resulting in a peak flow of 4-mgd(Maximum during this storm event). Based on this information an inflow pattern was developed for assessing the capacities of the sewer network to handle future wet weather situations. This was done by developing a wet weather flow hydrograph and incorporating it into the flows developed at each sub-basin. It is known that there are roof drains connected to the sanitary system in the downtown area. With this factor 35% of the total wet weather inflow was attributed to the downtown area and the remaining 65% was distributed among all other sub-basins. Storm flows were then distributed between sub-basins based on their area. In the capacity analysis for the future system it was assumed that the wet weather inflow under build-out conditions would be based on this same ratio as outlined above for the existing conditions.

LAND USE INFORMATION

The first step in developing model flows was to utilize the land use classification provided by the City to determine what is currently on each parcel. The land use is based upon the Property Classification and Factor Book Codes in the assessor's database. Therefore, the land use designation represents an accurate description of what is currently on the parcel.

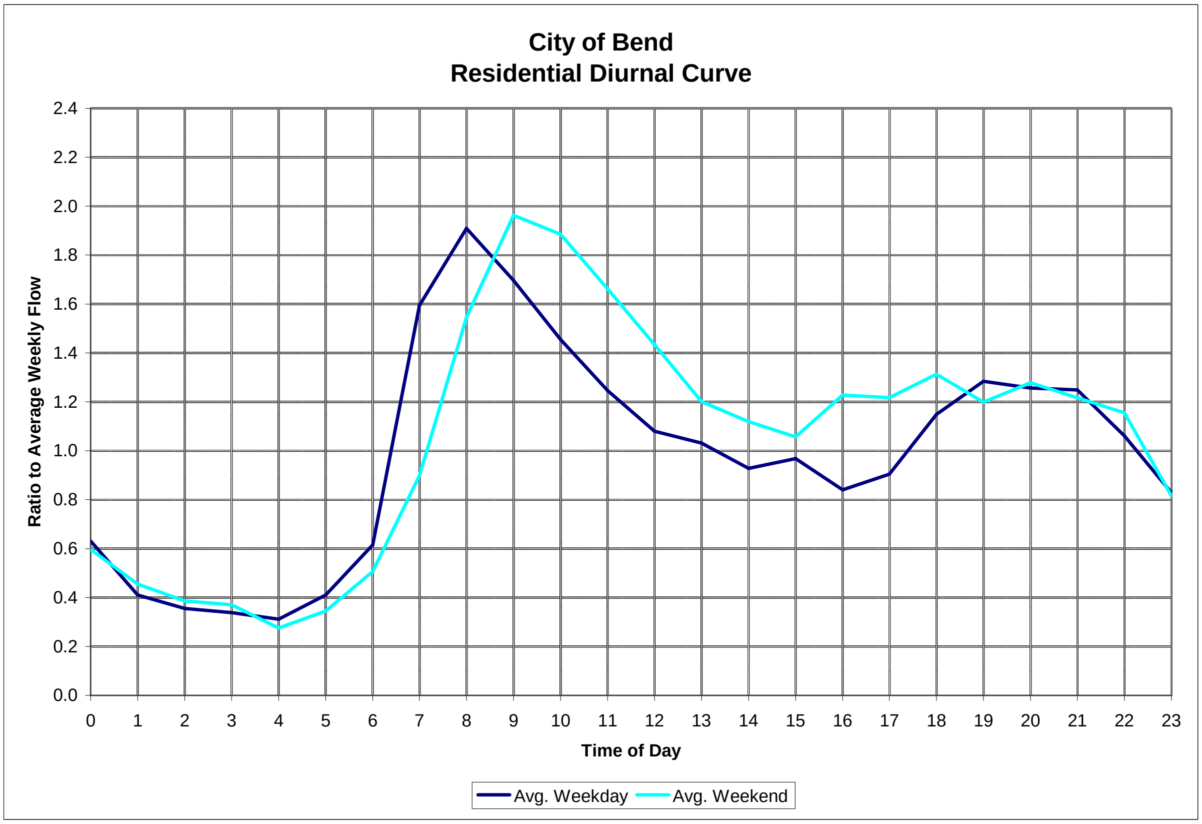


Figure 2-5 – Residential Diurnal Curve

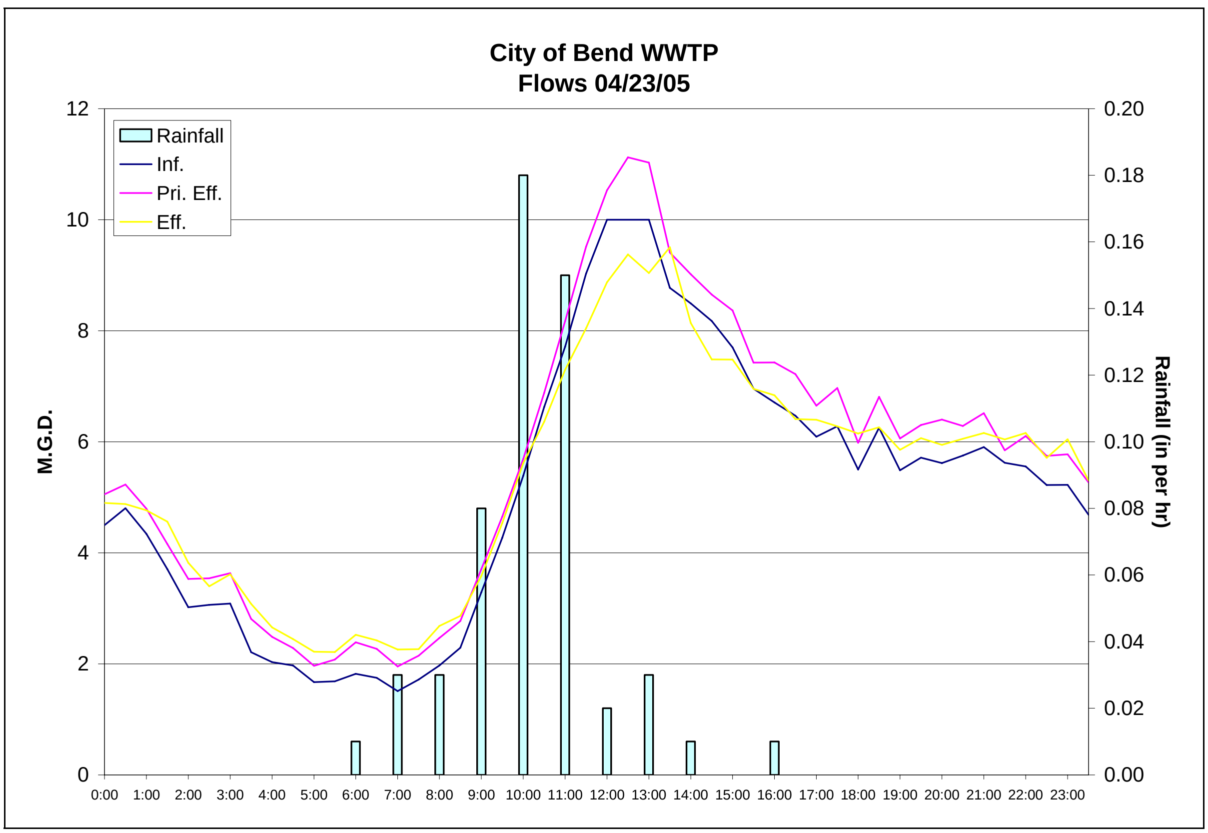


Figure 2-6 – April 23, 2005 Storm Event

BASIS FOR DETERMINATION OF SEWERED PROPERTIES

It was assumed that parcels labeled Unbuildable or Vacant do not currently contribute wastewater flow to the collection system. Additionally, it was assumed that parcels labeled Recreational (primarily parks and golf courses) can be ignored for purposes of wastewater flow generation because their wastewater flow contributions are minor in comparison to their size (acreage). The Bend Country Club is an exception that is assumed to have a potential of being redeveloped at some point in the future. Generally golf courses within a platted subdivision are assumed to remain as is.

Areas designated ASI (areas of special interest) were assumed to develop to the same level of densitiy as their zoning classification. Sewer Service Codes and the Service Status information provided with the billing data were used to determine which of the parcels currently have sewer service. Based on a discussion with the City's Finance Department, the Service Codes shown in ***Table 2-6*** were determined to represent sewered parcels.

Table 2-6
City of Bend Sewer Service Codes

Code	Service
CS	Commercial Sewer
JS	SFD Res Wastewater
MS	Mobile Home Sewer
PS	Product Service
RS	RV Sewer
SE	Sewer Only Flat
SM	Sewer Metered
SO	Sewer Metered Old
SW	Sewer Flat Rate
WC	Wastewater/Commercial

RESIDENTIAL LAND USE DENSITIES

There has been a tremendous amount of discussion concerning the densities that should be assumed for existing developed areas as well as areas to be developed in the future. Due to increased land prices the residential densities have been increasing. The GENPLAN classification (General Plan Zone) was used to determine the land use type for parcels within the UGB.

The average densities shown in ***Table 2-7*** was applied to residential parcels within the UGB on a net acre basis to determine the number of dwelling units for flow generation calculations for vacant parcels and those parcels considered to be large enough to subdivide. These values reflect the average densities per net acre for residential housing construction over the last 6 years, as inventoried by the City of Bend Planning Department.

Dwelling unit density for all areas outside the UGB and within the UAR was based on the average residential density for RS zoning on a net acre basis. The exception is the Juniper Ridge, Section 11 and Tetherow proposed developments. In these proposed developed areas, the detailed land use density information provided in their respective master plans was used. The density of 5.3 DU/acre represents an estimate of the projected average density for the UAR assuming a blend of RL, RS, RM, RH as well as commercial, industrial and mixed use areas.

Table 2-7
City of Bend
City of Bend Inventoried Residential Densities per Net Acres

Land Use Category	Land Use Designation	Average Density (DU/acre)
Residential Low Density	RL	1.7
Residential Standard Density	RS	5.3
Residential Medium Density	RM-10	8.0
Residential Medium Density	RM	14.5
Residential High Density	RH	32.4

DWELLING UNIT POPULATION

The 2000 census and previous planning studies have shown that the population per dwelling unit for the City of Bend UGB is 2.4 to 2.5 residents per dwelling on the average. Therefore, for the Master Plan, a dwelling unit density of 2.5 residents per DU was used.

ACTUAL vs. NET ACRES

There are two specific development scenarios within the UGB that were evaluated. The first is the development of a parcel that has previously not been developed and the second is the subdividing of a parcel that is currently developed. In either case, there needs to be an allowance for public facilities such as streets, parks and schools. Based on previous planning work done by the City, a 0.7 factor for converting actual acres to developed acres was recommended by the City of Bend Planning Department.

This factor was applied to all residential parcels that meet the criteria for being large enough for further development. Parcels large enough to be redeveloped include: undeveloped areas greater than 0.5 acres and developed parcels greater than one acre. These rules are summarized in ***Table 2-8***. The developed parcels of less than one acre were assigned the number of dwelling units actually existing on the parcel.

TABLE 2-8
ACTUAL VS. NET ACRE FACTORS

DEVELOPED STATUS	FACTOR
NOT DEVELOPED > 0.5 ACRES	0.7
NOT DEVELOPED ≤ 0.5 ACRES	1.0
DEVELOPED > 1.0 ACRES	0.7
DEVELOPED ≤ 1.0 ACRES	1.0

POPULATION PROJECTIONS

The population projections used in this plan are based on the formal planning document that was developed in a concerted effort between the City, Deschutes County and the State of Oregon. This document is the Deschutes County Coordinated Population Forecast – 2000–2025 (Deschutes County Plan). This study was completed on August 24, 2004.

POPULATION GROWTH RATES

The population projections used for the Master Plan are based on the estimated 2005 population. Population growth was then projected based on the population growth rates used in the Deschutes County Plan. The population growth rate used for the period 2025-2030 was not provided in the Deschutes County Plan. The growth rate used for this period was 1.7%. The projected growth rates are summarized in ***Table 2-10***.

The build-out population was based on building out the area of study under the General Plan zoning conditions. The build-out conditions was assumed to be the population of all parcels with 100% of the buildable lands developed.

2005 POPULATION

The 2005 base population used for this study was the July 1, 2005 Certified Population Estimate for the City of Bend UGB produced by Portland State University Population Research Center. This estimated population is 70,330. This estimate is different than the 2005 population of 69,004 that was estimated in the Deschutes County Plan.

HISTORICAL POPULATION

Population growth occurs through births, migration into the City and through annexation. The population of the City has grown dramatically between 1970 and 2005. The Average Annual Growth Rates (AAGR) for various historical periods are shown in ***Table 2-9***. This data shows that the rate of population growth was fairly low between 1970 and 1990 averaging 2.05%. The rate of population growth has increased dramatically since 1990 with an average annual growth rate (AAGR) 5.33%. This information is shown graphically in ***Figure 2-7***. This figure clearly shows the high rate of growth that has occurred over the past 15-years.

Table 2-9
City of Bend
Average Rate of Growth

Period	AAGR
1970-1990	2.05%
1970-2003	3.34%
1980-2003	3.76%
1990-2003	5.33%

PLANNED POPULATION GROWTH

The historical population growth provides an explanation of how the wastewater flows have increased in the system over time. The high rate of growth over the past 15-years provides insight into the reasons why there are capacity deficiencies in the existing system. Projecting future population growth is critical to the planning of future infrastructure for the City. The rate at which the City’s population grows and the specific areas where growth will occur determines when and where the investment in future infrastructure must be made. In addition, an understanding of the rate of growth is essential in the development of financing strategies for new projects.

The formal planning document that was developed in a concerted effort between the City, Deschutes County and the State of Oregon is the Deschutes County Coordinated Population Forecast – 2000–2025. This study was completed on August 24, 2004. This document provides the official population forecast that must be used in infrastructure planning. This

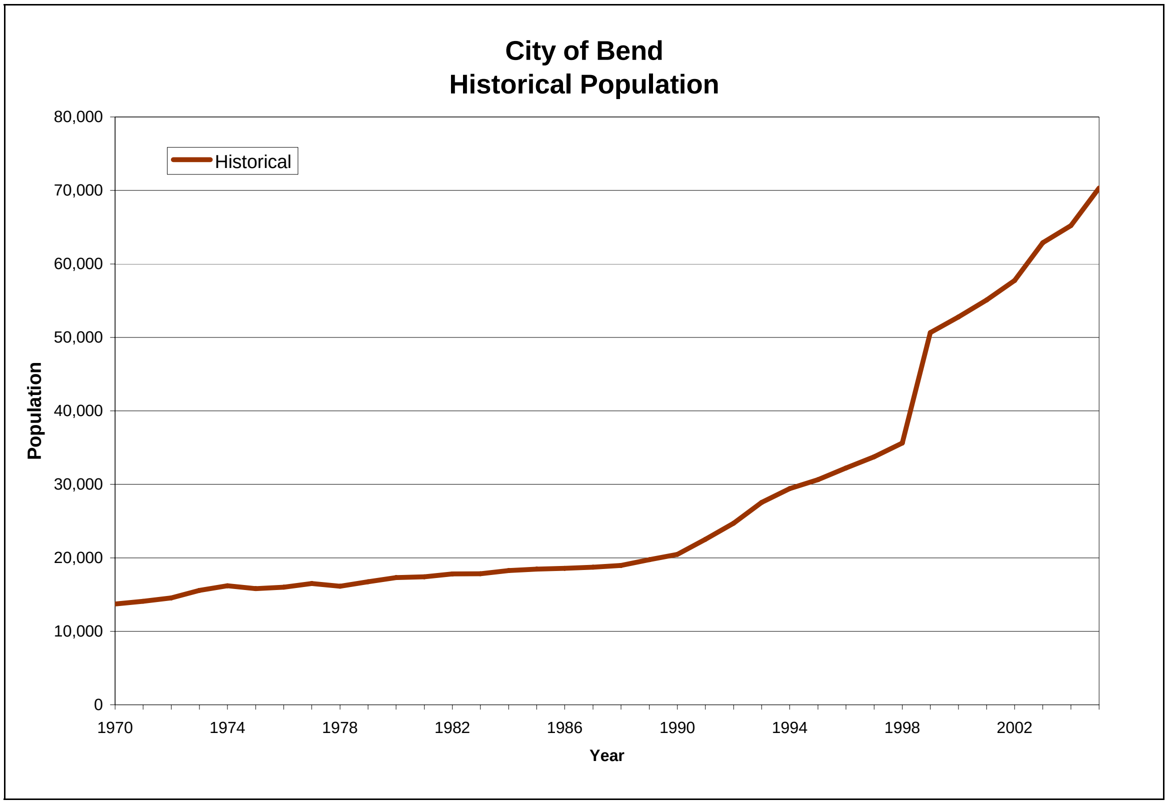


Figure 2-7 – Historical Population

study presented population projections for the period between 2000 and 2025. The 2030 projected population used in this study used an AAGR of 1.7% for the period 2026–2030. The official population projections and the applicable growth rates for the City are summarized in ***Table 2-10***. These projections combined with the historical population from 1970 to 2005 are shown graphically in ***Figure 2-8***.

TABLE 2-10
POPULATION FORECAST FOR BEND UGB[1]

YEAR	POPULATION	ANNUAL GROWTH RATE[3]
2000	52,800	-
2005	69,004[2]	4.74%
2010	81,242	2.52%
2015	91,158	2.33%
2020	100,646	2.00%
2025	109,389	1.68%
2030	119,009	1.70%

Notes:
1. Population Forecast Based On State Of Oregon Office Of Economic Analysis.
2. The Actual 2005 Certified Population For The City Of Bend Is 70,330.
3. Average Annual Growth Rate (AAGR) Since 1990 Has Averaged 5.33%

Note that the estimated population for the City of Bend was 69,004 for the year 2005. Even though the 2005 population was higher than forecasted at 70,330, the forecasts and projected growth rates for future years as developed in the Deschutes County August 2004 planning document were used for the Master Plan. This forecast is subject to refinement, and is scheduled to be updated in 2009.

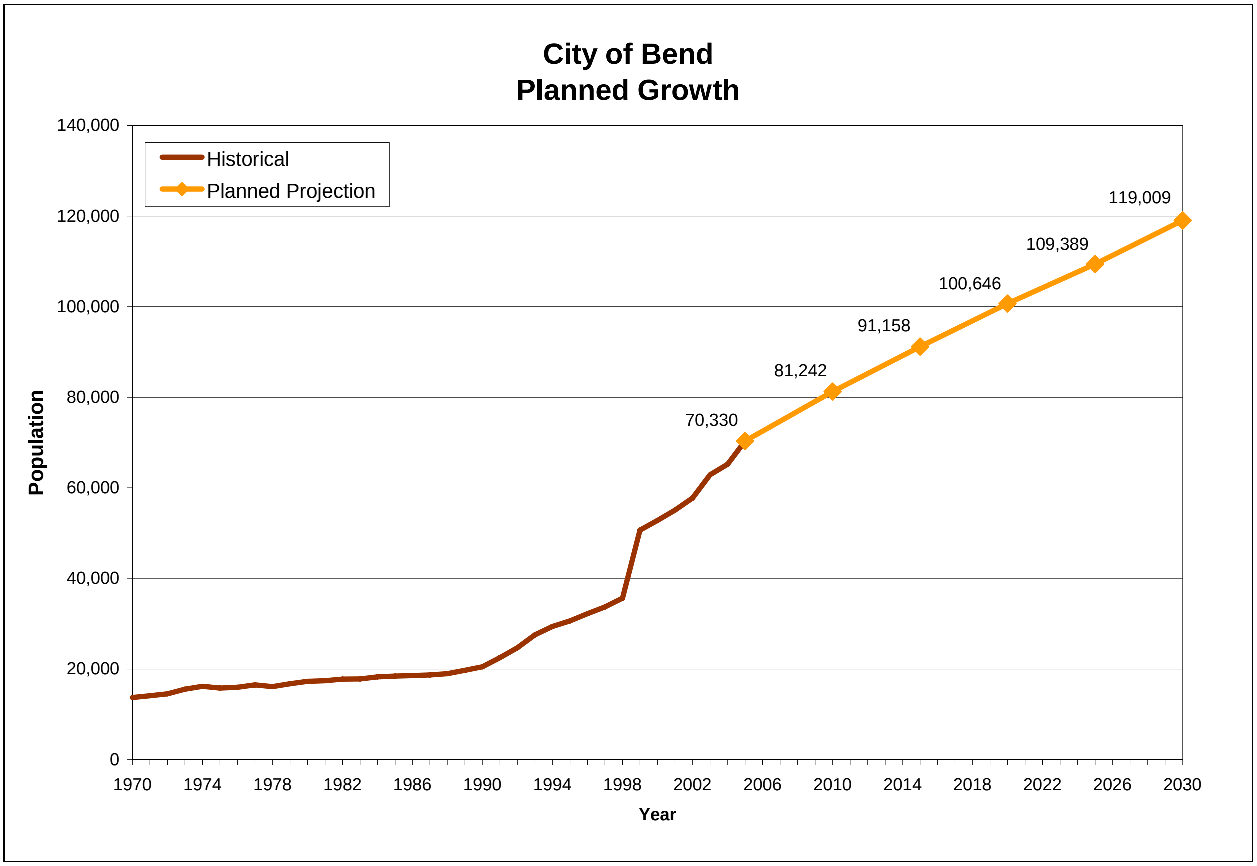


Figure 2-8 – Planned Growth

As shown graphically in ***Figure 2-7***, the planned population growth projects a slowing rate of growth for the City. To provide an understanding of the future populations that will require service, if the rate of growth continues at a high rate, two additional growth scenarios were developed. The first was for the AAGR to continue at a rate of 5% per year through 2015 and then follow the planned growth rate. The second was for the AAGR to continue at a rate of 5% per year through 2030.

The first scenario of a 5% growth through 2015 and then planned growth through 2030 is shown graphically in ***Figure 2-9***. This growth scenario ends with a population of 149,414 at 2030, which is about 30,000 more people than in the planned growth scenario.

The second scenario of a 5% growth rate through 2030 is shown graphically in ***Figure 2-10***. This growth scenario ends with a population of 238,162 which is 119,000 more than the planned growth scenario.

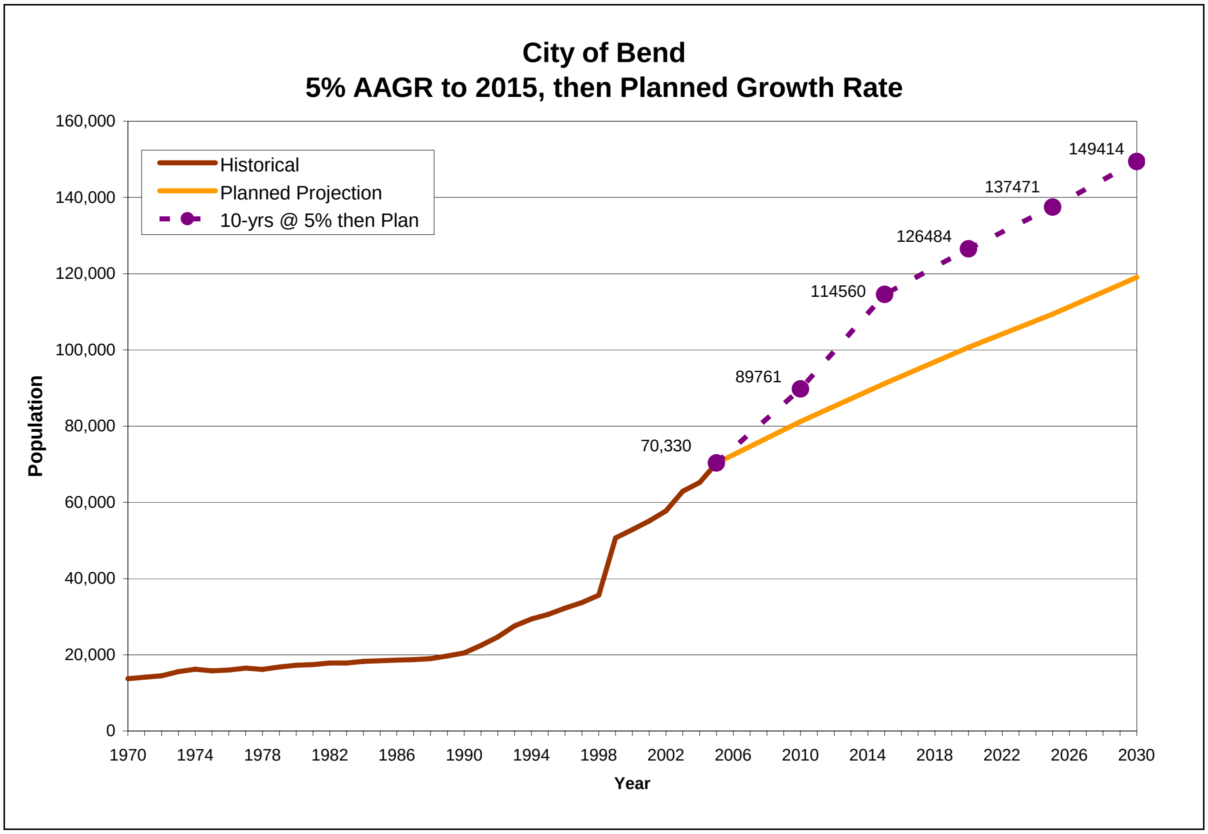


Figure 2-9 – 5% AAGR to 2015, then Planned Growth Rate

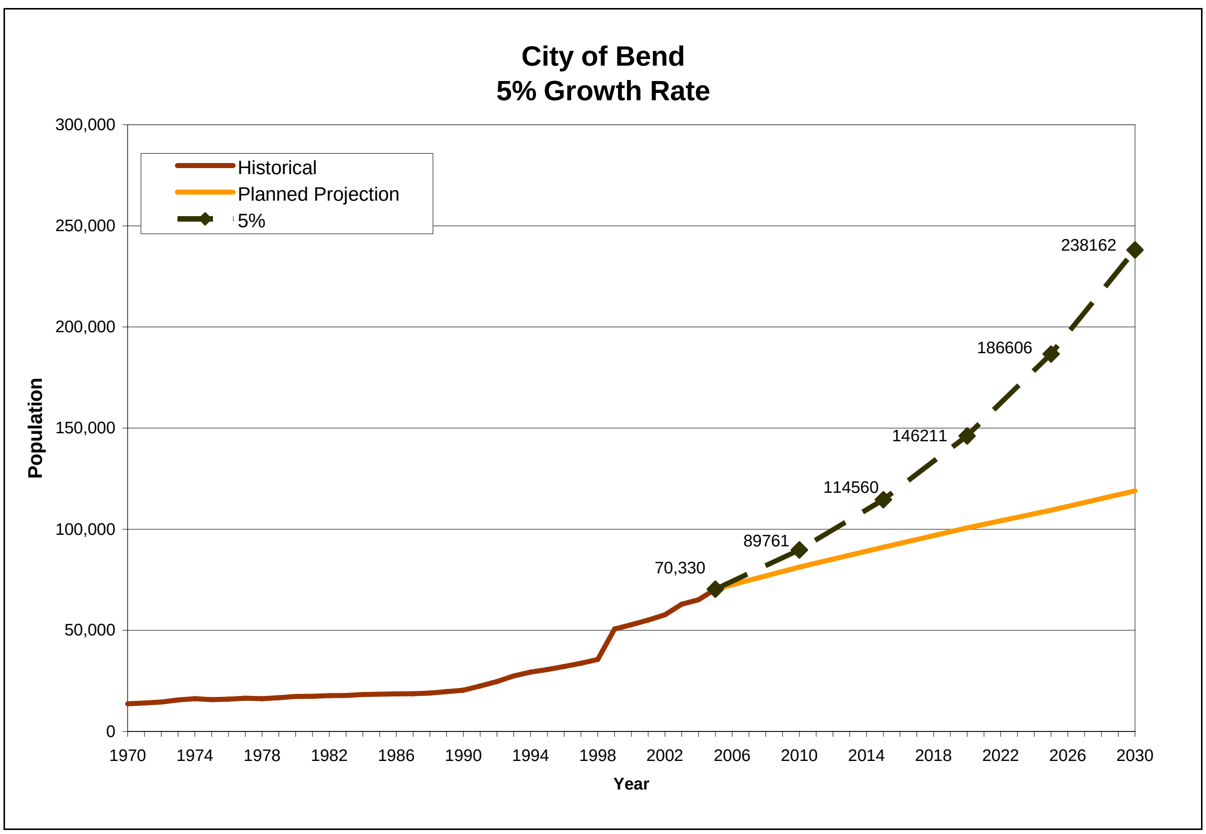


Figure 2-10 – 5% AAGR

POPULATION PROJECTION DEVELOPMENT

The populations were developed at the parcel-level based on parcel-level information. This will provided the most accurate representation of flows entering the collection system and allowed greater flexibility during modeling of the system.

Population Projections for Residential Parcels

The process for determining population from currently sewered parcels is as follows. The number of dwelling units on each residential parcel was developed based on its zoning type. The average residential density is multiplied by the number of net acres available on the parcel. The result is the number of dwelling units on each parcel. The number of dwelling units is then multiplied by the dwelling unit population of 2.5 to get the build-out population for the parcel.

PROJECT COST ESTIMATES

Project costs for capital projects identified in the Master Plan need to be specific to the City. This is due to many factors such as:

- Contractor availability
- Contractor expertise
- Unique geotechnical conditions
- Demand for pipe
- Materials cost
- Construction and development climate

The project costs that were developed for each project in the Master Plan are based on costs unique to construction in the City. All costs were developed in 2006 dollars based on an ENR Index of 8449.

BASIS OF COSTS

Estimates of the capital and operations and maintenance costs associated with the preferred collection system alternatives were prepared and used during the evaluation process. All cost estimates prepared as a part of the planning effort are order-of-magnitude estimates as defined by the American Association of Cost Engineers (AACE). An order of magnitude estimate is one that is made without detailed engineering data, and uses techniques such as cost curves and scaling factors from similar projects. The overall expected level of accuracy of the cost estimates presented is +30 percent to -20 percent. This is consistent with the guidelines established by the AACE for planning level studies.

The project costs presented in this plan include estimated construction dollars, contingencies, permitting, legal, administration and engineering fees. Construction costs are based on the preliminary concepts and layouts of the collection system components developed in the master planning process. The estimated construction costs prepared at the planning level are intended to represent average bidding conditions for projects that are similar in nature. With this in mind, it is understood that variations in the bidding environment at the time of project implementation will likely affect actual construction costs. Although estimated costs have been adjusted to account for known conditions at this time, they are reflective of planning level efforts and will not be as accurate as costs developed during final design. For these reasons, construction costs will be lower or higher than estimated in this plan.

LOCAL CONTRACTOR INFORMATION

It is very important to obtain construction costs from local contractors to ensure that local factors and conditions are properly applied to the construction cost estimates. MWH provided the City with a template to gather construction cost information from their local contractors. MWH received only one cost estimate. This information was used as the basis for the pipeline installation and rock excavation costs used in developing the cost estimates in the Master Plan.

COST DEVELOPMENT

The methodology for developing the costs for constructing new gravity sewers, upgrading the capacity of existing gravity sewers, constructing new force mains and for new pump stations and pump station capacity upgrades were developed. This methodology sums the cost for materials, installation, engineering and administration and to develop the project cost. In addition, a project contingency is applied to each project to cover the cost of unknowns that will be identified during detailed design of each project. The basis of cost for each type of project is summarized in the following sections.

NEW GRAVITY SEWERS

New gravity sewers will be constructed as part of each and interceptor and in the currently undeveloped areas. The costs to construct the gravity sewers include the costs for pipe, manholes, installation and restoration of the surface of the excavated area back to its natural state. The basis for each of these cost elements is summarized on ***Table 2-11***.

The pipe material that was assumed for new gravity sewers was dependent on the size of the line. The pipe materials that were used in estimating costs are PVC and reinforced concrete pipe, depending on the required diameter. PVC pipe was used for all gravity sewers less than 15-inches in diameter. The specification for the type of pipe that the cost estimate is based is SDR35 ASTM D-3034. Reinforced concrete pipe (RCP) was assumed for all sewers 18-inches in diameter and over.

Manholes

Manholes are assumed to be located at a maximum spacing of 400-feet and at every change in the direction of sewer. The manhole costs include the cost for the base, frame, standard cover and installation. The manhole material and installation costs were developed for each manhole diameter and depth combination. No restoration cost was included as this cost is included in the cost of the gravity sewer. The total estimated cost for each manhole based on size and depth is summarized in ***Table 2-12***.

