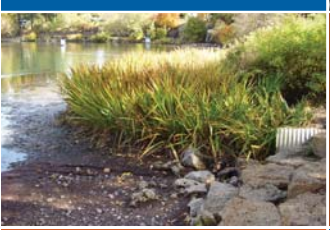
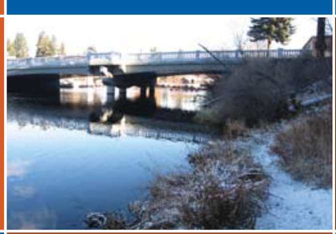
City of Bend

Stormwater Master Plan

Public Draft: December 2008





URS

PUBLIC DRAFT

CITY OF BEND
STORMWATER MASTER PLAN

December 2008

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ACRONYMS

BMPs	Best Management Practices
BMPRD	Bend Metro Parks and Recreation District
BNSF	Burlington Northern Santa Fe
CIP	Capital Improvement Project
CN	Curve Number
COID	Central Oregon Irrigation District
COSM	Central Oregon Stormwater Manual
CWA	Clean Water Act
DMA	Designated Management Agency
DEM	Digital Elevation Model
DWPA	Drinking Water Protection Area
EPA	U.S. Environmental Protection Agency
°F	degrees Fahrenheit
GIS	Geographic Information Systems
ISWMP	Integrated Stormwater Management Plan
LID	Low Impact Development
MB	Major Basin
MCL	Maximum Contaminant Level
MS4	Municipal Separate Storm Sewer System
ND	Non-Detect
NPDES	National Pollutant Discharge Elimination System
NRCS	Natural Resources Conservation Service (Previously Soil Conservation Service)
ODEQ	Oregon Department of Environmental Quality
ODOT	Oregon Department of Transportation
OSHD	Oregon State Health Division
SBUH	Santa Barbara Unit Hydrograph
SDWA	Safe Drinking Water Act
SPA	Shaun Piggott & Associates
SWMP	Stormwater Management Plan
T_c	Time of Concentration
TMDL	Total Maximum Daily Loads
UIC	Underground Injection Control
UDWC	Upper Deschutes Watershed Council
UGB	Urban Growth Boundary
USGS	United States Geological Survey
WPCF	Water Pollution Control Facility
WRF	Water Reclamation Facility

DEFINITIONS

Catch Basin – A catch basin is a box-shaped receptacle fitted with a grilled inlet and a pipe outlet drain to collect rain water and floating debris from the roadway surface and to retain solid material for periodic removal. Catch basins may be installed horizontally in the roadway surface or be imbedded in the curb (curb inlet).

Detention Pond – A detention pond is a facility that is designed to temporarily hold stormwater runoff while slowly draining to an outlet. Detention ponds are a means to reduce downstream flooding by slowing the movement of stormwater to downstream pipes, creeks, and rivers. They have a negligible effect on water quality (compared to dry ponds) because sediments and pollutants do not remain in the ponds long enough to settle out of the stormwater. These facilities are normally dry when it is not raining.

Drill Hole – A drill hole is a borehole that is drilled, hammered, or blasted through impermeable geologic layers. Drill holes are used for disposal of stormwater in areas where dry wells do not function. Many of the city's Drill holes were installed in the earlier days of the city's development before dry wells became common practice. Drill holes are typically 6 to 8 inches in diameter and extend deep into the ground. Because drill holes pose a greater threat to groundwater, the Oregon Department of Environmental Quality (ODEQ) does not allow them to exceed 100 feet in depth unless they are covered under a UIC WPCF Permit.

Dry Pond – Dry ponds (also known as dry extended detention basins) are basins whose outlets are designed to detain the stormwater runoff from a rain event for a minimum duration (e.g., 24 hours) to allow sediment particles and pollutants associated with them to settle out. Water flows more slowly through dry ponds than through detention ponds. Dry ponds do not have a permanent pool of water and are normally dry between storm events.

Dry Well – A dry well is a vertical drainage facility (a well) with perforations along its walls that drain stormwater into the surrounding soil. A dry well is surrounded by crushed drainage rock to enhance infiltration capabilities and provide additional void space for storage. They are intended to dry up between storms.

Retention Pond – See Wet Pond.

Swale – Vegetated swales (also known as grassed channels or biofilters) are constructed facilities that are open-channel drainageways used to convey and treat stormwater runoff. Vegetated swales are often used either instead of traditional storm sewer pipes or to provide treatment for discharges from stormwater pipes. Swales encourage infiltration, and water does not pond in them for very long. Vegetated swales generally have a relatively flat slope to provide sufficient time for treatment of pollutants, including sediment.

Sonde – A sonde is a submersible multi-parameter continuous recording device for monitoring physical and chemical water quality parameters.

T_c – The time in minutes that it takes a drop of water to travel from the farthest point in a drainage area to the point of discharge.

Total Maximum Daily Load – The Total Maximum Daily Load process determines how much of a pollutant a water body can receive without violating water quality standards.

Two-Year Time of Travel – In reference to drinking water protection areas, the horizontal distance a particle of water is expected to travel in an aquifer before entering a water well.

Underground Injection Control – Underground injection control (UIC) facilities are drainage systems that allow stormwater to infiltrate into the ground. Dry wells and drill holes are the most common UICs in Bend. The Safe Drinking Water Act regulates UICs to protect groundwater quality for current or potential beneficial uses such as drinking water.

Urban Growth Boundary – A regional boundary set in an attempt to control urban sprawl by allowing the area inside the boundary to be used for higher-density urban development and the area outside for lower-density development. An urban growth boundary circumscribes an entire urbanized area and is used by local governments as a guide to zoning and land use decisions.

Water Quality Design Storm – The water quality design storm is defined as the storm that produces the runoff that requires water quality treatment prior to discharge. For the City of Bend, the water quality storm is the 6-month NRCS Type I storm or other type of storm as designated in the Central Oregon Stormwater Manual, latest edition. Treatment of the design storm runoff is intended to treat 80 to 90% of the first-flush pollutant-generating impervious surface runoff.

Wet Pond – Wet ponds (also known as stormwater ponds, retention ponds, and wet extended detention ponds) are facilities designed to contain a permanent pool of water throughout the year, particularly in the wet season. Ponds provide treatment of incoming stormwater runoff by capturing and holding the water for a long time, allowing solids and associated pollutants to settle. Nutrient removal also occurs as a result of plant activity and activity of aquatic organisms.

EXECUTIVE SUMMARY

INTRODUCTION AND BACKGROUND INFORMATION

This is the first Stormwater Master Plan developed for the City of Bend. It is a starting point for the development of more detailed plans to address the specific stormwater issues identified in this Plan.

The stormwater challenges the City faces over the next several years are categorized as follows:

1. Complying with water quality requirements mandated by state and federal laws
2. Improving the collection and conveyance of stormwater so that the regulatory requirements can be met
3. Reducing flooding to protect property and public safety
4. Determining the vulnerability and susceptibility of groundwater to contamination from injected stormwater
5. Determining if and how stormwater discharged to the Deschutes River may be interfering with the river's beneficial uses and affecting compliance with receiving water quality standards
6. Ensuring that limited stormwater funds are spent on projects that are most likely to provide demonstrable benefits

The first two items are not optional as the regulatory requirements are explicit and not likely to change in the foreseeable future. Compliance with these requirements will be expensive and there are currently no significant state or federal funding sources for these types of projects. The City must identify and develop funding sources for this work. Although not required, by implementing items 4 and 5, the City may limit the impact of implementing the first two items. For example, if the City can demonstrate that stormwater runoff is not negatively impacting water quality of either groundwater or the Deschutes River, then costs for pretreatment of stormwater can potentially be reduced.

How the City deals with items 3 through 5 will depend largely on the wishes and priorities of the City's residents, elected officials and City management.

Before 2007, hydrologic, hydraulic, and geologic data for the City had not been comprehensively analyzed within the context of stormwater management. Since drainage and flooding problems have been increasing in recent years due to the increasing amount of impervious surface area, the City started documenting these problems in 2007. The purpose of this plan is to address the City's stormwater drainage system within the current (2007) urban growth boundary, and to meet increasingly stringent regulations governing stormwater.

Bend's topography ranges from relatively flat to hilly. There are two distinctive buttes in Bend, Awbrey and Pilot. Regional geologic features are largely the result of volcanic activity and subsequent weathering along the Cascade Range. These processes have resulted in the relatively recent deposition of a thick sequence of volcanic and volcanically derived sedimentary rocks. The volcanic geology has created a complex landscape with many ridges, drops, sinks, and hills.

Drainage patterns and directions vary greatly throughout the City, although both surface and subsurface flows are generally northward. Several large irrigation canals run through the City, conveying water from the Deschutes River to serve agricultural areas as far away as Madras, some 50 miles to the north. These canals and laterals have a strong influence on drainage patterns within the City. The Deschutes River divides the City into eastern and western halves.

Some areas of the City are underlain by consolidated basalt or "pink tuff", which is highly impermeable and does not provide acceptable geotechnical conditions for the use of dry wells or drill holes that are not deep enough to penetrate through it.

A large part of Bend's drinking water comes from a deep, very high-quality and abundant aquifer beneath the City that is fed by snow melt high in the Cascade Mountains. The City and its residents are committed to protecting this valuable resource.

EXISTING DRAINAGE SYSTEM

For many years, the City of Bend's drainage system has depended primarily on underground injection (dry wells and drill holes) to discharge stormwater into the fractured volcanic rock that underlies much of the City. Bend does not have a city-wide piped storm drain system. The lack of defined drainage ways, the expense of digging in rock, and the difficult topography have limited the installation of piping. The piped system is limited to about 13 miles of pipe and 20 outfalls to the Deschutes River. There are approximately 4,000 dry wells and 1,100 drill holes on public property in the City and an unknown number on private property.

HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic and hydraulic analysis of the City of Bend was undertaken to define drainage basins in order to develop recommendations in the form of capital improvement projects (CIPs).

The drainage basins were defined using ArcGIS (Hydrology Modeling, ESRI) to identify low-lying areas and the direction of flow based on topography. Flow patterns were established to identify subbasins and major basins. Equations in the Central Oregon Stormwater Manual and the Santa Barbara Urban Hydrograph method were used to calculate peak runoff flows and total volumes for three storm events: the 6-month water quality storm (1.0 inch in 24 hours), along with the 25-year (2.52 inches in 24-hours) and 100-year (3.2 inches in 24-hours) storms.

WATER QUALITY

Bend relies heavily on groundwater to provide potable water for the City. Within its Urban Growth Boundary, the City owns 21 municipal drinking water wells, and there are about 400 private water wells. Although the City obtains some of its drinking water from a surface water supply, the other water franchises in Bend obtain theirs solely from water from wells.

Water quality pollutants in Bend include typical urban stormwater pollutants such as sediment, nitrates, chlorides and oil and grease and heavy metals from motor vehicles.

Underground Injection Control (UIC) regulations do not allow stormwater injection within 500 feet of any drinking water well or within the 2-year time-of-travel zone delineated by the Oregon Health Division as Drinking Water Protection Areas. These restricted areas cover a large part of the City and UICs located within them must either be decommissioned or be equipped with pretreatment that treats the stormwater to drinking water standards prior to being discharged underground, a potentially costly requirement.

Stormwater discharge sampling completed to date provides only preliminary information on the quality of stormwater in Bend.

Water quality recommendations include:

- Promote the use of low-impact development (LID) principles in all City projects; and require private projects to consider LID principles.

- Develop a better understanding of water quality in stormwater runoff by the continuation of monitoring water quality in UICs, river outfalls and the Deschutes River.

- Install efficient sediment traps in the storm drain system ahead of discharges to either surface waters or groundwater. Excessive sediment from unpaved roads, poorly installed landscaping, poor sediment and erosion control at construction sites and traction materials used on City streets during the winter months contribute the majority of the sediment that is discharged through stormwater runoff. The City has already implemented some measures to reduce the negative effects of traction materials.

- In partnership with the U.S. Geological Survey, conduct a groundwater vulnerability study as soon as possible. Drinking water protection areas should be updated and all areas where underground injection is prohibited should be identified.

- Use manufactured treatment devices only where other pretreatment options are not feasible. The performance, reliability, maintenance and life-time costs should be considered.

- Consider permeable pavement (asphalt, concrete and pavers) in all new and re-development projects including residential streets, driveways and parking lots.

- Install sediment removal pretreatment components for efficiently removing solids, sediment and trash in all storm drain systems discharging to surface waters.

STORMWATER GOALS, POLICIES, ORDINANCES, AND STANDARDS

Stormwater policies, ordinances, and standards were reviewed along with City goals to identify improvements and updates to support implementation of a comprehensive stormwater management program.

Recommended policies to address the City's goals include:

- No new development or significant redevelopment shall be allowed to occur without requirements in place for maximizing LID and providing onsite storm drainage that will meet water quality requirements and provide safe passage of runoff to the final disposal point.

- Upgrading of streets and storm drainage systems to meet City standards shall be a minimum requirement before new areas are accepted for annexation into the City. The City shall require that areas outside the City limits have a stormwater utility plan that shows the stormwater facilities for the development prior to annexation.

- New developments and neighborhoods can hasten the process of constructing new stormwater facilities by paying for the construction of regional facilities, defined as any system that serves more than one tax lot. Written agreements shall be required for all participants of stormwater districts to ensure the equitable funding of storm drainage improvements and the ongoing maintenance of these improvements.

- Improvements identified in this Master Plan may be used to develop System Development Charges to fund storm drainage facilities.

    - Sensitive areas, such as drinking water protection areas, areas adjacent to clean-up sites, areas near private well-heads, and industrial sites or other areas where the potential for a hazardous material spill is great or the impact of such a spill would be large may need greater protection, including more stringent location requirements, treatment, or spill control standards.

    - Strategic regional drainage areas may be reserved for stormwater treatment and storage.

STORMWATER UTILITY FUNDING

Funding for construction, maintenance and operation of stormwater infrastructure and stormwater management programs to address water quality issues requires a consistent and dedicated source of revenue. The City convened a citizen's task force to discuss the issues, evaluate options, and develop recommendations.

The Task Force made the following recommendations to the City Council:

- The primary funding approach should be a stormwater utility service charge.
- A separate utility is the preferred structure for the funding program. The utility would be dedicated to stormwater management. The rate can be related to a customer's estimated use or contribution of runoff to the stormwater system.
- The appropriate basis of the service charge should be the measured impervious surface area because it is most closely related to runoff factors.
- Based on an estimate of the City's total impervious area, the initial rate per month per Equivalent Residential Unit, or ERU, would be $4.00 to meet the annual rate revenue requirement.
- A credit procedure should be available to non-residential stormwater customers. The credit should be structured to reflect the degree to which constructed facilities or best management practices exceed current standards, and therefore provide a benefit to the utility.
- Stormwater system development charges (SDCs) should be considered after the City Council approves the Stormwater Master Plan.

The stormwater utility recommended by the Task Force was formed in April, 2007 and the stormwater service charge of $4/month/ERU was approved by the City Council on June 20, 2007.

DRAINAGE IMPROVEMENT ALTERNATIVES

A number of alternatives were evaluated for addressing stormwater issues in the City of Bend. Funds are limited and it is important to maximize benefits of capital improvement projects while addressing stormwater flooding, water quality regulations, and public concerns. Possible solutions to the stormwater drainage and water quality problems evaluated and discussed herein are listed below. Some of these alternatives are not applicable in all parts of the City.

- Implement LID techniques, including pervious pavement, on City property and require their consideration for all new development and redevelopment.
- Continue using dry wells and drill holes where geotechnical conditions are appropriate and this is the most cost-effective alternative.
- Pipe with pretreatment and, as necessary pump, to the Deschutes River.
- Pipe, with pumping as necessary, to stormwater only infiltration/evaporation ponds at the Water Reclamation Facility.
- Construct piped systems with regional detention and treatment in strategic locations.
- Combine construction of stormwater infrastructure with construction of other utilities, such as roads, sanitary sewers, and water lines.
- Work with other agencies such as Oregon Department of Transportation and Bend Metro Parks and Recreation District to develop facilities that accomplish several functions (e.g., a cloverleaf green area that is also a detention facility, or a ball field that functions as a detention facility when it rains).
- Work with irrigation districts to use the ground surface in existing easements for stormwater management.
- Work with Oregon Department of Environmental Quality to recognize optimized street sweeping as a stormwater best management practice.
- Develop plans and facilities to prevent or respond to spills from railroads and streets that may threaten surface water or groundwater.

CAPITAL IMPROVEMENT PROJECT PRIORITIZATION CRITERIA AND ALTERNATIVES

The most important criteria for prioritizing storm drainage CIP projects are the following:

- Fire, life, and safety considerations
- Property damage
- Magnitude of impact
- Compliance with water quality regulations

Based on the above criteria and discussions with the City, the strategy for implementation is to address the most serious flooding problems, addressing water quality protection as an integral part of each project. Construction of a pipeline network would occur as development proceeds and funding allows. In addition, the City will pursue construction of LID projects to minimize concentration of stormwater and associated flooding. It is also recommended that the City actively coordinate with other agencies to evaluate sites for regional facilities.

New developments can provide land for localized regional detention. Setting aside areas at the time of planning for developments can provide a network of localized regional facilities for storage, treatment, and disposal of stormwater.

Solving Bend's drainage problems is important to other functions of the City. Poor drainage in the streets causes additional wear and tear and reduces the longevity of the pavement and supporting base material. Early replacement of streets and increased maintenance result in added costs to the City. The demands on City staff and equipment are sometimes overwhelming during flooding events. Police services are required when streets flood. Runoff must be properly collected and conveyed before it can be pretreated.

RECOMMENDED CAPITAL IMPROVEMENT SYSTEM

The basic Capital Improvement Program provides a City-wide drainage and water quality solution for the area within current city limits. Consisting of regional piping and regional water quality facilities, the basic CIP provides solutions to solve the drainage and water quality problems in Bend. Regional detention is recommended for the northwestern part of the City due to the limited options for installing a piped system, while piping and regional water quality facilities are recommended for the majority of the remainder of the City. Areas naturally draining to the Deschutes River will continue to do so, with treatment prior to discharge.

In many parts of the City, LID combined with regional piped systems, including detention, retention, treatment, and disposal, will provide solutions to existing and future drainage and water quality problems. The City should require and implement LID techniques for all new development and redevelopment to minimize flow rates and volumes, and to reduce the amount of soil erosion conveyed to City streets. Solutions such as dealing with erosion from unpaved streets, using pervious pavement, and installing rain gardens should be considered in the comprehensive plan to address stormwater quality and quantity in the City of Bend.

Major components of the recommended CIP involve the construction of underground piping, culverts, open channels, regional storage, and water quality treatment facilities. A network of pipe was identified to drain each major basin. The proposed pipe network would provide drainage to the Deschutes River, the Water Reclamation Facility,[1] or undeveloped land that might be available for a regional infiltration pond. Runoff from some subbasins would be routed to neighboring basins to provide an appropriate discharge point for the drainage. All drainage improvements would include pretreatment.

Proposed storm drainage facilities are shown in Figure ES-1.

CIP PHASING

This is an initial phasing recommendation for CIP projects. Several factors, primarily regulatory requirements, development patterns and the availability of capital, are likely to cause the priorities and phasing to change.

The City has developed a matrix for prioritizing water quality projects and expects to begin using it in early 2009. This matrix will allow the City to assign a numerical priority rating to each UIC based on regulatory requirements and the potential threat to groundwater quality. Results will be used to adjust CIP phasing and refine cost estimates.

The recommended CIP for addressing the highest priority flooding and water quality problems is presented in three phases. The projects have been phased to address the highest priority problems first. High-priority projects are recommended to be constructed over the next 5 years; medium-priority projects are to be constructed in 5 to 10 years; and long-term projects are to be constructed in 10 to 20 years and beyond. CIPs for medium- and long-term construction have been phased to spread costs over a number of years and to provide a logical progression for constructing the costly drainage system and water quality improvements needed for future build-out conditions.

[1] Stormwater would be routed to and treated on land area near the Water Reclamation Facility for eventual infiltration and evaporation.

Due to the complexity of stormwater management in the City and because this is the first attempt by the City to develop a CIP for its stormwater system, URS recommends that one of the projects in the first 5-year period be a feasibility study for implementing subsequent projects. URS recommends that the City reassess its priorities and perform additional feasibility studies prior to implementing the recommended projects.

Prior to this Master Plan, the City began working on two legacy stormwater CIP projects (Westside Meadows and Drake/Dohema) that it expects to complete by 2010. The City has also begun work on the 3rd Street Underpass project and plans to complete the first phase of this project by 2010.

The projects addressed in this Master Plan and the estimated costs for the three phases are listed in Tables ES-1, ES-2, and ES-3.

Table ES-1
High-Priority Projects (within 5 years)

HP#1 Westside Village Shopping Center (this project is also part of Pipe ID53)	See ID53
HP#2 Franklin Avenue Underpass	$931,000
HP#3 Third Street Underpass (Area A – See Appendix B)	$4,816,000
HP#4 Archie Briggs	$609,000
HP#5 Fairway Heights at Awbrey Butte	$529,000
(HP#7 Greenwood Avenue Underpass[1])	
Pipe ID10	$898,000
Pipe ID19	$466,000
Pipe ID9	$218,000
Pipe ID53	$3,661,000
Water Quality Facilities	$200,000
Land Acquisition for regional facilities[2]	$2,000,000
Decommissioning existing drywells (50)	$50,000
LID projects	$300,000
Total for High-Priority Projects	***$14,678,000***

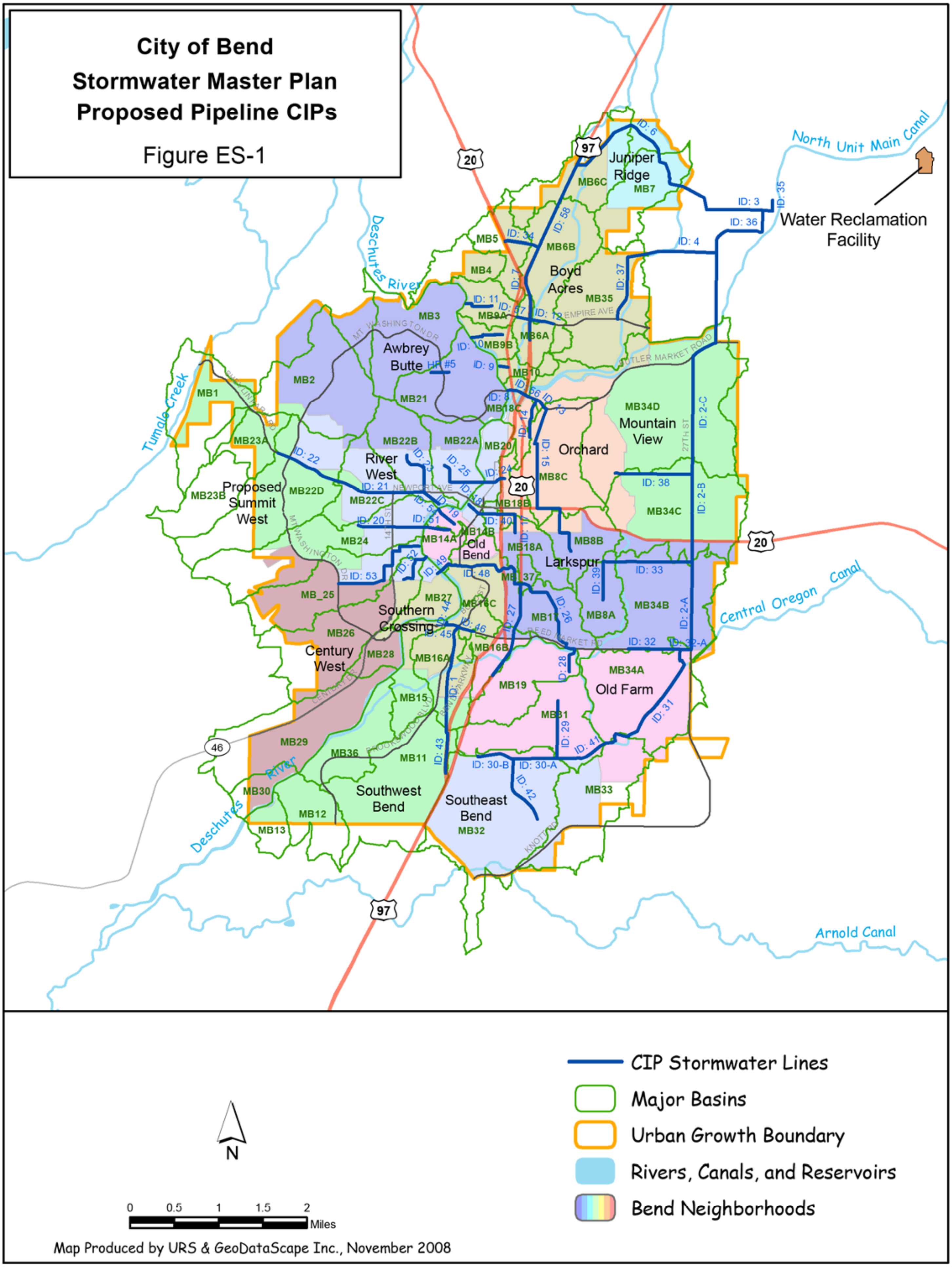
Notes:
[1]The solution to the Third Street and Franklin Avenue drainage problems may also provide a major part of the solution to the Greenwood Avenue problem and may be integrated into the Third Street/Franklin project even though Greenwood is #7 on the priority list.
[2]Land acquisition costs are highly variable and details are unknown at this time. Cost estimates are provided for budgeting purposes only.

Table ES-2 Medium-Priority Projects (5 to 10 years)	
ID18, 40, 17	$3,033,000
ID22, 21, 54	$7,425,000
HP#3 Third Street Underpass	$8,853,000
Water Quality Facilities	$500,000
Land Acquisition for regional facilities	$2,000,000
Decommissioning existing drywells	$500,000
LID projects	$500,000
Total for Medium-Priority Projects	***$22,811,000***

Table ES-3 Long-Term Projects (10 to 20 years and beyond)	
Pipe ID 1, 2a, 2b, 2c, 3, 4, 6, 7, 8, 11-15, 20, 23-29, 30a, 30b, 31, 32a, 32, 33-39, 41-46, 48, 49, 51, 52, 56-59 (see Table 10-1)	$145,130,000
Area 4 Regional Retention and Treatment Facilities	$3,125,000
Water Quality Facilities	$7,667,000
Decommissioning existing drywells (1,000)	$1,000,000
Water Reclamation Facility	$500,000
Land Acquisition for Regional Facilities	$15,000,000
Total for Long-Term Projects	***$172,422,000***

City of Bend
Stormwater Master Plan
Proposed Pipeline CIPs

Figure ES-1



1.0 INTRODUCTION, AUTHORITY, AND SCOPE

1.1 INTRODUCTION

This Master Plan has been developed in light of historic development practices in Bend. Since March of 1983 and possibly earlier the City's development code has required that surface drainage be retained on site. As a practical matter, given the City's topography and geotechnical conditions, it is often not possible to safely retain all stormwater on site. Consequently, on-site retention has not been a common practice within the City and may never be feasible for much of the City, especially in the developed areas. Therefore, this Master Plan assumes that most stormwater will not be retained on the site of origin and will, instead, be released to City streets. This Master Plan recommends a stormwater system capable of handling this runoff and providing the necessary water quality pretreatment.

Starting out as a small logging community around the turn of the twentieth century, the City of Bend had become a highly desirable place to live by the 1990s. Between 1995 and 2007, the population more than doubled, growing to 77,780, at a rate of growth that at times was the highest in the country.

Bend has a semi-arid climate with a large amount of open space and well draining but generally shallow soils, and until recently the management of stormwater has not caused much concern. In the earlier history of the city when most development was close to the Deschutes River, piped systems were constructed to convey stormwater to the river. As growth expanded, drill holes became the main stormwater disposal method followed by dry wells. Dry wells and, to a lesser extent, drill holes have been used for many years to dispose of stormwater in the City. Because they worked reasonably well and are relatively inexpensive to install, their use has continued throughout the City even in areas where they should not have been used.

Dry wells and drill holes are difficult to maintain. Road cinders (used to improve traction for the motoring public during icy weather), eroded soils, and debris accumulate in them, reducing their effectiveness, and many of them fail within five years of installation. Failed or failing dry wells, dry wells installed in inappropriate places, and the increase in the impervious surface area all contribute to the frequent and widespread flooding that now takes place in Bend.

In recent years, flooding has more frequently rendered underpasses on three of the City's busiest streets impassable for up to several hours at a time. Detours over crowded streets are both an annoyance to the public and a safety hazard. Population growth and the resulting increase in development density have exacerbated drainage problems by increasing flooding frequency, duration, and impacts. Flooding has become a public safety problem and a threat to homes and businesses.

Stormwater quality is also a serious issue. Environmental regulations and the City's commitment to protect the Deschutes River and its underground source of drinking water require pretreatment of stormwater before it is discharged either to the river or into the ground. Currently, virtually none of the stormwater discharged by the City is pretreated. The federal Safe Drinking Water Act (SDWA) and the State of Oregon's Underground Injection Control (UIC) and Drinking Water Protection rules regulate the City's dry wells and drill holes. The federal and state National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer (MS4) Phase II rules regulate the City's discharges to the Deschutes River. Both of these regulatory programs require the City to obtain and comply with a permit and to use Best Management Practices (BMPs) to reduce the amount of pollutants discharged.

Outdated, weak, or poorly enforced development standards allow continued construction of inadequate drainage systems as evidenced by photographs of flooding and the growing list of documented drainage complaints. Recognizing the need to construct systems that prevent flooding and adequately protect water quality, the importance of the Deschutes River as a Bend icon, and the protection of groundwater as a high priority drinking water resource, the City has embarked on a program to address its stormwater problems responsibly. Consequently, it issued a Request for Proposals to implement a stormwater utility funded through user service charges; develop a stormwater Master Plan for meeting existing and future infrastructure needs; provide conceptual solutions for several of the highest priority flooding problems; and develop recommendations for meeting regulatory requirements.

This is the first stormwater Master Plan developed for the City of Bend. Before 2007, there was little documentation of drainage or flooding problems, or characterization of hydrologic, hydraulic, and geologic data. Now, flooding problems are increasing, and the regulations governing stormwater quality have become more stringent. The City of Bend is now faced with the need to define the issues surrounding stormwater, including the magnitude of the water quantity and water quality problems, consider the benefits of addressing policies and programs, and develop the best approach to fund stormwater services.

1.2 AUTHORITY

URS Corporation signed a contract with the City of Bend in November 2006 to prepare a comprehensive stormwater Master Plan for areas within the City's Urban Growth Boundary (UGB), a regional boundary that was set in an attempt to control urban sprawl by encouraging higher density urban development inside the boundary. An urban growth boundary circumscribes an entire urbanized area and is used by local governments as a guide to zoning and land use decisions.

Because the City relies heavily on dry wells and drill holes for storm drainage, URS teamed with GeoEngineers, Inc. to prepare a geologic study and produce a report on the subsoil conditions and infiltration capabilities in Bend. Using existing reports and studies, GeoEngineers prepared a report generally describing the relative infiltration rates that are likely in various parts of the City.

Shaun Pigott and Associates (SPA), the third member of the URS team, prepared the financial analysis and recommendations for funding stormwater management activities in Bend. SPA led a community Task Force in a process of evaluating options and studying issues for development of a stormwater utility and appropriate service charges.

1.3 OUTLINE OF THE MASTER PLAN

This stormwater Master Plan was developed to address existing problems and identify future needs for public drainage and water quality infrastructure in the City of Bend. The scope of work did not include private facility stormwater management. The project was divided into two phases with the following specific tasks:

Phase 1

- Identification of high-priority problem areas and development of a prioritization process to determine the top ten flooding problems
- Preparation of conceptual solutions and fact sheets, including cost estimates, for the five highest-priority flooding areas
- Preparation of a geologic study of the soils to identify opportunities and appropriate applications for infiltration of stormwater

- Development of a financial analysis to evaluate options for funding the stormwater program
- Implementation of a stormwater utility

Phase 2

- Delineation of drainage basins for the City of Bend
- Preparation of a hydrology and hydraulic analysis of peak runoff flows and runoff volumes from drainage basins in the City
- Evaluation of existing data to identify water quality and stormwater quantity capital improvement projects (CIPs) to meet regulations and public concerns
- Identification of CIPs that address water quality and quantity for existing conditions and future buildout development

This Stormwater Master Plan was prepared to provide the City with a number of options to alleviate flooding and address water quality concerns for the NPDES Phase II and the UIC regulations and permits. CIPs to accomplish these goals were identified and prioritized as part of this plan.

Chapter 2 provides information about the City of Bend. Chapter 3 reviews environmental regulations and discusses a geologic analysis performed for this project. Chapter 4 describes existing drainage conditions, evaluates existing problems, and suggests solutions for the highest-priority areas. Hydrologic and hydraulic analyses are presented in Chapter 5. Water quality concerns, issues and existing conditions are discussed in Chapter 6. Chapter 7, written in part by City of Bend staff, provides a review, analysis and recommendations regarding the City's stormwater ordinances, policies, standards, specifications and codes. The financial analysis and process used in forming the stormwater utility and determining the service charges are presented in Chapter 8. The CIP drainage improvement alternatives are discussed in Chapter 9; the CIP program is described in Chapter 10.

REFERENCES

Portland State University Center for Population Research and the U.S. Census Bureau. Economic Development Center website. Accessed August 24, 2008.

2.0 STUDY AREA CHARACTERISTICS

2.1 LOCATION

The City of Bend is the county seat of Deschutes County in Central Oregon. On a high plateau in the foothills east of the Cascade Range, the City is about 16 miles south of Redmond and 30 miles north of LaPine (Figure 2.1). Its clear view of Mt. Bachelor and the Three Sisters, along with a recreational bounty of year-round outdoor activities, make Bend a very desirable place to live. Bend covers an area of 32 square miles within the Urban Growth Boundary (UGB) (Figure 2.2). Highways 97, 97 Business, and 20 run through the City.

2.2 POPULATION

Incorporated in 1905, Bend has grown from a small logging town of 300 residents to a City with an estimated population of 77,780 in 2007 (Portland State Population Research Center, 2008). By 1990, the City had a population of approximately 20,000. The population increased from 29,425 to 77,780 between 1995 and 2007. The average annual growth rate varied from 5 percent in the late 1990s to 15 percent in recent years (Portland State University Center for Population Research and the U.S. Census Bureau, 2008), and at times its growth rate was the fastest in the country. Bend's growing economy, abundant high-quality drinking water, dry climate, and year-round recreational opportunities have attracted many residents, contributing to the City's high growth rate.

2.3 LAND USE

Land use in Bend currently consists of a mix of residential, commercial, and industrial properties within the City. The downtown district is in the center of town near the Deschutes River. Figures 2.3 and 2.4 depict current land use and zoning for future growth, respectively.

About 37 public parks throughout the City are operated and managed by the Bend Metro Parks and Recreation District (Figure 2.5), and additional facilities are being planned. Drake Park along Mirror Pond and Juniper Park in the eastern part of the City are two of the largest parks in Bend. Pilot Butte, a popular hiking trail and scenic overlook, also in the eastern part of the City, is managed by the Oregon State Parks Department.

2.4 INDUSTRY

Central Oregon is home to a diverse group of industries. Top employers include government, retail industries, and leisure and hospitality (Economic Development for Central Oregon, 2008). Manufacturing, natural resources, mining, and construction follow closely behind the three major employment sectors. Recreation and tourism are large industries for the City. As Bend grows, industries continue to diversify and provide more jobs. Most of Central Oregon's residents shop in Bend, and stores and shopping centers in the City are increasing in number and size.

2.5 CLIMATE

Bend has a mild climate, classified as semiarid or High Desert. With average annual rainfall of only 11.7 inches, the City experiences an average of 300 days of sunshine per year. Most of the 34 inches of average annual snowfall occurs between October and May. Bend is to the east of the Cascade Mountains and in their rain shadow, and receives a fraction of the precipitation experienced west of the mountains as storms from the Pacific Ocean bring warm moist air inland. Although there is relatively little annual rainfall, it often comes in short, intense bursts, particularly in the spring and fall, causing considerable localized flooding throughout the City. During the winter months, when drainage systems are blocked by snow and ice, rapid snowmelt and rain-on-snow events exacerbate flooding.

Average monthly low temperatures of 23 to 35 degrees Fahrenheit (°F) occur in winter months, while average high winter temperatures vary from 41 to 65°F. Average monthly summer temperatures vary from lows of 38 to 46°F to highs of 73 to 82°F (Oregon Climate Service, 2008).

2.6 VEGETATION

Except where it is irrigated, vegetation is limited to drought-tolerant species in the arid, high desert climate of Bend. A number of deciduous and evergreen trees and shrubs are drought tolerant; these include plants native to Central Oregon (Native Plants of Oregon, 2008), and other such as juniper (*Juniperus occidentalis*) and ponderosa pine (*Pinus ponderosa*). Deciduous trees growing in Bend include alder (*Alnus* sp.), ash (*Fraxinus latifolia*), aspen (*Populus tremuloides*), larch (*Larix occidentalis*), and maple (*Acer macrophyllum*). Chokecherry (*Prunus virginiana*), elderberry (*Sambucus racemosa* or *Sambucus nigra* ssp. *cerulea*), rabbitbrush (*Chrysothamnus* sp.), and snowberry (*Symphoricarpus alba*) are a few of the local shrubs. Sagebrush and bunch grasses thrive in the area. Xeriscaping™, landscaping with vegetation that requires minimal amounts of water, is widely practiced.

Invasive species create problems for wildlife by removing habitat, increasing soil erosion, and outcompeting native vegetation. Concern over the spread of invasive weeds is being addressed through a public information program, including the creation and distribution of pamphlets describing how to identify and eradicate problem vegetation. Some of the major invasive weeds of concern are Canadian thistle, Scotch thistle, poison hemlock, whitetop, perennial pepperweed, spotted knapweed, diffused knapweed, Dalmatian toadflax, and purple loosestrife.

2.7 WETLANDS

A local wetlands inventory map prepared by the City is shown on Figure 2.6. Significant wetlands have been identified along the length of the Deschutes River in the City. These wetlands may not yet have been field verified, and need to be evaluated by a wetlands scientist to verify their protection status before any activity that could affect them can be undertaken.

2.8 TOPOGRAPHY

Central Oregon's topography ranges from relatively flat to hilly, with two distinctive buttes in the vicinity of Bend. Awbrey Butte is the highest point in the City, at an elevation of 4,214 feet and Pilot Butte is nearly as high at 4,138 feet (Figure 2.7). The volcanic geology has created a tortured landscape with many ridges, drops, sinks, and hills. Drainage patterns and directions vary greatly throughout the City, although both surface and subsurface flows are generally northward. The Deschutes River parts the City into eastern and western halves. Tumalo Creek influences the drainage patterns in the northwestern area of the City. There are no other creeks or significant drainage ways in the City. East of the river the ground slopes in a northeasterly direction, directing stormwater away from the river.

Mirror Pond, an icon in the heart of the City, was created in the first decade of the 1900s by a hydroelectric dam now owned by Pacific Power and Light. The pond is in an approximately one-mile-long stretch of the Deschutes River, bordered roughly by the Galveston Bridge to the south and Newport Bridge to the north. The dam is a few hundred feet downstream from the Newport Bridge.

Several large irrigation canals run through the City, conveying water from the Deschutes River to serve agricultural areas as far away as Madras, some 50 miles to the north. These canals and laterals still have a large influence on drainage patterns within the City.

The canals and laterals or their rights-of-way could potentially be used for stormwater conveyance and disposal. For several reasons, irrigation districts are unwilling to risk contaminating irrigation water with potential stormwater pollutants and may also be concerned that accepting stormwater may require them to obtain NPDES discharge permits.

2.9 GEOLOGIC AND HYDROGEOLOGIC CONDITIONS

The following summary of geologic and hydrogeologic conditions within the City of Bend and surrounding area is based on the more technical and comprehensive text provided in GeoEngineers' 2007 report entitled *Stormwater Infiltration Evaluation, City of Bend, Oregon*. This report is a geologic and geotechnical study based on existing documentation, and provides general guidance on the effectiveness of dry wells and drill holes in various areas of Bend.

Regional geologic features are largely the result of volcanic activity and subsequent weathering along the Cascade Range. These processes have resulted in the relatively recent deposition of a thick sequence of volcanic and volcanically derived sedimentary rocks (GeoEngineers, 2007). For example, Awbrey Butte, in the northwestern part of town, is a volcanic vent composed of basalt. Volcanic rock is at or near the surface throughout the City, and its permeability and topography vary, creating many areas where stormwater infiltration is very slow with a high risk of localized flooding.

As the volcanic and sedimentary rocks weather, they create a thin soil layer that ranges in depth from 0 to 60 inches or more. In some areas, the soil layer is too thin to allow for deeply rooted vegetation. Soil within the City tends to drain well, with some exceptions, such as Tumalo and Plainview sandy loams. Soil close to or within the Deschutes River channel is primarily river deposits composed of gravels, sand, and silt. The soil layers adjacent to the river have variable permeability (GeoEngineers, 2007).

Portions of the City are underlain by basalt that is relatively fractured with a sufficiently high permeability to allow for infiltration of stormwater at relatively high rates, particularly given the relatively low annual rainfall experienced in Central Oregon. Before the City was developed, the permeability of this basalt was generally high enough to allow infiltration of large quantities of stormwater runoff, even for large storm events. Dry wells for disposal of stormwater runoff performed reasonably well when Bend was a smaller town with a smaller impervious area. However, when stormwater runoff is concentrated because of the increase in impervious area, the permeability of the basalt does not allow the increased stormwater runoff to infiltrate quickly enough, and flooding occurs.

Some areas of the City are underlain by consolidated basalt or pink tuff, which is highly impermeable and does not provide acceptable geotechnical conditions for the use of dry wells or drill holes that are not deep enough to penetrate through it. Many of these areas can be identified by the presence of drill holes, some up to 450 feet deep, installed to allow stormwater to be disposed of below near-surface low-permeability layers. Drill holes are generally about 6 inches in diameter with casing in the top several feet.

With Bend’s rapid growth in the past 20 years, the number of dry wells and drill holes in public right-of-way has increased to over 5,000. Many private properties also have dry wells but the number and location are unknown. Construction of piped drainage is expensive in Bend due to the rocky geology and has been avoided in most areas of the City. The City has not had the time or resources to develop an adequate drainage infrastructure to keep up with the growth in population and the resulting increase in impervious areas. Many of the existing dry wells and drill holes no longer handle the design volume and rate of stormwater runoff for reasons such as improper installation, inappropriate geotechnical conditions, plugging by road traction cinders, soil erosion from construction sites, and having been constructed according to standards and specifications that are now outdated.

In their 2007 report, GeoEngineers identified four major drainage areas (shown on Figure 2.8).

Drainage Area 1 is composed of fractured basalt and generally provides the best geotechnical conditions for the use of dry wells, drill holes and infiltration. The older basalt rock of Drainage Areas 2 and 3 provides moderately good geotechnical conditions for dry wells, drill holes and infiltration. Drainage Area 4 has an impermeable layer of volcanic rock locally known as pink tuff and is generally not suitable for dry wells or infiltration.

The infiltration capabilities of underlying soil and rock are only one consideration in the siting and operation of infiltration facilities. State and federal regulations, drinking water wells located throughout the City, percent slope, protection of drinking water sources, and maintenance of these facilities are additional issues to evaluate when considering whether to construct infiltration facilities. These issues are explored further in Chapter 3, Regulations, Chapter 4, Existing Drainage System, and Chapter 6, Water Quality.

2.10 WATER QUALITY

A large part of Bend's drinking water comes from a deep, very high-quality and abundant aquifer beneath the City that is fed by snow melt high in the Cascade Mountains. The City has won several awards for the quality of its drinking water, and the City and its residents are committed to protecting this valuable resource. Dry wells and drill holes are subject to strict groundwater protection requirements and are not allowed to discharge directly into aquifers. Chapter 6 discusses water quality in more detail.

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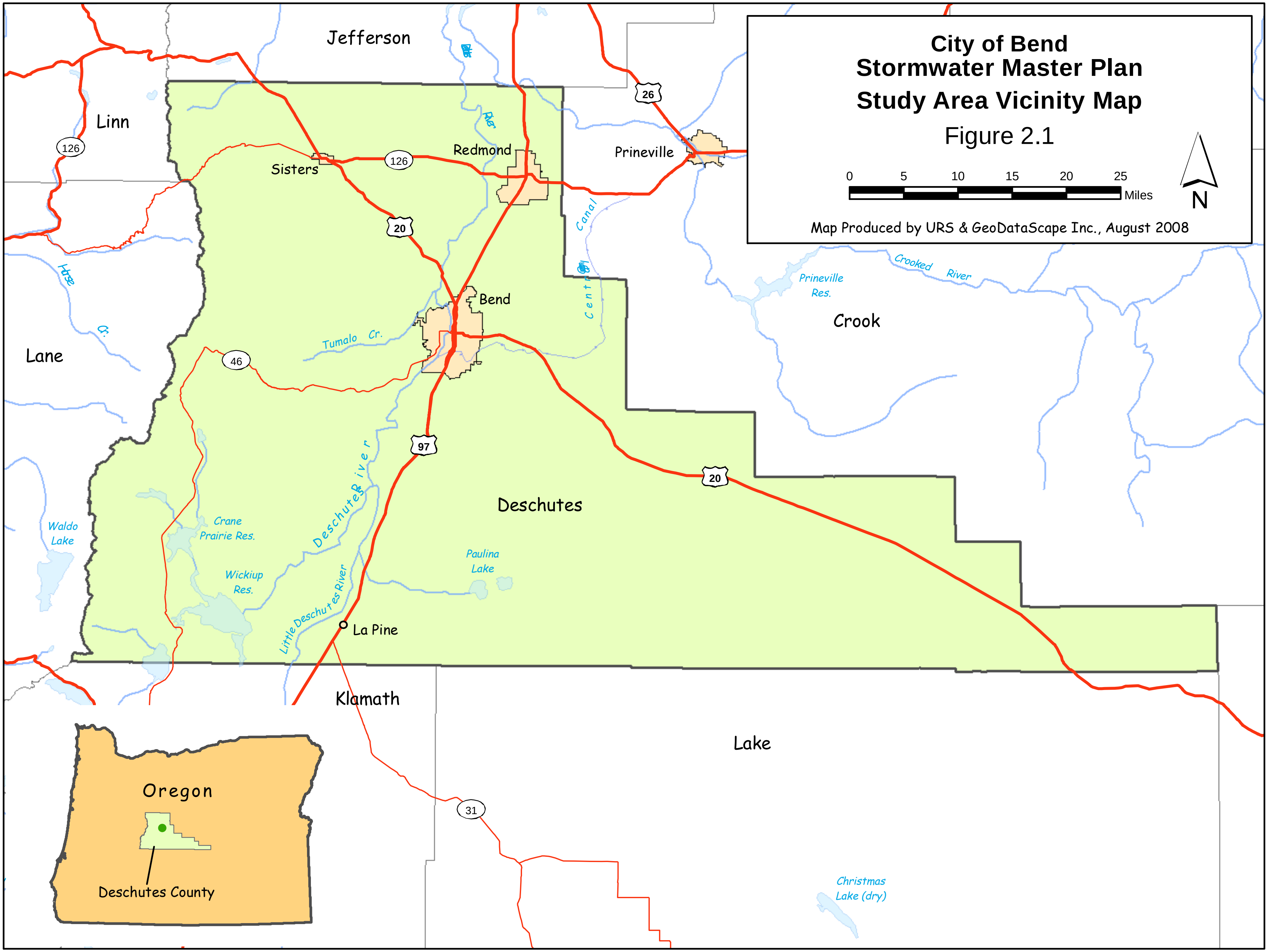
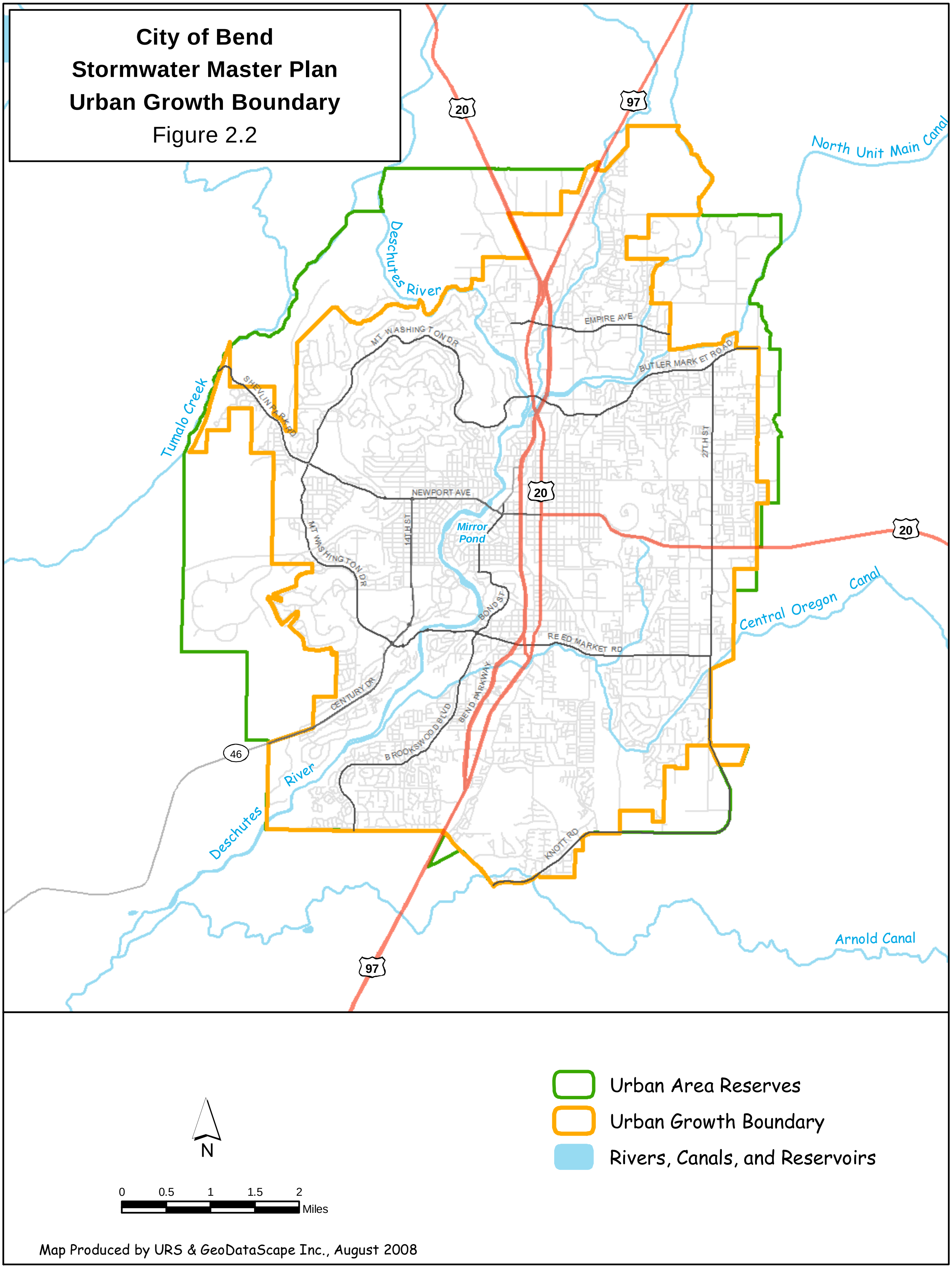
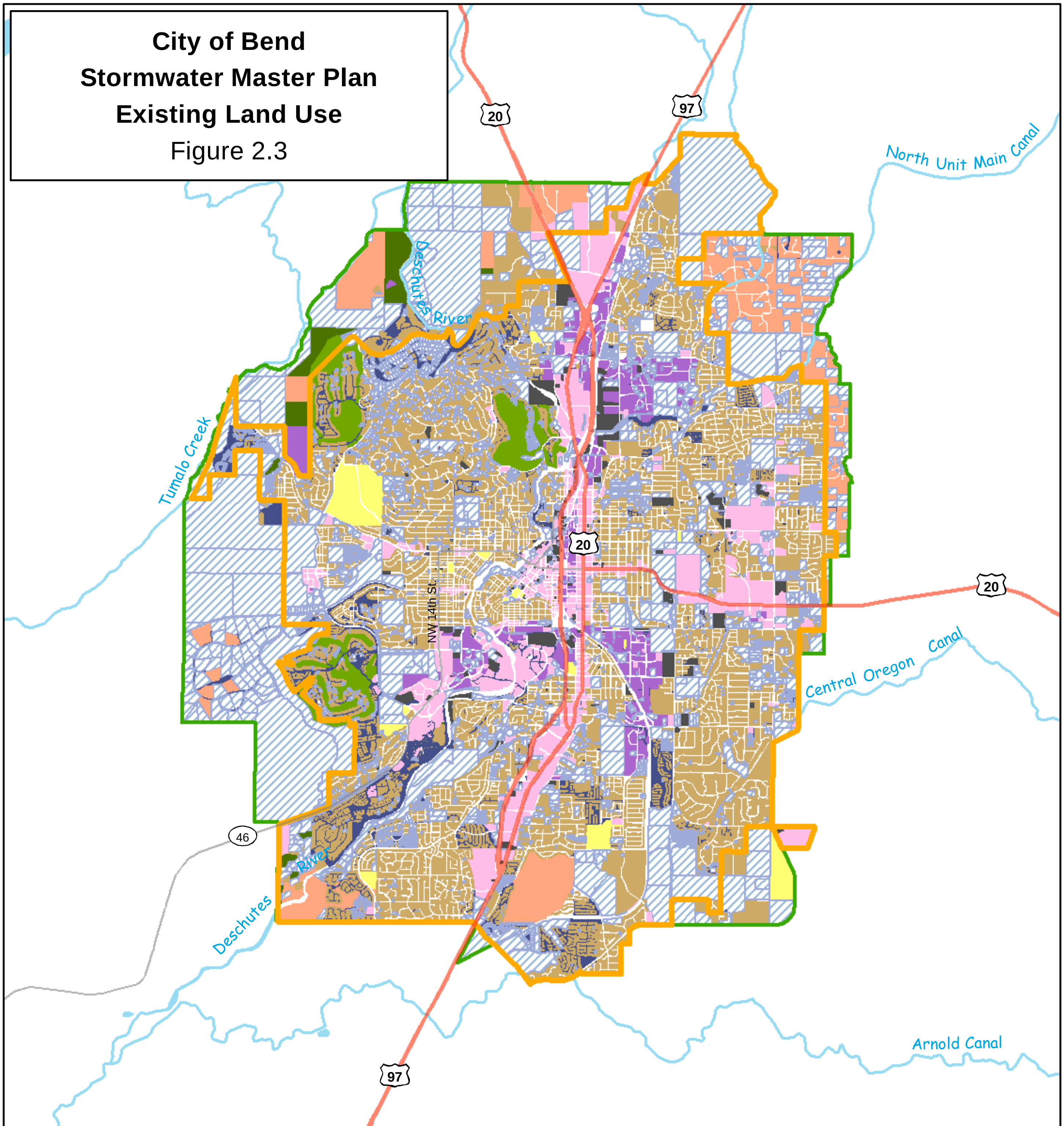


City of Bend
Stormwater Master Plan
Study Area Vicinity Map
Figure 2.1
0 5 10 15 20 25
Miles
N
Map Produced by URS & GeoDataScape Inc., August 2008
Jefferson
Linn
Lane
Crook
Deschutes
Klamath
Lake
Sisters
Redmond
Prineville
Bend
La Pine
126
26
20
46
97
31
Tumalo Cr.
Canal
Prineville Res.
Crooked River
Crane Prairie Res.
Wickiup Res.
Deschutes River
Little Deschutes River
Paulina Lake
Waldo Lake
Christmas Lake (dry)
Oregon
Deschutes County


City of Bend
Stormwater Master Plan
Urban Growth Boundary
Figure 2.2
20
97
North Unit Main Canal
Deschutes River
EMPIRE AVE
BUTLER MARKET ROAD
MT WASHINGTON DR
SHEVLIN PARK RD
Tumalo Creek
27TH ST
NEWPORT AVE
14TH ST
Mirror Pond
MT WASHINGTON DR
BOND ST
REED MARKET RD
Central Oregon Canal
CENTURY DR
BEND PARKWAY
BROOKSWOOD BLVD
46
Deschutes River
KNOTT RD
Arnold Canal
N
0 0.5 1 1.5 2 Miles
Urban Area Reserves
Urban Growth Boundary
Rivers, Canals, and Reservoirs
Map Produced by URS & GeoDataScape Inc., August 2008

City of Bend
Stormwater Master Plan
Existing Land Use
Figure 2.3



N

0 0.5 1 1.5 2 Miles

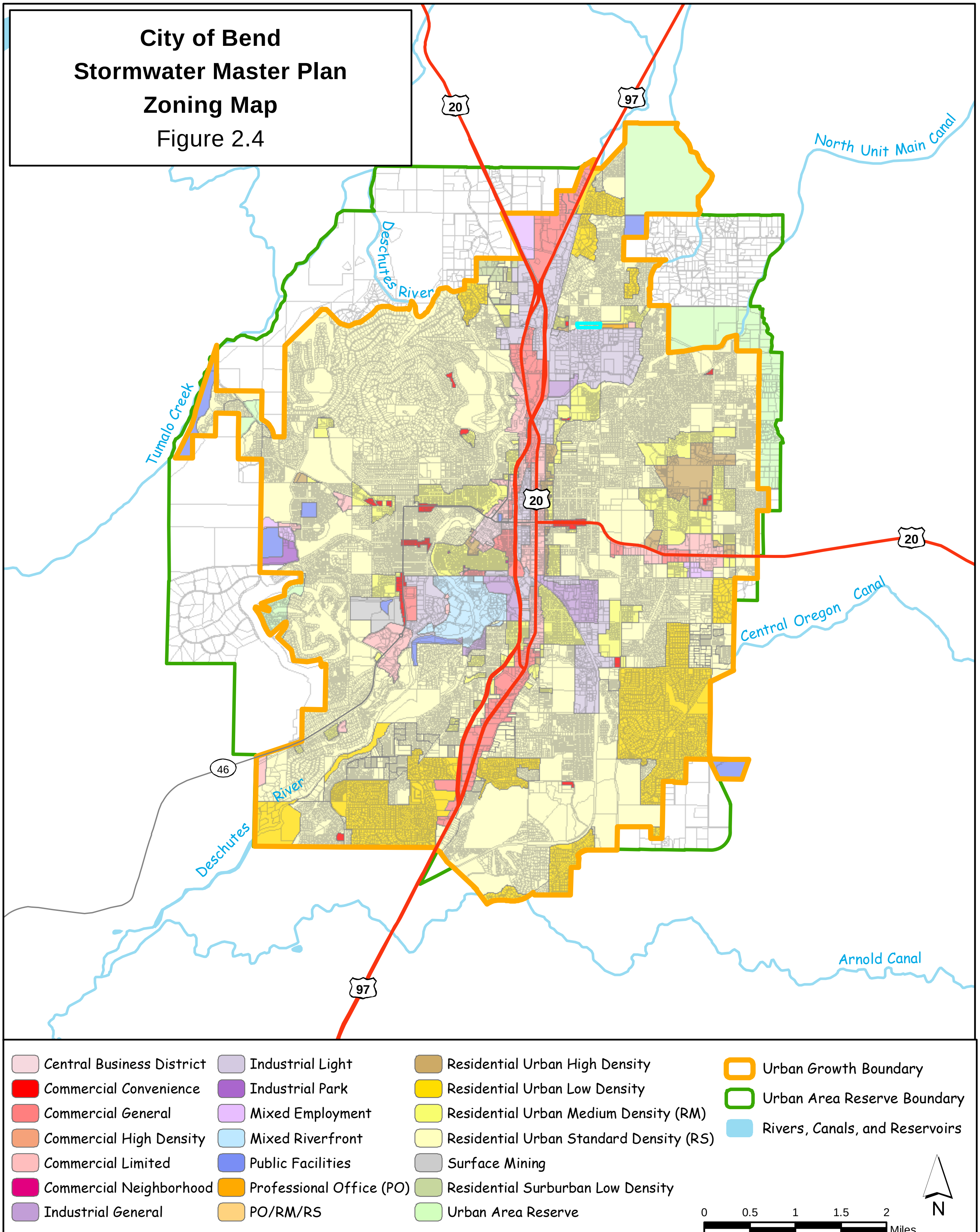
COMMERCIAL
FOREST
GOVERNMENT
INDUSTRIAL
OPEN SPACE
RECREATIONAL
RESIDENTIAL
SCHOOL
UNBUILDABLE
VACANT

Urban Growth Boundary
Urban Area Reserve

Map Produced by URS & GeoDataScape Inc., August 2008

Source: Deschutes County - Community Development Department, August 19, 2007

City of Bend
Stormwater Master Plan
Zoning Map
Figure 2.4

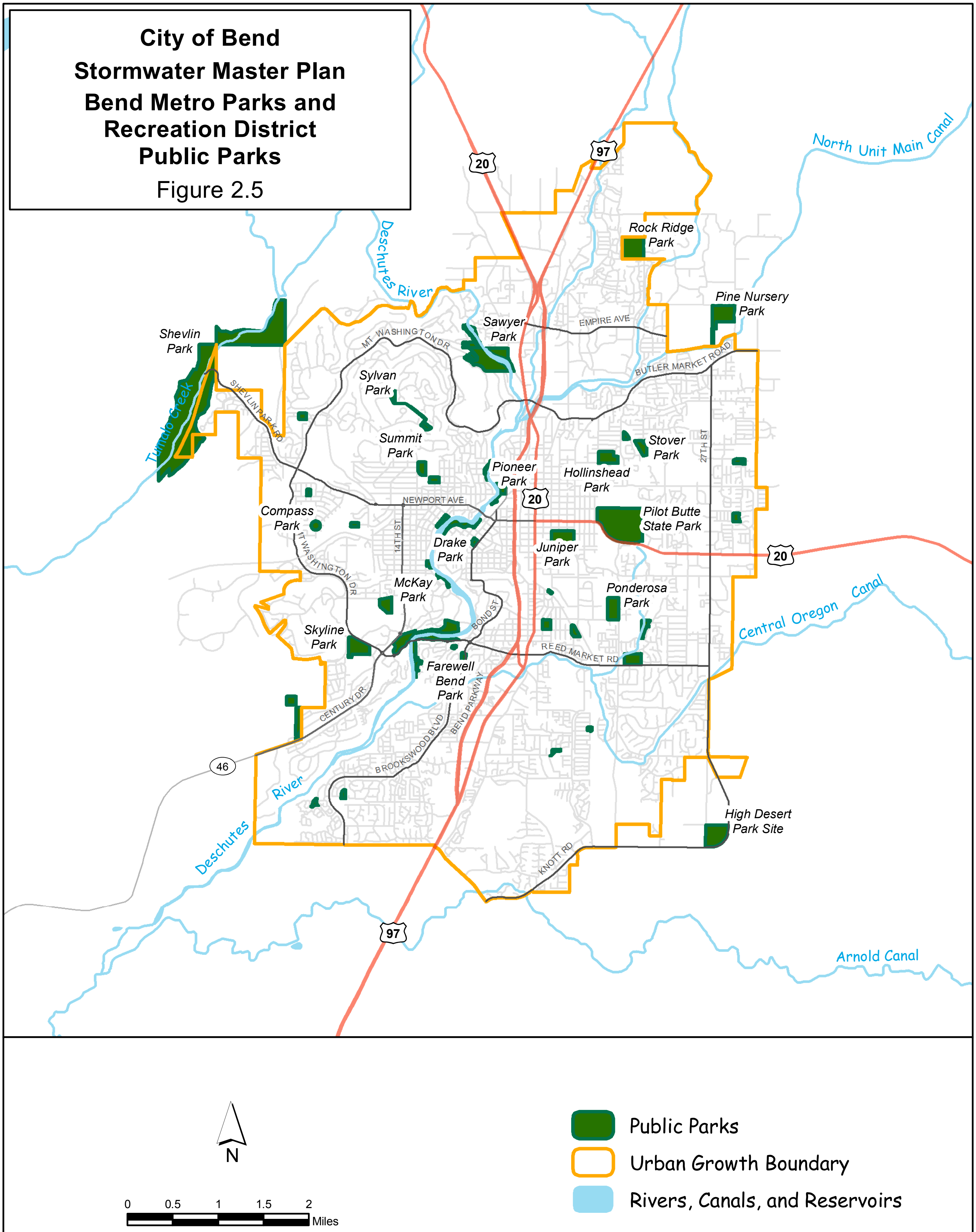


Map Produced by URS & GeoDataScape Inc., August 2008

Source: Deschutes County - Community Development Department, 2006

City of Bend
Stormwater Master Plan
Bend Metro Parks and Recreation District Public Parks

Figure 2.5



Public Parks

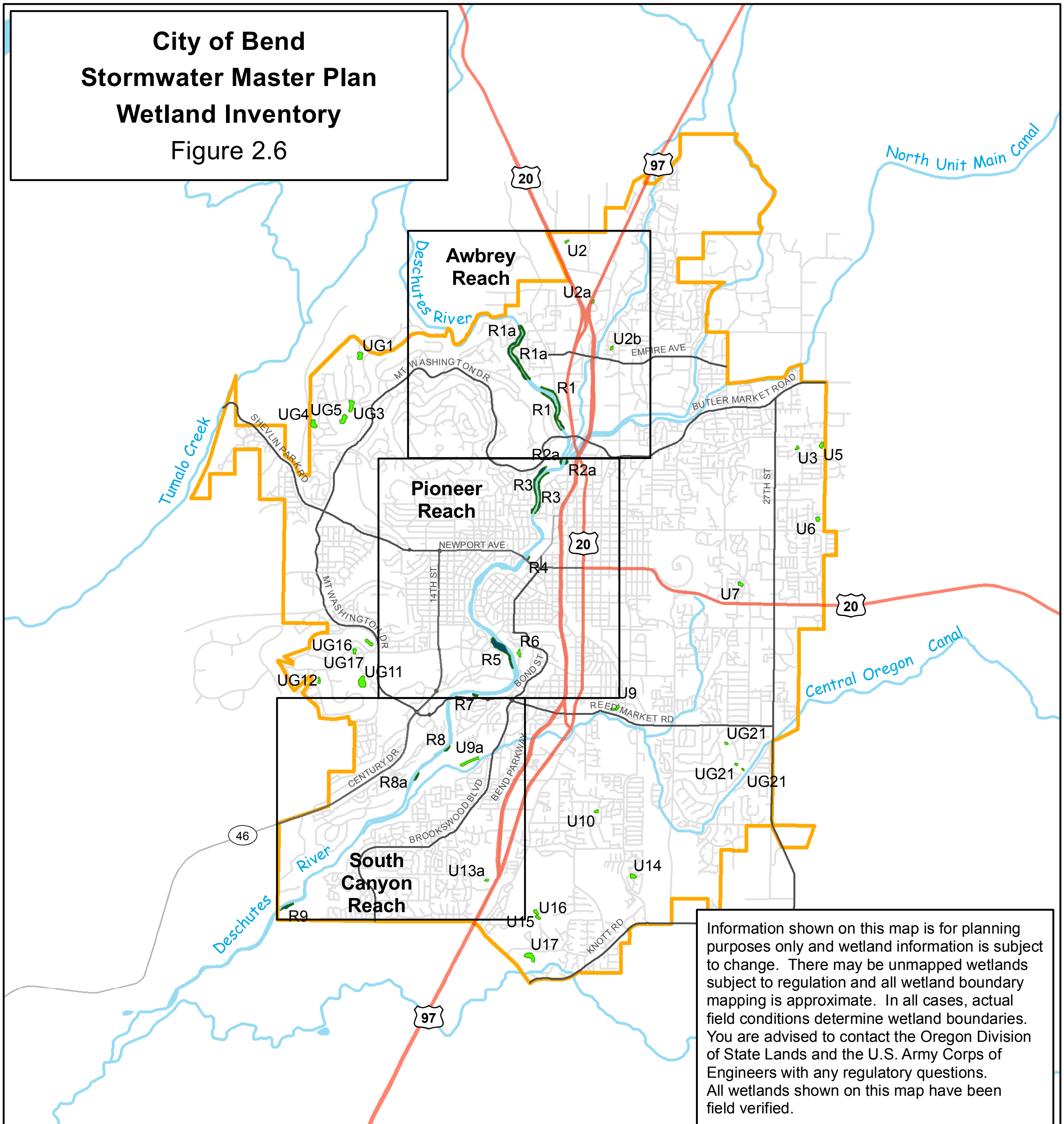
Urban Growth Boundary

Rivers, Canals, and Reservoirs

Map Produced by URS & GeoDataScape Inc., November 2008

City of Bend Stormwater Master Plan Wetland Inventory

Figure 2.6



Information shown on this map is for planning purposes only and wetland information is subject to change. There may be unmapped wetlands subject to regulation and all wetland boundary mapping is approximate. In all cases, actual field conditions determine wetland boundaries. You are advised to contact the Oregon Division of State Lands and the U.S. Army Corps of Engineers with any regulatory questions. All wetlands shown on this map have been field verified.

