**TECHNICAL MEMORANDUM**

MWH

# TM 3.1 – Planning Criteria

**To:** Heidi Lansdowne, P.E.
City of Bend, Oregon
Engineering Division

**Date:** Final – March 14, 2007

**From:** R. Dale Richwine, P.E. - MWH

**Prepared By:** Dale Richwine - MWH

**Reviewed By:** City of Bend Staff
Signatures Below

**Copies:** Paul Rheault – Bend
Michael Magee – Bend
Gordon Merseth – CaMES

**Confirmation and agreement with the planning criteria and assumptions is critical for the successful completion of this project. A check box has been provided next to the header of each planning assumption documented in the TM. Initial the box next to each planning assumption if you agree with the criteria/assumption.**

**Following review of the TM, please sign in the appropriate signature block below to show your agreement with the assumptions that have been checked.**

Ken Fuller _____

Mike Miller _____

Michael Magee _____

Heidi Lansdowne _____

Paul Rheault _____

Dave Lee _____

Brian Shetterly _____

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## INTRODUCTION

It is important to have a complete understanding of the planning assumptions that will be used during the planning process early in the project. This Technical Memorandum (TM) provides a summary of the planning assumptions that will be used to develop population projections and flows in the Collection System Master Plan.

## PLANNING AREA

The planning area for this project will consist of the areas defined in the 1998 Bend Area General Plan (plus approved updates since that time). The General Plan provides two areas for planning. The first area is bounded by the City Limits (or Urban Growth Boundary, UGB) and the second area is the Urban Reserve Area (UAR). The planning area provided by the General Plan is shown in ***Figure 1***. Both of these areas plus three other areas: Juniper Ridge, Section 11 and a west side destination resort known as "Cascade Highlands" will be included in the Master Plan.

**_____City Limits**

The City Limits is shown in ***Figure 1*** as the area within the Urban Growth Boundary. The City has provided information in GIS for the evaluation of each parcel (Tax lot) within this area. This area will be defined as the City Limits in the Master Plan.

Lava Ridge Refinement Plan

Medical District Overlay Zone

Northwest Crossing Refinement Plan

Dean Swift Refinement Plan

NOTE: Area covered by Awbrey Butte Master Plan

T17S

T18S

# BEND URBAN AREA GENERAL PLAN

**LEGEND**

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

- CB- CENTRAL BUSINESS DISTRICT
- CC- COMMERCIAL CONVENIENCE
- CG- COMMERCIAL GENERAL
- CL- COMMERCIAL LIMITED
- IG- INDUSTRIAL GENERAL
- IL- INDUSTRIAL LIGHT
- IP- INDUSTRIAL PARK
- ME- MIXED EMPLOYMENT
- MR- MIXED RIVERFRONT
- PF- PUBLIC FACILITIES
- PO- PROFESSIONAL OFFICE
- PO/RM/RS
- RH- RESIDENTIAL URBAN HIGH DENSITY
- RL- RESIDENTIAL URBAN LOW DENSITY
- RM- RESIDENTIAL URBAN MEDIUM DENSITY
- RS- RESIDENTIAL URBAN STANDARD DENSITY
- SM- SURFACE MINING
- UAR- URBAN AREA RESERVE

BEND OREGON 1905

N

0 1,300 2,600 5,200 Feet

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

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

### _____Urban Reserve Area

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

### _____Juniper Ridge Area

The Juniper Ridge Concept Plan specifies approximately 1500 acres on the north end of the City planned for light industrial, research and residential development. Phase 1 of the project will be approximately 500 acres slated for light industrial and research. Phase II includes over 1,000 acres of land that is planned for a mix of residential, commercial, industrial and institutional development. This development is outside of the 1998 General Planning Area, but will be included in the planning area for the Collection System Master Plan. It is assumed that in addition to the 1,500 acre Juniper Ridge Area, adjacent lands bounded by US 97 on the west, Deschutes Market Road on the east and Deschutes Junction / Tumalo Road on the north will be included in a UGB expansion (Per Jerry Mitchell – City of Bend Development Manager, April 6, 2006).