Table 2-11
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
8-inch Diameter									
1	0' - 10' deep	5.65	67.00	7.35	16.71	3.89	80.00	89.36	76.54
2	10' - 15' deep	5.65	85.00	7.35	16.71	3.89	98.00	107.36	94.54
3	15' - 20' deep	5.65	110.00	7.35	16.71	3.89	123.00	132.36	119.54
10-inch Diameter									
4	0' - 10' deep	8.85	70.00	7.35	16.71	3.89	86.20	95.56	82.74
5	10' - 15' deep	8.85	88.00	7.35	16.71	3.89	104.20	113.56	100.74
6	15' - 20' deep	8.85	113.00	7.35	16.71	3.89	129.20	138.56	125.74
12-inch Diameter									
7	0' - 10' deep	12.75	72.00	7.35	16.71	3.89	92.10	101.46	88.64
8	10' - 15' deep	12.75	90.00	7.35	16.71	3.89	110.10	119.46	106.64
9	15' - 20' deep	12.75	115.00	7.35	16.71	3.89	135.10	144.46	131.64
15-inch Diameter									
10	0' - 10' deep	18.80	77.00	7.88	17.90	4.17	103.68	113.70	99.97
11	10' - 15' deep	18.80	95.00	7.88	17.90	4.17	121.68	131.70	117.97
12	15' - 20' deep	18.80	120.00	7.88	17.90	4.17	146.68	156.70	142.97

Table 2-11 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
18-inch Diameter									
13	0' - 10' deep	17.00	87.00	8.40	19.09	4.44	112.40	123.09	108.44
14	10' - 15' deep	17.00	105.00	8.40	19.09	4.44	130.40	141.09	126.44
15	15' - 20' deep	17.00	130.00	8.40	19.09	4.44	155.40	166.09	151.44
16	20' - 25' deep	17.00	145.00	8.40	19.09	4.44	170.40	181.09	166.44
17	25' - 30' deep	17.00	160.00	8.40	19.09	4.44	185.40	196.09	181.44
21-inch Diameter									
18	0' - 10' deep	18.50	97.00	9.45	21.48	5.00	124.95	136.98	120.50
19	10' - 15' deep	18.50	115.00	9.45	21.48	5.00	142.95	154.98	138.50
20	15' - 20' deep	18.50	140.00	9.45	21.48	5.00	167.95	179.98	163.50
21	20' - 25' deep	18.50	155.00	9.45	21.48	5.00	182.95	194.98	178.50
22	25' - 30' deep	18.50	170.00	9.45	21.48	5.00	197.95	209.98	193.50
24-inch Diameter									
23	0' - 10' deep	22.00	107.00	9.45	21.48	5.00	138.45	150.48	134.00
24	10' - 15' deep	22.00	125.00	9.45	21.48	5.00	156.45	168.48	152.00
25	15' - 20' deep	22.00	150.00	9.45	21.48	5.00	181.45	193.48	177.00
26	20' - 25' deep	22.00	165.00	9.45	21.48	5.00	196.45	208.48	192.00
27	25' - 30' deep	22.00	180.00	9.45	21.48	5.00	211.45	223.48	207.00

Table 2-11 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
27-inch Diameter									
28	0' - 10' deep	35.00	135.00	11.00	25.00	6.00	181.00	195.00	176.00
29	10' - 15' deep	35.00	150.00	11.00	25.00	6.00	196.00	210.00	191.00
30	15' - 20' deep	35.00	180.00	11.00	25.00	6.00	226.00	240.00	221.00
31	20' - 25' deep	35.00	215.00	11.00	25.00	6.00	261.00	275.00	256.00
32	25' - 30' deep	35.00	250.00	11.00	25.00	6.00	296.00	310.00	291.00
30-inch Diameter									
33	0' - 10' deep	40.00	160.00	12.60	28.64	6.67	212.60	228.64	206.67
34	10' - 15' deep	40.00	175.00	12.60	28.64	6.67	227.60	243.64	221.67
35	15' - 20' deep	40.00	205.00	12.60	28.64	6.67	257.60	273.64	251.67
36	20' - 25' deep	40.00	215.00	12.60	28.64	6.67	267.60	283.64	261.67
37	25' - 30' deep	40.00	230.00	12.60	28.64	6.67	282.60	298.64	276.67
36-inch Diameter									
38	0' - 10' deep	46.00	190.00	14.18	32.22	7.50	250.18	268.22	243.50
39	10' - 15' deep	46.00	205.00	14.18	32.22	7.50	265.18	283.22	258.50
40	15' - 20' deep	46.00	235.00	14.18	32.22	7.50	295.18	313.22	288.50
41	20' - 25' deep	46.00	245.00	14.18	32.22	7.50	305.18	323.22	298.50
42	25' - 30' deep	46.00	265.00	14.18	32.22	7.50	325.18	343.22	318.50

Table 2-11 (cont)
City of Bend Collection System Master Plan
Gravity Sewer Estimated Unit Construction Costs

No.	Description	Pipe Material ($/ft)	Installation ($/ft)	Surface Restoration			Total		
				Local ($/ft)	Arterial ($/ft)	Dirt/Gravel ($/ft)	Local St. ($/ft)	Arterial St. ($/ft)	Dirt/Gravel ($/ft)
42-inch Diameter									
43	0' - 10' deep	57.00	220.00	15.75	35.80	8.33	292.75	312.80	285.33
44	10' - 15' deep	57.00	235.00	15.75	35.80	8.33	307.75	327.80	300.33
45	15' - 20' deep	57.00	265.00	15.75	35.80	8.33	337.75	357.80	330.33
46	20' - 25' deep	57.00	275.00	15.75	35.80	8.33	347.75	367.80	340.33
47	25' - 30' deep	57.00	300.00	15.75	35.80	8.33	372.75	392.80	365.33
48-inch Diameter									
48	0' - 10' deep	72.00	250.00	15.75	35.80	8.33	337.75	357.80	330.33
49	10' - 15' deep	72.00	265.00	15.75	35.80	8.33	352.75	372.80	345.33
50	15' - 20' deep	72.00	300.00	15.75	35.80	8.33	387.75	407.80	380.33
51	20' - 25' deep	72.00	325.00	15.75	35.80	8.33	412.75	432.80	405.33
52	25' - 30' deep	72.00	350.00	15.75	35.80	8.33	437.75	457.80	430.33

Table 2-12
City of Bend Collection System Master Plan
Manhole Construction Costs
($ per Manhole)

Manholes	Materials	Installation	Restoration	Total
48-inch Manhole				
0' - 10' deep	1440	2200	0	3640
10' - 15' deep	1790	3200	0	4990
15' - 20' deep	2140	4600	0	6740
20' - 25' deep	2490	5600	0	8090
25' - 30' deep	2840	6600	0	9440
60-inch Manhole				
0' - 10' deep	3345	5000	0	8345
10' - 15' deep	4345	6500	0	10845
15' - 20' deep	5345	8000	0	13345
20' - 25' deep	6345	9500	0	15845
25' - 30' deep	7345	11000	0	18345
72-inch Manhole				
0' - 10' deep	3445	10000	0	13445
10' - 15' deep	4445	12500	0	16945
15' - 20' deep	5445	15000	0	20445
20' - 25' deep	6445	18000	0	24445
25' - 30' deep	7445	21000	0	28445

Canal Crossings

The irrigation canal system runs throughout the City and must be crossed many times. It is assumed that canal crossing can be done during the winter season when the canals are not in operation. This will minimize the construction cost as the construction can be done using open cut construction instead of boring under the canal. Cutting through the canal will require additional restoration to reconstruct the canal where the excavation was made. A cost of $250 per lineal foot was assumed for each canal crossing. The length of each canal crossing was assumed to be 200-feet.

Highway and Railroad Undercrossings

Construction can be done on major streets with proper traffic control. This will present disruptions to the areas local to the construction. It was assumed that open cuts could not be made at crossings of Highway 97 and Highway 20. It was assumed that the pipelines would be bored under these major highways so that the traffic would not be disrupted. A cost of $1000 per lineal foot was assumed for each highway crossing. The length of each highway crossing was assumed to be 250-feet.

Erosion Control

Erosion control is required by the State of Oregon on all projects. This cost may be minimized in the Bend area due to the low rainfall and lack of drainage areas. The cost of erosion control was still added to each project at a cost of $4.00 per lineal foot of constructed sewer.

Siphon Structures

Two siphon structures are required on the Plant Interceptor, one on each side of the canal. It has been assumed in this work that a new structure will be constructed next to each existing structure and tied into the existing structure to provide the flexibility for using any combination of the siphons. A lump sum cost of $150,000 was estimated for the construction of each siphon box.

Traffic Control

Traffic control will be required for all construction projects. The cost and level of effort for traffic control is based on the time required to construct the project. The cost for traffic control was based on two flaggers at $35 per hour for the estimated number of days that it would take to construct the project. The estimated number of days was based on a production rate based on the size of the line and the complexity of the construction. The cost for traffic control has been separately itemized for each project.

Easements

Most of the new sewers will be constructed on public rights-of-way. In these situations, there is no requirement for easements. There are some areas that easements will be required for the new interceptors. In these situations, an easement unit cost of $10.00 per lineal foot was assumed. This value was determined by using a cost for easements of 5-percent of the property value and a property value of $500,000 per acre.

GRAVITY SEWER CAPACITY UPGRADES

The Master Plan has identified a number of gravity sewers that are currently beyond their design capacity. Many will reach their capacity as the City continues to grow. The capacity of these sewers will need to be increased by replacing the existing sewer with one of a larger diameter to provide the required capacity. A number of assumptions were made to develop a cost estimate for upgrading the capacity of existing sewers by replacement with a larger line. These include:

- Each pipeline will be increased in diameter to a designated pipe diameter as determined by system modeling for build-out flow
- All lines are located in paved public streets - arterials
- Replacements will be done by cut-and-cover methods
- All replacements will require traffic control
- Existing backfill will not be reused

- Lines < 15" will be PVC, lines 18" and larger will be RCP
- Current flows will be handled by bypass pumping for all lines
- Service reconnection assumed 2 connections per 100 ft of sewer line

The materials and installation costs were assumed to be the same for replacement and capacity upgrades of existing sewers as those for new sewers. Therefore, the costs for materials and installation of capacity upgrades are also provided in ***Table 2-11***. In addition to those costs, there will be a cost for bypass pumping and reconnection of sewer laterals. The basis for these costs is defined in the following sections.

Bypass Pumping

The sewers with capacity deficiencies will need to continue to pass flow while they are being upsized. It has been assumed that each capacity upgrade will be done on the same alignment as the existing sewer. This will require the pumping of flow from the upstream to the downstream manholes while construction is being done on each line segment. This bypass pumping must be done in a manner that will provide no spillage of wastewater during the operation.

The project team obtained the costs of pumps, hoses and diesel generators for use in the Bend area. These costs were then factored into an average production rate for the upsizing of these sewers. This resulted in an average cost of $11.60 per foot for bypass pumping. This cost was applied to each sewer capacity upgrade project as a lump sum cost.

Reconnection

The replacement of sewers will require the termination of lateral connections and reconnecting each lateral following the placement of the larger pipe. An estimated cost of $1000 was assumed for handling each sewer lateral during construction. The number of sewer laterals was assumed to be two per 100-feet of sewer. This assumption was based on the assumption that the average lot was 100-feet wide. This cost was applied to each sewer capacity upgrade project as a lump sum cost.

PRESSURE SEWERS

Pressure sewers are required for pump station force mains. The Master Plan includes the need to replace existing force mains that are undersized and for constructing new force mains for new pump stations. The cost for the installation of force mains was done using the same installation costs that was used for 0 to 10-foot deep gravity sewers. PVC pipe was assumed to be the material of choice for all pressure sewers.

Pipe Material

The PVC pipe that the force mains (pressure sewers) were estimated around was based on the ASTM specification D2241. This pipe is designed for sanitary sewer service. The pressure rating of the pipe and the surge requirements need to be considered during design and the specific pipe with the proper pressure rating needs to be specified. The costs for PVC pressure pipe were obtained from a pipe supplier located in the City. The pipe costs used to estimate force main costs are summarized in ***Table 2-13.***

Table 2-13
Force Main Costs

PVC Pipe
6" - $6.00/ft
8" - $7.87/ft
10" – 12.34/ft
12" – 17.72/ft
15" – 26.33/ft
18" – 41.78/ft

ENGINEERING, ADMINISTRATION & LEGAL

Engineering, administration and legal costs are those costs required to design, permit, and provide construction management and administration of the project. These costs have been broken down into two categories, engineering and administration.

The engineering costs include design, surveying and construction management for the project. Engineering will cost more on a more complex project requiring canal crossings, highway crossing, utility confirmation and special planning for traffic control. The typical engineering cost for an effort such as this is 25% of the construction cost. This factor was applied to all new construction.

The engineering for smaller upgrade and replacement projects will be less due to better knowledge of the construction conditions and utilities, if proper record drawings are available. On these projects, the line grade has been established requiring less design. For sewer capacity upgrade projects, an engineering cost of 15% of the construction cost was used.

The administration and legal costs are those associated with the City providing oversight of the contract. These costs were estimated at 10% of the construction cost.

CONTINGENCY

At the planning level of an engineering project, a contingency must be applied to cover the cost of uncertainties in the estimate. These uncertainties include unknown details of the project not covered in the unit costs, changes in site conditions and variability in the bidding climate. For the estimated costs developed in this Master Plan, a contingency of 30% has been applied on the sum of the estimated construction and engineering costs.

PUMP STATIONS

The methodology for estimating the cost of new pump stations and pump station upgrades was done using a similar methodology to that used for estimating sewers. In this methodology, the individual component costs were estimated and then engineering, administration and contingency factors were applied. This was done in a 5-step process.

> ***Step 1*** – Determine the major mechanical components for the pump station. A preliminary sizing of these components was done and a cost estimate of the purchase price for the equipment item was obtained from the manufacturer. The costs for new and replacement pumps were based on Flygt pumps. A 30% mechanical installation factor was then added to the total equipment cost.
>
> ***Step 2 –*** Determine the cost of any structure. This item will consist of wet wells, dry wells and buildings. The major structural elements are itemized by component and a

unit cost for the type of structure is applied. The estimated cost for all of the structural components is then added together for the total estimated structural cost.

Step 3 – Determine the cost of yard piping. This item consists of lines between tankage, valves and other associated equipment. The estimated cost for all of the yard piping is then added together for the total estimated yard piping cost.

Step 4 – Determine the cost of any other appurtances or specialty items. In the example in Table 5, the cost for excavation is included in this category. This category can include special mitigation requirements, flow meters, fencing and other such items. The estimated cost for all of the other appurtances is added together for the total estimated other appurtances cost.

Step 5 - Total the estimated costs of equipment, mechanical installation, structural and other appurtances. This total becomes the accumulated total. This accumulated total is used as the value to determine the cost of specialties. The specialties consist of the following project components:

- <u>Demolition</u> – The cost to demolish existing facilities. This cost includes the labor and expenses for demolition. An estimate of the demolition cost was included based on the size of the estimated size of the project and the potential salvage value of the facilities being removed from services.
- <u>Site Work</u> – The cost to develop the site. This includes site preparation, stormwater management facilities, etc. A percentage of 2% of the accumulated cost was applied to the project for site work.
- <u>General Conditions</u> – This is the cost for the contractor to perform those items identified in the general conditions of the contract. This will include: manufacturers O&M manuals, warranties, project scheduling and management. A percentage of 5% of the accumulated cost was applied to the project for general conditions.
- <u>Finishes</u> – This is the cost for painting and protective coatings of concrete and exposed metals. A percentage of 1.5% of the accumulated cost was applied to the project for finishes.
- <u>Electrical/I&C</u> – This is the cost for providing electrical, instrumentation and control (I&C) for the project. This will include the cost for motor control centers, SCADA, communications and wiring of the electrical components. A percentage of 9% of the accumulated cost was applied to the project for electrical and I&C.
- <u>Mechanical</u> – This mechanical cost is the cost for heating, ventilation and air conditioning components for the project. A percentage of 9% of the accumulated cost was applied to the project for mechanical systems.

The sum of the specialties is then added to the accumulated total to arrive at the total cost of construction. This value is then multiplied by a specific percentage for each of the contract management components of the project and then totaled. These include:

- Contractor Mobilization, Legal & Administration – This consists of the contractor's costs for project mobilization and contract administration. A percentage of 5% of the accumulated subtotal is applied to this component. The estimated project cost is then subtotaled to include this cost.
- Contingency – In this cost estimate, the project contingency is added to the project at a rate of 30% of the project accumulated subtotal. The estimated project cost is then subtotaled to include this cost.
- Engineering/Legal/Administration – This project component includes the cost of engineering, legal and project administration for the owner. A percentage of 25% was applied to the project for this component. The estimated project cost is then subtotaled to include this cost.
- Construction Difficulty Factor – Many projects will have a higher cost due to the difficulty of construction. This difficulty factor can be based on providing temporary services, maintaining systems in operation during construction and confined construction activities. Each of these variables will make construction more difficult and will require coordinated scheduling of the project construction. This will result in a longer construction period, resulting in additional project costs. The construction difficulty factor provides the estimated additional cost that is a result of these project variables. A construction difficulty factor can range from 0% for a Greenfield project to 40% for a very confined project that requires a large amount of construction sequencing.

Each component cost is then totaled to get the cost of the project.

PROJECT COST

The project cost is the cost used in the budget and/or Capital Improvement Plan (CIP) by the City. The project cost includes each of the elements of the project including construction, engineering, administration and contingency.

The project cost has been developed in 2006 dollars at an ENR-CCI of 8449 (Engineering News Record Construction Cost Index). Therefore, the project cost estimates identified in this Master Plan need to be increased by inflation for future years beyond 2006.

PRESENT WORTH ANALYSIS

The present worth analysis is used to compare various project alternatives based on capital, operating and maintenance costs that occur over a specific time period. An example of the analysis used in the Master Plan was the evaluation of the continued operation of a pump station compared to the construction of a gravity sewer to remove the station from service. The present worth analysis determines the comparable amount of monies that are required today to pay for operation and maintenance (O&M) and capital projects over a designated period of time. In the analysis performed for this study, a present worth analysis for a 20-year and a 50-year period was done. The 20-year period is a good period for evaluating mechanical equipment. The 50-year period is a good period for the evaluation of long-life assets, such as a gravity sewer. The shorter life mechanical equipment is replaced at 20-year operating intervals in the 50-year analysis. The costs and methodology used in developing the present worth of the various project alternatives is summarized in the following sections.

O&M COSTS

Operation and Maintenance (O&M) costs are based on the estimated manpower needs, resource requirements and equipment replacement and maintenance costs over the period of the analysis. O&M costs in this analysis were based on the current costs in the 2005–2006 operating budget.

The costs for maintenance of the sewer lines were developed as a unit cost per 1,000 LF feet based on the budget. The City had 349,349-LF of force main and 1,565,913-LF of gravity sewer for a total of 1,915,317-LF of sewer in May 2005. During this same period of time, the City maintained 86 pump stations. The 2005-2006 operating budget for the operation and maintenance of the sewer lines and pump stations was $1,903,141. This budget is itemized in ***Table 2-14***.

Table 2-14
City of Bend
2005-2006 Collection System O&M Budget

Object	Sewer Lines	Pump Stations
Labor Expense	$ 417,420	$ 402,521
Material and Services	$ 224,400	$ 152,500
Electricity	$ -	$ 86,300
Odor Control	$ -	$ 110,000
Capital	$ 200,000	$ 270,000
Vehicle & Communication Replacement	$ 20,000	$ 20,000
Total	**$ 861,820**	**$ 1,041,321**
Total Minus Electricity & Odor Control	$ 861,820	$ 845,021
Total Minus Elec, Odor Control & Capital	-	$ 710,021

Using the budget for O&M of the sewer lines, assuming both gravity and pressure, the annual cost to maintain the 1,915,317-LF of sewer is $449.96 per 1000-LF. The same calculation was done to determine the average annual cost for operating and maintaining each pump station. The cost for electricity and odor control were subtracted from the O&M cost prior to performing the calculation so the calculated average annual O&M cost per pump station of $8,256.06 does not include those costs. This was done because these costs are for the current flows. As the system flows increase, the cost for electricity and odor control (chemicals) will increase proportionally. These cost increases are added into the operating cost on an annual basis in the present worth analysis.

PRESENT WORTH DEVELOPMENT

Economic evaluations of the alternatives presented in this plan are based in part on comparison of their estimated Net Present Worth (NPW). An alternative's NPW is an estimate of the dollar value that would need to be invested in year zero, given an appropriate interest rate, in order to finance all capital and O&M costs that will be incurred over the planning period. Although all of the alternatives are assumed to have the same useful life over the planning period, they will each have different capital and O&M cost requirements. Determination of their PW is a way to compare them on an equivalent basis.

Given estimates of project capital costs and O&M costs, the associated NPW is calculated by the equation:

$$NPW = PW_c + PW_{O\&M}$$

Where: PW_c = present worth of capital costs
$PW_{O\&M}$ = present worth of O&M costs incurred over the 20 or 50-year planning period
NPW = Net Present Worth

A variety of cost components are required to develop the present worth of a specific project alternative. The components and the value used in this analysis are:

- PW Discount Rate - The discount rate (cost of money) used to bring annual O&M costs and future capital costs back to their net present worth value was 3% per year. This represents the assumed rate used to finance the alternatives minus the rate of inflation.
- Power Escalation Rate – The power escalation rate used in this analysis is 5% per year. A power escalation rate that is higher than the PW Discount Rate was used because the cost of power is projected to increase at a higher rate than inflation.
- O&M Escalation Rate – The O&M escalation rate is the rate of increase for operation and maintenance activities. This has increased at a greater rate than inflation over the past few years due to the higher than normal increases in medical programs and state retirement programs. A conservative rate of 3% per year was used in this analysis.
- Power Cost – A power cost of $0.065 per kW-hr was used in this analysis. This is slightly higher than the current rate, but is comparable to the current rate when demand charges, excess transmission charges and other miscellaneous charges are added to the power cost.
- Bioxide Cost – The chemical used for odor control is bioxide. This is a form of nitrate that provides oxygen to the wastewater, minimizing septicity. It was assumed that 50 gallons of bioxide would be used per million gallons of wastewater pumped at a cost of $1.25 per gallon.
- Service Area Growth Rate – A service area growth rate was incorporated into the analysis to provide an increase in flow rate. The growth rate was adjusted in each analysis to provide growth so that build-out of the service area would occur no later than 2035.
- Replacement Costs – The replacement costs are the costs to replace the pump station pumps. The replacement costs were obtained from Flygt pumps based on a comparable pump based on flow and TDH. The pumps were replaced every 20-years in the analysis beginning in 2025.

- Capital Costs – The capital costs were the estimated costs to construct a new gravity sewer that would allow for the pump station to be removed from service. This cost also included the cost to decommission and remove the existing pump station. It was assumed that the capital project would occur in 2015 in each analysis.

The present worth was then calculated for two scenarios. The first scenario was for continued operation of the pump station and the second was for removing the station from service. This analysis was done using an Excel worksheet. The results of this analysis are summarized in Section 5.

SECTION 3

MODELING AND CAPACITY ANALYSIS

INTRODUCTION

A new collection system model was developed using InfoSWMM to replace the City's existing HYDRA model. This section documents the development of the model and use of the model to evaluate existing conditions and the various alternatives to plan for future needs. The scenarios that were evaluated are:

- Existing sewer system with existing flows
- Existing sewer system (no new interceptors) with build-out flows
- New Interceptors with build out flows

Many options for design of new interceptors were evaluated in order to design a Master Plan to meet anticipated needs with the least long-term cost and disruption of existing City services.

The term "existing" is used when referring to the wastewater flows and physical sewer system that existed as of May 2005. This is the system that was used to develop the model and calibrate flows. This model can adequately represent the growing system. This is because the model was calibrated on the existing flows and conditions and this calibrated model was used to predict flows for build-out of the UGB and UAR. These build-out flows will represent the system unless zoning or the planning area is changed.

SUB-BASIN DELINEATION

Sub-basins were delineated within the collection system to assist in development of model loads and defining where those loads will enter the modeled network. Each sub-basin represents an area draining to a single manhole in the modeled network or several manholes in close proximity. Sub-basins were delineated within the existing collection system in a logical manner to meet the needs of developing and calibrating the hydraulic model. Sub-basins were also delineated for undeveloped or unsewered areas inside of the Urban Growth Boundary (UGB) and the Urban Area Reserve (UAR) boundary. In general, sub-basins within the existing collection system were delineated to be between 30 and 50 acres in size. The sub-basin delineation is shown in ***Figure 3-1***.

MODEL DEVELOPMENT

Task 1 of the Sewer System Master Plan Project was to develop a new computer model of the City's collection system. The new collection system model was developed using InfoSWMM to replace the City's existing HYDRA model. This section documents the model build, flow

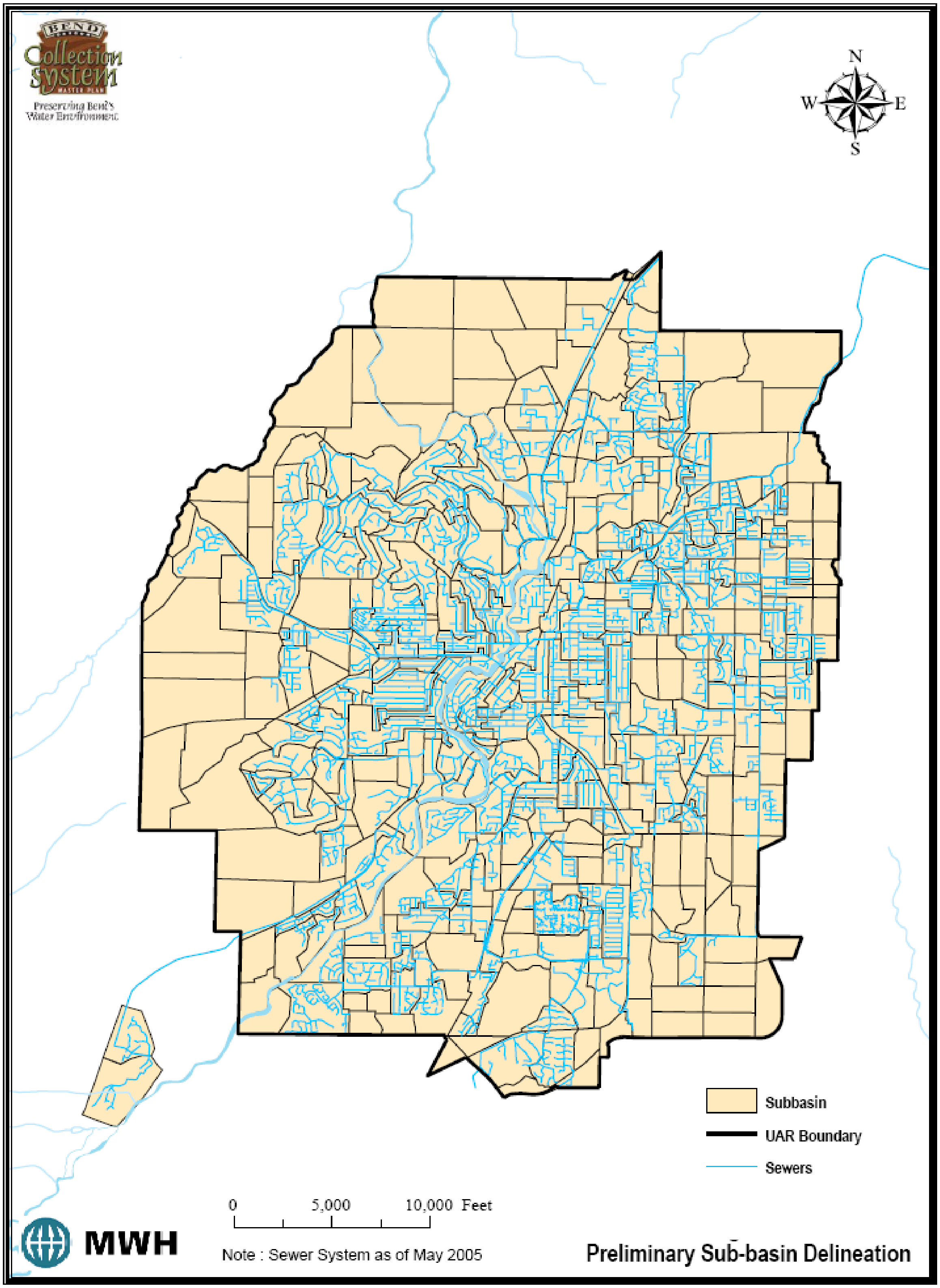


Figure 3-1 – Sub-basin Delineation

development and calibration of the model. The InfoSWMM model is a significant upgrade to the HYDRA model in that it is a GIS base “dynamic” model where the HYDRA model is not dynamic. A dynamic model utilizes more sophisticated algorithms that mathematically represent the changing flows throughout the system as they occur. This type of model represents actual conditions much better than a model that is not dynamic. The results from this type of model are representative of actual operating conditions enabling the system elements to be optimally sized.

MODEL COMPONENTS

The model network includes approximately 26 percent of the existing pipes and manholes in the collection system, including 27 of the largest pump stations. This includes all lines 10-inch and greater with some 8-inch lines that will be required to serve newly develop or expanding areas. The wet well sizes, pump curves and force main characteristics are entered for each pump station. Pumps can operate on either differential level or as variable speed pumps matching influent flow. The InfoSWMM model supports multiple pump stations pumping into a common force main. The dynamic model handles the changing hydraulics as flows change in the force main. The model network is shown in ***Figure 3-2***

The model also accepts diurnal curves for each model input. This allows the system to be properly characterized based on the area demographics such as residential, commercial or combinations of the two. Finally, the model provides the capability to enter infiltration and inflow hydrographs at each input into the system. This allows the local affects of rainfall to be characterized by the system in different areas.

MODEL STRUCTURE

A thematic representation of the collection system model development is shown in ***Figure 3-3***. This diagram shows the input and output files used by the model. This shows that model input is placed in the model through Excel files, ArcGIS files and directly into the InfoSWMM model.