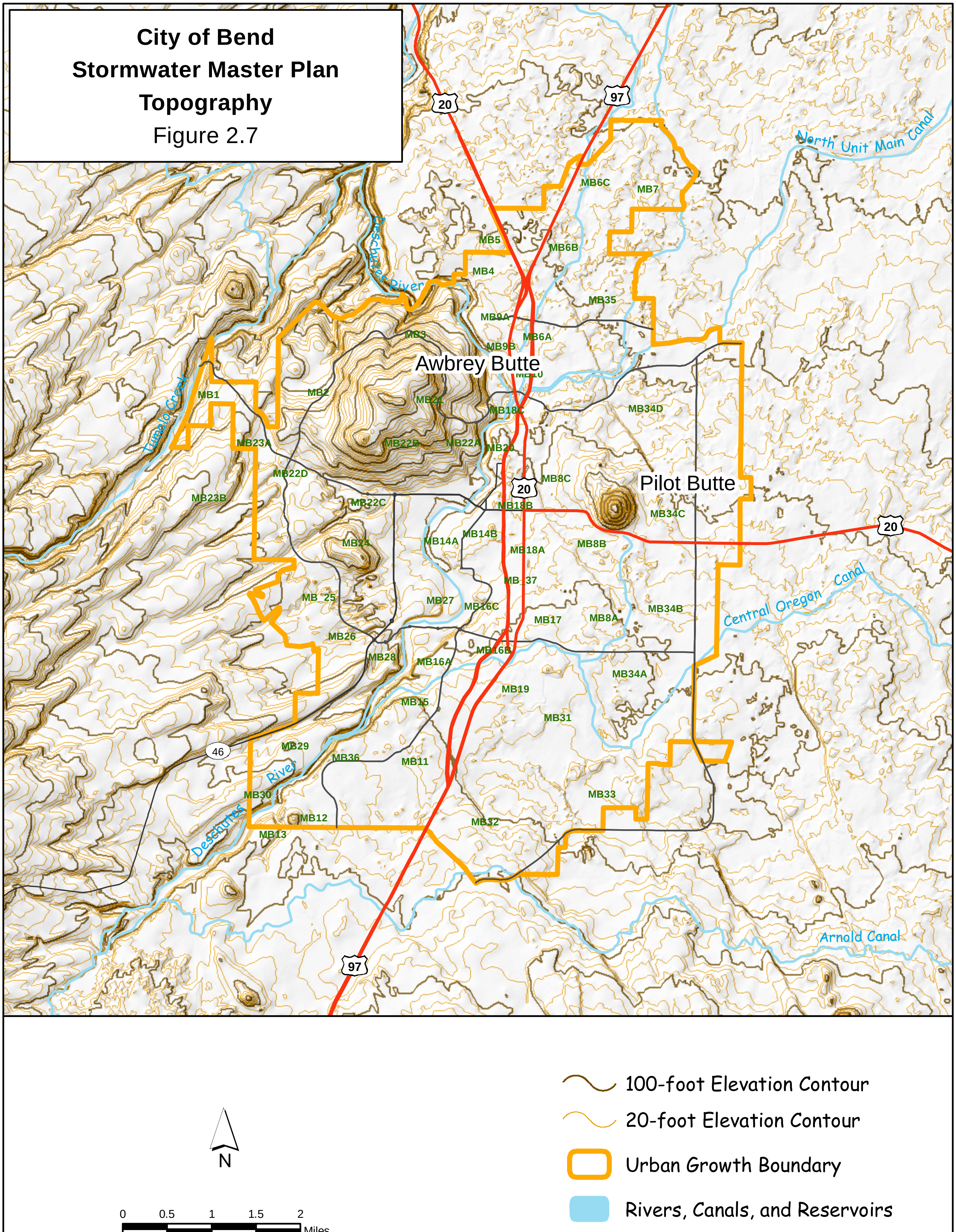
N

0 0.6 1.2 1.8 2.4 Miles

- Significant Identified Wetlands
- Non-Significant Wetlands
- Urban Growth Boundary
- Rivers, Canals, and Reservoirs

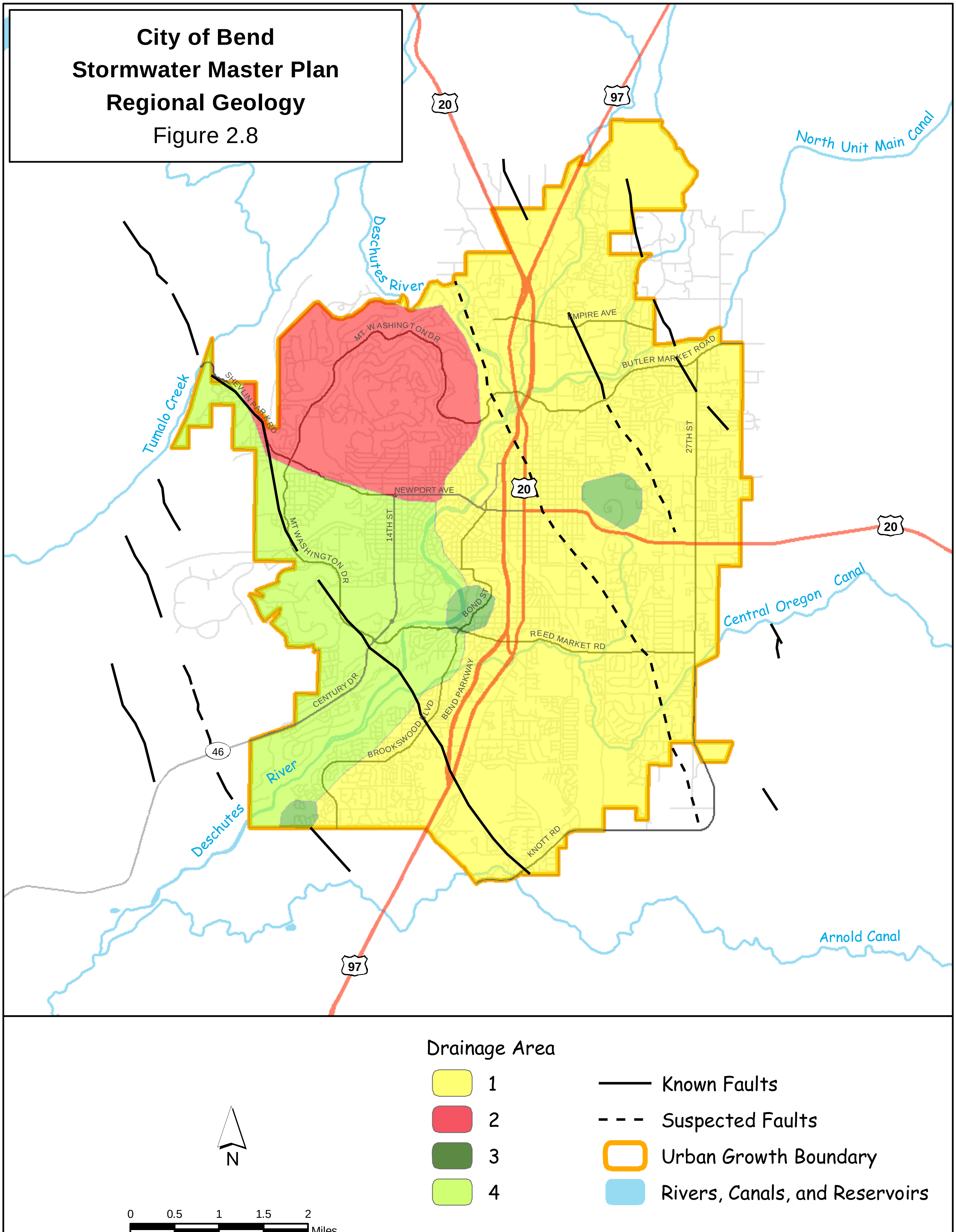
Map Produced by URS & GeoDataScape Inc., November 2008

City of Bend
Stormwater Master Plan
Topography
Figure 2.7



Map Produced by URS & GeoDataScape Inc., August 2008

City of Bend
Stormwater Master Plan
Regional Geology
Figure 2.8



Map Produced by URS & GeoDataScape Inc., August 2008

Source: Geological information from U.S. Geological Survey Open-File Report 03-67 (revised 1/5/2005).

3.0 REGULATIONS

Federal regulations address the quality of stormwater that is discharged to surface waters and groundwater. Discharges to surface water are regulated by the federal Clean Water Act (CWA) through National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer System (MS4) permits. Certain construction sites are required to obtain NPDES 1200C permits to ensure that erosion control procedures are in place. Discharges to groundwater are regulated by the federal Safe Drinking Water Act (SDWA) and state regulations.

To comply with the regulations for both stormwater and groundwater, the City prepared an Integrated Stormwater Management Plan (ISWMP). The ISWMP is a living document that will be updated as necessary.

3.1 DISCHARGES TO SURFACE WATER

In compliance with CWA requirements, the City of Bend applied for a Phase II NPDES permit, for cities with populations greater than 50,000 and less than 100,000. The Phase II NPDES permit requires the City to reduce the amount of pollutants it discharges to the Deschutes River “to the maximum extent practicable” (MEP) using BMPs. The permit application was submitted to the ODEQ on March 10, 2003. One year later, the City submitted to the ODEQ an *Integrated Stormwater Management Plan* (ISWMP) defining, among other things, activities the City would undertake to address pollution associated with stormwater discharged to the Deschutes River. The Phase II permit was delayed by legal issues and resource limitations, and the City was obliged to update the ISWMP in 2006. The permit was finally issued in 2007 and the ISWMP was made part of the permit by reference. (The ISWMP is discussed further in Chapter 7.) The City prepares an annual report, submitted to ODEQ by November 1 of each year, outlining the City’s progress in implementing the ISWMP.

According to the Population Research Center at Portland State University, if the City continues its current rate of growth its population will likely exceed 100,000 by the year 2020. The City will need a Phase I NPDES permit when its population exceeds 100,000. The City is preparing for the Phase I permit and this will require more staff and funds than the current Phase II permit to meet additional requirements including expensive monitoring and inspecting public and private water quality treatment facilities.

3.1.1 Clean Water Act 303(d) List of Impaired Waters

CWA regulations require pollutants of concern for water bodies to be identified on a 303(d) list and Total Maximum Daily Loads (TMDLs) to be developed for each of those pollutants. ODEQ and others collect water quality sampling data for streams and rivers throughout the state. If the sample data indicate that water quality standards are not being met, the water body is considered impaired and is placed on the 303(d) list. ODEQ sets water quality standards for Oregon, develops the 303(d) list and updates the list every two years. If the water quality does not improve, ODEQ creates TMDLs for the pollutants of concern within a defined segment of the creek or river.

The Deschutes River has been on the 303(d) list for a number of years. ODEQ has initiated the process of developing TMDLs for the Deschutes River by identifying the scope of work, compiling available data, and performing additional monitoring. If the ODEQ determines that the city's stormwater discharges significantly affect Deschutes River water quality, the ODEQ may identify the City of Bend as a Designated Management Agency (DMA) that must develop and comply with waste load allocations for the pollutants of concern. Stormwater is the only water the city is allowed to discharge to the Deschutes River. The DEQ is scheduled to complete the TMDL process for the Deschutes River by the end of 2010.

3.1.2 Development of Total Maximum Daily Loads

To develop TMDLs, ODEQ uses a complex technical analysis to identify the quantity of a pollutant that a stream segment can absorb without violating water quality standards. This analysis is performed for each pollutant of concern and for each segment that does not meet water quality standards.

When the TMDLs are established, the City of Bend may become a DMA. Each DMA must develop a TMDL Implementation Plan, indicating how it plans to reduce pollutant loads to meet the TMDL load and wasteload allocations. TMDLs apply to all wastewater, including stormwater, that contributes to water quality violations.

ODEQ will only develop TMDLs for parameters for which it has sufficient information to verify ongoing violations of the water quality standard. Parameters for which there is insufficient or only preliminary data will remain on the 303(d) list while additional data are collected.

If the City of Bend's stormwater discharges are found to contribute significantly to the impairment of the river, the City will have one year, following completion of the TMDLs, to develop an Implementation Plan to submit to ODEQ. Stormwater discharges are generally infrequent and of short duration so it can be difficult to determine their impact on receiving water quality. One of the readily visible effects of stormwater is the sediment and trash that accumulate near outfalls. Since 2003, the City and the Upper Deschutes Watershed Council (UDWC) have jointly monitored the river to try to determine the impact of stormwater discharges, among other things. To develop effective TMDLs, it is necessary to know how a given reduction in the discharge of a pollutant of concern will affect the concentration of that pollutant in the river. This information will be provided through the use of existing data and computers that model the fate and transport of pollutants within the river.

Pollutants of concern in the Deschutes River include chlorophyll-a, dissolved oxygen, pH, temperature, turbidity, and sedimentation. Stormwater is one of the sources of turbidity and sedimentation. Excess chlorophyll-a typically indicates that an excessive amount of algae has grown in a waterway as a result of excess nutrients; this can result in algae-filled channels, odors from decomposing algae, and reduced dissolved oxygen and pH levels. Oxygen is taken up in the decomposition process, reducing its availability for fish, insects, and other aquatic life. A reduction in pH creates greater acidity in the water, which is harmful to aquatic organisms.

Temperature is an issue for nearly every water body in the state. Elevated water temperatures are harmful to aquatic life in general, and particularly for salmon and efforts to restore healthy populations in Oregon. While temperature is a parameter of concern in the river, the relative significance of the City's stormwater discharges on river temperature is considered to be minor because of the highly transient nature of stormwater discharges.

Communities with Phase II NPDES permits are not required to address the 303(d) list unless and until required to do so through the TMDL waste load allocation process. After ODEQ completes the TMDLs, the permit renewal may require the City to provide an analysis of how it will manage its stormwater discharges to meet the TMDL allocations, and to develop benchmarks to meet those allocations. NPDES permits are valid for five years, but are often administratively extended rather than renewed due to limited ODEQ resources.

3.1.3 Water Quality Monitoring

Communities like Bend with Phase II NPDES permits are not required to perform water quality monitoring. When the City's population exceeds 100,000, it will need a Phase I permit which will require monitoring.

The City should develop and implement a plan to monitor stormwater and river water in a manner that will allow the effects of stormwater on river water quality to be ascertained.

3.2 EROSION CONTROL FOR CONSTRUCTION PROJECTS

NPDES also regulates certain construction site erosion control by means of the 1200C NPDES permit. Construction sites that disturb an area of one acre or more are required to obtain a 1200C NPDES permit from ODEQ if there is a potential for runoff to enter the Deschutes River or Tumalo Creek directly or via a conveyance system. Construction plans must be submitted to ODEQ along with the permit application that provides details on how erosion will be minimized and soil maintained on the construction site. Plans for construction sites, including sites smaller than one acre, are reviewed by the City.

3.3 UNDERGROUND DISCHARGES

Dry wells, drill holes, and some other types of infiltration systems are considered UICs. Groundwater quality is particularly important in Bend because much of the City's drinking water comes from the City's 21 municipal wells. In addition, three private water purveyors have several wells, and several hundred individual families have residential water wells.

All UICs must be registered with the ODEQ. In addition, each UIC must either meet the stringent rule-authorization requirements or be covered under a UIC WPCF permit. Many of Bend's UICs do not meet rule authorization requirements so the City has applied for a UIC WPCF permit.

Under the state's UIC program rules, Bend is required to conduct a representative monitoring program to determine the concentrations of certain pollutants it discharges underground. Because some UICs are in the same areas served by the City's piped system, monitoring in those areas provides important information about underground discharges as well as river discharges. See Chapter 6 for more information about monitoring.

3.3.1 Drinking Water Protection Areas

Drinking water safety and quality are regulated through the SDWA. The SDWA and Oregon's equivalent rules establish protection areas and strictly regulate UICs that have the potential to contaminate or contribute to the contamination of sources of drinking water. As can be seen in Figure 3.1, a large percentage of the area of the City is located within one or more of these protection areas.

DWPAs are delineated for the municipal wells and some of the wells owned by the private purveyors. A permit is required for any UICs located in a DWPA or within 500 feet of a water well and the stormwater must be treated to at least meet drinking water standards. The DWPAs shown in Figure 3.1 were delineated by the Oregon State Health Division (OSHD) in 2003 and are due to be updated. DWPAs are delineated by the OSHD using computer models. The DWPAs in Figure 3.1 show that groundwater flows from the southwest toward the northeast. The state UIC program prevents or restricts the use of UICs within the 2-year time-of-travel DWPA. This is the part of the DWPA where groundwater, if contaminated, would convey the contamination to the water well in two years or less. In order to incorporate uncertainties in the delineation process , a 20 degree wing has been added to the DWPA. A DWPA is an elevated risk area within which a community should develop protection strategies for the groundwater. It is also the outer zone of the area within which microbial sources could affect the drinking water. No new UICs may be installed within a 2-year time-of-travel DWPA without a UIC WPCF permit.

Figure 3.1 is based on the best available data in 2003. Since then, the City has installed additional water wells and models have been improved. The City is in the process of updating the DWPAs for its water wells.

The City must develop a plan to provide protection for the groundwater underlying its approximately 4,000 publicly owned dry wells and 1,000 drill holes. Each UIC must be registered, per ODEQ's UIC regulations, and each must either be decommissioned and replaced with an alternative drainage system, or retrofitted to treat stormwater to meet drinking water standards before stormwater is discharged underground. It will take several years for the City to obtain the funds and other resources to either decommission these high risk UICs and provide other means of disposal, or install adequate pretreatment. No new UICs (private or public) should be constructed in the DWPAs. New developments must provide water quality treatment for discharges to UICs.

3.3.2 Cleanup Sites

Figure 3.1 shows ODEQ cleanup sites within the City.

To protect human health and the environment, ODEQ investigates sites that are contaminated with hazardous materials. ODEQ assists and enforces the prompt cleanup of sites, while trying to control expenses. ODEQ's goal is to issue No-Further-Action (NFA) designations swiftly and cost effectively. Dry wells need careful review prior to being installed close to areas designated by the ODEQ as cleanup sites to avoid risks of expanding the contaminated area or interfering with cleanup of the sites. The buffer zones around the cleanup sites are shown with a ½ mile radius. The DEQ may approve a smaller radius on a case-by-case basis.

3.3.3 Discharge Monitoring

Under the state's Underground Injection Control (UIC) program rules, Bend is required to conduct a representative monitoring program to determine the concentrations of certain pollutants it discharges underground. The City began monitoring some of its stormwater discharges as early as 2004. See Chapter 6 for more information about monitoring.

3.4 CENTRAL OREGON STORMWATER MANUAL

Recognizing that unique stormwater issues affect Central Oregon, the communities of Bend, Madras, Redmond, Prineville, Sisters, and Crook and Deschutes County, joined forces with the Central Oregon Intergovernmental Council to develop the Central Oregon Stormwater Manual (COSM, 2007). The stormwater drainage manual provides guidance on good engineering practices for conditions specific to Central Oregon. The Association of Clean Water Agencies and the Central Oregon Investment Board assisted with the development of this award-winning guidance document.

The COSM is designed to standardize stormwater design processes appropriate for Central Oregon, and addresses stormwater runoff quality and quantity to protect surface and groundwater resources. Guidance and design criteria for stormwater conveyance and water quality treatment specific to the climate and geology of Central Oregon are provided. Conditions characteristic of Central Oregon include volcanic rock, reliance on groundwater for drinking water, relatively dry climate, potential for short intense storms, snow and ice in winter months, and rapid population growth. Minimum criteria are provided for stormwater drainage design for new development, re-development, and roadway projects. The City has recently reviewed its development standards to determine how best to incorporate the COSM into Bend codes and policies for stormwater management. COSM criteria were used in the hydrologic and hydraulic calculations, and water quality recommendations for this Master Plan.

3.5 INTEGRATED STORMWATER MANAGEMENT PLAN

The ISWMP outlines a comprehensive program to protect the quality of the Deschutes River and the City's groundwater. The ISWMP identifies a number of BMPs for preventing pollutants from entering stormwater or removing them before the water is discharged to the river or underground.

The following BMPs are required elements of the Phase II (surface water) program:

- Public Education and Outreach
- Public Involvement and Participation
- Illicit Discharge Detection and Elimination
- Construction Site Stormwater Management Activities
- Post-Construction Stormwater Management in New Development and Redeveloped Areas
- Pollution Prevention/Good Housekeeping for Municipal Operations

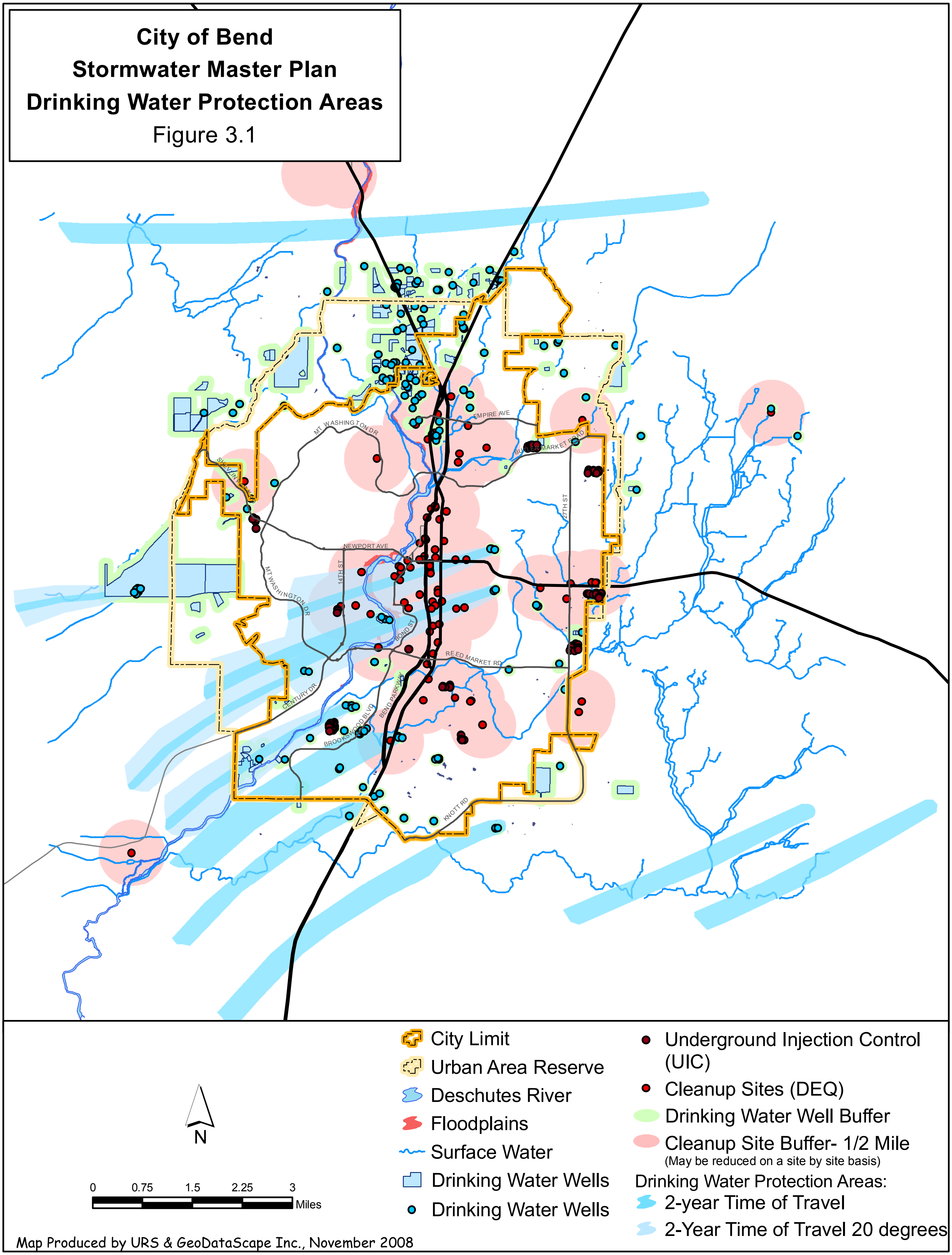
Bend's ISWMP also addresses monitoring and protecting drinking water sources.

REFERENCES

COSM (Central Oregon Stormwater Manual), 2007. OTAK, May 2007.

Integrated Stormwater Management Plan for the City of Bend, Oregon, 2004. City of Bend, March 10, 2004; revised November 2006.

Population Research Center at Portland State University, 2008. http://www.edcoinfo.com/COFacts/population/ Accessed July 20, 2008.



City of Bend
Stormwater Master Plan
Drinking Water Protection Areas
Figure 3.1

4.0 EXISTING DRAINAGE SYSTEM

For many years, the City of Bend's drainage system has depended primarily on underground injection (dry wells) to discharge stormwater into the fractured volcanic rock that underlies much of the City. One big advantage of dry wells and other types of dispersed infiltration is that they help maintain groundwater recharge patterns. Another advantage is that disposing of stormwater at many dispersed locations avoids the problems associated with managing high-volume discharges such as those from piped systems that serve large areas. When the City was not as densely developed, the percentage of impervious area was much lower and dry wells and drill holes worked reasonably well.

Bend does not have a city-wide piped storm drain system; the lack of defined drainage ways, the expense of digging in rock, and the difficult topography have limited the installation of piping. Areas nearest the river drain through about 13 miles of pipe and several outfalls to the Deschutes River (Figure 4.1). The existing piped system is undersized hydraulically and much of it has exceeded its life expectancy.

Undisturbed soils in Bend are able to absorb large amounts of rainfall with little or no runoff even during intense storm events. For this reason, current standards for new development require all storm drainage to remain on site, and require catch basins and dry wells to be installed below grade to dispose of stormwater. (City of Bend General Plan-Public Facilities and Services Policy No. 12, Stormwater and City Development Code 10-10). This code requirement has resulted in the installation of dry wells throughout the City.

Dry wells do not work well in areas underlain by layers of impermeable material. Drill holes are an alternative to dry wells, intended to penetrate impermeable layers to reach more permeable material beneath them. The City has installed drill holes in areas where dry wells are not appropriate. The City is responsible for about 4,000 dry wells and 1,000 drill holes in public rights-of-way and on public property. Public underground injection controls (UICs) are reviewed by the City of Bend; however, they are also required to meet federal and state regulations. A large but unknown number of dry wells and drill holes are owned privately. Private UICs are installed to meet City drainage requirements. The City requires privately-owned UICs to meet its installation and drainage requirements, but their water quality is regulated by the ODEQ. The City's current standards do not require water quality treatment of private stormwater prior to discharge to UICs or downstream pipe.

Bend experiences a variety of weather conditions that can cause drainage problems, including short and intense storms, long periods of subfreezing temperatures, heavy snows, snow with freezing temperatures followed by rain, and rain on snow. Non-piped drainage systems are particularly vulnerable to failure during these kinds of weather conditions, and these failures occur when the need for adequate drainage is greatest.

The use of cinders on roads in winter causes a major maintenance problem for the City's stormwater division, as the cinders fill and reduce the performance and life expectancy of dry wells, drill holes, pretreatment filters, and infiltration ponds. With the fees generated by the new stormwater service charge that went into effect on July 1, 2007, the City has stepped up its maintenance efforts, but this will likely fall short of what is needed to overcome the problems associated with cinders. Without a stormwater service charge rate increase or other source of funding, the City will not have the funds to replace the injection systems that have failed and will fail because of road cinders.

Maintenance of the City-owned or operated storm drainage facilities is the responsibility of the Public Works Department Stormwater Division. Drainage and maintenance for the three highways that run through the City—97 Parkway, 97 Business from the north to Highway 20, and Highway 20 east—are the responsibility of the Oregon Department of Transportation (ODOT).

4.1 CANALS

Effective coordination with the irrigation districts will be important for efficiently addressing stormwater drainage in areas near canals. As mentioned in Chapter 2, several irrigation canals and laterals running through the City affect the City's drainage patterns. The canals and laterals rights-of-way could potentially be used for stormwater purposes. Concerned about the potential for contaminating the irrigation water with possible pollutants in the stormwater, and the possibility that if they accept stormwater they may be required to apply for National Pollutant Discharge Elimination System (NPDES) permits, the irrigation districts have not allowed the canals to accept stormwater runoff. In part, because of these concerns and concerns about cost and liability associated with obtaining and operating under an NPDES permit, some of the irrigation districts have built berms along portions of their canals to prevent natural stormwater drainage from entering the canals. In several areas, open canals have been replaced with low-pressure pipe placed near the top of the previously used trench and some canals have been lined with concrete. Berms are still present to keep storm drainage out of the canals and from crossing the canal rights-of-way.

The disturbance of natural drainage patterns caused by the canals and laterals presents some major stormwater management challenges. For example, in one section of the Central Oregon Canal that flows north past Pilot Butte, the canal has been piped and backfilled. The backfilling of the canal has removed a barrier to stormwater runoff from Pilot Butte, and subdivisions downgradient from the canal are now experiencing new stormwater runoff and associated flooding. Sandbags have been placed across a pathway from a nearby park to keep stormwater from running down the path into the subdivision until a permanent solution is constructed.

4.2 DRAINAGE PROBLEMS

Bend’s drainage problems are increasing due to its rapid growth, lack of funding for construction and maintenance of infrastructure and challenging landscape. The City established a database to track complaints about drainage, and as of August 2008, there are more than 100 complaints.

Rainfall often comes in short, intense bursts, causing considerable localized flooding throughout town. Many catch basins and dry wells do not have sufficient capacity to handle runoff from these storm events, and flooding can thus be expected to occur every year or two.

Drainage problems can adversely affect real estate transactions. With Oregon’s Real Estate Disclosure requirements and the common practice of banks and buyers requiring Environmental Site Assessments as routine elements of commercial real estate transactions, the City’s Stormwater Division is receiving an increasing number of telephone inquiries regarding stormwater drainage and flooding.

4.2.1 Primary Issues

The conditions that contribute to drainage problems include:

- Under-design of infiltration systems and installation of infiltration systems in areas not suitable for infiltration. (See Chapter 2 for a discussion of soils.)

- Lack of sufficient criteria for new development and redevelopment for design and testing to ensure adequate drainage and disposal.
- Lack of other drainage alternatives when infiltration is not feasible.
- Construction in areas of high groundwater causing flooded crawl spaces and basements.
- Uneven terrain creating ridges and valleys that are barriers to flow.
- Inadequate maintenance resources reducing the effectiveness of dry wells and drill holes.
- Plugging of infiltration facilities with road traction cinders.
- Incorrect construction resulting in drainage bypassing catch basins with inlets that are too high.
- Intense rainfall, snow melt and rain-on-snow events that generate large rates and volumes of water that exceed the capacity of catch basins, dry wells and pipes.
- Drain inlets plugged with ice and plowed snow.
- Areas added to the City that had no drainage facilities when they were annexed from the county.
- Canals, laterals and canal piping that modify drainage patterns.
- Stormwater facilities that do not meet state and federal water quality requirements.

4.2.2 Identification of Sites with High-Priority Drainage Problems

Recognizing that stormwater flooding problems and water quality concerns were increasing in significance and needed to be addressed, the City embarked on the development of a stormwater Master Plan and the creation of a stormwater utility dedicated to capital improvement projects and maintenance activities for the stormwater system and funded by a stormwater service charge. The utility will also cover monitoring and implementation of BMPs needed for water quality and to comply with the permits.

As part of the preparation of this Stormwater Master Plan, before establishment of the database mentioned in the introduction to section 4.2 above, a list was made of 35 “hotspots” experiencing drainage problems (please see Appendix A). These areas are identified in Figure 4.2 and listed in Appendix A. The flooding problems are fairly evenly distributed around the City and are based on complaints.

City staff and the URS team met in a workshop setting to identify and discuss the problem areas and to prioritize the list to determine the five highest-priority problems to be further analyzed. Some problems were removed from further discussion because they were already being addressed by the City.

4.2.3 Criteria for Selecting High-Priority Sites

Criteria for prioritization of the hotspots due to the increasing public frustration with chronic flooding problems, included consideration of the following:

- Concerns about safety, health, and fire
- Regulatory compliance
- Magnitude of impact
- Costs for repair
- History of flooding – length of problem
- Whether a solution is apparent
- Property damage (actual and perceived)
- Access
- Effects on water quality
- Number of complaints
- Severity of flooding
- Whether flooding is private or public
- Equity – conceptual solutions need to be established for areas around the City, not focused in one area

The City chose three of the above criteria from the above list to establish priorities: Safety/health/fire, Property damage, and Magnitude of impact.

The Fire and Life criteria have to do with ensuring that the standards for protecting the public are met, including not only access for emergency vehicles, but also timely response of emergency vehicles. Safety involves the protection of drinking water, and includes decommissioning or treating dry wells in Drinking Water Protection Areas (DWPAs).

Property damage includes damage by flooding structures and can also include heavy erosion of yards and landscaping.

Magnitude of impact considers the number of people affected by the problem and the amount of public benefit gained by the solution.

The list did not take into account water quality issues because a risk assessment has not been conducted. A risk assessment matrix has been developed and will help identify the highest water quality risks.

4.2.4 Refining the List of Priority Sites

Ten sites were selected for field survey. These sites are listed in Appendix A. To further refine the list to five highest-priority sites, a URS engineer and a hydrogeologist visited the sites to determine drainage areas, identify flows generated for a 2-year and 25-year storm event, identify potential solutions, and determine whether infiltration is a workable solution based on the underlying soils. The five sites listed below, not necessarily in order of priority, were identified as the areas most urgently needing resolution. Table 4.1 summarizes the priority of these sites according to the selection criteria. The sites were rated at high, medium or low for each criterion.

Table 4.1
Summary of Prioritization for Top Five Hotspots

Criteria	**HP#1**	**HP#2**	**HP#3**	**HP#4**	**HP#5**
Fire/life/safety	H	H	H	H	L
Property damage	H	L	L	M	H
Magnitude of impact	H	H	H	M	H

H = High Priority ***M = Medium Priority*** ***L = Low Priority***

HP#1 Bend Westside Fire Station – Simpson and Century

This commercial area includes developments both north and south of Simpson and east of Century. The area sits over shallow pink tuff where infiltration capacity is very low. Flooding is common in the area. The location of the catch basins away from the curb allows water to bypass the basins and their associated dry wells. A cascading effect occurs as runoff from Safeway crosses Simpson Avenue, combines with runoff from Ray's Foods and the shopping center, and inundates the fire station with 12 to 18 inches of water. The runoff continues past a storage facility and then discharges down an embankment, flooding Nosler's manufacturing plant.

HP#2 Franklin Avenue Underpass

This is an excavated low area where Franklin Avenue passes under the Bend Parkway (Highway 97) and the Burlington Northern Santa Fe (BNSF) railroad tracks. This underpass is closed to traffic due to flooding twice a year on average. It receives drainage from a large area that is almost entirely impervious. Dry wells and drill holes are unable to keep up with the rate and volume of stormwater runoff even during small storm events. Flooding of this underpass creates a barrier and safety hazard for vehicles traveling east and west on this busy street. This is a serious concern, because emergency vehicles need to be rerouted.

HP#3 Third Street Underpass

Similar to the Franklin Avenue underpass, the Third Street underpass is in an excavated low area where the roadway was constructed under the at-grade railroad, and drains some 55 acres. The underpass floods to the point of blocking traffic an average of two or three times a year. This is one of the busiest streets for motorists moving north and south through the City. Detours over crowded streets are time consuming and pose a safety hazard to residents who live along the detour routes. Public safety is also an issue, because drivers sometimes attempt to drive through the flooded area and become stranded, and emergency vehicles are sometimes rerouted and delayed. Several of the dry wells and drill holes at this underpass are in one or more of the City's Drinking Water Protection Areas. As is the case with the other underpasses, this one is vulnerable to spills from the railroad, as well as from trucks and other vehicles.

The drainage solution to this problem may be combined with solutions to similar flooding problems at the Franklin Avenue and Greenwood Avenue underpasses.

This hotspot is currently in final design that includes pumping the runoff to infiltration ponds at the Colorado Avenue/Bend Parkway cloverleaf, owned by ODOT. The drainage area that flows to the underpass is identified as drainage basin MB37. Greenwood Underpass, another problem area, was not analyzed as part of this project, but its stormwater may be incorporated into the solution for the Third Street underpass and the stormwater pumped to the same Colorado Avenue/Bend Parkway cloverleaf.

HP#4 Archie Briggs Road West of the Deschutes River

This section of Archie Briggs Road is steep, collects runoff from a large area, and lacks adequate drainage structures. During heavy rains, stormwater blocks one of the lanes of traffic, leaves the uncurbed roadway, and discharges onto residential property and then into the Deschutes River.

HP#5 Fairview Heights on Awbrey Butte

Stormwater from both public and private areas combines to create this problem. A large part of Awbrey Butte drains to too few or poorly constructed dry wells and through undersized ditches and culverts. At its lower end, the drainage flows through a residential area, flooding garages, driveways, and sometimes homes before it discharges to the golf course below. Easements throughout the drainage way do not all line up, so water short-circuits some of the structures, causing much of the damage. It is noted that high liability is associated with this drainage problem.

These five sites were analyzed and evaluated to develop alternatives and conceptual solutions. Fact sheets were developed for each alternative (see Appendix B). Alternatives include piping, pumping, onsite storage, offsite storage, and increased sizing or rearrangement of existing facilities. Each solution includes a water quality component.

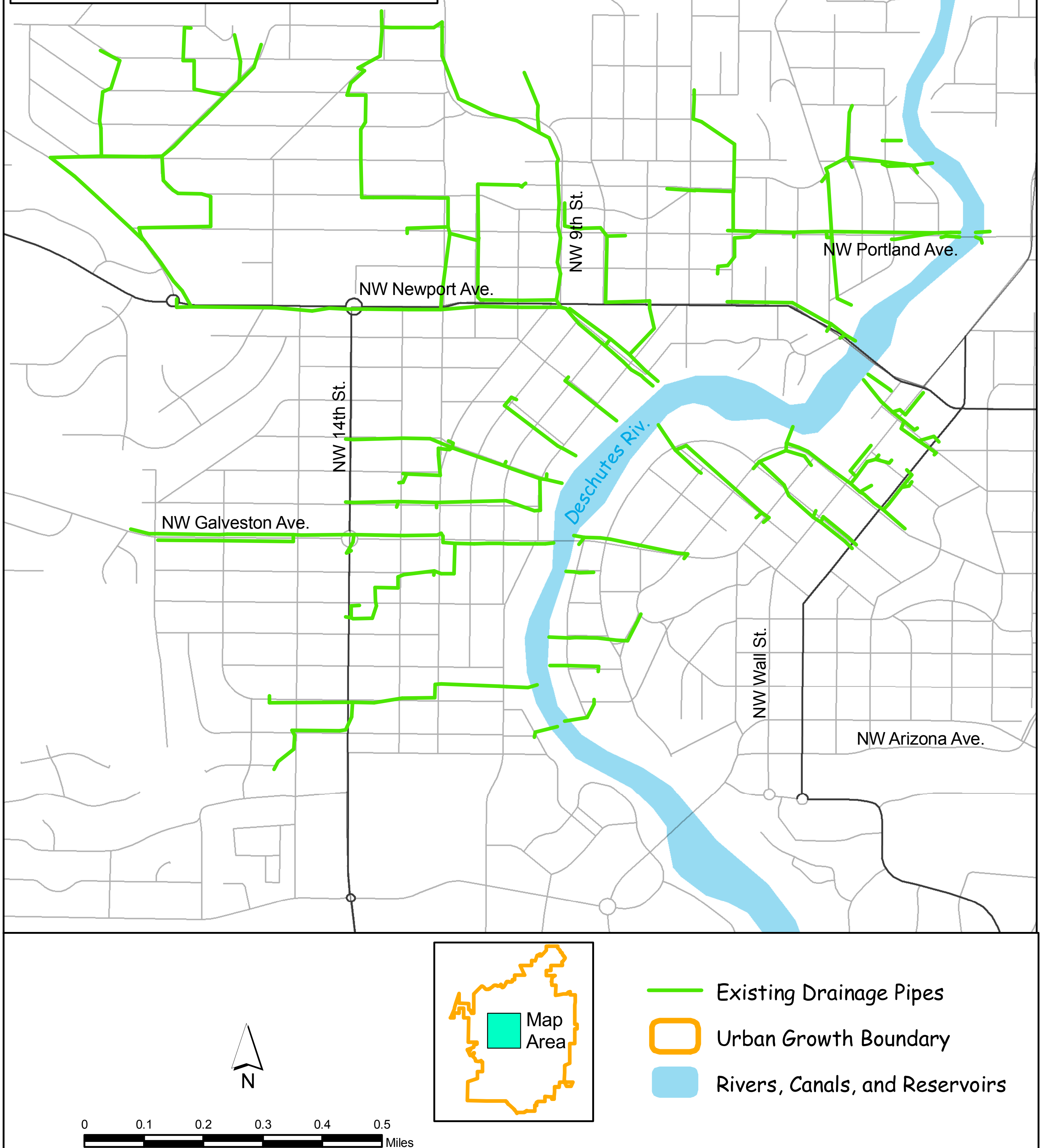
Priorities may change over time for several reasons including regulatory mandates, funding availability, opportunities to coordinate with other utility projects and development patterns.

REFERENCES

City Development Code 10-10, Section 2.1.300 Subsection F.8 and Section 2.3.600 Subsection 7.

City of Bend General Plan. Public Facilities and Services Policies, Stormwater-Number 12.

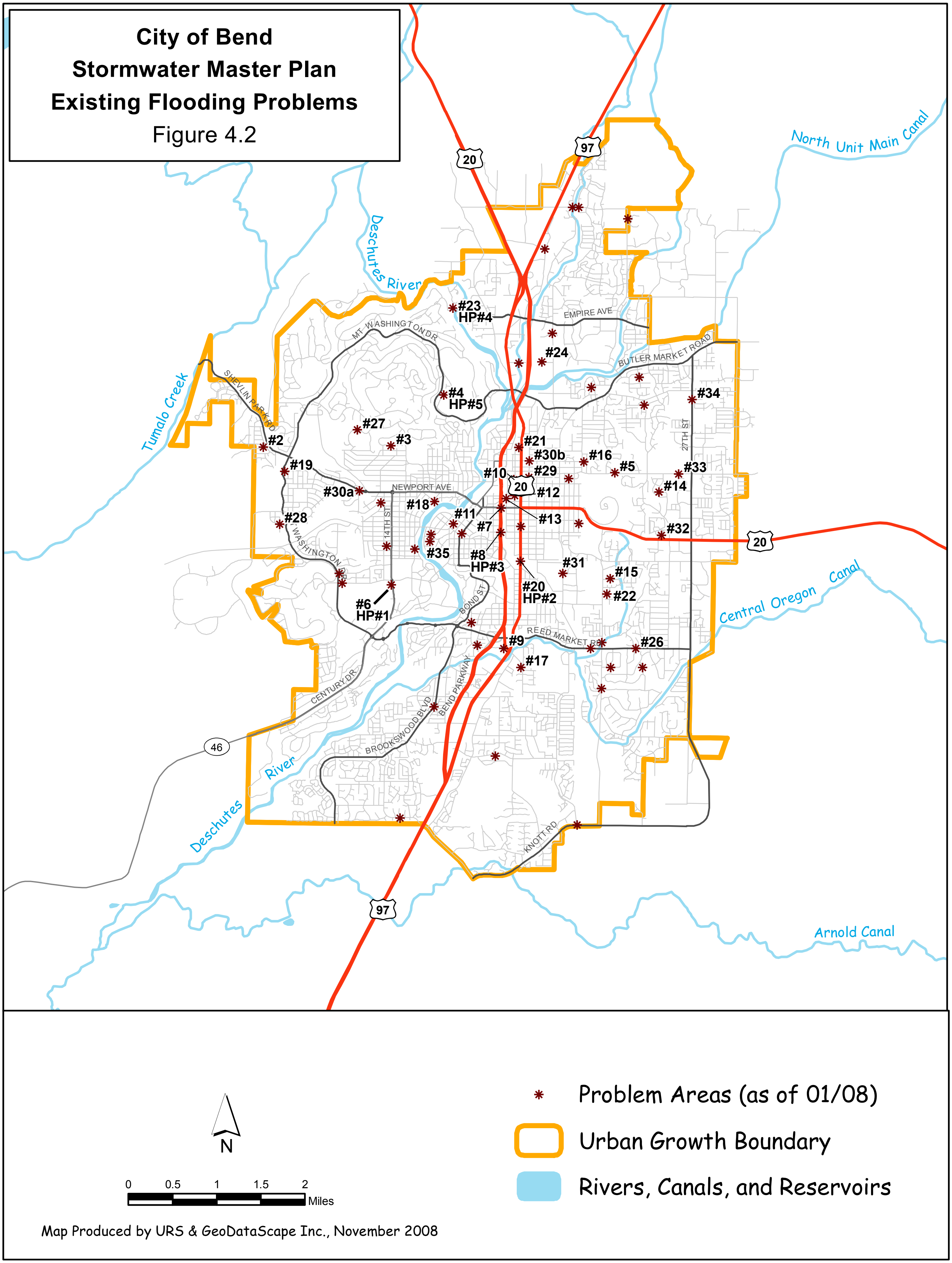
City of Bend
Stormwater Master Plan
Existing Piped Drainage Areas
Figure 4.1



Map Produced by URS & GeoDataScape Inc., November 2008

City of Bend Stormwater Master Plan Existing Flooding Problems

Figure 4.2



Problem Areas (as of 01/08)

Urban Growth Boundary

Rivers, Canals, and Reservoirs

Map Produced by URS & GeoDataScape Inc., November 2008

5.0 HYDROLOGIC AND HYDRAULIC ANALYSIS

A hydrologic and hydraulic analysis of the City of Bend was undertaken to define drainage basins in order to develop CIP recommendations. These CIPs will establish a basic infrastructure that would provide a drainage outlet to the major drainage basins in the City. This chapter describes the analyses performed to define drainage basins and to determine stormwater peak runoff flows and volumes in the City of Bend. Peak flows and volumes are used to determine the size of storm drainage and treatment facilities, such as pipeline diameters and the capacity needed for regional detention.

While the City does not currently require it, detention can reduce peak flows downstream and thereby save costs by allowing the use of smaller pipes, pumps and treatment devices, and also by reducing maintenance. Some detention designs also allow stormwater to infiltrate, which helps maintain aquifer recharge and reduce the volume of stormwater for disposal. Smaller pipe sizes are less expensive, easier to maintain, require smaller machinery for installation, and can be installed on steeper slopes. A single large regional detention facility is much easier to maintain than many smaller detention systems.

The drainage basin analysis involved establishing major basins by grouping subbasins based on direction of flow, topography, and potential CIPs. The direction of flow and locations of discharge points were used to initially identify major basins. After these major basins were mapped, the low point of each major basin was identified. These basins were then used in the development of the Drainage Improvement Alternatives, which are discussed in Chapter 9. The discharge flow rate and volume for each of the major basins are shown in Tables C.1 and C.2 for existing and future land uses. See Chapter 9 for a discussion of results and alternatives.

The list of stormwater facilities proposed to be constructed as part of the CIP program can be found in Chapter 10.

5.1 DRAINAGE BASINS

The drainage basins were defined for the first time as part of the work performed for this Stormwater Master Plan. This task was difficult because of the complicated and variable topography and geology; the disruption of natural drainage due to the canals and their laterals; the lack of a city-wide piped drainage infrastructure; and the use of underground injection. Numerous canals and laterals convey water from the Deschutes

River through open and piped systems within the City and to agricultural areas throughout Central Oregon.

From the 10-foot contours on U.S. Geological Survey (USGS) maps it was determined that the topographic features generally run in a northward and easterly direction. Initial basins identified using USGS maps with 10-foot contours resulted in basins of several hundred acres in size. Because the City wanted to find localized solutions to its drainage problems, it needed to define smaller basins that would indicate how local areas drain.

ArcGIS (Hydrology Modeling, ESRI) was used to identify low-lying areas and the direction of flow based on topography. This Geographic Information System (GIS) model allows the development of flow lines and provides information on flow direction. The City's 2-foot contour GIS was used to refine the analysis of the drainage basins. A Digital Elevation Model (DEM) derived from 2-foot contours divided the ground surface into cells (units of approximately 40 acres in area). The difference in elevation between adjacent cells was used to determine slope direction and the direction of surface water flow. GIS was used to compute how many cells contribute flow to a given cell until a specified threshold number of cells was reached. Cells contribute flow until a subbasin fills to the specified threshold, then water flows into the next downstream group of cells to define the next subbasin. This continues until a river or creek is reached, or the cells are outside of the City's boundary. Infiltration, or the use of dry wells, was not included in this part of the analysis. The use of underground injection controls (UICs) is discussed in Chapters 3 and 9.

The first iteration of this model was performed using a threshold of 50,000 cells to define a subbasin. This threshold resulted in basins of several hundred acres, similar to the USGS analysis, and larger than desired for this project. Because of the complex landscape, the difficulty in determining drainage patterns, and the strong interest in using low-impact development techniques to address water quality concerns locally, it was necessary to identify subbasins on a smaller scale. A second iteration using a threshold of 25,000 cells to define a subbasin resulted in subbasin sizes that range from a fraction of an acre up to 170 acres. About 80 percent of the subbasins were smaller than 40 acres, a suitable size both for identifying local solutions and for groundtruthing model results.

To accurately develop overland flow directions, one of the first steps in the modeling process was to fill all sinks to eliminate trapped flow. The model's primary disadvantage is its inability to define a “sink,” or a low area that has no natural outlet. For example, Shevlin Ridge and Westside Meadows Developments (MB 23A and 23B, Figure 5.1) are in a bowl with no natural outlet. The model shows this area draining out and illustrates why groundtruthing is necessary. These developments are examples of areas in Bend that do not drain anywhere.

Roadways, railroads, and the irrigation canals all are barriers that mislead the model. Groundtruthing was required to adjust some of the watershed boundaries to reflect existing topographic conditions. Resulting major basins and subbasins are shown in Figure 5.1.

Major basins were created by following the flow lines of the smaller drainage basins. Figure 5.2 provides a graphical view of general drainage patterns. In general, basins adjacent to and on both sides of the Deschutes River flow naturally to the river. Areas farther east of the river but west of Pilot Butte tend to flow northward while areas east of Pilot Butte tend to flow north and east. The areas west of the river that do not flow toward the river tend to flow in a northwesterly direction toward Tumalo Creek. At an elevation of 4,214 feet (UTM NAD 27) Awbrey Butte is the highest point in the City and is a prominent topographical feature in Bend. Except for the southern and southeastern sides of the butte, which drain toward the river, drainage flows down the butte and joins the general drainage flowing north and east. Pilot Butte, a state park east of the Deschutes River, is at 4,138 feet almost as high as Awbrey Butte, but is smaller in circumference. Storm drainage runoff from Pilot Butte flows down the steep hillside and then follows the surrounding drainage flowing in a northeasterly direction.

More than 2,500 subbasins were identified for Bend and the surrounding areas to allow analysis of the drainage patterns. In addition to identifying drainage areas and patterns within the Urban Growth Boundary (UGB), it was necessary to determine detailed topography between the UGB and the City’s Water Reclamation Facility. The City owns 1,000 acres at the Water Reclamation Facility that can be used for stormwater storage and treatment. This option is explored further in Chapter 9.

The GIS model established a total of 954 subbasins within the current UGB. To develop Master Planning level CIPs, the subbasins were grouped into 36 major basins, as shown in Figure 5.1. In general, each of the major basin numbers MB1 through MB36 are comprised of subbasins that flow in the same direction and either naturally flow to the Deschutes River or to points outside the UGB. Major basins that became very large were subdivided and designated by adding letters to the major basin designation, such as drainage basin MB34A through MB34D.

5.2 ANALYTICAL CRITERIA

When the preliminary engineering was done for the five highest-priority hotspots, the Central Oregon Stormwater Manual (COSM) was still in draft form and the criteria for a design rainfall distribution required the use of an NRCS Type II storm for conveyance system design. A Type II storm is a high-intensity storm that produces a higher peak runoff rate than produced by a Type I storm. The design storm was changed to Type I when the COSM was finalized. The hotspot flooding evaluations and solutions are based on the previously required Type II storm and the Master Plan basin analysis is based on the Type I storm. The Master Plan major basins, subbasins, and watersheds cover all areas within the City, including the flooding hotspots discussed in Chapter 4.

Equations in the COSM were used to calculate the parameters used for the hydrologic calculations, as discussed in Section 5.3. The Santa Barbara Urban Hydrograph method was then used to calculate peak runoff flow rates and total volumes for four storm events: the 6-month water quality storm along with the 25- and 100-year storms. These storms were used to evaluate each of the subbasins as well as the major basins. The 10-year storm event was added for analysis of the major basins. These storm events are defined by the May 2007 version of the COSM and the City of Bend as follows:

water quality storm:	1.0 inch/24 hours
10-year storm:	2.1 inches/24 hours
25-year storm:	2.5 inches/24 hours
100-year storm:	3.1 inches/24 hours

The storms selected for evaluation address the major criteria and elements of storm drainage planning and design, including water quality, conveyance, detention, disposal, and life safety and property damage.

Water Quality: Per the COSM and the ODEQ water quality regulations for underground injection systems, the stormwater from a water quality storm is required to be treated prior to being discharged underground.

Conveyance and Detention: Chapter 8 of the COSM requires the storm drainage system capacity to be designed for at least a 25-year storm, including pipe systems and regional detention.

Life Safety and Property Damage: The COSM requires providing safe passage for the 100-year storm event to protect the public from infrequent yet potentially dangerous flooding. The rate and volume of water resulting from this storm need not be included in the design of conveyance systems but must be provided safe passage to the point of discharge.

5.3 ANALYSIS OF PEAK RUNOFF FLOW RATES AND VOLUMES

Due to the City's inadequate storm drainage infrastructure, minimal available information on existing systems, and challenging topography and geotechnical conditions, a decision was made to perform hydrologic calculations using the Santa Barbara Unit Hydrograph (SBUH) to identify water quality and quantity CIPs. As stated in the COSM, the SBUH is an approved method for identifying peak flow rates and volumes. Once funds are available from the stormwater service charges or other sources, the modeling results in this Stormwater Master Plan should be refined and the volumes and flow rates updated for the major basins and subbasins.

The SBUH method develops peak runoff flow rates and volumes for a specified storm defined by the depth, intensity, and duration of rainfall using the following information:

- Pervious and impervious areas
- Curve number (CN) based on the infiltration capacity of the soil
- Time of concentration (TOC), a measure of how rapidly the basin responds to storms to produce runoff

The CN is a runoff coefficient that is based on the infiltration rates of the various surface soils in the basin. Higher CN values indicate less infiltration and higher rates and volumes of runoff. Soils are categorized into four different hydrologic soil groups based on their drainage, from Type A which drains well to Type D which drains poorly. Hydrologic soil groups for the City of Bend are identified on Figure 5.3.

Table 5.1 in the COSM provides CN values for various ground covers. Impervious areas of Bend, such as pavement and roofs, were given a CN value of 98. CN values for other areas depend on the ground cover and hydrologic soil group of the underlying soils. These "pervious" areas were assumed to be in the category identified as "Pasture, Grassland, or Range Continuous Forage for Grazing" per the COSM. Fair condition values were used, described as ground cover of 50 to 75 percent. The CN values used in the calculations are as follows:

Soils Runoff Coefficient CN

Soil Type	A	B	C	D
CN[1]	49	69	79	84
Approximate range of infiltration rates[2]	10 - 100 inches/hour	1 - 10 inches/hour	0. 1- 1 inches/hour	0.01 – 0.1 inches/hour

1. Source: COSM, 2007
2. Source: USDA technical manual, Chapter3c

The time of concentration, T_c, is the amount of time it takes the first runoff from the most distant point in the basin to arrive at the discharge point. For a given area, the longer the T_c the lower the peak runoff rate. For highly developed basins that are mostly impervious, the T_c is short, producing high runoff rates. Other factors affecting runoff include the medium used for transporting flows, such as surface sheet flow, channel flow, or pipe flow. The roughness of each of these components affects the T_c, as the greater the friction, the longer it takes flows to reach their destination. Slope and the amount of stormwater detention distributed throughout the basin are major factors in determining T_c.

Sheet flow is calculated using the following equation (Equation 5-5, COSM, 2007, Page 5-9): $T_c = \frac{0.42(n_s L)^{0.8}}{(P_2)^{0.5}(S_o)^{0.4}}$

where:

T_c = travel time in minutes
n_s = Manning's effective roughness coefficient for sheet flow
L = flow length in feet
P_2 = 2-year, 24-hour rainfall in inches (a value of P_2 = 1.5 inches is used for this Master Plan)
S_o = slope of the land surface in feet/foot

Shallow concentrated flow is based on the following equations (Equations 5-6, 5-7, and 5-4, COSM, 2007, Page 5-9,10):

$$T_c = \frac{L}{60V}$$

$$V = k(S_o)^{5.0}$$

$$k = \frac{1.49R^{2/3}}{n}$$

where:

V = average velocity in feet/second
k = time of concentration velocity factor in feet/second
R = hydraulic radius
n = Manning's roughness coefficient for open channel flow, in this case, the same as n_s used above

The following assumptions were made:

- The first 300 feet of flow was sheet flow, with T_c calculated from COSM Equation 5-5.
- The remaining surface flow was shallow concentrated flow based on the velocity and open channel flow equations (COSM Equations 5-6, 5-7, and 5-4).
- The pipe flow was estimated to be 3 feet/second.

T_c was developed for both subbasins and major basins. Appendix C describes simplifying assumptions used in the development of T_c for subbasins.

Future conditions were evaluated using the City's zoning map and land use designations. Where existing land use had a larger percentage of impervious surface area than future zoning, the existing percentage was used. Impervious percentages for different land uses were obtained from Table 5.1, Page 5-6 of the COSM, and are as follows:

Commercial	85%
Industrial	72%
High-density residential	65%
Medium-density residential	38%
Low-density residential	25%
Open space and parks	15%

T_c calculations were made for existing and future land use. The City Community Development Department provided existing information on land use and impervious areas. Slopes were calculated from topographical maps provided by the City, and CN values were established for each subbasin as part of the hydrologic analysis. Future zoning data provided by the City did not include parks and open spaces. Runoff from these areas was conservatively accounted for as low-density residential land use.