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

### _____Section 11

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

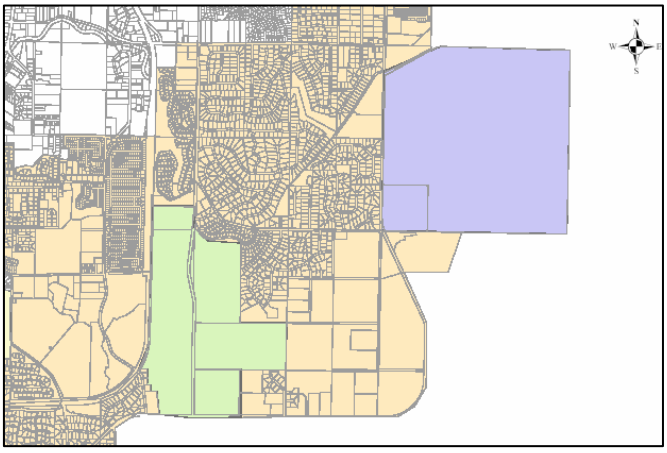

Figure 2 – Section 11

A recent communication from Mike Miller (3/10/2006) assumes that this area will contain a mixture of residential land use that includes 1713 single family dwellings at a density of 5 dwelling units(DU)/acre, 406 duplexes, triplexes or four-plexes at a density of 12 DU/acre and 517 apartments in 5 or more units at a density of 22 DU/acre for a total of 2636 DU. There will also be parks, schools and other commercial properties. The area is currently assumed to have a build-out population of 6327.

This will be the information used to develop flows for this area. There is currently no information on when this area is planned to be developed.

### _____Cascade Highlands

There is currently a destination resort being planned on the west side of the City. The parcel for this area will be included in the Collection System Master Plan.

The Cascade Highlands resort property includes approximately 706 acres of unique topography with rolling and undulating terrain. Experience suggests build-out of the Cascade Highlands Destination Resort will occur over the next 10-20 years

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

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

### _____Study Areas

The Planning Area defined above has been divided into nine study areas. These Study Areas are shown in ***Figure 3***. The Collection System Master Plan will include a local plan of the trunk sewers required, pipe sizing, pipe depth and costs to eliminate deficiencies and provide sewer service to each of the Study Areas. Statistics for each study area are shown in ***Table 1***.

Table 1
2006 Collection System Master Plan
Study Area Characteristics
Served and Unserved Parcels

| Study Area | Study Area (Acres) | Areas Within the UGB | | | | | |
|---|---|---|---|---|---|---|---|
| | | Parcels Served | | Parcels Not Served | | Developed but Unserved | |
| | | Number | Acres | Number | Acres | Number | Acres |
| **1** | 1359 | 19 | 35.58 | 112 | 339.40 | 2 | 30 |
| **2** | 4927 | 4714 | 1969.85 | 1534 | 1423.32 | 135 | 45 |
| **3** | 3919 | 1948 | 823.91 | 1201 | 1418.33 | 400 | 166 |
| **4** | 4624 | 215 | 95.64 | 231 | 311.28 | 158 | 186 |
| **5** | 2186 | 1636 | 807.02 | 968 | 927.06 | 267 | 285 |
| **6** | 1217 | 2212 | 610.28 | 836 | 222.86 | 273 | 27.85 |
| **7** | 3941 | 1484 | 950.00 | 1955 | 1836.00 | 1475 | 938 |
| **8** | 3925 | 3061 | 1013.44 | 2217 | 1909.00 | 1013 | 727.57 |
| **9** | 3853 | 5256 | 1748.18 | 1147 | 1100.78 | 523 | 397 |
| **Total** | **29,953** | **20,545** | **8353.89** | **10,201** | **9488.02** | **4246** | **2802.42** |

Note: Data based on May 2005 City of Bend Planning and Financial information.