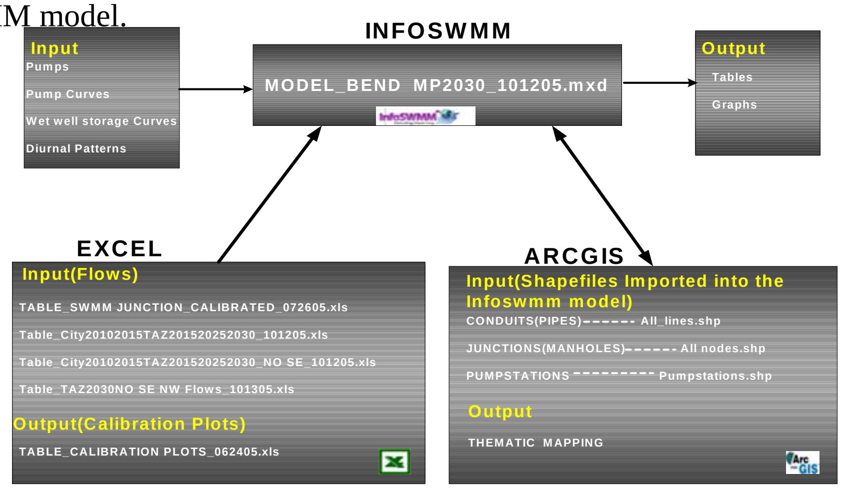


Figure 3-3 – Thematic Representation of Model Development

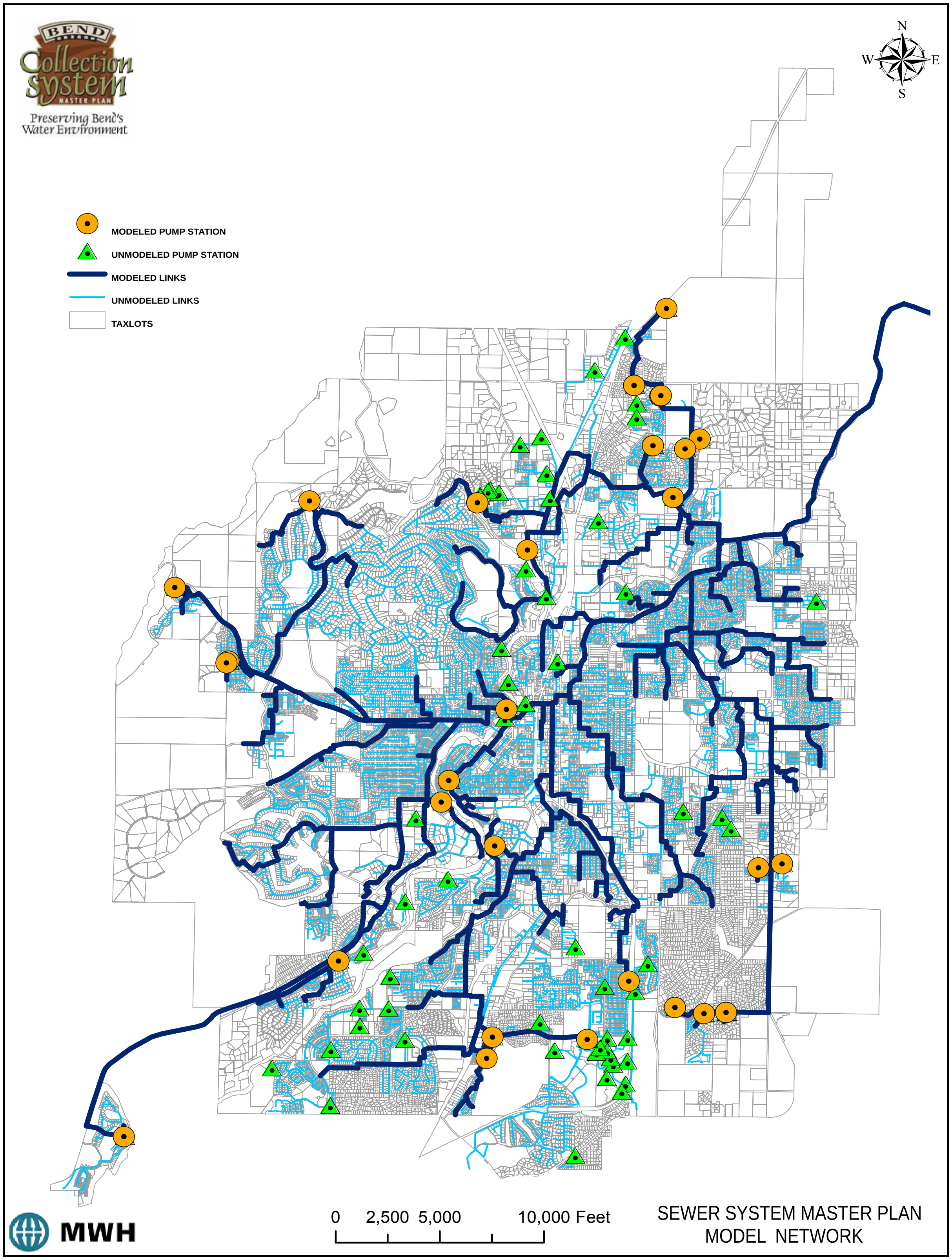


Figure 3-2 – Model Network

MODEL CALIBRATION

Calibration is a process by which modeled flows are compared to actual observed flows from flow monitoring data. Model corrections are then made to achieve a reasonable match to the observed flows. The collection system model was calibrated for dry weather conditions based upon flow monitoring data collected early in the project. Since flow conditions differ from weekdays to weekends, it is important to ensure that the model can reasonably replicate the dry weather flow patterns for the full week. Once calibrated, the model can be used to simulate hypothetical design conditions (i.e., future growth scenarios) and identify capacity problems.

Flow Monitoring Program

A flow monitoring program was performed by SFE Global between February 27 and March 7, 2005. The monitoring program consisted of 22 temporary flow monitors located throughout the City. The flow monitors were placed so that the flows in various areas could be characterized based on the type of zoning and demographics of the areas. The monitoring program took place over one weekend so the affects of weekend flows could be evaluated. The position of the flow monitors and the basins they represents is shown in ***Figure 3-4***.

The flow monitoring data was normalized to develop representative diurnal curves for each monitoring basin. One example of the information obtained from the flow monitoring program can be demonstrated with the diurnal curves obtained from Meter 6. Meter 6 was located upstream of the Westside Regional Pump Station. This meter measured an average flow of 0.56-mgd for the monitoring period. This meter provided the following information:

- The diurnal curve on the weekend lags two hours from the weekday diurnal curve
- The daily peaking factor is 1.42 on a weekday and 1.60 on the weekend
- The diurnal peak occurs at 9:00 AM on a weekday
- A second smaller diurnal peak occurs later in the day around 7:00 PM
- The system low flow occurs around 5:00 AM
- The low flow has a factor of 0.35 of the average daily flow

This type of information was obtained from each of the flow meters placed in the system. This information was assembled to obtain diurnal curves for residential, commercial and residential/commercial basins. The residential diurnal curve was shown in ***Figure 2-5***. The diurnal curves obtained from the monitoring at each station were input into the model on each sub-basin contributing to the model. This provided the initial calibration of the model. The flow monitoring program is summarized in the Task 1 Summary Report and the SFE Flow Monitoring Report.

Model Calibration Process

The calibration process was started by compiling all sewered taxlot information into an Excel spreadsheet and then assigning each taxlot its appropriate land use classification. The

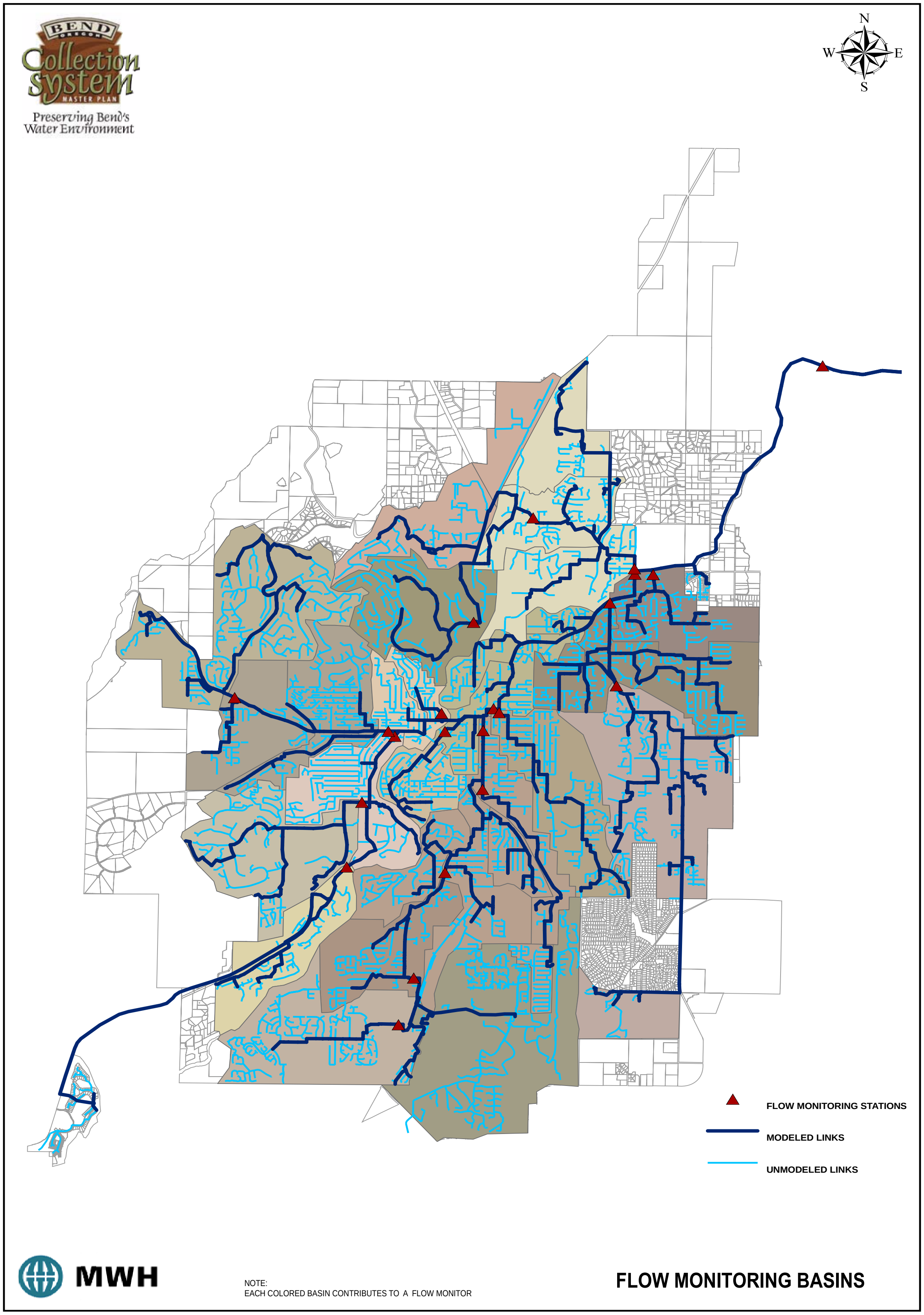


Figure 3-4 – Flow Monitoring Basins

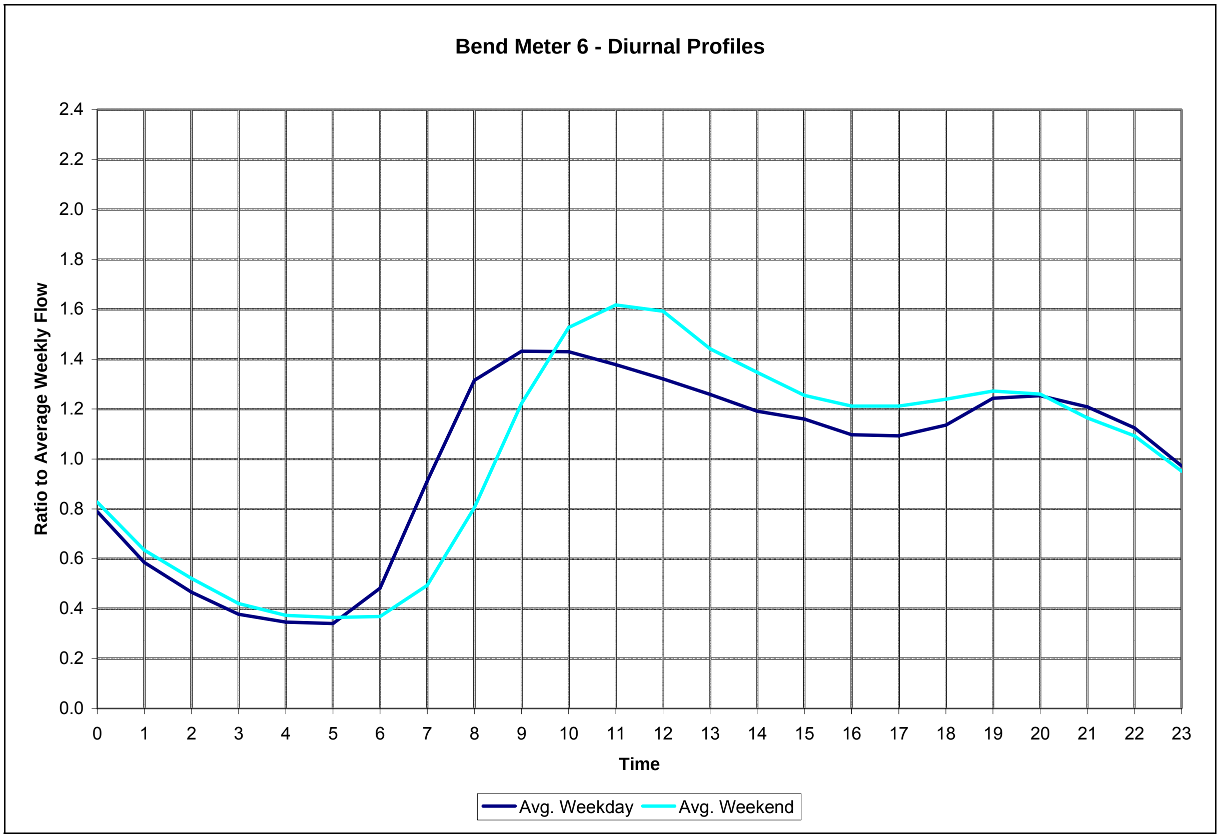


Figure 3-5 – Meter 6 Diurnal Profiles

sewered taxlots were then grouped together depending on which flow monitoring basin they were located within. It should be noted that each flow monitoring basin is comprised of a number of subbasins. The flow from each subbasin is ultimately entered into the model. Once the sewered taxlots were grouped by flow monitoring basins, the unit flow factors, discussed in the Section 2, were adjusted until the flow from the sewered taxlots approximated the average flow at each flow monitor and also, the total average flow at the WRF during the monitoring period. Due to the higher-than-normal percentage of seasonal homes in the City, an occupancy field was also used to adjust flow from each monitor basin. Initially, it was assumed that there was 100% single family home occupancy and 80% multi-family home occupancy. The occupancy value was only adjusted in areas of the City where it had been indicated that the predominate number of homes were seasonal. Additionally, it was discovered that adjusting non-residential flow factors had negligible effect on the total flow from the basins. The seasonal flow factors that were developed for the calibrated model were shown in ***Table 2-5***.

In addition to adjustment of the seasonal occupancy factor, changes to the diurnal curves in specific locations were also made. When it was decided that the model had reached an acceptable level of calibration, the model was run as a complete system. The model output at each of the flow monitoring stations was then compared to the flow monitor data. This was done by creating calibration plots. An example of the calibration plot for Meter 6 is shown in ***Figure 3-6***. This calibration plot shows the level of representation that the dynamic model provides of the actual flows in the collection system. The calibration plots for each of the flow monitoring stations are provided in the Task 1 Summary Report.

It should be noted that further calibration can only be performed following the collection of new flow monitoring data within the collection system. It is not necessary to recalibrate the model each time additional areas of new development are added to the model. Typically, new areas are added to the model using 'design flow factors', which may be conservative, but are necessary to adequately plan for the new development. The calibration process ensures that the new development and design flow factors are applied to a model, which represents the actual operation of the collection system. The flow monitoring and calibration process may be undertaken whenever the City deems it necessary; and should be performed after significant growth or redevelopment in any specific portion of the City.

This model was constructed to provide the capability to model various scenarios of growth and zoning within the UGB and UAR. As the areas develop, the inputs for actual development can be entered into the model. The model can then be run to identify the affects of the new development.

In addition, the model can also be used to determine the affect of changing zoning or densities of development within the planning area. The flows are based on the number of lots and type of zoning within each sub-basin. These can be changed on various modeling scenarios to determine how the changes will affect system capacity.

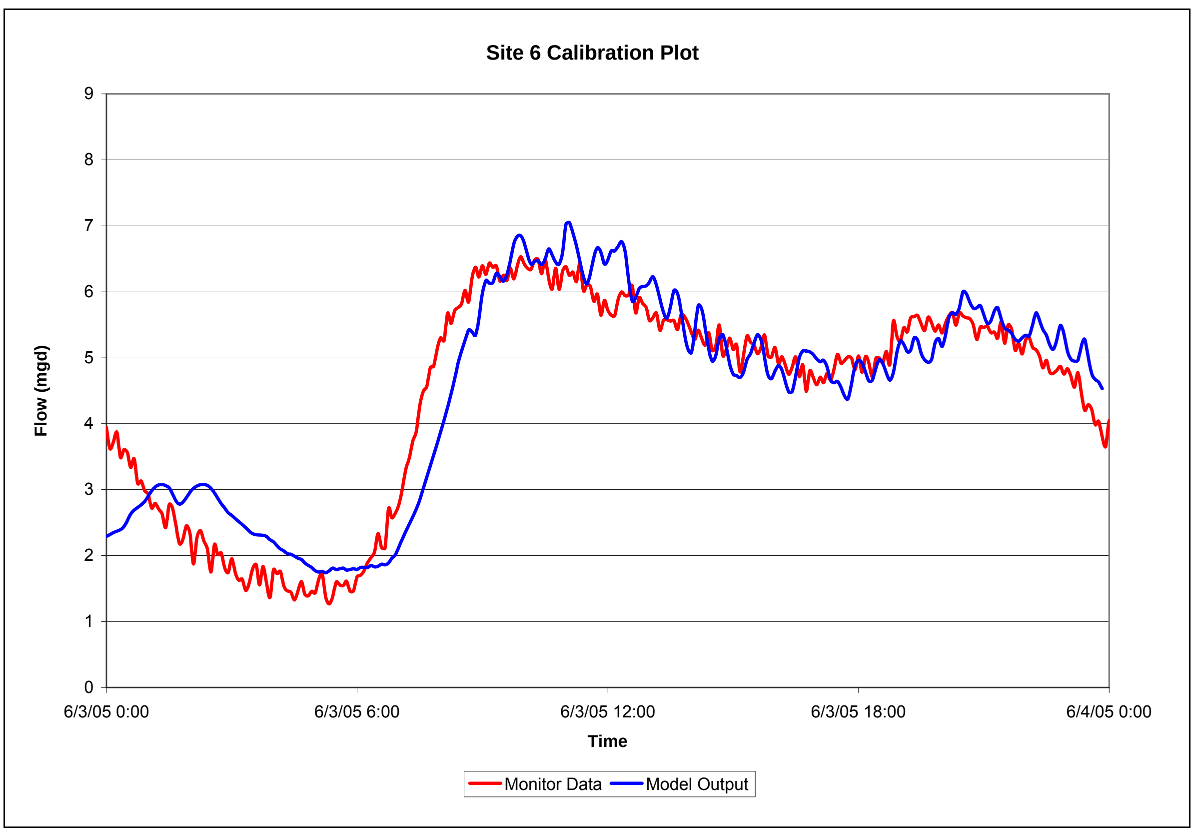


Figure 3-6 – Meter 6 Calibration Plot

MODELING APPROACH

The modeling of various alternatives under current and build-out conditions was performed. The model provided output that described the flow rate, velocity and depth of flow in each of the modeled elements throughout the modeled flow period. This output was then evaluated to determine the elements that exceeded capacity. Modifications were then made to the network (i.e. increasing pipe sizes, modifying pump station operation, etc.) to provide additional capacity at points in the system where capacity was not adequate. The model was then run again to determine the changes that resulted from the modifications. This process was continued until the final results providing adequate capacity were obtained for each scenario.

MODELING OF CAPACITY IMPROVEMENTS

The model was first run under dry weather flow conditions to evaluate if there was sufficient system capacity. The depth of flow (d) in each gravity sewer element was then compared to its diameter (D). A depth/diameter (d/D) ratio greater than or equal to 0.8 was defined as the maximum design depth for a gravity sewer. If this (d/D) ratio was greater than or equal to 0.8 at any time during the simulation, changes were made in order to improve sewer capacity. Depending on the particular layout of each pipe section, possible changes would be: increase the pipe diameter, adjust a contributing pump station flow rate (model variable flow pumping), or increase the pump station force main diameter.

As this analysis was performed, care was also taken to ensure that unnecessary capacity upgrades were not made. For instance, in highly developed areas, if d/D was between 0.8 and 0.9, the profile was examined closely and often no capacity upgrades were recommended. This was done to minimize disruption of city services and minimize system cost due to unnecessary construction. Similarly, if d/D was only slightly greater than 0.8 and the model indicated long sections of pipe would need to be modified to improve flow, no changes were made.

In order to keep estimated capacity upgrades conservative, pipes were generally only increased by one size increment at a time. The model was then re-run to evaluate if these repairs were adequate. When increased capacity was modeled in a particular segment, this often increased flow to downstream segments due to the removal of the upstream bottleneck. Thus, segments not identified with deficient capacity in the initial run could become capacity deficient in the second run. Therefore, this process was repeated until all deficiencies were addressed.

Following the modeling of dry weather flow and the optimization of the system capacity, wet weather flows were added into the model and the model was run again. During wet weather flows, pipe surcharging was acceptable (d/D => 1 is allowed). Under wet weather flows, the criteria used to determine system capacity deficiencies was the elimination of sewage overflows at manholes.

In scenarios that involved construction of new interceptors, these interceptors were sized to meet the same design criteria that was determined for the existing system. This criterion is:

- During peak dry weather flows d/D < 0.8
- During peak wet weather flows, no overflows
- Pump stations meet peak pumping capacity with largest pump out of service
- Force main velocity < 6 feet per second

The system model for the City is fairly large. A single model run can take between 45-minutes and one hour to run. This long run time, made it impractical to run the entire system at once to assess various alternatives that impact only a portion of the sewer system. Therefore the City's Sewer system was divided into four modeling sections. They include Southeast, West, North and Core. The system was divided into discrete sections reflecting the actual division of flows from specific areas where changes in influent flows or system configuration had little or no effect on the other sections. In each of the sections, the sub-basins were grouped together depending upon which interceptor they flow into. For example all the sub-basins that flow to the SE Interceptor are grouped together into one section and were modeled separately to size and evaluate the SE interceptor. After pipe sizing was performed on individual sections, the entire model was run to verify if the upsized pipe diameters were sufficient to handle the flow. The four sections accumulated flow was also modeled to evaluate the Plant Interceptor portion of the model.

The force main velocity criterion was only applied to new force mains; the model was not used to systematically evaluate force mains and pumps. As long as d/D and overflow criteria were satisfied, the pumps and force mains were not evaluated in the model. Instead, detailed calculations were performed for each individual pump and associated force mains. These results are presented in TM 3.8. Thus, the model provides information regarding fixes needed for the gravity portions of the system, and TM 3.8 provides information regarding the pumps and force mains. These two sources were used as input in the development of the Area Plans.

RESULTS OF HYDRAULIC EVALUATION

A number of scenarios were evaluated to develop the final system master plan. The first evaluation was to model the existing system under both daily peak dry weather flows and peak daily wet weather flows for the year 2005 to determine the existing capacity limitations. The existing system was then modeled under build-out flows. This was done to develop the capacity issues of the existing system at build-out. This was used as the Base Case condition. The rest of the modeling was done at build-out conditions to evaluate the various alternatives.

EVALUATION UNDER CURRENT FLOWS

In the existing flow scenario, the 2005 peak daily flows, both dry weather and wet weather were applied to the existing system in separate evaluations. There were no changes made to the existing system in this scenario. This scenario identified the capacity limitations that exist under the existing flow conditions. The existing system deficiencies are shown in ***Figure 3-7***.

This analysis showed that there are currently a few capacity deficiencies in the system. The most critical of these deficiencies are:

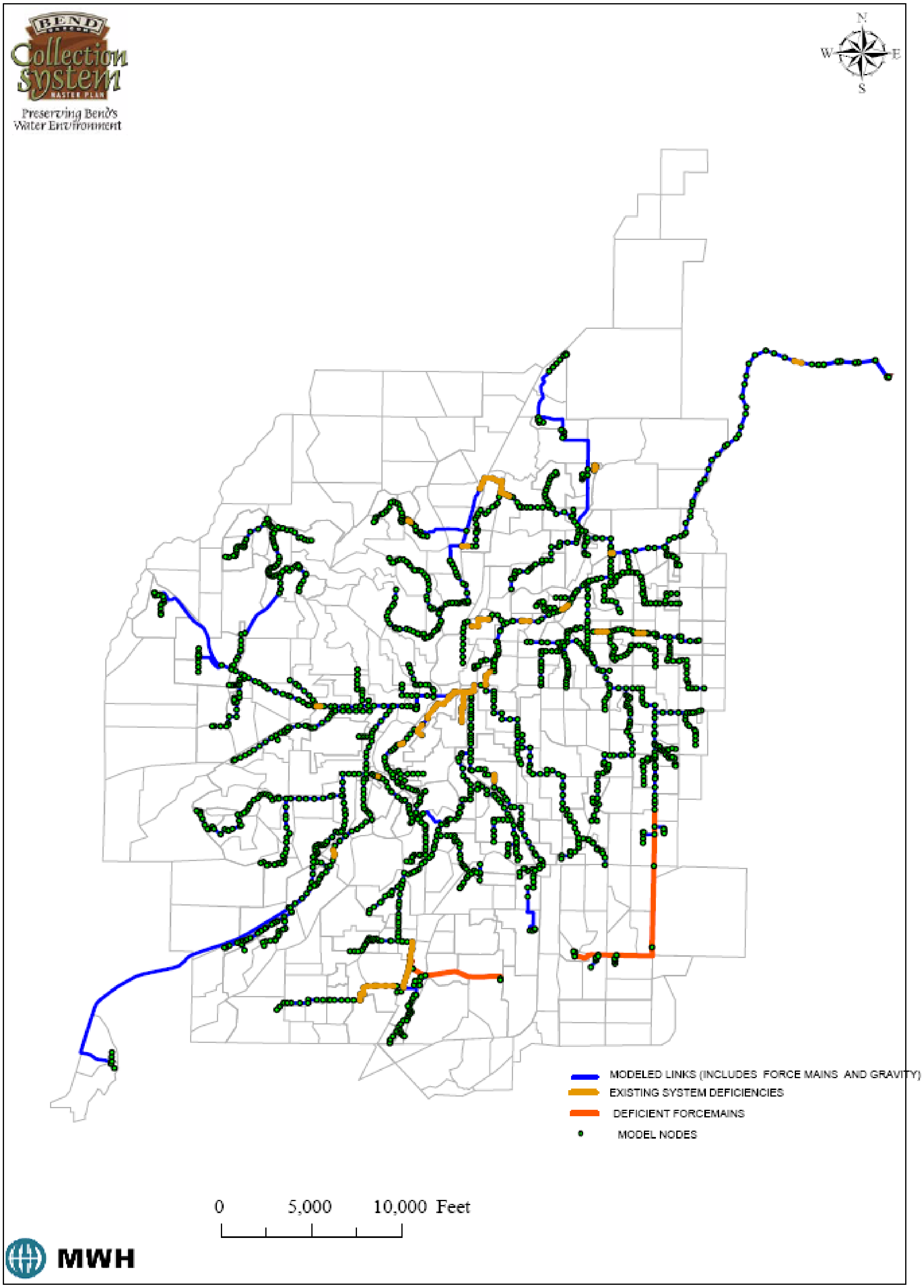


Figure 3-7 – Existing System Deficiencies

- Deficient capacity in the forcemain discharging from the Murphy Road Pump Station
- Deficient capacity at the discharge of the Westside Regional Pump Station
- Deficient capacity at the discharge of the Wyndemere and Sawyer Park Pump Stations

Each of these capacity limitations will be addressed in the Master Plan.

EVALUATION UNDER BUILD-OUT FLOWS WITHOUT INTERCEPTORS

In this scenario, build-out flows, both peak dry weather and peak wet weather, were applied to the existing system. No modifications were made to the existing system. Flows from currently unsewered and undeveloped basins were placed into the system at an appropriate point. The objective of this scenario was to get an indication of how extensive system deficiencies would be without the addition of new interceptors. Only one model run was made in this scenario and no upgrades were made of any capacity limitations. Therefore, the result of this analysis only shows a portion of the system capacity problems. At each point where a capacity limitation occurred, there is a flow restriction to downstream flows and possibly an overflow, resulting in flows leaving the system. The effort was not done to identify all of the capacity limits in the system, because it was determined that the capacity limits identified in the first model run were so excessive that continuing with this scenario had no merit. The system deficiencies identified in this model run are shown in ***Figure 3-8***.

An estimate was made of the number of capacity repairs that would be required, including the portions of the system that the capacity limitations were not determined. The initial deficiencies depicted in ***Figure 3-8*** underestimate the total length of pipe that needs to be upgraded. Based on experience with other build-out scenarios, it was estimated that there would be an additional 20% of the system with capacity limitations once these initial deficiencies were removed. Thus, the estimate from the initial run was increased by 20% to represent the potential deficiencies that may be in the system under these flow conditions. This analysis showed that there are approximately 157,747-feet or 29.9-miles of the existing gravity system that is deficient if it was required to handle system build-out flows in the future. This is 10% of the existing gravity system.

EVALUATION OF MASTER PLAN ALTERNATIVES

A number of alternatives were evaluated to develop the final alternatives that have been recommended in the Master Plan. Each of these alternatives included a new interceptor or a combination of new interceptors to redirect existing and future flows from the existing core system. The main elements of the systems that were evaluated include:

- Parallel Plant Interceptor – provides additional capacity from the City to the Water Reclamation Facility (WRF)
- Southeast Interceptor – Provides service to the east, south and southeast Bend areas, relieving capacity limitations in the existing core system

- Westside Interceptor – Redirects flows generated on the west side of the Deschutes River and pumped by the Westside Regional Pump Station to the North Interceptor, relieving capacity limitations in the existing core system
- Reduction of westside flows by redirecting the Shevlin Commons, Awbrey Glen, and three undeveloped westside sub-basins to the North Interceptor
- Redirect Sawyer Park and Wyndemere Pump Stations to the new Westside Interceptor relieving capacity limitation in the existing core system
- North Interceptor – Provide service to the undeveloped areas on the north end of the City, the new Juniper Ridge development and basins on the northwest side of the City

The parallel Plant Interceptor parallels the existing plant interceptor and adds capacity to accommodate projected growth within the Bend planning area. It is planned to be intertied with the existing interceptor to maximize flexibility in operations and allow for diversion during times of intensive maintenance. All future flows will be conveyed by one or both of the plant interceptors.

The new interceptor elements that were evaluated and incorporated into the Master Plan are shown in ***Figure 3-9***. In this figure, the sub-basins are shaded according to whether their flow goes to the Southeast Interceptor, Westside Interceptor, North Interceptor, or Core System (existing system). This figure also shows the location of recommended repairs needed to meet the projected build-out flows. Repairs for Shevlin Commons and Awbrey Glen , are not shown on this figure. This is because these stations are removed from service with their flows redirected to the North Interceptor in the Master Plan. Currently Flows from Shevlin Commons and Awbrey Glen flow into Westside PumpStation but in the Master Plan it was assumed that it is more cost effective to divert flows from these two pump stations to the North Interceptor through the proposed Trunk sewers However, other scenarios where Shevlin Commons continues to flow into the Westside Pump Station indicated that no capacity upgrades were needed for Shevlin Commons but some capacity upgrades were needed in the Awbrey Glen basin. In addition, capacity upgrades will be needed in the Awbrey Glen pump station and the gravity sewer downstream of the station discharge if it continues to flow through the Westside pump station.