5.4 SUMMARY

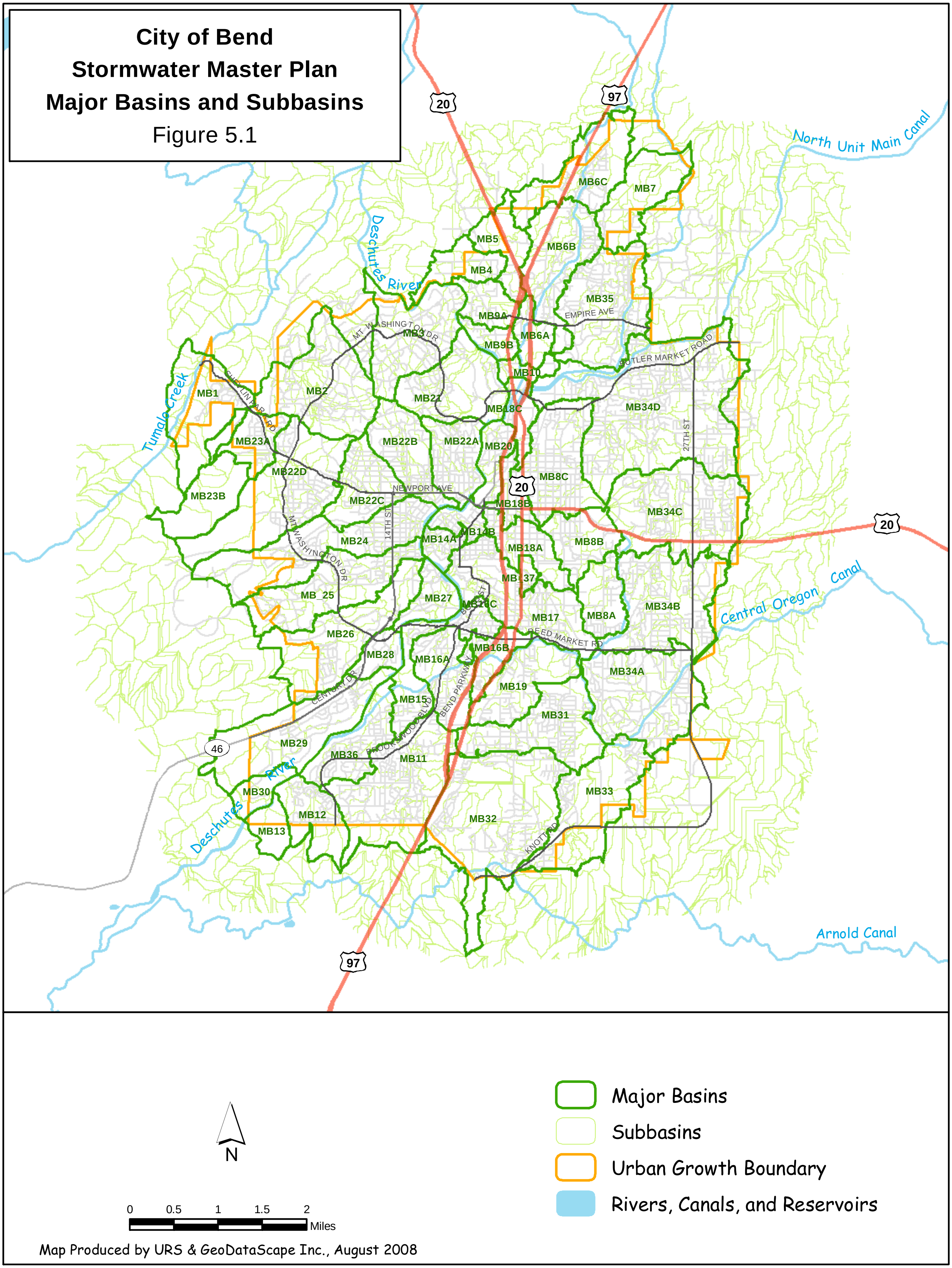
Each subbasin and major basin was evaluated to establish runoff volumes and peak flows. The subbasin evaluation was based on a number of simplifying assumptions to establish T_c. These assumptions and results for the subbasins are presented and discussed in Appendix C. Tables C.1 and C.2 show the discharge flow rates and volumes for each of the major basins for existing and future land uses. Subbasins were evaluated to provide information for onsite facilities such as low-impact development or shallow infiltration units. (See Chapter 9 for more information.) Major basins were analyzed to identify CIPs that would provide appropriate storm drainage infrastructure for all parts of the City. Major basins were used to establish pipe sizes and to evaluate regional detention and treatment systems. Table C.3 shows the pipe sizes required to accommodate the flows from the major basins.

REFERENCES

Central Oregon Stormwater Manual, May 2007, OTAK

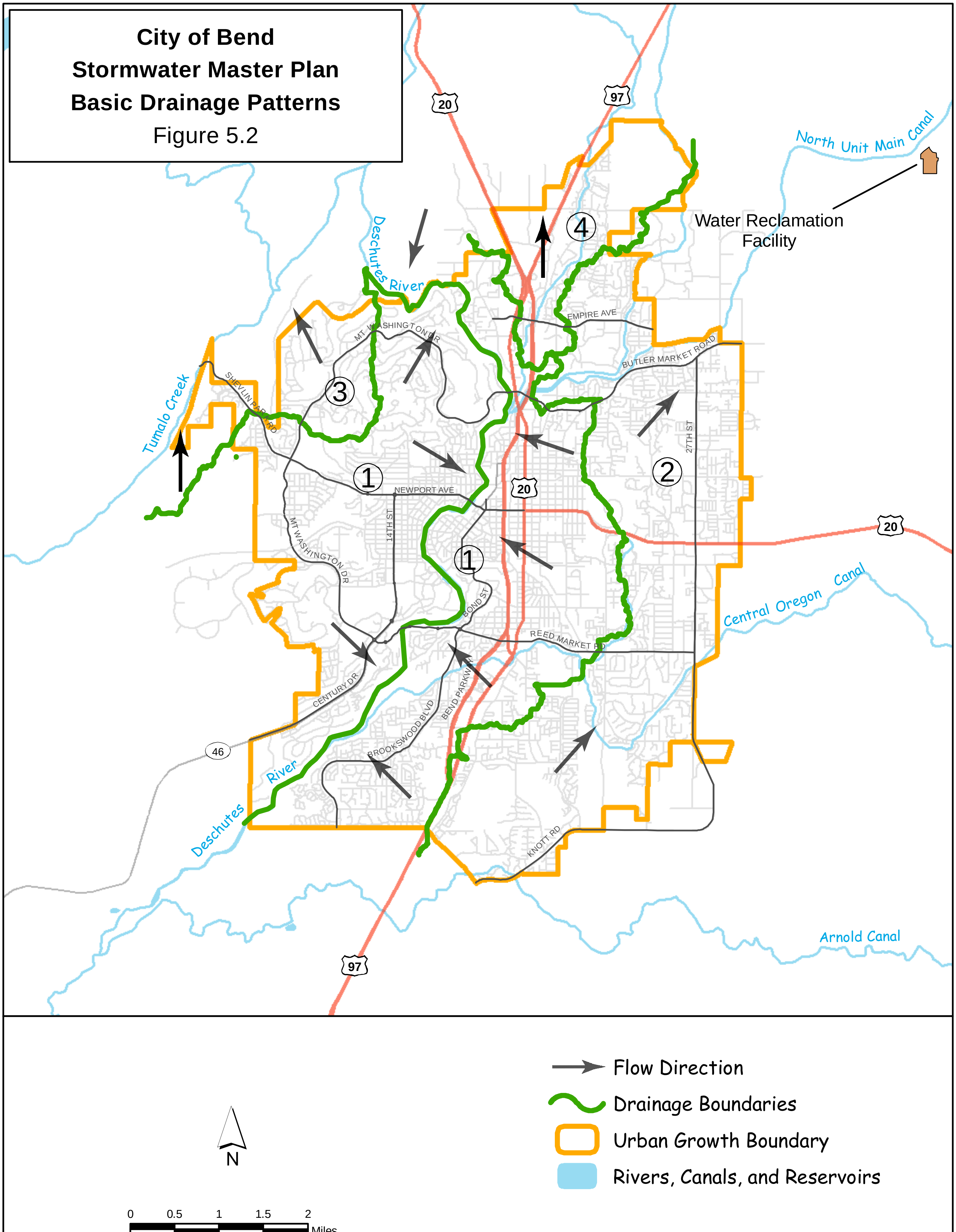
Hydrology Modeling, ESRI, 2007. ArcHydro v1.2.

City of Bend
Stormwater Master Plan
Major Basins and Subbasins
Figure 5.1



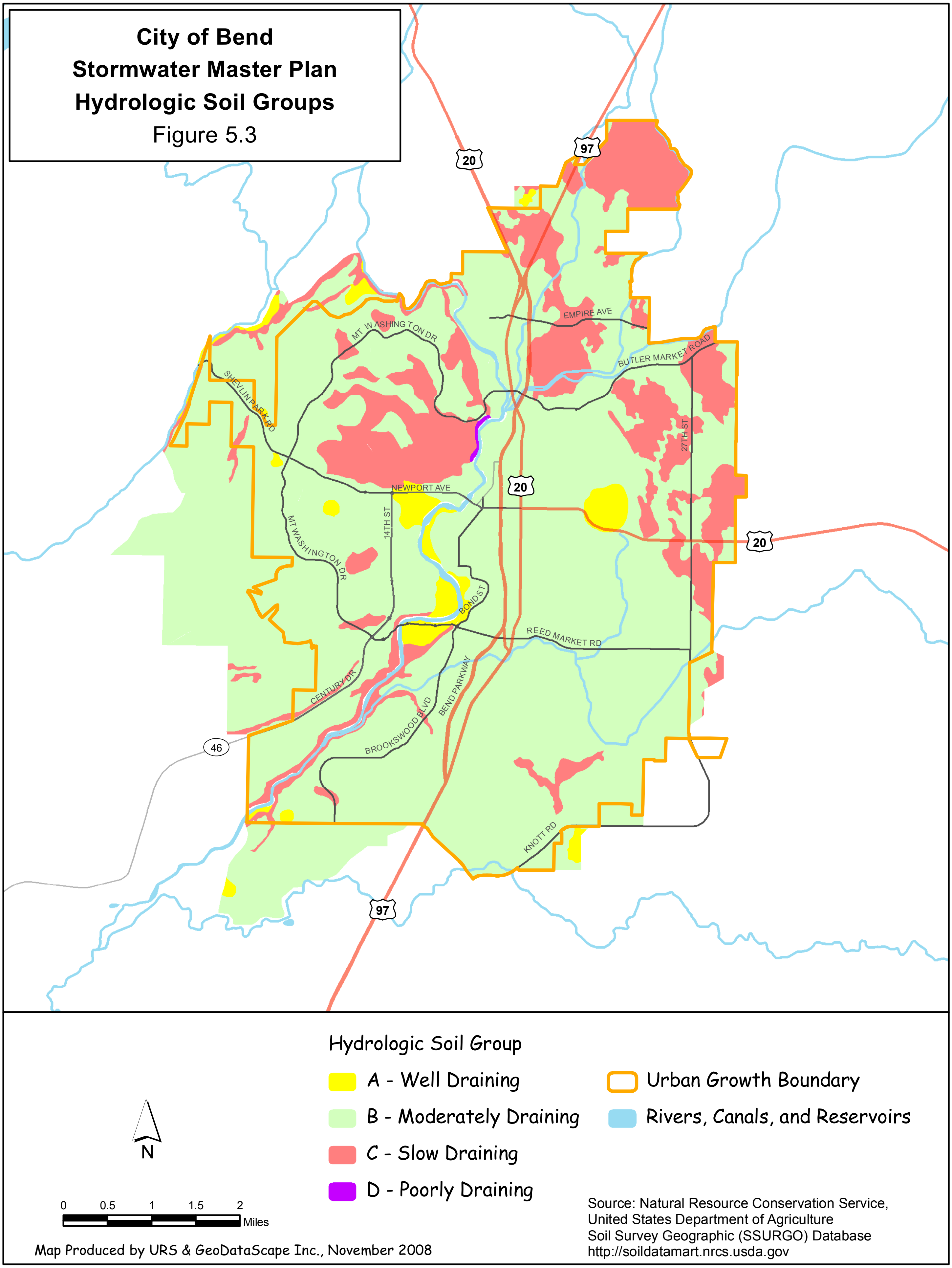
Map Produced by URS & GeoDataScape Inc., August 2008

City of Bend
Stormwater Master Plan
Basic Drainage Patterns
Figure 5.2



Map Produced by URS & GeoDataScape Inc., August 2008

City of Bend
Stormwater Master Plan
Hydrologic Soil Groups
Figure 5.3



Map Produced by URS & GeoDataScape Inc., November 2008

Source: Natural Resource Conservation Service,
United States Department of Agriculture
Soil Survey Geographic (SSURGO) Database
http://soildatamart.nrcs.usda.gov

6.0 WATER QUALITY

6.1 BACKGROUND AND REGULATIONS

Bend relies on groundwater for a significant portion of its drinking water. Water quality regulations affecting the City include the federal Clean Water Act (CWA) and the federal Safe Drinking Water Act (SDWA). Underground injection control systems (UICs), including dry wells and drill holes, are governed by SDWA rules. The City has applied for a UIC Water Pollution Control Facility (WPCF) permit from the ODEQ for its estimated 4,000 dry wells and 1,000 drill holes and is currently negotiating the permit conditions.

The City will be required to install pretreatment on all of its UICs unless it obtains more monitoring data and is able to demonstrate that its stormwater does not contain significant quantities of pollutants of concern and performs studies to show that its groundwater is not susceptible to contamination.

Although the UIC permit has not yet been issued, the ODEQ's position is that the UIC regulations already apply and require pretreatment for all underground discharges. Less than a dozen of the City's UICs have pretreatment. At this time, ODEQ has only granted full approval of one manufactured UIC pretreatment device for public street runoff, a proprietary device with specifically designed filters to remove pollutants. ODEQ also supports the use of bioswales, phytofiltration (vegetative filter buffers), and constructed wetlands for stormwater treatment (ODEQ, 2003). The City is requiring all development projects—public or private- to consider non-UIC stormwater disposal such as engineered infiltration ponds and swales.

6.2 EXISTING WATER QUALITY CONDITIONS

The City has done a limited amount of stormwater runoff monitoring mainly to gain knowledge that will help it design an appropriate UIC and river discharge monitoring program. Data from such a program will help the City identify the main pollutants of concern, provide information to help select and design BMPs to remove the pollutants of concern, and determine compliance with regulatory requirements.

The City has also participated with the UDWC in a Deschutes River water quality monitoring program aimed in part at determining the effects of the City's stormwater discharges on the river.

6.2.1 Stormwater Runoff Monitoring

Runoff monitoring has been conducted at Pageant Park where stormwater pipes discharge to Mirror Pond, on Newport Avenue at the inlet to a stormwater treatment vault that was installed as part of the Veteran's Memorial Bridge project, and at the inlet and outlet of a treatment device located in Neff Avenue at Pilot Butte Middle School. All of these monitoring locations are located where high pollutant concentrations would be expected because of land use and traffic count. The Neff Road treatment device is a proprietary device under evaluation by the City.

The City has also installed two tipping bucket rain gauges, one on Awbrey Butte at the water facility and one on the roof of the Public Works building on 15th Street. Data from these gauges, along with the AgriMet Gauge near the Old Mill District, are used to correlate sampling times with runoff curves, determine storm sizes and improve the spatial accuracy of rainfall data.

Stormwater monitoring conducted to date is not conclusive. Data show that particulate matter and three stormwater contaminants may be present at levels of concern. These are Barium and Nitrates among the inorganics and Bis(2-ethylhexyl)phthalate among the organics on the DEQ's list of 19 inorganic and 27 organic potential stormwater contaminants.

Particulate matter (sediment) is the primary stormwater pollutant of concern both for underground and river discharges. Particulate matter plugs underground injection systems and infiltration ponds and creates unsightly sediment deposits around the river outfalls. Some other contaminants attach themselves to particulate matter so particulate matter removal also removes some of these contaminants.

6.2.2 Phase II Permit Sampling

Although monitoring is not required by the Phase II NPDES program or permit, the City has chosen to work cooperatively with the Upper Deschutes Watershed Council (UDWC) and ODEQ to monitor the Deschutes River and stormwater discharges to try and determine whether and how those discharges may affect the quality of the river and its beneficial uses. This information will help the City target its stormwater quality management funds and efforts to obtain maximum benefits.

In 2004, the City and UDWC began jointly sampling for pollutants in the Deschutes River. Currently, most of the field and laboratory work is done by the City, and the data analysis and reporting are done by the UDWC.

As discussed above, the City has conducted limited sampling and analysis on stormwater discharges to the Deschutes River. This has helped the City plan future sampling programs. Funds have not been available to conduct the kind of monitoring that is required for making defensible stormwater management decisions.

Starting in September 2005, the City began taking continuous readings of several pollutants in the Deschutes River by use of submersible sondes. The sondes record continuous measurements of basic parameters including pH, temperature, specific conductivity, turbidity, and dissolved oxygen. One sonde is upstream of all City stormwater outfalls and one is downstream of all City outfalls. A third, roving sonde is currently at the Drake Park Footbridge. These sondes have been in place during several significant runoff events and the results are currently being studied to see how stormwater discharges affect river water quality.

To gain an understanding of impacts of the City's stormwater discharges on river water quality, sampling is performed both upstream and downstream of the City's Urban Growth Boundary (UGB) along the Deschutes River and at the confluence of the river with Tumalo Creek. Grab samples are taken at 12 locations along with continuous temperature monitoring and 5 locations have continuous monitoring of several parameters.

River water quality is significantly affected by a hydroelectric impoundment and irrigation impoundments and withdrawals on the river. Large quantities of sediments are transported into Mirror Pond from upstream bank erosion.

6.2.3 Groundwater Quality Monitoring

No groundwater testing has been done or is currently planned for the purpose of determining the effects of stormwater discharges on groundwater quality.

URS recommends that additional data be gathered to develop a better understanding of existing groundwater quality conditions and threats to groundwater quality and to track changes and trends. A groundwater vulnerability study should be conducted to determine the potential for groundwater to be contaminated by stormwater discharges.

The study will help the City of Bend decide if it needs to develop and implement a groundwater monitoring program to determine whether underground injection of stormwater poses a threat to groundwater quality. Existing monitoring results for drinking water wells may augment the information developed under the future groundwater monitoring plan. Results of this monitoring will help identify where specific water quality treatment may be required within the City. URS recommends that the City develop BMPs to mitigate sources of concern, and continue groundwater monitoring to track long-term changes and trends in groundwater quality.

Drinking Water Protection Areas (DWPAs) that are based on a two-year time of travel have been delineated for the City's water wells with assumptions for flow of groundwater through the aquifer beneath the City. Improved groundwater models will provide greater accuracy for the delineation of DWPAs, providing the City with better information with which to protect its drinking water. The above-mentioned vulnerability study should include a groundwater modeling component.

6.3 WATER QUALITY ISSUES

Potential water quality pollutants in Bend include typical urban stormwater pollutants such as sediment, and oil and grease and heavy metals from motor vehicles. In addition, as discussed in Chapter 3, the City must consider the pollutants-of-concern on the Deschutes River 303(d) list.

6.3.1 Water Quality Limited Streams

As discussed in Chapter 2, the ODEQ has determined that the water quality of the Deschutes River is impaired by several pollutants. When ODEQ develops TMDLs for the Deschutes River, the City may be required to develop and implement a program to reduce the pollutants that are addressed by the TMDLs.

6.3.2 Materials Used for Winter Road Safety

The City uses cinders, crushed basalt, and magnesium chloride on its streets during the winter. The water quality issues associated with these materials are described below.

Cinders. For many years, the City has used cinders for traction on its streets during the winter. The cinders are pulverized as vehicles drive over them. The fine material is washed into dry wells, drill holes, pretreatment filters, and infiltration ponds, severely reducing the capacity, life expectancy, and performance of these devices. Material that cannot be swept up is washed into the Deschutes River, creating visible and objectionable islands of sediment and debris, or gets washed into UICs reducing their effectiveness. The extensive use of cinders for traction is not compatible with the City's use of underground injection, pretreatment devices, or infiltration ponds but is necessary for public safety.

Although used judiciously, cinders are often applied to roads in large quantities all across the City. Cinders are relatively inexpensive and are less prone to damage vehicles than sand or gravel. The City does its best to sweep up this material as soon possible after it is applied but weather conditions often delay sweeping.

Crushed Basalt. During the winter of 2007-2008, the City began experimenting with crushed and screened basalt in place of cinders. The basalt is denser than cinders and less likely to be pulverized. This is desirable from a stormwater system maintenance and air quality perspective. The City plans to discontinue using cinders when the existing supply is exhausted.

Magnesium Chloride. The City began using the ice-preventing agent magnesium chloride (Mag) about eight years ago. To maximize its effectiveness and to minimize the amount used, Mag must be applied before icing occurs. It is mixed with an organic carrier such as corn syrup and applied as a liquid. In Bend, Mag is often used along with cinders or crushed basalt. Although it is more expensive than salt (sodium chloride), the City has chosen to use Mag because it is relatively less toxic and does not attract wildlife as salt does. The main environmental concern associated with Mag is its chloride content. Chloride is highly mobile in soil and can contaminate groundwater.

6.3.3 Groundwater

The three major water purveyors providing drinking water to Bend residents are Avion Water District, Roats Water District, and the City of Bend. Within its UGB, the City owns 21 municipal drinking water wells, and there are about 400 private water wells. The City currently relies mainly on surface water for its drinking water except during the irrigation season, but Avion and Roats rely solely on groundwater year round.

As discussed in Chapter 3, UIC regulations do not allow UICs within 500 feet of any drinking water well, within the 2-year time-of-travel delineated as DWPAs for municipal wells unless the UICs are covered under a UIC WPCF permit. These restricted areas cover a large part of the City, as shown on Figure 3.1. Both public and private dry wells and drill holes have operated for years in these areas with no pretreatment. These UICs must either be decommissioned or be equipped with pretreatment that treats the stormwater to drinking water standards or better before it is discharged underground. DEQ-registered cleanup sites must also be considered when locating UICs.

6.3.4 Dry Wells and Drill Holes

As Bend has grown, so has the amount of impervious surface area. Storm drainage practices that were acceptable in the past are no longer acceptable. Although dry wells are effective where geotechnical conditions are appropriate, geotechnical conditions vary greatly throughout the City. Dry wells and other types of dispersed infiltration help maintain groundwater recharge patterns and avoid the problems associated with managing high-volume discharges. However, a drainage system based primarily on underground injection has many disadvantages, particularly in Bend. The advantages and disadvantages of dry wells are discussed in previous sections.

In the past 10 years or so, drill holes have been installed only where dry wells have proven not to be effective. In some areas, such as the areas of pink tuff on the west side of Bend (see Chapter 2), even drill holes are not always effective. Drill holes are not allowed in drinking water protection areas unless the water is treated to drinking water standards.

Oregon’s UIC and groundwater protection rules do not allow untreated stormwater to be discharged into groundwater. Groundwater is defined as any water below the ground surface, including seasonal high or perched groundwater and water mounded around a dry well after a storm event. This is a major problem for underground injection in Bend because many dry wells and most drill holes discharge directly into “groundwater” at some time during the year. Providing pretreatment for all of these UICs would be very expensive for the City.

Bend has many areas where groundwater is seasonally high and many lenses of perched groundwater, particularly on the west side. Perched or seasonal high groundwater is often encountered in dry wells that are only 10 to 15 feet deep.

The City owns over 1,000 drill holes that are as deep as 450 feet. Some drill holes, such as those at the Third Street underpass, are in DWPAs. The City has begun, and should complete as quickly as possible, a risk assessment that will establish priorities and a schedule for decommissioning or adding pretreatment to its UICs. Drill holes, particularly those in DWPAs, will be the highest priority. When UICs are decommissioned, alternative means of disposal must be developed. This is especially difficult and expensive in highly developed areas where little space is available for ponds or swales.

In areas where neither dry wells nor drill holes are effective, or where underground injection can cause structural or flooding problems, the only option is a piped system, using pumps where necessary, to convey the drainage to a location where it can be adequately treated and disposed of. Disposal will be to the river after pretreatment or into the ground by means of infiltration at regional ponds.

6.3.5 Lack of Spill Protection

Bend does not have an adequate spill protection plan for its stormwater system. Spills on the railroad or any of the City's streets would quickly flow to the nearest dry well or drill hole or to the river before the spill could be contained and recovered. Stormwater management that includes retention or detention can help protect groundwater and surface water from spills. The greatest risk is from hydrocarbon spills. Systems and devices are available for retrofitting catch basins with automatic valves that can prevent hydrocarbons from being released from the catch basins. URS recommends that the City develop a stormwater spill prevention and response plan.

6.3.6 Sources of Contamination

Sources of pollutants associated with stormwater runoff in urban areas may include the following:

- illegal dumping of trash and debris
- spills
- construction site and landscape runoff
- runoff from industrial or commercial sites
- motor vehicle leaks, break wear and wheel weights
- roadway traction materials

- ice prevention chemicals
- landscape fertilizers and pesticides
- air pollutant deposition
- runoff from residential sites

These are examples of typical potential sources of contamination. Further information can be found in the ISWMP.

6.3.7 Mirror Pond

Mirror Pond, in the Deschutes River in downtown Bend, is the location of many of the City's piped stormwater outfalls. It has been estimated that these outfalls contribute about 5% of the sediment that accumulates in Mirror Pond. The majority of the sediment is transported from upstream and adversely affects the recreational, water quality, and aesthetic values of the pond. Sediment and debris that accumulate near each of the outfalls, while small in quantity relative to sediment coming from upstream, is unsightly and causes sedimentation problems in the pond. Sedimentation is a water quality parameter.

Mirror Pond is created by a Pacific Power and Light hydroelectric dam. If Pacific Power or a future owner of the dam were to abandon it, the City would probably be interested in maintaining Mirror Pond, which requires the dam to remain in place and be maintained in a safe condition. Whether or not the pond remains, Phase II NPDES rules require the City to reduce the amount of pollutants it discharges to the pond and the river "to the maximum extent practicable" using best management practices (BMPs). Currently, only one of the stormwater discharges to Mirror Pond (Newport Bridge) receives treatment.

6.4 SUMMARY AND RECOMMENDATIONS

The City needs more information about the water quality impacts of stormwater discharges. Discharge and river sampling completed to date provide only preliminary information. Without conclusive data on the potential risk of underground injection to groundwater resources, the City may need to install expensive pretreatment on all 5,000 of its UICs. This is a concern both for the City and for the owners of thousands of private UICs.

URS recommends the following projects, in addition to those identified in the CIP Program.

- With the increasing costs of water quality treatment and maintenance, the City should select appropriate systems to protect water resources and to provide sufficient treatment for parameters of concern. The City should develop and implement a plan to assess the impact of its stormwater discharges on Deschutes River water quality. Any studies done by the City that can potentially relieve it and private owners from these high costs will benefit all and allow limited resources to be focused where they will provide the greatest benefit.

- Traction cinders and crushed basalt applied to its streets during the winter are a major problem for the City's stormwater system. Monitoring data, visual observations, street department maintenance records, and Mirror Pond dredging studies all support the need for sediment traps ahead of the discharges to either surface waters or groundwater. The traps will help prevent filters, dry wells, drill holes and other infiltration devices from becoming plugged.

- More monitoring data are needed for the City to make informed and defensible decisions about stormwater management. A groundwater vulnerability study should be conducted jointly by the City and the U.S. Geological Survey as soon as possible. As a prelude to, or as part of the vulnerability study, the public drinking water protection areas should be re-delineated using the most up-to-date modeling procedures, and all private wells, cleanup sites, and other areas where underground injection is highly restricted should be identified.

- Manufactured treatment devices are a viable stormwater treatment option, especially where the land area required for other options is too expensive or not available. Manufactured treatment devices must be regularly maintained which significantly increases the lifetime costs, and generally should not be used where other options are available.

- It is recommended that hydrodynamic separators or other solids, sediment and trash removal be installed in all storm drain systems discharging to the river and Tumalo Creek.

- The City is beginning to promote the use of low-impact development (LID) principles in all of its projects, and requires all private projects to seriously consider LID principles before resorting to other stormwater management measures. Typical LID systems include rain gardens, porous pavement, grassy swales, street trees with structured soil, green roofs, smaller building footprints and less impervious surface area. LID techniques are already being applied by some developers in the City. Natural systems that maximize the use of native vegetation and minimize impervious surface areas should be used. City development code requirements are being upgraded to encourage and facilitate the use of LID.

A combination of these various treatment techniques is discussed further in Chapter 9 Drainage Improvement Alternatives.

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Santa Clara Valley Urban Runoff Pollution Prevention Program, 2000. “Application of Water Quality Engineering Fundamentals to the Assessment of Stormwater Treatment Devices,” August 2000.

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7.0 STORMWATER GOALS, POLICIES, ORDINANCES, AND STANDARDS

The stormwater program, policies, ordinances, and standards were reviewed along with City goals to identify improvements and updates to support implementation of a comprehensive stormwater management program. Recommendations are provided to address water quality and water quantity issues for new development and redevelopment, to meet federal and state regulations, and to protect Bend's water resources.

7.1 STORMWATER UTILITY GOALS

The City's stormwater utility was formed by the passage of City Council Resolution No. 2623 in April 2007. The Council set up the stormwater utility to have regulatory and enforcement authority and responsibility for planning, design, construction, maintenance, administration, and operation of all City-owned stormwater conveyances and facilities. In passing the resolution, the City Council determined:

- That the City's physical growth and urban development has and will continue to increase the volume of stormwater runoff collected in and routed through the City's manmade and natural stormwater facilities and system ("stormwater system");
- That stormwater runoff, when not properly managed and treated, can cause property damage and erosion; carry concentrations of nutrients, heavy metals, oil and toxic materials into receiving waters and ground water; degrade the integrity of City streets and the transportation system; and reduce citizen access to emergency services and pose hazards to both lives and property;
- That stormwater runoff must be managed in a manner that protects the public health, safety and welfare, and the environment;
- That the City must meet regulatory requirements related to water quality;
- That stormwater quality and quantity problems cannot be allowed to escalate as a result of inadequate design criteria, regulation, maintenance, improvement, public awareness or code enforcement;
- That the City's stormwater system must be funded in a manner that enables regulatory compliance, ongoing maintenance, operation, regulation and system improvements;

- That absent effective maintenance, operation, regulation, enforcement, and control, existing stormwater systems in all areas of the City constitute or will constitute a potential hazard to the environment, health, safety and general welfare of the City; and
- That natural and manmade stormwater facilities and conveyances, including those owned by the City, constitute a stormwater system.

Based on the above Council findings, the following goals have been developed to address general, stormwater drainage and stormwater quality components of the City's stormwater utility.

7.1.1 General Stormwater Utility Goals

1. Ensure that public and private stormwater systems and facilities provide adequate levels of service to the public at reasonable cost.

2. Ensure that development, including development involving the installation of drinking or irrigation water wells, pays its fair share of the cost of installing and upgrading stormwater facilities that are needed to support the development and meet City, state and federal stormwater quantity and quality standards.

3. Ensure that before new areas are annexed, they are either brought up to City stormwater quantity and quality standards or pay their fair share of the cost of upgrading stormwater facilities that are needed to support the areas to meet City stormwater drainage quantity and quality standards.

4. Eliminate drainage nuisance problems.

5. Meet all federal and state regulatory requirements, including but not limited to the federal Clean Water Act, federal Safe Drinking Water Act, and Oregon Groundwater Protection and Oregon Drainage Law requirements.

6. Work with stakeholders in the watershed to realize efficiencies in protecting stormwater quality and providing stormwater drainage.

7. Provide education to help citizens protect themselves from flood hazards and understand how to prevent stormwater pollution.

7.1.2 Stormwater Drainage (Quantity) Goals

1. Reduce and manage runoff from developed lands.

    1.A. Require stormwater to be managed on the site of origin except when formal offsite arrangements that address both stormwater runoff quantity and quality have been negotiated and recorded.

    1.B. Ensure that systems are sized and maintained correctly to ensure that stormwater is safely and adequately maintained on site and to allow safe passage for the 100-year storm.

    1.C. Ensure that stormwater facilities are suited to the specific geologic conditions of the site.

2. Preserve and maintain natural drainage systems.

3. Preserve floodplains and drainage low spots for stormwater drainage.

7.1.3 Stormwater Quality Goals

1. Protect the health, safety, and general welfare of the public and the environment with respect to stormwater quality.

    1A. Protect underground aquifers from urban runoff pollutants.

    1B. Protect surface waters from urban runoff pollutants.

2. Manage stormwater pollutants at the source to the degree possible using low-impact development and other development techniques.

3. Engage in a watershed approach to ensure surface drainage (river/creek) and groundwater health.

7.2 EXISTING CITY POLICIES

The existing City of Bend policies, codes, and ordinances related to stormwater management are summarized below. One of the purposes of this first Stormwater

Master Plan is to assess whether additional or different policies or measures should be considered to conform to the utility goals outlined in Section 8.1.

7.2.1 Critique of Stormwater Quantity Policy

The City restricts development within the 100-year floodplain, and both the General Plan and the Bend Code specify that stormwater must be kept on site, thereby promoting the limitation of runoff to pre-development levels. The City's Standards and Specifications also have language regarding keeping water on site, but this currently refers to parking lot runoff only.

Storm Sewer Policy No. 12. General Plan (1998), Public Facilities and Service Policies, Storm Sewer, Policy No. 12:

> 12. Due to the lack of a defined drainage pattern for most of the urban area, development shall contain storm drainage on site.

Residential Districts. Chapter 2.1 of the Development Code applies only to Residential Districts. Section 300, Paragraph F.8 reads as follows:

> Onsite surface water drainage shall be retained on the lot of origin and not trespass onto the public right-of-way or private property, including roof drainage.

Mixed Use Districts. Chapter 2.3 applies only to Mixed Use Districts. Section 600, Paragraph D.7., reads as follows:

> All drainage from buildings, parking/loading areas, and other impervious surfaces shall be retained on the development site or directed to a drainage facility as part of an overall drainage Master Plan using dry wells or other City approved methods such as landscaping, retention basin, swale, or similar bio-filtration systems that are not directly connected to a surface stream or canal.

Storm Drainage Improvements. Chapter 3.4 of the Development Code applies to Public Improvements except for Table D which applies to private streets. Section 500 applies to Storm Drainage Improvements and reads as follows:

3.4.500 Storm Drainage Improvements.

A. Storm Drainage Improvements Required. Storm drainage facilities shall be depicted on City-approved engineered construction drawings and installed to serve each new development in accordance with applicable City construction specifications as described in the City of Bend Standards and Specifications and the Grading/Clearing Ordinance NS-1879.

B. Accommodation of Upstream Drainage. Drainage facilities shall be designed and constructed to accommodate increased runoff so that discharge rates existing before the proposed development shall not be increased, and accelerated channel erosion will not occur as a result of the proposed land disturbance or development activity. Such facilities shall be subject to review and approval by the City Engineer.

C. Effect on Downstream Drainage. Where it is anticipated by the City Engineer that the additional runoff resulting from the development will overload an existing drainage facility, the City shall withhold approval of the development until provisions have been made for improvement of the potential condition or until provisions have been made for management of additional runoff caused by the development in accordance with City of Bend Standards and Specifications. Drainage shall not be directed to an existing watercourse, channel, stream, or canal. Storm drainage facilities shall comply with applicable state and federal regulatory requirements.

D. Easements for Existing Watercourses. Where an existing watercourse traverses a development, such as a natural watercourse, drainage way, channel, or stream, or any other existing drainage facility including but not limited to irrigation canals, laterals, and associated ditches, there shall be provided and recorded an easement conforming substantially with the lines of such existing watercourses and such further width as will be adequate for conveyance and maintenance, as determined by the City Engineer.

E. Easements for Developed Drainage Facilities. Where new drainage facilities are provided that include elements located outside the dedicated public right-of-way, such facilities shall be located within an area provided for in a recorded easement. The easement shall be adequate for conveyance and maintenance as determined by the City Engineer.

> Footnote 1 of Table D of Section 500, which applies to private streets, reads as follows: "1. Drainage must be retained on site and not drain to public right-of-way."

As there is no obvious reason for having different code requirements for stormwater management for residential districts, mixed use districts and public improvements, the requirements should be consolidated into their own chapter. The City should consider modifying Development Code Section 3.4.500, Storm Drainage Improvements, to allow properly treated stormwater to flow to surface water if, due to the geology or public health/safety concerns, no other options are available.

Nuisance Ordinance. Other stormwater-related requirements are incorporated into the City's nuisance code. Specifically, the nuisance code contains sections related to stormwater drainage and illicit discharges.

With respect to drainage, the nuisance code reads:

5.365 Surface Waters, Drainage.

(1) No owner or person in charge of a building or structure shall permit rainwater, ice, or snow to fall from the building or structure onto a street or public sidewalk or to flow across the sidewalk.

(2) The owner or person in charge of property shall install and maintain, in a proper state of repair, adequate drainpipes or a drainage system so that overflow water accumulating on the roof or about the building is not carried across or onto the sidewalk.

(3) A violation of this section is a Class B Civil Infraction.

Because this section refers only to water or ice that falls directly onto a street from a building or across a sidewalk, it can be argued that it does not cover water that flows down a driveway or across unpaved land and then onto the streets or public property. A recommended update is to rewrite the section to apply to water that gets onto the streets or public property regardless of the course it takes first, whether or not it falls directly from a building or crosses a sidewalk.

The Development Code should also be revised to clarify that water cannot be allowed to flow onto an adjacent private lot (a subservient lot), even if that lot is under common ownership, unless there is a recorded drainage easement on the subservient lot.

The nuisance code contains general language to prevent illicit discharges:

> **4.502 Use of Public Sewers Required.**
>
> (1) No person shall place, deposit, or permit any human or animal excrement, garbage or other objectionable waste to be deposited in any unsanitary manner on public or private property within the City of Bend, or on any City property outside the City.
>
> (2) No person shall discharge any sewage or other polluted waters into any natural outlet within the City of Bend, or in any area under the jurisdiction of the City, except where suitable treatment has been provided in accordance with this provision.

Here, a natural outlet means any outlet into a watercourse, pond, ditch, lake, or other body of surface water or groundwater. The City may want to develop more specific language for addressing stormwater illicit discharges.

Floodplain Development. The City has a floodplain zone ordinance that was updated in September 2007 and incorporated into Development Code Section 2.7.600 Waterway Overlay Zone (WOZ). Section 640, Paragraph E reads as follows:

> No development shall occur in an FP [Flood Plain] zone unless a permit has been received for the work. Except for improvement of an existing structure which is less than substantial, as determined by the City, no permit shall be issued unless the work will be reasonably safe from flooding, otherwise complies with this ordinance, and all necessary state and federal, and local permits will be obtained as a condition of approval on any permit in an FP zone.

Section 640, Paragraph B reads as follows:

2. The Planning Director is hereby appointed to administer and implement the Flood Plain Combining Zone by granting or denying development permit applications in accordance with its provisions…

   c. Review all development permits to determine if the proposed development is located in the floodway. If located in the floodway, assure that the encroachment provisions of Section M.1 are met.

Section 640, Paragraph M reads as follows:

1. Prohibit encroachments, including fill, new construction, substantial improvements, and other development unless certification by a registered professional civil engineer is provided demonstrating through hydrologic and hydraulic analyses performed in accordance with standard engineering practice that encroachments shall not result in any increase in flood levels during the occurrence of the base flood discharge.

The City may consider incorporating additional language into the development rules to protect itself from liability for drainage overflows from private developments.

7.2.2 Critique of Stormwater Quality Policy

The City has performed a thorough analysis of its development policies, codes, and ordinances with respect to water quality as part of a separate study entitled “City of Bend Stormwater and Watershed-based Development Policy, Code, and Ordinance Review” (July 2008), which is incorporated by reference. The report includes highlights and recommends improvements for consideration. The analysis found:

- Inconsistencies among the General Plan, Development Code, Standards and Specifications and implementing ordinances that should be rectified.
- Construction site erosion, sediment control, good housekeeping requirements, and education should be improved to help minimize pollutants from construction sites.
- Adoption of the design standards in the Central Oregon Stormwater Manual would help to ensure that water quantity and quality issues are properly addressed.

- The City should examine ways to offer incentives for single-family residences and duplexes to implement stormwater best management practices.
- The City should require as-built drawings of developments to provide a better understanding of impervious surface coverage, and location and sizing of stormwater drainage and treatment facilities throughout the City.
- The City should consider including requirements or encouragement for specific types of source controls and other appropriate post-construction controls by land use.
- The City should establish policies and implementing measures to ensure that private and public stormwater controls are operated and maintained over the life of the project.
- The City should consider incorporating expanded buffers along local waterways where practicable in the built environment and especially within newly incorporated boundaries to allow for protection of riparian vegetation to help address pollutants of concern that may impair Deschutes River or Tumalo Creek water quality.
- The City has in place good policies to promote alternative transportation and limit auto use.
- The City should consider using overlay maps or specific plans for applying more stringent design standards and prioritization of water quality retrofits for underground injection controls (UICs) in drinking water protection areas and areas proximate to clean-up sites and private wells.

As an example of the inconsistencies alluded to above, some City stormwater policies are vague, some require stormwater treatment or filtration prior to disposal to surface waterways, and some do not allow any drainage to surface waterways. The City's General Plan includes a policy to "work to minimize the discharge of street run-off directly into the Deschutes River," and the City's Development Code requires applicants for developments in the Waterway Overlay Zone to "demonstrate that surface runoff from impervious areas will not flow unfiltered or untreated into the adjacent waterways." The stormwater section of the code does not allow drainage to be directed to an existing waterway:

3.4.500 Storm Drainage Improvements.

> **C. Effect on Downstream Drainage**. Where it is anticipated by the City Engineer that the additional runoff resulting from the development will overload an existing drainage facility, the City shall withhold approval of the development until provisions have been made for improvement of the potential condition or until provisions have been made for management of additional runoff caused by the development in accordance with City of Bend Standards and Specifications. Drainage shall not be directed to an existing watercourse, channel, stream or canal. Storm drainage facilities shall comply with applicable state and federal regulatory requirements.

Similar discrepancies occur with regard to underground injection controls, erosion and sediment controls, and the definition of steep slopes.

Administration of the UIC Program. The City should consider obtaining authority from the ODEQ to administer the UIC program on private property. Currently, developers must wait a long time for state approval, and some ask City staff to make final approvals before the state responds. If the City obtained administrative authority, it could have more control over the quality of the runoff it receives from private properties and the protection of its groundwater and surface water. This would, however, significantly increase the workload for City staff.

Drinking Water Protection Area Plan. The City has completed the first part of its voluntary drinking water protection plan—delineation of the drinking water protection areas. It has not yet determined what sources pose the greatest risks to its drinking water or developed a protection plan.

7.3 TRENDS AND CHALLENGES IN STORMWATER MANAGEMENT

Regulatory Trends. The U.S. Environmental Protection Agency, which nationally oversees the federal Clean Water Act and federal Safe Drinking Water Act, promotes a watershed management approach for addressing stormwater management. This includes addressing stressors in a geographic area defined by hydrology by working with stakeholders on a watershed level to address the principle water resource goals for the watershed in a strategic, coordinated manner.

Oregon's Department of Environmental Quality has permit authority in the State of Oregon to provide oversight for the federal Clean Water Act and federal Safe Drinking Water Act. In 2000, ODEQ outlined its environmental priorities:

Priority One: Increase opportunities for Oregonians to prevent and solve environmental problems.

Priority Two: Clean up Oregon's rivers and streams.

Priority Three: Protect Oregonians from harmful toxics.

National Trends in Stormwater Management. Over the past twenty years, a national trend has emerged where communities are turning to better site designs, low-impact development and "smart growth" to address both quantity and quality issues, including addressing pollutants at the source. The fundamental aspects of better site design include the following:

- Define the development envelope. At the initial conceptual stages of the project, first examine the unique hydrologic and topographic features of the site, and determine which areas should be protected and which areas are best suited for development. This can result in a site plan that reduces both environmental and construction costs.
- Minimize directly connected impervious surface coverage and maximize permeability. This will help reduce both the stormwater volume and velocity and reduce the amount of stormwater treatment that is needed.
- Plan for alternative modes of transportation to reduce automobile-related pollutants to stormwater.
- Design with drainage in mind. Using drainage as part of the design element can allow for infiltration where appropriate, suggest alignments optimum locations for parks and play areas, and building sites that work with the natural environment.
- Incorporate source controls, such as covered loading docks and waste disposal areas, that keep stormwater from coming into contact with pollutants.

Low-impact development can have both environmental and economic benefits to a development site. The Central Oregon Stormwater Manual, a regional design manual addressing stormwater concerns, promotes better site design.

Another national trend that is emerging is the recognition that, to be effective, post-construction/permanent stormwater controls must be adequately maintained over the life of the project. Poorly maintained controls can actually contribute to the problem by causing localized flooding when blocked. Maintenance and operation verification programs, including maintenance agreements, are beginning to be implemented in communities nationwide to ensure this occurs.

Challenges. As elaborated upon in other chapters of the Master Plan, the City of Bend faces some common and some unique challenges in managing both stormwater quantity and quality that should be taken into account when developing stormwater policies, ordinances, and standards. These challenges are described below:

- **Development Rule Consistency.** Current development rules are inconsistent and therefore do not provide for adequate stormwater drainage protection and quality treatment. They allow for loopholes and result in developments being installed that do not meet the intent of the City's regulations. The City needs to ensure that it has consistent adequate legal authority throughout its development rules to provide for public safety and meet regulatory requirements for both drainage control and treatment.

  Because it is diffused rather than a point source, stormwater runoff and the pollutants associated with it are difficult to control. Therefore, preventing drainage and pollutant issues is the most effective management tool for addressing stormwater. Stormwater pollution prevention and drainage volume considerations are best considered during the conceptual review stage of a development rather than added in at the end of the project. Long-term operation and maintenance agreements for operational and treatment controls should be required and verified over the life of the project.

  However, in areas that are predominantly built out, there is less opportunity to promote pollution prevention via new development standards. Redevelopment retrofits should be considered in such areas.

  City divisions also need to work together to ensure that any potential conflicts that might result from proposed changes to the development rules to protect stormwater are understood and addressed to find the best overall solutions that optimize public safety across disciplines.

- **Geologic Implications.** The City currently lacks adequate geotechnical requirements for plan approval of development projects. Parts of the City infiltrate well, but other parts are underlain with pink tuff, basalt, or lava tubes. The local volcanic geology of Bend makes the proper selection, and sizing of drainage systems and their associated water quality protection facilities challenging, and, in many cases, expensive. Understanding the geology of the area is important to ensure the drainage system being installed will work effectively and is not illegal (e.g., underground injection controls cannot be installed to directly commingle with groundwater and drill holes cannot extend past 100 feet underground).

- **Increases in Impervious Surface.** As the City becomes more urbanized, more land is compacted and covered with impervious surfaces, reducing the landscape's natural abilities to infiltrate runoff or for stormwater to evapotranspirate naturally. As a result, increased amounts of water typically run off the site than would occur if the site were in its natural, pre-developed state.

  Because impervious surfaces do not have vegetation to slow precipitation and typically are not structured to slow down the runoff, the runoff drains off impervious surfaces at a higher velocity than it would under natural conditions. Without proper mitigation, this can have erosive impacts when the water outfalls to a stream or soil-covered area.

  This problem is especially serious in areas annexed from the County where the existing roadways have few drainage structures, and instead rely on the rural character of the surrounding land for runoff disposal. When these lands are annexed into the City and become developed, the City takes on the burden of ensuring that adequate drainage is provided.

- **Limited Financial Resources.** The City has a Municipal Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) permit and an Underground Injection Control (UIC) Water Pollution Control Facility (WPCF) permit (currently under negotiation and anticipated in

2009). Meeting the requirements of these permits is financially challenging for the City because of the necessary treatment and associated maintenance costs.

In addition to the piped system draining to the river, the City has a dispersed system of dry wells and drill holes (UICs) for which the water quality regulations require treatment to drinking water standards. New permit requirements for UICs will include increased monitoring requirements. Dispersed treatment sites and underground manufactured treatment can be very costly, both initially and from an ongoing operation and maintenance perspective, and can be problematic if maintenance is deferred. Moreover, the number of approved manufactured controls to treat stormwater pollutants is very limited, and these are approved only at certain velocities and only for certain pollutants. Land costs for landscape controls are high.

Concurrently, other public systems (water, wastewater) will also need upgrading over the next twenty years to maintain adequate levels of service for Bend’s expected growth.

- **Drinking Water Protection Areas and Other Restricted Areas.** Many areas of the City are within Drinking Water Protection Areas. These are priority areas for special considerations to ensure that groundwater quality is not impacted by stormwater runoff or spills. Underground injection controls are restricted in these areas and near cleanup sites and private drinking water wells. Drill holes are not allowed in these areas except under a UIC WPCF permit and with adequate pretreatment.

- **Hazardous Spill Management.** A liquid spill almost anywhere in the City would quickly flow to a nearby UIC or to the river. Detention capacities in these systems are short and provide little opportunity for retain a spill until it can be cleaned up. The nearest spill response contractor is in Prineville and by the time the contractor arrived in Bend, groundwater or the river could be seriously contaminated. The City should address spill issues in a stormwater spill prevention, containment and cleanup plan.

- **Winter Driving Safety.** During the winter, the City uses traction materials and magnesium chloride ice melt on the streets to improve winter driving safety. Unfortunately, the use of traction materials not compatible with current and recommended drainage systems of UICs and low-impact development (LID) techniques. Traditional piped systems would also require pretreatment because traction materials would also plug catch basins and downstream pipe, particularly in locations where siphons are proposed. Magnesium chloride has less impact on the environment than other types of road salts.

7.4 RECOMMENDED POLICIES

To address the City's goals, described in Section 7.1, the following recommendations are made to improve the City's development rules, building off the analysis in Section 7.2, and the trends and challenges outlined in Section 7.3.

7.4.1 General Policies

New Development and Significant Redevelopment

No new development or significant redevelopment shall be allowed to occur without requirements in place for maximizing onsite storm drainage and provisions for downstream drainage to meet current requirements. Onsite storage and treatment can include a number of LID facilities or design techniques, as described in the COSM. UICs with pretreatment can be used where allowed. Minimum requirements for new development and redevelopment shall be clearly specified and enforced. Geologic studies shall be required to determine suitable drainage options.

Annexations to City Boundaries

Annexations of areas previously developed and maintained under Deschutes County regulations and standards occur for a variety of reasons. Owners of some properties are interested in City services for police and fire protection. Other annexations occur for access to urban utilities and the ability to develop to higher densities. As annexations occur, Bend's limited maintenance budget is stretched beyond its abilities to provide upgrades for storm drainage or streets to meet City standards in these areas. Newly annexed areas tend to have chronic drainage problems, and increase the list of flooding concerns the City needs to deal with. The ability to provide stormwater facilities for developments proposed for annexation into the City shall be a consideration for annexation approval. Upgrading of streets and storm drainage systems to meet City standards shall be a minimum requirement prior to accepting new areas into the City. The City shall require that areas outside the City limits shall have a stormwater utility plan that shows how the development would get stormwater service prior to annexation. These areas shall be required to meet current City, state, and federal stormwater quantity and quality standards prior to development approval.

Funding Options

Stormwater facilities will be expensive and will take a long time to plan, design and construct. New developments, and neighborhoods, can hasten the process by paying for the construction of regional facilities, defined as any system that serves more than one tax lot. These facilities may be of many types, such as pipe, regional treatment, pretreatment for UICs, and LIDs, to name a few.

Written agreements shall be required for all participants of stormwater districts to ensure the equitable funding of storm drainage improvements and the ongoing maintenance of these improvements.

Alternatively, or in addition to stormwater districts, the City may use the improvements identified in this Master Plan to develop System Development Charges (SDCs) to fund storm drainage facilities. SDCs are fees assessed on new developments to pay for improvements required to serve future needs of buildout conditions within the City. In part, SDCs are also new developments' contribution to the City for the ability to use an existing system that has been installed and paid for by existing development. There are strict regulations for calculating SDCs. New development can only be assessed the difference in costs between needs for existing development and facility needs for future development. In other words, SDCs cannot be used to build infrastructure to solve existing problems.

Restricted Areas

The City shall consider more stringent location requirements, treatment, or spill control standards in restricted areas, such as drinking water protection areas, adjacent to cleanup sites, near private well-heads, and industrial sites or other areas where the potential for a hazardous material spill is great or the impact of such a spill would be large. This could potentially be accomplished using an overlay map. The City shall complete its drinking water protection program, including specifically restricting UICs in drinking water protection areas to protect water quality. The City should locate all of the water wells within the UGB and make this information available to the public so these wells can be protected.

Special Drainage Areas

The City shall seek to reserve strategic regional drainage areas for stormwater treatment and storage.

Winter Weather Deicing/Traction

Due to public safety concerns, it is not recommended to completely stop the use of traction materials. However, the City shall continue studying how best to use traction materials, deicers and investigate methods of application and cleanup to provide the best balance between public safety and stormwater management. Another important component is the education of both staff and the public on the issues and concerns related to traction material use, particularly the maintenance costs and facility replacement costs when systems fail.

7.4.2 General Plan Policies

The City promotes incorporating the following General Plan policies into the next update of the General Plan to assist in meeting the goals of the stormwater utility described at the beginning of this chapter. These goals include but are not limited to protecting public and environmental health and safety. Additionally, the City shall review the recommendations in the City of Bend Policy, Code, and Ordinance Review (July 2008) and make additional modifications to the General Plan, as appropriate, resulting from that effort during the comprehensive review.

Storm Drainage Facilities and Systems

1. All public and private stormwater facilities shall be designed and operated in accordance with the City's Stormwater Master Plan and shall meet appropriate drainage quantity and quality requirements, including, but not limited to, the requirements in the City's National Pollutant Discharge Elimination System MS4 Stormwater Permit, Integrated Stormwater Management Plan, WPCF Underground Injection Control Permit and any applicable Total Maximum Daily Load requirements. Underground injection and surface discharges to the Deschutes River or Tumalo Creek shall only be

approved when other alternatives, such as detention or retention basins or bioswales, are not reasonably available. Low impact site designs shall be a required part of all new development and redevelopment projects.

2. Due to the lack of defined drainage patterns for most of the urban area, development shall, to the extent practicable, contain and treat storm drainage on site. In instances where containing storm drainage on site would not be safe or practicable, the developer shall enter into a formal and recorded arrangement with the City or a private party to adequately address the storm drainage off site.

3. The use of stormwater disposal systems shall be coordinated with the Oregon Department of Environmental Quality and Water Resources Department to protect the quality of groundwater and surface water.

4. The City shall work to minimize the discharge of untreated stormwater run-off from streets into the Deschutes River and Tumalo Creek.

5. The City shall seek efficiencies and consistency by working with other municipalities and stakeholders within Central Oregon on land use issues to address flood control, watershed health, and stormwater pollution prevention.

6. The City shall require the following stormwater protection measures for all new development and redevelopment proposals during the planning, project review, and permitting processes:

   - Submit geotechnical site assessments whenever dry wells or other infiltration or injection systems are proposed.
   - Avoid conversion of areas particularly susceptible to erosion and sediment loss (e.g., steep slopes), or establish development guidance that identifies these areas and protects them from erosion and sediment loss.
   - Retain natural drainage channels in their natural state to prevent undue erosion of banks or beds, and preserve or restore areas that provide water quality or quantity benefits and/or are necessary to maintain riparian and aquatic biota.

- Promote site development that limits impacts on, and protects the natural integrity of, topography, drainage systems, and water bodies.

- Promote integration of stormwater quality protection into construction and post-construction activities at all development and redevelopment sites.

7. The City shall review its Stormwater Master Plan and Integrated Stormwater Management Plan as needed for compliance with changes in state or federal requirements and at least every five years.

8. The City will initiate funding options (e.g., SDCs. grants, low-income loans) for stormwater capital projects in accordance with applicable laws.

9. The ability to provide stormwater facilities for developments proposed for annexation into the City shall be a consideration for annexation approval.

7.4.3 Drainage Requirements

In addition to the water quality considerations outlined in the *Stormwater and Watershed-based Development Policy, Code, and Ordinance Review,* July 2008, the City should improve Code language pertaining to drainage requirements. The City should consider revising the section on Stormwater Drainage to read:

Except as provided below, impervious surface stormwater drainage shall be retained on the lot of origin and not trespass onto the public right-of-way or private property.

1. If the City Engineer or Public Works Director determines that retaining all stormwater on the site of origin would pose a threat to public safety or adjacent properties, or if the developer chooses to direct all or part of the runoff off site and there is enough capacity in the conveyance system, the runoff or a specified portion thereof shall be directed to an off site drainage facility approved by the City Engineer or Public Works Director.

2. When runoff from non-City-owned property is directed to or allowed to flow to City-owned property, the owner(s) of the lot(s) of origin shall compensate the City for the costs it incurs for constructing, operating, and maintaining the additional stormwater drainage and treatment capacity.

3. Access to, and maintenance and operation of, all stormwater facilities on private property shall be as required by the most current version of the Central Oregon Stormwater Manual.

The Code should also be revised to include the definition of "impervious surface" that was adopted as part of the City's stormwater service charge resolution:

> *Impervious surface:* A hard surface area that either prevents or retards the entry of water into the soil mantle. Common impervious surfaces include building roofs, walkways, patios, driveways, parking lots, concrete or asphalt paving, gravel roads, and packed earthen materials.

This definition is intended to include all surfaces that impede the natural infiltration of stormwater. These include gravel roads, compacted soils, and even permeable pavement. This definition does not include landscaped areas.

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8.0 FUNDING EVALUATION AND DEVELOPMENT OF UTILITY FEE

8.1 BACKGROUND

The purpose of this Stormwater Master Plan is to lay groundwork for correcting and preventing stormwater drainage and water quality problems. In the early 1980s, the City made a big financial commitment to protect its groundwater by constructing a sanitary sewer system and treatment plant. Prior to this, sewage was discharged to septic systems many of which were failing, lava tubes and drill holes. (There are still several hundred septic systems within the UGB.) The City must now address stormwater quantity and quality and the potential effects of spills to the stormwater system on the quality and safety of surface water and groundwater. This Stormwater Master Plan is the first significant effort to estimate the costs of bringing the stormwater system up to federal, state and City standards and to lay out a plan and schedule for accomplishing this.

The highest priority is to correct the most serious existing problems and prevent new problems from being created as the City continues to grow. This must be done quickly. Funding the stormwater improvements needed for continued growth, protection of critical water resources and public amenities, and compliance with state and federal regulations will be expensive and a major commitment by the City. Federal Clean Water Act grants and low-interest loans are not currently available for stormwater projects. Efforts are under way at various levels of government to make such funding available for stormwater projects, but it is not clear if or when this will happen.

The City decided to establish a funding source that legally can be used only for stormwater. Consequently, during Phase I of this Stormwater Master Plan, the City Council established a Stormwater Utility and a stormwater service charge. Assisted by a financial consultant, the City prepared an evaluation of its stormwater needs and developed funding options for providing the resources necessary to implement a stormwater program. To assist with the development of the utility fee, the City convened an advisory Citizens Stormwater Utility Fee Task Force (Task Force) to discuss issues, evaluate options, and develop recommendations.

8.2 CITIZENS STORMWATER UTILITY FEE TASK FORCE

The Task Force was convened in February 2007, at the City Council's direction, to provide input into the design and implementation of the stormwater utility fee. A diverse group of stakeholders was recruited, including members of the business community, environmental interests, neighborhood associations, City staff, and a Bend City Council member. Task Force duties identified in the Charter (Appendix D) consisted of the following four elements:

1. Review and make recommendations concerning the elements of the stormwater program and utility.

2. Review and make suggestions with respect to the stormwater utility's goals, objectives, and levels of service.

3. Review and provide advice on the financing for the stormwater utility.

4. Assist in developing and participating in a community awareness and education program.

The Task Force met five times. Working with an aggressive agenda and under a tight schedule, the Task Force delivered its recommendations to the City Council in June 2007.

8.3 ISSUES ADDRESSED BY THE TASK FORCE

The Task Force first discussed the needs of a comprehensive stormwater program. They determined that components of a program sufficient to meet regulatory needs and citizen expectations include:

- Capital improvement projects for flood control and water quality.
- Operation and maintenance of existing facilities.
- Plan review, inspection, and enforcement for new development.
- Controls for new construction runoff to address erosion.
- Post-construction controls to address water quality.
- Illegal discharge detection and elimination for spills and cross connections.
- Public education and involvement.

Shaun Piggott and Associates, working with the City, developed issue papers both as a mechanism to provide information and to respond to questions raised by the Task Force (see Appendix D). Each issue paper provided background information and alternatives for the Task Force to consider and explore before they provided recommendations to City staff and the City Council. The issue papers addressed the following topics:

1. What is the most appropriate basis for a stormwater rate structure in Bend?

2. How should Bend's stormwater utility address the issue of service charge exemptions and credits?

3. How should Bend structure the calculation of stormwater service charge credits?

4. How should private roads within special subdivisions such as Planned Unit Developments be treated under the stormwater utility's rate structure?

The first issue paper surveyed other jurisdictions regarding how they developed their service charges and how much they charge. Because some of these utilities have been challenged in court over their procedures and charges, the results of their cases were used to help Bend ensure that its procedures and charges are legally defensible. The service charge must be related to the cost of providing the service; proportionate among customer classes; equitable; and include provisions for customers to opt out if they do not make use of or benefit from the services.

Many jurisdictions assess service charges based on impervious surface area and courts have found this to be an equitable method. Impervious surfaces shed water that otherwise would naturally filter into the ground. Generally, the service burden for the City is proportionate to the amount of impervious surface area. The Task Force agreed that impervious surface area should be used as the basis for the rate structure.

The Task Force recommended the following approach and the City agreed. Fifty single-family/duplex residential lots in the City were randomly selected. The impervious surface area for each lot was determined using high-resolution multi-spectral aerial imagery. The average area of impervious surface for these lots, 3,800 square feet, was defined as an Equivalent Residential Unit (ERU). All persons who have the right to occupy developed single family and duplex residential lots are charged monthly for one ERU; all persons or entities that have the right to occupy any other type of lot or facility pay on the basis of the number of ERUs assigned to them. The initial per-ERU charge was determined to be $4.00/month, based on the stormwater utility budget and the number of ERUs estimated to be in the City.

Issue paper 2 dealt with rate exemptions and credits. It was determined that parcels that were completely in their natural state or that had been restored to their natural state would not be charged a fee. Because City streets and some private streets are designed to collect and convey stormwater runoff, they are also exempt from the fee; however, other public properties and entities that are exempt from paying taxes would not be exempt from the stormwater service charge. (This is consistent with the concept that the stormwater service charge is a fee for services rendered and not a tax, an important legal distinction.) Credits would be granted for entities that provide onsite stormwater management facilities that exceed code requirements, in recognition that such facilities proportionately reduce City stormwater management costs. An appeals process was also established for customers to request corrections in their delineated impervious surface area.

Credits were further explored in issue paper 3, which discussed a possible structure for the rate credit program. A credit approach determined by the Task Force to be equitable was used to categorize types of utility costs as either fixed or variable. Fixed costs are largely unaffected by the quality or quantity of stormwater managed by the City; variable costs are roughly proportionate to quality and quantity. Only the variable portion of the utility budget could be used for determining credits, and only occupants of properties that are not residential single-family or duplex can qualify for credits. This is because all other occupants are charged the same fixed monthly rate. City staff were tasked with developing a process for the public to apply for credits. Using this issue paper and the legal requirements that apply to service charges as a foundation, the City developed a detailed credit approach that includes specific design standards as the basis for determining credit eligibility and for applying a credit calculation.

Issue paper 4 addressed the specific topic of whether to charge private roads within special subdivisions. In analyzing the issue, it was determined that some of the private streets were not designed to City standards and may add to the stormwater problem. Recommendations from the Task Force provided for exemption from the utility rate for those private streets that were designed and constructed to meet the City's street standards and function as part of the stormwater management system. Other private streets would be charged the stormwater fee.

The City Council agreed with the Task Force recommendations that the City should charge itself, just as it charges others, for any impervious surface areas that do not function as part of a stormwater management system. Task Force members recognized the effort required to review each public street to confirm whether it functions as part of the stormwater conveyance system, and recommended that this be performed after the initiation of the stormwater service charge. The Task Force recommended that, in the mean time, all City streets be presumed to be part of the stormwater conveyance system.

8.4 BUDGET ESTIMATES FOR STORMWATER PROGRAM

The Task Force discussed likely program functions and services for the initial stormwater program along with budget estimates for these program functions. Budgets were developed for Fiscal Year 2007-2008 based on City costs, and were upgraded to reflect an increased level of effort for maintenance for the stormwater system.

Maintenance: Emphasis on field maintenance operations throughout Bend will be increased. This emphasis on increased maintenance frequency and enhanced maintenance procedures that are necessary to reduce stormwater pollutant loads will require a commitment of labor and equipment resources to this program element. The relative large prominence of maintenance in this program reflects the fact that many of the initial operations will involve remedial maintenance on a stormwater system that has never been adequately maintained. Currently, maintenance of the system is sporadic and focuses on problem dry wells, drill holes, catch basins, and inlet grates. A more preventative level of stormwater maintenance service is outlined in Table 8.1.