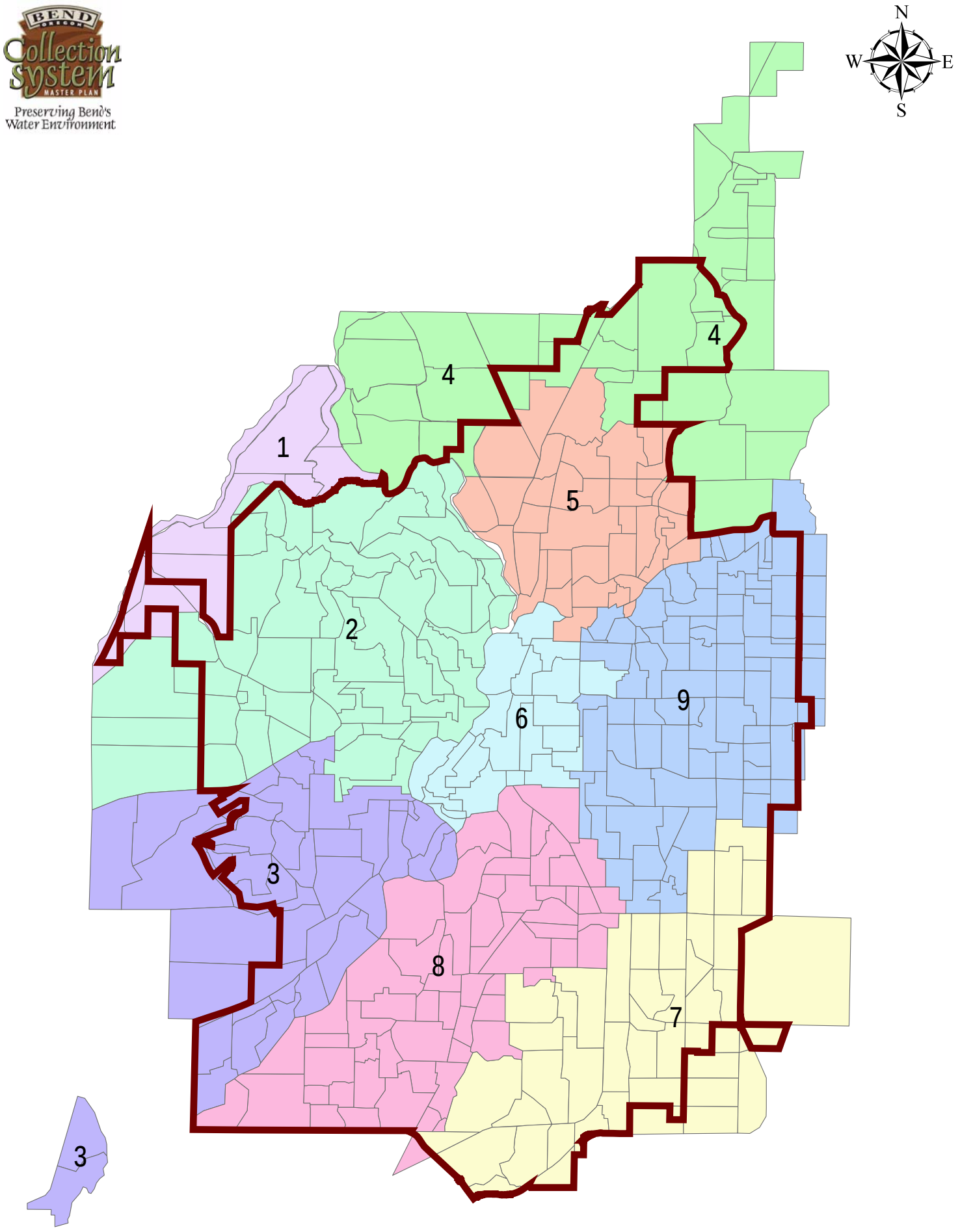


FIGURE 3
PLANNING STUDY AREAS

# HYDRAULIC LIMITATIONS

The hydraulic limitations define the capacity of the collection system gravity sewers, force mains and pump stations. The following criteria will be used to define the capacity of the system.

### _____Gravity Sewer Dry Weather Design Criteria

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

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

It should be noted that the d/D of 0.80 that will be used for the gravity sewer capacity is the maximum velocity for a gravity sewer. As the depth of flow in the gravity sewer gets greater than a d/D of 0.80, the velocity in the sewer is restricted by the greater headloss due to the increased wetted diameter. This is shown in ***Figure 4***.