SE INTERCEPTOR WITH BUILD-OUT FLOWS

Table 3-1
Recommended SE Interceptor Pipe Sizes

Diameter (inches)	Length (feet)
18	5,962
24	40,330
36	3,702
Total	**49,994**

The Southeast Interceptor alignment along 27th Street was added to the model. Each point where a sub-basin on the east side of 27th Street crossed the interceptor, the sub-basin flows were assigned to the interceptor at the points where the sewers intersected. The sub-basins that will be served by the SE Interceptor and the interceptor pipe sizes are shown in ***Figure 3-10***. The specific alignment of the SE Interceptor is discussed in detail in TM 3.9 – Interceptor Evaluations. Flow from appropriate sub-basins was directly input into the interceptor at the nodes show in the figure. The area served by the gravity system upstream of the current Murphy Road Regional Pump Station was diverted into the upstream end of the Southeast Interceptor. In the model, these pipes were disconnected from their current

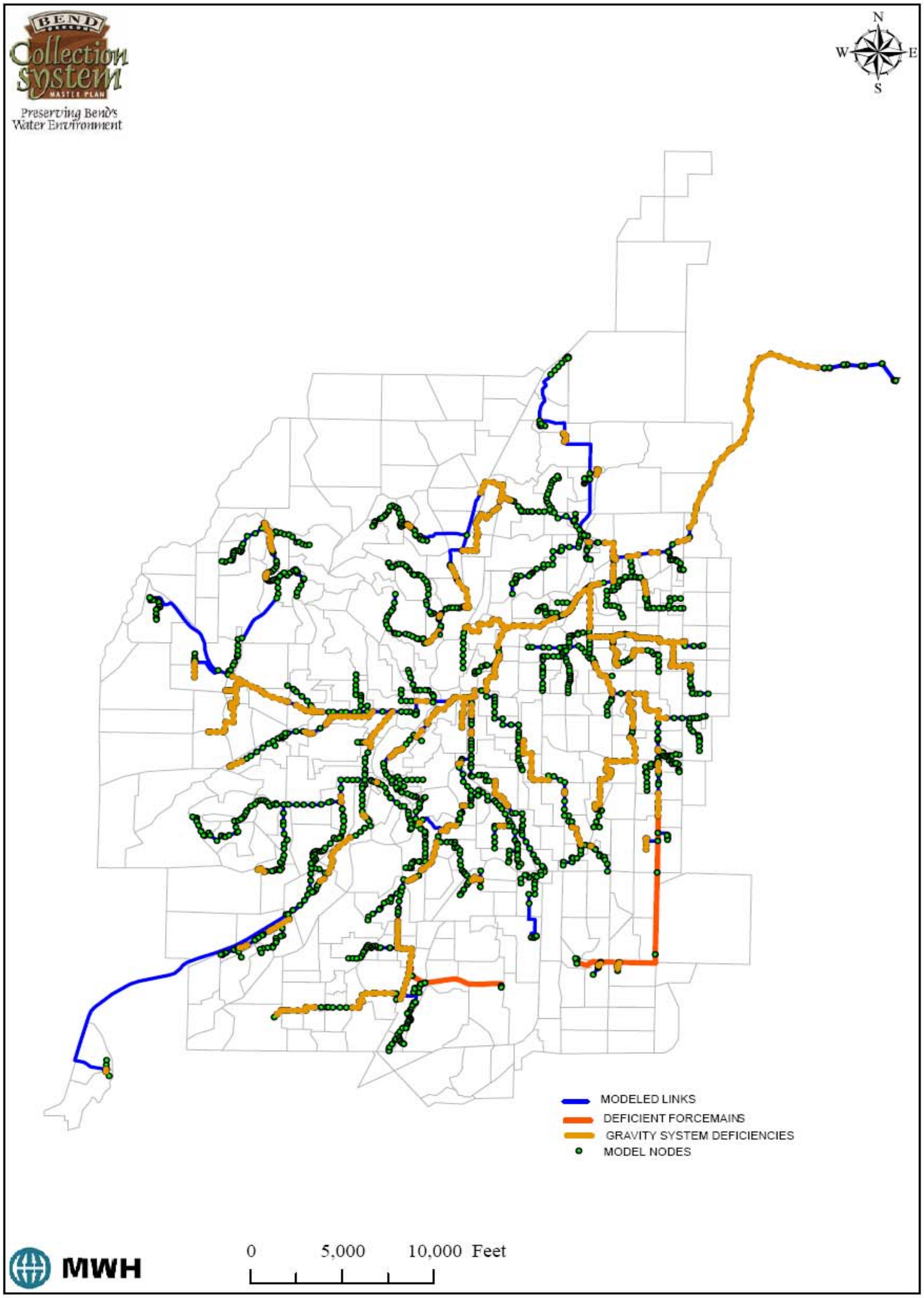


Figure 3-8 – Existing System at Build-out Flows

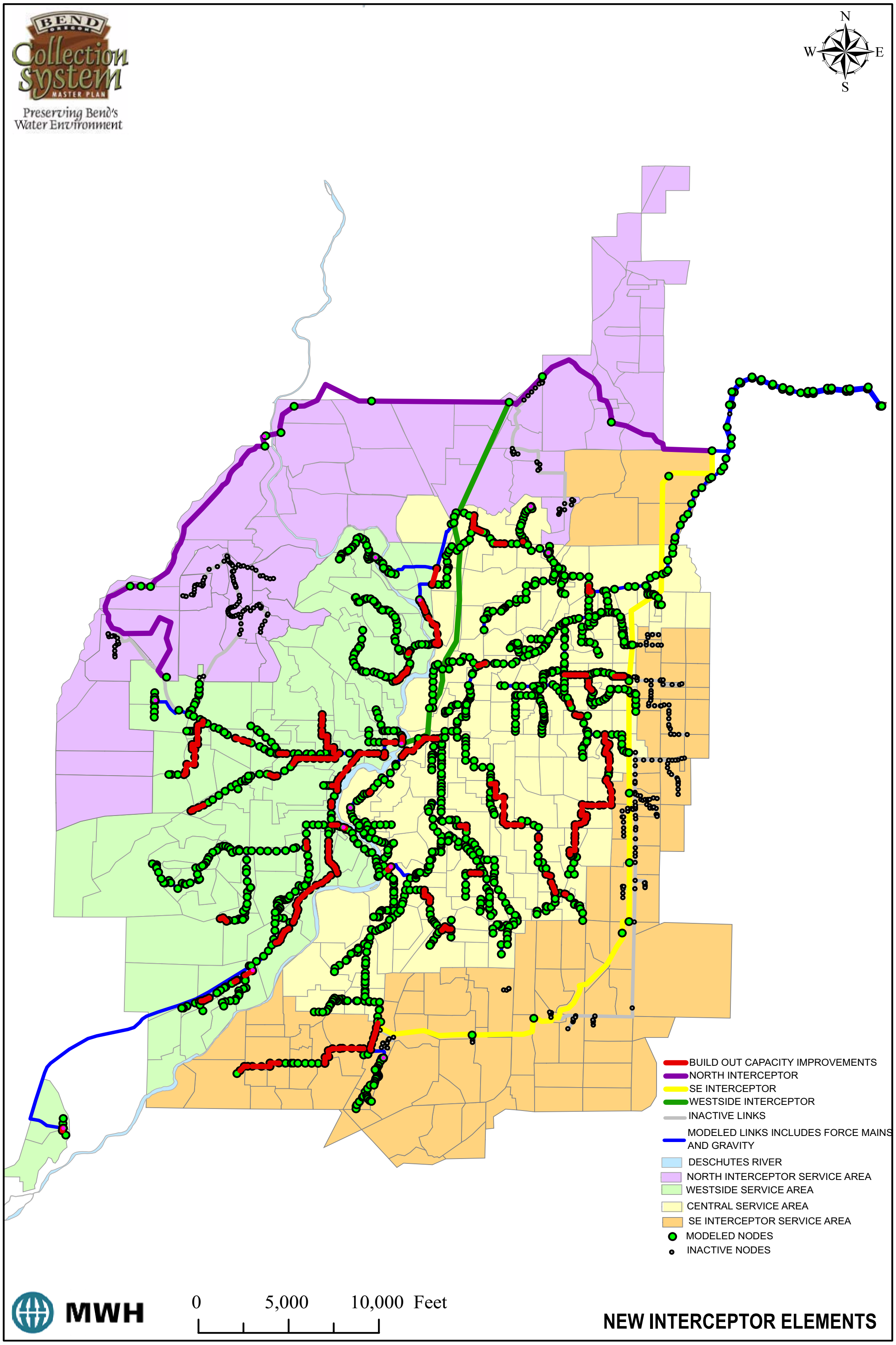


Figure 3-9 – New Interceptor Elements

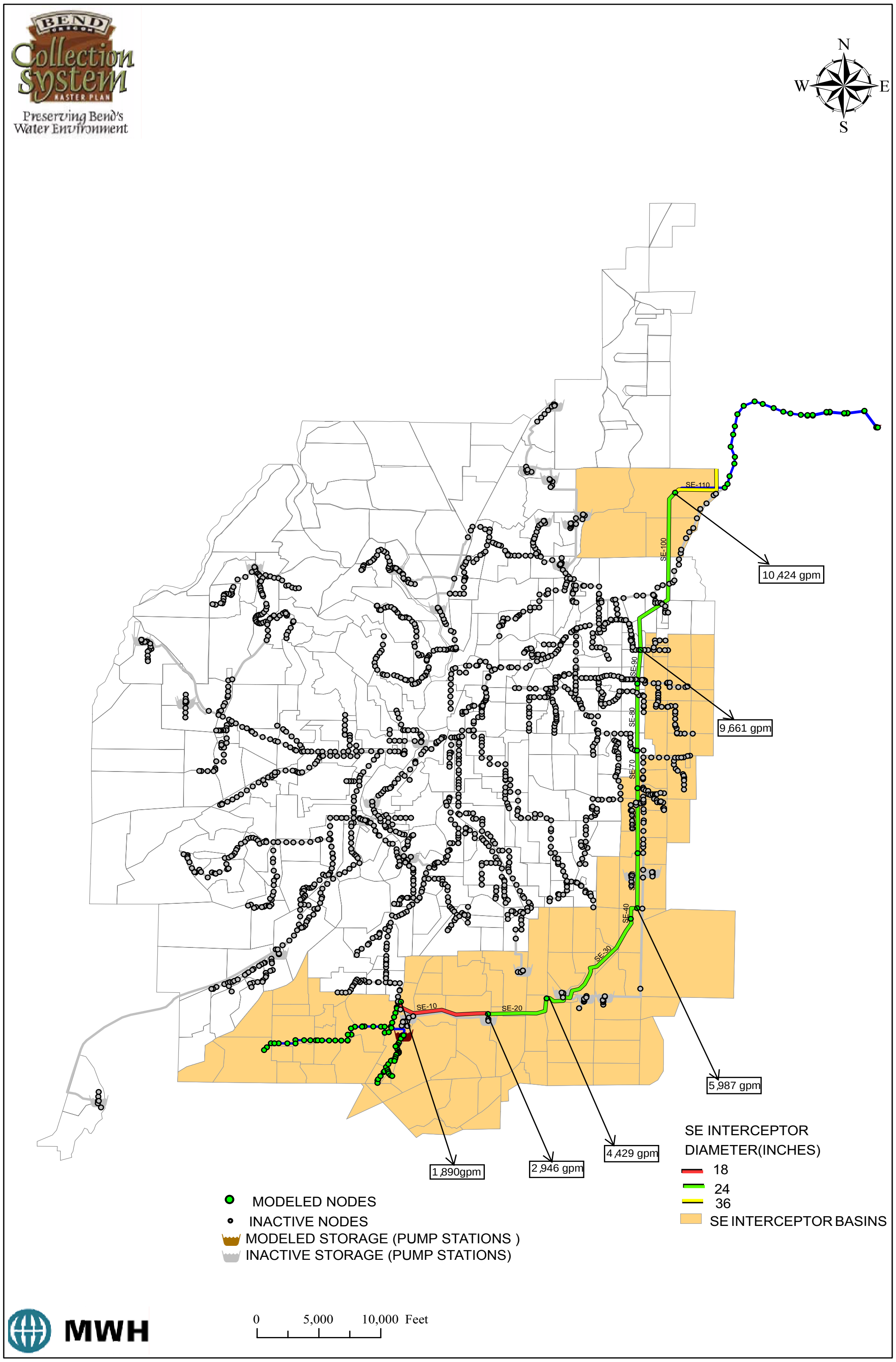


Figure 3-10 – SE Interceptor Flows and Sizes northern flow, and connected to the upstream end of the Southeast Interceptor. All the "grayed-out" portions of the model are turned off for this scenario. This scenario was run iteratively to determine optimum pipe sizes for the Southeast Interceptor under build-out conditions. The SE Interceptor pipe lengths and sizes that were modeled are shown in ***Table 3-1***.

WESTSIDE PUMP STATION BASIN SCENARIOS

Four scenarios were examined in order to evaluate the flows generated at build-out on the west side of the Deschutes River that will flow to the Westside Regional Pump station. All Westside scenarios include a new Westside Interceptor. Most of these flows go to the Westside Regional Pump Station. All Westside scenarios include a new Westside Interceptor. This interceptor begins with a forcemain approximately 3,000 feet long, followed by a gravity sewer approximately 21,000 feet long, discharging into the North Interceptor west of Juniper Ridge along Highway 97. There may be slight variations depending on the alignment selected, but this will not affect the final results. Constructing the new Westside Interceptor will redirect flow away from the existing core system and significantly reduce the deficiencies that will occur in there.

A number of scenarios were modeled to determine the most cost-effective long-term management of the flows in the Westside Regional Pump Station basin. The optimum solution included diversion of flows from the Awbrey Glen Pump Station, Shevlin Pump Station and some of the westerly basin to the North Interceptor. The deficiencies in the Westside Regional Pump Station basin for the recommended plan is shown in ***Figure 3-11***.

NORTH INTERCEPTOR

A new interceptor is planned to serve the existing northern areas of the City. All flows from northern sub-basins that can flow by gravity into the North Interceptor were assumed to do so. This included all undeveloped sub-basins outside the UGB as well as some currently developed sub-basins within the UGB. The sub-basins contributing to the North Interceptor, final interceptor sizing and flows are shown in ***Figure 3-12***. In the final Master Plan recommendation, the North Interceptor includes flows from all of the sub-basins from the proposed Juniper Ridge Development, the Shevlin Commons and Awbrey Glen Pump Stations and three currently undeveloped sub-basins located south of Shevlin Park on the west side of the City

In addition to the basins directed to the North Interceptor, the flows from the Sawyer Park, Wyndemere and Westside Regional Pump Stations were redirected into the North Interceptor through the proposed Westside Interceptor. The redirection of all of these flows to the new Westside Interceptor provided capacity relief to the existing downtown core system, minimizing the capacity upgrades that would be necessary in that system.

The model was used to optimize the size of the North Interceptor. The sizes and flows in the interceptor are shown in ***Figure 3-12***. A detailed analysis of the North Interceptor is provided in TM 3.9 – Interceptor Evaluations.

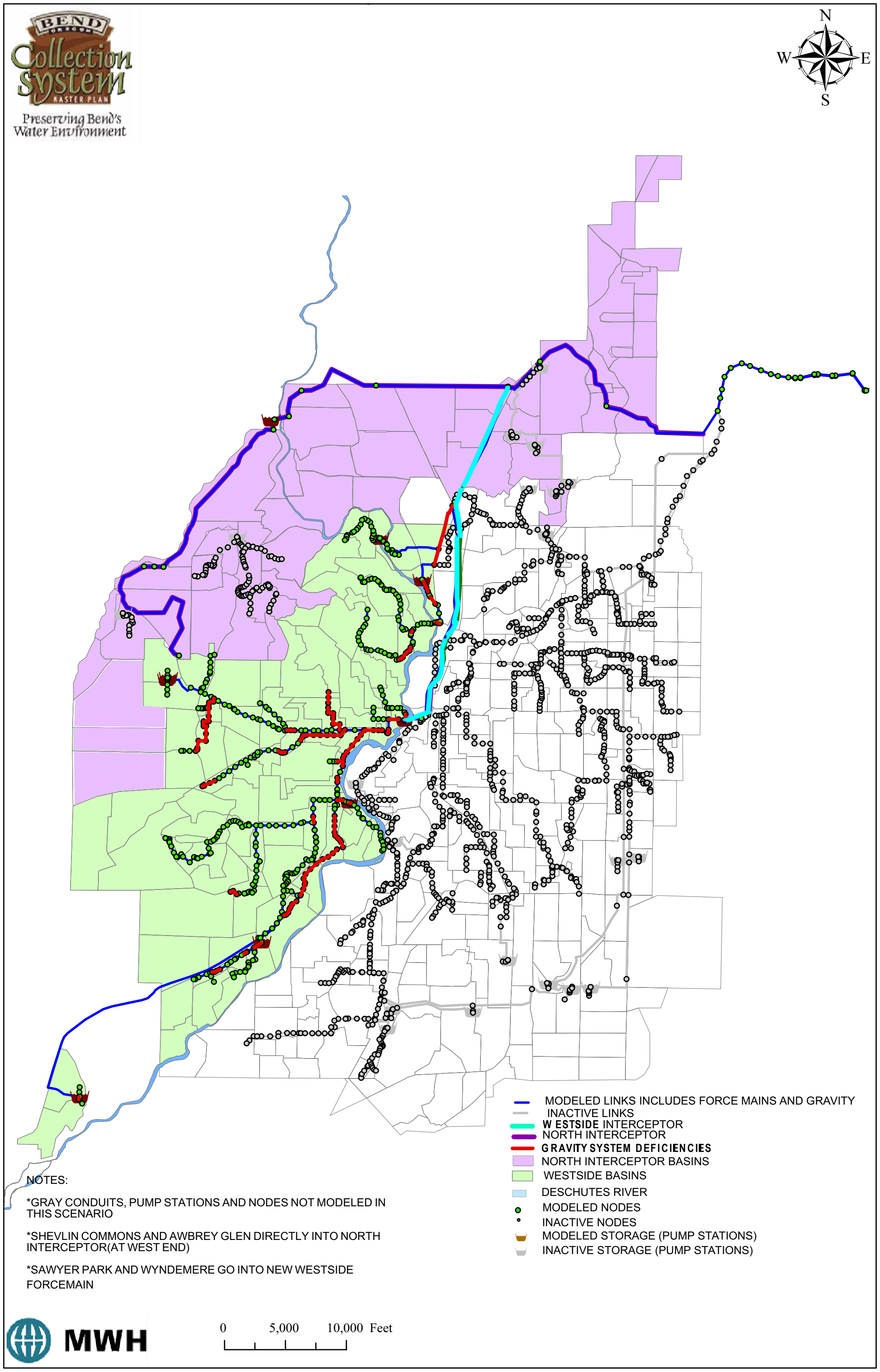


Figure 3-11 – Westside Basin Deficiencies

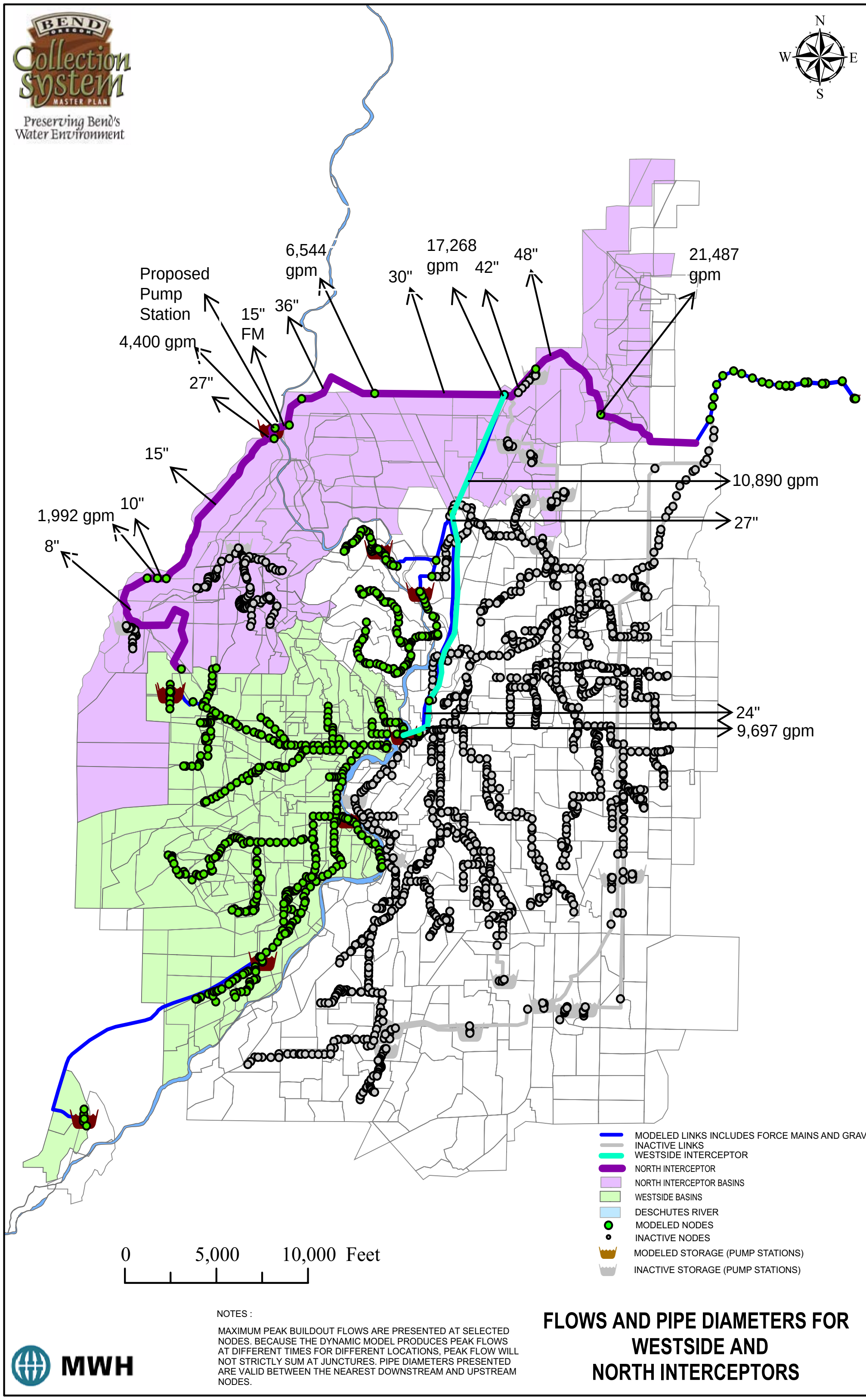


Figure 3-12 – Flows and Sizes for North and Westside Interceptors

CORE SYSTEM EVALUATION

All sub-basins that were not assigned to the Southeast, Westside or North Interceptors were directed to Core System Basin. Two Core System Basin scenarios were run. In the first scenario, the Sawyer Park and Wyndemere Pump Stations discharges were not changed and they continued to flow through the core system. This analysis showed that there were a large number of capacity deficiencies downstream of Sawyer Park and Wyndemere. These deficiencies are shown in ***Figure 3-13***.

The discharges from the Sawyer Park and Wyndemere Pump Stations were then redirected away from the core system basin by connecting them to the proposed Westside Interceptor. A second Core System Basin scenario was then run without these flows. The results of this scenario showed that there were very few capacity upgrades required downstream of the Sawyer Park and Wyndemere Pump Stations. The results of this analysis are shown in ***Figure 3-14***. The reductions in the required capacity upgrades to the Core System Basin were significant enough to make this the preferred option. Therefore, the discharge from the Sawyer Park and Wyndemere Pump Stations along with the discharge from the Westside Regional Pump Station will be removed from the Core System Basin by redirecting them to the North Interceptor through the proposed Westside Interceptor.

PLANT INTERCEPTOR SYSTEM AND SIPHONS

A new Plant Interceptor parallel to the existing interceptor is proposed. The Southeast Interceptor will connect to the North Interceptor southeast of Juniper Ridge. From there, the new Plant Interceptor flows parallel to the existing interceptor to the siphon box. At this point, the flows from the two interceptors will be joined in an expanded siphon box. The existing siphon is made up of two lines until just prior to the headworks where they combine into a 30-inch line that continues to the headworks.

A new headworks will be constructed at the treatment plant. As part of the new headworks, there will be a flow diversion box constructed. The hydraulic surface in the headworks diversion box used in modeling the system is 3373.72-feet. It is being recommended in the Master Plan that the two existing siphons not be combined into the common 30-inch line, but flow separately to the new headworks diversion box. A new 48-inch siphon is modeled in the Master Plan to connect the expanded siphon box to the new headworks diversion box. This will provide three independent siphon lines between the siphon box and the headworks diversion box. A more detailed analysis of siphon sizing needs to be done in predesign to match future flow increases.

In addition to the new siphon, the model has been configured with the SE Interceptor connecting to the existing Plant Interceptor at the point where it crosses the interceptor. This configuration allows flows from the Core System Basin to be diverted to the new Plant Interceptor.

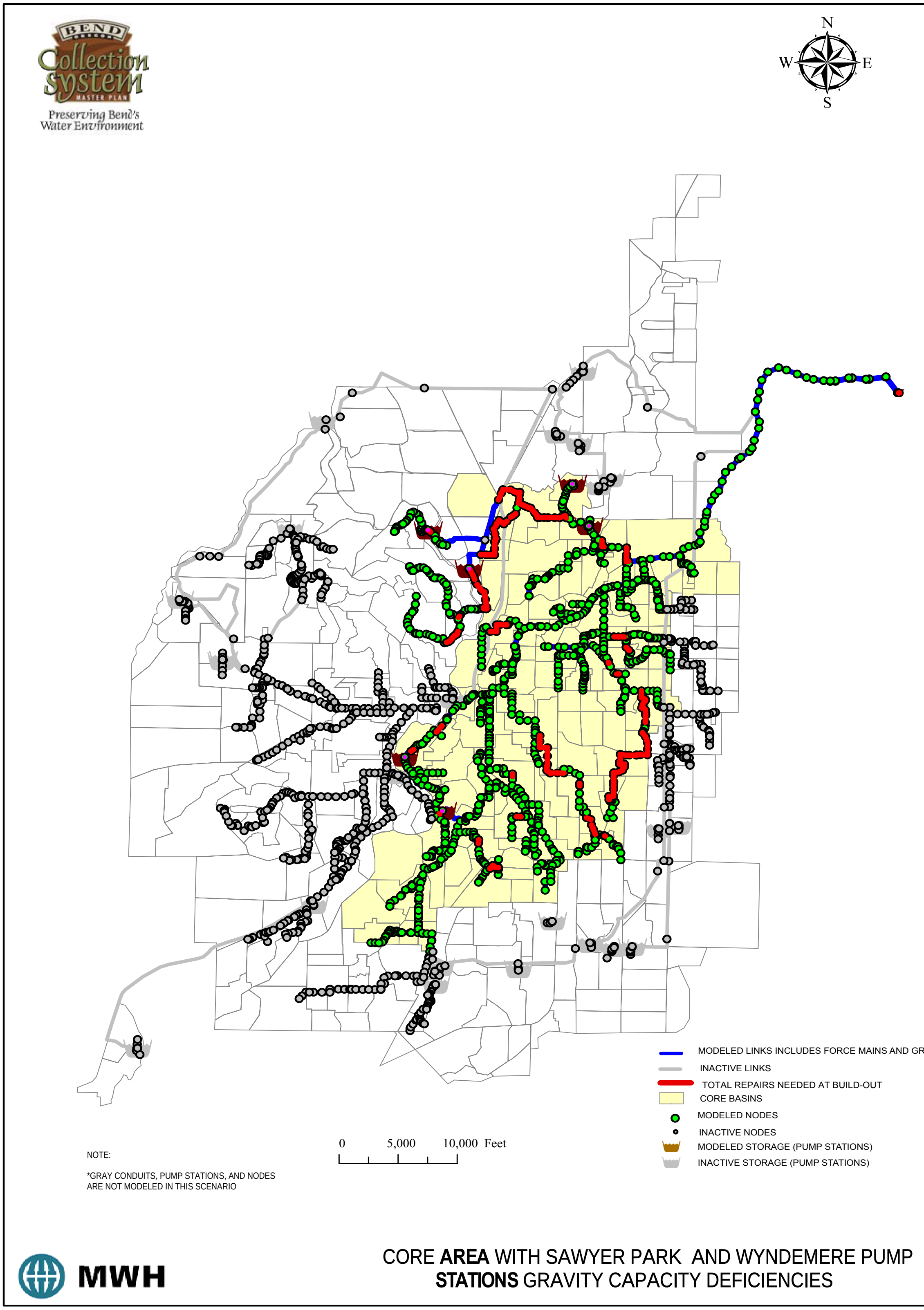


Figure 3-13 – Core System Deficiencies with Sawyer and Wyndemere Pump Stations

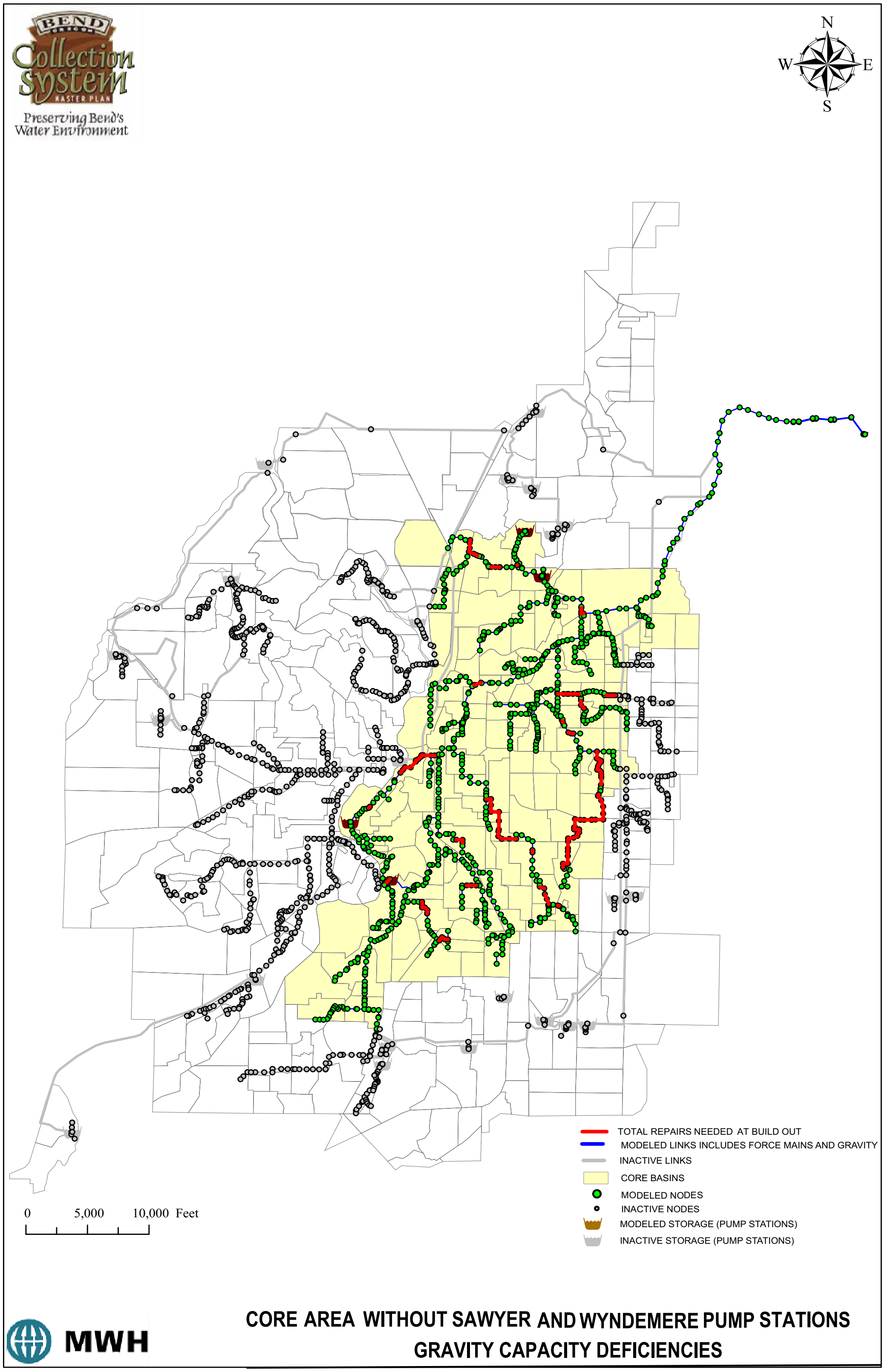


Figure 3-14 – Core System Deficiencies without Sawyer and Wyndemere Pump Stations

The interceptors were sized based on the design criteria as outlined in Section 2. The instantaneous peak flows and hydraulic conditions for both dry and wet weather conditions at the terminus of each major interceptor and at various elements within the system are summarized in ***Table 3-2***.