Budget Estimate = $286,560 for FY 2007-2008

Table 8.1
City of Bend
Stormwater Maintenance Program Activity List
-Preliminary Review Draft-

No	Category	Maintained	Type of Measure	Frequency (Times/Year)	Standard	Type of Measure	Crow Size	Total Days Annually	Preliminary Cost Est. Labor ($240/day)	Preliminary Cost Est. Totals	Labor Cost/Unit
1	Clean Catch Basins/Inlets	300	EA	2.0	30	EA/DA	2	40	$9,600	$9,600	$16.00
2	Detention Pond: Sediment	5	EA	3.0	2	EA/DA	3	23	$5,400	$5,400	$360.00
3	Drainage Ditch	50000	LF	0.2	400	LF/DA	3	75	$18,000	$18,000	$1.80
5	Maintenance	75	EA	1.0	2	EA/DA	2	75	$18,000	$18,000	$240.00
6	Water Quality Devices	3280	EA	0.2	2	EA/DA	2	656	$157,440	$157,440	$240.00
7	Drywells	1020	EA	0.2	4	EA/DA	2	102	$24,480	$24,480	$120.00
8	Drill Holes	20	LF	1.0	1	EA/DA	2	40	$9,600	$9,600	$460.00
9	System Repair &	1	EA	1.0	0.5	EA/DA	4	8	$1,920	$1,920	N/A
10	Construction	1	EA	3.0	1	EA/YR	6	18	$4,320	$4,320	1,440.00
11	Training/Education/Safety	1	EA	180.0	3	EA/DA	1	60	$14,400	$14,400	N/A
12	Flood Response	240	EA	1.0	4	EA/DA	1	60	$14,400	$14,400	N/A
13	Equipment Maintenance	150	EA	1.0	4	EA/DA	1	38	$9,000	$9,000	$60.00
	Work										
	Schedules/Monitoring										
	Customer										
	Complaint/Investigate										
Sub-Total: All Maintenance Categories:								**1,194**	**$286,560**	**$286,560**	
Grand Total:										**$286,560**	

Capital Improvement Project (CIP) Program: The CIP Program will focus on local structural improvements and neighborhood repairs/replacement of the stormwater system. Specific repairs will largely be identified based on complaint logs and subsequent engineering analysis. The high-priority “hotspot” projects listed below are included in this part of the budget. (See Chapter 4 for more information about the hotspots.)

1. *Westside Village Shopping Center & Bend Fire Station*: This is an area with very poor infiltration. The solution will be to provide a regional piped collection network and convey the stormwater to regional detention and treatment pond for ultimate disposal in the Deschutes River.

2. *Franklin Underpass*: Water will be collected in a sump and pumped to the Colorado-Parkway interchange for treatment and disposal by means of infiltration.

3. *Third Street Underpass*: Water will be collected in a sump and pumped to the Colorado-Parkway interchange for treatment and disposal by means of infiltration.

4. *Archie Briggs Road*: Stormwater will be conveyed by means of a new drainage pipe beneath a new sidewalk along the roadway then to a treatment system and an energy dissipater prior to discharging to the Deschutes River. This will reduce chronic flooding from the steep roadway west of the river.

5. *Fairview Heights on Awbrey Butte*: Steep open channel flows will be piped, existing piped systems will be replaced with larger pipe and new manholes constructed to contain flows as the drainage changes direction and proceeds downhill. A water quality pond will be constructed at the end of the pipe to treat the stormwater and reduce the velocity of the stormwater prior to overland flow at the bottom of the hill. These actions will address the undersized culverts and the drainage easements that are being bypassed as flows from Awbrey Butte increase.

Additional equipment will also be needed, including a Vactor truck (used for line, catch basin, and dry well cleaning) and a utility truck. In addition, Stormwater Master Plan development expenses will be funded under this budget category.

Budget Estimate = $521,000 for FY 2007-2008

Water Quality Management: Ongoing permit compliance with the National Pollutant Discharge Elimination System (NPDES Phase II) as defined in the City's adopted Integrated Stormwater Management Plan (see Table 10.1) will require additional expenditures for public education, detection of illicit discharges, construction site controls, and development of best management practices. Compliance monitoring will be an additional ongoing and increasing cost to the City.

It should be emphasized that activities related to implementation of the ISWMP are contained in virtually all of the budget categories, and that the budget amounts do not include the costs of water quality activities that are included in the ISWMP but were under way prior to adoption of the stormwater utility fee. Costs related to water quality are specific to a response to the regulatory requirement permit conditions.

Budget Estimate = $329,000 for FY 2007-2008

Table 8.2 is the City of Bend Budget Forecast for implementing the Stormwater Management Plan.

Table 8.2
Budget Forecast - Implementing the Bend Integrated Stormwater Management Plan

Program/BMP	FY '08 Labor Hours	Labor	Materials	Total Costs
	Hrs	Cost		$$
Program Administration, Finance, and Planning (Section II)				
1. Administration and Coordination	1,235	$43,917	$4,392	$4,839
2. Legal Authority	368	$11,628	$1,163	$12,791
3. Financing	1,176	$38,282	$3,828	$42,110
4. Planning	80	$2,554	$255	$2,809
5. Annual Reporting	198	$5,912	$591	$6,503
6. UIC Registration	104	$3,306	$331	$3,637
Subtotal	3,161	$105,599	$10,560	$116,159
Public Education and Outreach (Section III)				
1. Utility Bill Inserts, Brochures or Posters	204	$5,722	$5,572	$11,294
2. Stormwater Pollution Prevention Web Site	59	$1,676	$168	$1,844
3. City News Broadcast Stormwater Quality Messages	130	$4,196	$420	$4,616
4. Stormwater/Watershed Diorama	42	$1,104	$110	$1,214
5. Performance Standards	0			$0
Subtotal	435	$12,698	$6,270	$18,968
Public Involvement and Participation (Section IV)				
1. Public Advisory Committee (PAC)	72	$2,318	$232	$2,550
2. Public Meetings	118	$4,168	$417	$4,585
3. Stormwater Quality Volunteer Opportunities	26	$802	$80	$882
4. Performance Standards	0			$0
Subtotal	216	$7,288	$729	$8,017
Illicit Discharge Detection and Elimination (Section V)				
1. Public Education on Illegal Discharges & Improper Disposal	54	$1,460	$5,146	$6,606
2. Illicit Discharge Reporting Mechanism	54	$1,806	$181	$1,987
3. Post Warnings About Illicit and Illegal Discharges	17	$581	$58	$639
4. Post Illicit Discharge Prevention Information on Web Site	42	$1,362	$136	$1,498
5. Stormwater System Map	0			$0
6. Illicit Discharge Ordinance	92	$3,110	$311	$3,421
7. Program to Detect and Address Illicit Discharges	46	$1,428	$143	$1,571
8. Minimize Landscape Irrigation Runoff	30	$984	$98	$1,082
9. Promote Commute Alternatives for Municipal Employees and the Public	0			
10.Performance Standards	0			
Subtotal	335	$10,731	$6,073	$16,804
Construction Site Stormwater (Section VI)				
1. Evaluate and Update Regulatory Authority and Procedures	174	$6,158	$616	$6,774
2. Construction Site Brochures or Flyers	106	$2,912	$17,291	$20,203
3. Construction Site Inspection and Violation Hotline	0			$0

Program/BMP	FY '08 Labor Hours	Labor	Materials	Total Costs
4. Construction Site Education	212	$6,852	$3,685	$10,537
5. Regional Stormwater Control Manual	129.4	$4,097	$410	$4,507
6. Performance Standards				
Subtotal	621.4	$20,019	$22,002	$42,021
Post-construction Stormwater Management in New and Redevelopment (Section VII)				
1. Acceptable Controls	50	$1,826	$183	$2,009
2. Regional Stormwater Control Manual/Tailor to City of Bend	205.4	$6,725	$672	$7,397
3. Operation and Maintenance	124	$3,972	$397	$4,369
4. Evaluate and Update Plan Review and Inspection Programs	214	$6,734	$673	$7,407
5. Post-Construction Control Education	258	$8,960	$896	$9,856
6. Performance Standards				
Subtotal	851.4	$28,217	$2,821	$31,038
Municipal Operations and Maintenance (Section VIII)				
1. Street Sweeping	24	$764	$76	$840
2. Parking Lot Sweeping and 3. Litter Collection and Material Disposal	28	$892	$89	$981
4. Landscape Maintenance Practices	0			$0
5. Improve Catch Basin/ Storm Drain Facilities Cleaning	38	$1,190	$119	$1,309
6. Spill Prevention, Response Materials, and Training				
7. Illicit Dumping				
8. City-owned Corporation Yards, Industrial and Commercial Facilities				
9. Detect and Correct Cross-connections and Leaks				
10. Performance Standards				
Subtotal	90	$2,846	$284	$3,130
Monitoring (Section IX)				
1. Discharges to Deschutes River				
2. Enhanced Water Well Monitoring	584	$16,840	$1,684	$18,524
3. Stormwater Monitoring				
4. Performance Standards				
Subtotal	584	$16,840	$1,684	$18,524
DWPA Investigation, Re-delineation and Management (Section X)				
1. DWPA Delineation			$55,000	$55,000
2. Drinking Water Protection Plan	298	$9,396	$940	$10,336
3. Groundwater Vulnerability Study	104	$3,608	$361	$3,969
Subtotal	402	$13,004	$56,301	$69,305
Total	**6,696**	**$217,242**	**$106,724**	**$323,966**

*Includes consultant costs + 10% of labor assumed.
Note: Costs do not include those activities underway prior to creation of the stormwater utility.

Engineering and Project Management: This function involves implementation of neighborhood projects as they are developed. The engineering element will provide lead technical support for all stormwater program areas and be a direct service provider in the area of plan review, design, field inspection, and enforcement. Although project management will be an increasingly important function, emphasis will also be placed on both structural and non-structural program planning. Initial program priorities will include preparing consistent design criteria and standards and developing an accurate stormwater system inventory. This Stormwater Master Plan will be managed within this program function. A complete physical feature inventory and condition assessment of the stormwater system within the service area has not been completed, but will be an important element within this program heading.

Regulatory functions of nonstructural aspects of the stormwater system include enforcement and oversight of stormwater policies within the City. It is through enforcement of the regulatory provisions that the overall Stormwater Management Program will be applied on a consistent basis and maximizes nonpoint load reductions from all areas of Bend. This mechanism also provides the means to monitor the consistent application of standards and criteria to provide a uniform level of water quality and quantity protection to Bend citizens.

Budget Estimate = $110,000 for FY 2007-2008

Public Information: The public information component includes expenditures for public awareness brochures and flyers about the stormwater program. Newsletters about onsite controls for quantity and quality will also be developed. A number of different approaches can be used to integrate the stormwater program into the community. Public education needs to emphasize what can be done through a commitment to stormwater management. Among the approaches considered by the Task Force are using the theme “We All Live Downstream” or stenciling inlet grates with the statement “Drains to the Deschutes.” Programs geared toward grade-school children that show how stormwater systems work and how pollutants get into these systems can be a very effective tool. The use of onsite water quality best management practices regarding issues such as fertilizer application and erosion control should also be part of these education programs.

Budget Estimate = $17,500 for FY 2007-2008

City Administration: Internal City Services and Administration includes the transfers to various City departments for services provided to the stormwater utility, including facility management, administrative support, financial services, and utility billing.

The 2007-2008 estimated budget is summarized in Table 8.3.

Annual Budget Estimate = $197,000 for FY 2007-2008

Total Budget Estimate for Fiscal Year 2007-2008

Table 8.3

Stormwater Annual Program Requirements (FY 2007-2008):	
Maintenance	$286.000
Capital Improvement Program	$521,000
Water Quality Management	$329,000
Engineering and Project Management	$110,000
Public Information	$17,500
City Administration	$197,000
Total	**$1,460,500**

FY 07-08 Total Budget Estimate = $1,460,500

Based on the results of a preliminary impervious surface estimate that took into account the number of single-family residences as well as the City's zoning and commercial development statistics, and the preliminary budget estimate for the utility, a rate recommendation of $4 per ERU per month was made in order to generate the revenue necessary to support the City's estimated program costs. These estimates were developed in advance of the final measurement data prepared by the City through a separate subcontractor.

8.5 TASK FORCE REPORT TO THE BEND CITY COUNCIL

In its final report to the City Council on June 6, 2007, the Task Force noted the following issues affecting stormwater management in the City of Bend:

- The City's stormwater system is not being maintained on a routine or preventative level. This has resulted in more flooding during smaller storm events. Repairs and replacements to the system are long overdue due to lack of funds;
- Bend has not kept up with its infrastructure needs, and has put off building necessary capital facilities.
- Pollutants carried by stormwater to the Deschutes River are affecting water quality;
- The pace of new development and redevelopment is significant, and the City's ability to ensure that developers meet Bend stormwater regulations also needs to increase;
- The public needs to be an active partner in this program, and the City needs to better inform them regarding their role in stormwater quality; and
- Compliance with the NPDES regulations affecting stormwater quality and state Underground Injection Control (UIC) requirements affecting dry wells and drill holes are immediate needs, and a long-term expense.

In response to these issues, the Task Force made the following statements to the City Council:

- Bend has significant and largely unfunded needs in terms of stormwater quantity and quality management.
- Bend is required to comply with both federal and state NPDES Phase II and UIC regulations.
- Bend has tremendous water resources and natural systems that are vital to the City's economic and quality-of -life standards. Stormwater is a key factor affecting these systems and should be managed into the future.
- The question is not if but when Bend will begin to address these problems. The City's existing system is largely at or over its design capacity for very small storm events.
- Long-term fixes to the City stormwater system require dedicated and consistent revenues in order to plan for and carry out maintenance and capital improvements.
- The primary funding approach should be a stormwater utility service charge.

- A separate utility is the preferred structure for the funding program because by law, the revenues generated by the utility fee will be dedicated to stormwater management, and the rate can be related to a customer's estimated use or contribution of runoff to the stormwater system.

- The appropriate basis of the service charge should be measured impervious surface coverage because it is consistent and most closely related to runoff factors. It is also reasonable to apply a uniform rate of one ERU to single-family residences.

- Based on a representative sampling of homes in Bend, the average amount of impervious surface for a single-family residence is approximately 3,800 square feet.

- Based on a very preliminary estimate of total impervious coverage, the rate per month per ERU would be about $4.00 to meet the annual rate revenue requirement.

- A credit procedure should be available to non-residential stormwater customers. The credit should be structured to reflect the degree to which constructed facilities or best management practices (BMPs) exceed current standards, and therefore provide a benefit to the utility.

These recommendations were presented to the public in an Open House on May 24, 2007. Comments were provided to the City on issues and concerns. Comments and responses are provided in Appendix D. The Task Force Report was presented to the Bend City Council on June 6, 2007. Following the Task Force process, public hearings, and council briefings, the City Council adopted the recommended $4 monthly utility rate at their regularly scheduled meeting on June 20, 2007 and specified that any revenues above the budgeted amount be used for CIP projects. The stormwater utility was implemented July 1, 2007. Complete meeting summaries from each Task Force meeting, Issue Papers, summary reports, and recommendations are included in Appendix D.

The CIP program identified in this Stormwater Master Plan is extensive. The cost of the proposed CIP program will require more funds than can be raised through the stormwater utility rate. Other potential sources of funding for the CIP program are listed below.

The rate adopted by the Bend City Council in June 2007 primarily focused on the programmatic elements of utility operations. It was expected that as the full scope of the capital improvements were identified through this Stormwater Master Plan, both a revised rate and a new stormwater system development charge (SDC) would be considered by the Council. It is also anticipated that some construction cost sharing can be achieved by combining efforts with other utilities, such as sanitary and water line construction. The City should also consider applying for grant funding, and taking advantage of low interest loans available for public projects through the State Revolving Loan Fund. In the event that federal money becomes available in future years, the City should apply for any appropriate funding, particularly for federally mandated work. Finally, Bend's establishment of the stormwater utility and service charge does allow the City to issue revenue bonds for stormwater capital projects. Under this bonding scenario both stormwater utility rates as well as SDC revenues can be used to pay back both the principal and interest for these bonds.

The CIPs informed the Task Force about the magnitude of the infrastructure problem and the expense of addressing existing problem areas. Costs for constructing the five highest priority problems were presented to the Task Force and were incorporated into budgets developed to determine the appropriate monthly stormwater utility fee.

9.0 DRAINAGE IMPROVEMENT ALTERNATIVES

9.1 OVERVIEW OF ALTERNATIVES

A number of alternatives were evaluated for addressing stormwater issues in the City of Bend. Funds are limited and it is important to maximize benefits of capital improvement projects while addressing stormwater flooding, water quality regulations, and public concerns. Rapid development and increases in impervious surface area have increased flooding within the City despite the relatively low 11.7 inches of average annual rainfall. Water quality concerns are increasing for both surface and underground stormwater discharges. In public meetings, citizens have expressed concern that the new UIC regulations will cause the City to discharge more stormwater to the Deschutes River, which could result in negative impacts from higher flows and increased pollutant discharges.

The City takes into account costs of construction and maintenance, protecting water quality, solving chronic and increasing flooding problems, and meeting regulatory requirements, as it implements its stormwater program and develops an effective stormwater Master Plan. Because of the challenging topography, lack of adequate infrastructure, and the cost of building pipelines in rock, it is necessary to evaluate a number of alternatives.

Water quality treatment is potentially very expensive. Treatment can be provided in a number of ways, including using underground filters or other mechanical devices, natural systems, or a treatment train with a combination of natural and structural systems.

Stormwater quality requirements cannot be met unless stormwater quantity (flow rate and volume) is properly managed. Runoff that bypasses collection, conveyance and treatment components because they are underdesigned will not be treated before it is injected underground or discharged to the river.

Possible solutions to the stormwater drainage and water quality problems evaluated and discussed herein are listed below. Some of these alternatives may not be applicable in some parts of the City.

- Continue using dry wells and drill holes where geotechnical conditions are appropriate.

- Pipe, with pumping as necessary and pretreatment, to the Deschutes River.
- Pipe, with pumping as necessary, to stormwater only infiltration/evaporation ponds at the Water Reclamation Facility (WRF) location.
- Construct piped systems with regional detention and treatment in strategic locations.
- Implement LID techniques on City property and require their use for all new development and redevelopment.
- Combine construction of stormwater infrastructure with construction of other utilities, such as roads, sanitary sewers, and water lines.
- Work with other agencies such as ODOT and Bend Metro Parks and Recreation District (BMPRD) to develop dual-purpose facilities that that serve transportation or recreation purposes as well as stormwater management purposes.
- Work with irrigation districts to use the ground surface in existing easements for stormwater management.
- Work with ODEQ to recognize optimized street sweeping as a stormwater BMP.
- Develop plans and facilities to prevent or respond to spills from railroads and streets that may threaten surface or groundwater.
- Evaluate various pretreatment technologies to determine what works best in Bend.
- Complete an accurate stormwater drainage system asset management GIS.
- Develop a hydrology model using GIS data for further analysis in order to refine recommended drainage systems.

These alternatives address all stormwater drainage within the City of Bend, with the exception of a newly annexed area known as Juniper Ridge in the northernmost part of the City. This planned development covers many acres and will include a mixture of residential and commercial development. A separate Master Plan has been prepared specifically for Juniper Ridge. The plan addresses regional stormwater management as well as on-site management.

These alternatives are discussed below and costs estimates provided where possible. Chapter 10 describes the recommended alternatives. The criteria used to select the top-priority areas are discussed below. Prioritization is not static and will change based on new data, capital availability, development patterns, road and street upgrades, and several other factors.

9.2 CIP PRIORITIZATION CRITERIA

Criteria for prioritizing storm drainage CIP projects were established during Phase I in 2006 and are discussed in Chapter 4. The three criteria that were deemed to be the most important at that time are:

- Fire, Life, and Safety considerations
- Property Damage
- Magnitude of impact

Based on the above criteria and discussions with the City, the strategy for implementation is to address the most serious flooding problems first. Construction of portions of the pipeline network described in Figure 10.1, and discussed in Section 10.1 would occur concurrently or later. Steps need to be taken immediately to prevent new drainage problems from being created during new or re-development.

In addition to building a piped system, the City will pursue construction of LID projects to help distribute the costs and benefits of the stormwater program throughout the City. It is also recommended that the City actively coordinate with other agencies to evaluate sites for regional facilities.

9.3 DRY WELLS AND DRILL HOLES

Dry wells and drill holes have been used for many years with success in much of the City. Until recently, infiltration through dry wells and drill holes has been the stormwater disposal method of choice by both the public and private sector. Without a piped drainage system, there is no stormwater network for connecting new development. The apparent low cost of dry wells and drill holes without flow management and pretreatment perpetuates their use even where they are not appropriate. As discussed in Chapters 2 and 6, there are areas throughout the City where dry wells do not work well and should not be allowed. Unclear, inappropriate, and confusing codes, standards, specifications and test methods perpetuate the problem.

Dry wells and drill holes can become ineffective in a few years if adequate precautions are not taken. Over a period of 5 years or less, cinders used on roads in winter and other sediments and debris accumulate in dry wells and drill holes and cause many of them to lose their infiltration capacity. Attempts to restore their capacity are often not successful. The best defense against dry wells and drill holes failing due to plugging is to remove sediment by means of efficient pretreatment. Catch basins and sedimentation manholes are not efficient enough for this purpose. Extended detention and filters perform best. Hydrodynamic separators may be acceptable in some applications. Unpaved streets and roads, road traction cinders, and poor erosion control during and after construction are also major contributors to dry well and drill hole failures. Poor dry well construction practices and location of inlets also contribute to the problem. If catch basins are not properly placed, stormwater from intense storms can bypass the inlets and cause flooding due to the catch basins being too far from the curb or the pavement being lower than the catch basin inlets.

Bend's drainage systems do not include any provisions for capturing spills before they enter the river or disappear underground. Spills, therefore, pose a high risk of environmental damage and expensive remediation. The risk is particularly acute at the railroad underpasses and on streets with heavy truck traffic.

As the number of UICs without adequate pretreatment and spill protection continues to increase, the risks of groundwater contamination also increase. State and federal laws and regulations require that drinking water supplies and groundwater be protected from contamination. The City is committed to protecting the groundwater its residents rely on for a significant portion their drinking water. The State of Oregon's UIC regulations implement the federal Safe Drinking Water Act. In the UIC rules and Oregon's Groundwater Protection Rules, groundwater is defined as any water found underground, including seasonal high groundwater and water that mounds around UICs as a result of runoff events. UIC rules require the City to pretreat all of its stormwater before discharging it underground unless the City can demonstrate that discharging without treatment will not pose a threat to groundwater. The canals in Bend create large areas of shallow groundwater that extend far beyond the canal easements. Areas with pink tuff, clay layers, and consolidated rock often contain lenses of perched groundwater. Unless the City obtains more monitoring data to demonstrate that its stormwater does not contain pollutants of concern and performs studies to show that its groundwater is not susceptible to contamination, it will be required to install pretreatment on all of its UICs. This is in addition to the pretreatment that it must provide for its discharges to the Deschutes River.

Large portions of the City are within a Drinking Water Protection Area (DWPA) (Figure 3.1) or within 500 feet of private water wells. Stormwater discharged via UICs, covered under a permit, within these protection areas has to be pretreated to meet drinking water standards. The DWPAs have been delineated by the Oregon State Health Division (OSHD) using simple modeling methods that do not accurately depict protection areas in Central Oregon's complicated geology. More sophisticated and appropriate models such as groundwater models developed by the U.S. Geological Survey and others should be used to develop state-of-the-art delineations for all water wells with DWPAs that originate within or extend into the City. Unless covered under a UIC WPCF permit such as the one the City has applied for, UICs are not allowed within these protection areas. Since few private UIC owners have obtained or plan to obtain a UIC WPCF permit, their UICs must be decommissioned if they are located in a protection area.

The City currently has about 5,000 UICs and there is an unknown number of private UICs within the UGB. Where land area is not available for non-UIC disposal, manufactured pretreatment devices are available but, to date, the ODEQ has fully approved only one device for use in high traffic public streets. These pretreatment devices are only designed to treat the water quality 6-month design storm. The balance of the runoff, along with the sediment, debris and other pollutants it contains, bypasses pretreatment and flows directly to the UICs. These pretreatment devices need to be protected from the high sediment loads from unpaved streets, erosion, and road traction material by an efficient upstream sediment removal device. In almost all applications, the design should include upstream detention in order to manage flow to the treatment system and help settle out some of the solids.

Pretreatment will extend the life of UICs but many of them will still need to be replaced after a few years of service. Oils and greases from roadways and the fine sediments that cannot easily be removed by most pretreatment devices will plug these systems in a few years, even if they are well maintained.

Situating detention and sediment removal as near as possible to the stormwater's point of origin is highly desirable. Detention greatly reduces peak flow rates, and consequently, the costs of pumps, pipes, and other downstream hardware. Detention helps remove sediment, thereby protecting pumps and downstream piping hardware from erosion, abrasion, and plugging.

Advantages and disadvantages of UICs are summarized in Table 9.1.

Table 9.1
Comparison of Advantages and Disadvantages of the use of UICs

Advantages	Disadvantages
Inexpensive to install (about $5,000 each without pretreatment or flow control)	Short life expectancy, about 5 to 10 years based on public works maintenance staff experience and public complaints
Work well in well-draining soils	Many areas of the City have geotechnical conditions that are not suitable for infiltration
Prevent water from accumulating in downstream areas due to dispersion of stormwater	Restoration of failed UICs often not possible
Help maintain groundwater recharge patterns	Traction materials tend to plug UICs, creating problems for maintenance and reducing the lifespan of the system
Little land area is required	Federal and state regulations require pretreatment for all UICs and, even with pretreatment, do not allow stormwater to be discharged directly into groundwater
Systems can be installed quickly, avoiding project delays	UICs may provide a conduit for spills to contaminate groundwater
	UICs are prone to illegal dumping
	A single spill or groundwater contamination incident can result in enforcement action by the state and federal government
	Maintenance of UICs and responding to flooding complaints for failed systems is time-consuming and expensive for the City
	Actual capacity of UIC is difficult to determine before installation due to inadequate testing procedures

The disadvantages of UICs outweigh the advantages so other options are being explored.

9.4 PIPE AND PUMP TO THE DESCHUTES RIVER

As discussed in Chapter 2, the natural topography, in addition to roads and canals, prevents drainage of parts of the City to the Deschutes River or Tumalo Creek. Where UICs work well, they help overcome drainage barriers to stormwater flow, as does the limited piped system. Stormwater accumulates in natural depressions where, before development, it eventually overflowed to the river, infiltrated into the ground, or dissipated through evaporation and evapotranspiration. In soils left in their natural condition, evapotranspiration alone can dissipate approximately 43 inches annually in Bend (Agrimet). Where development covers over these natural soils, the area available for infiltration and evapotranspiration is greatly reduced and drainage to the river increases. Manmade barriers also interfere with natural drainage. When constructed disposal methods cannot infiltrate enough runoff to make up for these losses, flooding occurs. One solution is to install a piped system to collect and convey the stormwater to the river or a regional infiltration pond. Undeveloped natural depression areas should be evaluated to and acquired if they are in a suitable location for stormwater detention or disposal.

Many areas of the City naturally drain by gravity toward the Deschutes River. These areas are recommended to be part of the overall stormwater solution. Costs for these systems are presented in Chapter 10. The City's need to better manage its stormwater quality is not solely determined by federal and state mandated regulatory requirements, but also by the City's responsibility to protect the quality of the Deschutes River and Tumalo Creek. Therefore, all drainage to these surface waters should be treated. Only a minor amount of this drainage is currently treated.

Approximately 11.4 square miles within the UGB do not naturally drain to the river. In some of this area, stormwater would need to be pumped over a 30-foot ridge in order for it to drain to the river. This is not a practical alternative. Other alternatives include the continued use of UICs where appropriate, regional treatment and infiltration, and piping to Bend's WRF for disposal in dedicated infiltration ponds.

9.5 PIPE STORMWATER TO THE WATER RECLAMATION FACILITY

Bend's WRF, about 3 miles northeast of the City, provides treatment for the City's sanitary sewer flows. The WRF was not designed to accept or treat stormwater, nor is it allowed to do so by its state permit. However, the City owns approximately one thousand acres of land at the WRF where infiltration ponds could be constructed for stormwater disposal. Large areas on the east side of the City naturally drain in the direction of the WRF. Sanitary lines already exist for most of the City, but a recently completed Wastewater Master Plan identifies a number of new interceptors planned to enhance sanitary sewer service throughout Bend, particularly for new development. Two proposed new gravity flow wastewater interceptors are expected to connect to the WRF. If gravity flow stormwater pipe were to be installed at the same time, adjacent to the new sewer pipe, the City could reduce overall construction costs and derive other benefits, such as savings on rock excavation and road repairs, and reduced inconvenience to the community.

As mentioned above, it is highly desirable to situate detention and sediment removal as close as possible to the stormwater's point of origin. Detention greatly reduces peak flow rates and, consequently, the costs of pumps, pipes, and other downstream hardware. Detention helps remove sediment, thereby protecting pumps and downstream pipe from erosion, abrasion, and plugging. To convey stormwater under the canals and other obstacles located throughout the City, siphon systems will need to be installed. Minimizing the sediment load will benefit these siphons by increasing their effectiveness, decreasing plugging, and reducing maintenance costs. One such siphon system at the end of the stormwater pipeline will allow the stormwater to emerge at the WRF without causing backwater problems along the outfall line, and will avoid using a pump station at the WRF. Stormwater will be disposed of at the WRF by means of dedicated infiltration and evaporation ponds. Additional siphon systems have not been identified as part of this stormwater Master Plan process, but will be necessary to connect pipelines under canals and other obstacles.

Because most of the sanitary sewer system is already in place, upgrades for the wastewater interceptor will be sporadic, and will occur as opportunities arise rather than starting downstream and continually working upstream. Installing pipe out of sequence will cause some surcharging, which is acceptable to the stormwater system. Sections of pipe will need to be installed for the stormwater system as opportunities arise to coordinate with wastewater pipe installation. Consequently, the stormwater system will not be completed for a number of years. Eventually, a skeleton stormwater interceptor system will be available for connections throughout the City and will drain the eastern and northern parts of Bend. Until that system is completed, the City can install sections of pipe in the drainage system to allow for storage of stormwater for a variety of uses. Stormwater can be recovered as irrigation water for neighboring areas. These pipes can slowly release water to regional detention systems along the pipe route for treatment and infiltration.

A piped network discharging to the Deschutes River and the WRF is expected to work in conjunction with several other concepts to provide drainage and treatment for the City.

9.6 REGIONAL DETENTION, TREATMENT, AND DISPOSAL

Another alternative is to use gravity flow piping and open channels to convey stormwater to natural depressions, where it can either be retained and allowed to infiltrate, or detained and pumped to another location for disposal. There are several locations throughout the City where this alternative may be the most desirable way to solve existing drainage problems and allow development to proceed. Regional detention and treatment systems can provide multiple benefits, including recreation and enhanced natural areas, in addition to functioning as stormwater facilities. These systems would specifically be beneficial to the piped system draining to the WRF. Regional systems can also be amenities to the neighborhoods.

One option to finance regional systems is to create a special district for funding the capital improvements and the ongoing maintenance of the facility. Properties that benefit from the system would be assessed a charge to cover the construction and ongoing maintenance and operating costs.

Vacant land is still available in many areas of the City, and some of these lands are suitable for stormwater facilities, especially detention facilities. Even considering land acquisition costs, detention facilities often will be cost-effective because they greatly reduce downstream system costs.

New developments can provide land for regional detention, treatment and, possibly, disposal. Setting aside areas at the time of planning for large developments can provide a network of regional facilities for storage, treatment, and disposal of stormwater. This set-aside of land can be made a condition for development approval. Alternatively, the City can acquire land, build a regional facility, and require new developments to purchase rights to use the facility.

Regional systems are recommended as a component of the overall capital improvement plan and are discussed further in Chapter 10.

9.7 IMPLEMENT LOW IMPACT DEVELOPMENT SYSTEMS

LID techniques should be evaluated for stormwater management in all new development and redevelopment for both public and private projects in the City. The City's development code should require this. Information on LID systems is readily available from numerous sources, including the COSM.

LID projects can be implemented as needed anywhere in the City. One of the great advantages of LID is that it reduces stormwater pollutants, peak flows, and volumes at the points of origin. In addition, it helps maintain groundwater recharge patterns. Further information on LID systems can be found in the COSM and on the Internet.

9.8 COORDINATE WITH OTHER CITY UTILITIES

This is an expansion of one of the previous alternatives, and would coordinate stormwater infrastructure improvements with other utility infrastructure improvements. This saves construction costs and minimizes community disruptions. The City should formalize its internal procedures to facilitate this type of coordination.

9.9 COORDINATE WITH OTHER AGENCIES

Opportunities exist for the City to coordinate drainage projects with other agencies, such as ODOT and BMPRD. The City has already negotiated an Intergovernmental Agreement with ODOT and is in the process of negotiating one with BMPRD. Both agencies have areas that can be used for stormwater purposes while providing improvements consistent with the agency's objectives. Currently, the City is working with ODOT to use portions of the cloverleaf at Colorado Avenue as part of the solution to the Third Street, Franklin, and potentially Greenwood underpass flooding problems.

Although this Master Plan project is being managed by the Public Works Department, that Department has and will continue to coordinate with and seek input from other City Departments such as Community Development, Transportation, Engineering, Water, and Water Reclamation.

9.10 COORDINATE WITH IRRIGATION DISTRICTS

Numerous canals are located throughout the City, taking water from the Deschutes River to agricultural areas inside and outside of the Urban Growth Boundary. Although many of the canals are still open, irrigation districts are systematically moving ahead with piping and lining these systems due to concerns about pollution, safety, and water losses from evaporation and leakage. The districts have built berms in part to prevent stormwater drainage from entering the canals.

Piping the canals may present opportunities for the City to share the easement and land for stormwater purposes. Swales can provide temporary storage, slowing down stormwater, and thereby reducing required pipe sizes downstream. Swales can also effectively treat and dispose of stormwater. The easements in the City are based on gravity flow, making them desirable for storm drainage conveyance.

Preliminary discussions with an irrigation district indicated some interest in discussing potential opportunities. Some time will be needed to discuss a number of issues with the various irrigation districts. This endeavor will be worthwhile because using canal easements can help the City meet some of its stormwater needs cost effectively.

Coordination with the irrigation districts would be a long-term project that would require negotiations and agreements to make sure all issues are properly addressed. This element is recommended to be a component of the stormwater CIP.

9.11 SUMMARY

In summary, each of the alternatives offers part of the solution for providing better stormwater management in the City. It will be necessary to continue using dispersed underground injection until other stormwater solutions can be constructed. For piped systems, the City should explore opportunities to acquire land for regional facilities, coordinate with other utilities, coordinate with ODOT and BMPRD for joint projects, and implement LID projects throughout the City.

Solving Bend’s drainage problems is important to other functions of the City. Poor street drainage reduces the longevity of the pavement and supporting base material. Early replacement of streets and increased maintenance result in added costs to the City.

Table 9.2 provides a comparison of the alternatives discussed in this chapter by drainage as shown in Figure 5.2.

Chapter 10 discusses the implementation strategy for the recommended CIP.

Table 9.2
Comparison of Alternatives
(Refer to Figure 5.2 for drainage area boundaries)

Drainage Area	Piped System	Regional Detention	Infiltration – Dry Wells and Drill Holes[1]	Low Impact Development
Area 2[2]	To WRF; Long-term drainage solution.	Suitable for new development and vacant properties. Provides relatively quick solution as it is not dependent upon upstream and downstream drainage facilities.	Generally acceptable solution with approved pretreatment.	Potential for early action by the City providing drainage relief; recharging of groundwater and improvements to water quality.
	Expensive solution due to topography and rocky terrain; Will take time to construct.	Takes property out of development and taxable status. Requires ongoing maintenance that is not typical of public works projects, i.e., vegetation control; Property acquisition can be expensive.	Systems may clog due to use of cinders; Systems need to be replaced when no longer functioning; Potential for damaging groundwater; Dry wells and drill holes may pose unacceptable risk to groundwater in many areas of the City, especially within drinking water protection areas.	Concern over some LID techniques such as porous pavement. Codes, standards, specifications, policies, and interpretations may need to be changed to allow.
Area 1 East of Deschutes River	Pipe to Deschutes River; Long-term drainage solution.	Same as Area 1, above.	Same as Area 1, above.	Same as Area 1, above.
	Same as for Area 1 above.	Same as Area 1, above.	Same as Area 1, above.	Same as Area 1, above.
Area 1 West of Deschutes River	Pipe to Deschutes River; Long-term drainage solution.	Same as Area 1, above.	Not generally suitable without additional testing for infiltration capability.	Need to consider evaporative systems due to difficulty of infiltration with existing soils.
	See Area 1 above	Same as Area 1, above.	Soils not suitable for infiltration.	Soils do not allow infiltration in many areas.
Area 4	Pipe to WRF; Long-term drainage solution.	Same as Area 1, above.	Same as Area 1, above	Same as Area 1, above
	See comment for Area 1.	Same as Area 1, above	Same as Area 1, above	Same as Area 1, above
Area 3	Pipe to regional detention and to Tumalo Creek; Long-term drainage solution.	Not suitable for regional detention due to steep slopes.	Same as Area 1, above	Same as Area 1, above
	Requires property acquisition.	NA	Same as Area 1, above	Same as Area 1, above

Notes:

1. See GeoEngineers Report, Stormwater Infiltration Evaluation, City of Bend, Oregon, October 4, 2007, for further information.
2. See Figure 5.2 for location of areas described.

REFERENCES

Agrimet. Pacific Northwest Cooperative Agricultural Weather Network. http://www.usbr.gov/pn/agrimet/monthlyet.html.

10.0 RECOMMENDED CAPITAL IMPROVEMENT SYSTEM

The basic Capital Improvement Projects (CIPs) presented here provide a City-wide drainage solution for the area within current city limits. Consisting of LID, regional piping and regional water quality facilities, the basic CIP provides a variety of solutions to solve the drainage and water quality problems in Bend. Table 10.1 summarizes the solutions for each area. Regional detention is recommended for the northwestern part of the City, collecting drainage from Awbrey Butte, due to the limited options of installing a piped system, while piping and regional water quality facilities are recommended for the majority of the remainder of the City. Areas naturally draining to the Deschutes River will continue to do so, but treatment will be provided prior to discharging to the river.

In many parts of the City, regional piped systems, including detention, retention, treatment and disposal, will provide solutions to existing and future drainage problems. The City should require and implement LID for all new development and redevelopment to minimize flow rates and volumes, and to reduce the amount of soil erosion conveyed to City streets. Solutions such as paving unpaved streets to reduce a source of erosion, the use of pervious pavement, and construction of rain gardens should be considered in the comprehensive plan to address water quality and quantity.

The basic CIP consist largely of piped systems. In order to make use of gravity flow, the pipes must be placed at least 3 feet below the lowest sink. Because Bend has many ridges and dips, the slopes are low, and low slopes require more costly larger pipes. The large pipes and the need to provide adequate cover for the pipe through the tortured volcanic landscape significantly affect CIP costs. Minimum design pipe flow is 3 feet per second to avoid sedimentation in the pipe and reduce maintenance costs.

Options are presented after the basic CIP that will allow some reduction in pipe sizes, potentially saving costs for the overall system. Regional systems, LID, and continued use of dry wells where appropriate and with pretreatment, will enhance groundwater recharge.

In addition to the basic CIP and options, this chapter presents budget level cost estimates, criteria for prioritizing implementation, and recommended project phasing.

City of Bend Stormwater Master Plan
Table 10.1
Estimated Costs - 25-year storm (Page 1 of 4)

Pipe ID	Basins	Pipe Size inches	Costs Pipe/Ft.	Rock Exc. Cost/Ft.	Backfill Cost/Ft.	Pavement Restoration	Cost/Ft. $$/ft.	Misc. @25%	Cost for Pipe $$
Area 1 - Discharge to WRF - Pipe Draining to Water Reclamation Facility									
ID42	MB32	60	300	108	71	93	571	714	$2,985,474
ID29	MB31	48	200	88	59	83	429	536	$1,849,681
ID30-a	MB32	60	300	108	71	93	571	714	$1,870,025
ID30-b	MB32	36	170	68	48	73	358	448	$997,617
ID41	MB31,MB32	60	300	108	71	93	571	714	$3,058,347
MB33	MB33								
ID31	MB31,MB32,MB33,MB34A	84	500	158	97	113	867	1,084	$8,049,786
ID32-a		84	500	158	97	113	867	1,084	$716,235
ID32	MB34A	36	170	68	48	73	358	448	$1,390,129
ID2-A	MB31,MB32, MB33, MB34A,MB34B	84	500	158	97	113	867	1,084	$5,667,032
ID2-B	MB31,MB32, MB33,MB34A, MB34B,MB34C	84	500	158	97	113	867	1,084	$5,693,037
ID38	MB34C	60	300	108	71	93	571	714	$3,291,101
ID2-C	MB31,MB32, MB33, MB34A,MB34B,MB34C,MB34D	84	500	158	97	113	867	1,084	$15,195,881
ID37	MB35	72	400	132	83	103	718	897	$3,503,517
ID4	MB35	60	300	108	71	93	571	714	$3,810,140
ID36	MB31,MB32,MB33,MB34A,MB34B ,MB34C,MB34D,MB35	96	600	178	110	129	1,017	1,271	$6,364,982
ID35	MB31,MB32,MB33,MB34A,MB34B ,MB34C,MB34D,MB35,MB5,MB6A ,MB6B,MB6C,MB7	96	600	178	110	129	1,017	1,271	$1,555,628
Plant Interceptor	MB6A,MB5,MB6B,MB6C,MB31,M B32,MB33,MB34A,MB34B,MB34C ,MB34D,MB35	96	600	178	110	129	1,017	1,271	$19,076,772
								Flow	$85,075,383
								Sedimentation Manholes	$1,455,240
								Subtotal	**$86,530,623**

City of Bend Stormwater Master Plan
Table 10.1
Estimated Costs - 25-year storm (Page 2 of 4)

Area 2 - Discharge to the Deschutes River - Pipe Draining to Deschutes River									
ID43	MB11	60	300	108	71	93	571	714	$1,802,005
ID39	MB8A	42	190	78	53	78	398	498	$1,163,288
ID33	MB8A & MB8B	60	300	108	71	93	571	714	$3,799,291
ID17	MB18A	60	300	108	71	93	571	714	$777,702
ID40*	MB8A,MB8B,MB18A	60	300	108	71	93	571	714	$1,617,884
ID18	MB8A,MB8B,MB8C, MB18A	60	300	108	71	93	571	714	$637,379
ID19	MB14B	24	130	52	37	63	282	352	$465,883
ID15	MB8C	72	400	132	83	103	718	897	$9,578,374
ID13	MB8C	48	200	88	59	83	429	536	$704,490
ID14	MB18C	48	200	88	59	83	429	536	$1,267,492
ID56*	MB8C,MB18C	42	190	78	53	78	398	498	$252,338
ID8	MB8C,MB18C	42	190	78	53	78	398	498	$511,950
ID24*	MB18B,MB20	36	170	68	48	73	358	448	$640,891
ID51	MB14A	24	130	52	37	63	282	352	$542,204
ID26	MB17, MB19	60	300	108	71	93	571	714	$4,231,110
ID48*	MB17,MB19,MB16B	60	300	108	71	93	571	714	$4,159,476
ID28	MB19	36	170	68	48	73	358	448	$960,917
ID27	MB16B, MB17	72	400	132	83	103	718	897	$5,324,808
ID46	MB16C	24	130	52	37	63	282	352	$348,356
ID1	MB11, MB16A	60	300	108	71	93	571	714	$4,615,036
ID44	MB16C, MB11, MB16A	48	200	88	59	83	429	536	$99,684
ID45	MB16C,MB11, MB16A	48	200	88	59	83	429	536	$405,490
ID52	MB26	48	200	88	59	83	429	536	$1,337,593
ID53	MB25	48	200	88	59	83	429	536	$3,660,721
ID20	MB24	36	170	68	48	73	358	448	$1,762,949

City of Bend Stormwater Master Plan
Table 10.1
Estimated Costs - 25-year storm (Page 3 of 4)

MB23A	MB23A								
ID22	MB23A,MB22C, MB22D	60	300	108	71	93	571	714	$4,190,355
ID21	MB23A,MB22D, MB22C	60	300	108	71	93	571	714	$2,423,824
ID23	MB22B	42	190	78	53	78	399	498	$1,477,917
ID54	MB23A,MB22D, MB22C,MB22B	60	300	108	71	93	571	714	$811,248
ID25	MB22A	60	300	108	71	93	571	714	$2,319,973
ID49	MB27	36	170	68	48	73	358	448	$415,338
ID9	MB10	36	170	68	48	73	358	448	$217,515
ID11	MB9A	42	190	78	53	78	398	498	$886,106
ID10	MB9B	36	170	68	48	73	358	448	$898,347
								Flow	$64,307,935
								Hydrodynamic Separators	$6,120,000
								Subtotal	**$70,427,935**
Area 3 - Discharge north to WRF - Pipe Draining North to North Interceptor									
ID57	MB6A	36	170	68	48	73	358	448	$345,921
ID12*	MB6A	30	150	60	42	68	320	400	$622,144
ID34	MB5	72	400	132	83	103	718	897	$1,868,483
ID7	MB6A, MB6B	84	500	158	97	113	867	1,084	$6,239,153
ID58	MB6A,MB5,MB6B,MB6C	72	400	132	83	103	718	897	$6,177,046
ID6	MB6A,MB5,MB6B, MB6C, MB7	84	500	158	97	113	867	1,084	$10,420,729
ID3	MB6A,MB5,MB6B, MB6C, MB7	72	400	132	83	103	718	897	$4,850,734
								Flow	$30,524,209
								Sedimentation Manholes	$791,948
								Subtotal	**$31,316,157**

* Pipe ID 56, 12, 24, 40 and 48 include bored casings to cross under freeways or railroads.

City of Bend Stormwater Master Plan
Table 10.1
Estimated Costs - 25-year storm (Page 4 of 4)

Area 4 - Discharge North to Regional Treatment Facilities

Regional Retention and Treatment

	Acres(1)	Unit costs	Subtotal	Misc. @ 25%	Project Cost
Land Purchase	10	200,000	2,000,000	2,500,000	$2,500,000
Regional Treatment	10	50,000	500,000	625,000	$625,000

1. Assumes facilities have 5 feet depth for volume

Subtotal **$3,125,000**

High Priority Hotspot Flooding Projects (See Appendix B for details)

HP#1	Westside Village Shopping Center (part of ID53)	See ID 53
HP#2	Franklin Avenue Underpass	$931,000
HP#3	Third Street Underpass	$13,669,000
HP#4	Archie Briggs	$609,000
HP#5	Fairway Hts.at Awbrey Butte	$529,000

Subtotal **$15,738,000**

Cost Summary:

Flow	$179,907,528
Water Quality	$8,367,188
Regional Detention	$3,125,000
Treatment at WRF	$500,000
Flooding Hotspots	$15,738,000
LID Projects	$800,000
Land Acquisition for Regional Detention	$19,000,000
Total for 25 year storm	**$227,437,716**

10.1 BASIC CIP

Major components of the recommended basic CIP involve the construction of underground piping, culverts, open channels, regional detention, and water quality treatment facilities. A pipe network was identified to drain each major basin. The proposed pipe network would provide drainage to the Deschutes River, dedicated infiltration and evaporation ponds at the Water Reclamation Facility (WRF), or undeveloped land that might be available for a regional infiltration pond. Runoff from some subbasins would be routed to neighboring basins to provide an appropriate discharge point for the drainage.

Potential pipelines were identified to provide a basic infrastructure for the major basins. A time of concentration (T_c) was determined for each major basin and volumes and peak flows were calculated. Proposed pipeline sizes were based on the 25-year peak flow into the pipeline from contributing drainage areas. A minimum pipe cover of 3 feet was assumed. A ground surface profile was run on each of the proposed pipe systems to confirm the feasibility of gravity drainage to the final discharge point and the minimum pipe cover.

Proposed pipe sizes and full flow velocities for future development are shown in Table C.3 of Appendix C. Pipe diameters range from 24 inches for smaller drainage areas to 96 inches for the last sections draining to the WRF. Pipe sizes are increased in places where pipe velocities would exceed 15 feet per second at full flow (based on the ODOT Hydraulic Manual, 2005, Chapter 5, p. 5-25). Pipe sizes are also increased to match upstream pipe size if the downstream pipe is smaller than the upstream pipe due to increased slope.

Another significant, but low-cost, component of the CIP is the use of LID techniques, added as separate costs in the recommended CIP, throughout the City to address some of the flooding problems, improve or protect water quality, and to reduce the size and cost of City-owned stormwater systems.

Proposed storm drainage facilities for each of the four quadrants shown in Figure 5.2 are described below. Proposed pipelines are shown in Figure 10 through 10.7 and are listed in Table 10.1.

Area 1 Drainage to the Deschutes River, both east and west of the river

a. An existing pipe network discharges to the river. Little information on this pipe network is currently unavailable. An evaluation of this system is recommended to determine the ability to upgrade the capacity of the pipe by constructing parallel pipe or increasing the size of the existing pipe to accommodate additional stormwater. Alternatively, detention could be added at several locations in the drainage area which would allow continued use of existing pipes. Pretreatment will be required to protect the River from sediment, cinders, debris, and other pollutants of concern.

   i. Some sections of pipe need to be bored under Highway 97.
   ii. Siphons or small pump stations may need to be installed in a few locations to drain water under or around canals and other barriers.

b. Flow controls plus hydrodynamic separators or other treatment to efficiently remove sediment and other pollutants prior to discharging to the Deschutes River.

c. Space on BMPRD or ODOT sites may be available for use as water treatment facilities. Such options should be explored with the BMPRD as sites are developed. A partnership would enable both entities to seek opportunities that would benefit both parties.

Area 2 Discharge to dedicated stormwater ponds at WRF via route of proposed southeast sanitary sewer Interceptor.

d. Piped system starting on Murphy Road parallel to the new wastewater pipe, in the same trench, running north on 27th Street, along the route of the proposed WRF Plant North Wastewater Interceptor.

e. Combined pipe and open channel system parallel to the proposed and existing WRF Plant Wastewater Interceptor to the WRF.

f. Sediment removed at critical locations using detention or filtration, and disposal through dedicated evaporation and infiltration ponds at the WRF.

Area 3 Discharge north to stormwater retention facilities at WRF via routes of proposed Westside and North Wastewater Interceptors

a. Piped system runs north, along Highway 97, adjacent to and in the same trench with the proposed Westside Wastewater Interceptor.

b. Piped system continues east, adjacent to and in the same trench with the proposed North Wastewater Interceptor.

c. System discharges to the combined pipe and open channel system described in Area 2b, above.

d. Sediment removal provided as needed. Stormwater will be piped towards the WRF, then siphoned under the canal where collection of the drainage in a vault will force the water to rise and drain to dedicated infiltration and evaporation ponds at the WRF.

Area 4 Discharge north to regional treatment facilities

a. Existing dry wells appear not to be able to contain the stormwater flows. Culverts, drainage pipe, and natural drainages will convey water to the bottom of Awbrey Butte where a treatment facility will be built to infiltrate some of the water, treat remaining stormwater, and discharge water downgradient to the Deschutes River. Functioning natural drainages well will be left in place. Areas where erosion is occurring, such as between home sites, will benefit from a piped system, as is recommended in the CIP.

b. Water quality provided by vegetated ponds or swales at regional facilities.

Facility sizing is based on the following:

- Piped Systems: 25-year Type II NRCS storm profile

- Low-Impact Development

Table 10.1 provides pipe sizes and pretreatment costs, including some funding for LID projects, for the northwestern quadrant. Regional pretreatment in the northwestern quadrant (Area 4) has been sized for a water quality storm with overflow to Tumalo Creek.

This CIP list represents a skeleton pipe system that identifies major trunk lines to provide storm drainage within the Urban Growth Boundary (UGB). Cost estimates for a drainage collection and conveyance system throughout each major basin to connect to the trunk lines is outside the scope of work for this project and is not included.

The basic CIP also includes the flooding hotspots discussed in Chapter 4.

10.2 CIP PHASING

A phased CIP is presented to cover construction of projects over three time periods. High priority projects are to be constructed over the next 5 years; medium-priority projects over 5 to 10 years; and long-term projects in 10 to 20 years and beyond. The projects have been scheduled to address the highest priority problems first, as defined by the City through the prioritization process described in Chapter 4. CIPs identified for medium- and long-term construction have been identified to spread costs over a number of years and to provide a logical progression for constructing the costly drainage system needed for future build out conditions. It should be noted that priorities will change over time due mainly to regulatory and permit requirements and the amount of funds available. Table 10.2 provides cost details for projects listed below.

Table 10.2
Cost Estimating Details

Pipe Diameter	Cost/Lineal Foot	Excavation	Cost	Backfill	Cost	Paving	Cost	Cost of Bored Casing
		cubic yards/lineal foot	cost/cubic yard	cubic yard/lineal foot	cost/cubic yard	square feet/lineal foot	cost/square foot	lump sum
18	$120	2.2	$44.00	2.16	$32.40	11.5	$58	
24	$130	2.59	$51.80	2.48	$37.20	12.5	$63	
27	$140	2.8	$56.00	2.65	$39.75	13	$65	
30	$150	3	$60.00	2.82	$42.30	13.5	$68	$52,500
36	$170	3.4	$68.00	3.17	$47.55	14.5	$73	$60,000
42	$190	3.89	$77.80	3.53	$52.95	15.5	$78	$67,500
48	$200	4.38	$87.60	3.91	$58.65	16.5	$83	
60	$300	5.4	$108.00	4.7	$70.50	18.5	$93	$83,250
72	$400	6.6	$132.00	5.55	$83.25	20.5	$103	
84	$500	7.88	$157.60	6.45	$96.75	22.5	$113	
96	$600	8.9	$178.00	7.35	$110.25	25.7	$129	

Excavation	$20 per cubic yard for rock
Backfill	$15/cubic yard
Paving	$5/square foot
Misc.	25% for traffic control/erosion/contingency/engineering/etc.

Project costs were developed using a combination of 2007 Means Catalogue, 2007 bid tabs for construction projects, and information from local contractors. Costs presented herein are Project Level Costs that include design, engineering, construction, permitting, legal, and administration costs.

Due to the complexity of stormwater management in the City and because this is the first attempt by the City to develop a CIP for its stormwater system, the City should perform additional feasibility studies prior to implementing the recommended projects. The projects in the first 5 -year period include a feasibility study for implementing these high-priority projects.

High-Priority Projects to be constructed during first 5 years

HP#1 Westside Village Shopping Center (this project is also part of Pipe ID53)	See ID53
HP#2 Franklin Avenue Underpass	$931,000
HP#3 Third Street Underpass (Area A – See Appendix B)	$4,816,000
HP#4 Archie Briggs	$609,000
HP#5 Fairway Heights at Awbrey Butte	$529,000
(HP#7 Greenwood Avenue Underpass[2])	
Pipe ID10	$898,000
Pipe ID19	$466,000
Pipe ID9	$218,000
Pipe ID53	$3,661,000
Water Quality Facilities	$200,000
Land Acquisition for regional facilities[3]	$2,000,000
Decommissioning existing drywells (50)	$50,000
LID projects	$300,000
Total for High Priority Projects:	***$14,678,000***

Medium-Priority Projects, to be constructed in 5 to 10 years:

ID18, 40, 17	$3,033,000
ID22, 21, 54	$7,425,000
HP#3 Third Street Underpass	$8,853,000
Water Quality Facilities	$500,000
Land Acquisition for regional facilities	$2,000,000
Decommissioning existing drywells	$500,000
LID projects	$500,000
Total for Medium-Priority Projects:	***$22,811,000***

[2] The solution to the Third Street and Franklin Avenue drainage problems may also provide a major part of the solution to the Greenwood Avenue problem and may be integrated into the Third Street/Franklin project even though Greenwood is #7 on the priority list.

[3] Land acquisition costs are highly variable and details are unknown at this time. Cost estimates are provided for budgeting purposes only.

Projects to be constructed in 10 to 20 years

Pipe ID 1, 2a,2b,2c,3,4,6,7,8,11-15,20, 23-29, 30a, 30b, 31, 32a, 32, 33-39, 41-46,48,49, 51, 52, 56-59 (see Table 10.1)	$145,130,000
Area 4 Regional Retention and Treatment Facilities	$3,125,000
Water Quality Facilities	$7,667,000
Decommissioning existing drywells (1,000)	$1,000,000
Water Reclamation Facility	$500,000
Land acquisition for regional facilities	$15,000,000
Total for Long-Term Projects:	***$172,422,000***

These CIPs provide a basic stormwater infrastructure for the City of Bend and do not include a pipe network to collect storwmater and connect to the major trunklines identified for each basin. As mentioned earlier, if land is acquired for regional detention, the City would experience cost savings in reducing pipe sizes for discharge piping. However, some of these cost savings would be offset by construction costs for the regional facilities. Nevertheless, regional detention facilities are recommended for the City to pursue due to the advantages of water quality treatment and timing of installation. Aboveground facilities can be installed at intermediate locations, providing flood relief, and independent of downgradient pipe installation.

10.3 OPTIONAL CIP COMPONENTS

The City may wish to pursue several additional approaches for providing effective major basin drainage systems and potentially reduce costs of the basic option identified above. These optional components are presented in Table 10.2.

10.3.1 Maximizing Use of LID

The use of LID principles in projects constructed throughout the UGB would immediately address some of the chronic flooding while the City is building larger CIP projects to address flooding from major storm events. Examples of LID elements are rain gardens, porous pavement, ecoroofs, grassy swales, rain barrels, vegetative treatment, and storage under sidewalks and streets. Some of these systems may not be suitable for industrial areas. Porous pavement may not be suitable on slopes greater than 5 percent, for streets with heavy truck traffic, or for areas with a high water table.

An analysis was conducted to determine whether there would be a cost savings to the basic CIP by installing LID projects throughout the City. As mentioned earlier, if the water quality storm were disposed of on individual sites, the reduction of pipe sizes downstream would result in cost savings estimated to be $4,000,000, in 2008 dollars[4]. Costs for implementing this level of LID would range from about $6,000 to $20,000 per acre. The costs for residential land uses are at the low end of the range; commercial land use is at the high end. As the City implements the Stormwater Master Plan over the next 20 years and beyond, the costs savings from LID will continue to accrue. Costs savings can be experienced by the City when requiring development to implement LID principles in new and redevelopment. The City is in the process of updating its codes, ordinances, standards, and specifications to ensure that LID principles are incorporated into all new and redevelopment.

Based on this analysis, it is recommended that the City make LID a requirement of all new development and redevelopment. This will help alleviate drainage problems and demonstrate the benefits the City can count on when planning future drainage projects.

10.3.2 Regional Treatment Facilities

Cost estimates for regional treatment facilities for the northwest quadrant, draining north toward Tumalo Creek, are included in the basic CIP. Additional areas throughout the City could be used for storage, treatment, or disposal of stormwater. The City could pursue acquisition of property and construction of regional stormwater systems at a number of potential sites. The City should pursue opportunities to use these sites for construction of public stormwater facilities. Construction of these facilities in strategic locations could provide many benefits to the City. Feasibility studies should be conducted to evaluate sites for regional treatment potential. As regional detention sites are identified, evaluated, and constructed, the sequencing and sizing of capital improvement projects recommended in this chapter should be reevaluated. The recommended CIP does not include costs or benefits from the construction of regional detention facilities where they would be located is not known.

Land acquisition costs vary and are not discussed here. The cost of constructing water quality treatment facilities, such as ponds, is estimated to be $60,000 per acre.

[4] The cost savings of downstream facilities from constructing onsite low impact development facilities were estimated by calculating the volume of stormwater runoff for a water quality storm and identifying the remaining volume of runoff, which is equivalent to the volume of runoff for a 10-year storm.

10.3.3 New Development Construction

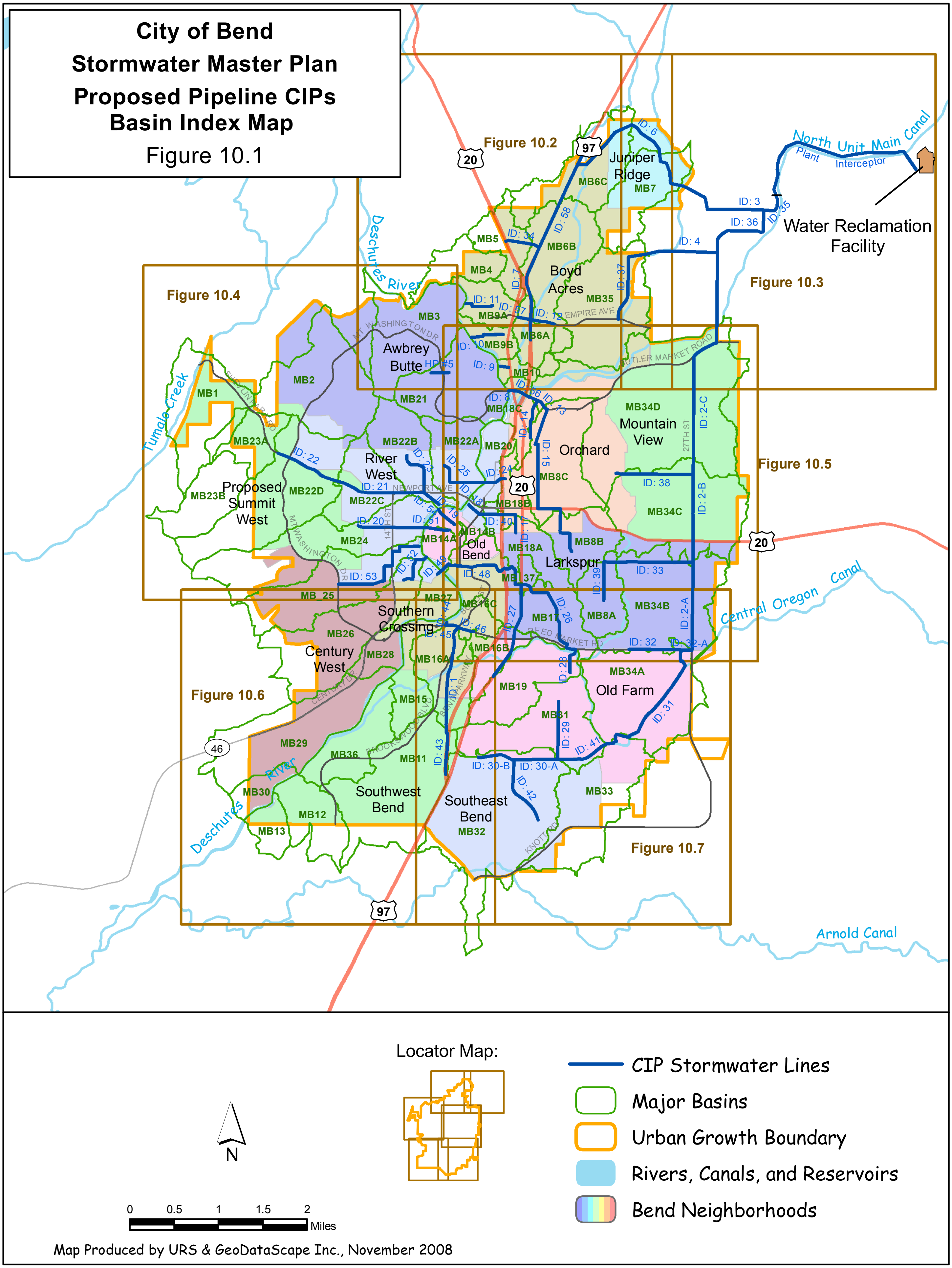
Wherever new development is planned, there are opportunities to construct regional stormwater systems. The City should explore opportunities to offer incentives for new development to construct regional stormwater facilities. These developments can be encouraged to participate in building new public infrastructure to facilitate development approval and to enhance opportunities for annexation. Savings on fees and approval times could also be used as incentives.