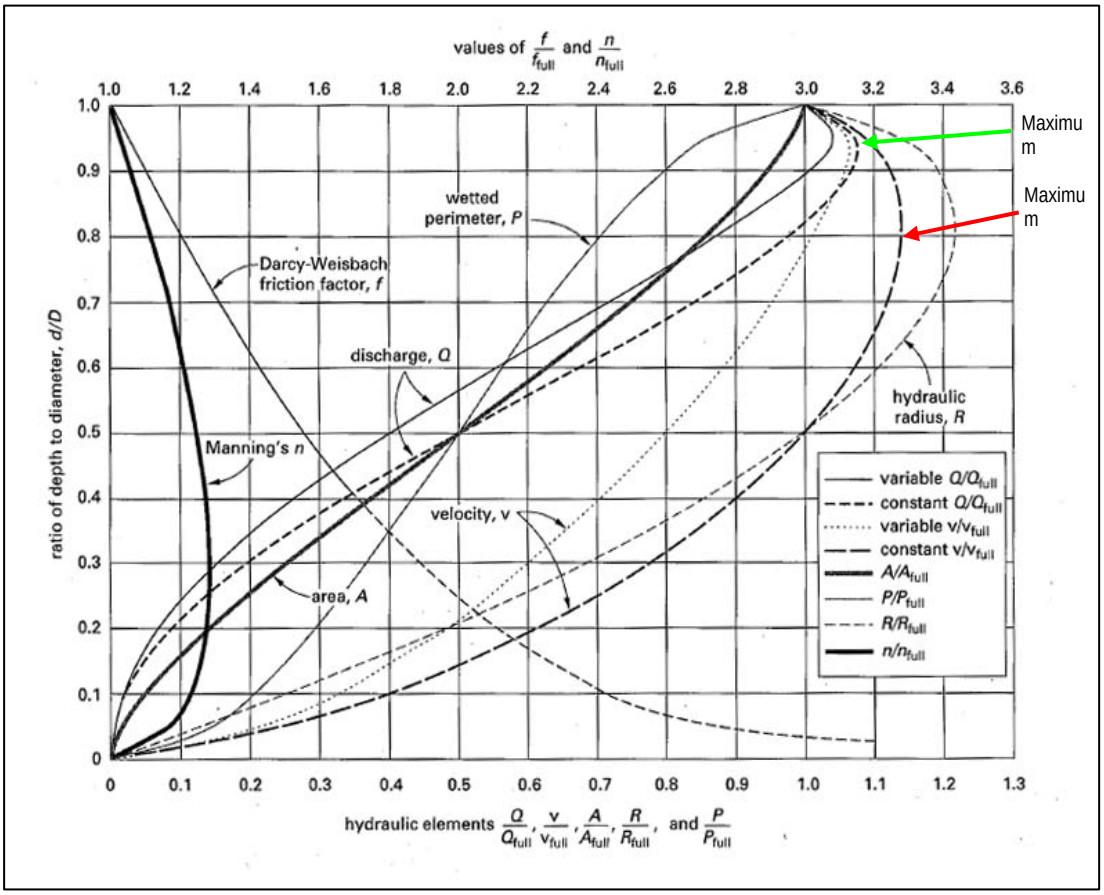


Figure 4 – Hydraulic Elements Graph for Circular Sewers

### _____Gravity Sewer Wet Weather Design Criteria

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

### _____Force Main Design Criteria

A friction value of 0.013 (n=0.013) will be used for all force mains to define flow conditions for all existing and future sewers.

The maximum flow velocity that will be allowed in a force main under operating conditions under the firm capacity of the pump station (redundant pump out of service) will be 6 feet per second (fps) . The maximum flow velocity shall not exceed 10 fps with all pumps in service.

### _____Pump Station Design Criteria

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

## LAND USE INFORMATION

The first step in developing model flows will be to utilize the LANDUSE classification provided by the City to determine what is currently on each parcel. It is our understanding that the LANDUSE was based upon the Property Classification and Factor Book Codes in the assessor's database. Therefore, it should represent an accurate description of what is currently on the parcel.