Table 3-2
Interceptors Build out Flow Summary

Line segment	Line size (in)	Flow (gpm)	Flow (MGD)	Depth (ft)	d/D	Velocity (fps)
WET WEATHER FLOWS						
North Interceptor	48	20993	30.2	3.48	0.87	4.04
SE Interceptor	36	10,409	15.0	2.27	0.76	4
System Core	36	16143	23.2	1.98	0.66	7.25
Upstream of Siphon Box	48	26389	38.0	2.46	0.62	7.3
	36	20993	30.2	2.61	0.87	7.14
Downstream of siphon Box	48	30000	43.2	2.985	0.75	9.259
	21	3216	4.6	1.75	1.00	3.833
	36	13676	19.7	2.485	0.83	5.751
Siphon Discharge	48	30000	43.2	4	1.00	5.3
	21	3216	4.6	1.75	1.00	2.3
	36	13679	19.7	2.5	0.83	6.2
DRY WEATHER FLOWS						
North Interceptor	48	17780	25.6	3.01	0.75	3.907
SE Interceptor	36	9442	13.6	2.23	0.74	4.047
System Core	36	12438	17.9	1.68	0.56	6.811
Upstream of Siphon Box	48	21356	30.8	2.15	0.54	6.897
	36	17910	25.8	2.52	0.84	6.302
Downstream of Siphon Box	48	22766	32.8	2.66	0.67	9.246
	21	3134	4.5	1.54	0.88	3.833
	36	13366	19.2	2.16	0.72	5.737
Siphon Discharge	48	22764	32.8	4.00	1.00	4.036
	21	3135	4.5	1.75	1.00	2.904
	36	13368	19.2	2.50	0.83	6.067

HYDRAULIC EVALUATION SUMMARY

A number of scenarios were modeled to determine capacity deficiencies that would develop under build-out flows. The scenarios were refined to develop a Master Plan that included four new interceptors: Parallel Plant Interceptor, North Interceptor, SE Interceptor and Westside Interceptor. The final modeled scenario provided the deficiencies that will exist in the system when build-out flows are experienced in the system that is recommended in the Master Plan. These deficiencies are shown in ***Figure 3-15.***

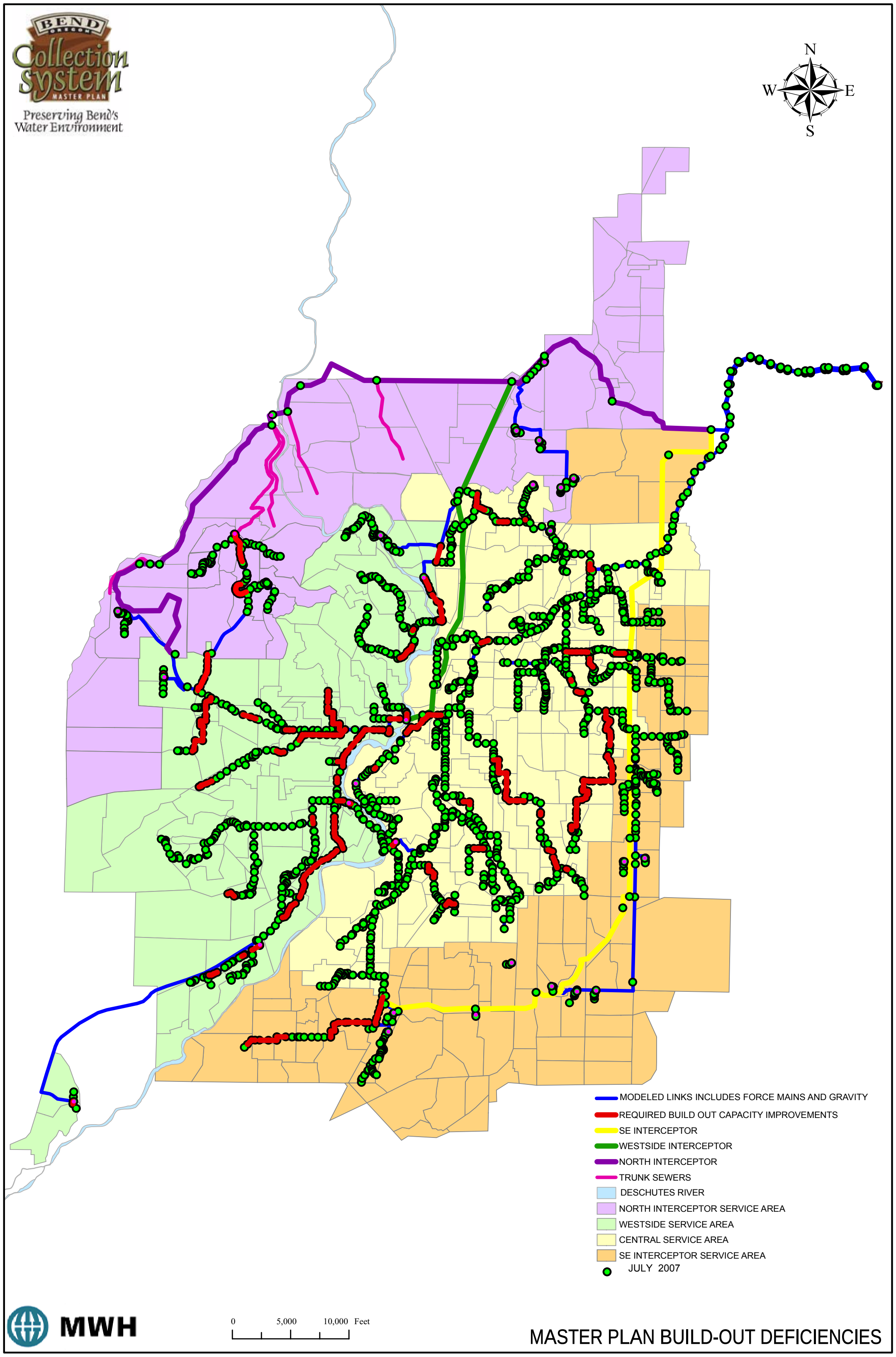


Figure 3-15 – Master Plan System Deficiencies

SECTION 4

CAPACITY IMPROVEMENT PROJECTS

INTRODUCTION

The planning area has been divided into nine study areas to provide for a more focused presentation of the final planning information. A stand-alone Study Area Plan was developed for each of the defined study areas. This section summarizes the gravity sewer capacity improvement projects that have been identified in each of the study areas.

STUDY AREAS

The entire planning area, both UGB and UAR, was divided into nine different study areas. The study areas were defined based on the "natural" drainage basins. In addition, the areas were defined to provide the best possible connectivity to the existing and future sewer system in terms of capacity and cost effectiveness. The system was modeled in InfoSWMM evaluating multiple alternatives, such as building new gravity sewers, diverting flows and increasing the capacity of the existing pump stations. ***Figure 4-1*** shows the nine defined study areas.

There are currently many areas within the City that do not receive sewer service. The planning team gathered GIS data and financial data on the system in May 2005. This information was combined to determine the tax lots that were provided with sanitary service (served) and those that were not (unserved). Based on this information, statistics for each of the study areas were developed. The methodology for determining served and unserved parcels is described in Section 2. This information is summarized in ***Table 4-1*** for each of the study areas.

SYSTEM CAPACITY IMPROVEMENTS

A number of scenarios were evaluated to develop the final system master plan. The first evaluation was to model the existing system under 2005 flows to determine the existing capacity limitations. The existing system was then modeled under build-out flows. This was done to determine the capacity issues of the existing system at build-out. This existing system with build-out flows was used as the "Base Case" condition. The rest of the modeling was done under build-out conditions to evaluate the various alternatives.

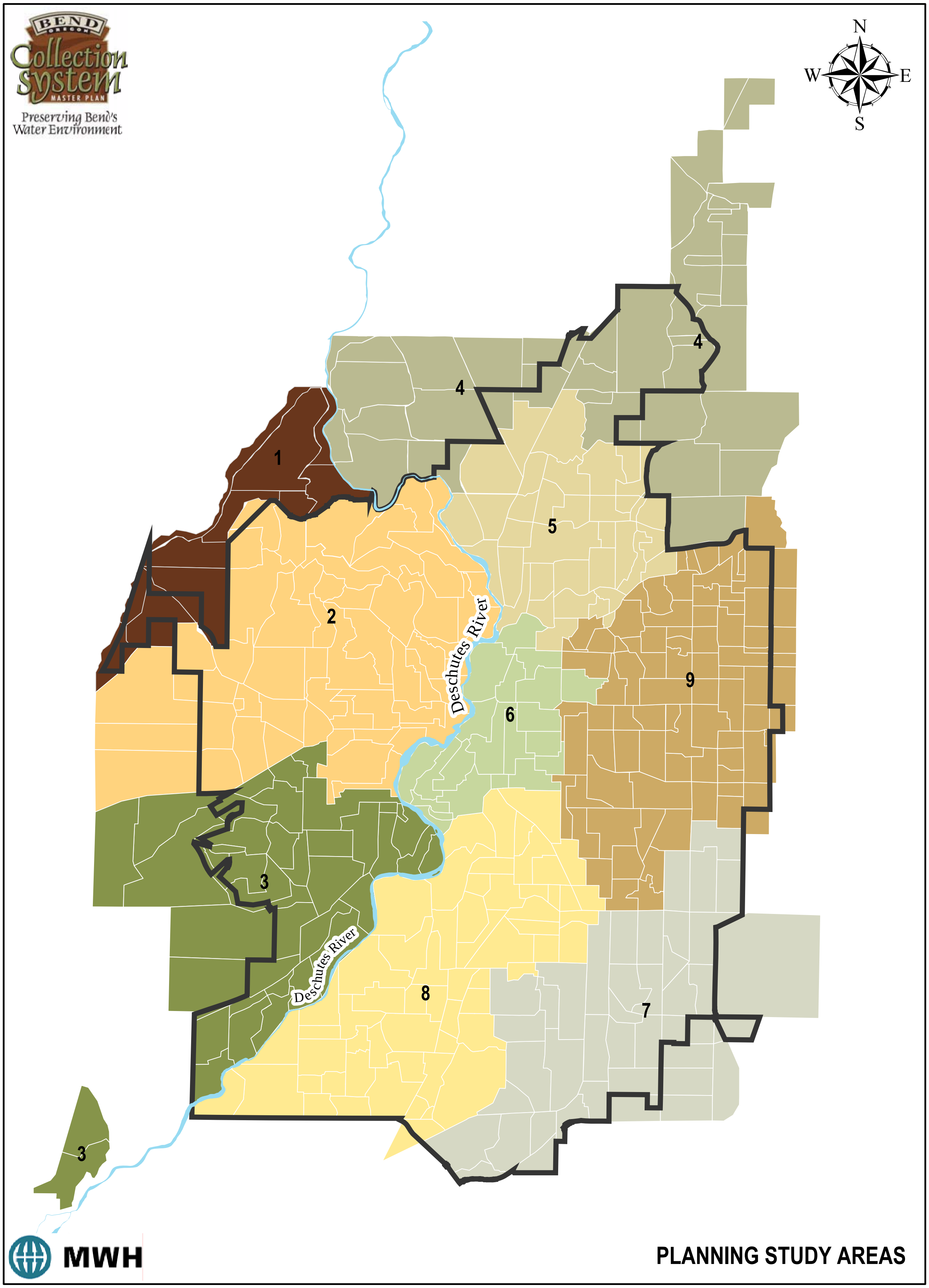


FIGURE 4-1 – PLANNING STUDY AREAS

Table 4-1
2006 Collection System Master Plan
Study Area Characteristics

Study Area	Total (Acres)	[1]Served (Acres)	[1]Unserved (Acres)
1	1376	36	339
2	4927	1970	1423
3	3920	824	1418
4	4625	96	311
5	2186	807	927
6	1218	611	223
7	3941	950	1836
8	3925	1313	1909
9	3853	1748	1100
Total	**29,971**	**8,353**	**9,488**

Notes:
1. Data based on May 2005 City of Bend Planning and Financial Information.

EXISTING SYSTEM DEFICIENCIES

In the existing flow scenario, the 2005 peak flows, both dry weather and wet weather were applied to the existing system in separate evaluations. There were no changes made to the existing system in this scenario. This scenario identified the capacity limitations that exist under the existing flow conditions. The existing system deficiencies are shown in ***Figure 4-2***.

This analysis showed that there are currently a few capacity deficiencies in the system. The most critical of these deficiencies are:

- Deficient capacity at the discharge of the Murphy Road Pump Station
- Deficient capacity at the discharge of the Westside Regional Pump Station
- Deficient capacity at the discharge of the Wyndemere and Sawyer Park Pump Stations

Each of these capacity limitations are addressed in the TM 3.8 Pump Station Master Plan.

REQUIRED CAPACITY IMPROVEMENTS

A number of scenarios were modeled to determine capacity deficiencies that would occur under build-out flows. The scenarios were refined with a Master Plan that included four new interceptors: Parallel Plant Interceptor, North Interceptor, SE Interceptor and Westside Interceptor. The final modeled scenario provided the deficiencies that will exist in the system when build-out flows are experienced in the system that is recommended in the Master Plan. These deficiencies are shown in ***Figure 4-3***. The capacity deficiencies that have been determined in this modeling effort have been evaluated and an estimated cost to upgrade each deficiency has been developed. The status of each capacity deficiency has also been noted as existing or future. An existing deficiency is one that exists at this time under current flows that will not be corrected once the major interceptors are constructed. The time period when a future capacity limitation will occur has not been determined. This will be dependent on how the growth occurs in each area throughout the City. City staff will need to monitor the flows at each of the identified deficiency areas to determine when the deficiency needs to be corrected.

PLANNING BY STUDY AREA

The planning area has been divided into nine study areas to provide for a more focused presentation of the final planning information. The study areas were defined so that they follow "natural" drainage basins and provide the best possible connectivity to the existing and future sewer system in terms of capacity and cost effectiveness. ***Figure 4-1*** shows the nine defined study areas. The system capacity deficiencies have been organized by study area and the capacity improvements shown here are sized and costed for build out flow conditions and are discussed in each of the following sections.

STUDY AREA 1

Study Area 1 is located on the northwest corner of the Bend planning area. Most of this 1376 acre study area is located outside of the UGB. Only 375 acres are within the current UGB with the rest of the study area in the UAR. The area is mostly undeveloped with only 19 parcels currently receiving sanitary sewer service. A more detailed description of the projects identified for this study area are described in the Study Area 1 Master Plan.

STUDY AREA 2

Study Area 2 is located on the west side of the Bend planning area. This is the largest of the planning areas at 4927 acres. This planning area includes the Aubrey Glenn and Shevlin communities. Most of this study area is within the UGB with only 834 acres outside of the UGB. There has been a large amount of development in this study area over the past five years. Approximately 1970 acres receive sewer service with 1423 acres available for development within the UGB.

There are 15 capacity improvements that need to be performed in Study Area 2. The total value of these improvements is estimated at $5,799,415. The segments of the collection system requiring improvements are shown in ***Figure 4-4***. The scope of each project and the estimated cost for each project is itemized in ***Table 4-2***. A more detailed description of the projects is provided in the Study Area 2 Master Plan.

Two capacity deficiencies exist today and are noted as projects 2-3 and 2-15. The estimated cost to correct these deficiencies is $607,211.

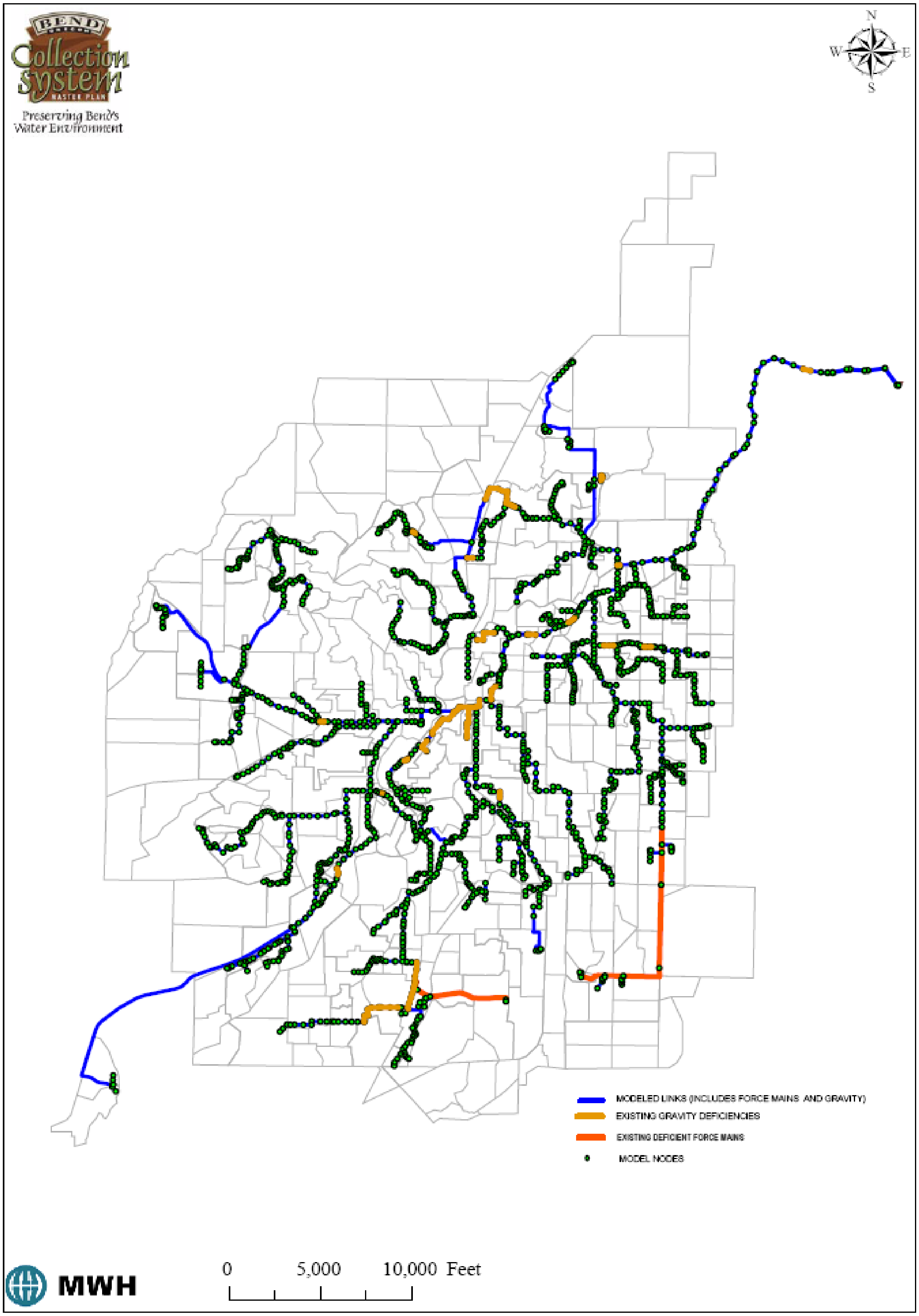


FIGURE 4-2– EXISTING SYSTEM DEFICIENCIES

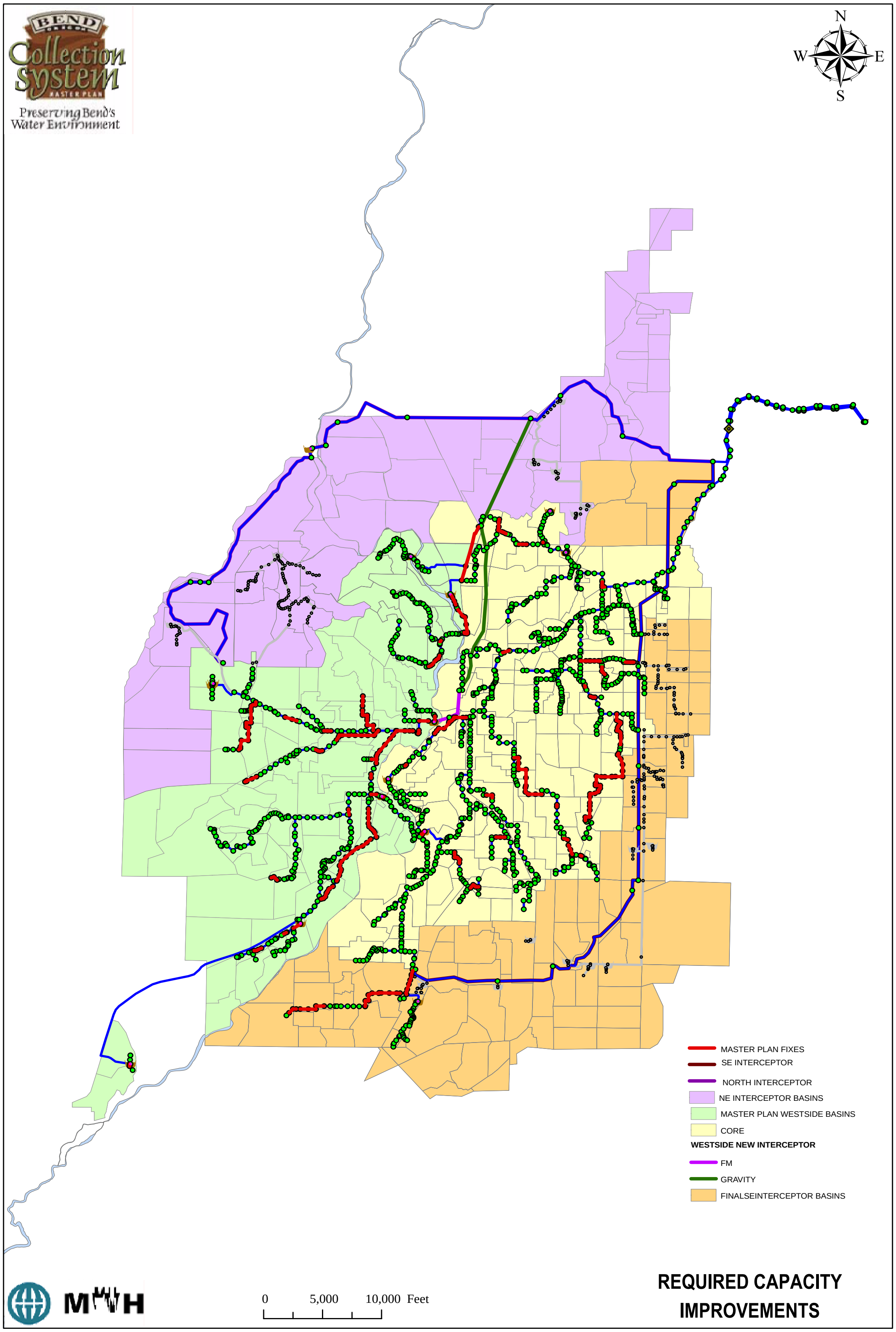


FIGURE 4-3– REQUIRED CAPACITY IMPROVEMENTS AT SYSTEM BUILD-OUT

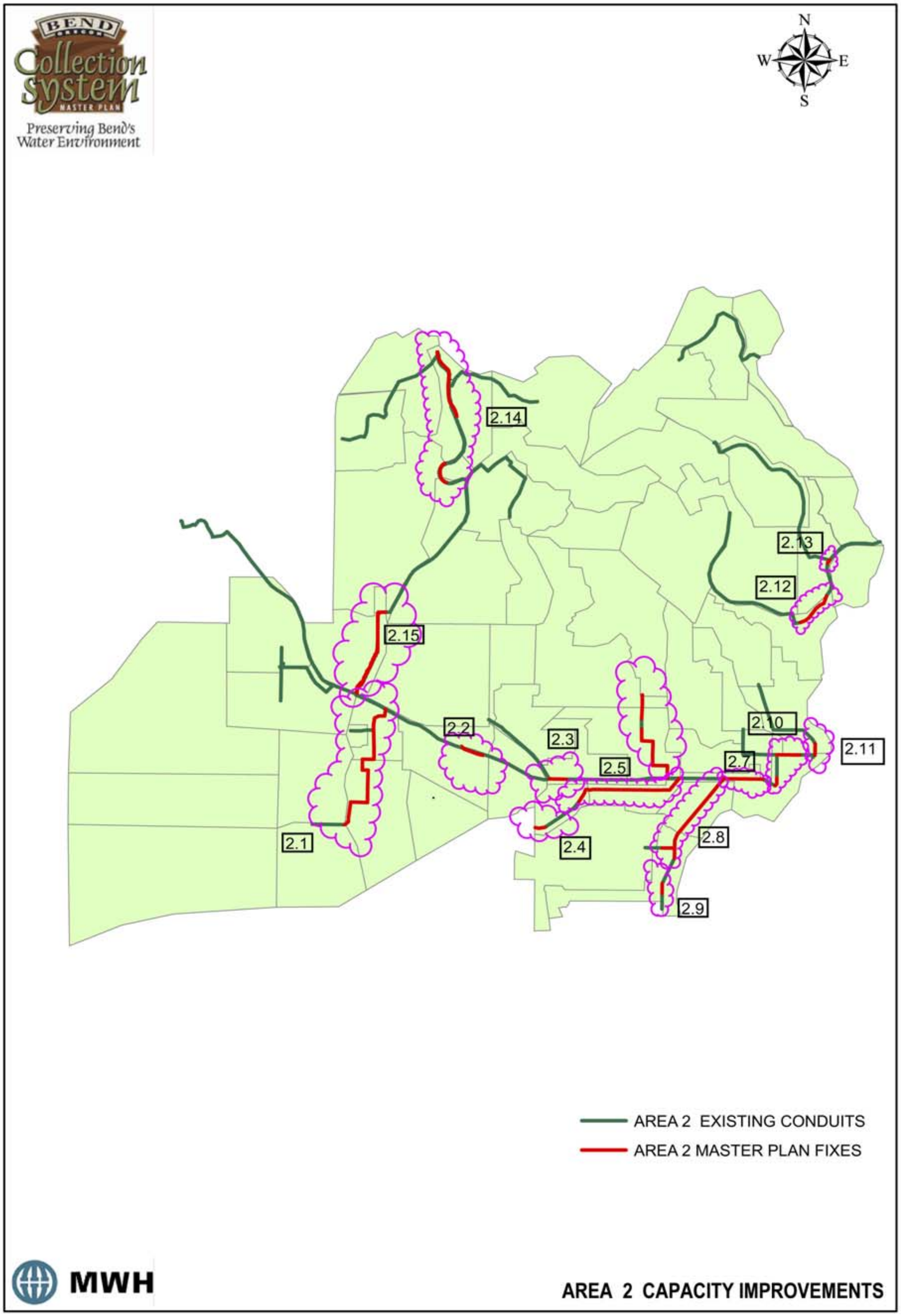


FIGURE 4-4– STUDY AREA 2 REQUIRED CAPACITY IMPROVEMENTS

Table 4-2
City of Bend Collection System Master Plan
Study Area 2 Capacity Improvement Projects

Project	Status	Description	Parameters Existing (in)	Future (in)	Length (ft)	Project Total ($)
2-1	Future	Gravity Sewer Upgrade	10	12	775	932,843
			8	12	464	
			8	10	2892	
2-2	Future	Gravity Sewer Upgrade	12	15	309	183,176
			10	12	450	
2-3	Existing	Gravity Sewer Upgrade	8	12	425	99,052
2-4	Future	Gravity Sewer Upgrade	8	10	252	56,123
2-5	Future	Gravity Sewer Upgrade	8	15	624	666,577
			8	12	819	
			8	10	1,426	
2-6	Future	Gravity Sewer Upgrade	10	15	325	596,294
			8	18	690	
			8	12	435	
			8	10	1,020	
2-7	Future	Gravity Sewer Upgrade	27	30	989	465,101
2-8	Future	Gravity Sewer Upgrade	21	27	1,606	1,056,263
			21	24	877	
			8	24	305	
2-9	Future	Gravity Sewer Upgrade	21	24	249	84,695
2-10	Future	Gravity Sewer Upgrade	30	36	798	412,363
2-11	Future	Gravity Sewer Upgrade	10	15	294	74,496
2-12	Future	Gravity Sewer Upgrade	8	10	986	219,592
2-13	Future	Gravity Sewer Upgrade	8	10	93	20,712
2-14	Future	Gravity Sewer Upgrade	8	10	914	423,969
			8	12	759	
			8	15	504	
			10	12	40	
2-15	Existing	Gravity Sewer Upgrade	8	10	1311	508,159
			8	12	612	
			8	15	67	

STUDY AREA 3

Study Area 3 is located on the southwest side of the Bend planning area. This study area is 3920 acres in size with 1655-acres in the UAR. Approximately 1418 acres are available for development. This planning area includes the Widgi Creek service area. The Widgi Creek service area is served by the City under a special agreement and is not located within the UGB or UAR.

There are 8 build-out capacity improvements that need to be performed in Study Area 3. The total value of these improvements is estimated at $2,547,757. The segments of the collection system requiring improvements are shown in **Figure 4-5**. The scope of each project and the estimated cost for each project is itemized in ***Table 4-3***. A more detailed description of the projects is provided in the Study Area 3 Master Plan.

Table 4-3
City of Bend Collection System Master Plan
Study Area 3 System Capacity Improvement Projects

Project	Status	Description	Parameters			Project Total ($)
			Existing (in)	Future (in)	Length (ft)	
3-1	Future	Gravity Sewer Upgrade	8	12	446	107,796
3-2	Future	Gravity Sewer Upgrade	8	15	504	280,250
			8	10	640	
3-3	Existing	Gravity Sewer Upgrade	10	15	3,914	1,694,372
			10	12	1,269	
			8	15	364	
			8	10	1,141	
3-4	Future	Gravity Sewer Upgrade	15	18	352	98,082
3-5	Future	Gravity Sewer Upgrade	8	12	347	109,274
3-6	Future	Gravity Sewer Upgrade	8	10	796	183,843
3-7	Future	Gravity Sewer Upgrade	8	10	185	42,727
3-8	Future	Gravity Sewer Upgrade	6	8	143	31,413

One capacity deficiency exists today and is noted as project 3-3. The estimated cost to correct this deficiency is $1,694,372.

STUDY AREA 4

Study Area 4 is located in the north of the Bend planning area. This is the second largest of the planning areas at 4625 acres. Approximately 96 acres receive sewer service. No build-out capacity deficiencies were identified in Study Area 4. This area will be served in the future by the North Interceptor. A detailed description of the projects identified for this study area is provided in the Study Area 4 Master Plan.

STUDY AREA 5

Study Area 5 is located in the North-central area of Bend planning providing service on the east side of the Deschutes River. This study area is 2,186 acres in size. This area does not have any UAR lands.

There are 6 build-out capacity improvements that need to be performed in Study Area 5. The total value of these upgrades is estimated at $2,186,005. The segments of the collection system requiring improvements are shown in ***Figure 4-6***. The scope of each project and the estimated cost for each project is itemized in ***Table 4-4***. A more detailed description of the projects is provided in the Study Area 5 Master Plan.

Table 4-4
City of Bend Collection System Master Plan
Study Area 5 System Capacity Improvement Projects

Project	Status	Description	Parameters			Project Total ($)
			Existing (in)	Future (in)	Length (ft)	
5-1	Existing	Gravity Sewer Upgrade	24	30	425	176,638
5-2	Future	Gravity Sewer Upgrade	12	15	2582	678,476
5-3	Future	Gravity Sewer Upgrade	6	8	3,586	787,751
5-4	Existing	Gravity Sewer Upgrade	12	15	494	415,149
			8	12	268	
			8	10	955	
5-5	Future	Gravity Sewer Upgrade	15	18	15	4180
5-6	Existing	Gravity Sewer Upgrade	21	24	351	123,811

Three capacity deficiencies exist today and are noted as projects 5-1, 5-4 and 5-6. The estimated cost to correct these deficiencies is $715,598.

STUDY AREA 6

Study Area 6 serves the downtown core of the Bend planning area. This study area is 1218-acres in size with no acres in the UAR. Approximately, 611 acres receive sewer service and 195 acres are either undeveloped or not buildable within the UGB.