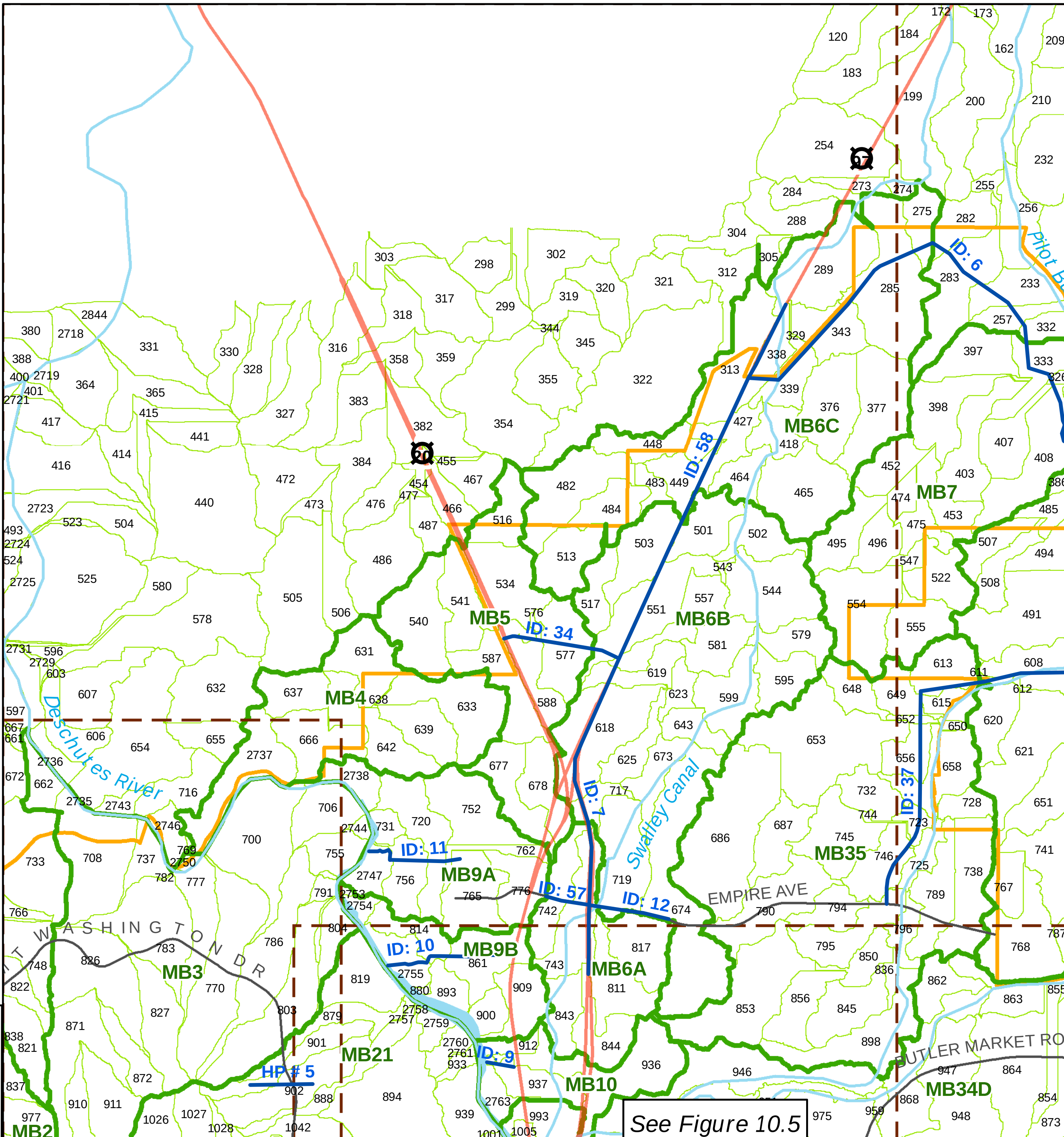
10.3.4 Opportunities to Coordinate with Other Agencies and Utilities

The City should also take advantage of opportunities that arise through coordination with other entities. Building a stormwater pipe simultaneously with new water lines or wastewater lines, for example, can save perhaps 60 to 70 percent of the cost of constructing a line independently. Opportunities may exist to work with other entities such as ODOT, irrigation districts, and BMPRD, which own land within the City. The Public Works Department will continue to coordinate with and ask for input from other City Departments such as Planning, Transportation, Engineering, Water, and Water Reclamation.

REFERENCES

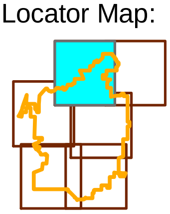
Oregon Department of Transportation Hydraulic Manual, 2005.


City of Bend
Stormwater Master Plan
Proposed Pipeline CIPs
Basin Index Map
Figure 10.1
Figure 10.2
Figure 10.3
Figure 10.4
Figure 10.5
Figure 10.6
Figure 10.7
North Unit Main Canal
Plant Interceptor
Water Reclamation Facility
Deschutes River
Tumalo Creek
Central Oregon Canal
Arnold Canal
Juniper Ridge
Boyd Acres
Awbrey Butte
River West
Proposed Summit West
Mountain View
Orchard
Old Bend
Larkspur
Southern Crossing
Century West
Old Farm
Southwest Bend
Southeast Bend
Locator Map:
CIP Stormwater Lines
Major Basins
Urban Growth Boundary
Rivers, Canals, and Reservoirs
Bend Neighborhoods
N
0 0.5 1 1.5 2 Miles
Map Produced by URS & GeoDataScape Inc., November 2008



City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.2

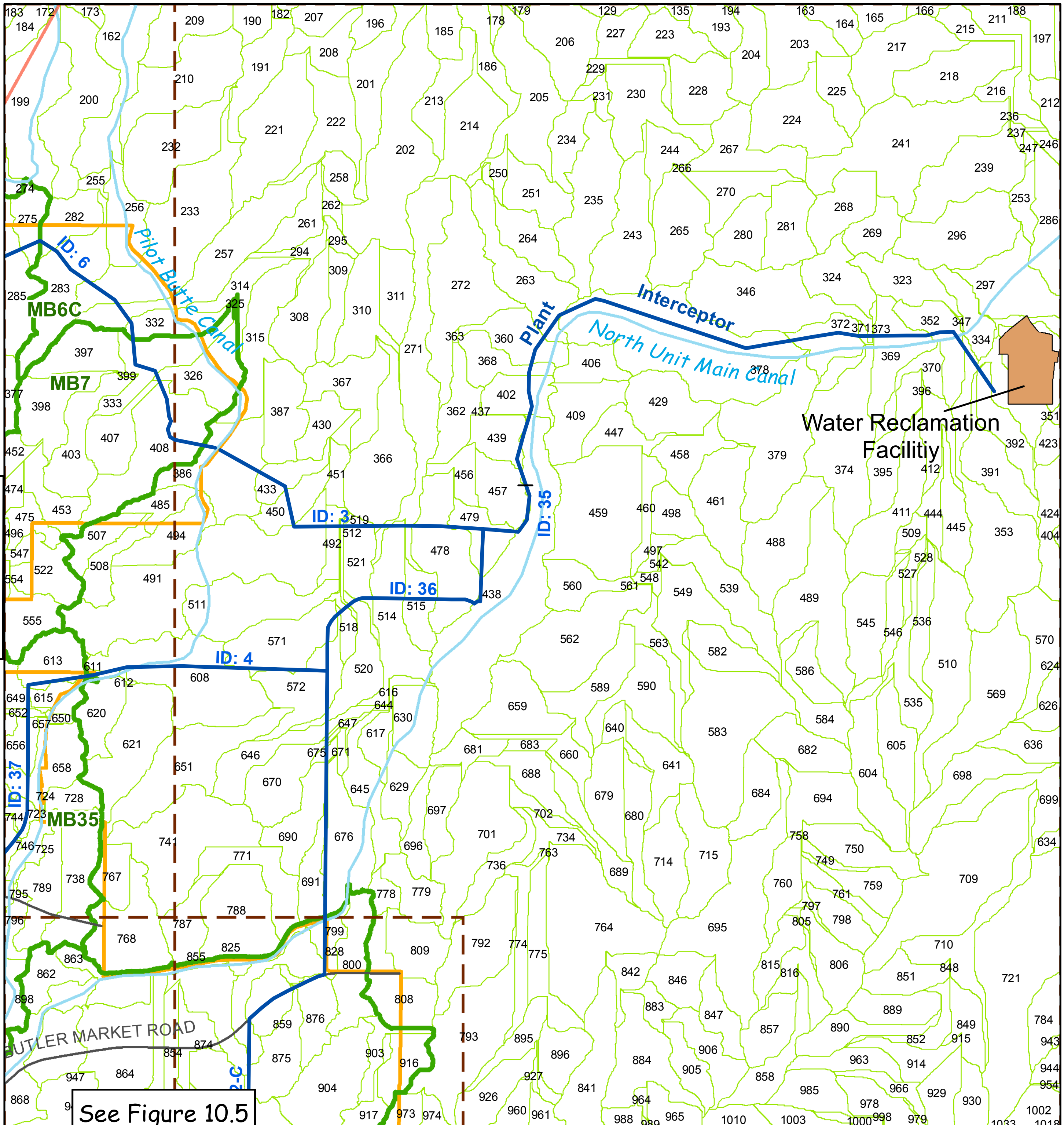
Locator Map:



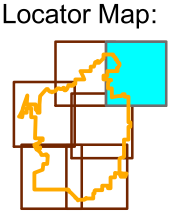
Major Basins
Subbasins
CIP Stormwater Lines
Urban Growth Boundary
Rivers, Canals, and Reservoirs
Adjacent Figure Bounds

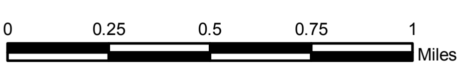
0 0.25 0.5 0.75 1 Miles

Map Produced by URS & GeoDataScape Inc., November 2008



City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.3

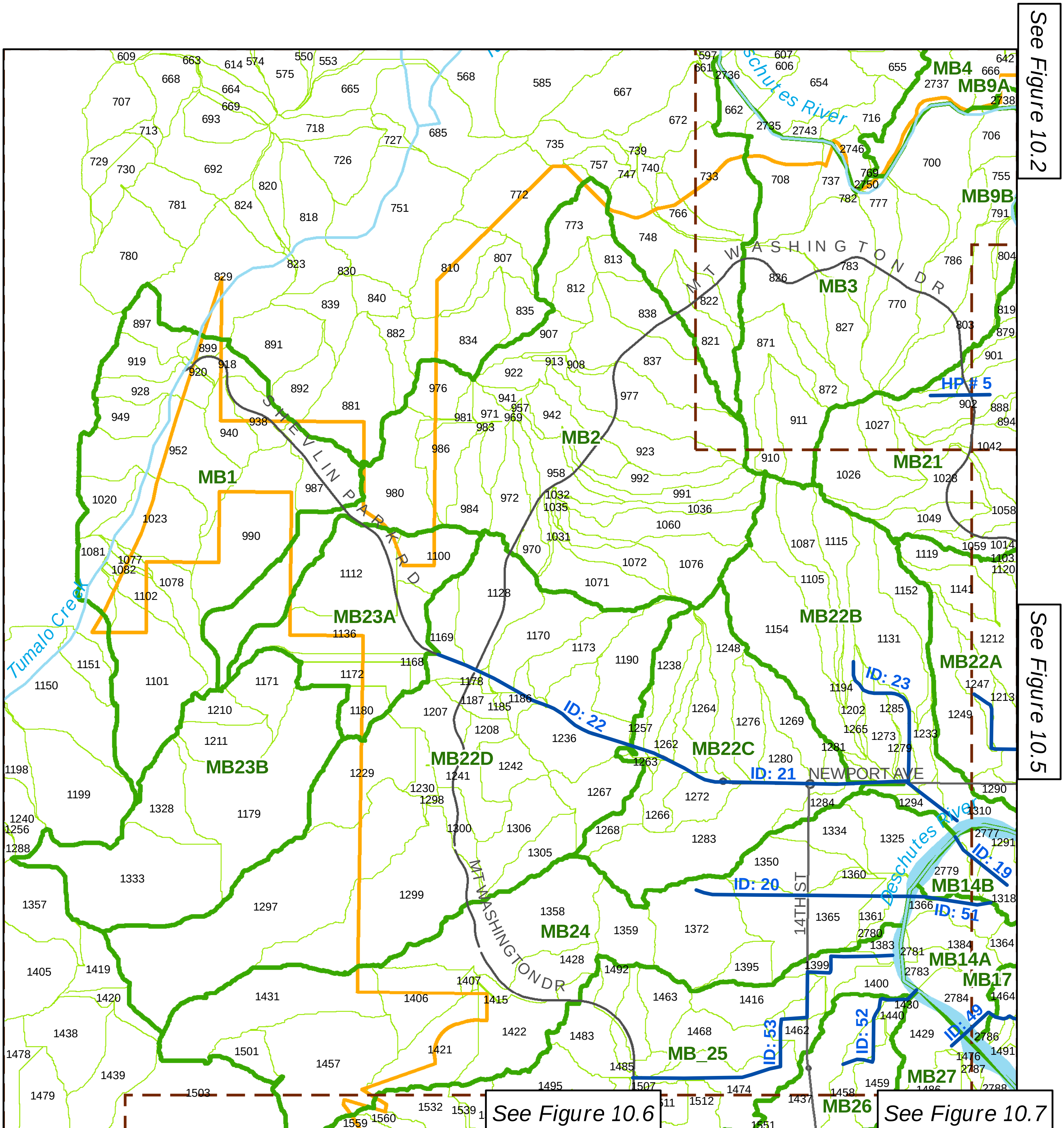




Major Basins
Subbasins
CIP Stormwater Lines
Urban Growth Boundary
Rivers, Canals, and Reservoirs
Adjacent Figure Bounds

N

Map Produced by URS & GeoDataScape Inc., November 2008



City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.4

0 0.25 0.5 0.75 1 Miles

Map Produced by URS & GeoDataScape Inc., November 2008

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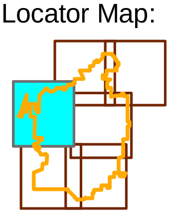
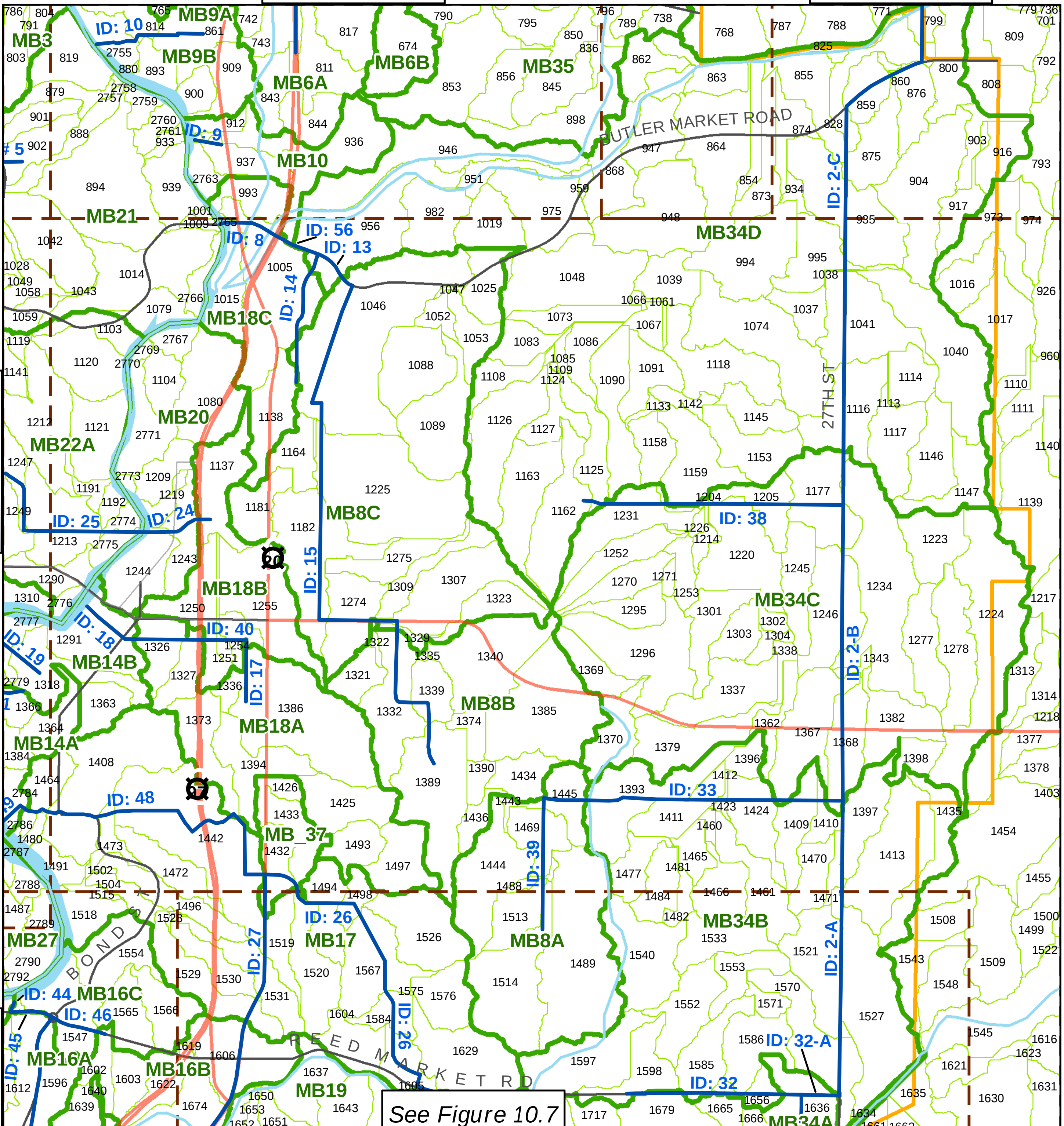


- *Major Basins*
- *Subbasins*
- *CIP Stormwater Lines*
- *Urban Growth Boundary*
- *Rivers, Canals, and Reservoirs*
- *Adjacent Figure Bounds*



Locator Map:

City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.5

Major Basins
Subbasins
CIP Stormwater Lines
Urban Growth Boundary
Rivers, Canals, and Reservoirs
Adjacent Figure Bounds

0 0.25 0.5 0.75 1 Miles

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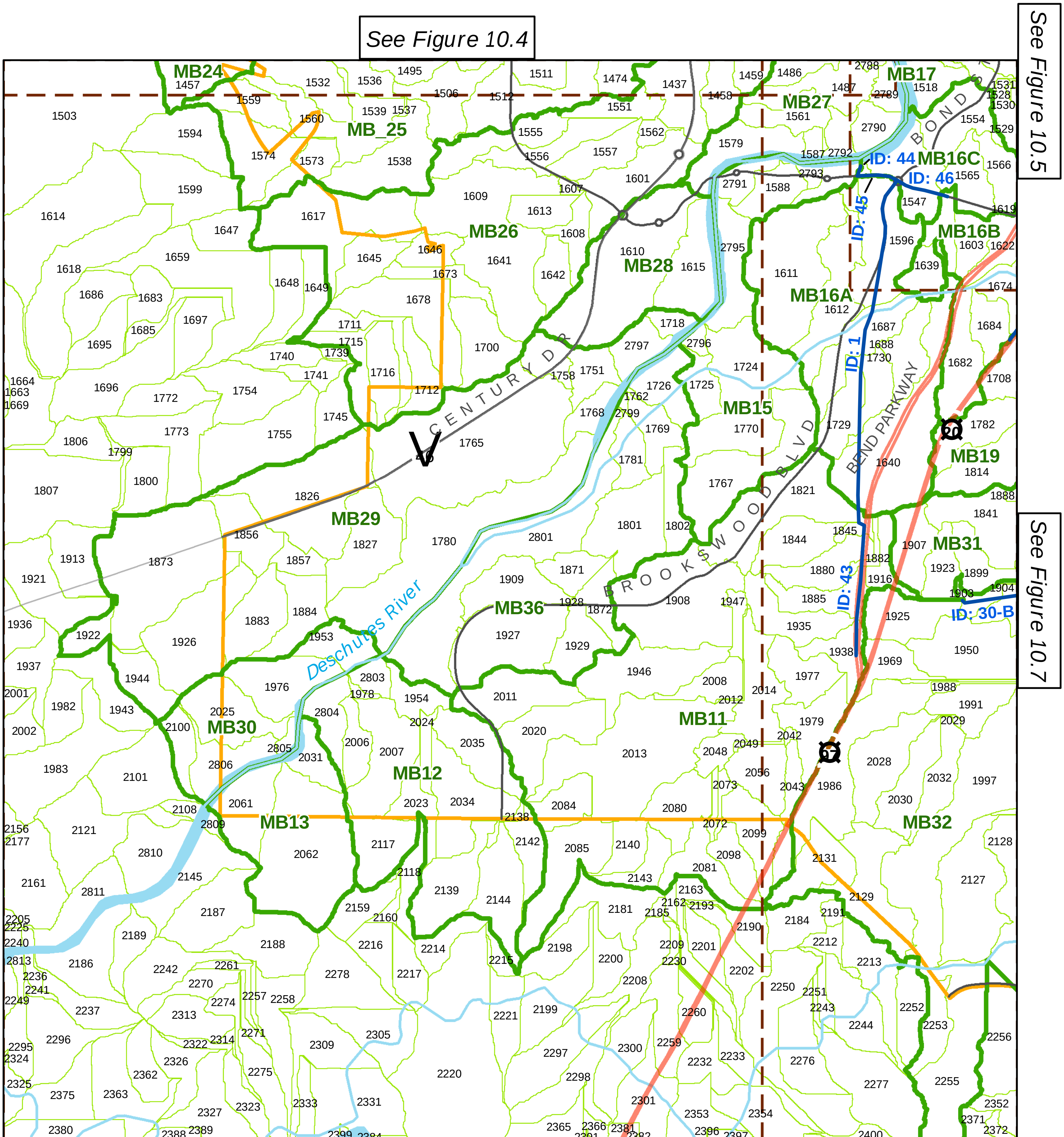
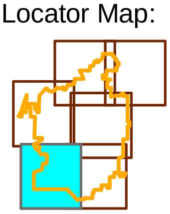


City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.6

Locator Map:



0 0.25 0.5 0.75 1 Miles

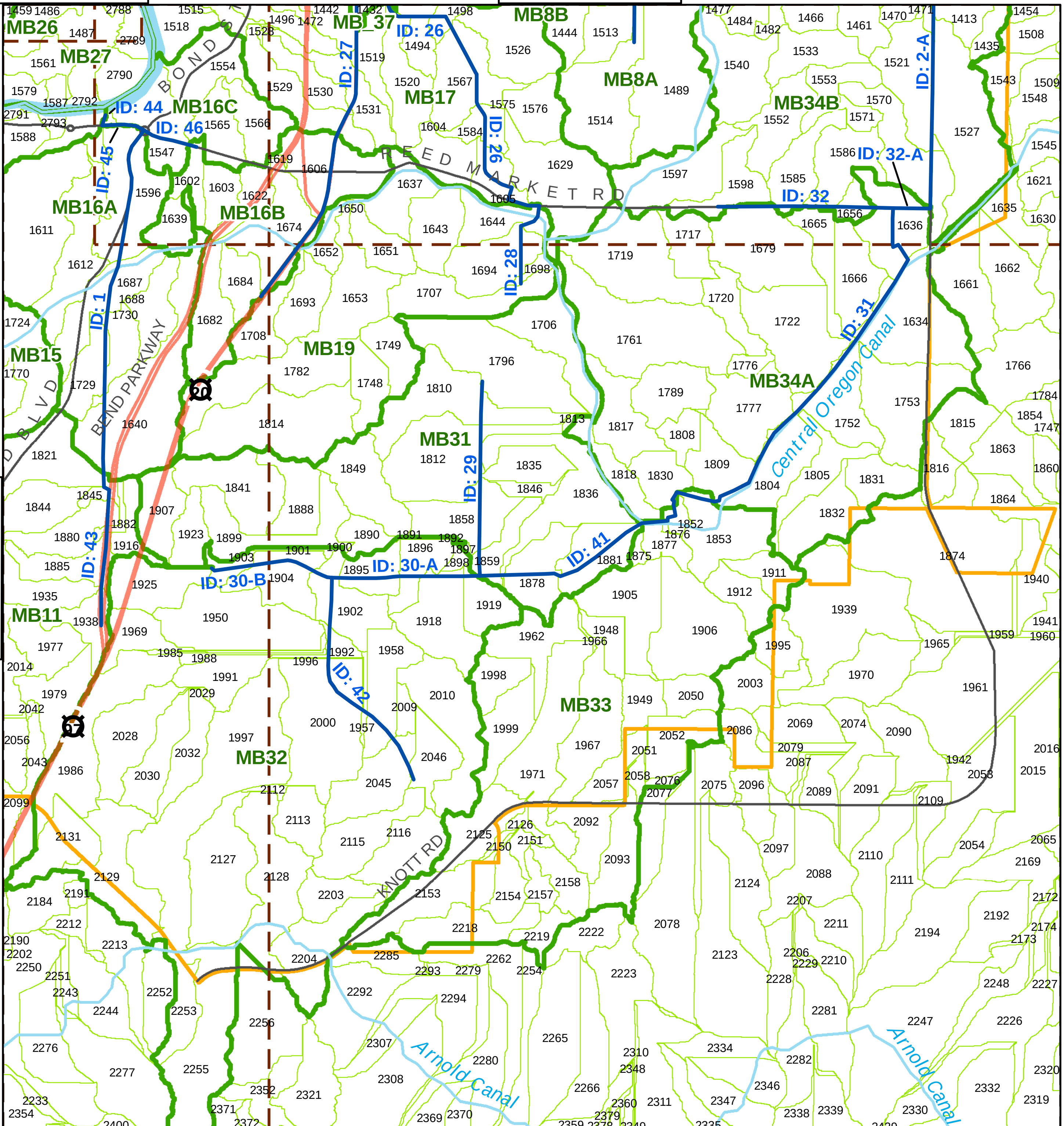
Map Produced by URS & GeoDataScape Inc., November 2008

- *Major Basins*
- *Subbasins*
- *CIP Stormwater Lines*
- *Urban Growth Boundary*
- *Rivers, Canals, and Reservoirs*
- *Adjacent Figure Bounds*

See Figure 10.4

See Figure 10.5

See Figure 10.6



City of Bend
Stormwater Master Plan
Detail, Proposed Pipeline CIPs
Figure 10.7

0 0.25 0.5 0.75 1 Miles

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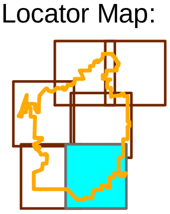
Locator Map:



- Major Basins
- Subbasins
- CIP Stormwater Lines
- Urban Growth Boundary
- Rivers, Canals, and Reservoirs
- Adjacent Figure Bounds

City of Bend Master Plan

Existing Problem Area Workshop

January 9, 2007

Summary of the five Highest Priority Existing Problem Drainage Sites:

1. Westside Village Shopping Center and Bend Fire Station – Simpson and 14th – NE Corner:
   An old commercial development, this area sits over shallow pink tuft where infiltration does not appear to work. In addition, catch basins are located away from the curb, allowing water to bypass existing drywells. A cascading effect starts at Safeway, adds flows from Ray's Foods, prior to inundating the fire station and, added flows from a storage facility, cause large volumes of water to flow into and through Nosler's manufacturing plant.

   Prioritization:
   Fire Life Safety – High; Property Damage – High; Visibility – High; Priority Number 1.

2. Franklin Underpass
   A low spot surrounded by a large amount of paving, this area floods readily during storms. Dry wells are unable to keep up with the volume and this area floods during many storm events.

   Prioritization:
   Fire Life Safety – High; Property Damage – Low; Visibility – High; Priority Number 2.

3. 3rd St. Underpass
   Similar to Franklin St., 3rd Street is a low spot surrounded by a large impervious area, and floods easily during storm events.

   Prioritization:
   Fire Life Safety – High; Property Damage – Low; Visibility – High; Priority Number 3.

4. Archie Briggs –
   Archie Briggs has a very steep roadway slope that collects water from an even steeper hillside. The roadway in the lower areas is damaged from the large amount of water coming through the area. Stormwater blocks one of the lanes of traffic and then leaves the uncurbed roadway to drain into residential property.

Prioritization:
Fire Life Safety – High; Property Damage – Medium; Visibility – Medium; Priority Number 4.

5. Fairview Heights on Awbrey Butte:
   Both public and private stormwater combine to create this problem area. A large part of Awbrey Butte drains to culverts and through residential sites, at one point entering peoples' homes, prior to draining to the golf course below. Easements are located throughout the development, and on the golf course. However, they don't line up well and water tends to go straight, detouring around some of the easements.

   Prioritization:
   Fire Life Safety – Low; Property Damage – High; Visibility – High; Other – High Liability; Priority Number 5.

   Potential Solutions:
   Need to reduce debris load;
   Need to reduce speed of water;
   Some of the water passes through a 90 degree angle;

City of Bend Master Plan

Existing Problem Area Workshop

January 9, 2007

Attendance: Ollie Fick, Wendy Edde, Mike Miller, Kevin Ramsey, Mike Linkof, Cindy Hartman, Aaron Henson, Jeff Nelson, Ela Whelan, Don Kliewer, Sarah Hubbard Gray, Jim Harrakas, Jon Rudders.

This workshop was held to identify, specifically locate, and discuss the major stormwater problem areas in the City. Most of these problems are flooding problems although water quality is an issue and sometimes contributes to the flooding problems.

After listing all the problems, a process for prioritizing the problems was discussed and implemented. Ten high priority sites were selected for field visits with the goal of developing conceptual solutions and planning level cost estimates for 5 sites. Prioritized sites should include projects that may be completed this year. Larger projects, such as a piping system for downtown, may not be completed for some time.

Problems identified included:

1. Westside Meadows (Wine Country):
   Shevlin Park Rd. at Shevlin Meadows Drive – Skyline Ranch Road and Chardonay - this project is already being addressed by the City and is off the table for this effort. Costs for the resolution of this work will be provided to URS for inclusion in the master plan CIP.

   Prioritization:
   Fire Life Safety – High; Property Damage – High; Visibility – High (still off the table for this project).

2. Shevlin Ridge – same as above, not to be included in this effort.

3. City Heights on Awbrey Butte:
   Property Damage issue,
   drill holes are plugged leaving nowhere for the drainage to go;
   private property erodes;
   flooding onto private property;
   erosion is causing the drill holes to plug;
   bark dust and debris erode, plugging the drill holes.
   Bark dust is primary contributor.
   Need a “bark is bad” campaign.

Need private property stabilization; education and code enforcement;
about 70% of people participate in private fixes;
a downstream pipe about 300 feet away could be connected to for overflow stormwater;

Prioritization:
Fire Life Safety – Low; Property Damage – High; Visibility – Low; Priority Number 10.

Potential Solutions:
Stabilize the soil
Provide code enforcement
Add detention to the stormwater system
Talk to landscapers about site stabilization techniques
Homeowners Association might be helpful
An existing pipe, about 300 ft. away, could be used to pipe away excess flows;

4. Fairview Heights on Awbrey Butte:
Public and private water combined;
Parks and recreation own a trail;
Awbrey Butte master plan is about 30 years old;
Easements don't line up in the development;
City has easements all the way to the golf course, but drainage takes detours.
Water moves from public to private and back to public ROW;
Water goes through someone's garage;
The water eventually winds up at the golf course, for which there are easements;
There is a large tributary area, about half of Awbrey Butte, that drains to this problem;

Prioritization:
Fire Life Safety – Low; Property Damage – High; Visibility – High; Other – High Liability; Priority Number 5.

Potential Solutions:
Need to reduce debris load;
Need to reduce speed of water;
Some of the water passes through a 90 degree angle;

5. Neff at Pilot Butte School:
School District – this problem is in the process of being resolve and is not to be included in this project.
Runoff excessive.
This problem is partially corrected.
School is working at fixing the rest of the problem.
This project not needed to be included in this effort.

6. Westside Village Shopping Center and Bend Fire Station – Simpson and 14th – NE Corner
   Shallow pink tuft in this area;
   Infiltration doesn't appear to work;
   There were design problems with this development;
   The catch basins are located to far away from curb to receive water;
   This is an old commercial development;
   There is a cascading effect – Safeway drains to Simpson, that drains to Ray's, that drains to the fire station and finally to Nosler.

   Prioritization:
   Fire Life Safety – High; Property Damage – High; Visibility – High; Priority Number 1.

7. Greenwood Underpass – also number 8 and 20 – Underpasses; Greenwood, Franklin and 3rd St:
   UIC issue;
   Franklin – easy to pump; pump to Hill St., then to River.
   3rd Street – need tank and pump.
   Existing containment; need second containment.

   Prioritization:
   Fire Life Safety – High; Property Damage – Low; Visibility – High; Priority Number 2&3.

8. Franklin Underpass – See number 7

9. Street at Mike's Fence at Hayes St.
   Private Property issue.
   Consultant has been hired; property owners are working to fix.
   Not to be included in this project.

10. Alley behind Ernestos
    Drill holes have failed.
    Private and public runoff overflowing drill holes.

    Prioritization:
    Fire Life Safety – Low; Property Damage – High; Visibility – Low;

11. Wall Street Downtown
    Business District
    Lots of flooding
    Minnesota and Wall – bigger problems
    Old system
    Piped system not adequate.
    Downspouts are major part of the problem

Basements used as detention.
Existing piped system to River
System surcharges.
Tin Pan Alley
Roof runoff biggest problem.

Prioritization:
Fire Life Safety – Low; Property Damage – Medium; Visibility – High;

12. 2nd and Lafayette
    See Number 10 above.

13. 1st and Mission Linnen
    Older industrial area.
    Failing drill hole.
    No drainage.
    Lots of private drainage.

14. Paula and Williamson; by St. Charles.
    Drill hole and drywells in pink rock; system doesn't handle runoff;
    Drain gets overpowered;
    East side of River
    1160 Paula, specific address, floods every time.
    Drainage system doesn't work.
    Takes water eventually, just floods for awhile.

    Prioritization:
    Fire Life Safety – Low; Property Damage – High; Visibility – Low;

15. Virginia and Windermere
    Not included in this project.

16. Revere between12th and 13th
    Flooding occurs in house.
    Not included in this project; City staff repairing.

17. Deer Glen Park Apartments
    Behind sewage treatment plant on Brosterhouse
    High water
    When developed will be a problem.
    Not an issue for now.

18. Drake Road – high priority
    Off Harmon
    Infill development
    Low spot;
    Floods houses
    Located below river level; close to River.
    Basements flood.
    West side of Deschutes River; just past Newport Bridge;
    A couple of drill holes are failing
    Stormwater surcharges sewer
    Groundwater is high
    Drake west is a problem.

    Prioritization:
    Fire Life Safety – Low; Property Damage – High; Visibility – Low; Other – Powerful; Priority Number 6.

19. Shields – NW Crossing entryway.
    South of Shevlin Park
    Built in natural drainageway
    Dry wells are failing
    Low spots are a problem
    Wave action from traffic pushes water into houses
    Pink Rock area
    Area doesn't drain
    Don't include this problem at this time.

    Prioritization:
    Fire Life Safety – Low; Property Damage – High; Visibility – High; Other – Future Development may help;

20. 3rd Street Underpass – see number 7

21. Backstrom's – at NE Thurston and Seward, at 2nd.
    All impervious;
    Impacts wastewater pump station
    Low spot
    Drill holes don't work
    Drains from Revere to Seward down hill to Thurston.
    Stormwater coming from ODOT and Mall
    5 drill holes, at lumberyard, don't work.
    Can't maintain system
    May be greater than 100 feet deep
    Division St. works.
    Option – pipe under railroad to West Division St.
    Robertson drains across highway.

Prioritization:
Fire Life Safety – Low; Property Damage – High; Visibility – Medium;

22. Wildcat
    1545 Skylark
    Cul de Sac
    Drill hole fills with boulders and rock.
    When maintained, system works.
    System doesn't drain.
    Kids fill up and play in ponds.
    Mostly a maintenance issue.

    Prioritization:
    Fire Life Safety – Low; Property Damage – Medium; Visibility – Low;

23. Archie Briggs – both sides of River.
    East Side – Caddisfly Lane – not major problem
    Several spots are a problem.
    East side problem not as sever as west side problem.

    Bigger problem on west side of river.
    Stormwater blocks lane
    Stormwater leaves roadway and goes to common area.
    Owned by Rimrock West
    Road way not curbed and is steep

    Prioritization:
    Fire Life Safety – High; Property Damage – Medium; Visibility – Medium;
    Priority Number 4.

24. Murray Road off Boyd Acres, Brian's Cabinets
    Fuqua
    Property owners in compliance.
    No drainage.
    No curbing.
    Old County Road has been paved.
    Paved everything.
    10 acres of asphalt.
    Old industrial area.

    Prioritization:
    Fire Life Safety – Low; Property Damage – High; Visibility – Low; Other – Large employer; Priority Number 9.

25. First St., below Todd's Crest; - off Mt. Washington.

Stormwater from homes empty to street, to 1st Avenue.
Drainage takes out trail and garage.
Todd's Crest is private.
Todd Crest flows to 1st and then to River via trail.

Prioritization:
Fire Life Safety – Low; Property Damage – Medium; Visibility – Medium/Low;

26. Reed Market and Tangle Wood, Arbor Wood
    Old area
    CIP issue
    No existing system
    Tangle Wood – failed drill hole
    Drainage from Reed Market
    No drainage system at Reed Market.

    Prioritization:
    Fire Life Safety – Low; Property Damage – Medium; Visibility – Low; Other – Single Property Issue.

27. Glassow and Sumit
    Summit – 12th St.
    Floods a house.
    Old System.
    Drains into house when overflowing dam.

    Prioritization:
    Fire Life Safety – Medium; Property Damage – High; Visibility – Low;

28. Clearwater and York
    From Summit High School and business
    Exist downtown overwhelmed
    Drainage in street not working;
    Pink rock
    Drywells don't work.
    Empties into one house.

    Prioritization:
    Fire Life Safety – Medium; Property Damage – High; Visibility – High; Priority Number 7.

29. Olney and 4th NE
    On Olney, east of 4th.
    Drywells drain to homes;
    Drywells too high;
    May need to dig drywells deeper, east of 4th;

Take to River, put in swales.

Prioritization:
Fire Life Safety – Low; Property Damage – High; Visibility – High; Priority Number 8.

30a. Roundabout at College Way and Newport;
Older and newer drainage;
New roundabout.
Systems don't work.
A dam has been created by the roundabout that diverts water.
Portland intersection.
Insufficient catch basin capacity.
This problem not included in this effort.

Prioritization:
Fire Life Safety – Low; Property Damage – High; Visibility – High; Other – Flows into Gas Station.

30b. Intersections with Revere – not now, but include eventually.

31. 9th and Textron
Industrial area.

Prioritization:
Fire Life Safety – Medium; Property Damage – Medium; Visibility – High;

Additional flooding problems discussed:

32. The Forum
33. Medical Center and Naef Road
34. Faith Drive and Wichita Way
35. Riverside and McCann

Discussion:
Maintenance issues need to be addressed.
Most systems are receiving too much water.
Explore options for limiting flows to existing systems – remove flows upstream.

Prioritization:
Criteria explored for prioritization include:

- Safety/Health/Fire
- Regulatory
- Visibility

- Costs for repair
- History of flooding – length of problem
- Apparent Solution
- Property Damage (actual and perceived)
- Access
- Water Quality Concern
- Number of Complaints
- Severity of Flooding
- Private versus public flooding
- Equity added to list – fair geographic distribution

Other issues were added to specific problem areas, as they arose in the discussion. Ratings for each problem are listed with the problem description.

Safety, property damage, and visibility/equity were deemed to be the top three issues to use in developing the top ten priorities for the City. Visibility would be evaluated first and equity would be considered after the ten sites had been chosen. To reduce the number of sites to ten, first sites, that had not been eliminated for other reasons, receiving high evaluations in all three categories were chosen. Following that, receiving a high in Fire/Life/Safety were selected next. Sites with two high evaluations were included as well as sites that had Other considerations, such as high liability. This produced too many sites, and staff evaluated each of the lower priority sites included in the previous evaluation, to determine which the City could tackle themselves, which could wait, and which should be included in the existing problem evaluation being conducted by URS. Ten sites will be examined in the field by the URS team, and five will be selected to develop conceptual solutions and planning level costs.

Evaluation criteria are listed with each problem description above, along with priority number. Only the top ten problems received a priority number. Most of the problems that were not deemed to be part of this project did not receive a criteria rating.

Results of the prioritization process included the following sites:

Nr 3. City Heights at Awbrey Butte; Priority Number 10.
Nr 4. Fairway Heights at Awbrey Butte; Priority Number 5.
Nr 6. Simpson and 14th; Priority Number 1.
Nr 8. Franklin Underpass; Priority Number 2.
Nr 18. Drake Rd. – off Harmon; Priority Number 6.
Nr 20. 3rd St. Underpass; Priority Number 3.
Nr 23. Archie Briggs – West Side; Priority Number 4.
Nr 24. Murray Rd. – off Boyd Rd.; Priority Number 9.
Nr 28. Clearwater and York; Priority Number 7.
Nr 29. Olney and 4th; Priority Number 8.

Mike Linkoff and Kevin Ramsey are the best source of answers with questions about each problem. Both work Wednesdays, which would be the best time to reach them.

Mike is preparing a summary of all of the problem areas and the summary will be available on Friday of this week.

City of Bend Stormwater Priority Problem Areas - Final Draft **20-Sep-07**

Cost Summary		**Construction Costs**		**Twenty Year Maintenance**	
Priority and Location	**Alternative:**				
Priority One	Alternative 2	**$**	**2,122,325**	$	873,200
Westside Village Shopping Center					
Priority Two	Alternative 1		**$931,250**		$365,500
Franklin Avenue Underpass					
Priority Three					
3rd St. Railway Underpass					
Rdway and A	Alternative 3	$	2,988,310	$	1,824,000
Area B		$	1,723,615	$	101,000
Area C		$	5,540,115	$	101,000
Area D		$	1,588,850	$	51,000
	Subtotal	**$**	**11,840,890**		
Priority Four			**$608,935**		$300,000
Archie Briggs - West Side					
Priority Five		**$**	**529,240**	$	155,000
Fairway Hts. at Awbrey Butte					
	Total	**$**	**16,032,640**		

Schedule - Timeline for Construction

2007 - 2008	2008 - 2009	2009 - 2010	2010 - 2011	2011 - 2012
Design Priority No. 1 for a regional solution - Westside Village Shopping Center				
Start implementing solutions for 3rd St.Underpass - remove/minimize upstream drainage areas.				
	Construct Priority No. 1 Reprioritize Problem Areas Based on Masterplan Design Priority No. 2 - Franklin Avenue Underpass			
		Construct Priority No. 2 Design Priority No. 3 - 3rd Street Underpass		
			Construct Priority No. 3 Design Priority No. 4 & 5- Archie Briggs and Awbrey Butte	
				Construct Priority No. 4 & 5 Design Priority No. 6

Proj # **Name:** **#6 WESTSIDE VILLAGE SHOPPING CENTER AND BEND FIRE STATION - Simpson & 14th (NE Corner)**
PRIORITY 1

Existing Condition Description

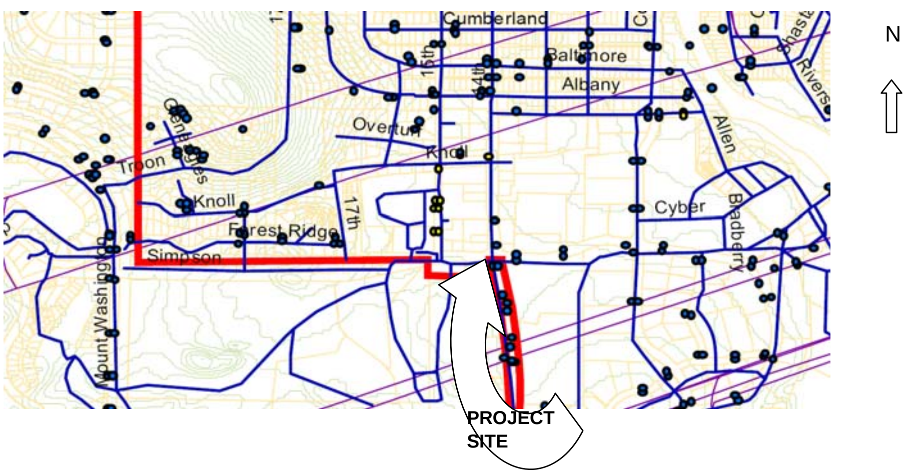
This area is prone to flooding during heavy rainfall, causing the flooding of Simpson Street and affecting the operation of the Fire Station. A runoff cascading effect occurs when drainage from the east side of Safeway moves north to Simpson Street, then proceeds north to Ray's Market, continuing east to the Fire Station, and combining the the storage units north, to finally travel north east to flood Nossler's manufacturing plant. Up to one foot of water has hit the back door at Noslers and traveled through the plant. Infiltration does occur, but is very slow in the existing Drywells/Drill Holes; possibly due to the very slow draining, shallow, pink tuft in this area. An additional drainage issue for this old commercial development includes catch basins and drywells located too far from the curbs to receive water or too high in elevation to recieve water. A recently constructed bioswale in the median between the fire department and the commercial area may help with some of the localized flooding.

Prioritization:
Fire Life Safety – High; Property Damage – High; Visibility – High; Priority Number 1.

Alternatives

1. Install storage tanks and drill holes.
   Sediment manholes ahead of storage vault.
2. Install pipe that carries all water to Deschutes River.
   Sediment manholes ahead of storm drain pipe.

Map:



	Drainage Area Served by Capital Project :	9.5	Acres
	% Impervious (Existing) :	87%	
Design Storm	Water Quality Treatment	2/3 of 2 year	1"/24 hr.
	Storage	25	2.5"/24 hr.
	Safe Passage	100	3.1"/24 hr.

Return Frequency Storm	**Area 1**	**Total Study Area (1&2)**
Assume Type II storm	**2.6 acres**	**9.5 acres**
2/3 of 2 year	2.2 cfs; 6,700 cf	7.1 cfs; 23,900 cf
25 year	6 cfs; 19,700 cf	19.9 cfs; 71,000 cf
100 year	7.6 cfs; 25,000 cf	25.2 cfs; 90,500 cf

Summary of Costs	**Alternative 1**	**Alternative 2**
Construction Costs	$ 2,153,525	$ 2,122,325
Twenty Year Maintenance	$ 74,000	$ 873,200
Total Life Cycle Costs	$ 2,227,525	$ 2,995,525

Project Elements **Alternative No. 1** Install equalization containment vaults and drill holes.

Item No.	Description	Quantity	Units		Unit Cost	Total Cost
1	Decommission existing drywells[1]	10	EA		$ 2,000	$ 20,000
2	Infiltration capacity testing	1	LS		$ 750	$ 800
3	Install new drill holes	4	EA		$ 5,000	$ 20,000
4	Install stormfilters for new drywells[2]	2	EA		$ 5,000	$ 10,000
5	Install sedimentation manholes	4	EA		$ 1,500	$ 6,000
6	Install storage tanks[3]	540,000	Gallons		$ 2	$ 1,080,000
7	Rock Hammer for pink tuff	150	Hour		$ 150	$ 22,500
8	Onsite piping to storage tanks	1	LS		$ 10,000	$ 10,000
9	Dwnstrm channel - 100 yr storm overflow	1	LS		$ 8,000	$ 8,000
10	Erosion Control	1	LS		$ 5,000	$ 5,000
11	Traffic Control	1	LS		$ 20,000	$ 20,000
12	Mobilization	1	LS		$ 95,000	$ 95,000
						$ 1,297,300
	Design/Constr (30%)					$ 389,200
	Property Acquisition					$ -
	Construction					$ 1,297,300
	Other					$ -
	Administration (11%)					$ 142,700
	Contingency (25%)					$ 324,325
					Total Construction Cost	**$ 2,153,525**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Clean Sediment MH	4	EA	Annually	$ 500	$ 2,000
Clean drill holes	2	EA	Annually	300	$ 600
Change filters	4	EA	Annually	150	$ 600
Clean holding tanks	2	EA	5 year interval	1000	$ 2,000
				Total Annual Maintenance Cost	$ 3,700
				Twenty Year Maintenance Cost	**$ 74,000**
				Total Project Cost for 20 yrs.	**$ 2,227,525**

Project Elements **Alternative 2** Construct pipe that discharges water to Deschutes River.

Item No.	Description	Quantity	Units		Unit Cost	Total Cost
1	Decommission existing drywells[1]	10	EA		$ 1,000	$ 10,000
2	Construct new storm drain[4]	470	LF	48" dia. pipe	$ 200	$ 94,000
3	Construct new storm drain[4]	2000	LF	60" dia. Pipe	$ 300	$ 600,000
4	Construct new sedimentation manholes/catch basins	8	EA		$ 1,500	$ 12,000
5	Construct pipe network to new pipe	1	LS		$ 10,000	$ 10,000
6	StormFilter Treatment System[5]	2	EA		$ 197,250	$ 394,500
7	Add energy dissipation at outfall	1	LS		$ 65,000	$ 65,000
8	Erosion Control	1	LS		$ 8,000	$ 8,000
9	Traffic Control	1	LS		$ 20,000	$ 20,000
10	Mobilization	1	LS		$ 65,000	$ 65,000
						$ 1,278,500
	Design/Constr Admin (30%)					$ 383,600
	Property Acquisition	Note: Downstream Easement for 100 yr. overflow might be donated.				$ -
	Construction					$ 1,278,500
	Other					$ -
	Administration (11%)					$ 140,600
	Contingency (25%)					$ 319,625
					Total Construction Cost	**$ 2,122,325**

Maintenance Requirements

	Quantity		Frequency		
Maintain water quality facility	215	EA	Annually	150	$32,250
Clean sediment manholes	8	EA	Annually	500	$4,000
Clean storm drain	2,470	LF	Every 5 year	12	$29,640
				Total Annual Maintenance Cost	$ 43,660
				Twenty Year Maintenance Cost	**$ 873,200**
				Total Project Cost for 20 yrs	**$ 2,995,525**

Notes:

1 *Includes removal of access to drywell and capping per State regulations.*
2 *Includes construction of a facility with 2 cartridges, to treat 0.06 cfs.*
3 *Includes construction of two tanks; One tank, 100 ft. by 33 ft. by 8 ft. deep; one tank 100 ft. by 86 ft. by 8 ft. deep; assumes 2 ft. freeboard; includes excavation, except rock exc., bedding, backfill.*
4 *Storm drain costs include manholes, inlets, bedding, backfill, and surface restoration.*
5 *Includes construction of 2 water quality facilities with a total of 215 cartridges, to treat a total of 7.1 cfs.*

6 Alternative 2 presents a piped solution that is sized to address the priority problem at the Westside Village Shopping Center and the Fire Station only, and is therefore to be used largely for comparison purposes to other alternatives. This solution could evolve into a regional solution, addressing a larger drainage area and additional flooding concerns. Larger piping and treatment facilities would be included in a regional solution.

7 These alternative assume all of the drainage is conveyed and treated, including drainage from both private and public properties. Of the 9.5 total acres, 7.32 acres are on private property, or about 77%, 0.23 acres are public property, or 23%.

Proj # **Name:** **#8 FRANKLIN UNDERPASS**
PRIORITY 2

Existing Condition Description

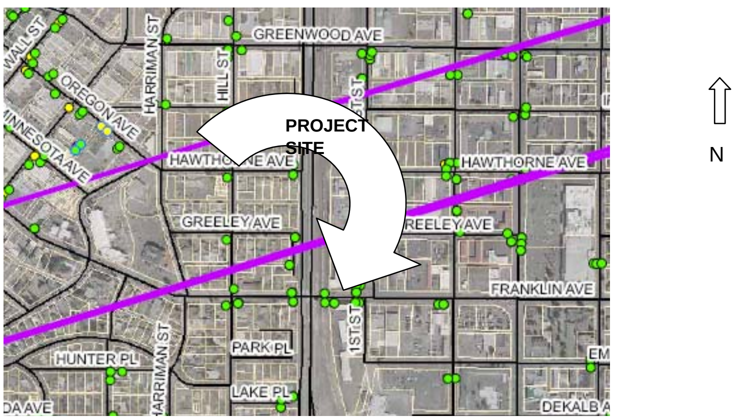
The Franklin Avenue underpass is underwater during heavy rainfall events. Flooding causes the underpass to be closed to traffic requiring difficult and time consuming detours for emergency vehicles as well as the general public. The existing on-site improvements are drillhole/basins linked to concrete containment vaults under the pedestrian walkway. The existing drillhole/basins work during average rain events when the systems are kept on a quarterly cleaning cycle, but are unable to keep up during moderate to heavy rains. The addition of storm water runoff from surrounding business property has the greatest impact on the system. As adjacent private property drainage systems fail, stormwater overflows into Franklin St., causing flooding and requiring pumping of the underpass.

Alternative:

1. Flows for up to 25 year storm, are pumped west to Wall Street for gravity drainage and treatment prior to discharging to the Deschutes River.
   Install (1)-200 gpm, (1)-750 gpm & (2)-1,500gpm pumps into new pump vault/storage facility
   Install 2 sediment manholes prior to pumps
   Install new discharge piping to Wall St.
   Install treatment for River discharge

2. Same as above, with exception of pumping flows for a 100-year storm.
   Install (1)-200 gpm, (1)-750 gpm & (2)-2,200 gpm pumps into new pump vault/storage facility
   Install 2 sediment manholes prior to pumps
   Install new discharge piping to Wall St.
   Install treatment for River discharge

Map:



	Drainage Area Served by Capital Project :	1.35	Acres	(Roadway)
	% Impervious (Existing) :	100%		
Design Storm	Water Quality Treatment	2/3 of 2 year	1"/24 hr.	
		25 year	2.5"/24 hr.	
		100 year	3.1"/24 hr.	

Return Frequency	**Area 1**	**Total Study Area**
Assume Type II storm	(Roadway)	(Roadway plus private area)
2/3 of 2 year	1.4 cfs; 3,900 cf	3.6 cfs; 10,800 cf
25 year	3.7 cfs; 11,100 cf	9.7 cfs; 31,900 cf
100 year	4.6 cfs; 14,000 cf	12.4 cfs; 41,000 cf

Summary

	Alternative 1	**Alternative 2**
Construction Costs	$ 931,250	$ 1,092,610
Twenty Year Maintenance Costs	$ 365,500	$ 365,500
Total Life Cycle Costs	$ 1,296,750	$ 1,458,110

Project Elements **Alternative #1** Pump 25 year flows west to Wall St.; stormfilter treatment for water quality storm

Item No.	Description	Quantity	Units	Unit Cost	Total Cost
1	Decommission Existing Drywells[1]	7	EA	$ 2,000	$ 14,000
2	1,500 GPM pumps*	2	EA	$ 18,000	$ 36,000
3	750 GPM pump	1	EA	$ 8,000	$ 8,000
4	200 gpm pump	1	EA	$ 1,500	$ 1,500
5	Pump controls	1	LS	$ 10,000	$ 10,000
6	Electrical power	1	LS	$ 25,000	$ 25,000
7	Build new precast pump vault[2]	48	CY	$ 1,275	$ 61,200
8	Excavation - boring & drilling	551	CY	$ 20	$ 11,000
9	Backfill	383	CY	$ 15	$ 5,700
10	10" discharge piping[3]	4,510	LF	$ 50	$ 225,500
11	36" gravity line	175	LF	$ 170	$ 29,800
12	Sedimentation Manholes	2	EA	$ 1,500	$ 3,000
13	Water Quality Treatment	1	EA	$ 52,500	$ 52,500
14	Erosion Control	1	LS	$ 5,000	$ 5,000
15	Traffic Control	1	LS	$ 22,800	$ 22,800
16	Mobilization	1	LS	$ 50,000	$ 50,000
					$ 561,000

Design/Constr Admin (30%)	$ 168,300
Property Acquisition	$ -
Construction	$ 561,000
Other	$ -
Administration (11%)	$ 61,700
Contingency (25%)	$ 140,250
Total Construction Cost	**$ 931,250**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout sedim. manholes	2	EA	Annually	500	$ 1,000
Change water quality filters	43	EA	Annually	150	$ 6,500
Maintain Pumps	4	EA	Annually	1,000	$ 4,000
Clean stormdrain line	2,255	LF	Every 5 years	12	$ 27,100

Annual Maintenance Cost	$ 18,275
Twenty Year Maintenance Cost	**$ 365,500**
Total Project Cost for 20 years	**$ 1,296,750**

* Pump sequence: 200 gpm pump starts for small flows;
With increasing flows, 750, gpm pump starts, 200 gpm pump shuts down;
First 1,500 gpm pump starts next;
Second 1,500 gpm pump starts next;
200 gpm added to other pumps provides the 25 year capacity.

Project Elements **Alternative #2** Pump 100 year flows west to Wall St.; stormfilter treatment for water quality storm

Item No.	Description	Quantity	Units	Unit Cost	Total Cost
1	Decommission Existing Drywells[1]	7	EA	$ 2,000	$ 14,000
2	2,200 GPM pumps	2	EA	$ 25,000	$ 50,000
3	750 GPM pump	1	EA	$ 8,000	$ 8,000
4	200 gpm pump	1	EA	$ 1,500	$ 1,500
5	Pump controls	1	LS	$ 10,000	$ 10,000
6	Electrical power	1	LS	$ 25,000	$ 25,000
7	Build new precast pump vault[2]	92	CY	$ 1,275	$ 117,300
8	Excavation - boring & drilling	534	CY	$ 20	$ 10,700
9	Backfill	133	CY	$ 15	$ 2,000
10	10" discharge piping[3]	4,510	LF	$ 50	$ 225,500
11	36" gravity line	175	LF	$ 170	$ 29,800
12	Sedimentation Manholes	2	EA	$ 1,500	$ 3,000
13	Water Quality Treatment[4]	1	EA	$ 83,600	$ 83,600
14	Erosion Control	1	LS	$ 5,000	$ 5,000
15	Traffic Control	1	LS	$ 22,800	$ 22,800
16	Mobilization	1	LS	$ 50,000	$ 50,000
					$ 658,200
	Design/Constr Admin (30%)				$ 197,460
	Property Acq				$ -
	Construction				$ 658,200
	Other				$ -
	Administration (11%)				$ 72,400
	Contingency (25%)				$ 164,550
				Total Construction Cost	**$ 1,092,610**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout sedim. manholes	2	EA	Annually	$ 500	$ 1,000
Maintain Water Quality	43	EA	Annually	150	$ 6,500
Maintain Pumps	4	EA	Annually	1000	$ 4,000
Clean stormdrain line	2,255	LF	Every 5 years	12	$ 27,100
				Annual Maintenance Cost	$ 18,275
				Twenty Year Maintenance Cost	**$ 365,500**
				Total Project Cost for 20 years	**$ 1,458,110**

* Pump sequence: 200 gpm pump starts for small flows;
With increasing flows, 750, gpm pump starts, 200 gpm pump shuts down;
First 2,200 gpm pump starts next;
Second 2,200 gpm pump starts to provide 25 year capacity.

Notes:

1 *Includes removal of access to drywell and capping per State regulations.*
2 *Precast containment vault includes all forms, precast concrete, supplies, and materials to build complete vault.*
3 *Includes 2 - 10 inch discharge pipe to limit velocities during high flows.*
4 *Water quality treatment includes construction of vault, filter cartridges, supplies and materials for complete treatment facility.*
5 Alternatives have the potential for incorporating additional drainage and providing additional treatment for a larger, regional solution. These alternatives are only provided for comparison purposes. Regional storm drainage requirements need to be evaluated.
6 These alternative assume all of the drainage is conveyed and treated, including drainage from both private and public properties. Of the 5.1 total acres, 3.3 acres are on private property, or about 65%, 1.8 acres are public property, or 35%.

Proj # **Name:** **#20 3RD STREET RAILWAY UNDERPASS**
PRIORITY 3

Existing Condition Description As with other underpasses in the City, this site floods during heavy rainfall and impedes emergency vehicles. Detours are difficult and time consumming. There have been several improvements and modifications to the drainage structures from Burnside Ave. to Railroad St. over a period of years. The addition of a pumped system, installed by the Oregon Department of Transportation, helped move water northward to a series of drill holes. These drill holes are unable to manage the water during moderate to heavy rain/snow events; typically 1/4 inch of rain per hour over two hours will overwhelm this system. This area is also impacted by private water runoff from adjoining property.

	Roadway :	**Roadway and Area A**	**11.8 Acres**	
Alternative:	1&2. Install pumps at underpass; pump to adjacent property for treatment and infiltration;	8.4 cfs	24,800 cf	WQ storm
	3&4. Pump flows to southwest for treatment and discharge to Deschutes River.	22.8 cfs	73,350 cf	25 yr.storm
	Both alternatives:Install Rain Gardens upstream to reduce flows.	29.2 cfs	94,400 cf	100 yr.
	Area A: South and East of Railroad Tracks:			
	Decommission drywells			
	Future construction of Rain Gardens to remove upstream flows			
	Area B: North of RR Tracks, west of 3rd St.		**5.8 Acres**	
	Maintain flows on site	5.4 cfs	16,600 cf	WQ storm
	Build water quality treatment	14.7 cfs	47,600 cf	25 yr.storm
	Test/clean existing drywells	18.4 cfs	60,100 cf	100 yr.
	Provide storage for 100 yr. storm			
	Future construction of Rain Gardens			
	Area C: North of RR Tracks, east Third St.		**27.1 Acres**	
	Test/Maintain existing drywells	16.8 cfs	56,400 cf	WQ storm
	Build regional treatment - in ROW	46.1 cfs	167,100 cf	25 yr.storm
	Provide storage for 100 yr. storm	58.9 cfs	215,200 cf	100 yr.
	Future construction of Rain Gardens			
	Area D: Further north, residential area		**6.5 Acres**	
	Test/Maintain existing drywells	4.8 cfs	15,000 cf	WQ storm
	Provide water quality treatment	13.2 cfs	44,000 cf	25 yr.storm
	Provide storage for 100 yr. storm	16.7 cfs	56,300 cf	100 yr.
	Future construction of Rain Gardens			

Map:

N

Design Storm

2/3 of 2 year	1"/24 hr.
Water Quality Treatment	
25 year	2.5"/24 hr.
100 year	3.1"/24 hr.

*Area A includes roadway

Return Frequency *Assume Type II storm*		**Area A***	**Area A**	**Area B**	**Area C**	**Area D**
	2/3 of 2 year	8.4 cfs; 24,800 cf		5.4 cfs; 16,600 cf	16.8 cfs; 56,400 cf	4.8 cfs; 15,000 cf
	25 year		22.8 cfs; 73,350 cf	14.7 cfs; 47,600 c	46.1 cfs; 167,100 cf	13.2 cfs; 44,000 cf
	100 year	29.2 cfs; 94,400 cf		18.4 cfs; 60,100 c	58.9 cfs; 215,200 cf	16.7 cfs; 56,300 cf

Summary	**Area A - Infiltration 25 yr. storm** 11.8 acres	**Area A - Infiltration - 100 yr. storm** 11.8 acres	**Area A - River Discharge - 25 yr. Storm** 11.8 acres	**Area A - River Discharge - 100 yr. storm** 11.8 acres	**Area B** 5.8 acres	**Area C** 27.1 acres	**Area D** 6.5 acres
Construction Costs	$ 4,815,615	$ 5,489,615	$ 2,988,310	$ 3,028,210	$ 1,723,615	$ 5,540,115	$ 1,588,850
Twenty Year Maintenance Costs	$ 215,000	$ 215,000	$ 1,824,000	$ 1,824,000	$ 101,000	$ 101,000	$ 51,000
Total Life Cycle Costs	$ 5,030,615	$ 5,704,615	$ 4,812,310	$ 4,852,210	$ 1,824,615	$ 5,641,115	$ 1,639,850

Alternative 1

Project Elements **Area A (includes roadway)** 25 yr. storm - drains to pond treatment and infiltration.

Item No.	Description	Quantity	Units	Unit Cost	Total Cost
1	Decommission existing drywells[2]	16	EA	$ 2,000	$ 32,000
2	4,000 GPM pumps*	2	EA	$ 35,000	$ 70,000
3	1,500 GPM pumps	1	EA	$ 18,000	$ 18,000
4	750 GPM pump	1	EA	$ 8,000	$ 8,000
5	200 gpm pump	1	EA	$ 1,500	$ 1,500
6	Pump controls	1	LS	$ 15,000	$ 15,000
7	Electrical power 3 phase	1	LS	$ 25,000	$ 25,000
8	Build new precast pump vault[2]	69	CY	$ 1,275	$ 88,000
9	Excavation - boring & drilling for pump vault	1,041	CY	$ 20	$ 20,800
10	Backfill	758	CY	$ 15	$ 11,400
11	10" discharge piping (2 parallel lines	200	LF	$ 50	$ 10,000
12	36" gravity line	100	LF	$ 170	$ 17,000
13	Infiltration capacity testing	1	LS	$ 750	$ 800
14	Install 2 new drill holes	2	EA	$ 5,000	$ 10,000
15	Excavation - boring & drilling for pond Treatment and Infiltration	74,600	CY	$ 20	$ 1,492,000
16	Sedimentation Manholes	2	EA	$ 1,500	$ 3,000
17	Construct bioswale	1	EA	$ 30,000	$ 30,000
18	Erosion Control	1	LS	$ 5,000	$ 5,000
19	Traffic Control	1	LS	$ 22,800	$ 22,800
20	Mobilization	1	LS	$ 79,000	$ 79,000
					$ 1,959,300

Design/Construction (30%)				$ 587,790
Property Acquisition	Commercial	54,000 SF	25	$ 1,350,000
Construction				$ 1,959,300
Other				$ -
Administration (11%)				$ 428,700
Contingency (25%)				$ 489,825
			Total Construction Cost	**$ 4,815,615**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout sed. MH	2	EA	Annually	$ 500	$ 1,000
Maintain Bioswale	1	EA	Annually	$ 500	$ 500
Maintain Pumps	5	EA	Annually	$ 1,000	$ 5,000
Maintain drill holes	8	EA	Annually	$ 500	$ 4,000
Clean pond	1	EA	Every 5 years	$ 1,000	$ 1,000
				Annual Maintenance Cost	$ 10,750
				Twenty Year Maintenance Cost	**$ 215,000**
				Total Project Cost for 20 years	**$ 5,030,615**

* Pump sequence: 200 gpm pump starts for small flows;

With increasing flows, 750, gpm pump starts, 200 gpm pump shuts down;

1,500 gpm pump starts next;

First 4,000 gpm pump starts next to add to 1,500 gpm.