There are 2 capacity improvements that need to be performed in Study Area 6. The total value of these improvements is estimated at $661,496. The segments of the collection system

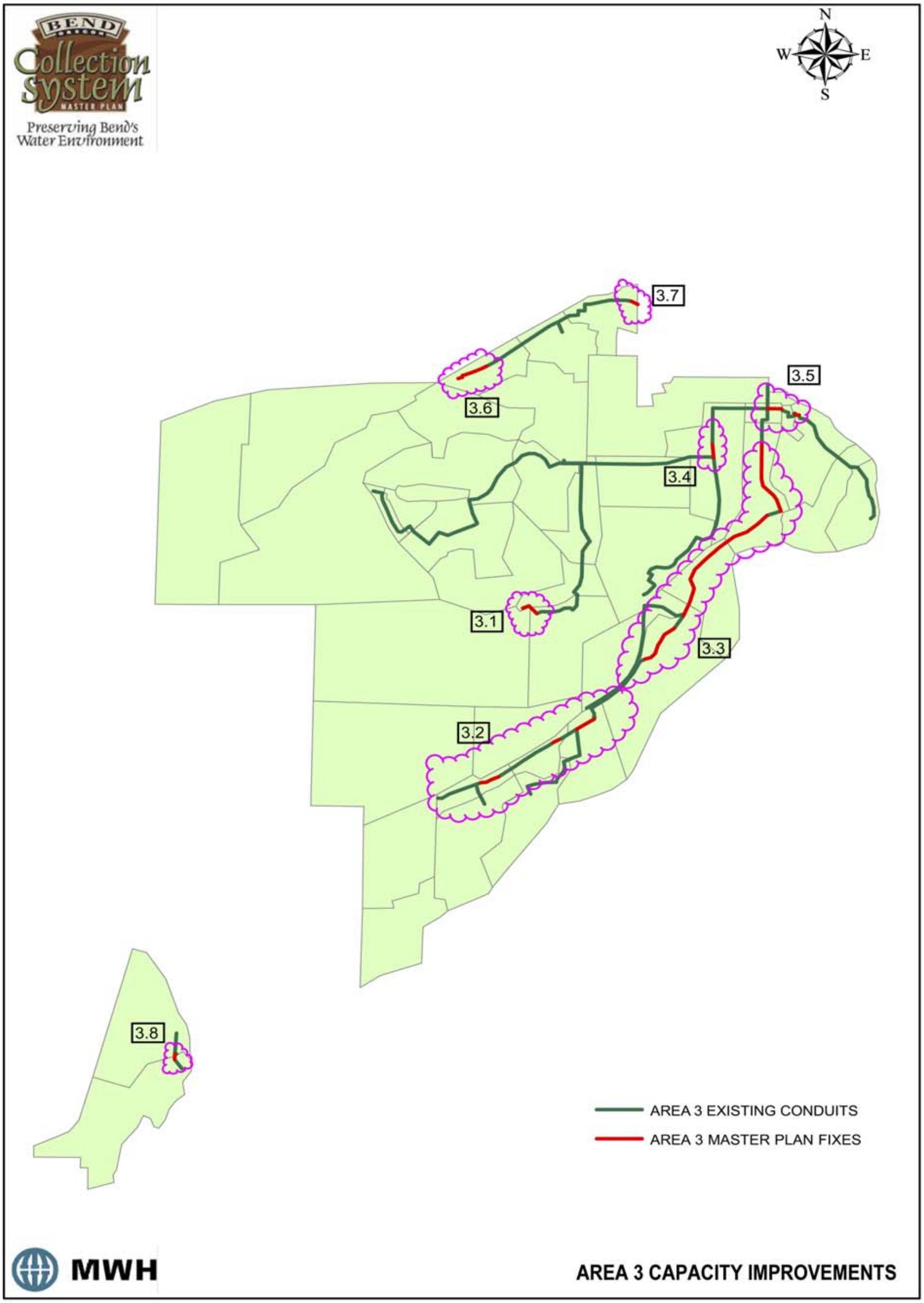


FIGURE 4-5– STUDY AREA 3 REQUIRED CAPACITY IMPROVEMENTS

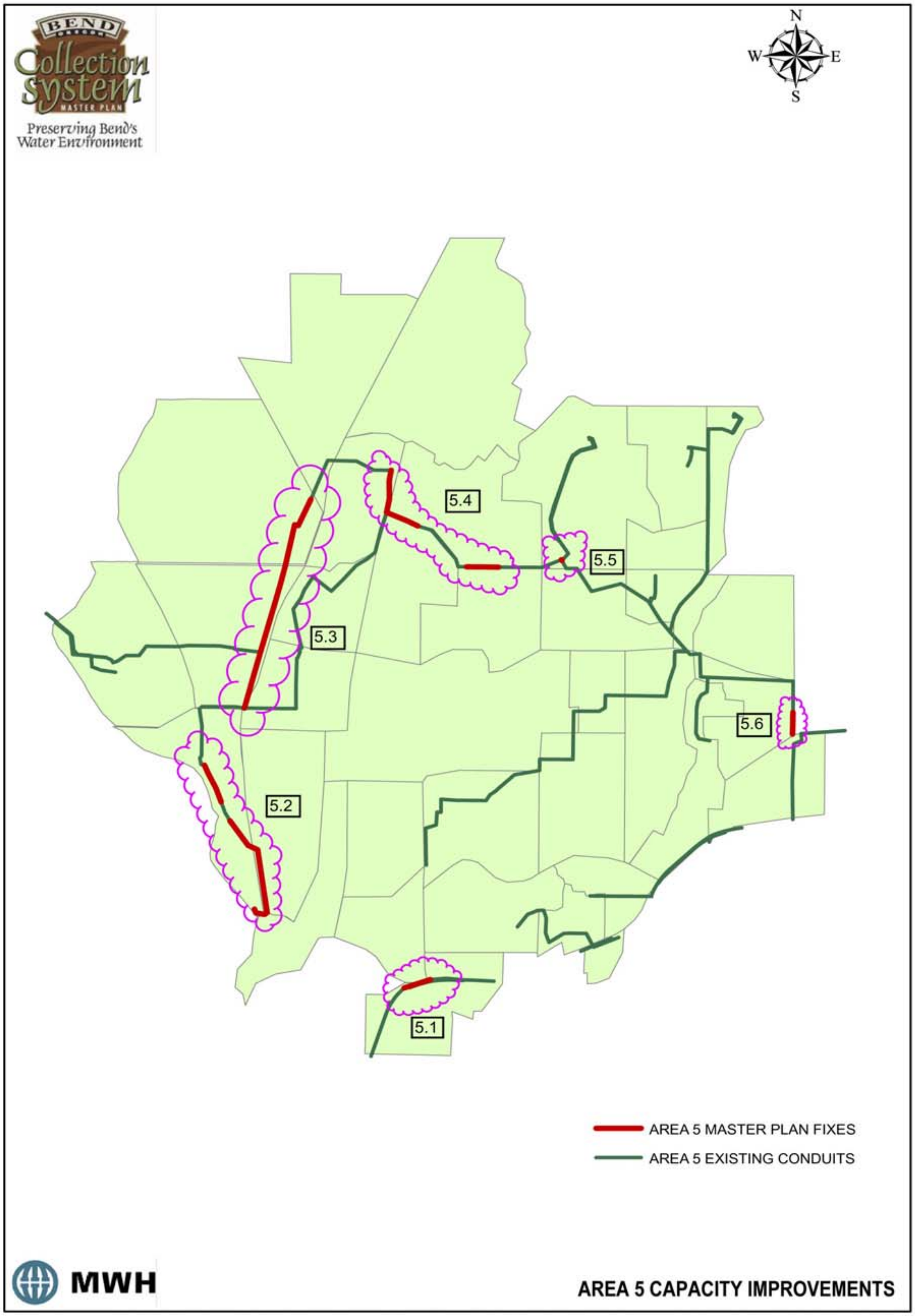


FIGURE 4-6– STUDY AREA 5 REQUIRED CAPACITY IMPROVEMENTS

requiring improvements are shown in ***Figure 4-7***. The scope of each project and the estimated cost for each project is itemized in ***Table 4-5***. A more detailed description of the projects is provided in the Study Area 6 Master Plan.

Table 4-5
City of Bend Collection System Master Plan
Study Area 6 System Capacity Improvement Projects

Project	Status	Description	Parameters			Project Total ($)
			Existing (in)	Future (in)	Length (ft)	
6-1	Existing	Gravity Sewer Upgrade	8	12	95	22,961
6-2	Existing	Gravity Sewer Upgrade	12	15	2235	638,535
			16	18	195	
6-3	New	New Pump Station	300-gpm			$575,000

Two deficiencies exist today that are capacity limitations in gravity sewers. These are noted as projects 6-1 and 6-2. The estimated cost to correct these deficiencies is $661,496.

Project 6-3 was identified to correct a grade problem in the system where a new pump station needs to be constructed. The City did a project in 2001 to remove the 4th and Addison Pump Station. The pump station was replaced with a manhole and 14.6-feet of 21-inch PVC line. The flow enters this manhole 4.5-feet lower than it exits the manhole. This results in the surcharge of 1200-feet of gravity sewer upstream of this manhole. The upstream gravity sewer is located in an area that would be extremely difficult to replace with one at a grade that would not cause surcharging of the system. The gravity sewer upstream of this manhole crosses Highway 97. For this reason, it is recommended that a new pump station be constructed to lift this flow and eliminate the system surcharging. This pump station will need to pump a peak flow of 300-gpm at system build-out. The estimated cost for this station is $575,000. This includes an estimated cost for land of $200,000.

STUDY AREA 7

Study Area 7 is located in the southeast corner of the Bend planning area. This study area is 3941-acres in size with 1155-acres in the UAR. The Master Plan for providing gravity sewers to this area is dependent on the construction of SE Interceptor. The SE Interceptor will allow the decommissioning of the Murphy Road Regional Pump station as well as provide the required capacity to serve this area in both near and long terms. A detailed description of

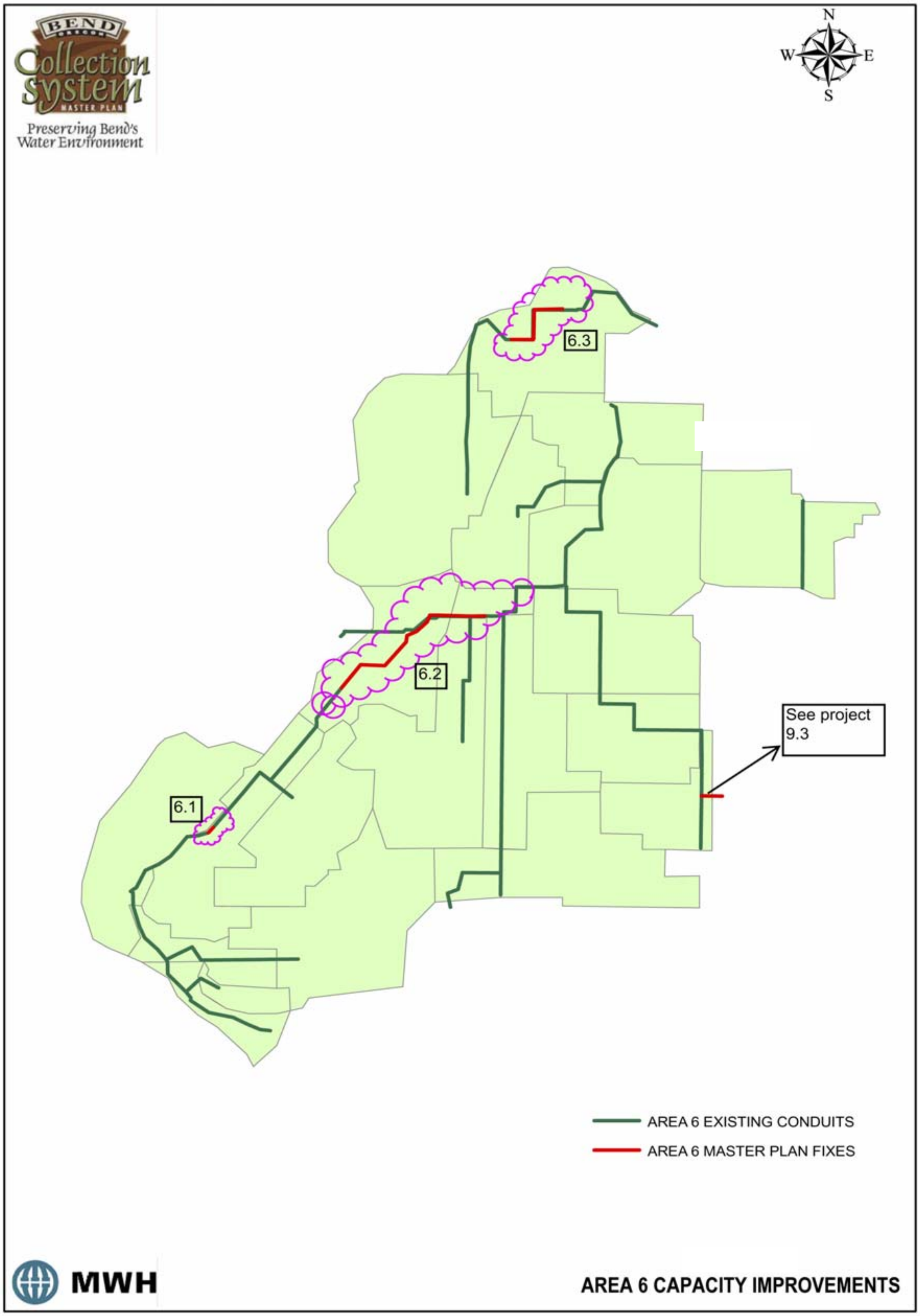


FIGURE 4-7– STUDY AREA 6 REQUIRED CAPACITY IMPROVEMENTS

projects identified for this study area is provided in the Study Area 7 Master Plan.

STUDY AREA 8

Study Area 8 is located on the south side of the Bend planning area, east of the Deschutes River. Approximately 1,313 acres receive sewer service. This study area is 3925-acres in size with only 7-acres in the UAR.

There are 7 build-out capacity improvements that need to be performed in Study Area 8. The total value of these upgrades is estimated at $2,266,186. The segments of the collection system requiring improvements are shown in ***Figure 4-8***. The scope of each project and the estimated cost for each project is itemized in ***Table 4-6***. A more detailed description of the projects is provided in the Study Area 8 Master Plan.

Table 4-6
City of Bend Collection System Master Plan
Study Area 8 System Capacity Improvement Projects

Project	Status	Description	Parameters			Project Total ($)
			Existing (in)	Future (in)	Length (ft)	
8-1	Future	Gravity Sewer Upgrade	10	12	962	463,565
			8	12	1027	
8-2	Existing	Gravity Sewer Upgrade	15	18	80	1,181,453
			12	18	2433	
			12	15	1949	
8-3	Future	Gravity Sewer Upgrade	8	10	640	142,534
8-4	Future	Gravity Sewer Upgrade	12	15	737	186,746
8-5	Future	Gravity Sewer Upgrade	10	12	250	58,266
8-6	Future	Gravity Sewer Upgrade	8	10	527	117,368
8-7	Existing	Gravity Sewer Upgrade	8	10	522	116,254

Two capacity deficiencies exist today and are noted as projects 8-2 and 8-7. The estimated cost to correct these deficiencies is $1,297,707.

STUDY AREA 9

Study Area 9 is located on the east-central side of the Bend planning area. This study area is 3,853-acres in size. Approximately 1,748 acres receive sewer service. Approximately 1,005 acres are outside the UGB.

There are 8 build-out capacity improvements that need to be performed in Study Area 9. The total value of these upgrades is estimated at $3,834,660. The segments of the collection system requiring improvements are shown in **Figure 4-9**. The scope of each project and the estimated cost for each project is itemized in ***Table 4-7***. A more detailed description of the projects is provided in the Study Area 9 Master Plan.

Table 4-7
City of Bend Collection System Master Plan
Study Area 9 System Capacity Improvement Projects

Project	Status	Description	Parameters			Project Total ($)
			Existing (in)	Future (in)	Length (ft)	
9-1	Future	Gravity Sewer Upgrade	10	12	268	227,138
			8	10	703	
9-2	Future	Gravity Sewer Upgrade	8	10	136	31,410
9-3	Future	Gravity Sewer Upgrade	12	15	3,919	1,034,532
			8	15	18	
9-4	Future	Gravity Sewer Upgrade	10	12	1,544	1,853,664
			8	12	313	
			8	10	7,354	
9-5	Future	Gravity Sewer Upgrade	15	18	397	110,621
9-6	Future	Gravity Sewer Upgrade	10	12	538	130,032
9-7	Existing	Gravity Sewer Upgrade	8	10	515	118,943
9-8	Existing	Gravity Sewer Upgrade	12	18	515	328,320
			12	15	693	

Two capacity deficiencies exist today and are noted as projects 9-7 and 9-8. The estimated cost to correct these deficiencies is $447,263.

SUMMARY OF PROJECT COSTS

The cost in 2006 dollars for mitigating all existing and "build-out" capacity deficiencies were summarized for each of the nine study areas. These capital improvements are required to provide adequate sanitary service to the planning area between now and system build-out. These costs are summarized in Table ***4-8*** by study area. This summary shows that the cost to provide upgrades to the existing system is $17,870,530.

Table 4-8
Existing and Build-out
Capacity Improvements Summary

System Component	Project Cost ($)
Study Area 1	0
Study Area 2	5,799,415,
Study Area 3	2,547,760
Study Area 4	0
Study Area 5	2,186,005
Study Area 6	1,236,500
Study Area 7	0
Study Area 8	2,266,190
Study Area 9	3,834,660
Total Cost at Build-out	***17,870,530***

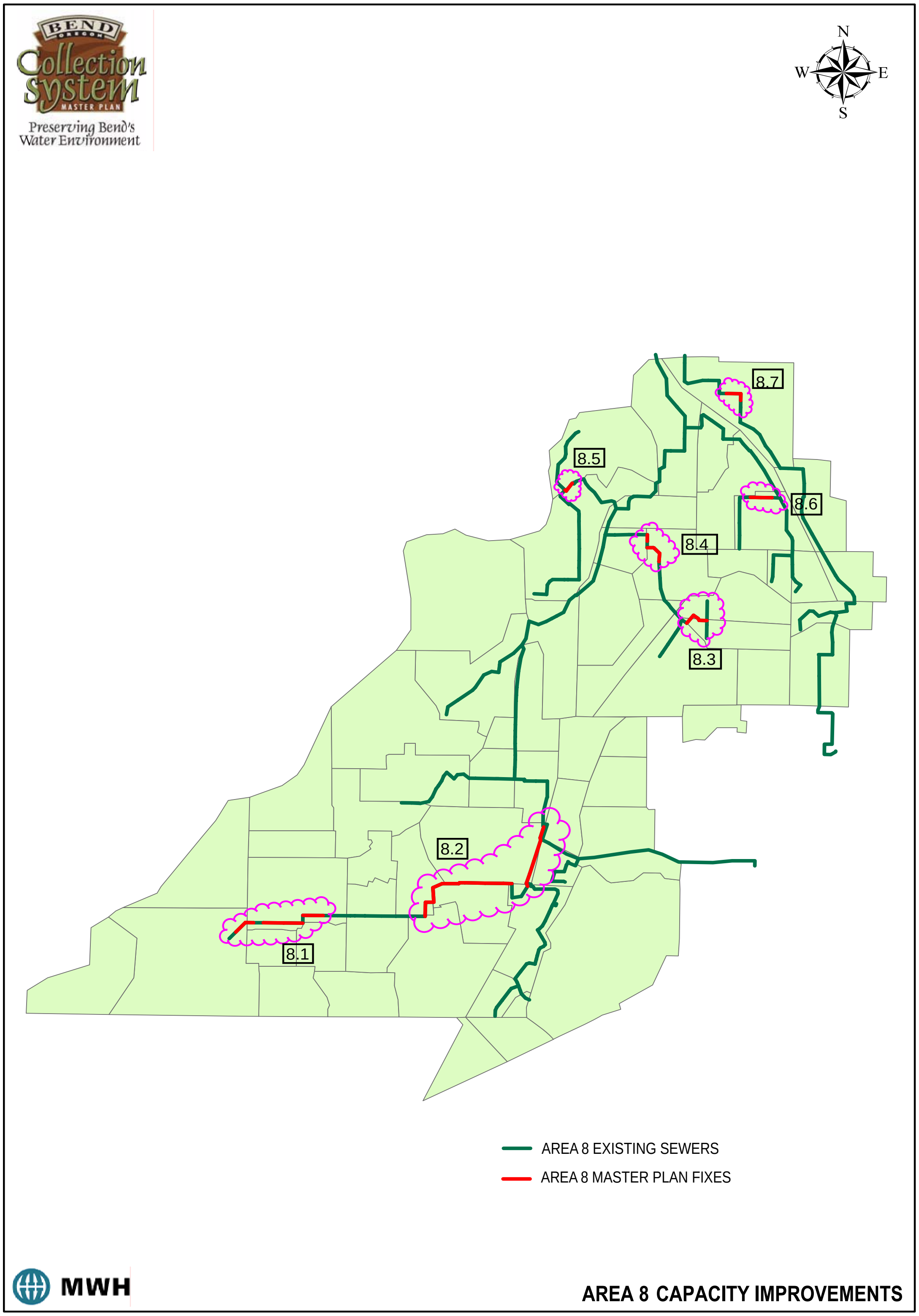


FIGURE 4-8– STUDY AREA 8 REQUIRED CAPACITY IMPROVEMENTS

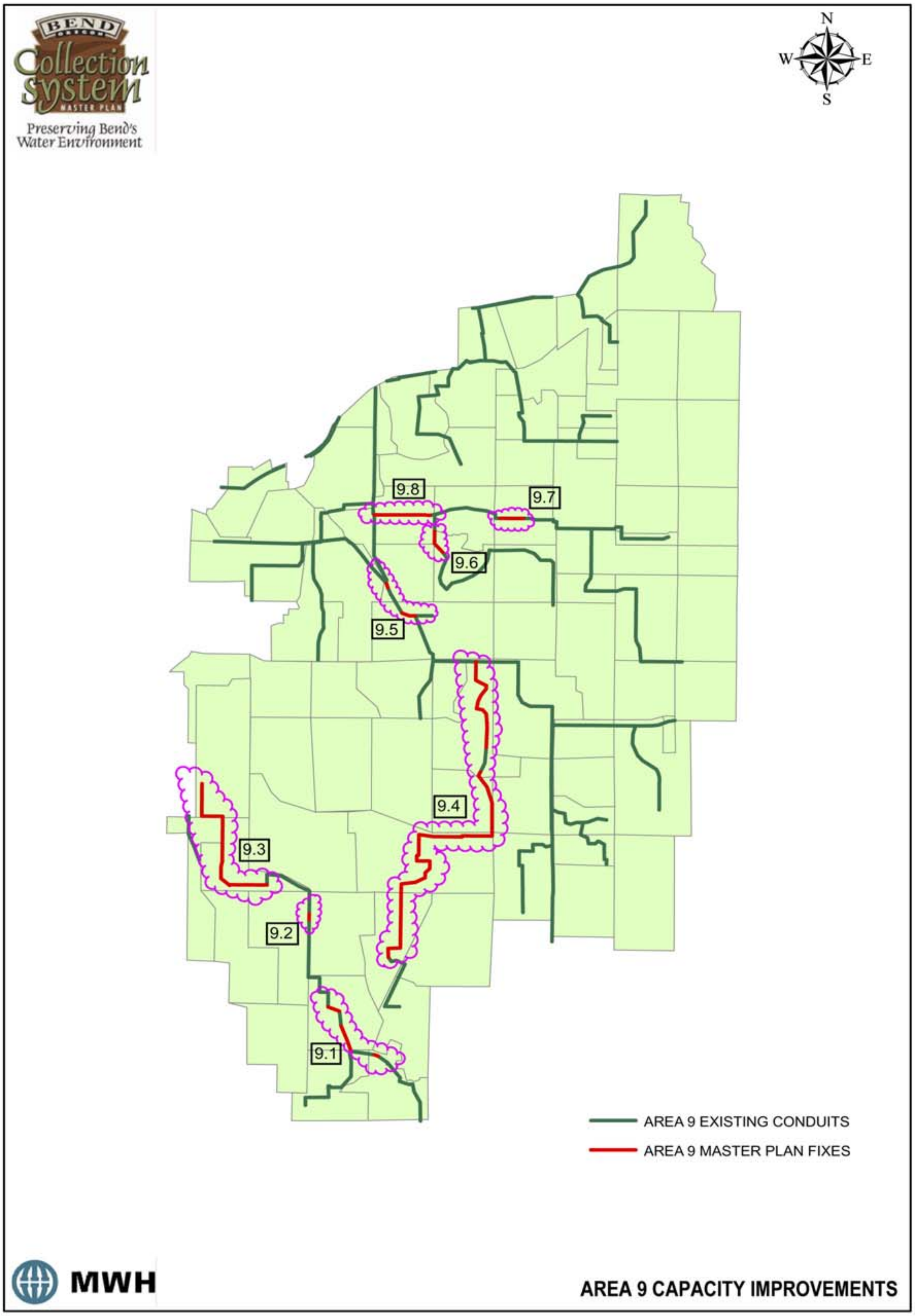


FIGURE 4-9– STUDY AREA 9 REQUIRED CAPACITY IMPROVEMENTS

As part of the total capacity improvements identified, there are existing capacity deficiencies that need to be corrected to ensure that system overflows do not occur. These existing deficiencies are summarized in ***Table 4-9***. Fourteen projects will be required to correct these deficiencies at a total cost of $5,423,647.

Table 4-9
City of Bend Collection System Master Plan
Existing Capacity Improvement Summary

Project	Status	Description	Parameters			Project Cost ($)
			Existing (in)	Future (in)	Length (ft)	
2-3	Existing	Gravity Sewer Upgrade	8	12	425	99,052
2-15	Existing	Gravity Sewer Upgrade	8	10	1311	508,159
3-3	Existing	Gravity Sewer Upgrade	10	15	3,914	1,694,372
			10	12	1,269	
			8	15	364	
			8	10	1,141	
5-1	Existing	Gravity Sewer Upgrade	24	30	425	176,638
5-4	Existing	Gravity Sewer Upgrade	12	15	494	415,149
			8	12	268	
			8	10	955	
5-6	Existing	Gravity Sewer Upgrade	21	24	351	123,811
6-1	Existing	Gravity Sewer Upgrade	8	12	95	22,961
6-2	Existing	Gravity Sewer Upgrade	12	15	2,430	638,535
8-2	Existing	Gravity Sewer Upgrade	15	18	80	1,181,453
			12	18	2,433	
			12	15	1,949	
8-7	Existing	Gravity Sewer Upgrade	8	10	522	116,254
9-7	Existing	Gravity Sewer Upgrade	8	10	515	118,943
9-8	Existing	Gravity Sewer Upgrade	12	18	515	328,320
			12	15	693	
Total Cost to Relieve Existing Capacity Deficiencies						***5,423,647***

SECTION 5
PUMP STATION MASTER PLAN

INTRODUCTION

There are 82 pump stations maintained by the City staff currently in operation. Other private stations and private home sumps are also used throughout the system. The City has defined three stations as Regional Pump Stations and the other stations as Area Pump Stations. Area Pump Stations provide service to a single drainage area. Regional Pump Stations provide service to a larger area that encompasses multiple drainage areas.

An essential element in the development of the Pump Station Master Plan was to determine the current and future service area for each pump station. The service areas for each station are shown in ***Figure 5-1***. Once the service area for a station is determined, the current and future flow for the station can be calculated based on the land use designation and flow requirements for each parcel. A data summary form with basin size and current and future flow estimates is included in TM 3-8 – Pump Station Master Plan.

REGIONAL PUMP STATIONS

There are three regional pump stations within the City. These stations are the Westside Regional Pump Station, Sawyer Park Regional Pump Station and the Murphy Road Regional Pump Station. The service areas for the regional pump stations are shown in ***Figure 5-2***.

WESTSIDE REGIONAL PUMP STATION

The Westside Regional Pump Station receives flow from most of the service area located on the west side of the Deschutes River. This station currently pumps flow across the river discharging to the core gravity system in the downtown area. The wastewater then flows by gravity to the treatment plant.

The existing station has four pumps. Two variable speed pumps with a range from 750-gpm to 2400-gpm each and two 600-gpm constant speed pumps. These pumps discharge through a 2060-foot long 16-inch force main. The station has a backup generator to provide service during power outages.

The service area for this station is 10,261 acres. This station service area is currently 25% sewered serving 5884 of the 23,221 potential build-out dwelling units. The current (2005) estimated base flow for this station is 800-gpm with a peak flow of 3940-gpm. The build-out estimated base flow for this station is 3140-gpm with a peak flow of 10,900-gpm. The InfoSWMM modeled flow for the station under build-out conditions for peak dry weather flow and peak wet weather flow is shown in ***Figures 5-3*** and ***5-4***, respectively. The station does not have the hydraulic capacity to meet the long-term requirements of the service area.

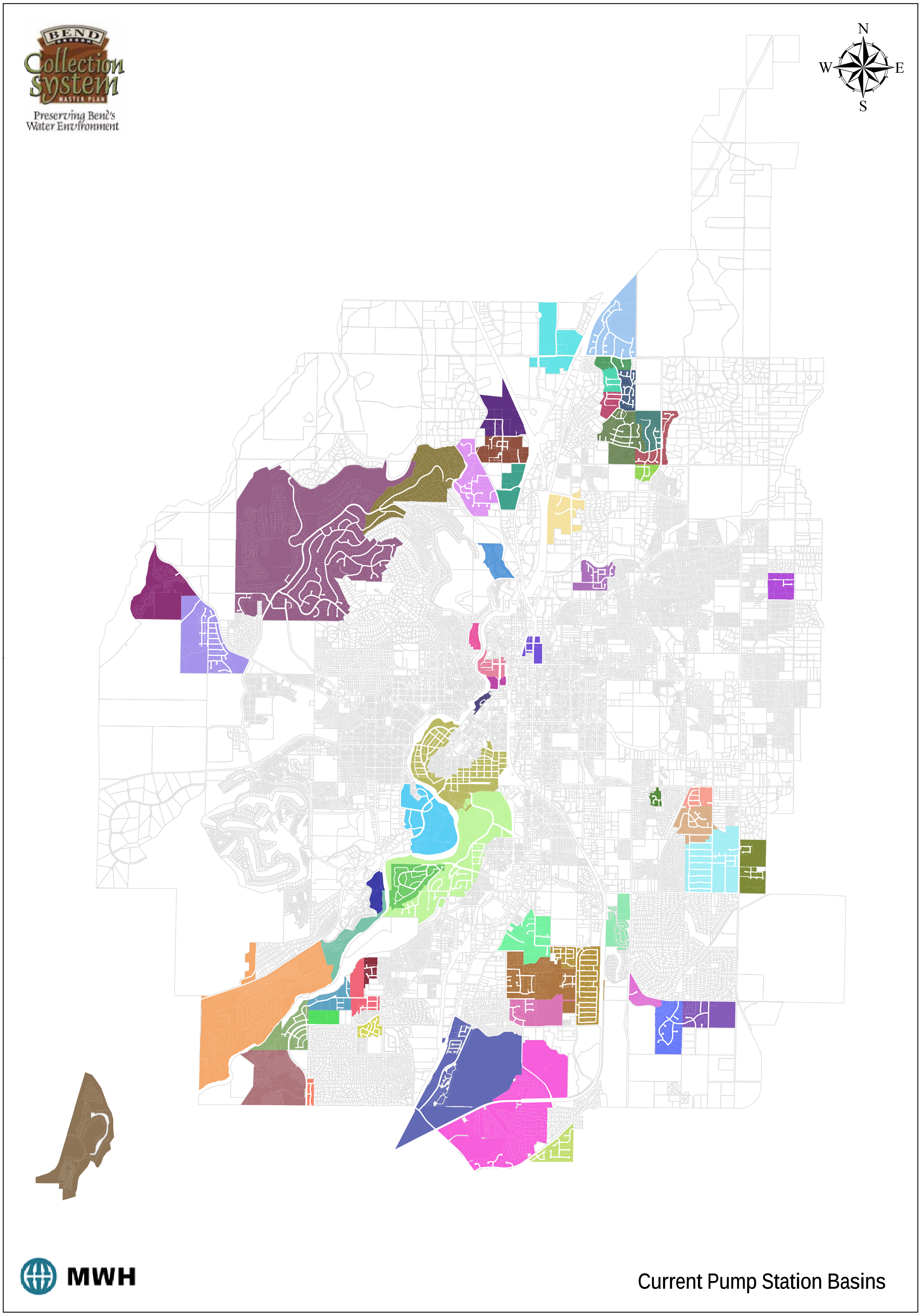


FIGURE 5-1 – PUMP STATION BASINS

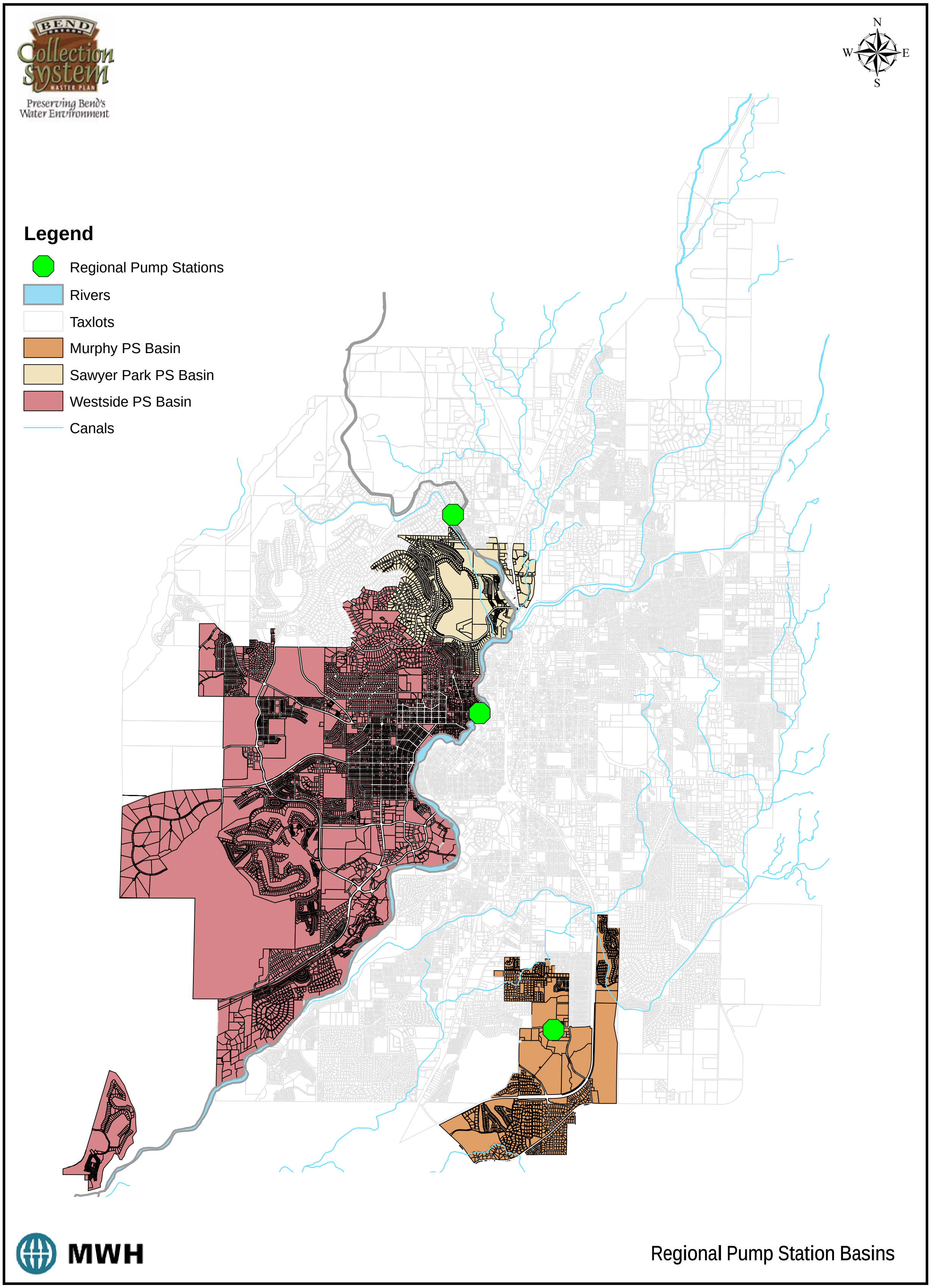
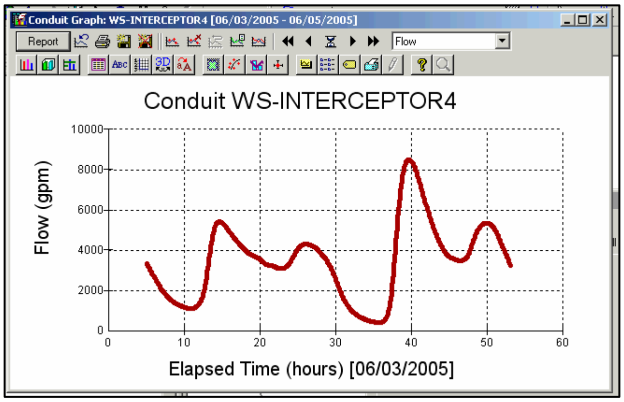


FIGURE 5-2 – REGIONAL PUMP STATION BASINS



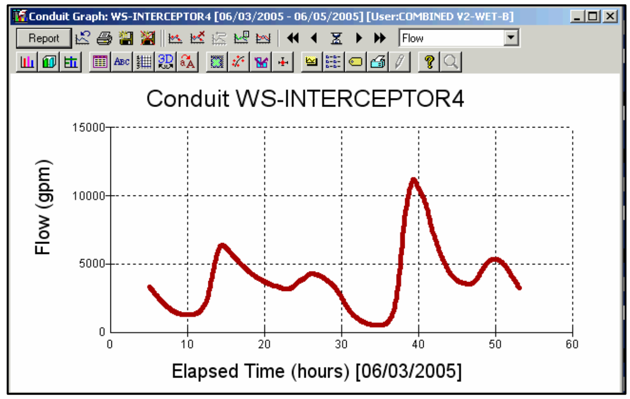


Figure 5-3: Dry weather flow – 8350 - gpm

Figure 5-4: Peak wet weather flow – 10,900 - gpm

To provide the required capacity for the future, a new station will need to be constructed to provide a peak hydraulic flow of 10,900-gpm. A new station has been assumed in this evaluation instead of upgrading the existing station due to the large increase in pumping capacity that will be required. The cost of the new pump station is estimated at $3.77M. This includes the cost of the new pump station with three 4000-gpm pumps and two 2000-gpm pumps. Two of the 4000-gpm pumps and both of the 2000-gpm pumps will have VFD's to provide a pumping range from 500-gpm to the required peak flow of 10,800-gpm. Also included in the cost estimate are an odor control system, standby power and $400,000 for land purchase.

In addition to the new station, a new force main and interceptor will need to be constructed to discharge the flows pumped from this station to the new North Interceptor. This combination of force main and gravity interceptor has been named the Westside Interceptor.

Two alternative routes have been developed. Alternative 1 crosses the river on the NW Portland Avenue bridge and follows NE Onley Avenue to NE 4th Street where it turns north. The alignment follows NE 4th Street to NE Boyd Acres xx which becomes NE Vogt. The alignment then follows NE Vogt to the North Interceptor. This alignment will require a new 2,765-foot, 18-inch force main that will discharge to a 21,150-foot, 27-inch gravity trunk that discharges to the new North interceptor.

Alternative 2 crosses the river on the NW Portland Avenue bridge and turns north on NW Wall Street. The route follows NW Wall to NW Revere Avenue where it turns east to Division Street. The route then follows Division Street to Business 97, then follows Hwy. 97 to the North Interceptor. This alignment will require a new 1,600-foot, 18-inch force main that will discharge to a 19,950-foot, 27-inch gravity trunk that discharges to the new North interceptor. The estimated cost of the new Westside Interceptor is $9.78M.

SAWYER PARK REGIONAL PUMP STATION

The Sawyer Park Regional Pump Station receives flows from a small service area located on the west side of the Deschutes River on the northern portion of the City and a small area on the east side of the river. The station is located on the east side of the river.

The existing station has three pumps. Each pump has a rated flow of 560-gpm. The design system curve shows a total station firm capacity of 700-gpm with two pumps in operation. Pump tests have shown that the combined flow of two pumps is 1,000-gpm resulting in a firm capacity of 1,000-gpm instead of the design firm capacity of 700-gpm. These pumps discharge through a 1,566 LF 8-inch force main where the flows are split between a discharge to a gravity system and a 6-inch force main that connects to the Wyndemere Pump Station force main discharging to another location in the gravity system. Both forcemain systems where these stations discharge are at capacity and have no capacity for additional flows.

The service area for the Sawyer Park station is 765 acres. The current (2005) estimated base flow for this station is 71-gpm with a peak hour flow of 320-gpm. The build-out estimated base flow for this station is 365-gpm with a peak flow of 1,165-gpm. The station has a firm capacity of 1,000-gpm that may meet the long-term requirements of the service area. Additional evaluation of the RDII for this system needs to be done prior to determining if this station capacity will be adequate under build-out peak flow conditions.

A new force main can be constructed to discharge to the new Westside Interceptor sending the flows to the North Interceptor. This will eliminate most of the capacity problems in the gravity system downstream of the current discharge point. This new force main can also continue to handle the flows from the Wyndemere Pump Station.

MURPHY ROAD REGIONAL PUMP STATION

The Murphy Road Regional Pump Station receives flow from the old Juniper Utility sewer system located on the south side of the City.

The existing station has two (2) pumps. Each pump has a rated flow of 300-gpm. The City staff has tested this station and has rated the actual flow to be 250-gpm. The station pumps through a 4,297 LF 6-inch force main. The flow is pumped west along Murphy Road to its discharge at Highway 97. The service area for this station is 3,064 acres. This station service area is currently at 33% sewered serving 1,547 of the 4,675 potential build-out dwelling units. The current (2005) estimated base flow for this station is 215-gpm with a peak flow of 1,122-gpm. The build-out estimated base flow for this station is 560-gpm with a peak flow of 1,898-gpm. The station is currently under capacity. This station does ***NOT*** have capacity to meet the build-out conditions for this service area. Expansion of this station is not feasible because the gravity system to which it currently pumps does not have the capacity to handle the flows from this station. This station will be removed from service with the construction of the SE Interceptor.

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AREA PUMP STATIONS

There are 79 area pump stations located throughout the service area. These stations are listed in ***Table 2-2*** in Section 2 of this report. An evaluation of the capacity of each pump station was performed. This analysis is summarized in TM 3-8 – Pump Station Master Plan.

EVALUATION CRITERIA

The capacity of each pump station was evaluated to determine if the existing station has adequate capacity for future growth conditions. For stations that were modeled, the dynamic peak flow determined by the InfoSWMM model was used as the peak flow. For stations that were not modeled, first the current and future service area for each station was determined. Next, the number of dwelling units and base flow for each service area was determined based on the land area and zoning based on the criteria outlined in TM 3.1 – Planning Criteria. Finally, the peak flow was calculated by applying peaking factors and an RDII flow of 150 gallons/acre/day. The following terms and peaking factors were used in the evaluation of each pump station:

- Modeled – Yes in this column means that pump station is included in the INFOSWMM hydraulic model. No means it has not been included in the model
- Firm Capacity – The firm capacity is the capacity of the station with one pump out of service to act as a redundant pump. This is a regulatory requirement.
- Base Flow – The base flow is the winter season flow based on area zoning.
- RDII Flow – RDII flow is the flow based on inflow into the system during heavy rainfall.
- Peak Flow – The peak hour flow for non-modeled pumps was estimated as the base flow multiplied by a diurnal peaking factor of 1.8 and the seasonal peaking factor of 1.25 to which the RDII flow was added

The application of this criteria determined if the pump station will meet the build-out flow of its respective service area or not. For stations where their installed capacity will not serve the build-out flows, the time at which the stations will reach capacity was not part of this evaluation. This must be determined by the respective growth rate in each pump station's service area. The respective service area estimated growth rates was not available for this evaluation.

PUMP STATION CAPITAL PROJECTS

Capital improvement projects are required to upgrade the capacity of some of the pump stations due to growth in the station's service area. Another type of capital project relating to the pump stations is the construction of gravity sewers that will allow for the removal of the stations from service.

Required Pump Station Capacity Improvements

Some of the pump stations do not meet the projected capacity requirements for their service areas. This can be due to a variety of factors including:

- Expansion of the original pump station service area
- Increase in the density of dwelling units in the service area
- Changes in zoning

Whatever the reason, capacity improvements are required for a number of pump stations in the system. The stations requiring a capacity increase prior to the build-out of their service area are listed in ***Table 5-1***. These stations are shown on ***Figure 5-5***. A more detailed description of the basis for the required upgrades in discussed in TM 3.8 – Pump Station Master Plan. The estimated project costs were developed using the methodology summarized in Section 2.

Table 5-1
Pump Stations Requiring Improvements for Build out

Study Area	Station Name	Station Capacity (gpm)		Required Improvements	Project Cost ($x1000)
		Existing	Build-out		
1	Shevlin Commons	118	202	Increase pumping capacity and construct new force main	$889
2	Awbrey Glen	450	1747	Increase pumping capacity, construct new force main and improve downstream gravity sewers	$2,531[1]
2	Shevlin Meadows	145	464	Increase pumping capacity	$91
2	Westside Regional[2]	3600	10,800	Build new pump station	$3,770
3	Sunrise Village #1	250	660	Increase pumping capacity	$80
3	Widgi Creek	297[3]	420	Evaluate system to determine cause of capacity limitation	$15
5	Deschutes Co. Jail	115	130	Evaluate RDII and increase pumping capacity, if required.	$25
5	Empire	50	100	Increase pumping capacity	$25
6	Drake	650	500	Replace pump station with new 500-gpm station	$363
7	Desert Skies	95	176	Increase pumping capacity	$31
7	Nottingham #2	55	202	Increase pumping capacity	$31
8	Deschutes River X-ing	148	100	Reduce pumping capacity to 100-gpm when pumps are replaced	NA
8	Old Mill	300	600	Increase pumping capacity and evaluate installation of VFDs	$60
8	River Rim	150	200	Increase pumping capacity	$40
8	South Village	265	330	Increase pumping capacity	$25
8	Tri-Peaks	120	150	Increase pumping capacity	$25

Notes:1. Awbrey Glen pump station cost does not include $508,000 cost to upgrade downstream gravity lines, because this cost was included as Capital Project 2-15.
2. Westside Regional cost are for pump station only. Cost for force main are included in Westside Interceptor Costs
3. Widgi Creek actual measured capacity is 297-gpm. Design capacity is 450-gpm.
NA: Not Applicable; costs for this removal associated with routine maintenance.

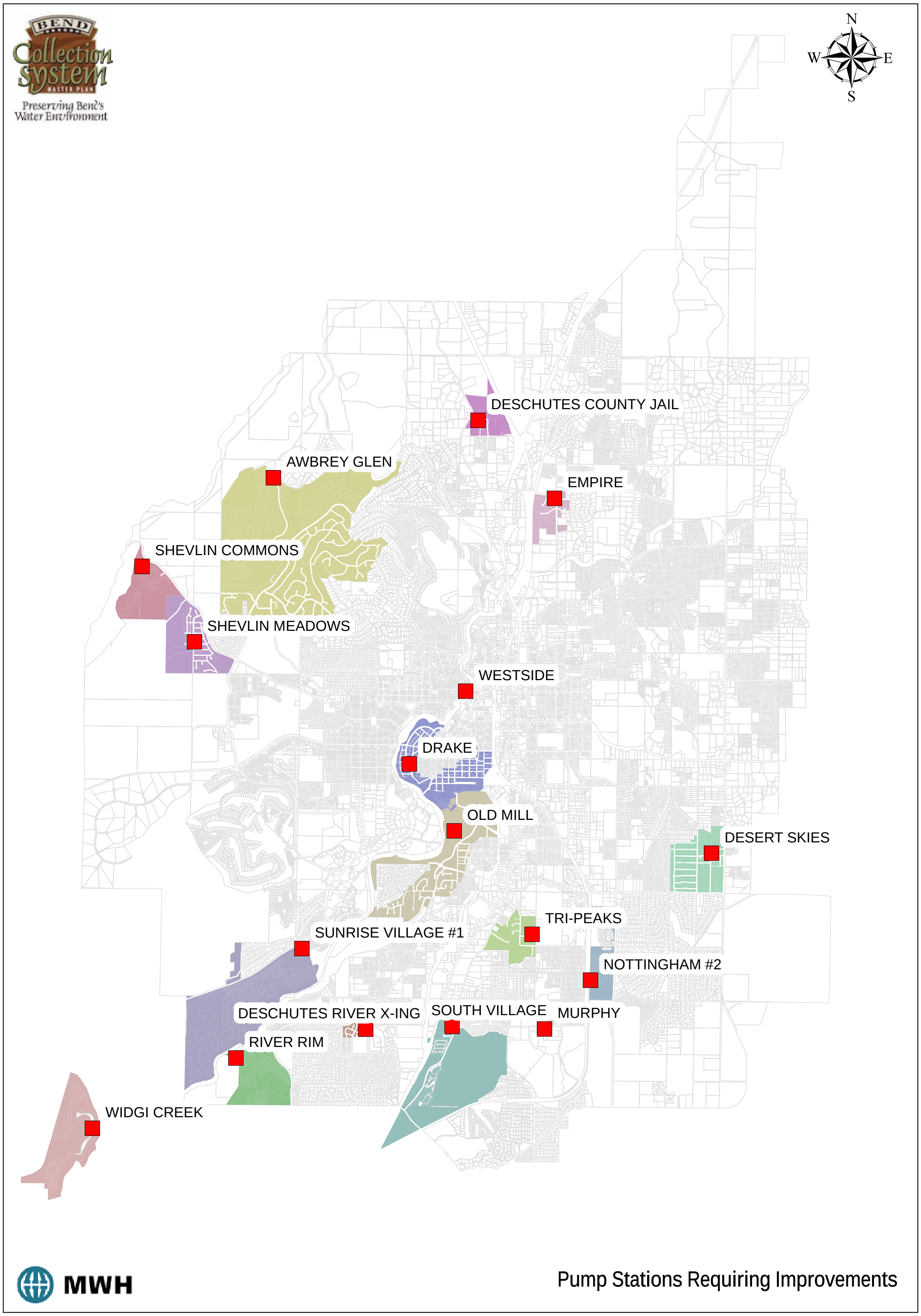

FIGURE 5-5 – PUMP STATIONS REQUIRING IMPROVEMENTS

REMOVING PUMP STATIONS FROM SERVICE

Nineteen of the existing pump stations can be removed from service by constructing a gravity trunk to an existing gravity system or to one of the new gravity interceptors that will be constructed as part of the Master Plan. A summary of the stations that can be removed from service with the associated cost of removal are listed in ***Table 5-2***. This includes the estimated cost for removal of each of these stations. These stations are shown on ***Figure 5-6***. A more detailed description of the basis for the estimated costs is presented in TM 3.8 – Pump Station Master Plan.

Table 5-2
Pump Stations to be Removed from Service

Study Area	Station Name	Project Description	Cost to Remove ($x1000)
1	Shevlin Commons	Construct 380-foot trunk sewer to North Interceptor	$97.5
2	Awbrey Glen	Construct North Interceptor Trunk 4	$1,483
4	Boyd Acres	Construct 460-foot trunk sewer	$97
4	Highlands	Construct 2512-foot trunk sewer	$418
4	Holiday Inn	Construct 382-foot trunk sewer	$70
4	Northpointe	Construct 350-foot trunk sewer	$80
4	North Wind	Construct 400-foot trunk sewer when area north of pump station is sewered	$88
4	Phoenix	Connect to new gravity system to the north when it is constructed	$41
4	Summer Meadows	Construct 450-foot trunk sewer	$95
5	Deschutes Co. Jail	Connect to gravity sewer system when it is constructed to the northeast of the station	$25
5	Majestic	Construct 1800-foot gravity sewer to Summer Meadows PS basin when Summer Meadows PS is removed from service	$306
5	North Fire Station	Connect to gravity sewer system when it is constructed to the northeast of the station	$25
7	Blue Ridge	Connect to new gravity system to the east when it is constructed	$41
7	Darnell Estates	Construct 300-foot trunk sewer to SE Interceptor on 27th Ave.	$74
7	Desert Skies	Construct 550-foot trunk sewer to SE Interceptor on 27th Ave.	$111
7	Murphy Road Regional	Remove station when SE Interceptor is constructed on Murphy Road	NA
7	Ridgewater #1	Construct 250-foot trunk sewer to SE Interceptor on 15th Ave.	$64
7	Sun Meadows	Construct 1500-foot trunk sewer to connect to new gravity system east of the basin when it is constructed	$229
8	South Village	Construct 400-foot sewer to connect to the SE Interceptor on Murphy Road	$88
9	Summit Park	Construct 500-foot sewer to connect to the SE Interceptor on 27th Street	$93.5

Notes: 1. NA-Not Applicable. Costs for this removal are associated with construction of the SE Interceptor.

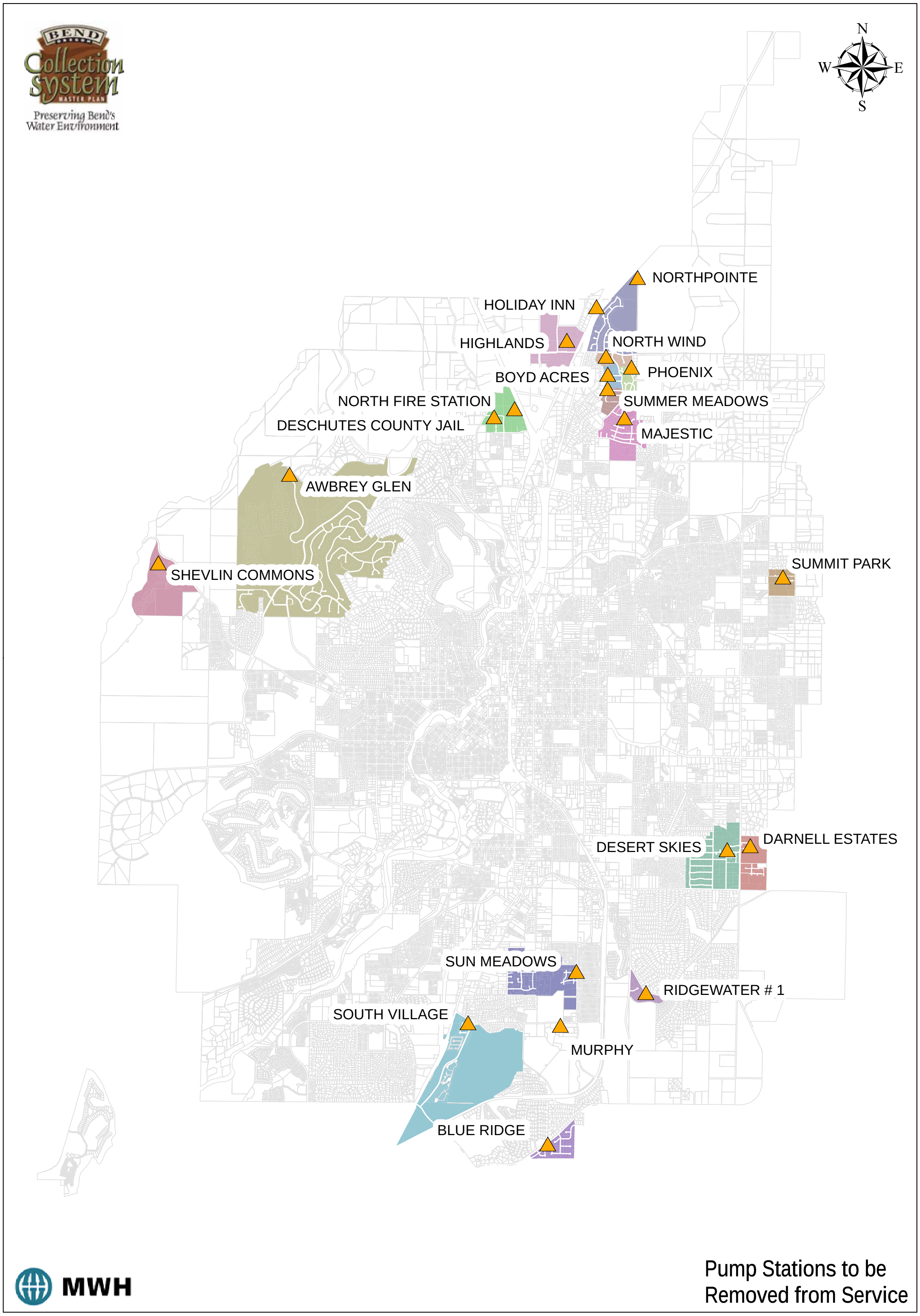

FIGURE 5-6 – PUMP STATIONS TO BE REMOVED FROM SERVICE

Included in the analysis for the removal of each station is a 20 and 50-year Net Present Value Analysis (NPV) comparing the continued operation of each pump station to the cost of removing the station. In each situation, it was cost effective over a 50-year analysis to remove the station. In all but a few instances, the 20-year present worth analysis showed that it is cost effective to remove the station from service.

Table 5-3
Pump Stations to be Removed from Service
Net Present Value Analysis

Study Area	Station Name	Removal Cost ($x1000)	Net Present Value ($x1000)			
			Keep Operating		Remove from Service	
			20-year	50-Year	20-Year	50-Year
1	Shevlin Commons	97.5	1,119	1,542	197	202
2	Awbrey Glen	1,483	2,678	3,988	1,842	1,955
4	Boyd Acres	97	204	497	181	187
4	Highlands	418	275	759	527	561
4	Holiday Inn	70	214	517	160	164
4	Northpointe	80	264	678	187	191
4	North Wind	88	195	481	167	172
4	Phoenix[1]	41	209	506	-	-
4	Summer Meadows	95	201	494	176	183
5	Deschutes Co. Jail[2]	-	-	-	-	-
5	Majestic	306	265	651	421	445
5	North Fire Station[1]	41	-	-	-	-
7	Blue Ridge	41	211	513	132	125
7	Darnell Estates	74	194	517	153	159
7	Desert Skies	111	255	642	191	199
7	Murphy Road[3]	-	-	-	-	-
7	Ridgewater #1	64	206	500	149	152
7	Sun Meadows	229	235	620	323	341
8	South Village	88	230	626	173	178
9	Summit Park	93.5	193	485	177	194

Notes:
1. The estimated cost for removal of the Pump Station is $41,000. The timing is based on the sewering of the area north of the station. Due to the low cost and unknown timing of a project, no NPV for station removal was done.
2. No NPV analysis was performed because the gravity sewer that would allow the station to be removed from service would serve a variety of parcels as well as both the Deschutes County Jail and North Fire Station Pump Stations. The analysis can only be done for a single project for a pump station.
3. No NPV analysis was performed for the Murphy Road Pump Station because it will be removed with the construction of the SE Interceptor.

SECTION 6

INTERCEPTOR MASTER PLAN

INTRODUCTION

The interceptor master plan recommends the construction of four new gravity interceptors. These new interceptors will provide the following basic functions:

- Provide sanitary service to the Juniper Ridge and north Bend areas
- Provide sanitary service to the SE Bend areas
- Reroute flows away from the downtown core area of Bend relieving current and future capacity deficiencies
- Provide system capacity necessary to allow the growth of sanitary service to portions of Bend west of the Deschutes River
- Provide a second interceptor to the treatment plant providing additional required capacity
- Provide a means to remove pump stations from service, wherever possible

The cost to construct these interceptors will be a considerable investment for the residents of the City. In order to manage cash flow, the City may need to construct these lines as areas develop and the additional sanitary service is required. For this reason, each interceptor has been divided into multiple capital projects to provide the City with an opportunity to construct each interceptor using a phased construction approach.

The Master Plan consists of four new gravity interceptors. The function of each of these interceptors is:

- Plant Interceptor – New parallel plant interceptor to provide additional and redundant required capacity from the City to the Water Reclamation Facility
- North Interceptor – Service to the new Juniper Ridge Development, future north Bend development and service to the northwest areas of Bend reducing flows through the Westside Pump Station and downtown core system
- SE Interceptor – Service to unsewered areas and new development in the southeast and south Bend areas, relief of flows through the Murphy Road Pump Station (old Juniper Ridge Utility) and relief of flows through the downtown core from the SW Bend areas east of the Deschutes River
- Westside Interceptor – Rerouting the flows discharged from the Westside Pump Station, Sawyer Park Pump Station and Wyndemere Pump Station to relieve the core area system by diverting these flows to the North Interceptor

A recommended alignment has been developed for each of these four interceptors. In addition, sizing and the development of a cost estimate to construct each of the interceptors has been developed. A description of each of these interceptors is summarized in the following sections. The alignment of each of the four interceptors is shown in ***Figure 6-1***.

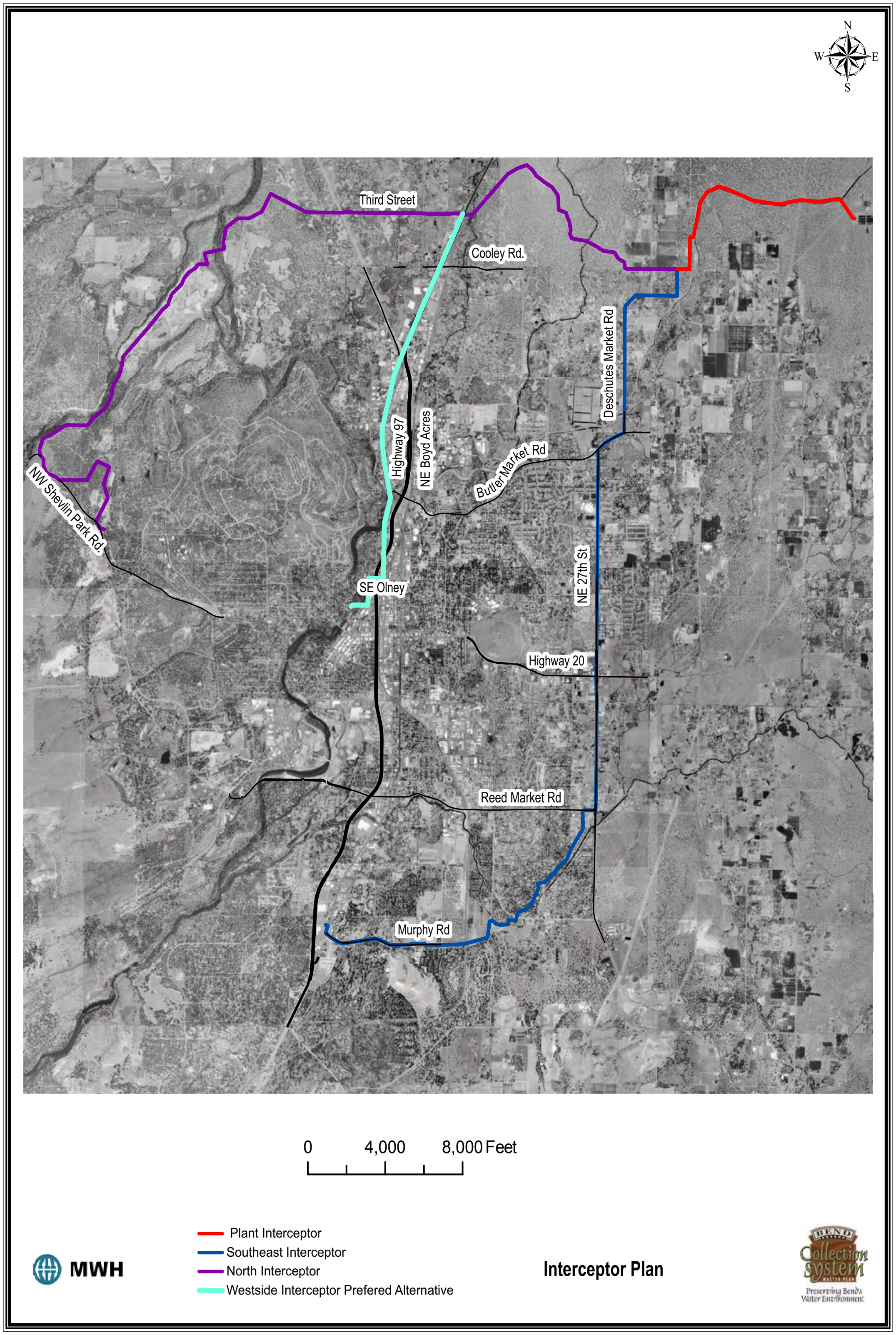

FIGURE 6-1 – INTERCEPTOR PLAN

PLANT INTERCEPTOR

The existing plant interceptor is currently limited to a peak hydraulic flow of approximately 30-mgd. In the existing configuration, raw wastewater flows through a plant interceptor ranging in size from 30 to 42-inches in diameter to the siphon box about 5100-feet upstream of the plant. At that point, the system becomes pressurized (an inverted siphon) and flow continues through two pipes, a 21-inch and a 36-inch, to the treatment plant. At the treatment plant, these two lines combine into one 30-inch line that takes the flow to the headworks. This 30-inch line limits the flow to the headworks structure. The City is currently designing a new headworks for the Water Reclamation Facility (WRF) based on an instantaneous peak plant capacity of 30 MGD. Included with this design is a new distribution box. This will allow for modification of the existing 30-inch bottleneck on the treatment plant grounds. The existing and proposed new plant interceptor alignment is shown on ***Figure 6-2***.

The new plant interceptor will take flow through a 48-inch gravity sewer to an expanded inverted siphon structure. A new siphon line or pair of lines will parallel the two existing inverted siphons to the treatment plant. The existing 30-inch line creating a flow bottleneck will be decommissioned and each of the inverted siphon lines will be connected directly to the new distribution box. This new interceptor arrangement will provide a peak hydraulic capacity of up to 68-mgd which will meet the build-out peak hydraulic flows for the current planning area. The new plant interceptor will parallel the existing line to Pioneer Loop Road. At this point, the interceptor will follow Pioneer Loop Road to Margaret Lane. The plant interceptor terminates at station 130+94 at the intersection of Margaret Lane and Pioneer Loop Road.

This new plant interceptor consists of three distinct elements. These are the inverted siphon, the siphon box, and the 48-inch interceptor from the siphon box to the junction with the North Interceptor and SE Interceptor. The estimated cost for the Plant Interceptor is $9.4M.