Second 4,000 gpm pump is next, to start to provide 25 year flows;

Alternative 2

Project Elements **Area A (includes roadway)** 100 yr. storm - drains to pond treatment and infiltration.

Item No	Description	Quantity	Units			Unit Cost		Total Cost
1	Decommission existing drywells[2]	16	EA		$	2,000	$	32,000
2	4,000 GPM pumps*	3	EA		$	35,000	$	105,000
3	1000 GPM pump	1	EA		$	15,000	$	15,000
4	200 gpm pump	1	EA		$	1,500	$	1,500
5	Pump controls	1	LS		$	15,000	$	15,000
6	Electrical power 3 phase	1	LS		$	25,000	$	25,000
7	Build new precast pump vault[2]	69	CY		$	1,275	$	88,000
8	Excavation - boring & drilling for pump vault	1,041	CY		$	20	$	20,800
9	Backfill	758	CY		$	15	$	11,400
10	10" discharge piping (2 parallel lines	200	LF		$	50	$	10,000
11	36" gravity line	100	LF		$	170	$	17,000
12	Infiltration capacity testing	1	LS		$	750	$	800
13	Install 2 new drill holes	2	EA		$	5,000	$	10,000
14	Excavation - boring & drilling for pond Treatment and Infiltration	95,600	CY		$	20	$	1,912,000
15	Sedimentation Manholes	2	EA		$	1,500	$	3,000
16	Construct bioswale	1	EA		$	30,000	$	30,000
17	Erosion Control	1	LS		$	5,000	$	5,000
18	Traffic Control	1	LS		$	22,800	$	22,800
19	Mobilization	1	LS		$	79,000	$	79,000
							$	2,403,300
	Design/Construction (30%)						$	720,990
	Property Acquisition		Commercial	51,200 SF		25	$	1,280,000
	Construction						$	2,403,300
	Other						$	-
	Administration (11%)						$	484,500
	Contingency (25%)						$	600,825
						Total Construction Cost	**$**	**5,489,615**

Maintenance Requirements

	Quantity	Units	Frequency		Unit Cost		Total Cost
Cleanout sed. MH	2	EA	Annually	$	500	$	1,000
Maintain Bioswale	1	EA	Annually	$	500	$	500
Maintain Pumps	5	EA	Annually	$	1,000	$	5,000
Maintain drill holes	8	EA	Annually	$	500	$	4,000
Clean pond	1	EA	Every 5 years	$	1,000	$	1,000
					Annual Maintenance Cost	$	10,750
					Twenty Year Maintenance Cost	**$**	**215,000**
					Total Project Cost for 20 years	**$**	**5,704,615**

* Pump sequence: 200 gpm pump starts for small flows;
With increasing flows, 1,000, gpm pump starts, 200 gpm pump shuts down;
First 4,000 gpm pump starts next;
Second 4,000 gpm pump starts next;
Third 4,000 gpm pump is next to start to provide 100 year flows.

Alternative 3

Project Elements **Area A (includes roadway)** 25 yr. storm Discharge to river

Item No	Description	Quantity	Units	Unit Cost	Total Cost
1	Decommission exist. drywells[1]	16	EA	$ 2,000	$ 32,000
2	4,000 GPM pumps	2	EA	$ 35,000	$ 70,000
3	1,500 GPM pumps	1	EA	$ 18,000	$ 18,000
4	750 GPM pump	1	EA	$ 8,000	$ 8,000
5	200 gpm pump	1	EA	$ 1,500	$ 1,500
6	Pump controls	1	LS	$ 15,000	$ 15,000
7	Electrical power 3 phase	1	LS	$ 25,000	$ 25,000
8	Build new precast pump vault[2]	69	CY	$ 1,275	$ 88,000
9	Excavation - boring & drilling for pump vault	1,041	CY	$ 20	$ 20,800
10	Backfill	758	CY	$ 15	$ 11,400
11	10" discharge piping	1,950	LF	$ 50	$ 97,500
12	48" gravity line to pumps	100	LF	$ 200	$ 20,000
13	60" gravity line to River	3,400	LF	$ 300	$ 1,020,000
14	Sedimentation Manholes	2	EA	$ 1,500	$ 3,000
15	StormFilter WQ Treatment[3]	1	EA	$ 260,000	$ 260,000
16	Erosion Control	1	LS	$ 5,000	$ 5,000
17	Traffic Control	1	LS	$ 40,000	$ 40,000
18	Mobilization	1	LS	$ 65,000	$ 65,000
					$ 1,800,200
	Design/Construction (30%)				$ 540,060
	Property Acquisition				$ -
	Construction				$ 1,800,200
	Other				$ -
	Administration (11%)				$ 198,000
	Contingency (25%)				$ 450,050
				Total Construction Cost	**$ 2,988,310**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout sed. MH	2	EA	Annually	$ 500	$ 1,000
Maintain Stormfilter	500	EA	Annually	$ 150	$ 75,000
Maintain Pumps	5	EA	Annually	$ 1,000	$ 5,000
Clean storm drain	3,400	LF	Every 5 years	$ 12	$ 40,800
				Annual Maintenance Cost	$ 91,200
				Twenty Year Maintenance Cost	**$ 1,824,000**
				Total Project Cost for 20 years	**$ 4,812,310**

* Pump sequence: 200 gpm pump starts for small flows;
With increasing flows, 750, gpm pump starts, 200 gpm pump shuts down;
1,500 gpm pump starts next;
First 4,000 gpm pump starts next, to add to 1,500 gpm.
Second 4,000 gpm pump is next to start to provide 25 year flows.

Alternative 4

Project Elements **Area A (includes roadway)** 100 yr. storm Discharge to river

Item No	Description	Quantity	Units		Unit Cost		Total Cost
1	Decommission exist. drywells[1]	16	EA	$	2,000	$	32,000
2	4,000 GPM pumps	3	EA	$	35,000	$	105,000
3	1,000 GPM pumps	1	EA	$	15,000	$	15,000
4	200 gpm pump	1	EA	$	1,500	$	1,500
5	Pump controls	1	LS	$	15,000	$	15,000
6	Electrical power 3 phase	1	LS	$	25,000	$	25,000
7	Build new precast pump vault[2]	69	CY	$	1,275	$	88,000
8	Excavation - boring & drilling for pump vault	1,041	CY	$	20	$	20,800
9	Backfill	758	CY	$	15	$	11,400
10	10" discharge piping	1,950	LF	$	50	$	97,500
11	48" gravity line to pumps	100	LF	$	200	$	20,000
12	60" gravity line to River	3,400	LF	$	300	$	1,020,000
13	Sedimentation Manholes	2	EA	$	1,500	$	3,000
14	StormFilter WQ Treatment[3]	1	EA	$	260,000	$	260,000
15	Erosion Control	1	LS	$	5,000	$	5,000
16	Traffic Control	1	LS	$	40,000	$	40,000
17	Mobilization	1	LS	$	65,000	$	65,000
						$	1,824,200
	Design/Construction (30%)					$	547,260
	Property Acquisition					$	-
	Construction					$	1,824,200
	Other					$	-
	Administration (11%)					$	200,700
	Contingency (25%)					$	456,050
					Total Construction Cost	**$**	**3,028,210**

Maintenance Requirements

	Quantity	Units	Frequency		Unit Cost		Total Cost
Cleanout sed. MH	2	EA	Annually	$	500	$	1,000
Maintain StormFilter	500	EA	Annually	$	150	$	75,000
Maintain Pumps	5	EA	Annually	$	1,000	$	5,000
Clean storm drain	3,400	LF	Every 5 years	$	12	$	40,800
					Annual Maintenance Cost	$	91,200
					Twenty Year Maintenance Cost	**$**	**1,824,000**
					Total Project Cost for 20 years	**$**	**4,852,210**

* Pump sequence: 200 gpm pump starts for small flows;
With increasing flows, 1,000, gpm pump starts, 200 gpm pump shuts down;
First 4,000 gpm pump starts next;
Second 4,000 gpm pump starts next;
Third 4,000 gpm pump is next to start to provide 100 year flows.

Project Elements **Area B**

Item No	Description	Quantity	Units		Unit Cost	Total Cost
1	Clean and Test drywells/drillholes	3	EA		$ 500	$ 1,500
2	Infiltration capacity testing	1	LS		$ 750	$ 800
3	Add new drywells	2	EA		$ 5,000	$ 10,000
4	Sedimentation Manholes	2	EA		$ 1,500	$ 3,000
5	Stormfilter treatment	1	EA		$ 5,000	$ 5,000
6	Storage Tank	450,000	gallons		$ 2	$ 900,000
7	Traffic Control	1	LS		$ 15,000	$ 15,000
8	Mobilization	1	LS		$ 50,000	$ 50,000
						$ 985,300
	Design/Constr Admin (30%)					$ 295,590
	Property Acq					$ 50,000
	Construction					$ 985,300
	Other					$ -
	Administration (11%)					$ 146,400
	Contingency (25%)					$ 246,325
					Total Construction Cost	**$ 1,723,615**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout drywells/sed. manholes	9	EA	Annually	$ 500	$ 4,500
Maintain Water Quality	2	EA	Annually	150	$ 300
Clean out Storage Vault	1	EA	Every 5 years	1000	$ 1,000
				Annual Maintenance Cost	$ 5,050
				Twenty Year Maintenance Cost	**$ 101,000**
				Total Project Cost for 20 years	**$ 1,824,615**

Project Elements **Area C**

Item No	Description	Quantity	Units		Unit Cost	Total Cost
1	Clean and Test drywells/drillholes	7	EA		$ 500	$ 3,500
2	Infiltration capacity testing	1	LS		$ 750	$ 800
3	Add new drywells	2	EA		$ 5,000	$ 10,000
4	Sedimentation Manholes	2	EA		$ 1,500	$ 3,000
5	Stormfilter treatment	1	EA		$ 5,000	$ 5,000
6	Storage Tank	1,610,000	gallons		$ 2	$ 3,220,000
7	Traffic Control	1	LS		$ 15,000	$ 15,000
8	Mobilization	1	LS		$ 50,000	$ 50,000
						$ 3,307,300
	Design/Constr Admin (30%)					$ 992,190
	Property Acq					$ 50,000
	Construction					$ 3,307,300
	Other					$ -
	Administration (11%)					$ 363,800
	Contingency (25%)					$ 826,825
					Total Construction Cost	**$ 5,540,115**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout drywells/sed. manholes	9	EA	Annually	$ 500	$ 4,500
Maintain Water Quality	2	EA	Annually	150	$ 300
Clean out Storage Vault	1	EA	Every 5 years	1000	$ 1,000
				Annual Maintenance Cost	$ 5,050
				Twenty Year Maintenance Cost	**$ 101,000**
				Total Project Cost for 20 years	**$ 5,641,115**

Project Elements **Area D**

Item No	Description	Quantity	Units	Unit Cost	Total Cost
1	Clean out existing drywells	2	EA	$ 500	$ 1,000
2	Infiltration capacity testing	1	LS	$ 750	$ 800
3	Add new drywells	2	EA	$ 5,000	$ 10,000
4	Sedimentation Manholes	2	EA	$ 1,500	$ 3,000
5	Stormfilter treatment	1	EA	$ 5,000	$ 5,000
6	Storage Tank	421,100	gallons	$ 2	$ 842,200
7	Traffic Control	1	LS	$ 15,000	$ 15,000
8	Mobilization	1	LS	$ 50,000	$ 50,000
					$ 927,000
	Design/Constr Admin (30%)				$ 278,100
	Property Acq				$ 50,000
	Construction				$ 927,000
	Other				$ -
	Administration (11%)				$ 102,000
	Contingency (25%)				$ 231,750
				Total Construction Cost	**$ 1,588,850**

Maintenance Requirements

	Quantity	Units	Frequency	Unit Cost	Total Cost
Cleanout drywells/sed. manholes	4	EA	Annually	$ 500	$ 2,000
Maintain Water Quality	2	EA	Annually	150	$ 300
Clean out Storage Vault	1	EA	Every 5 years	1000	$ 1,000
				Annual Maintenance Cost	$ 2,550
				Twenty Year Maintenance Cost	**$ 51,000**
				Total Project Cost for 20 years	**$ 1,639,850**

Notes:

1 *Includes removal of access to drywell and capping per State regulations.*

2 *Precast containment vault includes all forms, precast concrete, supplies, and materials to build complete vault.*

3

4 *Water quality treatment includes construction of vault, filter cartridges, supplies and materials for complete treatment facility. Water quality treatment for water quality storm.*

5 Cost savings can be realized by installing on-site facilities, such as Rain Gardens, to minimize regional treatment costs for construction and maintenance.

6 Rain Gardens, or Green Streets concepts should be built into Third St. as urban renewal takes place. Grassed medians and porous parking pavers, for example.

Proj # **Name:** **#23 ARCHIE BRIGGS - WEST SIDE**

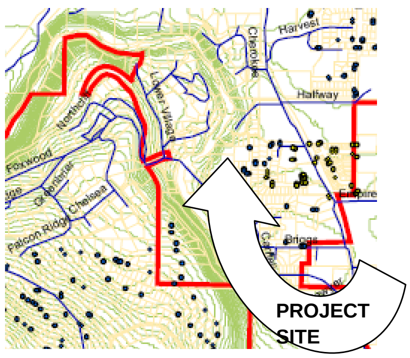
PRIORITY 4

Existing Condition Description

Stormdrainage from a steep hillside collects on Archie Briggs St., a steep roadway. Water has damaged the lower half mile of roadway near the Deschutes River. During moderate to heavy rain storms one lane of traffic is blocked, creating a safety hazard. As stormwater builds, it leaves the uncurbed roadway and drains to residential property directly north of the roadway.

Alternative: 1. Install a concrete box culvert and sidewalk to collect water to discharge to the Deschutes River. Energy dissipator and water quality treatment system to be installed at the end of the roadway, prior to discharging to the River.

Map:



N

Drainage Area Served by Capital Project :	10.2	Acres
% Impervious (Existing) :	20%	

Design Storm

Water Quality Treatment	2/3 of 2 year	1"/24 hr.
	25 year	2.5"/24 hr.
	100 year	3.1"/24 hr.

Return Frequency

Assume Type II storm

2/3 of 2 year	1.42 cfs	9,500 cf
25 year	8.5 cfs	48,700 cf
100 year	12.1 cfs	68,000 cf

Summary

Construction Costs	$ 608,935
Twenty Year Maintenance Costs	$ 300,000
Total Life Cycle Costs	$ 908,935

Project Elements

Item No.	Description	Quantity	Units		Unit Cost		Total Cost
1	Concrete box culvert and sidewalk[1]	1,370	LF	$	50	$	68,500
2	Curb (each side of street)	2,740	LF	$	23	$	61,700
3	Inlets	2	EA	$	1,000	$	2,000
4	12-inch pipe crossing street	50	LF	$	60	$	3,000
2	Excavation for box culvert.	977	CY	$	20	$	19,500
3	Backfill	603	CY	$	15	$	9,000
4	Water Quality Treatment[2]	1	LS	$	76,000	$	76,000
6	Install energy dissipation system	1	LS	$	50,000	$	50,000
7	Traffic Control	1	LS	$	20,000	$	20,000
8	Erosion Control	1	LS	$	10,000	$	10,000
9	Mobilization	1	LS	$	40,000	$	40,000
						$	359,700

Design/Constr Admin (30%)	$	107,910
Property Acq	$	-
Construction	$	359,700
Other	$	-
Administration (11%)	$	51,400
Contingency (25%)	$	89,925
Total Construction Cost	**$**	**608,935**

Maintenance Requirements

	Quantity	Units	Frequency		Unit Cost		Total Cost
Cleanout box culvert and pipelines	1,420	LF	Biannually	$	12	$	17,000
Clean inlets	2	EA	Annually	$	100	$	200
Maintain water quality	43	EA	Annually		150	$	6,500
					Annual Maintenance Cost	$	15,000
					Twenty Year Maintenance Cost	**$**	**300,000**
					Total Project Cost for 20 years	**$**	**908,935**

Note:

1. Concrete trough includes all work involved in precast concrete section, including sidewalk, and installation.
2. Water quality treatment is a Stormfilter System; treatment is for Water Quality Storm.

The majority of the storm water, over 90%, comes from private property. However, most of the area is undeveloped and very steep. Per Oregon Drainage Law, downstream property must take what comes naturally down gradient.

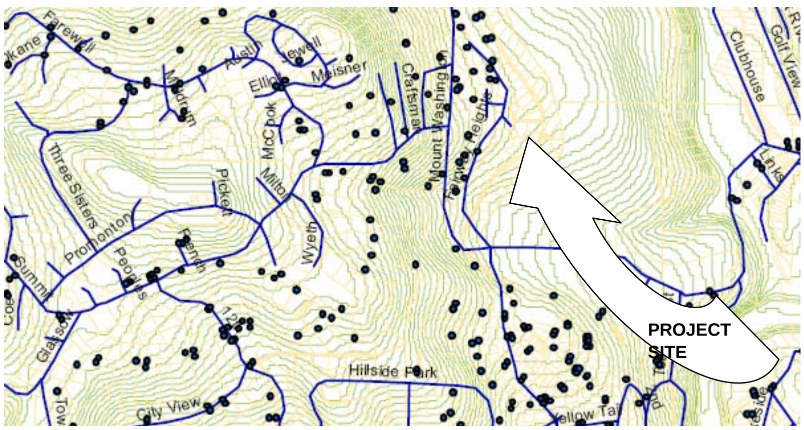
Proj # **Name:** **#4 FAIRWAY HEIGHTS at AWBREY BUTTE**
PRIORITY 5

Existing Condition Description

Awbrey Butte is a large hillside development, draining many acres of residences. Approximately half of Awbrey Butte, about 110 acres, contributes to problems in several locations. Drainage collects and travels down easements along the hillside and across public roadways. Stormwater moves from public to private and back to public domain as it moves from easements across roadways. Although easements exist, some don't line up in a linear fashion and drainage takes detours, sometimes through residences. Stormwater eventually discharges to the golf course, also causing flooding There are easements for stormwater at the golf course.

Alternatives: 1. Construct piping to reduce hazard next to residences.
Build water quality and detention facility at golf course, at pipe outfall.
Replace culverts at Lucus Ct., Mt. Washington Dr., and Fairway Hts. Dr.

Map:



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Design Storm

Water Quality Treatment	2/3 of 2 year	1"/24 hr.
	25 year	2.5"/24 hr.
	100 year	3.1"/24 hr.

Return Frequency	**Lucus Ct.**	**Mt. Wash. Dr.**	**Fairway Hts. Dr.**
Assume Type II storm			
Drainage Area	76.4 acres	97.5 acres	106.2 acres
2/3 of 2 year	12 cfs; 84,000cf	15 cfs; 107,100 cf	15.9 cfs; 116,600 cf
25 year	57.7 cfs; 368,600 cf	71.9 cfs; 470,300 cf	76.5 cfs; 512,100 cf
100 year	80 cfs; 504,400 cf	99.7 cfs; 643,400 cf	106 cfs; 700,000 cf

Summary

Construction Costs	$	529,240
Twenty Year Maintenance Costs	$	155,000
Total Life Cycle Costs	$	684,240

Project Elements

Item No.	Description	Qty.	Units	Pipe Size	Unit Cost	Total Cost
1	Install culvert at Lucus Court	100	LF	36-inch diameter	$ 170	$ 17,000
2	Install culvert at Mt. Washington Drive	100	LF	48-inch diameter	$ 200	$ 20,000
3	Washington Dr. and Fairview Hts. Drive	250	LF	36-inch diameter	$ 170	$ 42,500
4	Landscaping & Irrigation[1]	6,250	SF		$ 5	$ 31,300
5	Install culvert at Fairway Hts. Dr.	100	LF	48-inch diameter	$ 200	$ 20,000
6	Pipe betw. Fairway Hts. Dr. and golf course	240	LF	48-inch diameter	$ 200	$ 48,000
7	Landscaping & Irrigation[2]	6,000	SF		$ 5	$ 30,000
8	Water Quality Pond/detention	1	LS		$ 40,000	$ 40,000
9	Erosion control	1	LS		$ 15,000	$ 15,000
10	Install energy dissipation system	1	LS		$ 15,000	$ 15,000
11	Traffic Control	1	LS		$ 10,000	$ 10,000
12	Mobilization	1	LS		$ 30,000	$ 30,000
						$ 318,800

Design/Constr Admin (30%)	$ 95,640
Property Acq	$ -
Construction	$ 318,800
Other	$ -
Administration (11%)	$ 35,100
Contingency (25%)	$ 79,700
Total Construction Cost	**$ 529,240**

Maintenance Requirements

	Qty.	Units	Frequency	Unit Cost	Total Cost
Cleanout catch basins	5	EA	Annually	$ 500	$ 2,500
Cleanout pipeline	250	LF	Once every 5 years	$ 12	$ 3,000
Cleanout culverts	300	LF	Annually	$ 15	$ 4,500
				Annual Maintenance Cost	$ 7,750
				Twenty Year Maintenance Cost	**$ 155,000**
				Total Project Cost for 20 years	**$ 684,240**

Notes:
1. Landscaping and irrigation for area between Mt. Washington Drive Court and Fairview Hts. Drive.
2. Landscaping and irrigation for area between Fairway Hts. Dr. and golf course.

General Notes:

Stormfilter Treatment Systems used for all projects.
Filters are assumed to treat 0.033 cfs each.
Costs for fact sheets are from:
RSMeans Building Construction Cost Data, 2007, and RSMeans Heavy Construction Cost Data, 2006

Appendix C

Major Basins:

Flows and volumes for major basins for existing and future land use are in Tables C.1 and C.2.

Assumptions for Flow Evaluation

Calculations for subbasins were simplified due to the volume of the basins to be evaluated. Simplifying assumptions for evaluation of subbasins are described herein.

- Grouping subbasins into 20 acre increments, up to 60 acres,
- Defining ground surface as either asphalt or prairie grass/lawn for defining Manning's roughness coefficient for sheet flow, and the velocity factor for shallow concentrated flow,
- CN values for pervious soils were based on the classification 'fair' of the prairie grass/lawn category. See Chapter 5 for values. To aid in simplification due to the volume of subbasins, only one CN value was used.
- Basin slopes were divided into three ranges to identify average slopes across a subbasin in the T_c equation. This was an additional assumption to simplify calculations due to the volume of basins to analyze.
- Flow path across each subbasin was simplified by assuming the basin was either symmetrical, as in a square or circular shape, or non-symmetrical, with the length about 3 times the width. Average flow lengths were calculated within the acreage range used, based on the average size of the subbasin.

Each subbasin was evaluated for shape and upstream land surface to establish sheet flow.

Table C.4 shows the equations, simplifying assumptions and calculated times of concentration for the subbasins. Results of the evaluation of each of the subbasins for T_c and subsequent flow, for both existing land use is located in Table C.5.

Recommended CIPs:

Flows and volumes for recommended CIPs are located in Table C.6.

Table C.1

Flows and Volumes for Major Basines - Existing Land Use (Page 1 of 2)

Basin ID[1]	Acres	T_c	Impervious Acres	Pervious Acres	Soil Group (CN)	WQ storm Peak Runoff (cfs)	WQ storm Total Volume (CF)	10-year storm Peak Runoff (cfs)	10-year storm Total Volume (CF)	25-year storm Peak Runoff (cfs)	25-year storm Total Volume (CF)	100-year storm Peak Runoff (cfs)	100-year storm Total Volume (CF)
MB01	557	61	19	537	73	4	88,163	28	836,131	50	1,252,552	92	1,971,400
MB02	791	66	134	657	72	24	404,459	71	1,677,614	104	2,319,328	164	3,399,740
MB03	602	42	90	512	76	21	316,450	81	1,424,268	122	1,963,504	192	2,858,223
MB04	214	41	30	184	74	7	99,150	25	462,223	39	644,056	63	948,809
MB05	255	27	54	201	69	16	154,795	39	545,845	55	743,927	86	1,079,212
MB06A	149	30	70	80	69	19	198,768	45	541,473	57	688,776	78	925,026
MB06B	542	61	160	383	69	29	452,785	73	1,413,439	96	1,868,800	138	2,623,939
MB06C	518	68	61	457	62	10	171,877	25	587,784	31	854,942	50	1,344,546
MB07	413	87	30	383	74	4	114,805	24	735,628	38	1,062,944	65	1,619,346
MB08A	253	34	99	154	69	26	282,306	61	805,099	79	1,038,647	110	1,418,416
MB08B	299	27	92	208	69	27	263,023	65	807,326	86	1,063,349	125	1,486,920
MB08C	570	40	235	335	67	55	665,459	130	1,813,439	163	2,325,082	223	3,157,928
MB09A	182	22	52	131	72	16	153,009	44	507,205	61	672,318	90	943,833
MB09B	116	23	51	64	69	16	146,905	38	405,264	49	517,509	67	698,229
MB10	91	12	61	30	75	25	177,424	62	458,268	77	569,104	101	740,699
MB11	866	90	208	658	71	30	593,452	80	2,054,352	110	2,765,249	163	3,952,003
MB12	324	76	26	298	64	4	71,716	10	323,750	15	493,871	27	806,512
MB13	145	35	0	145	56	0	113	1	16,128	1	48,724	3	125,482
MB14A	106	21	48	58	53	16	136,604	36	325,703	44	402,802	55	529,611
MB14B	120	10	66	54	52	29	188,063	68	446,912	81	548,513	102	711,386
MB15	236	24	52	184	73	16	160,282	47	593,473	68	801,565	103	1,146,625
MB16A	359	43	92	266	74	21	281,466	61	989,635	85	1,319,869	126	1,861,976
MB16B	190	29	93	98	69	26	264,109	61	712,488	78	903,499	105	1,208,841
MB16C	114	18	38	75	57	13	109,167	31	269,935	37	344,114	46	470,215
MB17	653	77	303	350	64	48	847,391	113	2,171,957	137	2,747,736	180	3,680,286
MB18A	302	27	175	127	69	51	500,765	119	1,299,166	149	1,626,472	197	2,142,095
MB18B	133	13	85	49	69	34	242,299	79	617,655	98	768,629	129	1,004,674
MB18C	146	12	74	72	69	31	212,167	72	566,852	91	716,506	124	954,871
MB19	419	59	103	315	69	19	293,461	48	968,721	65	1,301,260	96	1,859,538
MB20	176	13	68	108	71	28	197,655	69	581,501	91	751,711	129	1,027,278
MB21	527	42	76	451	78	18	302,286	82	1,360,058	121	1,861,397	187	2,684,640
MB22A	319	19	110	209	77	38	353,307	116	1,136,113	155	1,476,185	219	2,019,924

Table C.1

Flows and Volumes for Major Basins - Existing Land Use (Page 2 of 2)

						WQ storm		10-year storm		25-year storm		100-year storm	
Basin ID[1]	Acres	T_c	Impervious Acres	Pervious Acres	Soil Group (CN)	Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)
MB22B	375	34	96	278	78	25	334,396	90	1,199,059	124	1,585,432	180	2,208,309
MB22C	347	26	103	244	68	31	294,839	74	904,340	98	1,194,115	143	1,675,466
MB22D	859	88	110	749	69	16	309,016	44	1,347,654	65	1,928,371	108	2,939,608
MB23A	208	37	36	172	63	9	101,603	21	314,249	25	436,329	38	653,223
MB24	773	95	155	618	68	21	433,151	55	1,519,012	76	2,081,729	115	3,041,828
MB25	606	61	144	462	70	26	414,001	68	1,428,734	94	1,924,823	141	2,754,455
MB26	694	73	141	553	71	23	410,937	64	1,541,620	91	2,103,795	139	3,047,722
MB27	191	17	61	130	55	22	174,877	52	425,734	62	540,366	78	737,628
MB28	139	17	33	106	79	12	120,512	46	444,710	64	589,655	93	823,170
MB29	753	57	90	663	76	17	348,451	80	1,722,253	122	2,395,702	194	3,514,257
MB30	137	29	3	134	78	1	35,526	18	278,521	30	401,313	51	606,481
MB31	574	76	140	434	71	22	402,151	59	1,390,236	81	1,868,491	121	2,665,322
MB32	1,215	96	177	1,038	71	24	510,612	73	2,208,449	107	3,106,815	173	4,643,899
MB33	666	92	73	593	65	10	202,728	24	784,453	35	1,151,532	59	1,816,051
MB34A	773	68	181	592	69	31	511,727	78	1,722,726	106	2,325,925	158	3,342,160
MB34B	924	60	357	567	69	66	1,009,218	160	2,884,620	205	3,725,333	284	5,094,202
MB34C	799	96	181	617	69	25	507,298	64	1,721,589	87	2,331,218	130	3,360,948
MB34D	1,683	106	519	1,164	69	66	1,441,572	166	4,382,559	218	5,770,054	310	8,069,098
MB35	705	56	167	538	69	32	474,346	80	1,591,624	109	2,146,421	163	3,080,163
MB36	358	17	46	313	74	17	153,179	63	741,259	98	1,040,323	159	1,544,043

(1) See Figure 5.1 for Basin ID information
CN - curve number
cfs - cubic feet per second
CF - cubic feet
T_c - time of concentration

Table C.2														
Flows and Volumes for Major Basins - Future Land Use (Page 1 of 2)														
						WQ storm		10-year storm		25-year storm		100-year storm		
Basin ID[1]	**Acres**	**T_c**	**Impervious Acres**	**Pervious Acres**	**Soil Group (CN)**	**Peak Runoff (cfs)**	**Total Volume (CF)**	**Peak Runoff (cfs)**	**Total Volume (CF)**	**Peak Runoff (cfs)**	**Total Volume (CF)**	**Peak Runoff (cfs)**	**Total Volume (CF)**
MB01	557	61	258	299	73	48	744,351	121	2,115,412	155	2,697,637	212	3,624,592
MB02	791	66	200	591	72	35	588,047	96	2,040,912	132	2,730,984	196	3,872,415
MB03	602	42	151	451	76	35	482,582	110	1,737,740	154	2,315,193	227	3,257,311
MB04	214	41	60	154	74	14	183,309	40	624,178	55	826,511	81	1,156,876
MB05	255	32	197	59	69	52	559,716	122	1,378,851	149	1,695,306	191	2,181,916
MB06A	149	14	111	38	69	44	318,160	101	787,899	124	970,611	160	1,252,373
MB06B	542	61	254	289	69	47	717,727	113	1,958,618	142	2,491,512	192	3,345,812
MB06C	518	68	204	314	62	35	574,048	82	1,486,070	100	1,899,478	132	2,581,403
MB07	413	87	132	281	74	19	391,178	54	1,268,611	73	1,663,612	104	2,304,614
MB08A	253	34	99	154	69	26	282,621	61	805,747	79	1,039,388	110	1,419,276
MB08B	299	27	105	195	69	30	300,214	73	883,902	96	1,150,831	136	1,588,356
MB08C	570	40	216	354	67	51	612,711	120	1,701,402	151	2,196,298	209	3,007,500
MB09A	182	22	72	110	72	23	210,141	58	620,139	76	800,264	107	1,090,720
MB09B	116	23	49	66	69	15	141,204	37	393,531	47	504,106	65	682,690
MB10	91	12	71	19	75	30	206,030	71	512,772	87	630,381	112	810,408
MB11	866	113	260	606	71	32	729,271	84	2,315,939	112	3,057,957	160	4,281,515
MB12	324	76	85	238	64	14	238,838	32	689,810	40	917,421	57	1,305,104
MB13	145	35	36	109	56	9	102,880	21	255,834	26	332,008	32	467,343
MB14A	106	21	42	64	53	14	119,071	32	284,354	38	353,532	48	469,590
MB14B	120	10	64	56	52	28	182,519	66	433,823	79	532,892	99	692,324
MB15	236	24	79	157	73	24	235,426	65	740,344	87	967,570	125	1,336,673
MB16A	359	43	112	247	74	26	335,304	71	1,093,724	96	1,437,247	138	1,995,985
MB16B	190	14	114	76	69	45	326,728	106	842,291	132	1,052,194	175	1,381,961
MB16C	114	18	41	72	57	14	117,722	33	289,765	40	367,478	50	498,311
MB17	653	34	353	300	64	92	1,002,646	213	2,521,305	259	3,156,860	337	4,170,334
MB18A	302	27	208	94	69	60	592,633	141	1,488,320	173	1,842,565	224	2,392,656
MB18B	133	13	92	41	69	37	264,632	87	663,581	107	821,084	138	1,065,480
MB18C	146	12	118	28	69	49	337,961	114	825,514	139	1,011,932	178	1,297,323
MB19	419	59	182	236	69	34	515,184	82	1,426,731	104	1,824,814	142	2,467,028
MB20	176	7	110	66	71	56	318,450	133	823,564	167	1,026,802	220	1,344,314
MB21	527	42	153	374	78	35	506,438	117	1,734,199	159	2,278,570	229	3,154,595
MB22A	319	19	91	228	77	31	303,878	104	1,045,455	142	1,375,080	204	1,905,998

Table C.2

Flows and Volumes for Major Basins - Future Land Use (Page 2 of 2)

Basin ID[1]	Acres	T_c	Impervious Acres	Pervious Acres	Soil Group (CN)	WQ storm		10-year storm		25-year storm		100-year storm	
						Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)	Peak Runoff (cfs)	Total Volume (CF)
MB22B	375	34	105	270	78	27	355,847	94	1,238,000	128	1,628,764	185	2,257,008
MB22C	347	26	99	248	68	29	282,811	71	879,391	95	1,165,570	139	1,642,309
MB22D	859	88	320	539	69	46	895,545	113	2,568,303	145	3,325,722	201	4,563,750
MB23A	208	37	51	156	63	13	146,134	30	413,157	36	551,180	51	789,000
MB24	773	95	209	564	68	29	583,067	72	1,832,414	95	2,440,818	138	3,459,639
MB25	606	61	175	431	70	32	499,481	81	1,602,048	108	2,122,191	157	2,982,435
MB26	694	73	263	431	71	43	749,445	108	2,220,394	141	2,875,010	196	3,936,117
MB27	191	8	103	88	55	49	295,299	113	707,449	136	874,085	171	1,141,522
MB28	139	17	60	79	79	22	191,553	64	572,174	84	731,146	114	981,730
MB29	753	57	211	542	76	41	672,102	127	2,326,906	174	3,072,632	253	4,280,484
MB30	137	29	34	103	78	10	118,687	35	430,199	48	570,268	70	796,591
MB31	574	76	175	399	71	28	500,983	72	1,589,187	96	2,094,717	138	2,926,169
MB32	1,215	96	317	898	71	44	898,315	115	2,995,038	156	4,002,640	229	5,678,734
MB33	666	92	167	500	65	24	463,761	56	1,356,692	71	1,813,751	101	2,595,741
MB34A	799	96	200	598	69	27	560,447	70	1,831,845	94	2,457,352	138	3,507,439
MB34B	773	68	208	565	69	36	587,461	88	1,879,312	118	2,504,950	172	3,549,927
MB34C	924	60	411	513	69	76	1,161,227	183	3,198,655	232	4,084,314	315	5,510,744
MB34D	1,683	106	558	1,125	69	71	1,549,982	178	4,608,012	231	6,028,099	325	8,368,959
MB35	705	56	290	415	69	56	820,157	135	2,305,723	172	2,962,659	237	4,027,193
MB36	358	17	90	269	74	33	275,676	94	978,368	133	1,307,779	199	1,849,503

(1) See Figure 5.1 for Basin ID information
CN - curve number
cfs - cubic feet per second
CF - cubic feet
T_c - time of concentration

Table C.3
Pipe Sizes Required for 10-year and 25-year storms - Future Land Use (Page 1 of 2)

Pipe Identification	Major Basins Contributing Drainage	10-year			25-year			Pipe Length (ft)	Minimum Pipe Slope (ft/ft)
		Flow (cfs)	Velocity (ft/sec)	Pipe Diameter (inches)	Flow (cfs)	Velocity (ft/sec)	Pipe Diameter (inches)		
ID1	MB11, MB16A	114.22	5.8	60	152.12	7.8	60	6466	0.003
ID2-A	MB31,MB32,MB33,MB34A,MB34B	261.73	6.8	84	345.89	9.0	84	5230	0.0025
ID2-B	MB31,MB32,MB33,MB34A,MB34B,MB34C	346.90	9.0	84	456.00	11.9	84	5254	0.005
ID2-C	MB31,MB32,MB33,MB34A,MB34B,MB34C,MB34D	348.17	9.1	84	458.07	11.9	84	14024	0.0045
ID3	MB6A,MB5,MB6B, MB6C, MB7	215.29	7.6	72	272.39	9.6	72	5407	0.004
ID4	MB35	135.23	6.9	60	172.21	8.8	60	5338	0.005
ID6	MB6A,MB5,MB6B, MB6C, MB7	277.64	7.2	84	351.18	9.1	84	9617	0.003
ID7	MB6A,MB6B	257.34	6.7	84	321.69	8.4	84	5758	0.0025
ID8	MB8C,MB18C	98.18	10.2	42	123.85	12.9	42	1028	0.015
ID9	MB10	35.47	5.0	36	43.54	6.2	36	486	0.005
ID10	MB9B	36.80	5.2	36	47.16	6.7	36	2007	0.005
ID11	MB9A	54.64	5.7	42	70.65	7.3	42	1780	0.005
ID12	MB6A	29.04	5.9	30	35.55	7.2	30	1425	0.0067
ID13	MB8C	70.93	7.4	42	90.94	7.2	48	1315	0.005
ID14	MB18C	85.72	6.8	48	104.35	8.3	48	2365	0.005
ID15	MB8C	182.50	6.5	72	235.58	8.3	72	10676	0.003
ID17	MB18A	140.64	7.2	60	172.96	8.8	60	1090	0.005
ID18	MB8A,MB8B,MBC,MB18A,M14B	136.16	6.9	60	166.91	8.5	60	893	0.0036
ID19	MB14B	16.56	5.3	24	19.92	6.3	24	1324	0.007
ID20	MB24	43.70	8.9	30	57.95	8.2	36	3939	0.015
ID21	MB23A,MB22D, MB22C	145.93	11.6	48	188.32	9.6	60	3396	0.009
ID22	MB23A,MB22C,MB22D	141.20	7.2	60	181.20	9.2	60	5871	0.0077
ID23	MB22B	94.06	13.3	36	128.47	13.4	42	2965	0.032
ID24	MB18B,MB20	73.84	10.5	36	90.92	12.9	36	1298	0.02
ID25	MB22A	104.48	5.3	60	142.42	7.3	60	3250	0.003
ID26	MB17,MB19	97.58	5.0	60	121.79	6.2	60	5928	0.0038
ID27	MB16B,MB17	203.03	7.2	72	248.84	8.8	72	5935	0.0038
ID28	MB19	82.08	11.6	36	103.96	14.7	36	2147	0.005
ID29	MB31	71.81	7.5	42	95.53	7.6	48	3451	0.005
ID30-a	MB32	96.98	4.9	60	130.87	6.7	60	2620	0.0025
ID30-b	MB32	25.23	3.6	36	34.00	4.8	36	2229	0.003
ID31	MB31,MB32,MB33,MB34A	188.71	6.7	72	251.70	6.5	84	7429	0.0025
ID32-a		186.32	6.6	72	248.97	6.5	84	661	0.0025
ID32	MB34A	42.98	6.1	36	57.79	8.2	36	3106	0.0065
ID33	MB8A & MB8B	106.51	8.5	48	139.46	7.1	60	5323	0.005
ID34	MB5	122.17	6.2	60	149.13	5.3	72	2083	0.0025

Table C.3
Pipe Sizes Required for 10-year and 25-year storms - Future Land Use (Page 2 of 2)

Pipe Identification	Major Basins Contributing Drainage	10-year Flow (cfs)	10-year Velocity (ft/sec)	10-year Pipe Diameter (inches)	25-year Flow (cfs)	25-year Velocity (ft/sec)	25-year Pipe Diameter (inches)	Pipe Length (ft)	Minimum Pipe Slope (ft/ft)
ID35	MB31,MB32,MB33,MB34A,MB34B,MB34C,MB34D,MB35,MB5,MB6A,MB6B,MB6C,MB7	450.18	11.7	84	586.03	11.7	96	1224	0.005
ID36	MB31,MB32,MB33,MB34A,MB34B,MB34C, MB34D,MB35	341.82	8.9	84	448.89	8.9	96	5008	0.0025
ID37	MB35	135.23	6.9	60	172.21	6.1	72	3905	0.0025
ID38	MB34C	81.84	6.5	48	103.96	5.3	60	4611	0.003
ID39	MB8A	61.32	6.4	42	78.86	8.2	42	2337	0.006
ID40	MB8A,MB8B,MB8C,MB18A	153.24	7.8	60	188.34	9.6	60	2150	0.005
ID41	MB31,MB32	140.07	7.1	60	187.83	9.6	60	4285	0.005
ID42	MB32	76.70	6.1	48	103.81	5.3	60	4183	0.003
ID43	MB11	83.99	4.3	60	111.60	5.7	60	2525	0.0025
ID44	MB16C,MB11, MB16A	118.16	9.4	48	156.46	12.5	48	186	0.011
ID45	MB16C,MB11, MB16A	120.54	9.6	48	159.65	12.7	48	757	0.011
ID46	MB16C	24.88	7.9	24	29.95	9.5	24	990	0.015
ID48	MB17,MB19,MB16B	180.05	9.2	60	223.17	11.4	60	5711	0.01
ID49	MB27	85.06	12.0	36	102.30	14.5	36	928	0.02
ID51	MB14A	15.78	5.0	24	19.00	6.1	24	1541	0.01
ID52	MB26	108.15	11.2	42	140.61	11.2	48	2496	0.01
ID53	MB25	80.88	6.4	48	107.97	8.6	48	6831	0.005
ID54	MB23A,MB22D, MB22C,MB22B	167.31	8.5	60	219.39	11.2	60	1137	0.007
ID56	MB8C,MB18C	94.86	9.9	42	119.87	12.5	42	371	0.014
ID57	MB6A	29.04	5.9	30	35.55	5.0	36	773	0.005
ID58	MB5,MB6A,MB6B,MB6C	264.76	13.5	60	329.62	11.7	72	6885	0.01

Table C.4

Time of Concentration Summary Matrix (used for subbasins only)

Per COSM Guidelines for calculating time of concentration

Assumptions:

1 See full descriptions of assumptions on "Tc Calc" worksheet.

2 : Based on relative land use coverage, the following factors were used:

n_s : Manning's effective roughness coefficient for sheet flow

k_s : Time of Concentration velocity factor for shallow, concentrated flow

	Asphalt	Prarie grass/ lawn
n_s	0.012	0.15
k_s	27	11

3 : Given subbasin size and number of assumptions made in initial calcs, assume minimum time of concentration is 10 minutes.
Calculated tc values adjusted accordingly

Area (ac):	0-20	20-40	40-60	60+
Average (ac)	10	30	50	80
Assumed flow	933	1617	2087	2640
Assumed flow	1143	1980	2556	3233

Impervious (%	0-25	25-50	50-75	75-100
k(s) [3]	11	11	27	27

Slope (%):	0-10	10-20	20+
Average (ft/ft)	0.05	0.15	0.25

Upstream lan	Asphalt	Grass
n(s)	0.012	0.15

Sheet Flow: T = (0.42 * (n(s) * 300)^0.8)/(1.5^0.5)*(S^0.4)

Shallow Concentrated: T= L/(k(s)*(S^0.5)*60)

Notes: For purposes of estimating flow lengths, the average area for the range was used.
For purposes of calculating per incremental slope, the average slope was used.

2 Symmetrical flow length is calculated assuming subbasin is square or circular shape.
Unsymmetrical flow length is calculated assuming subbasin is a rectangular or assymetrical shape where the flow length is three times as long as the subbasin width

3 k(s) is the time of concentration velocity factor for shallow concentrated flow - asumed to be a component of % impervious

Impervious Percentage [1]	< 50%		>50%		
Dominant upstream land use coverage [2]	Asphalt	Grass	Asphalt	Grass	
Acreage = 0-20 acres					**Slope (%)**
symmetrical [3]					
	10	30	10	26	0-10%
	10	19	10	17	10-20%
	10	15	10	14	20%+
non-symmetrical [3]					
	11	32	10	27	0-10%
	10	20	10	17	10-20%
	10	16	10	14	20%+
Acreage = 20-40 acres					**Slope (%)**
symmetrical [3]					
	14	35	10	28	0-10%
	10	22	10	18	10-20%
	10	17	10	15	20%+
non-symmetrical [3]					
	17	37	10	29	0-10%
	10	23	10	19	10-20%
	10	19	10	15	20%+
Acreage = 40-60 acres					**Slope (%)**
symmetrical [3]					
	17	38	10	30	0-10%
	10	24	10	19	10-20%
	10	19	10	15	20%+
non-symmetrical [3]					
	20	41	10	31	0-10%
	12	25	10	19	10-20%
	10	20	10	16	20%+

Table cont.

Impervious Percentage [1]	< 50%		>50%		
Dominant upstream land use coverage [2]	Asphalt	Grass	Asphalt	Grass	
Acreage = 60+ acres					**Slope (%)**
symmetrical [3]					
	21	42	10	31	0-10%
	12	26	10	20	10-20%
	10	21	10	16	20%+
non-symmetrical [3]					
	25	46	12	33	0-10%
	15	28	10	21	10-20%
	11	22	10	17	20%+

Notes:

1 Range of impervious used to determine ks. Impervious < 50% assumes ks = 11; impervious >50% assumes ks = 27.

2 Dominant upstream land use coverage used to determine n_s. Asphalt upstream assumes n_s = 0.012; lawn upstream assumes n_s = 0.15.

3 If basin deemed to be symmetrical, assume square shape in calculating flow lengths. If basin deemed to be non symmetrical, assume rectangular shap where length is equal to 3* width.

Table C.5

Flow and Volume for Subbasins

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Storms: 4

CN (imp): 98

dt: 6

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
						Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
283	43	41	0	43	79	0	10,656	5	89,936	8	129,644	13	195,732
285	62	46	0	62	79	0	15,007	6	126,920	10	182,998	18	276,345
326	27	35	0	27	79	0	6,704	3	56,426	6	81,316	9	122,734
332	17	32	0	17	79	0	4,216	2	35,442	4	51,069	6	77,070
333	30	37	0	30	79	0	7,404	4	62,372	6	89,894	10	135,693
339	17	11	2	15	79	1	8,533	5	42,954	8	59,292	12	86,081
343	23	35	1	22	79	0	7,762	3	51,260	5	72,608	8	107,943
376	35	37	4	31	79	1	18,553	6	90,374	9	124,337	14	179,974
377	40	41	1	39	79	0	13,352	5	89,140	8	126,387	13	188,063
397	25	37	0	25	79	0	6,182	3	52,083	5	75,065	8	113,309
398	30	35	0	30	79	0	7,516	4	63,260	6	91,164	10	137,598
403	29	37	0	29	79	0	7,245	4	61,037	6	87,969	10	132,787
407	21	37	0	21	79	0	5,217	3	43,953	4	63,347	7	95,621
408	57	41	0	57	79	0	14,084	6	118,867	11	171,348	18	258,695
418	15	10	4	11	79	2	14,583	7	50,890	9	66,877	13	92,510
427	18	11	3	15	79	1	12,654	6	52,371	9	70,595	14	100,187
449	16	32	5	11	69	1	13,820	3	42,327	4	55,722	6	77,876
452	18	30	0	18	79	0	4,518	3	37,941	4	54,664	7	82,488
453	18	32	0	18	79	0	4,683	2	37,630	4	54,066	7	81,389
464	14	30	4	10	69	1	11,088	3	35,163	4	46,720	5	65,965
465	44	38	12	32	69	3	34,193	7	109,531	10	145,934	14	206,682
474	7	32	0	7	69	0	52	0	6,636	0	11,051	1	19,062
475	12	30	1	11	69	0	3,057	1	16,552	1	24,357	3	38,052
483	6	11	1	6	69	0	2,357	1	10,572	1	15,104	3	22,958
485	12	32	0	12	79	0	2,957	2	24,856	3	35,815	4	54,050
495	22	17	5	18	69	2	14,009	4	48,911	6	66,508	9	96,253
496	15	30	3	12	69	1	7,649	2	29,146	3	40,412	4	59,669
501	23	14	6	17	69	2	16,866	6	55,077	8	73,699	12	104,853
502	21	14	4	16	69	2	12,188	4	43,526	6	59,484	9	86,537
503	29	17	8	21	79	3	28,037	10	97,764	14	128,464	20	177,689
508	15	32	0	15	79	0	3,759	2	31,594	3	45,523	6	68,699
513	26	35	1	25	79	0	9,359	4	59,033	6	83,301	9	123,420
517	17	11	7	9	79	3	23,608	10	69,656	12	88,790	17	118,898
534	35	35	2	33	79	1	14,422	5	83,655	8	117,169	13	172,433
544	42	17	12	30	69	5	35,941	11	111,729	14	147,635	21	207,172
551	41	20	20	21	79	7	62,053	19	179,073	24	227,243	33	302,800
557	25	17	4	21	79	1	15,368	7	68,375	10	93,044	15	133,266
577	30	17	14	16	69	5	39,966	12	108,792	15	138,339	20	185,704
579	18	11	6	12	69	3	17,929	6	53,167	9	69,346	12	95,899
581	21	14	5	16	69	2	13,039	4	45,514	6	61,881	10	89,543

Flow and Volume for Subbasins

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		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
587	34	17	9	25	69	3	25,121	8	81,970	10	109,671	16	156,013
588	17	11	8	9	69	3	22,879	8	62,452	10	79,480	14	106,798
595	20	10	4	16	69	2	10,729	4	39,965	6	55,113	10	80,921
599	28	14	4	23	69	2	12,319	4	50,086	6	70,306	11	105,073
618	52	20	24	28	69	8	68,512	19	187,630	24	239,049	33	321,642
619	16	11	5	11	79	2	18,461	8	60,230	11	78,245	15	106,944
623	9	10	2	7	79	1	7,486	4	27,808	5	36,906	7	51,571
625	15	11	5	11	69	2	13,812	5	42,134	7	55,386	10	77,273
633	42	20	15	27	69	5	43,948	12	127,847	16	165,863	22	227,982
639	22	37	4	17	69	1	11,634	3	42,933	4	59,138	6	86,747
642	32	37	3	29	69	1	9,213	2	47,520	4	69,474	6	107,910
643	13	10	3	10	69	1	7,952	3	28,140	4	38,374	7	55,701
648	15	32	1	14	79	0	7,183	3	37,898	4	52,588	6	76,730
649	15	32	1	14	69	0	2,260	1	17,533	1	26,874	3	43,485
653	76	21	28	47	69	9	81,638	22	235,398	29	304,619	40	417,470
656	15	30	5	10	69	1	14,650	3	43,184	4	56,247	6	77,667
673	17	11	3	14	69	1	9,575	4	35,327	5	48,621	8	71,244
674	87	25	25	62	79	8	87,471	27	299,372	37	392,184	52	540,762
677	27	17	10	16	69	4	30,098	9	85,677	12	110,447	16	150,688
678	23	17	7	16	69	2	19,632	6	60,804	8	80,264	12	112,509
686	81	46	14	67	69	3	39,262	8	151,500	11	210,723	18	312,169
687	22	37	4	18	79	1	15,461	4	64,113	6	86,470	9	122,789
700	94	21	8	86	69	2	22,351	7	129,589	13	192,334	24	302,739
706	22	22	3	19	69	1	9,629	3	39,651	4	55,809	7	83,633
708	58	20	2	57	69	1	5,193	2	62,594	6	99,005	13	164,292
717	9	10	5	4	69	2	14,600	5	38,157	7	47,884	9	63,250
719	38	17	7	31	69	2	18,999	6	73,034	9	101,399	14	149,908
720	33	17	6	27	69	2	16,682	5	63,925	8	88,696	13	131,044
723	6	10	2	4	69	1	6,112	2	18,023	3	23,470	4	32,398
725	10	11	2	8	69	1	5,441	2	20,026	3	27,546	5	40,342
731	7	19	1	6	69	0	3,092	1	12,591	1	17,682	2	26,439
732	17	10	6	11	69	3	16,007	6	47,852	8	62,554	11	86,726
733	57	24	3	55	69	1	7,563	3	66,567	6	103,091	12	168,222
737	23	17	0	23	69	0	298	1	21,564	2	35,725	5	61,384
738	37	17	5	32	79	2	22,857	10	101,769	15	138,498	22	198,387
742	23	10	15	8	69	7	44,053	16	111,629	20	138,628	26	180,727
743	34	10	17	16	69	8	49,478	18	132,005	23	166,778	31	222,134
745	32	14	7	24	69	3	21,054	7	71,735	10	96,982	15	139,504
746	22	35	8	15	69	2	21,424	5	63,633	6	83,066	9	114,993
748	60	25	4	56	69	1	12,333	4	78,572	7	117,971	13	187,576
752	36	35	7	28	69	2	20,435	5	73,451	6	100,589	10	146,669
755	15	19	3	12	69	1	8,763	3	31,578	4	43,247	6	63,056

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
# Storms: 4													
CN (imp): 98													
dt: 6						Pt:	1	Pt:	2	Pt:	3	Pt:	3

Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
756	20	17	4	16	69	1	11,946	4	42,547	5	58,116	8	84,502
762	8	32	1	6	69	0	4,037	1	15,192	1	21,010	2	30,942
765	31	14	13	17	69	5	38,469	12	106,681	16	136,437	22	184,415
766	15	20	1	14	69	0	1,940	1	17,357	2	26,908	3	43,944
770	59	25	10	48	69	3	29,903	8	113,749	12	157,630	19	232,611
772	67	26	4	63	69	1	12,394	4	84,809	7	128,346	14	205,456
773	34	23	5	29	69	2	14,793	4	61,108	6	86,063	11	129,049
776	22	10	14	8	69	6	40,810	15	103,737	18	128,967	24	168,364
777	26	19	4	23	69	1	10,874	3	45,835	5	64,785	9	97,480
783	47	19	4	43	69	1	11,534	4	65,328	7	96,658	13	151,724
786	45	12	9	37	69	4	25,192	9	92,443	13	127,083	21	185,999
789	27	23	6	21	69	2	16,507	4	57,841	6	78,730	10	114,063
790	39	37	5	34	79	1	23,435	7	106,251	10	144,953	16	208,140
791	7	15	0	7	69	0	1,379	1	9,319	1	14,076	2	22,493
794	15	10	5	10	69	2	13,861	5	41,906	7	54,951	10	76,455
795	26	17	7	20	69	2	18,979	6	62,709	8	84,160	12	120,122
796	10	32	1	9	69	0	3,934	1	17,088	1	24,296	2	36,771
803	51	25	15	36	69	4	41,671	11	130,755	14	173,228	21	243,802
804	13	16	0	13	69	0	1,086	1	13,761	1	21,821	3	36,280
807	16	19	2	14	69	1	6,720	2	28,525	3	40,370	5	60,819
808	32	37	1	31	69	0	2,869	1	34,091	2	53,942	5	89,558
810	43	24	3	40	69	1	9,967	3	58,810	5	87,492	10	138,004
811	25	17	10	15	79	4	32,577	11	100,177	15	128,734	20	173,919
812	18	20	3	15	69	1	8,875	3	34,095	4	47,337	6	69,984
813	12	15	1	12	69	0	1,950	1	14,905	2	22,790	3	36,796
814	16	11	6	9	69	3	17,708	6	50,327	8	64,840	12	88,404
817	27	14	7	20	69	3	20,730	7	66,733	9	88,976	14	126,095
819	29	17	1	28	79	0	10,696	6	67,269	10	94,873	15	140,487
821	33	10	6	27	69	3	17,195	7	64,786	10	89,558	16	131,816
822	15	20	2	12	69	1	6,794	2	26,972	3	37,694	5	56,092
826	47	24	7	41	69	2	19,179	5	81,590	8	115,540	14	174,170
827	30	23	5	25	69	2	14,881	4	57,087	6	79,241	10	117,129
828	26	35	4	22	79	1	15,632	5	70,182	7	95,629	11	137,152
834	44	38	8	37	69	2	21,552	5	83,188	7	115,678	11	171,314
835	16	30	3	13	69	1	8,791	2	32,077	3	44,067	5	64,460
837	56	25	10	46	69	3	29,810	8	111,567	11	154,082	18	226,596
838	30	19	4	27	79	1	16,741	8	80,001	11	109,801	17	158,561
843	18	11	8	10	69	3	22,645	8	62,426	10	79,689	14	107,472
844	22	10	12	10	79	5	36,642	15	102,045	19	128,527	25	169,827
845	26	35	3	23	69	1	8,659	2	40,374	3	58,109	6	88,966
850	13	30	1	12	69	0	2,352	1	16,006	1	24,214	2	38,753
853	57	10	31	27	79	14	94,957	38	264,939	49	333,826	65	441,295

Flow and Volume for Subbasins

UPDATE

Active Scroll

	# Storms:		4										
	CN (imp):		98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
	dt:		6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
854	15	11	5	10	69	2	13,698	5	41,777	7	54,915	10	76,611
855	26	17	5	22	69	2	13,570	4	51,395	6	71,138	10	104,846
856	22	37	7	15	79	2	22,394	6	76,088	8	99,562	11	137,120
859	17	32	5	12	79	1	16,412	4	56,619	6	74,275	9	102,562
861	28	10	19	9	69	9	55,150	20	138,541	25	171,532	32	222,769
862	17	10	5	12	69	2	14,293	5	44,713	7	59,172	11	83,173
863	19	10	5	14	69	2	14,847	6	47,844	8	63,802	12	90,435
864	54	20	22	31	69	7	64,206	18	180,045	23	231,060	31	313,596
868	38	14	9	29	69	3	24,701	8	84,508	11	114,361	18	164,672
871	39	22	8	31	69	2	22,451	6	80,988	9	110,954	14	161,833
872	16	20	3	13	69	1	8,729	3	31,891	4	43,811	6	64,079
873	22	17	10	12	69	4	28,078	8	77,671	11	99,262	15	134,050
874	15	11	5	10	69	2	13,413	5	40,955	6	53,850	9	75,152
875	25	37	5	20	79	1	20,197	5	77,695	8	103,682	11	145,692
876	19	11	5	14	79	2	16,853	8	61,363	11	81,191	16	113,099
879	18	20	3	15	79	1	13,665	5	54,600	7	73,250	11	103,470
888	19	20	2	16	69	1	6,334	2	29,689	3	42,739	6	65,435
893	21	35	2	19	69	0	4,462	1	27,398	2	40,983	4	64,960
894	76	26	3	73	79	1	26,925	13	172,586	20	243,829	33	361,635
898	41	41	6	35	69	1	16,404	3	69,897	5	99,080	9	149,525
899	7	19	0	7	49	0	245	0	580	0	1,086	0	3,095
900	11	10	4	7	69	2	12,810	5	36,365	6	46,835	9	63,829
901	20	23	4	16	79	1	14,893	5	59,632	8	80,027	11	113,079
902	35	23	9	27	69	3	24,791	7	82,298	9	110,593	14	158,074
903	10	11	1	10	69	0	1,849	1	13,166	2	19,990	3	32,082
904	58	41	10	49	79	2	40,081	11	167,167	15	225,641	23	320,676
907	18	32	4	14	69	1	12,640	3	42,034	4	56,524	6	80,852
909	22	10	16	6	69	7	44,434	16	111,043	20	137,235	26	177,811
910	17	20	2	14	69	1	6,128	2	27,391	3	39,120	5	59,453
911	33	23	7	27	69	2	19,034	5	68,780	7	94,267	12	137,553
912	7	10	4	3	69	2	11,902	4	30,987	5	38,837	7	51,219
917	16	32	1	14	79	0	7,632	3	39,241	4	54,304	6	79,034
922	13	32	2	11	69	1	6,841	2	25,977	2	35,994	4	53,112
923	42	25	7	35	69	2	19,171	5	76,719	8	107,404	13	160,109
935	56	41	24	32	79	6	75,381	16	226,617	22	289,972	30	389,945
936	54	10	39	15	79	17	114,939	44	295,086	54	364,898	70	472,071
937	18	10	13	5	69	6	36,388	13	90,833	16	112,213	21	145,316
939	23	35	5	17	69	1	15,214	3	51,336	5	69,281	7	99,485
940	21	37	2	19	69	0	5,599	1	29,614	2	43,453	4	67,714
941	7	32	0	7	69	0	1,130	0	8,718	1	13,356	1	21,604
942	28	23	3	25	69	1	8,386	2	41,822	4	60,799	7	93,938
946	60	25	22	38	79	7	72,511	21	228,774	28	295,422	39	401,211

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
	# Storms:	4											
	CN (imp):	98											
	dt:	6				Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	**Acres**	**Tc**	**Impervious Acres**	**Pervious Acres**	**soil group (CN)**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**		
947	23	14	6	17	69	2	16,576	5	54,519	8	73,082	11	104,175
948	55	17	23	32	79	8	73,943	25	222,646	33	284,954	45	383,274
951	11	20	0	11	69	0	838	0	11,379	1	18,115	2	30,212
952	73	26	1	71	69	0	4,306	2	73,446	5	118,171	13	198,712
956	63	25	17	46	79	5	59,137	19	208,937	25	275,153	37	381,461
958	24	23	7	17	69	2	18,784	5	59,736	7	79,414	10	112,190
970	19	32	3	16	69	1	7,625	2	32,144	3	45,457	5	68,440
971	18	32	4	14	69	1	12,610	3	42,096	4	56,660	6	81,128
972	24	10	6	18	69	3	16,621	6	55,624	9	74,872	14	107,199
973	32	35	1	31	79	0	11,144	5	72,796	7	103,022	12	153,038
975	41	17	11	29	69	4	33,081	10	104,593	13	138,819	20	195,758
976	21	35	2	19	69	1	6,098	1	31,159	2	45,488	4	70,558
977	56	25	10	46	69	3	29,189	8	110,040	11	152,206	18	224,184
980	107	46	3	104	69	1	10,496	3	115,577	7	182,154	14	301,525
981	7	11	1	6	69	1	3,855	1	14,109	2	19,384	3	28,353
982	29	14	10	19	79	4	32,427	13	105,324	17	136,722	24	186,715
984	22	23	4	18	69	1	10,907	3	41,860	4	58,111	7	85,903
986	26	37	4	22	69	1	10,437	2	44,362	4	62,844	6	94,779
987	35	35	2	33	69	0	5,207	1	41,760	3	64,212	6	104,183
991	21	23	5	16	69	2	14,450	4	48,610	5	65,535	8	93,994
992	21	23	5	16	79	1	17,792	6	66,326	8	88,085	12	123,171
993	18	10	11	7	69	5	31,214	11	80,219	14	100,103	19	131,300
994	47	38	18	29	79	4	58,098	14	181,251	18	233,579	25	316,538
995	27	35	12	15	69	3	33,569	7	92,611	9	118,279	12	159,616
1005	70	25	32	39	69	9	90,188	22	248,205	29	316,721	39	426,960
1014	55	25	5	50	69	2	15,604	5	81,011	7	118,479	14	184,064
1015	33	10	6	27	69	3	16,575	6	63,679	10	88,382	16	130,612
1016	19	11	5	14	79	2	16,554	8	60,341	11	79,851	15	111,251
1019	22	35	10	12	69	3	29,699	6	81,013	8	103,099	11	138,540
1023	50	24	1	49	69	0	2,896	2	50,243	4	80,881	9	136,057
1025	19	32	6	13	69	2	17,917	4	54,060	5	70,877	8	98,602
1026	45	25	7	38	69	2	21,498	6	84,615	9	118,071	14	175,444
1027	21	23	6	15	79	2	21,166	7	73,251	9	96,138	13	132,813
1028	37	22	8	29	79	3	29,910	11	113,646	15	151,361	21	212,262
1036	21	23	5	16	69	1	13,051	4	45,308	5	61,538	8	88,956
1037	15	10	2	12	79	1	9,726	5	41,445	8	56,084	11	79,894
1039	19	10	8	11	79	4	25,854	11	77,113	14	98,508	19	132,223
1040	61	46	19	42	69	4	55,012	10	166,808	13	219,059	19	305,332
1041	46	17	14	33	69	5	39,537	12	122,791	16	162,211	23	227,563
1042	47	25	7	40	69	2	20,188	6	83,707	8	117,983	14	177,050
1046	125	46	54	71	69	12	154,399	28	428,217	36	547,862	49	740,909
1048	58	20	24	33	69	8	69,346	19	194,082	24	248,928	34	337,612