NORTH INTERCEPTOR

The North Interceptor carries flow from the northwest areas of Bend near Shevlin Park, around Awbrey Butte on the northern border of the Urban Area Reserve (UAR) to the Deschutes River. Raw wastewater will then be then pumped across the Deschutes River to continue by gravity on the northern border of the UAR to Highway 97. The alignment then crosses the new Juniper Ridge development to its downstream terminus at the Plant Interceptor. The interceptor has been divided into four sections:

- <u>Plant Interceptor to Highway 97</u> – Provides service to Juniper Ridge Development, several drainage basins currently pumped south to the existing interceptor, and accepts flow from the new Westside Interceptor
- <u>Highway 97 to Deschutes River</u> – Provides service to developed and undeveloped drainage basins along the north edge of the City
- <u>North Interceptor Pump Station and Force Main</u> – Provides the transmission of flow across the Deschutes River canyon

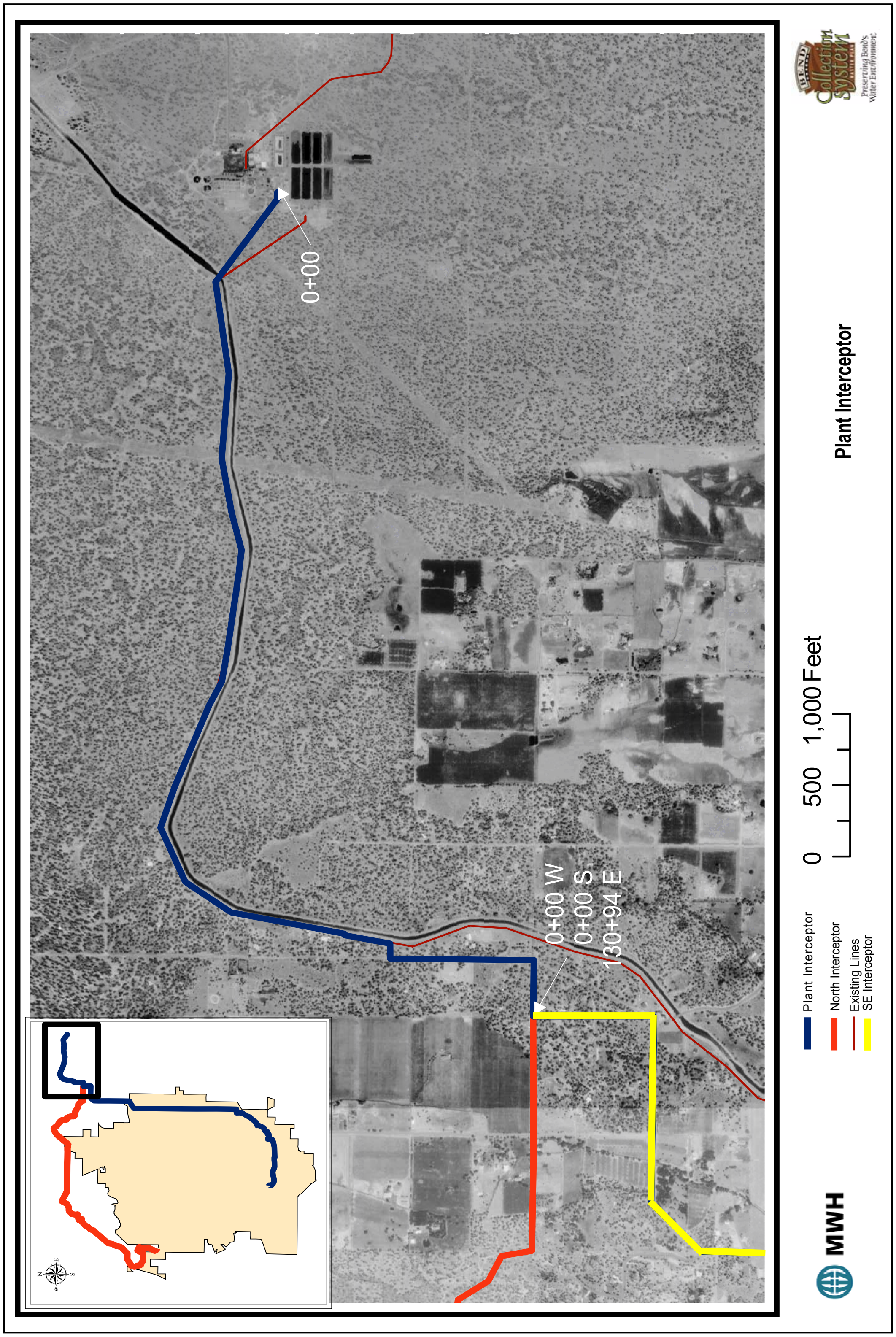

FIGURE 6-2 – PLANT INTERCEPTOR

- Deschutes River to Shevlin Park – Provides service to undeveloped northwest basins of the City and provides an opportunity to remove Awbrey Glen and Shevlin Commons Pump Stations from service

The proposed alignment for the North Interceptor is shown in ***Figure 6-3***.

PLANT INTERCEPTOR TO HIGHWAY 97

The first element of the North Interceptor is the portion between the Plant Interceptor terminus and Highway 97. This element is 15,010-feet long, 12,405-feet of 48-inch line and 2605-feet of 42-inch line. The alignment will provide gravity service to most of Juniper Ridge – Phase I and to the Westside Interceptor at the junction with Highway 97.

HIGHWAY 97 TO DESCHUTES RIVER

The second element of the North Interceptor is the portion between Highway 97 and the Deschutes River. This element is 14,340-feet long and is 30-inches in diameter. This alignment generally follows the northern border of the UAR. This alignment will allow all of the undeveloped areas south of the interceptor to be served by gravity through a network of trunk sewers.

DESCHUTES RIVER PUMP STATION AND FORCE MAIN

The Deschutes River Canyon is a direct barrier to the gravity interceptor. To cross this barrier, a pump station will need to be constructed on the west side of the river to pump flow across the river to the gravity interceptor on the east side. The pump station will be sized for a peak flow of 4400-gpm and will require a 15-inch force main that will be about 1610-feet long. This length is predicated on the assumption that a structure will be used to support the force main rather than having the force main constructed underground across the river.

For this river crossing to be cost effective, a bridge must be constructed over the river. This will be dependent on development that will occur in the future on the west side of the river. Therefore, the construction of the North Interceptor on the west side of the Deschutes is completely dependent on the construction of a bridge. The ultimate placement of the pump station and force main will be dependent on where this bridge is located. Development and analysis of the option to convey wastewater across the Deschutes River Canyon were beyond the scope of this study. Costs for the bridge structure were not included in the cost for this interceptor.

DESCHUTES RIVER TO SHEVLIN PARK

The fourth element of the North Interceptor is the gravity sewer from the Deschutes River pump station to Shevlin Park. This element is 23,810-feet long made up of 1605-feet of 27-inch line, 10,455-feet of 15-inch line, 1,110-feet of 10-inch line and 10,640-feet of 8-inch line. This alignment generally follows the northwest border of the UAR. This line will allow the undeveloped areas on the south and east sides of the interceptor to be served by gravity.

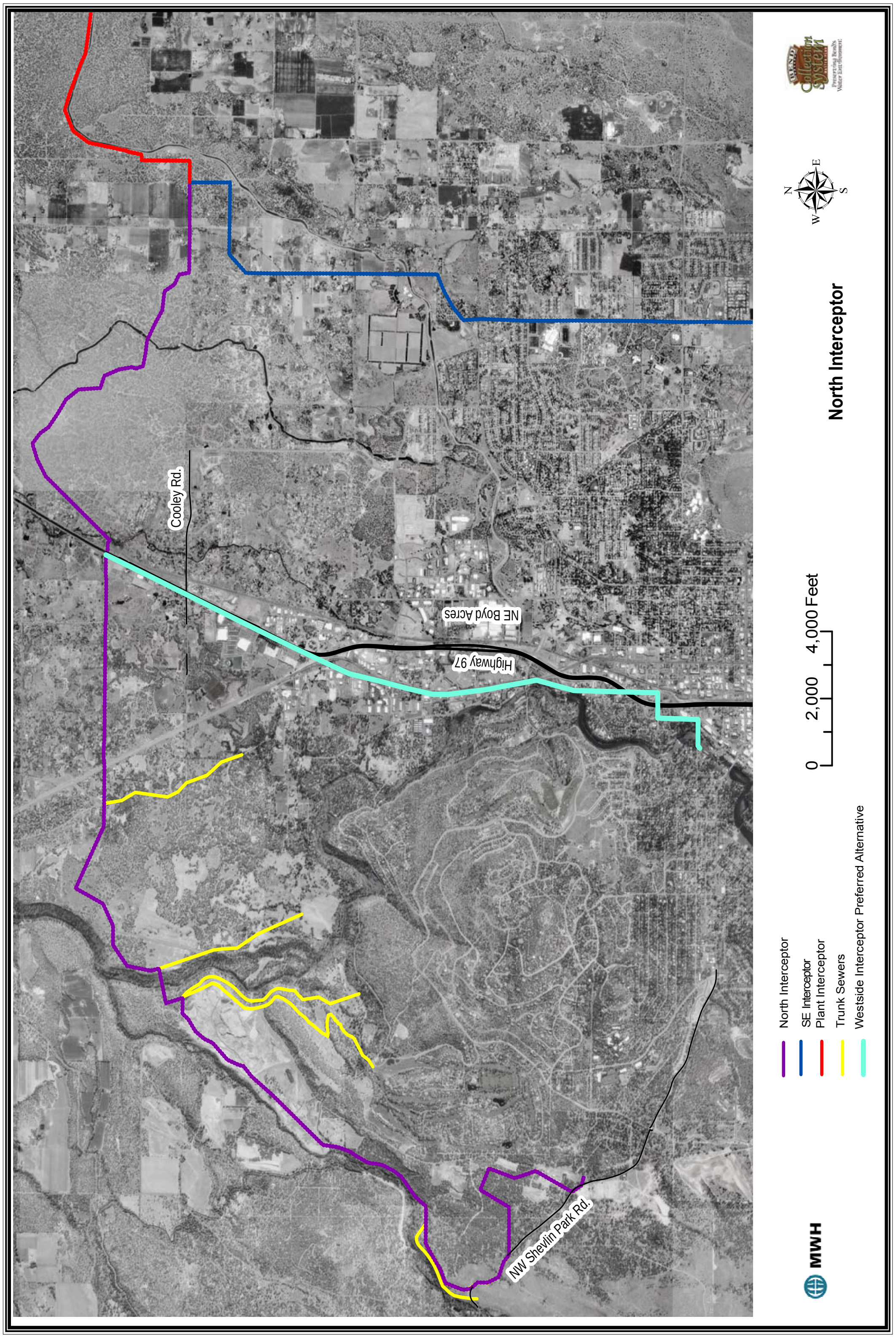

FIGURE 6-3 – NORTH INTERCEPTOR

This line segment has also been designed to provide for the removal of the Shevlin Commons Pump Station. Undeveloped areas to the south of Shevlin Commons will also be served by this interceptor.

NORTH INTERCEPTOR COST ESTIMATE

The estimated cost of the complete North Interceptor is $25.0M. The estimated cost of each of the four elements of the interceptor is:

- $ 11.5M -- Plant Interceptor to Highway 97
- $ 6.9M -- Highway 97 to Deschutes River
- $ 1.5M -- North Interceptor Pump Station and Force Main (Excluding support structure)
- $ 5.1M -- Deschutes River to Shevlin Park

This project can be completed in phases beginning with the Plant Interceptor to Highway 97 element following the construction of the Plant Interceptor. Construction of this phase of the project will provide the opportunity to construct and place the Westside Interceptor into service, providing capacity relief to the existing core system.

NORTH INTERCEPTOR – TRUNKS 1 & 2

The alignments for two trunk sewers to serve the undeveloped areas within the UAR south of the North Interceptor between Highway 97 and the Deschutes River have been identified. Trunk No. 1 connects to the North Interceptor at station 225+00. This trunk is a 4865-foot long 12-inch line. The estimated project cost for this trunk sewer is $834,600.

Trunk No. 2 connects to the North Interceptor at station 293+50. This trunk is a 4920-foot long 12-inch line. The estimated project cost for this trunk sewer is $843,800.

NORTH INTERCEPTOR – TRUNKS 3 & 4

Two trunk sewers will be required to serve two drainage basins on the west side of the Deschutes River. Trunk No. 3 connects to the Deschutes River Pump Station at station 309+50 of the North Interceptor. This trunk drains a fairly small basin. This trunk is a 6430-foot long 12-inch line. The estimated project cost for this trunk sewer is $1,103,000.

Trunk No. 4 also connects to the Deschutes River Pump Station at station 309+50 of the North Interceptor. This trunk terminates at the Awbrey Glen Pump Station allowing this station to be removed from service. This trunk is a 8350-foot long 12-inch line. The estimated project cost for this trunk sewer is $1,433,000.

NORTH INTERCEPTOR – TRUNK 5

Trunk sewer No. 5 connects to the North Interceptor at station 419+50. This trunk is a 3430-foot long 12-inch line. The estimated project cost for this trunk sewer is $588,000.

SE INTERCEPTOR

The Southeast Interceptor takes flow from the east, southeast and south areas of Bend. The recommended alignment goes east from the intersection of Highway 97 and Murphy Road to SE 15th Street. It then turns north up SE 15th to the Central Oregon Irrigation District (COID) canal where it follows public right of way through a neighborhood on the north side of the canal to Reed Market Road and 27th Street. It then goes north in the 27th Street right-of-way to Butler Market Road, following Butler Market Road where it intersects with the North Interceptor and discharges into the Plant Interceptor.

The interceptor has been divided into five parts:

- <u>Plant Interceptor to Highway 20</u> – Provides service to undeveloped areas on the south of Butler Market Road, sub-basins east of SE 27th Street and sub-basins currently in the UAR on the east side of Study Area 9.
- <u>Highway 20 to Reed Market Road</u> – Follows the right-of-way on SE 27th Street taking existing flow from developed and undeveloped areas east and west of SE 27th Street. A short segment of the line extends south from the intersection of 27th Street and Reed Market Road across the CIOD canal to provide service to Section 11.
- <u>Reed Market Road to SE 15th Street</u> – Parallels the COID canal on the north side of the canal within local street rights-of-way providing service to the unsewered area to the north of the canal between SE 15th and SE 27th Streets.
- <u>SE 15th Street to Murphy Road Pump Station</u> - Provides for the decommissioning of the Murphy Road Pump Station and redirecting the flow from the Murphy Road Pump Station (old Juniper Utilities) away from the downtown core system.
- <u>Murphy Road Pump Station to Highway 97</u> – Connects to the existing gravity sewer in Hwy 97 currently serving the south and southwest Bend area and redirecting these flows away from the downtown core system.

The recommended alignment for the SE Interceptor is shown in ***Figure 6-4***.

ALTERNATIVE IMPLEMENTATION STRATEGIES

Two alternative implementation strategies were evaluated for the 27th Street section of the SE Interceptor. The first alternative is the “All Gravity” plan which has deeper cuts, but provides for gravity flow from the intersection of Highway 97 and Murphy Road to the treatment plant. The second alternative is the “Shallow with Pumping” plan which will require one or two pump stations along the route. This alternative does not have the deeper cuts but will require long-term operation and maintenance of the pump stations. The specific alternative that will be implemented will be determined during the preliminary design of the interceptor. The “All Gravity” alternative will be used as the basis for the Master Plan.

Alternative 1 – “All Gravity”

The “All Gravity” alternative proposes a new line that will be constructed at an elevation suitable to connect the lowest influent line at the Murphy Road Pump Station to the wastewater treatment plant using gravity service. This option will provide the lowest long-

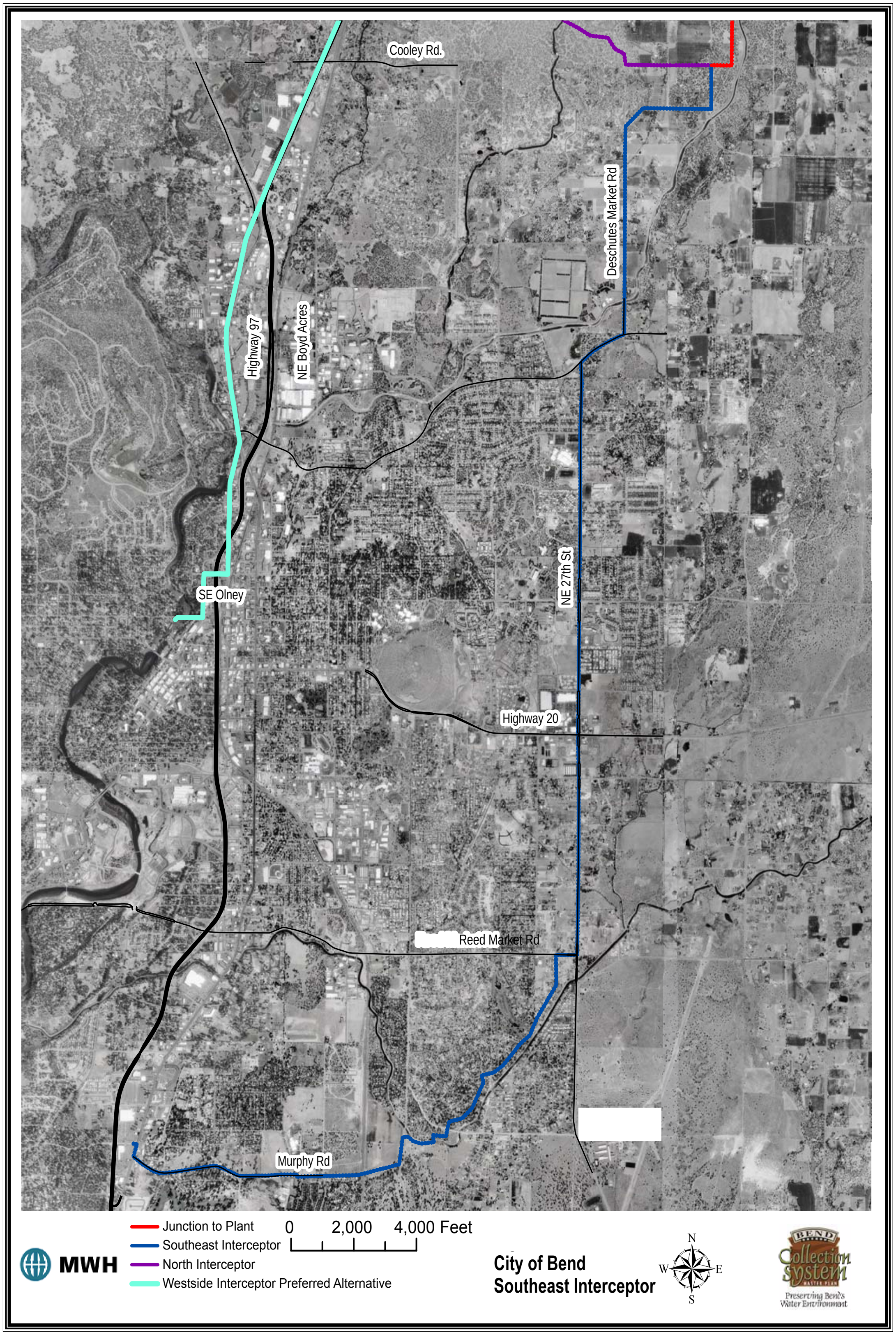

FIGURE 6-4 – SE INTERCEPTOR

term operating cost and will provide the opportunity to interconnect some of the existing basins on the east side of 27th Street. The disadvantage is that the deeper cuts will require more difficult construction in high-traffic areas. The estimated capital cost for this “All Gravity” alternative is $19.03M.

Alternative 2 – “Shallow with Pumping”

The “Shallow with Pumping” alternative proposes a more shallow line which requires one or two lift stations. This option will result in higher operating costs and a higher operational risk due to the potential for extended pump station outages. Failure of one of the pump stations will result in the loss of service to the complete service area of the SE Interceptor. The advantage of this alternative is that the construction in the high-traffic areas will take less time due to the shallower cuts. The estimated capital cost for this “Shallow with Pumping” alternative is $20.30M.

INTERCONNECTIONS

Two points of interconnection are proposed. One is where the existing plant interceptor is crossed by the SE Interceptor on Deschutes Market Road north of the North Unit Irrigation District (NUID) Main Canal. The other is at the junction of the terminus of the SE and North Interceptors where they discharge to the new Plant Interceptor. The system hydraulics and the hydraulic grade lines of the North Interceptor, SE Interceptor, new Plant Interceptor and existing Plant Interceptor need to be designed so they are close enough for flows from the three drainage areas, North Interceptors, SE Interceptor and Downtown Core, to be routed into either plant interceptor. This will allow either of the plant interceptors to be taken out of service for inspection, repair, cleaning or general maintenance.

PLANT INTERCEPTOR TO HIGHWAY 20

The first section of the SE Interceptor is the portion between the Plant Interceptor and Highway 20. This portion of the interceptor is 23,000-feet long. From the Plant Interceptor, the first 3678-feet is a 36-inch diameter gravity sewer and the remaining 19,322-feet is a 24-inch gravity sewer. This section of the interceptor provides service to undeveloped areas located outside of the UGB, but within the UAR, on the south of Butler Market Road. This section also provides service to the sub-basins east of 27th Street. As the alignment then extends south on 27th Street, the interceptor will collect flows from the existing system on the east side of 27th Street, when the elevation allows. New development on the east side of 27th Street can be designed to provide gravity discharge to the SE Interceptor.

HIGHWAY 20 TO REED MARKET ROAD

The second section of the SE Interceptor is the portion between Highway 20 and Reed Market Road. This section will be 6500-feet of 24-inch diameter gravity sewer. This section begins with a crossing of Highway 20. This can be done with a bore or a direct cut. The method to be used will be determined during preliminary design, based on the allowable impact to traffic in this busy intersection. The interceptor then follows the right-of-way south on SE 27th Street collecting existing flows from developed and undeveloped areas east and west of SE 27th Street. This section ends at station 295+00 at Reed Market Road.

REED MARKET ROAD TO SE 15TH STREET

The third section of the SE Interceptor is the portion between Reed Market Road and SE 15th Street. This section will be 9200-feet of 24-inch diameter line. There are two alternative alignments for this section of the interceptor. The first alternative is a gravity alternative and the second is a pumped alternative. The preferred alternative for the Master Plan is the gravity alternative.

Gravity Alternative

With the gravity alternative, the alignment turns west on Reed Market Road to SE Camelot Place south. Interceptor will follow SE Camelot Place, cross private property to SE Orion Drive and then continue down SE King Solomon Lane.

This alternative will provide service to the unsewered area north of the canal between SE 15th and SE 27th Streets. The interceptor crosses the canal as it leaves the local streets near SE 15th Street at station 387+00. The gravity alternative is preferred because of the low long-term operations and maintenance costs.

Pumped Alternative

The pumped alternative was developed as an alternative that could be implemented in the near-term. In the pumped alternative, a pump station is constructed near the intersection of 15th Street and the COID canal. The station then pumps through a force main with an alignment that leaves the pump station and follows the south side of the canal east to Ferguson Road. The force main then goes east on Ferguson Road to 27th Street. The force main turns north on 27th Street where it changes to gravity line and flows north. This 18-inch gravity sewer follows 27th Street north to the intersection of the Central Oregon Irrigation District (COID) canal and 27th Street. On the south side of the canal, the size of the gravity sewer is increased to a 24-inch line. This section of the 24-inch gravity sewer then follows 27th Street to Reed Market Road.

15TH STREET TO MURPHY ROAD PUMP STATION

The fourth section of the SE Interceptor is the portion between 15th Street and the Murphy Road Pump Station. This section will be 4100-feet of 24-inch diameter line. The gravity sewer follows 15th Street south to a point approximately even with the east/west alignment of Murphy Road. The interceptor then goes west on Murphy Road to the Murphy Road Pump Station.

This section of interceptor allows for the decommissioning of the Murphy Road Pump Station by redirecting the flow from the Murphy Road Pump Station (old Juniper Utilities) to the east and away from the downtown core system. The Murphy Road Pump Station is currently capacity limited and this gravity sewer will allow for removing the station from service in lieu of investing in additional capacity and a new force main.

MURPHY ROAD PUMP STATION TO HIGHWAY 97

The fifth section of the SE Interceptor is the portion between Murphy Road Pump Station and Business 97 (old Highway 97). This section will be 5980-feet of 18-inch diameter line. This gravity sewer follows the alignment of Murphy Road west to Highway 97. This line then is connected to the existing gravity sewer providing service to the southern and southeastern areas of the City. These flows will then be diverted east through the SE Interceptor to the treatment plant providing relief to the downtown core system.

SE INTERCEPTOR COST ESTIMATE

The estimated cost of the complete SE Interceptor is $19.03M. The estimated costs of each of the five elements of the interceptor are:

- $ 9.99M -- Plant Interceptor to Highway 20
- $ 2.81M -- Highway 20 to Reed Market Road
- $ 2.48M – Reed Market Road to SE 15th Street
- $ 1.80M – SE 15th Street to Murphy Road Pump Station
- $ 1.95M – Murphy Road Pump Station to Highway 97

This project can be completed in phases beginning with the Plant Interceptor to Highway 20 element following the construction of the Plant Interceptor.

WESTSIDE INTERCEPTOR

The Westside Interceptor redirects the flow from the Westside Pump Station to the North Interceptor providing capacity relief for the downtown core system. Raw wastewater is pumped from the Westside pump station to a gravity interceptor that discharges into the North Interceptor as the latter crosses Highway 97 on the north end of the City. This interceptor will also receive flow from the Sawyer Park and Wyndemere Pump Stations. This will relieve many of the capacity restrictions that exist now and in the future in the north and northeastern pressure and gravity system.

Two alignments have been proposed for this interceptor. These alignments are shown in ***Figure 6-5***. An alternative alignment to the preferred alignment is shown as the Alternative 1 alignment. Additional evaluation of a final alignment should be performed by the City during predesign of this interceptor. Factors such as traffic management and utility coordination will determine the best final alignment. One possible alternative alignment is to follow the preferred alternative alignment to the intersection with Highway 20, then go east to the Alternative 1 alignment and follow it to the North Interceptor. This alternative will allow for some pump stations to be removed earlier and will eliminate other projects that will be required along NE Vogt Street. The final alignment of the interceptor will be somewhere between the two alternatives shown in ***Figure 6-5***.

The estimated cost of the complete Westside Interceptor is $9.78M. This cost estimate is based on the preferred Alternative 2 alignment.

Preferred Westside Alternative

The preferred Westside Interceptor alignment is the westerly alternative. In this alternative, the alignment crosses the river on the NW Portland Avenue bridge and turns north on NW Hill Street. The alignment then follows NW Hill Street north to NE Revere Avenue where it turns east to Division Street. The alignment then turns north onto Division Street and follows Division Street north until it intersects with Business 97, then follows Business 97 north to where it intersects and discharges into the North Interceptor.

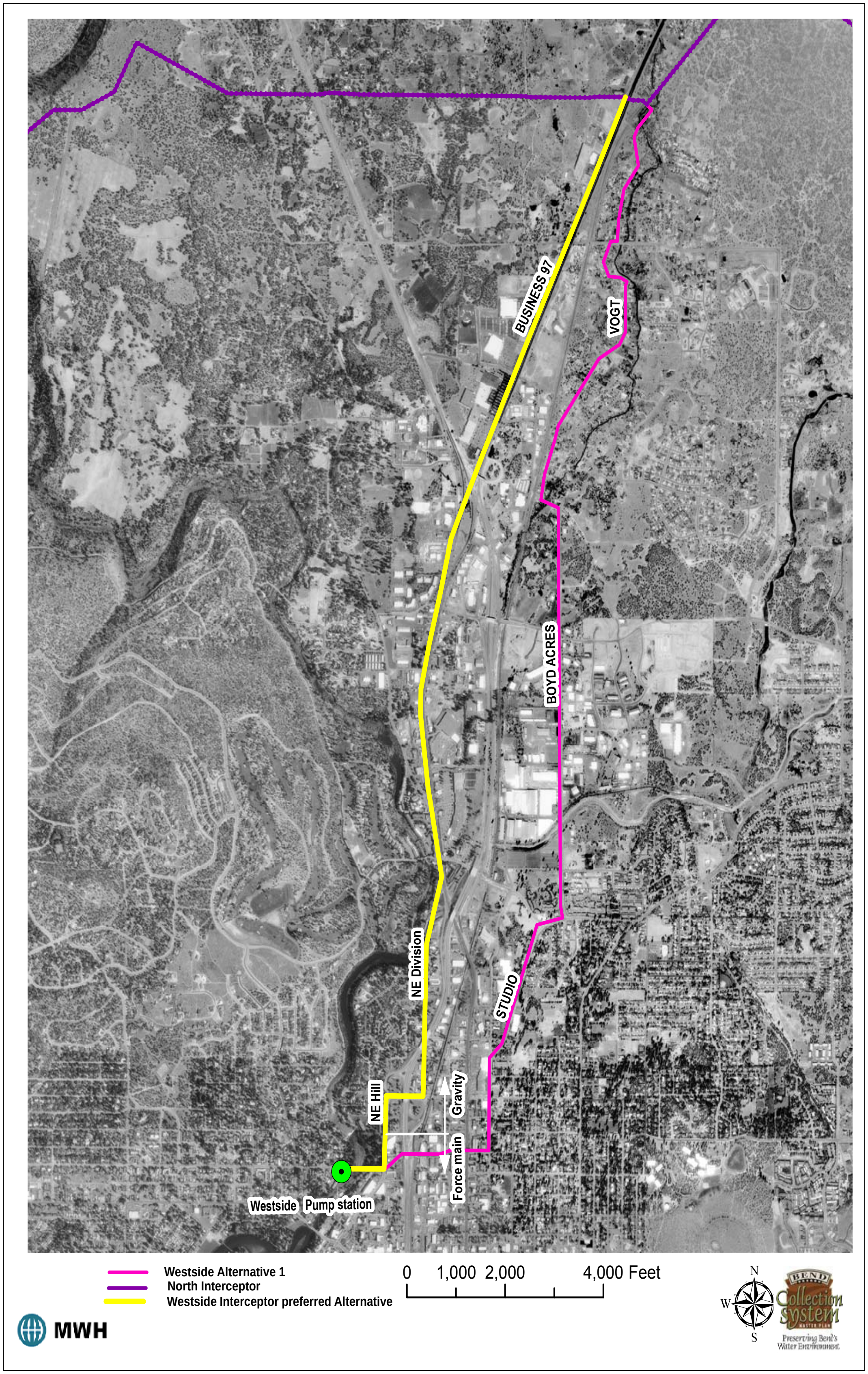

FIGURE 6-5 – WESTSIDE INTERCEPTOR

SUMMARY OF INTERCEPTOR PROJECT COSTS

Project costs have been estimated for each of the interceptor segments that will be required to provide sanitary service to the planning area between now and system build-out. These costs are summarized in ***Table 6-1***. The total cost for construction of the interceptors through build-out is $67,378,459.

Table 6-1
City of Bend Collection System Master Plan
Interceptor Project Cost Summary

Interceptor Segment	Diameter (inches)	Length (feet)	Project Cost ($)
Plant Interceptor			
Plant Interceptor	48	13,094	**9,448,000**
North Interceptor			
Plant Interceptor to Hwy 97	42 & 48	15,010	10,353,400
Hwy 97 to the Deschutes River	30	14,340	6,552,900
Deschutes River to Shevlin Park	8, 10, 15 & 27	23,810	5,058,000
Deschutes River Force Main	15	1610	277,800
North Interceptor Pump Station	10,800-gpm		1,226,400
Trunk 1	12	4865	835,000
Trunk 2	12	4920	844,000
Trunk 3	12	6430	1,103,000
Trunk 4	12	8350	1,434,000
Trunk 5	12	3430	588,000
Canal Crossings (3)			394,900
Traffic Control/Management			87,800
Erosion Control			373,200
Hwy 97 and Hwy 20 Bores			438,800
Railroad Undercrossing			263,300
Total			**29,830,500**
SE Interceptor			
Plant Interceptor to Hwy 20	24 & 36	23,664	8,610,767
Hwy 20 to Reed Market Road	24	6324	2,089,091
Reed Market Road to SE 15th Street	24	8554	2,279,644
SE 15th to Murphy Road Pump Station	24	4278	1,301,627
Murphy Road PS to Hwy 97	18	5980	1,811,702
Canal Crossings (2)			263,250
Railroad Undercrossing			403,650
Intertie Structures			702,000
Traffic Control/Management			789,750
Erosion Control			342,575
US Hwy 20 Undercrossing			438,750
Total			**19,032,806**
Westside Interceptor			
Force Main	18	2998	539,821
Gravity Interceptor	27	18,916	6,964,680
US Hwy 97 Undercrossing			702,000
Railroad Undercrossing			403,650
Traffic Control/Management			309,582
Erosion Control			147,420
Total			**9,067,153**
		Total Interceptor Cost	***67,378,459***