Flow and Volume for Subbasins

UPDATE

Active Scroll

		# Storms:	4										
		CN (imp):	98			**WQ storm**		**10 yr. storm**		**25 yr. storm**		**100 yr storm**	
		dt:	6			**Pt:**	**1**	**Pt:**	**2**	**Pt:**	**3**	**Pt:**	**3**
Basin_ID	**Acres**	**Tc**	**Impervious Acres**	**Pervious Acres**	**soil group (CN)**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**		
1049	19	20	3	15	79	1	13,671	5	54,986	7	73,837	11	104,395
1052	8	30	3	5	69	1	8,564	2	24,513	3	31,657	4	43,284
1053	16	32	5	11	69	1	14,334	3	43,439	4	57,022	6	79,437
1058	17	19	2	15	69	1	5,344	2	25,948	3	37,562	5	57,807
1059	15	20	3	12	79	1	12,003	5	46,921	6	62,752	9	88,367
1060	36	23	9	27	69	3	26,354	7	86,406	10	115,760	15	164,915
1067	8	10	3	5	69	2	9,653	4	27,421	5	35,324	7	48,153
1071	35	23	13	23	69	4	36,033	9	105,588	12	137,280	18	189,161
1072	18	20	4	14	69	1	11,556	3	39,826	5	53,997	7	77,908
1073	16	11	6	10	69	3	18,268	7	51,978	8	66,990	12	91,374
1074	65	46	24	41	79	5	77,695	16	244,569	22	315,717	30	428,644
1076	40	22	8	31	69	3	23,378	6	83,361	9	113,911	15	165,705
1079	15	19	1	14	69	0	3,366	1	20,526	2	30,652	4	48,506
1080	46	20	22	25	69	7	61,701	17	168,322	21	214,190	29	287,774
1083	15	10	6	9	69	3	17,734	7	49,876	8	64,058	12	87,018
1086	16	10	5	11	69	2	14,978	6	44,926	7	58,783	11	81,584
1087	29	23	6	22	79	2	23,304	8	88,875	11	118,437	16	166,185
1088	36	35	8	27	69	2	23,909	5	80,797	7	109,081	11	156,697
1089	42	38	14	28	69	3	39,831	8	119,378	11	156,242	15	216,936
1090	33	37	6	27	69	2	18,556	4	67,669	6	92,972	9	136,020
1091	20	35	3	18	79	1	11,858	4	54,463	5	74,416	8	107,012
1100	32	35	6	25	69	2	18,513	4	65,952	6	90,138	9	131,158
1102	14	20	0	14	69	0	108	0	13,135	1	21,847	3	37,645
1103	16	20	3	13	79	1	11,416	4	46,065	6	61,885	9	87,535
1104	14	11	5	10	69	2	13,720	5	41,159	7	53,857	10	74,753
1105	37	23	9	28	79	3	32,190	11	118,046	15	156,377	22	218,105
1108	15	11	6	9	69	3	16,991	6	48,150	8	61,982	11	84,423
1112	63	42	14	49	69	3	38,873	8	135,457	11	184,241	17	266,760
1114	17	30	8	9	69	2	22,843	5	62,060	7	78,875	9	105,819
1115	28	23	6	22	79	2	23,113	8	87,505	11	116,484	16	163,266
1116	40	14	15	24	69	6	44,092	14	126,236	19	163,001	26	222,818
1117	29	17	11	18	69	4	32,952	10	93,798	13	120,912	18	164,963
1118	39	37	11	29	79	3	37,082	9	130,867	13	172,326	19	238,891
1119	17	20	4	13	79	1	14,169	5	53,406	7	71,042	10	99,504
1120	32	10	10	23	79	4	33,013	15	112,665	21	147,509	29	203,263
1121	31	10	9	22	79	4	30,025	14	104,701	19	137,574	27	190,280
1125	22	17	6	16	69	2	17,012	5	54,734	7	72,971	10	103,405
1126	47	41	12	34	69	3	35,474	7	114,313	10	152,549	14	216,431
1127	14	10	4	10	69	2	12,302	5	38,203	6	50,459	9	70,774
1128	57	38	13	44	69	3	38,059	8	128,485	11	173,435	17	249,103
1131	60	25	7	53	79	2	32,113	13	155,318	19	213,482	29	308,713
1136	61	46	11	50	69	2	31,891	6	119,541	9	165,270	14	243,349

Flow and Volume for Subbasins

UPDATE

Active Scroll

 # Storms: 4

CN (imp): 98

dt: 6

						WQ storm		**10 yr. storm**		**25 yr. storm**		**100 yr storm**	
						Pt:	**1**	**Pt:**	**2**	**Pt:**	**3**	**Pt:**	**3**
Basin_ID	**Acres**	**Tc**	**Impervious Acres**	**Pervious Acres**	**soil group (CN)**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**		
1137	34	17	16	18	69	6	47,272	14	127,978	18	162,455	24	217,625
1138	29	10	24	5	69	11	69,914	25	170,129	31	208,262	39	266,519
1141	21	23	7	14	79	2	24,774	8	79,299	10	102,672	14	139,831
1142	7	11	2	5	79	1	6,481	3	22,923	4	30,190	6	41,856
1145	17	32	4	14	79	1	13,475	4	52,144	6	69,643	8	97,940
1146	26	17	10	17	79	3	31,428	11	99,708	15	128,883	20	175,218
1147	24	17	9	15	79	3	28,886	10	91,107	13	117,637	18	159,743
1152	28	23	6	22	79	2	22,659	8	86,869	11	115,853	16	162,685
1153	30	17	14	17	79	5	42,808	14	126,469	18	161,254	25	216,001
1154	88	28	24	64	79	7	84,491	25	295,928	34	389,170	49	538,757
1158	16	10	4	12	69	2	11,629	4	38,318	6	51,384	9	73,271
1159	35	14	13	22	69	5	36,014	12	105,264	15	136,741	22	188,225
1162	40	12	10	30	69	4	29,866	11	97,698	14	130,780	22	186,138
1163	38	10	12	26	69	5	33,177	12	102,321	17	134,899	25	188,822
1164	17	10	12	5	69	5	34,655	13	86,361	16	106,625	20	137,975
1168	13	32	2	10	69	1	6,324	2	24,195	2	33,577	3	49,624
1169	24	37	6	18	69	2	17,379	4	57,278	5	76,863	8	109,705
1170	40	37	4	35	69	1	12,547	3	60,714	5	87,914	8	135,355
1171	29	22	0	29	69	0	361	1	26,749	2	44,342	5	76,227
1173	29	23	7	22	69	2	21,510	6	70,282	8	94,077	12	133,902
1177	37	14	14	23	69	6	40,764	13	117,052	17	151,274	24	206,997
1180	16	30	0	15	69	0	714	0	15,251	1	24,742	2	41,869
1181	21	10	16	5	69	7	47,106	17	115,998	21	142,610	27	183,529
1182	58	30	30	28	69	8	84,767	19	225,866	24	285,282	33	379,851
1186	10	30	1	9	69	0	2,493	1	13,599	1	20,032	2	31,323
1187	11	30	2	9	69	0	4,743	1	19,288	2	27,091	3	40,518
1190	45	25	9	36	79	3	34,943	12	135,937	17	181,684	24	255,681
1191	7	10	3	4	79	1	9,117	4	27,135	5	34,649	7	46,486
1192	6	10	2	4	69	1	5,480	2	16,625	3	21,822	4	30,394
1202	10	10	2	7	79	1	8,109	4	30,357	6	40,338	8	56,434
1205	20	10	11	9	69	5	30,483	11	80,249	14	100,949	19	133,740
1207	30	35	2	28	69	1	6,376	2	40,004	3	59,992	6	95,299
1208	10	10	4	6	69	2	11,334	4	31,925	5	41,022	8	55,755
1209	16	11	6	10	69	2	16,280	6	47,757	8	62,100	11	85,580
1212	51	25	20	31	79	6	64,260	18	198,505	24	255,321	34	345,277
1213	37	17	16	21	69	6	45,807	14	127,002	17	162,420	24	219,525
1214	8	11	4	4	69	2	11,020	4	29,929	5	38,029	7	51,002
1219	8	10	2	6	69	1	5,717	2	18,937	3	25,425	5	36,305
1220	45	17	19	26	69	7	54,202	16	151,962	21	195,001	29	264,626
1223	26	14	12	14	79	5	37,190	14	109,737	18	139,885	24	187,324
1224	89	46	20	69	79	4	73,380	17	276,596	24	368,025	35	515,627
1225	91	42	33	58	69	8	93,903	18	273,459	24	355,005	33	488,362

Flow and Volume for Subbasins

UPDATE

Active Scroll

		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1229	57	25	0	57	69	0	413	1	51,304	4	85,373	9	147,173
1230	10	20	0	10	69	0	72	0	8,723	1	14,509	2	25,001
1231	35	10	9	26	69	4	27,310	10	87,992	14	117,336	21	166,309
1233	12	11	5	7	79	2	16,499	7	50,174	9	64,337	12	86,714
1234	81	46	33	47	69	7	94,057	17	264,490	22	339,828	31	461,886
1236	60	26	13	47	69	4	37,367	10	130,637	13	177,736	21	257,389
1238	26	10	8	18	79	4	27,747	13	93,366	17	121,947	24	167,620
1241	24	17	9	15	69	3	25,875	8	74,340	10	96,092	14	131,519
1242	23	14	8	15	69	3	22,419	7	66,259	10	86,345	14	119,286
1243	21	10	11	10	69	5	31,545	12	83,577	15	105,355	20	139,938
1244	31	14	18	13	69	7	52,271	17	135,213	21	169,103	28	222,421
1245	24	17	8	16	79	3	27,317	10	88,302	13	114,528	18	156,267
1246	40	20	17	23	69	6	48,587	13	135,767	17	174,050	24	235,924
1247	16	10	5	10	79	2	17,682	8	57,313	11	74,368	15	101,519
1248	35	10	10	26	79	4	34,133	16	119,291	22	156,803	31	216,957
1249	50	12	18	32	79	7	59,040	24	188,350	32	243,703	45	331,663
1250	32	10	17	15	69	8	50,121	18	131,756	23	165,662	31	219,344
1252	23	10	7	16	49	3	19,728	7	46,746	9	57,559	11	76,685
1253	11	10	7	4	69	3	18,654	7	47,990	9	59,906	11	78,611
1254	10	10	7	3	69	3	20,117	7	50,164	9	61,949	12	80,185
1255	53	31	41	12	69	11	115,521	26	284,707	31	350,117	40	450,729
1257	7	10	3	5	69	1	7,494	3	21,931	4	28,498	5	39,242
1262	13	10	5	8	79	2	15,199	7	48,607	9	62,919	12	85,668
1264	19	10	4	15	79	2	16,101	8	60,853	11	80,976	16	113,451
1265	6	10	3	3	49	1	9,126	3	21,623	4	26,395	5	34,161
1266	24	17	10	14	69	4	28,877	9	80,579	11	103,254	15	139,882
1267	32	35	0	31	69	0	1,135	1	30,209	2	49,334	4	83,903
1268	16	32	1	15	49	0	2,763	1	6,551	1	8,752	1	14,792
1269	28	10	9	19	79	4	29,599	14	98,940	18	129,082	26	177,215
1270	18	10	4	14	69	2	10,875	4	38,263	6	52,111	9	75,536
1272	22	14	8	14	69	3	24,192	8	69,682	10	90,136	14	123,467
1273	19	10	6	13	79	3	20,003	9	66,992	12	87,429	17	120,072
1274	31	14	16	15	69	6	44,632	14	119,530	18	151,206	25	201,701
1275	20	32	7	13	69	2	19,268	4	57,018	6	74,350	8	102,798
1276	25	10	9	16	79	4	28,962	13	92,489	17	119,691	24	162,920
1277	26	37	6	20	79	1	21,985	6	82,257	8	109,316	12	152,968
1278	35	17	14	21	79	5	44,063	15	136,572	20	175,767	28	237,844
1280	18	10	6	12	79	3	20,158	9	65,731	12	85,383	17	116,686
1281	6	10	2	4	79	1	5,973	3	20,838	4	27,382	5	37,875
1283	95	28	24	71	69	7	68,193	17	224,318	23	300,804	34	428,981
1284	10	11	5	5	49	2	14,482	5	34,316	6	41,903	8	54,295
1285	17	11	8	9	79	3	23,946	10	70,667	13	90,081	17	120,632

Flow and Volume for Subbasins

UPDATE

Active Scroll

Storms: 4

CN (imp): 98

dt: 6

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
						Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1290	18	11	9	9	69	4	24,523	9	66,326	11	84,164	15	112,697
1291	41	10	28	13	69	13	80,396	29	201,975	36	250,078	47	324,785
1294	9	10	4	5	49	2	11,725	4	27,781	5	33,940	6	44,051
1295	16	10	3	13	69	1	8,612	3	32,190	5	44,424	8	65,274
1296	56	10	17	38	69	8	50,260	19	153,439	25	201,740	37	281,522
1299	116	42	18	98	69	4	52,167	11	209,510	16	293,703	26	438,474
1300	14	32	3	11	69	1	9,866	2	33,120	3	44,639	5	64,008
1301	23	14	10	12	79	4	32,204	12	95,049	15	121,167	21	162,268
1303	14	10	6	9	69	2	15,899	6	45,651	8	58,993	11	80,715
1304	6	10	2	3	69	1	6,986	3	19,587	3	25,133	5	34,103
1305	23	37	0	23	69	0	158	1	20,589	1	34,304	3	59,200
1306	35	37	5	30	69	1	14,101	3	59,683	5	84,483	8	127,318
1307	45	12	18	27	69	7	51,102	18	145,554	23	187,656	32	256,057
1309	17	11	8	9	69	4	23,322	8	63,108	11	80,093	14	107,266
1310	26	14	7	19	69	3	21,278	7	66,997	9	88,820	14	125,092
1318	32	10	20	12	69	9	57,812	21	147,378	26	183,403	34	239,727
1321	14	30	3	12	69	1	7,497	2	28,223	3	39,033	4	57,486
1323	19	16	2	17	49	1	5,616	2	13,310	2	17,108	3	25,972
1325	45	17	17	27	49	6	49,705	15	117,796	18	144,306	22	189,106
1326	20	10	15	5	69	7	44,053	16	108,719	20	133,766	25	172,324
1327	16	10	10	6	69	4	27,396	10	70,468	12	87,961	17	115,417
1332	41	41	15	26	69	4	42,882	8	124,267	11	161,090	15	221,234
1334	24	14	11	13	49	4	30,991	10	73,439	12	89,758	15	116,685
1336	6	10	4	2	69	2	12,156	4	30,586	5	37,890	7	49,243
1337	35	10	19	16	69	9	55,871	21	146,431	26	183,932	34	243,237
1339	16	32	6	10	69	2	17,689	4	50,787	5	65,648	7	89,856
1340	51	24	9	42	69	3	27,027	7	101,310	11	139,957	17	205,883
1350	35	17	15	20	69	5	43,464	13	120,734	16	154,494	23	208,957
1358	106	28	16	91	69	4	44,912	12	186,805	17	263,483	29	395,673
1359	30	23	3	27	69	1	8,884	3	44,973	4	65,525	8	101,446
1361	8	10	5	3	69	2	13,530	5	34,975	6	43,730	8	57,500
1362	13	10	10	3	79	5	30,350	11	76,148	14	93,644	18	120,360
1363	17	10	9	8	69	4	26,493	10	69,607	12	87,504	16	115,834
1364	19	10	12	8	69	5	33,383	12	86,099	15	107,570	20	141,308
1365	67	21	32	34	69	10	91,816	25	248,267	31	315,037	42	421,843
1366	20	11	9	11	69	4	25,834	9	71,006	12	90,559	16	121,998
1367	43	10	31	12	79	14	90,911	35	233,335	43	288,520	56	373,232
1368	28	10	19	9	69	9	54,906	20	137,854	25	170,649	32	221,569
1369	17	10	1	16	49	0	2,690	1	6,375	1	8,621	1	14,848
1370	23	17	8	15	69	3	23,105	7	68,096	9	88,671	13	122,395
1372	66	26	16	51	69	5	44,661	11	150,782	16	203,469	24	292,124
1373	28	17	13	15	69	5	37,416	11	102,357	14	130,358	19	175,319

Flow and Volume for Subbasins

UPDATE		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
Active Scroll		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1374	9	30	1	9	69	0	2,461	1	13,410	1	19,750	2	30,880
1379	35	17	17	19	69	6	47,411	14	129,127	18	164,224	24	220,497
1382	29	14	8	20	79	3	29,150	12	99,481	16	130,250	23	179,487
1383	9	10	2	7	69	1	7,095	3	22,774	4	30,339	6	42,958
1384	26	10	13	12	69	6	38,408	14	102,195	18	129,003	24	171,639
1385	70	26	22	48	69	7	63,901	16	193,890	21	254,571	31	354,716
1386	84	10	53	31	69	24	152,059	56	388,166	69	483,277	91	632,069
1389	60	25	26	35	69	8	73,365	18	204,760	24	262,417	32	355,579
1390	7	30	2	5	69	1	6,087	1	18,758	2	24,734	3	34,631
1393	49	20	15	34	69	5	42,927	12	132,055	16	174,014	23	243,450
1394	30	10	21	9	69	9	59,417	22	149,243	27	184,774	35	239,952
1395	15	10	7	8	69	3	19,781	7	54,162	9	68,995	13	92,816
1396	9	10	3	5	69	1	9,508	4	27,417	5	35,474	7	48,606
1397	26	17	5	20	79	2	20,299	8	78,447	11	104,739	17	147,241
1398	11	30	0	11	79	0	3,515	2	24,703	3	35,159	4	52,490
1399	25	10	14	11	69	6	39,072	14	102,490	18	128,774	24	170,355
1400	15	11	5	10	69	2	15,669	6	45,692	7	59,313	11	81,578
1406	37	22	0	37	69	0	320	1	33,484	2	55,650	7	95,845
1408	72	25	36	36	69	11	103,497	26	276,812	32	350,044	44	466,751
1409	22	37	5	16	79	1	18,804	5	69,128	7	91,620	10	127,855
1410	8	11	3	6	79	1	9,273	4	30,458	5	39,615	8	54,213
1411	22	14	6	16	69	2	16,766	6	53,952	8	71,927	11	101,923
1413	56	41	6	50	79	1	28,465	9	141,605	13	195,288	20	283,318
1416	31	23	11	20	69	4	32,463	8	94,766	11	123,074	16	169,373
1421	45	41	5	40	69	1	14,734	3	69,919	5	100,949	9	155,015
1422	51	38	9	42	69	2	25,945	6	98,451	8	136,422	13	201,322
1424	26	37	6	20	69	2	18,061	4	60,220	5	81,042	8	116,024
1425	29	17	15	15	69	5	41,840	12	112,174	16	141,951	21	189,442
1426	9	11	4	5	69	2	10,177	4	28,751	5	36,976	7	50,310
1428	29	17	10	19	69	4	28,717	9	84,935	11	110,709	16	152,992
1429	30	35	13	17	69	3	37,176	8	102,907	10	131,565	14	177,765
1432	17	10	10	7	69	4	28,634	11	74,336	13	93,078	17	122,607
1433	19	32	6	13	69	2	17,609	4	53,168	5	69,722	8	97,017
1434	17	30	3	14	69	1	7,522	2	30,537	3	42,879	5	64,111
1436	9	11	3	6	69	1	9,671	3	28,118	5	36,468	6	50,108
1437	66	46	26	40	69	6	74,256	14	210,616	18	271,314	24	369,896
1440	5	30	1	5	69	0	1,493	0	7,533	1	10,974	1	16,988
1442	94	25	45	48	69	14	129,884	32	350,611	41	444,681	55	595,081
1444	45	20	21	23	69	7	61,260	17	165,860	21	210,554	29	282,075
1445	20	35	7	13	69	2	19,365	4	57,654	5	75,311	8	104,337
1457	95	42	0	94	69	0	1,094	2	85,327	5	141,744	11	244,109
1458	30	37	12	18	69	3	35,141	7	99,011	9	127,275	13	173,082

Flow and Volume for Subbasins

UPDATE

Active Scroll

 # Storms: 4

CN (imp): 98

dt: 6

Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	WQ storm, Pt: 1, Peak Runoff cfs	WQ storm, Pt: 1, Total Volume CF	10 yr. storm, Pt: 2, Peak Runoff cfs	10 yr. storm, Pt: 2, Total Volume CF	25 yr. storm, Pt: 3, Peak Runoff cfs	25 yr. storm, Pt: 3, Total Volume CF	100 yr storm, Pt: 3	100 yr storm, Pt: 3
1459	24	10	16	8	69	7	45,597	17	115,041	21	142,651	27	185,618
1461	28	37	6	22	69	1	16,462	4	58,735	5	80,308	8	116,906
1462	12	10	7	5	69	3	19,873	7	51,620	9	64,647	12	85,176
1463	24	23	6	18	69	2	16,537	4	55,145	6	74,187	9	106,162
1464	18	10	11	7	69	5	31,670	12	80,961	14	100,849	19	131,981
1465	11	11	4	8	69	2	10,438	4	31,452	5	41,206	7	57,272
1466	21	14	10	11	69	4	27,313	9	74,641	11	95,028	15	127,748
1468	31	10	10	21	69	5	30,044	11	90,013	15	117,740	22	163,351
1469	19	32	5	14	69	1	14,868	3	47,728	5	63,616	7	90,132
1470	16	11	4	12	69	2	11,641	4	38,700	6	52,009	9	74,338
1471	5	32	1	4	69	0	2,983	1	10,926	1	15,022	2	21,994
1472	21	10	14	7	69	6	39,907	15	100,983	18	125,348	24	163,316
1473	9	10	3	6	69	1	8,933	3	26,563	4	34,672	6	47,989
1474	44	38	10	34	69	3	29,561	6	100,023	9	135,089	13	194,140
1477	16	11	5	10	69	2	14,557	5	43,841	7	57,429	10	79,807
1482	6	11	2	4	69	1	5,890	2	17,876	3	23,465	4	32,687
1483	31	35	8	23	69	2	22,240	5	73,190	7	98,174	10	140,058
1484	18	11	5	13	69	2	13,251	5	43,279	7	57,911	10	82,388
1485	6	10	2	4	69	1	4,991	2	15,549	3	20,555	4	28,858
1486	23	37	10	13	69	2	28,653	6	79,328	8	101,428	10	137,059
1487	31	35	13	18	69	3	37,080	8	103,914	10	133,356	14	180,997
1489	90	46	29	61	69	6	81,954	15	247,590	20	324,813	29	452,218
1490	15	20	4	11	69	1	11,540	3	36,780	4	48,920	7	69,148
1491	13	10	1	12	49	0	2,950	1	6,990	1	9,141	2	14,507
1492	15	20	4	11	69	1	12,115	3	38,322	5	50,871	7	71,752
1493	16	10	8	9	69	4	22,479	8	60,964	11	77,426	14	103,781
1494	22	37	9	13	69	2	26,480	5	74,159	7	95,152	10	129,118
1495	40	10	9	30	69	4	27,030	10	91,219	14	123,032	22	176,529
1496	24	17	10	13	69	4	29,881	9	82,492	11	105,359	16	142,179
1497	26	10	17	9	69	8	49,781	18	126,076	23	156,541	29	204,033
1498	10	30	4	5	69	1	12,295	3	33,875	4	43,243	5	58,323
1504	10	11	5	5	69	2	14,611	5	39,284	7	49,755	9	66,471
1506	32	35	5	27	69	1	14,184	3	57,617	5	80,926	8	121,037
1511	15	19	0	15	69	0	465	0	14,587	1	23,884	3	40,688
1512	47	25	6	41	69	2	17,375	5	77,177	7	110,131	13	167,239
1513	19	11	5	14	69	2	14,715	5	47,296	7	63,031	11	89,280
1514	55	10	30	25	69	14	86,954	32	228,007	40	286,445	54	378,880
1518	20	10	11	9	69	5	32,245	12	84,093	15	105,457	20	139,177
1519	17	10	12	5	69	5	34,142	12	85,032	15	104,963	20	135,787
1520	31	37	12	19	69	3	34,203	7	97,464	9	125,712	13	171,639
1521	37	37	3	34	69	1	7,746	2	48,678	3	73,022	7	116,033
1526	38	10	22	16	69	10	64,028	23	166,086	29	207,905	39	273,771

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		# Storms:	4										
		CN (imp):	98										
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1527	70	46	7	63	69	2	20,621	4	103,904	7	151,455	12	234,635
1529	34	17	17	17	69	6	49,245	15	131,938	18	166,926	25	222,714
1530	17	11	8	9	69	4	23,980	9	64,648	11	81,951	15	109,597
1531	26	10	15	11	69	7	42,744	16	111,114	20	139,191	26	183,451
1532	29	17	6	23	69	2	16,787	5	60,337	7	82,583	12	120,330
1533	25	35	6	19	69	1	16,146	4	54,938	5	74,293	7	106,908
1536	17	32	5	12	69	1	13,389	3	42,387	4	56,295	6	79,450
1538	44	41	8	35	69	2	24,092	5	88,235	7	121,359	11	177,750
1539	14	30	4	11	69	1	10,061	2	33,268	3	44,670	5	63,797
1540	44	17	14	30	69	5	39,640	12	120,630	16	158,484	23	220,980
1543	21	37	0	21	79	0	5,117	2	42,697	4	61,500	7	92,785
1547	36	14	10	26	69	4	30,140	10	94,500	13	125,142	20	176,032
1551	16	16	1	15	69	0	3,080	1	20,282	2	30,550	4	48,705
1552	29	17	11	18	69	4	30,752	9	89,122	12	115,491	17	158,534
1553	17	10	4	13	69	2	10,573	4	37,115	6	50,521	9	73,192
1554	31	14	12	19	69	5	35,302	11	100,520	15	129,586	21	176,808
1555	29	23	4	26	69	1	10,558	3	47,822	5	68,463	8	104,281
1556	24	19	3	22	69	1	7,458	2	37,160	4	54,004	7	83,411
1557	22	23	9	12	79	3	29,599	9	88,848	11	113,646	15	152,763
1559	22	37	4	17	69	1	12,512	3	44,803	4	61,308	6	89,323
1560	30	35	7	23	69	2	19,508	4	66,904	6	90,642	9	130,694
1561	19	27	11	8	69	3	30,073	7	78,732	9	98,867	12	130,702
1562	5	10	1	5	69	0	2,186	1	9,395	1	13,321	2	20,103
1565	23	37	7	16	69	2	19,124	4	59,277	5	78,297	8	109,837
1566	22	37	9	14	69	2	24,445	5	70,171	7	90,706	9	124,160
1567	39	35	15	25	69	4	41,458	9	119,889	12	155,306	16	213,111
1570	42	41	7	36	69	2	18,878	4	76,142	6	106,825	10	159,603
1571	7	11	2	5	69	1	4,651	2	15,418	2	20,706	4	29,574
1576	22	10	13	9	69	6	37,519	14	97,051	17	121,374	23	159,639
1579	33	15	9	24	69	3	25,644	8	82,632	11	110,202	17	156,223
1582	11	11	3	9	49	1	7,309	3	17,318	3	21,483	4	29,313
1584	13	30	4	9	69	1	12,153	3	36,403	4	47,630	5	66,108
1585	24	17	7	18	69	3	19,953	6	62,896	8	83,412	12	117,523
1586	27	14	6	21	69	3	18,350	6	62,238	8	84,053	13	120,770
1587	5	10	1	5	49	0	1,656	1	3,924	1	5,015	1	7,484
1588	19	10	4	15	49	2	11,619	4	27,530	5	34,206	6	46,913
1596	49	41	10	39	69	2	29,748	6	104,512	8	142,416	13	206,600
1597	45	41	14	30	69	3	41,253	8	124,232	11	162,819	15	226,427
1598	24	17	10	15	69	4	28,247	8	79,938	11	102,867	15	140,058
1601	44	20	15	29	69	5	41,909	12	125,113	15	163,515	22	226,654
1602	12	11	4	8	69	2	11,628	4	34,629	6	45,222	8	62,623
1603	14	11	6	8	69	3	17,511	6	48,901	8	62,672	11	84,920

Flow and Volume for Subbasins

UPDATE

Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
	# Storms:	4											
	CN (imp):	98											
	dt:	6				Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1604	20	14	5	16	69	2	13,253	4	45,502	6	61,628	10	88,817
1605	16	10	7	10	69	3	19,157	7	54,039	9	69,468	13	94,467
1606	44	10	24	20	69	11	69,546	26	182,426	32	229,209	43	303,219
1608	14	10	5	9	69	2	14,832	6	43,213	7	56,080	10	77,106
1609	52	38	9	43	69	2	25,664	6	98,585	8	136,956	13	202,626
1610	99	25	26	73	69	8	74,891	19	242,107	26	323,225	39	458,751
1611	79	46	15	64	69	3	42,464	8	156,667	12	215,861	18	316,746
1612	42	41	8	34	69	2	23,660	5	85,591	7	117,404	11	171,481
1613	16	30	2	14	69	0	4,856	1	23,827	2	34,565	4	53,303
1615	40	15	7	33	79	3	27,723	12	115,533	18	155,888	26	221,444
1622	16	11	6	9	69	3	18,391	7	51,961	9	66,828	12	90,928
1629	57	41	18	38	69	4	51,778	10	156,446	14	205,229	19	285,702
1634	63	42	13	50	69	3	37,836	8	133,408	11	181,948	16	264,186
1635	19	32	0	19	69	0	658	1	18,054	1	29,499	3	50,184
1636	36	14	9	27	69	4	26,447	9	86,950	12	116,543	18	166,109
1637	26	35	5	22	69	1	13,333	3	50,744	4	70,351	7	103,870
1639	14	30	3	12	69	1	7,219	2	27,603	3	38,299	4	56,589
1640	91	25	33	58	69	10	93,962	24	274,289	31	356,234	44	490,265
1641	53	17	15	39	69	5	41,917	13	133,679	17	177,820	25	251,368
1642	16	32	4	12	69	1	11,867	3	39,027	4	52,335	6	74,641
1643	26	35	0	26	69	0	457	1	23,929	1	39,564	3	67,896
1644	22	35	6	16	69	2	17,977	4	56,624	5	75,109	8	105,855
1645	19	30	0	19	69	0	174	0	17,566	1	29,207	3	50,326
1651	18	32	4	14	69	1	11,844	3	40,581	4	54,963	6	79,222
1652	11	30	3	9	69	1	7,341	2	24,941	2	33,711	4	48,484
1653	40	35	8	32	69	2	21,879	5	80,238	7	110,369	11	161,660
1656	10	10	3	7	69	1	8,384	3	26,182	4	34,632	6	48,654
1661	38	17	1	37	69	0	3,287	2	40,663	4	64,398	9	106,963
1662	36	17	0	35	79	0	9,411	7	75,325	11	108,169	18	162,748
1665	19	10	4	15	69	2	11,101	4	39,500	6	53,933	10	78,384
1666	29	17	7	21	69	3	20,462	6	67,627	9	90,767	13	129,560
1673	14	10	4	11	69	2	10,530	4	34,436	5	46,091	8	65,593
1674	40	10	26	14	69	12	74,409	27	189,252	34	235,328	44	307,293
1679	52	17	11	40	69	4	32,860	10	113,624	14	154,158	22	222,581
1682	32	17	12	20	69	4	35,286	11	101,229	14	130,794	19	178,924
1684	17	10	11	6	69	5	30,923	11	78,455	14	97,473	18	127,143
1687	34	17	10	24	69	4	28,171	8	88,118	11	116,625	17	163,953
1688	22	17	4	18	69	1	11,518	4	43,595	5	60,334	9	88,911
1693	22	37	7	14	69	2	21,049	4	62,499	6	81,582	8	112,932
1694	32	37	10	22	69	2	28,749	6	87,181	8	114,472	11	159,520
1700	31	37	3	29	69	1	8,060	2	44,296	3	65,339	6	102,304
1706	38	37	2	35	69	1	7,206	2	48,091	3	72,631	7	116,083

Flow and Volume for Subbasins

UPDATE

Active Scroll

		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1707	36	37	2	34	69	1	6,141	2	44,718	3	68,151	6	109,759
1708	21	17	9	13	69	3	24,902	7	70,277	10	90,360	13	122,909
1715	20	32	0	19	69	0	1,500	1	20,741	1	33,073	3	55,239
1717	20	14	5	15	69	2	14,594	5	47,984	7	64,316	10	91,671
1718	9	15	1	8	79	0	4,505	2	22,733	3	31,389	5	45,586
1719	60	17	12	47	69	4	35,843	11	127,156	16	173,532	25	252,089
1720	18	11	4	14	69	2	11,009	4	38,606	6	52,540	9	76,101
1722	53	38	10	43	69	3	29,623	6	108,008	9	148,394	14	217,102
1724	45	24	3	42	69	1	8,047	3	56,476	5	85,684	10	137,453
1725	15	20	0	15	69	0	365	0	14,261	1	23,449	3	40,072
1726	24	17	0	24	79	0	6,347	5	50,978	7	73,224	12	110,194
1729	21	17	6	15	69	2	16,388	5	52,454	7	69,839	10	98,825
1730	17	11	5	11	69	2	15,654	6	47,153	8	61,771	11	85,848
1748	20	11	3	17	69	1	8,316	3	34,850	5	49,192	8	73,916
1749	20	17	5	15	69	2	14,656	4	48,067	6	64,392	9	91,725
1751	17	10	3	13	79	1	12,862	7	50,405	9	67,431	14	94,978
1752	33	14	8	25	69	3	22,384	7	75,504	10	101,835	16	146,115
1753	55	17	14	41	69	5	40,510	12	132,221	17	176,916	25	251,690
1758	15	10	4	11	69	2	12,807	5	40,145	7	53,154	10	74,757
1761	82	25	19	63	69	6	54,934	14	185,877	20	250,955	30	360,490
1765	157	25	36	120	69	11	103,943	27	353,110	37	477,191	57	686,163
1767	62	25	26	36	69	8	73,334	18	205,734	24	264,079	33	358,497
1768	14	15	0	14	79	0	4,374	3	31,041	5	44,201	8	66,014
1769	18	19	0	18	69	0	132	0	15,993	1	26,597	3	45,827
1770	31	14	11	20	69	4	31,606	10	92,810	13	120,722	19	166,429
1776	6	11	1	5	69	0	3,107	1	11,449	2	15,752	3	23,075
1777	40	14	9	31	69	4	25,880	9	88,755	12	120,177	19	173,151
1780	118	10	16	101	69	7	47,832	19	204,088	29	289,009	51	435,617
1781	16	20	0	16	79	0	3,980	3	33,281	4	47,929	7	72,293
1782	50	20	18	32	69	6	52,121	14	152,263	19	197,781	27	272,234
1789	27	14	6	22	69	2	16,045	5	57,364	8	78,415	12	114,105
1796	66	46	10	56	69	2	27,421	5	113,992	8	160,884	13	241,788
1801	45	41	5	40	69	1	13,272	3	66,726	5	97,206	8	150,503
1802	18	32	3	14	69	1	8,953	2	33,943	3	47,016	5	69,352
1804	33	17	7	26	69	3	20,114	6	71,150	9	97,035	14	140,867
1805	23	17	5	18	69	2	15,434	5	52,572	7	71,076	10	102,243
1808	11	10	3	8	69	1	7,742	3	25,865	4	34,801	6	49,806
1809	23	14	5	18	69	2	14,022	5	49,244	7	67,046	10	97,156
1810	51	20	17	34	69	6	48,774	14	145,464	18	190,062	26	263,369
1812	58	17	11	47	69	4	31,948	10	117,232	14	161,183	23	235,952
1814	70	25	23	47	69	7	64,592	16	194,853	22	255,424	31	355,258
1817	30	14	7	23	69	3	18,861	6	65,463	9	88,886	14	128,441

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		# Storms:	4										
		CN (imp):	98										
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
1818	19	11	4	15	69	2	11,009	4	39,792	6	54,522	9	79,527
1821	63	46	18	45	69	4	49,987	9	158,148	13	210,070	18	296,543
1827	40	41	11	29	69	3	31,977	6	101,289	9	134,570	13	190,000
1830	18	10	4	14	69	2	12,823	5	42,486	7	57,049	10	81,469
1831	19	10	5	14	69	2	14,990	6	48,095	8	64,066	12	90,700
1832	31	14	8	22	69	3	24,383	8	77,511	11	103,014	16	145,479
1835	19	10	7	12	69	3	20,219	8	58,564	10	75,873	14	104,118
1836	49	17	9	40	69	3	27,420	8	100,388	12	137,957	20	201,851
1841	40	14	11	29	69	4	31,270	10	99,740	14	132,672	21	187,540
1844	25	35	5	21	69	1	13,950	3	51,158	4	70,369	7	103,071
1846	6	11	2	4	69	1	4,643	2	14,944	2	19,922	3	28,229
1849	35	17	7	28	69	3	20,607	6	73,522	9	100,464	14	146,136
1853	38	14	9	28	69	4	26,871	9	88,902	12	119,344	19	170,382
1856	26	37	3	24	69	1	7,579	2	38,924	3	56,872	5	88,286
1857	10	32	0	10	69	0	1,437	0	12,062	1	18,616	2	30,295
1858	33	14	10	23	69	4	29,858	10	91,080	13	119,733	19	167,059
1859	15	11	7	8	69	3	20,995	7	56,654	9	71,839	13	96,109
1871	15	30	0	14	69	0	1,521	1	16,351	1	25,700	3	42,442
1872	17	11	3	13	69	1	9,702	4	34,908	5	47,782	8	69,625
1877	11	30	0	11	69	0	75	0	9,471	1	15,768	2	27,195
1878	29	14	6	22	69	2	18,201	6	63,049	8	85,570	13	123,591
1880	24	37	7	17	69	2	20,417	4	62,938	6	83,010	8	116,257
1881	27	35	1	27	69	0	1,884	1	27,913	2	44,670	4	74,816
1883	30	35	1	29	69	0	3,253	1	33,304	2	52,197	5	86,007
1884	26	37	2	24	69	1	7,018	2	37,596	3	55,263	5	86,257
1885	22	17	5	17	69	2	13,064	4	46,163	6	62,943	9	91,353
1888	23	14	6	17	69	3	18,502	6	58,852	8	78,227	12	110,492
1890	11	10	2	9	69	1	5,337	2	21,105	3	29,462	5	43,792
1895	17	30	1	16	69	0	3,877	1	23,418	2	34,952	4	55,289
1896	18	30	3	15	69	1	9,772	2	36,187	3	49,873	5	73,191
1899	32	17	10	23	69	4	27,897	8	86,286	11	113,862	16	159,543
1902	30	37	6	24	69	1	17,008	4	61,074	5	83,626	8	121,917
1903	7	11	3	4	69	1	9,257	3	25,660	4	32,813	6	44,343
1904	29	14	8	21	69	3	23,379	8	73,898	10	98,068	15	138,272
1905	39	35	1	38	69	0	3,401	1	41,850	3	66,342	6	110,303
1906	58	38	3	55	69	1	8,611	2	68,958	5	106,041	9	172,064
1907	23	10	15	8	69	7	43,269	16	109,824	20	136,466	26	178,039
1908	80	42	24	56	69	6	68,719	14	211,861	18	279,466	26	391,469
1909	29	35	4	25	69	1	11,229	3	48,946	4	69,646	7	105,482
1911	15	30	3	13	69	1	7,259	2	28,662	3	40,027	4	59,526
1912	18	11	4	14	69	2	12,162	4	40,937	6	55,181	10	79,126
1916	12	10	9	3	69	4	26,762	10	66,017	12	81,214	15	104,602

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
# Storms: 4						Pt:	1	Pt:	2	Pt:	3	Pt:	3
CN (imp): 98													
dt: 6													
Basin_ID	**Acres**	**Tc**	**Impervious Acres**	**Pervious Acres**	**soil group (CN)**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**		
1918	39	14	13	26	69	5	36,491	12	109,597	16	143,464	23	199,212
1919	18	10	7	12	79	3	21,980	10	69,521	13	89,809	18	122,016
1923	16	11	5	11	69	2	15,122	5	45,313	7	59,275	10	82,243
1925	29	35	7	22	69	2	20,144	4	67,234	6	90,499	9	129,589
1927	56	38	18	38	69	4	50,475	10	153,258	14	201,308	20	280,647
1929	22	14	8	15	69	3	21,720	7	64,455	9	84,090	13	116,322
1935	27	17	4	23	69	2	12,056	4	49,083	6	68,922	10	103,043
1938	18	30	3	15	69	1	8,905	2	34,038	3	47,224	5	69,772
1946	49	20	20	29	69	7	56,861	16	160,375	20	206,178	28	280,404
1947	7	11	2	5	69	1	6,529	2	19,843	3	26,057	5	36,313
1948	12	30	0	12	69	0	1,048	0	12,890	1	20,425	2	33,946
1949	15	30	1	14	69	0	2,482	1	18,484	1	28,219	3	45,510
1950	58	20	7	51	69	2	19,786	6	92,609	10	133,286	17	204,026
1953	20	19	1	19	69	0	2,381	1	22,310	2	34,708	5	56,842
1954	16	10	6	10	69	3	16,444	6	47,784	8	61,966	11	85,127
1958	31	37	2	29	69	1	6,696	2	41,266	3	61,762	6	97,945
1962	32	35	6	26	69	1	15,927	4	60,632	5	84,065	8	124,126
1967	44	41	1	43	69	0	2,679	1	43,911	3	70,616	6	118,727
1969	19	30	6	13	69	2	17,205	4	51,990	5	68,189	8	94,902
1971	58	41	5	53	69	1	15,474	3	83,256	6	122,478	11	191,314
1976	37	22	1	36	69	0	3,101	1	39,237	3	62,239	7	103,513
1977	23	35	1	22	69	0	3,228	1	27,336	2	42,230	4	68,781
1979	28	37	6	22	69	2	18,130	4	61,900	5	83,779	8	120,671
1986	61	46	13	48	69	3	36,381	7	128,323	10	175,049	15	254,230
1991	22	35	1	21	69	0	2,125	1	23,682	2	37,322	3	61,768
1992	7	30	1	5	69	0	3,335	1	12,656	1	17,532	2	25,865
1998	16	10	5	11	69	2	14,081	5	43,658	7	57,639	11	80,806
1999	26	17	7	18	69	3	20,797	6	65,595	8	87,005	12	122,608
2000	71	21	10	61	69	3	28,019	8	120,788	13	171,435	22	258,985
2003	24	35	0	24	69	0	168	1	21,706	1	36,157	3	62,386
2006	15	32	0	14	69	0	1,459	1	15,847	1	24,928	2	41,195
2007	43	41	5	38	69	1	14,372	3	66,991	5	96,442	8	147,695
2008	16	10	6	10	69	3	18,502	7	52,710	9	67,958	13	92,732
2009	6	30	0	6	69	0	529	0	6,498	0	10,297	1	17,113
2010	50	20	2	49	69	1	4,852	2	54,769	5	86,294	11	142,761
2011	37	37	13	24	69	3	35,760	7	106,157	10	138,562	14	191,797
2013	105	21	32	72	69	10	92,424	25	283,466	34	373,238	49	521,708
2014	34	17	12	21	69	4	35,321	11	102,788	14	133,361	20	183,317
2020	40	17	11	29	69	4	31,415	9	100,030	13	133,006	19	187,937
2023	17	32	2	15	69	1	5,624	1	26,558	2	38,299	4	58,740
2024	7	11	2	6	69	1	5,413	2	17,824	3	23,898	4	34,074
2025	36	35	1	35	69	0	2,924	1	37,408	2	59,428	5	98,973

Flow and Volume for Subbasins

UPDATE

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						WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		# Storms:	4										
		CN (imp):	98										
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
2028	37	37	10	27	69	2	28,520	6	90,947	8	121,029	12	171,186
2030	26	37	0	26	69	0	841	1	24,987	2	40,920	3	69,738
2031	17	20	0	17	69	0	128	0	15,576	1	25,907	3	44,641
2032	22	37	0	21	69	0	1,332	1	21,741	1	34,946	3	58,730
2034	43	38	2	40	69	1	7,081	2	52,183	3	79,625	7	128,373
2035	32	37	5	27	69	1	13,967	3	56,540	5	79,368	8	118,641
2043	17	32	1	16	69	0	2,265	1	19,565	1	30,270	3	49,358
2045	33	17	6	27	69	2	18,033	6	66,560	8	91,629	13	134,306
2046	20	35	1	19	69	0	2,271	1	22,525	1	35,224	3	57,937
2048	10	10	3	8	69	1	8,061	3	25,847	4	34,423	6	48,725
2050	15	30	0	15	69	0	105	0	13,262	1	22,080	2	38,080
2056	24	35	6	18	69	2	18,162	4	58,496	5	78,040	8	110,682
2057	17	32	1	15	69	0	3,343	1	21,578	2	32,459	3	51,698
2061	33	22	0	33	69	0	358	1	30,297	2	50,280	6	86,503
2080	27	35	6	22	69	1	15,844	4	56,685	5	77,548	8	112,951
2081	25	17	0	25	69	0	398	1	22,913	2	37,871	5	64,959
2085	44	20	0	44	69	0	446	1	40,512	3	67,261	8	115,750
2084	18	30	5	14	69	1	12,994	3	42,924	4	57,623	6	82,274
2086	22	37	3	20	69	1	8,385	2	37,069	3	52,882	5	80,292
2092	22	35	1	21	69	0	1,914	1	23,287	2	36,891	3	61,305
2093	28	37	0	28	69	0	324	1	25,251	2	41,930	4	72,185
2098	16	11	0	16	69	0	139	1	14,992	2	24,900	4	42,858
2113	19	30	4	15	69	1	11,390	3	40,508	4	55,333	6	80,468
2115	30	37	7	23	69	2	21,398	5	70,908	6	95,280	9	136,187
2116	32	35	8	24	69	2	23,369	5	76,552	7	102,566	10	146,142
2117	28	14	0	28	69	0	217	1	25,803	2	42,892	6	73,872
2125	28	17	6	22	69	2	18,719	6	63,586	8	85,911	12	123,498
2127	57	41	6	51	69	1	17,351	4	85,567	6	124,289	11	191,919
2128	54	41	10	45	69	2	27,661	6	104,647	8	144,933	13	213,776
2129	45	38	4	41	69	1	13,053	3	66,839	5	97,621	9	151,494
2140	15	10	0	15	69	0	115	0	13,536	2	22,492	4	38,725
2142	17	11	0	17	69	0	845	1	17,086	2	27,632	4	46,636
2154	15	11	0	15	69	0	455	1	14,472	2	23,689	4	40,341
2153	42	20	8	34	69	3	23,878	7	86,431	10	118,493	16	172,951
2203	17	11	5	12	69	2	15,788	6	47,936	8	62,933	11	87,676
2204	38	37	8	30	69	2	23,800	5	82,928	7	112,776	11	163,252
2218	28	37	5	23	69	1	13,957	3	53,596	4	74,448	7	110,134
2253	19	11	0	18	69	0	855	1	18,500	2	29,984	5	50,688
2255	92	25	2	90	69	1	7,591	3	97,521	7	154,849	17	257,756
2737	40	10	0	40	79	0	10,174	10	84,723	15	121,962	26	183,884
2738	14	19	2	12	69	1	4,885	2	22,492	2	32,283	4	49,290
2746	11	15	0	11	79	0	2,650	2	22,119	3	31,849	5	48,029

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		dt:	6			Pt:	1	Pt:	2	Pt:	3	Pt:	3
Basin_ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
2747	13	10	3	10	69	1	8,251	3	28,195	4	38,140	7	54,895
2754	6	10	1	5	69	0	2,257	1	9,641	1	13,655	2	20,586
2755	17	10	3	14	69	2	9,923	4	35,852	5	49,117	9	71,634
2759	7	32	0	7	69	0	592	0	7,834	1	12,465	1	20,784
2760	20	35	1	19	69	0	4,383	1	26,816	2	40,095	4	63,530
2763	11	10	5	6	69	2	14,670	5	39,740	7	50,452	9	67,595
2766	8	19	0	8	69	0	61	0	7,372	1	12,260	2	21,123
2767	9	19	2	7	69	1	5,087	2	18,615	2	25,580	3	37,425
2771	26	10	2	24	69	1	6,984	3	37,863	5	55,672	10	86,895
2774	5	10	2	3	69	1	5,162	2	15,255	3	19,877	4	27,456
2775	8	10	3	5	69	1	7,770	3	22,904	4	29,824	5	41,164
2776	6	10	1	5	69	0	2,972	1	11,327	2	15,694	3	23,155
2777	12	11	3	9	69	1	8,242	3	27,820	4	37,525	7	53,846
2779	18	10	5	13	69	2	15,552	6	48,187	8	63,608	12	89,157
2780	11	11	5	6	69	2	14,232	5	39,167	6	49,972	9	67,351
2783	10	11	4	6	49	2	12,507	4	29,634	5	36,252	7	47,263
2784	28	14	9	19	69	3	24,760	8	75,724	11	99,617	16	139,101
2788	8	30	1	6	49	0	3,592	1	8,516	1	10,663	1	15,031
2789	11	30	1	11	49	0	2,215	0	5,252	1	6,940	1	11,398
2790	15	30	1	14	49	0	2,939	1	6,969	1	9,185	1	14,983
2791	14	15	2	12	49	1	6,534	2	15,485	2	19,421	3	27,447
2792	11	30	0	10	49	0	1,376	0	3,263	0	4,501	0	8,192
2795	31	15	3	28	79	1	16,658	8	81,707	12	112,468	19	162,857
2797	18	15	2	16	79	1	9,839	5	46,954	7	64,431	11	93,023
2801	98	10	5	93	69	2	14,340	7	117,055	15	179,995	31	291,958
2803	10	10	2	7	79	1	8,485	4	31,134	6	41,244	8	57,522
2804	21	23	0	21	79	0	5,242	3	43,797	6	63,074	9	95,138
2806	27	22	0	26	79	0	7,021	4	56,261	7	80,806	12	121,600
2796	4	15	0	4	79	0	1,079	1	8,899	1	12,804	2	19,296
2805	4	19	0	4	79	0	1,057	1	8,831	1	12,718	2	19,182
2793	4	10	1	3	49	0	2,232	1	5,289	1	6,602	1	9,189
1480	4	11	1	2	69	1	3,876	1	11,316	2	14,694	3	20,218
933	4	32	1	3	69	0	3,080	1	9,528	1	12,578	1	17,632
2787	3	32	1	2	49	0	3,621	1	8,584	1	10,519	1	13,811
1009	3	20	1	2	69	0	3,661	1	10,557	1	13,661	2	18,721
2765	3	10	1	2	69	1	4,039	1	10,934	2	13,878	3	18,590
2744	3	19	1	2	69	0	1,763	1	5,983	1	8,083	1	11,617
2781	3	10	1	2	49	0	2,487	1	5,892	1	7,240	1	9,579
2773	2	10	1	2	69	0	1,451	1	5,040	1	6,843	1	9,888
880	2	19	0	2	69	0	11	0	1,380	0	2,295	0	3,954
1001	1	10	1	0	69	0	2,358	1	5,934	1	7,352	1	9,555
2012	1	11	0	1	69	0	1,333	0	3,771	1	4,851	1	6,603

Flow and Volume for Subbasins

UPDATE

☐ Active Scroll

		# Storms:	4										
		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
		dt:	6			Pt: 1		Pt: 2		Pt: 3		Pt:	3
Basin_ID	**Acres**	**Tc**	**Impervious Acres**	**Pervious Acres**	**soil group (CN)**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**	**Peak Runoff cfs**	**Total Volume CF**		
2761	1	10	0	1	69	0	516	0	2,057	0	2,876	1	4,282

Table C.6

CIP and Major Basins - Peak Flow and Volume for Water Quality Storm, 10 year, 25 year, and 100 year storms

UPDATE		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
Active Scroll Basin_ID or Pipe ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
ID43	818	108	245	572	69	31	681,192	78	2,092,289	103	2,761,563	147	3,872,354
ID42	1,213	104	315	898	69	41	878,397	104	2,832,661	139	3,787,694	204	5,387,770
ID 30 - Murphy	1,213	117	315	898	69	38	873,122	97	2,811,589	130	3,759,642	189	5,348,583
ID29	575	66	178	397	69	31	503,846	76	1,536,782	100	2,022,318	143	2,825,593
ID 41 Murphy I	1,788	141	494	1,295	69	53	1,349,777	135	4,246,867	179	5,647,814	258	7,988,022
MB33	666	81	167	500	68	25	466,381	62	1,493,154	83	2,003,269	122	2,863,105
ID 31	3,253	187	1,060	2,992	69	93	2,819,867	244	8,993,829	326	12,020,704	473	17,101,044
ID32	3,253	102	200	599	69	26	557,584	67	1,823,128	90	2,446,366	133	3,493,013
ID2-A	4,026	220	1,069	2,958	69	84	2,780,273	222	8,796,165	297	11,739,944	429	16,679,495
ID5	1,679	73	554	1,125	74	91	1,637,826	249	5,234,972	332	6,849,654	473	9,468,226
ID2-B	4,951	249	1,475	3,475	70	106	3,770,073	286	11,699,180	379	15,457,868	539	21,695,330
ID2-C	6,629	287	2,029	4,600	71	133	5,058,599	369	15,812,753	488	20,851,201	692	29,173,295
ID39 - MB8A -	253	30	99	154	69	27	282,658	65	806,249	84	1,040,131	118	1,420,425
ID33	553	59	204	349	69	38	576,521	93	1,669,347	119	2,164,141	166	2,972,537
ID16	553	59	204	349	69	38	576,521	93	1,669,347	119	2,164,141	166	2,972,537
ID17	302	24	208	94	69	64	595,038	149	1,493,488	183	1,848,583	237	2,399,837
ID40	855	74	412	442	69	67	1,158,217	161	3,127,095	202	3,968,083	271	5,313,978
ID18	954	86	470	484	69	69	1,313,299	166	3,528,079	209	4,470,115	280	5,975,426
ID15	566	92	233	334	66	33	647,801	78	1,742,859	97	2,232,714	131	3,032,014
ID13	566	92	233	334	66	33	647,801	78	1,742,859	97	2,232,714	131	3,032,014
ID14	118	20	95	22	69	32	272,216	74	665,044	90	815,262	115	1,045,245

CIP and Major Basins - Peak Flow and Volume for Water Quality Storm, 10 year, 25 year, and 100 year storms

UPDATE

Active Scroll

		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
Basin_ID or Pipe ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
ID56	684	99	328	356	67	44	910,495	105	2,406,128	131	3,049,232	175	4,082,531
ID8	684	101	328	356	67	43	909,728	104	2,403,937	129	3,046,445	173	4,078,812
ID24	150	23	103	46	69	32	295,339	75	741,267	92	917,509	120	1,191,108
ID51	65	15	34	31	69	13	97,477	31	258,891	38	326,620	52	434,270
ID26	117	38	63	54	69	15	179,949	36	474,028	46	596,512	61	790,658
ID48	328	55	177	151	69	35	500,824	83	1,318,961	103	1,659,798	137	2,200,124
ID47	1,311	70	708	603	69	119	1,991,652	285	5,243,914	355	6,599,115	471	8,747,781
ID28, ID27	418	74	184	234	69	30	517,525	72	1,428,520	91	1,825,560	124	2,465,664
ID46	609	115	298	310	69	36	823,667	88	2,213,187	111	2,805,111	149	3,751,620
ID1	1,176	144	356	820	69	37	972,336	95	2,967,283	125	3,912,980	177	5,482,750
ID45	1,785	144	655	1,130	69	69	1,784,255	172	5,147,213	221	6,675,956	307	9,178,338
ID52	711	91	270	441	69	38	755,335	94	2,164,862	120	2,799,560	166	3,834,751
ID53	622	100	180	442	69	24	503,053	60	1,563,457	80	2,069,837	115	2,912,062
ID50	470	69	127	343	69	22	358,557	53	1,145,129	71	1,525,753	104	2,161,337
ID20	762	101	206	556	67	27	570,840	66	1,734,878	87	2,309,083	125	3,276,157
MB23A	208	39	52	156	69	12	148,339	31	488,377	42	655,224	62	934,984
ID22	1,065	76	369	696	70	59	1,043,758	146	3,122,271	190	4,071,066	268	5,624,222
ID21	1,412	109	470	942	70	59	1,309,849	150	3,961,084	197	5,183,193	277	7,190,677
ID23	375	53	105	270	77	21	340,511	68	1,181,054	93	1,557,865	134	2,166,813
ID54	1,787	127	575	1,212	72	66	1,615,259	176	5,083,327	233	6,672,566	331	9,273,247
ID25	204	49	75	129	76	16	228,246	45	713,808	59	925,313	83	1,264,272
ID49	58	34	31	27	69	8	89,109	19	234,743	24	295,394	32	391,527

CIP and Major Basins - Peak Flow and Volume for Water Quality Storm, 10 year, 25 year, and 100 year storms

UPDATE

Active Scroll

		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
Basin_ID or Pipe ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
ID9	79	14	62	17	76	25	180,857	59	451,033	72	554,476	93	712,679
ID37&ID4	638	45	262	376	72	58	755,950	146	2,202,293	189	2,833,765	263	3,849,969
ID11	149	24	58	91	69	18	166,827	43	476,291	55	614,576	77	839,450
ID10	71	22	36	34	69	11	103,713	27	276,314	34	348,967	46	464,587
ID57	75	10	56	19	69	25	160,941	59	398,097	72	490,214	93	632,186
ID12	74	10	56	19	75	25	161,582	60	406,982	74	501,911	96	647,723
ID7	547	60	337	210	72	63	958,586	152	2,500,855	189	3,122,845	249	4,095,114
ID34	255	51	197	59	71	40	556,984	96	1,380,829	117	1,698,924	150	2,187,706
ID58	1,410	90	744	666	73	106	2,108,285	266	5,754,722	336	7,268,114	450	9,658,479
ID6	1,410	98	744	666	73	100	2,100,893	252	5,734,392	319	7,242,656	427	9,625,120
ID3	1,410	151	744	666	73	76	2,045,405	193	5,581,901	243	7,051,446	325	9,374,061
ID36	7,267	316	2,291	4,976	71	140	5,569,659	390	17,223,233	516	22,654,087	728	31,610,100
Plant Intercept	7,267	316	2,291	4,976	71	140	5,569,659	390	17,223,233	516	22,654,087	728	31,610,100

CIP and Major Basins - Peak Flow and Volume for Water Quality Storm, 10 year, 25 year, and 100 year storms

UPDATE

Active Scroll

		CN (imp):	98			WQ storm		10 yr. storm		25 yr. storm		100 yr storm	
Basin_ID or Pipe ID	Acres	Tc	Impervious Acres	Pervious Acres	soil group (CN)	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF	Peak Runoff cfs	Total Volume CF		
MB19	418	62	103	315	69	19	293,076	47	967,000	63	1,298,906	93	1,856,144
MB16B	190	33	93	98	69	24	263,777	58	711,538	73	902,300	99	1,207,255
MB11	818	90	188	630	69	27	527,368	68	1,782,006	93	2,410,013	139	3,469,787
MB16A	359	45	92	266	69	20	262,891	50	856,184	67	1,145,766	100	1,630,551
MB32	1,213	113	177	1,037	69	22	492,372	60	2,023,255	88	2,858,668	142	4,303,811
MB31	575	79	140	435	69	22	393,948	54	1,305,046	74	1,755,688	109	2,513,355
MB33	666	78	73	593	68	11	204,636	31	945,151	47	1,375,337	81	2,132,536
MB34A	799	94	181	617	69	25	507,718	65	1,723,478	88	2,333,760	132	3,364,533
MB34B	773	73	181	592	71	30	520,973	79	1,828,231	109	2,465,910	163	3,530,980
MB34 C	924	54	357	567	72	71	1,030,011	180	3,057,331	235	3,952,789	329	5,399,645
M34D	1,679	101	518	1,161	74	68	1,518,223	194	4,972,608	260	6,542,067	373	9,097,719
MB8A	253	33	99	154	69	26	282,403	62	805,420	80	1,039,063	112	1,418,981
MB8B	299	33	92	208	69	24	262,459	58	805,279	77	1,060,672	112	1,483,252
MB18A	302	52	175	127	69	36	496,611	84	1,288,135	105	1,612,721	138	2,124,146
MB14B	90	27	57	32	69	16	163,847	39	416,786	48	518,296	63	676,867
MB8C	566	52	233	334	66	47	657,546	111	1,772,673	138	2,271,175	187	3,084,130
MB18C	118	28	67	51	69	19	190,714	45	497,066	56	623,259	75	822,430
MB18B	150	33	93	57	69	24	263,545	57	675,390	71	842,044	93	1,103,242
MB14A	65	22	34	31	69	11	97,275	25	258,336	32	325,924	43	433,358
MB17-1	117	32	54	64	69	14	152,807	34	418,358	43	533,015	59	717,211
MB17-2	211	43	91	120	69	21	258,168	49	717,249	63	918,106	86	1,242,336
MB17-3	983	66	957	26	69	167	2,691,626	393	6,410,617	474	7,782,558	596	9,849,800
MB26	711	55	141	570	69	28	401,631	70	1,447,349	97	1,984,575	150	2,897,887
MB25	622	52	149	474	69	30	423,294	75	1,415,637	101	1,907,321	152	2,734,274
MB24-1	470	60	43	427	69	8	124,860	23	664,707	38	977,460	67	1,526,611
MB24-2	292	41	107	185	64	25	303,049	58	811,843	72	1,047,119	98	1,436,564
MB23	208	41	36	172	69	8	102,460	21	393,587	31	546,834	49	809,145
MB23B	342	58	1	342	69	0	3,682	8	304,446	15	506,716	34	874,098
MB22D	858	79	110	748	70	17	316,746	50	1,442,482	75	2,055,237	125	3,112,582
MB22C	347	26	103	244	72	30	303,800	81	988,240	110	1,304,906	161	1,824,425
MB22B	375	36	96	278	77	24	320,371	82	1,147,765	114	1,522,139	167	2,128,860
MB22A	204	21	75	129	76	24	230,741	70	721,505	93	935,088	130	1,277,241
MB27	58	22	24	34	69	8	69,893	18	195,430	24	250,591	33	339,763
MB10	79	29	56	23	76	15	161,593	38	414,524	47	513,385	61	665,804
MB35	638	54	157	481	72	31	461,008	84	1,614,264	117	2,165,966	175	3,080,784
MB9A	149	28	46	103	69	13	131,935	32	404,189	42	532,102	61	743,648
MB9B	71	24	36	34	69	11	103,645	26	276,117	33	348,717	44	464,254
MB6A-1	75	23	40	34	69	13	115,733	30	304,847	37	383,576	50	508,339
MB6A-2	74	23	29	45	75	9	87,990	25	266,858	33	344,329	46	468,342
MB6B	541	55	159	382	73	31	471,257	85	1,555,895	115	2,055,166	168	2,872,204
MB5	255	36	54	201	71	13	158,106	36	581,225	52	790,728	80	1,142,132
MB6C	465	52	56	409	74	11	189,904	43	946,750	67	1,332,219	111	1,981,530

CITY OF BEND

STORM WATER UTILITY DEVELOPMENT

DRAFT
COMMITTEE
CHARTER
AND
INTRODUCTORY MATERIALS

CITIZENS ADVISORY COMMITTEE

November 2006

STORM WATER PROGRAM DEVELOPMENT

CITIZENS ADVISORY COMMITTEE

– CHARTER –

PURPOSE:

The purpose of the Citizens Advisory Committee is to provide a link with the community and to involve impacted interest groups with Bend's Storm Water Program. The Committee will provide critical local input to the storm water program and its goals, objectives and funding structure. In addition, this group will help to educate the community and individual constituencies with respect to storm water related problems, needs, costs, services and solutions.

DUTIES:

1. Review and make recommendations concerning the elements of the Storm Water Program.

2. Review and make suggestions with respect to the Storm Water Program's goals, objectives, and proposed level of service.

3. Review and provide advice on the proposed financing for Bend's Storm Water Management Program.

4. Assist in developing and participate in a community awareness and education program.

AUTHORITY:

The Citizens Advisory Committee is to be established in accordance with Bend's City Council/Mayor procedures and will be in existence throughout development and implementation of the program. The purpose of this committee is to serve as an advisory group to the City and its storm water staff. As such, its authority will be limited to collecting information, conducting analyses and making recommendations. All position statements or recommendations of the Committee will be transmitted by its Chairman to the City.

ORGANIZATION:

The Citizens Advisory Committee will be chaired by a person selected by fellow Committee members. The Chairman will establish the rules of order and conduct all meetings. Each member will have one vote except for the Chairperson who will serve as a non-voting member except in the case of ties. City staff will provide direct support to the committee and its Chairperson.

MEETINGS:

It is anticipated that the Committee will initially meet every two weeks. The day of week and time for meetings will be established by the Committee at its initial meeting. The actual date of each meeting will be set by the Chairperson. As the storm water program takes shape more frequent meetings of the committee may be requested by the Chairperson.

The agenda will be established by the Chairperson and distributed to each member prior to the meeting. Suggestions for agenda items may be made to the Chairperson by any member. A majority of the total number of committee members may amend the agenda at any meeting.

Position statements of recommendations must be approved by a majority of the total number of committee members.

The Chairperson will document issues raised by the Committee as well as any recommendations from the Committee and transmit them to the City. Meeting summaries will be kept by Project staff and transmitted with the agenda and supporting materials to each member prior to the subsequent meeting. All summaries or other written communications from the Committee may be amended with approval of a majority of the total number of Committee members.

Members of the Committee will not be compensated for their services or the expense of attending meetings.

REPRESENTATION:

City Council member; Neighborhood/Community Group(s); Bend-LaPine School District; Chamber of Commerce; St Charles, Downtown Assoc., Business Owner; Budget Committee Member; Planning Commission Member; Deschutes Watershed folks, others.

Group size should be 10-13.

- PRELIMINARY -

STORM WATER UTILITY DEVELOPMENT PROGRAM CITIZENS ADVISORY COMMITTEE

EXAMPLE ISSUES (not in order)

- BEND’S STORM WATER SYSTEM, NEEDS AND COSTS
- STORM WATER FUNDING OPTIONS
- STRUCTURAL VERSUS NON-STRUCTURAL ALTERNATIVES
- NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PHASE II PERMITTING FOR STORM WATER
- SYSTEM MAINTENANCE SERVICE LEVELS
- PROGRAM BUDGET
- STORM WATER SERVICE CHARGES AND OTHER OREGON COMMUNITIES

STORM WATER PROGRAM DEVELOPMENT

CITIZENS ADVISORY COMMITTEE

AGENDA (first meeting)

I. Introductions

II. Short Presentation and Background on Storm water Management in Bend

III. Committee Goals and Objectives

IV. Project Organization and Committee Procedures

V. Committee Chairperson

VI. Committee Meeting Schedule

VII. Open Discussion

VIII. Adjourn

CITY OF BEND

STORM WATER PROGRAM DEVELOPMENT

CITIZENS ADVISORY COMMITTEE

(PRELIMINARY DRAFT)

COMMITTEE GOALS AND OBJECTIVES

GOAL: Ensure that the City's Storm Water Management Program - including financing alternatives - reflects the needs, priorities and concerns of Bend's citizens, businesses and organizations.

OBJECTIVES: Provide representative and objective community input to the development of the Storm Water Program.

Provide representative and objective community input to the development of goals/objectives and the establishment of a proposed level of service for a citywide Storm water Management Program.

Provide representative and objective community input to define existing drainage problems, identify nonpoint source pollution issues, prepare viable alternative solutions and develop a plan for implementing the recommendations.

Assist in developing and participate in a community education program on storm water management problems/resolutions; establish the goals, objectives and proposed financing to successfully implement the final recommendations.

CITY OF BEND

STORM WATER PROGRAM DEVELOPMENT

CITIZENS ADVISORY COMMITTEE

(PRELIMINARY DRAFT)

PROGRAM GOALS AND OBJECTIVES

OVERALL GOAL:

Provide and maintain a system of storm water facilities and nonpoint source pollution controls which will safeguard the property and lives of Bend's residents, protect and enhance the City's natural environment while complying with state and federal regulations.

GOAL #1: Minimize increases in storm water runoff and reduce peak flows.

GOAL #2: Reduce the environmentally detrimental effects of runoff in order to protect and enhance water quality and water related environs.

GOAL #3: Manage and operate the City's storm water system in the most efficient and cost effective manner.

GOAL #4: Provide sufficient funds to maintain the existing system/facilities, comply with federal nonpoint source regulations and undertake the capital planning necessary to most cost effectively locate/construct future drainage improvements.

CITY OF BEND
STORMWATER UTILITY FEE CITIZENS TASK FORCE

ISSUE PAPER NO. 1

ISSUE TITLE: **WHAT IS THE MOST APPROPRIATE BASIS FOR A STORMWATER RATE STRUCTURE IN BEND?**

BACKGROUND: Unlike water utility rate structures, neither stormwater nor sanitary sewer utilities have individual meters to measure flow as the basis for determining use of the system. In the case of sanitary sewer, flow estimates are based on "equivalent dwelling units" (EDU's) as determined through sampling of use, the number of plumbing fixtures or drinking water consumption. These types of measures are considered to be the best indicators of how much wastewater a customer is actually sending into the sanitary sewer system. Stormwater utilities employ a similar logic in allocating a fair share of the program's cost to individual customers. The logic is based on contribution of runoff to the stormwater system. As is the case with all rate funded utilities, the objective is to allocate costs to customers in direct proportion to their use of the system. The best indicator of stormwater system use has historically been related to the amount of impervious surface (pavement, rooflines etc) on an individual parcel. This impervious surface approach still provides a great deal of service charge flexibility in terms of credits, mitigation allowances, rate tiers and other forms of service charge offsets.

Two other points related to the structure for stormwater fees are important:

a) Legal Defensibility - virtually all cases involving the legality of stormwater rates apply a two tiered test addressing reasonableness and whether the structure is arbitrary. Reasonableness involves whether the charges are necessary and "cost of service" based for some specific public purpose. Non-arbitrary involves how the fee structure is applied to individual customers. Here the courts have looked for the rational nexus between the basis for the charge and the need for service. They have also looked for some measurable basis upon which the individual charges are calculated.

b) Rate Development - while the basis for the stormwater rate should stay largely intact through the initial development of Bend’s program, there is no reason why alterations cannot be made in the future. Alterations may include new customer classifications, additional tiers to the rate itself or allocations of program costs unique to specific areas or customer groupings. The attached graphic shows the various stormwater rate structures available to Bend in a way that relates real or perceived equity with the cost of building the database necessary to support the rate option. The bottom line is that Bend's funding structure can retain the flexibility to change as the needs of the program evolve and opportunities become available to increase the equity of the service charge structure.

Within this Issue Paper, the Task Force is being asked to provide direction as to the basic structure for the service charge approach.

DEFINITION: (Proposed)

"Impervious Surface" – A parcel's hard surface area that causes water to run off in quantities or speeds greater than under natural conditions. Some examples of impervious surfaces are rooftops; concrete or asphalt paving; walkways; patios; driveways; parking lots or storage areas; and gravel or dirt areas that have been subject to traffic, clearing/grading activities, or other compacting activities.

ALTERNATIVES:

Stormwater service charges must be based on factors which relate customer payment with use of the stormwater system and program. In most cases, stormwater programs quantify this relationship in terms of a property's developed condition and the corresponding increase of impervious area. Engineering analysis and legal precedent (Teter vs. Clark County Stormwater Utility - State of Washington; Long Run Baptist Association vs. Metropolitan Sewer District - State of Kentucky) have established the correlation between impervious factors and impact on the stormwater system. Accordingly, rate making for stormwater programs attempts to quantify a property's contribution of runoff to the stormwater system in an equitable and cost effective manner.

There are three basic approaches toward stormwater service charge structures, all of which revolve around the idea of impervious surface.

1. <u>Equivalent Dwelling Unit</u>

   The base unit of the service charge is referred to as an "Equivalent Dwelling Unit" (EDU). The stormwater EDU would be established through statistical analysis, however, the typical "average" amount of impervious area on a single-family property is between 2,500 and 3,000 square feet. This factor becomes the denominator in the rate equation with all single-family residences treated as 1 EDU. EDU's for all non single-family residential customers are calculated based on measured impervious area.

2. Density of Development Approach

This structure compares the gross area of the parcel with the amount of impervious surface. The result is a service charge that integrates the amount of impervious surface and the total parcel size with a density of development factor.

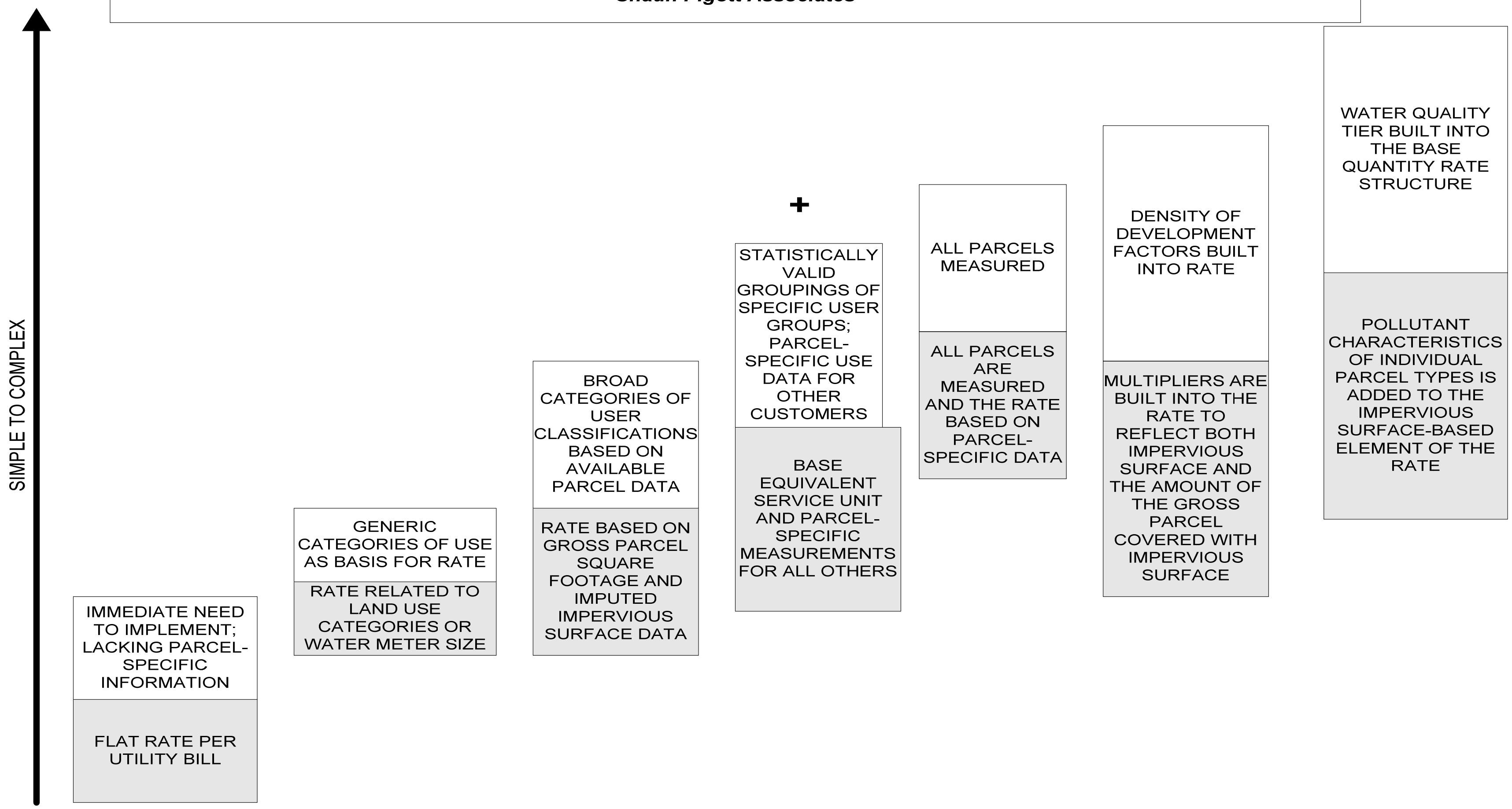
3. Runoff Factors

This rate design moves away from actual measurement of impervious surface and relies on gross parcel size as a key variable in the rate equation. This gross area factor is compared to the land use assigned to the developed parcel (single family, commercial, industrial etc). A "runoff coefficient" is assigned to the land use which identifies the engineering estimate of runoff. The multiplication of gross parcel size by the runoff coefficient percentage determines the effective amount of impervious surface.

RECOMMENDATION: To be developed at Task Force Meeting on 3/16/07

SERVICE CHARGE STRUCTURES FOR STORMWATER MANAGEMENT

Shaun Pigott Associates



CITY OF BEND
STORMWATER UTILITY FEE CITIZENS TASK FORCE

ISSUE PAPER NO. 2

ISSUE TITLE: **HOW SHOULD BEND'S STORMWATER UTILITY ADDRESS THE ISSUE OF SERVICE CHARGE EXEMPTIONS AND SERVICE CHARGE CREDITS?**

BACKGROUND: Implementation of a stormwater service charge requires policy direction regarding whether specific classifications of property or uses of such property will qualify for service charge exemption or credit. One key point to be considered is that "creation of artificial classification of customers" either through the rate design itself or through exemption/credit policies can impact the legality of the stormwater utility. It is also important to assure that all exemption/credit policy recommendations developed by the Task Force support Bend's program <u>as a utility</u> and <u>not as a tax</u>. The amount of a property's service charge must be linked to its proportionate share of stormwater program costs. Issues of equity or legal defensibility arise when exemption or credit policies move away from this utility rate making premise. Service charges must be fair and reasonable and bear a substantial relationship to the cost of providing services and facilities.

ALTERNATIVES: Given this background statement, the Task Force needs to review two basic questions:

1. Should service charge exemptions be allowed for undeveloped properties; publicly owned properties; properties owned by low income and/or elderly; and tax exempt properties?

Many basic policy decisions revolve around "who pays" when a stormwater service charge is applied to individual properties. The equivalent service unit approach presented in Issue Paper 1 and discussed by the Task Force is based on impervious area and would, therefore, exempt <u>undeveloped properties</u> which, by definition, do not have impervious area. Rate structures employing runoff coefficient classifications typically designate undeveloped property as a distinct class and charge them a reduced rate per gross area. If truly undeveloped i.e., left in its natural state, it may not be appropriate to include undeveloped land in a rate structure based on impervious area and contribution of runoff factors.

Most stormwater service charge structures do not consider property ownership in establishing rates. Instead, charges are based on property conditions/improvements that affect runoff in some manner. One exception is publicly owned properties where a variety of policies have been implemented. Some utilities apply stormwater service charges to public properties in the same manner as private properties. Others do not charge public properties because it is believed that the process only takes money from one City fund and transfers it to another. However, the method most often employed is to bill all public owned facilities (schools, city buildings etc) but exempt publicly owned streets. The logic supporting the exemption for <u>streets</u> being that they are <u>designed and operate as part of the City's stormwater conveyance system</u>.

Another question in the stormwater rate is exemption or reduction of the charge based on social issues of low income or elderly. No general rule has been set that enables service charge reductions based solely on ability to pay or age making this issue one established by local policy. The stormwater service charge should reflect the same policy of the City pertaining to low income/elderly as is reflected in the water and sewer rate structures. Therefore, the stormwater charge should be consistent with the City's other rate structures.

The issue of tax exempt properties being excluded from the service charge is legally straightforward. For the sake of maintaining consistency with legal requirements of service charges, the stormwater fee should be applied to properties owned by churches, non-profit organizations and others having tax exempt status.

2. Should credits be provided against stormwater service charges for those properties having on-site stormwater facilities or having made other special improvements to mitigate stormwater quality/quantity impacts?

Most stormwater utilities do provide for credits against service charges to recognize the effects of on-site detention, water quality mitigation or other means of stormwater control. Bend’s stormwater rate will be related to each property's contribution of runoff to the system. The objective of a service charge credit system is to provide incentives for developers to meet or exceed basic stormwater quantity/quality requirements. The level of credit should reflect the reduced effect a property with on-site controls has over a similar property lacking this mitigation. The amount of service charge reduction is a function of the service charge rate structure. Under the impervious surface approach, the credit results in a reduction of the equivalent units attributable to the property.

A key policy decision related to on-site controls is whether Bend wishes to make a credit available to only those who exceed development requirements or should the system provide credits to those who simply meet development requirements. Stormwater utilities are split on this issue, with many opting to offer the development credit to only those going beyond mandatory stormwater quantity and quality requirements.

This approach should also include provisions for rescinding the credit under conditions where the control is either removed or is not maintained to design specifications.

Finally, Bend should be prepared to support a decision to allow service charge credits with an appeals process. While administrative appeals to the base service charge should be anticipated by having a process in place, credits will also require procedures for review of the reductions allowed for on-site mitigation controls.

RECOMMENDATIONS: To be discussed by Task Force on 3/16/07

CITY OF BEND
STORMWATER UTILITY FEE CITIZENS TASK FORCE

ISSUE PAPER NO. 3

ISSUE TITLE: **HOW COULD BEND STRUCTURE THE CALCULATION OF STORMWATER SERVICE CHARGE CREDITS?**

BACKGROUND: In Issue Paper No. 2, it was generally agreed by the Task Force that Bend's stormwater program include a system of rate credits. It was further suggested that the credit calculation be consistent with the City's rate structure and not allow any property a total reduction of the service charge. The next step in the process is for the Task Force to evaluate the options for calculating the level of credit which is due a stormwater customer.

ALTERNATIVES: A key policy issue is how much of the service charge should be made available for credit. The case for making the entire charge available for credit would assume that if the site totally retains stormwater runoff, that customer is not being served by any of the programs or services offered by the utility. However, given the fact that access to the property is available during storm events and that stormwater utility activities such as water quality management, system maintenance, regulatory compliance and public information will be a service to all the City's customers, it is questionable whether any property is left totally unserved by the program. Based on this logic, it is generally accepted that some level of the fee remain in place regardless of the on-site facility constructed by the customer. The level of credit available can be a function of allocating program costs to "base" versus "use" factors. Base can be defined as program costs that are largely unaffected by stormwater flows. These typically include water quality management, maintenance, regulatory compliance, and billing/administration. Use costs are those that are related to stormwater flow or quality and may include budget categories such as capital improvements.

Another consideration is eligibility for credit and specifically whether a customer qualifies by meeting <u>or</u> exceeding Bend's design requirements for the site. The case for limiting credit eligibility to only those customers exceeding design requirements is premised on the fact that by going beyond requirements, the property has effectively reduced the amount of stormwater flow that will need to be handled by the City's downstream system. In essence, by exceeding requirements and handling more runoff on-site, the customer has added capacity to the City's stormwater system. This statement is not true for on-site facilities which simply meet Bend's design requirements as a condition of development approval. Theoretically, the City has sized its stormwater systems based on the engineering assumption that new development will control flows to meet established design requirements. Under these conditions, there is no cost avoidance or additional capacity made available to the City. Accordingly, simply meeting design requirements typically does not constitute a basis for service charge reduction. Again, the Task Force was in mid-discussion on this point at the last meeting and it will be resumed at the March 23 meeting.

Another consideration deals with the calculation of the charge itself. There are a number of variations all of which revolve around the desired level of simplicity, equity and administrative ease. At its simplest, a service charge credit is calculated as a percentage reduction based on the type of facility. A detention facility equals a certain percentage reduction; a retention facility a percentage; drywells another percentage. A higher level of accuracy is achieved when the calculation is based on a case-by-case comparison of site specific conditions on the site.

EXAMPLE: In order to give the Task Force an idea of what the credit application and calculation package might look like in Bend, the following example has been prepared. ***This is for discussion purposes only:***

ON-SITE STORMWATER CREDIT PROCEDURE
(for discussion purposes only)

DEFINITIONS:

Detention: Facilities designed to hold runoff while gradually releasing it at an allowable discharge. This would include drywells.

Retention: Facilities designed to hold water for a substantial period of time and releasing it through evaporation, plant transpiration or infiltration into the soil. This would include swales.

Drywells/drill holes: Facilities designed for the on-site disposal of stormwater into the ground.

Hydrologic Response: The manner by which stormwater collects on the property and is conveyed from that property. The principal measures of the hydrologic response may be stated in terms of total runoff volume, as a percentage of total precipitation generated by a storm of given duration, intensity or frequency.

BMP's: Schedules of activities, prohibitions of practices, maintenance procedures or other management practices to prevent or reduce the pollution of waters of the state. BMPs may include operational and structural source controls that minimize and prevent contaminants from entering stormwater as well as treatment that removes contaminants contained in stormwater runoff before disposal or discharge.

DISCUSSION

Some properties within the Bend stormwater service area, due to the construction and maintenance of stormwater control facilities, may have a hydrologic response substantially similar to properties with lesser amounts of impervious surface. Any non-single family residential property owner that has installed an approved on-site facility may apply for an adjustment of the service charge applied to that specific parcel. PROVIDED THAT the resulting adjustment will be commensurate with the facility's mitigating effects on runoff.

A stormwater quality credit is available to any non single-family residential property within Bend. In order to qualify for the stormwater quality credit, a property will implement source or treatment controls which reduce or eliminate pollutants from its stormwater runoff before it enters the ground or the City's stormwater system. These source or treatment controls are known as best management practices (BMPs) applicable in whole or in part to specific types of institutional, commercial and industrial operations.

The City's Stormwater Coordinator or designee may adjust the stormwater utility charge for such properties based on hydrologic data submitted to the City's Stormwater Coordinator by the property owner or agent which demonstrates a hydrologic response substantially similar to that of a property with a lesser amount of impervious surface. The Stormwater Coordinator will evaluate each case in determining the appropriate level of service charge adjustment. Provided that the amount of credit for stormwater quantity credits does not exceed ___% of the customer's original/unadjusted stormwater charge.

The premise behind the stormwater credit is that some properties with on-site facilities do reduce the City's actual stormwater management costs. The reduction in program costs is related to the budget categories for stormwater. These budget categories and percentages follow:

Budget Category	Credit Eligible	Percentage of Budget
Capital Improvements	Yes/No	%
Maintenance	Yes/No	%
Engineering Services	Yes/No	%
Water Quality Management	Yes/No	%
Small Works	Yes/No	%
Public Involvement	Yes/No	%
Billing/Admin./Indirect	Yes/No	%

All improved properties make use of or are directly served by base cost elements including (this has yet to be determined by the Task Force) engineering services, maintenance, water quality management, small works, public involvement and billing. The credit applies to the capital improvement cost categories or use elements (again, to be discussed with the Task Force) which are affected by the customer's on-site facilities. Due to the fact that the City does not require site specific stormwater runoff calculations as part of their drainage plan review process, the level of credit must be based on the construction of an on-site facility or BMP implementation.

CREDIT CALCULATION

The following information must be submitted to the City's Stormwater Coordinator in order to be eligible for a service charge credit:

- o approved drainage plan and calculations
- o signature of the person responsible for the accuracy of the credit application material.

Once received by the City, the applications will be reviewed and, if approved, will be reflected in a rate adjustment retroactive to the date the application was received. Where the credit is not approved or requires revisions by the applicant, the City will so notify the applicant.

All adjustments will remain in effect as long as:

- o The person responsible has obtained the stormwater permits required by the City and the facility has been constructed and is maintained in compliance with all approved plans and design criteria.
- o The person responsible for the improved property remains accountable for all costs of operation and maintenance of the facility.
- o The City will have access to the stormwater facility for purposes of inspecting its compliance with design, maintenance and operating standards.

POTENTIAL RATE REVENUE IMPACTS

To be determined…………….

RECOMMENDATION: Bend's stormwater credit calculation should be based on the fact that a facility has been constructed to the City's design requirements and/or BMP’s have been implemented; it is maintained in good working order; and City personnel have access to the facility for inspection purposes. Meeting these criteria then results in a fixed or graduating percentage reduction of the service charge. This reduction should be limited to the "use cost elements" of the stormwater utility's budget.

CITY OF BEND
STORMWATER UTILITY FEE CITIZENS TASK FORCE

ISSUE PAPER NO. 4

ISSUE TITLE: **HOW SHOULD PRIVATE ROADS WITHIN SPECIAL SUBDIVISIONS (including PUDs) BE TREATED UNDER THE STORMWATER UTILITY'S RATE STRUCTURE?**

BACKGROUND: During discussion of how the stormwater rate would be applied to publicly owned properties (see Issue Paper No. 2), a separate concern was identified regarding the treatment of private streets within special subdivisions/PUDs. The concern centered on the fact that these streets, while privately owned and maintained, function the same as City-owned streets in that they are designed as part of the stormwater conveyance system. Accordingly, the question was posed as to whether these private streets should be excluded from the stormwater utility service charge.

ALTERNATIVES: The Committee has opted to exclude City-owned streets from the stormwater service charge because these streets and arterials perform an essential function in the conveyance of stormwater into and through Bend's system.

In terms of the private road systems within special subdivisions, the street must be designed to City standards if it is identified on Bend's Transportation System Plan (TSP). However, those streets not contained in the City's TSP may be built to lesser standards if the Council deems that traffic volumes and patterns so warrant. Under these conditions the streets in these special subdivisions are not designed to accommodate through traffic and are constructed to meet the specific needs of the subdivision residents.

There are several of these special subdivisions within Bend, mostly comprised of single-family residences. The issue is whether the impervious surface on these private street systems should be measured for purposes of the service charge.

Alternatives include:

- o exclusion of the street system within special subdivisions on the same basis as City-owned streets;
- o inclusion of private streets just as any other parking and/or common impervious surface areas;

RECOMMENDATION: In those cases where the private roads within the special subdivision are consistent with the City's Transportation System Plan and/or the streets meet Bend's street design standards, then those roads are assumed to act as a stormwater drainage conveyance. Therefore, they would not be charged for stormwater. However, if private streets discharge stormwater onto public streets for storm events with return periods less than 25-years, then the owners of these streets should pay the service fee.

CITY OF BEND

STORMWATER UTILITY FEE
CITIZENS TASK FORCE

- MEETING SUMMARY-

February 23, 2007

Task Force Attendees: Mike Schmidt, Bill Robi, Andy High, Paul Eggleston, Bill Friedman, Joanne Richter, Chuck Arnold, Ron Neet

Task Force Members Not Attending: Fred Gientke, Jan Gifford

Staff & Consultant Attendees: Mike Miller, Ollie Fick, Wendy Edde, Shaun Pigott

This was the initial meeting of the Stormwater Utility Fee Citizens Task Force. Meeting packets were distributed containing the agenda, Task Force charter, and the project fact sheet. Copies of the PowerPoint presentation were also included. As the initial meeting, much of the agenda was oriented toward introducing the Task Force members to each other, reviewing the project objectives and discussing the process/procedures to be used in guiding the Task Force's work. At the same time, this initial session was also directed at providing the Task Force with information on the key issues and concerns impacting Bend's stormwater future.

As mentioned at the meeting, these summaries are intended to "hit the highlights" of each session and are not intended as verbatim meeting minutes. If key points are not identified that any Task Force member believes should be included in the summary, then those can be added at the request of the Task Force members.

- Mike Miller began the meeting by introducing the City's project team and consultant. A description of the current stormwater master planning process was provided and it was pointed out that Shaun Pigott was a subconsultant to URS Engineering (prime) and Shaun's responsibilities focused on the financial /utility issues supporting the master plan. It was also pointed out that Shaun has been a Deschutes County resident since 1988 and has worked in public finance and utility formation across the Country since 1985. Mike emphasized that the City Council has already committed to forming a stormwater utility and that a formation ordinance would be brought to Council in March. The Task Force was brought together for a very specific purpose in helping to design a rate structure and provide input on program priorities that would help the City in implementing the funding structure for the utility. Historically, funding for Bend's stormwater activities has been through the General Fund and Street Fund. These revenue sources are at a critical "stress point" as identified by Bend's financial forecast and are no longer available for stormwater. At the same time, Bend will soon be issued its National Pollutant Discharge Elimination (NPDES) stormwater permit that has a series of regulatory requirements. Underground Injection Control (UIC) permitting for the City is also pending and the City has a number of stormwater hotspots and maintenance needs that require a new revenue stream rather than reallocation of existing resources.

- Shaun Pigott then reviewed the Committee's charter (included in the packet) and highlighted the fact that the engineering aspects of a stormwater master plan are only part of the picture and that unless the funding structure is also addressed many cities are left with a plan that never makes it to implementation. By way of magnitude of need, the City was in the preliminary budgeting process for the next two years and was estimating that the initial stormwater program would cost upwards of 1.7 million annually. A Task Force member asked how that budget translated into a rate per month? Shaun replied that the initial forecast indicated that a rate of $4 per single family home would be a reasonable preliminary estimate. Under the standard stormwater rate approach non residential customers (commercial, industrial etc.) would pay a multiple of this base residential rate as a function of parcel specific measurement of impervious surface. The City is currently in the process of developing these measurements.

- Ollie Fick and Wendy Edde then described the City's current efforts regarding NPDES and UIC compliance along with the master planning underway. The City expects its NPDES stormwater permit the first week in March and the UIC permit in the not too distant future. (Even without the UIC permit, the City is obligated to comply with DEQ regulations.) The master plan is expected to be completed by the end of the year. A Task Force question was how specific the master plan would be in terms of evaluating water quality issues? The plan is expected to evaluate best management practices (BMPs) affecting stormwater quality but will not be doing discharge point monitoring and sampling. Among the 30 hotspots, 5 areas have been selected for detailed analysis and these locations are expected to include both stormwater quantity and quality issues. Another Task Force question was the level of involvement of DEQ in this plan and whether the City could really know what it is that DEQ requires? DEQ was not going to be on the Task Force but the City felt that they had a good handle on the requirements as presently structured but the whole regulatory environment was fairly dynamic. The City has already take step to meet regulatory requirements by putting together its own management program via the Integrated Stormwater Management Plan, the Central Oregon Stormwater Manual, and the City's Master Plan.

- Shaun then talked about known problem areas and the basic cost structure for new utilities which included capital improvements, water quality, maintenance, engineering/project management, plan review/inspection, public information and administration. Shaun emphasized that the capital improvements identified for purposes of the utility rate would be limited to smaller neighborhood improvements directed at "fixing" existing problems. The master plan would ultimately identify the larger system facility needs that would likely include future capacity requirements for growth, but this initial utility rate analysis would not address these future capacity considerations. The Task Force asked whether the initial program would include costs related to facility inspection for both new construction and for existing facilities? The short answer is yes as the program will include a program to assure that new facilities are built as designed and there will also be a need to do a field condition assessment on existing facilities.

- There were Task Force questions regarding the project schedule and how the public information element would be managed. Overall, implementation of the fee structure is presently scheduled for July 1, 2007 if all goes according to plan on the mechanical/utility billing/parcel measurement front. Some misinformation has already made it into the Bend Bulletin, which stated that the stormwater fee would be included in the water rate…this is not accurate. The stormwater rate will be a separate line item on the City's utility bill and revenue collected will be dedicated to the stormwater management program. In terms of getting the word out through the newsletters/e-mails of the organizations represented on the Task Force, it was requested that the City make the initial announcement as part of the Council action on the formation ordinance in March. Once that is complete, it is hoped that company/organizational newsletters can be used to further spread the word on the utility rate and the program.

- Procedurally, the Task Force's work will be completed by early spring and will require 4 additional meetings. Each meeting will be preceded with information sent to the members one week in advance using an "issue paper" format. Each meeting will be 90 minutes. Joanne Richter agreed to chair of the Task Force. Chuck Arnold agreed to be the co-chair.
- The agreed upon meeting schedule is as follows:

  March 16

  March 23

  April 13

  April 27
- All meetings are on Friday and the meeting time is 10:30 – Noon at the same location, the City Hall Board Room.
- The agenda for the March 16 meeting will be: stormwater rate structures; stormwater budget breakdown and likely questions/answers from the general public about the stormwater utility rate/program.

CITY OF BEND

STORMWATER UTILITY FEE
CITIZENS TASK FORCE

- MEETING SUMMARY-

March 16, 2007

Task Force Attendees: Mike Schmidt, Chuck Arnold, Paul Eggleston, Bill Robie, Joanne Richter, Ron Neet, Bill Friedman, Fred Gientke

Task Force Members Not Attending: Jan Gifford, Andy High

Staff & Consultant Attendees: Mike Miller; Ollie Fick; Shaun Pigott

This was the second meeting of the Stormwater Utility Fee Citizens Task Force. Meeting information had been distributed via e-mail the week before with the exception of the program cost overview which was scheduled for presentation/discussion at the meeting. At the 2/23/07 meeting Joanne Richter was chosen by the Task Force to chair the meetings and she called this meeting to order at 10:35.

Since one member who could not attend the first meeting was now present (Fred Gientke, Awbrey Butte Neighborhood Association) the Chair asked for Task Force member introductions. Fred indicated surprise that he was the only neighborhood association representative and it was pointed out that other neighborhoods had been invited and that Joanne Richter, although active in the Upper Deschutes Watershed Council, was on the Task Force not on behalf of the Watershed Council but as an interested Bend resident and also because of her experience as the Stormwater Utility Manager for the City of Olympia, WA. Some other Task Force members indicated that while they had been invited to be on the Task Force as members of groups/associations, they were also there as residents of the City. The Chair then reviewed the agenda for the meeting stating that there was a lot to cover in a limited amount of time. The information distributed via e-mail would be discussed; however the question and answer material was there more by way of background and would not be specifically discussed today.

- The first agenda item was Issue Paper No. 1 – Structure of Stormwater Rates. Shaun Pigott summarized the issue paper and provided some background on the history and legal precedence of stormwater utilities/rates in the U.S. and Oregon. In terms of legal defensibility, the rate needed to be related to the cost to provide service, proportionate among customers or customer classes and measurable. As stated in the issue paper, we do not have meters or flow monitors for runoff from individual properties so most utilities relate use of the system or contribution of runoff to an impervious surface measurement or estimate. Creation of impervious surface is what creates the need for stormwater systems and generates runoff at higher volumes and higher flows. There are variations on obtaining the impervious surface information which range from zoning classifications to parcel-specific measurements. It was also pointed out that where utilities start as far as a rate structure goes, is just that, a starting point - where the emphasis is on legality, ease of administration and simplicity. For these reasons, most if not all utilities use some form of measurement of impervious surface as the basis for the rate. Also, single family residences are typically treated as one equivalent residential unit (ERU) and all pay a rate based on 1 ERU. One ERU represents the average amount of impervious area on a single family parcel, usually in the range of 3,000 sq ft. All non-single family residential (NSFR) property (multi-family, commercial, industrial, institutional) pay a rate based on their parcel-specific measurement of impervious area. Impervious area includes rooftops, paved areas, decks, compacted gravel/soil, etc. There are other options and some utilities have evolved their rate structure to include density factors or area-specific rate factors.

Overall, the Task Force agreed that simplicity and fairness were key ingredients and that measured impervious surface for NSFR properties seemed the fairest way to go. The stormwater rate should also consider the City's existing low income/elderly adjustments that staff indicated were available in Bend's wastewater rate structure. However, there were concerns expressed by the schools that they had put in stormwater systems that met the City's drainage standards and that their impervious surface generated no runoff from their sites. The Hospital was also concerned that while their sites may discharge some stormwater off site, they had also installed a significant number of stormwater quality and quantity facilities, so simply measuring their impervious surface would not produce an equitable rate since these on-site investments were not factored in. Shaun responded that these parcel-specific issues could be addressed through a credit mechanism available to NSFR parcels and those would be discussed in Issue Paper No. 2 and No.3. At this point, staff was after direction on the basics of the rate structure.

The Task Force agreed that the City's rate structure should be based on impervious surface. The amount of impervious surface would be measured for all NSFR properties and that SFR would be based on a standard value and all charged for 1 ERU. SFRs would include both single family residences and duplexes. However, the Task Force requested that the City develop a value for the base ERU through a Bend-specific analysis for residential property.

- The second agenda item was Issue Paper No. 2 – Rate Exemptions and Rate Credits. Exemptions dealt with properties or types of properties that would be categorically excluded under the service charge structure. The Task Force felt that undeveloped properties (meaning a whole parcel that had been left in an "undisturbed" natural condition and therefore not having any impervious surface) would be exempted from the fee. It was also agreed that a property's tax exempt status would not have any bearing on the application of the rate. This prompted a clarification that City-owned facilities such as City Hall, and other buildings/impervious surfaces would pay the rate. The issue paper summarized the logic supporting not including the City's streets in the fee structure because they are designed to collect and convey stormwater runoff. Because the streets are effectively part of the storm drainage system, there is a basis for these impervious surfaces to not be included in the rate. It was also suggested that if the Task Force was in agreement on this approach, then private streets within planned unit developments (PUDs) would also need to be excluded from the rate. This prompted concerns about exempting PUD streets because some had been identified as the source of significant stormwater problems in areas of the City. It was suggested that some PUD streets may act as an effective part of the stormwater system but others do not, so exempting them all would not be a good policy. In terms of consistency, the Task Force felt that an across the board exemption of the City's streets would also not be appropriate. Rather, City streets and PUD private streets should be assumed as included in the rate but credits would be available to exclude from the rate those streets that are effectively functioning as part of the stormwater conveyance system.

This started the discussion of rate credit specifics. Basically, the objective of a rate credit is to recognize through some level of rate reduction, the property-specific conditions that result in a downstream reduction of the City's costs to provide stormwater services or otherwise represent a benefit to the utility as a whole. Overall, the Task Force was supportive of having a rate credit. While the issue paper was intended to ask the Task Force's opinion on whether a credit should be offered, the discussion delved into some of the specific factors affecting credit eligibility and amounts. The case in point being the schools having made significant drainage improvement on their sites, meeting City standards which are designed to match post development runoff volumes with pre development conditions…essentially zero discharge. That being the case, there would be no impervious surface basis for a charge to the schools although the schools do recognize some value from this type of stormwater program, just not the value that would result if all their impervious surfaces were included under the rate. The City is in the process of evaluating its drainage standards because the current requirements clearly do not result in zero net run off from developed sites and the criteria for on-site sizing/required number of drywells are not consistently understood or applied. So the statement that meeting existing drainage standards translates into no runoff leaving the site is probably not accurate. This generated some discussion of how the credit amounts might be calculated and Shaun described one approach which separates the utility's costs elements between fixed and variable. The fixed cost components are allocated among all customers while the variable costs become the basis for the credit amount (see Issue Paper No.3). The question was then raised about availability of the credit and specifically whether it would be available to those who meet or those that exceed the City's standards. Task Force discussion was split on this issue and Shaun mentioned that some cities include factors other than design standard compliance as criteria for credit eligibility (treatment prior to injection, best management practices etc). The objective is to have a credit mechanism that provides an economic incentive to "do the right thing" and at the same time create a benefit for the utility that justifies a commensurate rate reduction.

This information then tied into the planned discussion of the stormwater utility's program and costs. The Chair indicated that this would be an important discussion and that it was now nearly noon. It was suggested that this budget information be presented/discussed at the next meeting scheduled for March 23. It was also requested that the Task Force meet for 2 hours at its next session, which was agreed. Therefore the next meeting will be 3/23/07 from 10 to noon, at the same Board Room location.

The agenda will include Issue Paper No. 3 on the specifics of a rate credit and a discussion on the utility's estimated program costs. An update on the charging for streets issue will also be available along with the sampling approach for single family residences in Bend. Materials for the next meeting will be distributed as soon as possible given that the next meeting is one week away. The meeting was adjourned at noon.

Key Points of Agreement

1. Overall, the Task Force agreed that simplicity and fairness were key ingredients and that measured impervious surface for NSFR properties seemed the fairest way to go.

2. The stormwater rate should also consider the City's existing low income/elderly adjustments that staff indicated were available in Bend's wastewater rate structure.

3. The Task Force agreed that the City's rate structure should be based on impervious surface. The amount of impervious surface would be measured for all NSFR properties and that SFR would be based on a standard value and all charged for 1 ERU. SFRs would include both single family residences and duplexes. However, the Task Force requested that the City develop a value for the base ERU through a Bend-specific analysis for residential property.

4. The Task Force felt that undeveloped properties (meaning a whole parcel that had been left in an "undisturbed" natural condition and therefore not having any impervious surface) would be exempted from the fee.

5. It was also agreed that a property's tax exempt status would not have any bearing on the application of the rate.

6. Overall, the Task Force was supportive of having a rate credit.

7. Task Force felt that an across the board exemption of the City's streets would also not be appropriate. Rather, City streets and PUD private streets should be assumed as included in the rate but credits would be available to exclude from the rate those streets that are effectively functioning as part of the stormwater conveyance system.

CITY OF BEND

STORMWATER UTILITY FEE
CITIZENS TASK FORCE

- MEETING SUMMARY-

March 23, 2007

Task Force Attendees: Andy High, Mike Schmidt, Chuck Arnold, Paul Eggleston, Bill Robie, Joanne Richter, Ron Neet, Fred Gientke

Task Force Members Not Attending: Jan Gifford, Bill Friedman

Staff & Consultant Attendees: Mike Miller; Ollie Fick; Wendy Edde, Shaun Pigott

This was the third meeting of the Stormwater Utility Fee Citizens Task Force. Meeting information had been distributed via e-mail two days before the meeting due to the short turn around from the meeting the previous Friday (3/16/07). The meeting began at 10:05 AM.

Key Issues Discussed

- **March 16, 2007 Meeting Summary.** Two items were discussed. First, members discussed whether the Task Force had actually agreed to including City streets and streets within Planned Urban Developments (PUDs) in the rate and then evaluating their eligibility for credit. This seemed to be a lot of work to end up at the beginning point of not charging for these areas. It was generally agreed that Staff should try to identify more specific criteria that would appropriately make some streets exempt and others not. Shaun mentioned that the City has approximately 350 center line miles of public streets and 85 center line miles of private streets. Second, the Task Force requested making the meeting summaries short and bulleted.
- **Continuation of Issue Paper 2 discussion:** Service Charge Exemptions And Service Charge Credits – There was no further discussion of the properties to be exempted from the rate but there was discussion about the application and amount of the credit. However, the fact that a credit should be available and that the credit would be limited to non-single family residences was agreed. Single family homes in Bend are not required to have on-site facilities; however, there are stormwater facility requirements for whole subdivision developments and credits may be available to the developer and Homeowners Association (HOA) for those areas. Both the school district and the hospital felt that their properties would look toward the credits as a way to make this new utility affordable. They also felt that their on-site activities in both quantity and quality control should be reflected in the rate credit. The question was asked about how other cities had applied credits, and examples from Eugene and Orem, Utah were circulated for the Task Force to review.
- **Issue Paper No. 3 – Calculation of Service Charge Credits.** Shaun summarized the credit calculation approach and opened the topic for Task Force discussion. The lack of specific design criteria limits the ability of the City to have a graduating credit on the quantity side, so the best

option may be to simply either allow the full quantity credit or not. (All customers will pay for at least one ERU.) This could be an interim strategy until the City's standards and specifications are changed. This dealt with the issue of "meeting" or "exceeding" design requirements with at least one Task Force member feeling that those meeting standards should be quantity credit eligible while others felt that only those who go beyond the standards should be eligible. The Task Force concluded that the evaluation for the quantity credit would have to be done on a case by case basis. However, on the quality side, the use of BMPs would be an effective tool for applying a graduating rate of credit. As more or better BMPs are implemented, then more quality credit is allowed. Shaun stated that a full credit application package will be drafted for the next Task Force meeting.

- **Budget Estimates.** The Overview of Program Services and Budget Estimates was distributed and Shaun briefly summarized the cost categories and the overall proposed budget of $1.46 million. The discussion centered on several key items: 1) was the maintenance budget adequate; 2) was the capital program adequate to address at least the identified hotspot problem areas; and, 3) would this budget produce visible/meaningful results – quickly. The maintenance budget only reflected labor costs as equipment was capitalized under the City approach so the maintenance budget, while lean, is adequate. Point 2, yes the City would undertake the hotspots, likely with the Franklin Street and 3rd Street underpass projects being done first, though the first year budget incorporates engineering designs but not necessary completion of the necessary repairs. In terms of quick results, the Task Force was very clear that once the fee went into place the City needed to be in a position to provide visible services and problem fixes because planning would not be visible. The program element costs within the budget would constitute the fixed and variable components that would establish the ceiling for the credits. As presently structured, capital programs amount to 36% of the budget and water quality 26%. These cost factors will be discussed further in the draft credit application package.

- **Public Outreach.** The next agenda item addressed an upcoming public meeting on the stormwater utility, proposed for April 12. After discussion, the Task Force asked Staff to reschedule the public meeting for a later date and look to neighborhood forums for public outreach. At the same time, the organizations represented on the Task Force have ways to distribute information. Other avenues included press releases, association newsletters, and possibly contacting KBND for some time on the subject. The Task Force was concerned about a consistent message and was looking to the City to provide talking points.

- The meeting concluded at 12 PM.

Key Decisions Made/Action Items

- It was generally agreed that staff should try to identify more specific criteria that would make some streets exempt and others not.
- Concise meeting summaries will be developed rather than detailed minutes.
- A credit should be available and be limited to non-single family residences. All customers will pay for at least one ERU.
- The evaluation for the quantity credit would have to be done on a case by case basis.
- Staff will reschedule the proposed public meeting for a later date and look to neighborhood forums, with assistance from Task Force members, to conduct public outreach regarding the fee.
- The City will provide talking points and a timeline for public outreach to assist Task Force members in preparing informational outreach to their organizations.
- The next Task Force meeting is scheduled for ***April 13 from 10:30 to Noon at the Board Room***. The agenda will include: draft credit application review; impervious surface measurement process (with actual Bend properties as examples); master plan update & problem hotspots; upcoming key events.

CITY OF BEND

STORMWATER UTILITY FEE
CITIZENS TASK FORCE

- MEETING SUMMARY-

April 13, 2007

Task Force Attendees: Mike Schmidt, Chuck Arnold, Bill Robie, Joanne Richter, Ron Neet, Fred Gientke, Bill Friedman

Task Force Members Not Attending: Jan Gifford, Paul Eggleston, Andy High

Staff & Consultant Attendees: Ollie Fick; Wendy Edde, Shaun Pigott, Ela Whelan, Sarah Hubbard-Gray, Ken Fuller, Victoria Wodrich

This was the fourth meeting of the Stormwater Utility Fee Citizens Task Force. Meeting information had been distributed via e-mail earlier in the week and included the previous meeting summary, budget and revenue projections, service charge credit procedures and public outreach efforts. The meeting began at 10:00 AM.

Key Issues Discussed

- **March 23, 2007 Meeting Summary.** The summary from the previous Task Force meeting was reviewed. There were no material changes suggested and the meeting summary was accepted. The Chair noted that a significant amount of information had been distributed for this meeting…probably too much. The process could be improved if staff provided a short intro to each piece of information indicating why it was prepared and what staff is asking from the Task Force.

- **Utility Budget and Credit Approach –** Shaun had prepared an outline of the utility budget (details of which and written information had been discussed at the 3/23 meeting) for purposes of relating the utility's proposed budget of $1.46 million opposite the number of ERUs that would be necessary in order to produce a rate of approximately $4 per month. These estimated ERUs were NOT based on the impervious surface measurement process that was underway. This measurement information would be available on May 14. Shaun emphasized that this ERU estimate will likely understate the actual measured ERUs. The additional ERUs and the resulting additional revenue could be allocated to speeding up the capital projects identified as "hotspots" through the preliminary stages of the master planning project. Comparative rates for other NW and regional stormwater utilities were also discussed with the $4 rate being pretty much in the middle of the pack. Specific information regarding Medford's utility was also discussed and some members felt that this more detailed comparison of programs and what these programs have achieved would be good information. A graph showing the results of the analysis of 50 single family homes in Bend and their measured impervious surface was presented and discussed. The mean is at 3,800 feet without any statistical review of the data. The credits and credits application package were then discussed and Shaun went through a couple of examples. The approach was acceptable to the Task Force reflecting a quantity credit of up to 35% and a quality credit of up to 22% for a maximum credit for of up to 57%. Only commercial (non single family residential) properties who meet the City's design criteria may apply and then only those properties that exceed these baseline standards will be eligible for a credit. There was a concern from the members that the credit be reserved for only those properties that actually warrant a rate reduction and there should also be provisions for assuring the facilities are properly operated/maintained. The Task Force felt this was a reasonable place to start the credit program which could then be amended, if necessary, based on the results of the master planning.

- **Master Plan Update.** Ela Whelan, from URS and managing development of the stormwater master plan, discussed the "hotspot" problem areas within the City and explained the nature of the problem and likely directions toward addressing these stormwater quality and stormwater quantity concerns. Priorities were discussed along with general ranges of cost, which would be significant. The Fire Station drainage problem and the underpasses were of specific concern. Ela discussed the general nature of the problems (under capacity systems; systems that no longer function; flows being redirected etc). The master plan will prepare options to address these problems along with order of magnitude costs. One area of concerns were discharges to Mirror Pond and whether the stormwater quality issues would be addressed at the "end of the pipe" or through some other means. The impression may have been left that end of the pipe treatment was the only option which is not the case as treatment approaches including diversion through swales prior to discharge will be evaluated. The master planning options and costs for the hotspot projects would be available soon, perhaps by the next CTF meeting

Utility Public Notice/Information. The Task Force felt that the word on the utility needed to be distributed about the pending service charge and credit program. However, there was also concern about getting the cart before the horse and getting information out in the community before the Council had approved or before the final numbers were in. It was expected that by the time of the scheduled public meeting on May 24, that many of these questions would be answered. The Council was also going to be asked to accept/adopt a resolution committing to move forward on the stormwater utility (Council did take this action on April 18). In the meantime, the organizations represented by the Task Force all had the means for getting the word out and the City would be working with these organizations to develop a common message. The Task Force was very clear in stating that the utility needed to commit and be able to deliver on a specific set of services and a specific schedule for designing and "fixing" the chronic stormwater problem areas.

Key Decisions Made/Action Items

- Regarding street credits…all would be excluded from the initial fee but this would be revisited in the post master plan/second phase of the utility. This would be focused on identifying which streets actually function as part of the stormwater system vs. those that don't and actually create additional stormwater problems.

- Credits for non single family properties that exceed the City's standards with the level of credit applicable based on site specific conditions and on-going operation and maintenance of all credited facilities or BMPs

- A consistent public information message should be developed and be made available to the Task Force.
- The City must be able to state what it is that the utility will do within a specific timeframe to address chronic stormwater problem areas.
- There will be a public meeting on May 24 that the Task Force is invited to attend
- The next Task Force meeting is scheduled for **May 18** ***from 10:00 to Noon at the Board Room***. The agenda will include: final ERU and budget figures; public information program and implementation tasks/schedule.

May 24, 2007

Stormwater Utility Service Charge Public Open House

Summary of Comments Received

35 Attendees, 16 Responses Received

Questions Regarding the Stormwater Program and Proposed Service Charg

1. Do you feel that the proposed service charge is:

…necessary? __8__Yes _6_____ No ___2_____Not Sure _____NA

…equitable? __2__Yes __8____ No ___4____Not Sure __1___NA

(Circle one) …too high? 4 …too low? 1 …just right? 3

Comments:

- Not fair for the old farm district as we are not serviced by any UIC's or city sewer

- $4/month is not all that much, as long as positive, ongoing remedies come from it. The solutions need to be visible and effective.

- Has a room tax been considered, as roads, buildings etc. are used by tourists as well. Must consider future growth/development as it pertains to this issue (as I'm sure you have).

- I already pay taxes. This fee is just another tax without voter representation.

- Arbitrary assessments on my residence, which has no serwer or strom drain, without a vote is unfair. Although I see the need for 3rd St., Franklin underpasses – which would be to my benefit.

- New commercial with existing storm water retention should not be charged the same as old or existing.

- Not enough east side areas

- It's time we start doing this. Problems need to be fixed. Developers should also be charged for adding new streets and houses to the system.

- With our high desert environment, this is not needed.

- City needs to review for other applicable avenues of funding.

- Residential street flooding.

- Too late.

- This is not a priority for Bend. If Bend is going to be in violation of federal standards, then so will every city on the eastern seaboard. This committee is overreacting. We need to concentrate on other issues in Bend.

- Credits or incentives for residential would make this more equitable.

- The underpasses problems have existed for years. The City & ODOT has shined them on for years. Now all of a sudden it is an emergency. The other three priorities are the result of "Piss Poor Prior Planning." You cannot cover the earth with roofs and asphalt and not expect problems. Developers have needed to be more responsible for their creations years ago! We have needed to broaden SDC's for years.

-

2. Do you feel that you understand the proposed stormwater service charge better than you did prior to the meeting? _11_Yes ___3_ No ________Not Sure __2___NA

Please list those areas where you would like additional information, or those which you feel need a clearer explanation?

- **More information on credits. Will there be assistance for people who can't afford the fee? Any credits for residential developments that use homeowners fees to maintain their stormwater system?**
- **The whole scheme needs to be re-evaluated.**

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3. On a scale of 1 to 5 with 1 being the highest priority and 5 being not needed, rank the importance of the following (circle):

1. Protecting water quality in the Deschutes River from stormwater impacts: 1 2 3 4 5
2.06
2. Protecting groundwater quality from stormwater impacts: 1 2 3 4 5
2.06
3. Protecting streets and property from flooding: 1 2 3 4 5
1.88
4. Performing preventative maintenance 1 2 3 4 5
2.19

Comments:

- **The river is not impacted much by runoff. What does impact it is "Mirror Pond" and the sediment and water foul. Let's look at this realistically.**
- **Goose crap, garbage, oil, antifreeze are bigger problems for the river than stormwater. That is one of the main reasons for piping the canals.**

4. Do you support the idea of a credit and/or fee relief program?

Yes 6/ No 6/ Maybe 2/ Unsure 2

Comments:

- **I don't support the fee.**
- **For us who don't have sewer or drains**
- **Need to make sure the fee system is fair**
- **No. This is the committee feeling guilty. Let's keep this a standard fee or none at all.**
- **Again, credits for residential areas would be helpful.**

Please turn over; More on back

5. Do you know of a problem area within town with respect to localized flooding or stormwater quality? If so provide a detailed description of the problem, the exact location to the best of your ability, and your contact information below in case we have follow-up questions.

- **No**
- **Roosevelt St. on the east side of the parkway, my house was flooded.**
- **Neff from Purcell to Williamson, NE Paula and areas of Williamson Park**
- **27th St. @ Country Sunset Mobile Homes – Dry wells flood**
- **Ridgewater II Development floods no curbs, no wells**
- **13th & Fresno, I think the City knows about this already**

Name: Phone:

Public Meeting Effectiveness

1. On a scale of 1 to 5 with 1 being excellent, and 5 being awful, please rank the following:

	Excellent	Awful	
Effectiveness of Presenter(s):	1 2 3 4 5		2.93
Clarity of Message During Presentation:	1 2 3 4 5		2.80
Clarity of Message During Question and Answer:	1 2 3 4 5		2.75
Logistics of the Facility:	1 2 3 4 5		2.00
Adequacy of Notification of Meeting:	1 2 3 4 5		1.87

- **Could this be presented on boards around the room? (message)**
- **Too much frantic explanations**
- **Hard to get here at 5:15 due to after work w/all the traffic in this area**

Your General Comments or Questions

- **The presenters tried to effectively answer some volatile issues and did a commendable job with difficult attendees**
- **Increase in population has apparently exacerbated existing problems, plus creating more. I don't care to be assessed without knowing the $4 may double in the near future. I don't have sewer (promised when we incorporated) or storm drains. When do I get payback? (Orion Dr.)**
- **I feel this is a good program that needs to be done.**
- **For an "open house" the presentation shouldn't start for 20-30 minutes after the start time. People need a chance to get here and read the info.**
- **Provide more timely notification.**
- **Too late now.**
- **We need more time for public comment. It seems like this is just being pushed through with only the minimum public involvement.**
- **As usual – too short of time to get feedback from neighbors (association members) by the June 6th council meeting – Crisis management is a waste of time! Advisory committee was given a take it or leave - - - option on short notice.**

2. Would you like a city staff member to contact you with a response?
☐ 5Yes ☐ 5No, I just wanted to provide the above comments.

If yes, how would you like to be contacted? ☐ 2Phone ☐ 4E-mail ☐ 1Mail

Your Name: ______________________

Address (including zip): ______________________

____

E-mail: ______________________ Daytime Phone #: ______________________

Thank you for your time and comments.

Please return to the City of Bend Public Works Department, Attention Wendy Edde 575 NE 15th Street, Bend, OR 97702; wedde@ci.bend.or.us; fax: 541-389-2245

Additional comments:

- **Grade school education:**
  - **"The Magic School Bus" series has an animated episode, a book and maybe a scholastic news leaflet regarding water and stormwater.**

- **If any of these improvements help meet a Bend 2030 Vision goal(s) it would be beneficial for the City Council and the general public to be made aware of that.**
- **How will commercial building be assessed?**
  - **I understand the ERU**
- **Commercial lots may already have dry wells**
  - **Are these taken into consideration?**
- **Drywell cleaning – private/public?**
  - **Who pays?**
  - **How regulated?**

CITY OF BEND
STORMWATER UTILITY FEE CITIZENS TASK FORCE

FINAL REPORT TO CITY MANAGER AND CITY COUNCIL
(May 2007)

Bend's Stormwater Utility Fee Citizens Task Force was formed by the City Council to provide direct stakeholder input to the design and implementation of a stormwater utility fee for the City. The Committee worked to understand stormwater related costs such as those mandated by the federal/state stormwater regulations referred to as the National Pollutant Discharge Elimination System (NPDES) Phase II, and examined the question of how to best approach a stormwater utility service charge. Bend is also required to comply with state DEQ standards related to Underground Injection Controls (UIC) that regulate drywells and drill holes.

Prior to formation of the Task Force, City staff began investigating how to effectively prepare for NPDES Phase II and UIC requirements, and how to address stormwater system problems that have been made evident by recent storms and citizen drainage complaints. The Integrated Stormwater Management Plan, which the Council adopted in December 2006, was developed in response to NPDES Phase II requirements, and will largely serve as the Stormwater Utility's stormwater quality work plan for the next several years. The needs identified in this comprehensive plan, and their associated costs, clearly exceeded existing funding sources, and the City needed to look at new funding approaches.

Bend needs to move forward with effective and proactive stormwater management, and there needs to be a commitment from the City to implement a funding structure. Toward that end, the Task Force, consultant and City staff have been meeting on a bi- or tri-weekly basis since February 2007 to learn more about issues related to effective stormwater management, and options for adequately funding the City's stormwater program. The Task Force identified the following as some of the problems/issues Bend faces in stormwater.

- The City's stormwater system is not being maintained on a preventative level. This has resulted in more flooding during smaller storm events. Repairs and replacements to the system - which are long overdue - are put on hold due to lack of funds;
- Bend is behind in building necessary capital facilities;
- Pollutants carried by stormwater to the Deschutes River are affecting water quality;
- The pace of new development and redevelopment is significant, and the City's ability to ensure that developers meet Bend stormwater regulations needs to also increase;
- The public needs to be an active partner in this program, and the City needs to better inform them regarding their role in stormwater quality; and
- Compliance with the NPDES regulations affecting stormwater quality and state UIC requirements affecting drywells and drill holes are immediate needs and a long-term expense.

Overlaying these needs is the fact that current funding for the stormwater program is through sporatic allocations from Bend's General, Street and Wastewater Funds, sources never intended for on-going stormwater support. This approach toward funding cannot provide the consistent level of stormwater management necessary to meet the needs discussed by the Task Force.

The bottom line is that Bend has attempted to support a full time need with part time funding sources. Not surprisingly, this approach has meant that most improvements have been deferred, and repair / replacement of the system is done only after system failure. These existing needs and the additional costs attributable to specific water quality regulations have made it necessary for the Committee to evaluate the best approach toward a stormwater utility rate structure.

It is important to note that the stormwater program developed through this process will go beyond mere compliance with state and federal regulatory requirements. Bend's program as proposed will target both regulatory compliance, and establish the program structure for long-term water quality and quantity enhancement and management of the City's stormwater system. This can only be achieved by a comprehensive program that maintains, monitors, enforces, improves, repairs, replaces, educates, and involves the public in stormwater management issues.

Many communities across the country have determined that the best blend of funding equity and ability to meet stormwater needs is the service charge or utility approach. Just as water and sewer systems are rate supported, the growing consensus is that stormwater systems can and should be funded through their own dedicated revenues.

Looking at different approaches to a stormwater utility service charge, and how a fee structure might be designed, has been the primary focus of the Task Force's efforts. Their conclusion is that the utility's service charge should be based on the extent of impervious (roofs, pavement, non-infiltrating areas) surface coverage of developed non-residential parcels within Bend, as well as on a flat fee for single family and duplex residential homes. The residential flat fee is set based on the mean amount of impervious surface coverage for single family and duplex residential homes in Bend.

The structure developed by the Task Force also considers provisions for a service charge credit in cases where existing on-site improvements exceed City standards and therefore reduce the City's costs in providing downstream stormwater facilities. This results in an equitable, understandable and accurate utility service charge that can support a full time program for meeting Bend's stormwater needs.

This process has also reflected the City's commitment to spend an increasing amount of time speaking to groups and individuals about the stormwater program's objectives. In addition to Task Force meetings, the City has prepared an informational flyer and billing stuffer mailed to every business and residence in Bend, a detailed website, and has conducted neighborhood meetings and provided information at community events about the program. At least one citywide newsletter article on the program is anticipated. The stormwater utility was featured as a March 2006 segment of City Edition, and City staff were interviewed on Good Morning Central Oregon television in April. The press has done a good job of covering this issue. Every reasonable effort has been made to inform the public about the importance of this new program, and about how stormwater affects the Deschutes River as it flows through Bend.

Summary of Task Force Conclusions:

- Bend has significant and largely unfunded needs in terms of stormwater quantity and quality management.

- Bend is required to comply with both federal NPDES Phase II and state UIC regulations.

- Bend has tremendous water resources and natural systems that are vital to the City's economic and quality of life standards. Stormwater is a key factor affecting these systems and should be managed into the future.

- The question is not "if" but "when" Bend begins to address these problems. The City's existing system is largely at or over its design capacity for very small storm events.

- The estimated size of the City's stormwater needs is a minimum of about $1,460,000 annually. These annual program requirements and costs are estimated to include: $521,000 for capital improvement projects (CIP); $286,500 for maintenance; $329,000 for water quality management; $110,000 for engineering and project management; $17,500 for public information; and $197,000 for city administration and indirect costs. If additional revenues are realized by the utility, then funds should be directed at the hotspot capital improvements such as the 3rd, Franklin, and Greenwood Street underpasses.

- Long term "fixes" to the City stormwater system require dedicated and consistent revenues in order to plan for and carry out maintenance and capital improvements.

- The primary funding approach should be a stormwater utility service charge.

- A separate utility is the preferred structure for the funding program because by law, the revenues generated by the utility fee will be dedicated to stormwater management, and the rate can be related to a customer's estimated use or contribution of runoff to the stormwater system.

- The appropriate basis of the service charge should be measured impervious surface coverage because it is consistent and most closely related to runoff factors. It is also reasonable to apply a uniform rate of one equivalent residential unit (ERU) to single-family/duplex residences.

- At this time, all public and private streets should be considered part of the stormwater conveyance facility system and will not be included in impervious surface calculations. The City should revisit this upon completion of the Stormwater Master Plan and make any modifications as appropriate thereafter.

- Based on a representative sampling of homes in Bend, the average amount of impervious surface for a single-family/duplex residence is approximately 3,800 square feet.

- Based on a very preliminary estimate of total impervious coverage, the rate per month per ERU would be about $4.00 to meet the annual rate revenue requirement.

- There should be a credit procedure available to non-residential stormwater customers. The credit should be structured to reflect the degree to which constructed facilities or BMP's exceed current standards, and therefore provide a benefit to the utility. In the likelihood that City staff will need additional time to set up and implement the credit program, the CTF recommended that the City begin accepting applications on July 1, but tell the applicants that it may take up to120 days to act on the applications. If the City approves the credits, they would be retroactive to the date that the City received a complete application.

Issues Raised About These Recommendations:

- One CTF member is concerned about the timing of the service charge. The member felt that it would be better if it was initiated during the rainy season when people were more sensitive to drainage problems. The member also felt that delaying implementation for 6 months would allow businesses to take the new charges into account in their budgets. [The CTF in general felt that it is important to start the service charge in July because stormwater is no longer in the General Fund budget.]

- One CTF member felt that the City has not done a good enough job of explaining why, if stormwater is currently funded by the General Fund, there would not be a decrease in taxes as a result of this change. The stormwater budget in 2006-07 was $399,500 from the General Fund. This did not come close to meeting the City's stormwater needs. Shifting stormwater out of the General Fund frees up the General Fund for critical public safety services such as fire and police. This also allows the City for the first time to accurately track true stormwater costs so it can better budget and plan for the future. As a dedicated fund, the revenues from the stormwater service charge could only be used for stormwater work, allowing for better public oversight.