### _____Basis for Determination of Sewered Properties

It will be assumed that parcels labeled Unbuildable or Vacant do not currently contribute wastewater flow to the collection system. Additionally, it will be assumed that parcels labeled Recreational (primarily parks and golf courses) can be ignored for purposes of wastewater flow generation because their wastewater flow contributions are minor in comparison to their size (acreage) except for Bend Country Club which will be assumed to be able to be redeveloped. Generally golf courses within a platted subdivision will be assumed to remain as is.

Areas designated ASI (areas of special interest) will be assumed to develop to the same level of densitiy as their zoning classification.

Sewer Service Codes and the Service Status information provided with the billing data were used to determine which of the remaining parcels currently have sewer service. Based on a discussion with the City's Finance Department, the Service Codes shown in ***Table 2*** were determined to represent sewered parcels.

## Residential Land Use Densities

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

Table 2
City of Bend Sewer Service Codes

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

The average densities shown in ***Table 3*** will be applied to residential parcels within the UGB on a net acre basis to determine the number of dwelling units for flow generation calculations for vacant parcels and those parcels considered to be large enough to subdivide. These values reflect the average densities per net acre for residential housing construction over the last 6 years, as inventoried by the City of Bend Planning Department.

Table 3
City of Bend
City of Bend Inventoried Residential Densities per Net Acres

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

Dwelling unit density for all areas outside the UGB and within the UAR will be based on the average residential density for RS zoning on a net acre basis except for those parcels in Juniper Ridge, Section 11 and Cascade Highlands where master plans for those areas provide more detailed land use density information The density of 5.3 DU/acre represents an estimate of the projected average density for the UAR assuming a blend of RL, RS, RM, RH as well as commercial, industrial and mixed use areas.

## Dwelling Unit Population

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

## Actual vs. Net Acres

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

the City, a 0.7 factor for converting actual acres to developed acres has been recommended by the City of Bend Planning Department.

This factor will be applied to all residential parcels that meet the criteria for being large enough for further development. Parcels large enough to be redeveloped include: undeveloped areas greater than 0.5 acres and developed parcels greater than one acre. These rules are summarized in ***Table 4***. Developed parcels less than one acre will be assigned the dwelling units actually existing on the parcel.

Table 4
Actual Vs. Net Acre Factors

| Developed Status | Factor |
|---|---|
| Not Developed > 0.5 Acres | 0.7 |
| Not Developed ≤ 0.5 Acres | 1.0 |
| Developed > 1.0 Acres | 0.7 |
| Developed ≤ 1.0 Acres | 1.0 |

## POPULATION PROJECTION BASE

The population projections used for the Collection System Master Plan will be based on the estimated 2005 population. Population growth will then be projected based on the population projections developed in the Deschutes County Coordinated Population Forecast 2000 – 2025 (August 25, 2004). The build-out population will be based on building out the area of study under the GENPLAN zoning conditions.

### 2005 Population

The 2005 base population used for this study will be the recently announced July 1, 2005 Certified Population Estimate for the City of Bend UGB produced by Portland State University Population Research Center. This estimated population is 70,330.

This estimate is different than the previous estimated 2005 population of 69,004.

### Population Growth Rates

The City of Bend in cooperation with Deschutes County has been working to develop population projections that can be used in long-term planning for the City. The most recent work that provides population projections is the Deschutes County Coordinated Population Forecast 2000 – 2025 (August 25, 2004). In this report, the population projections for the City of Bend UGB summarized. These projections and the applicable growth rates are shown in ***Table 5***.

Table 5
Population Forecast For Bend UGB

| Year | Population | Annual Growth Rate |
|---|---|---|
| 2000 | 52,800 | - |
| 2005 | 69,004 | 4.74% |
| 2010 | 81,242 | 2.52% |
| 2015 | 91,158 | 2.33% |
| 2020 | 100,646 | 2.00% |
| 2025 | 109,389 | 1.68% |
| 2030 | 119,009 | 1.70% |

**NOTES:**
1) Population forecast based on State of Oregon Office of Economic Analysis.
2) The actual 2005 certified population for the City of Bend is 70,330.
3) Average Annual Growth Rate (AAGR) since 1990 has averaged 5.33%

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

### 2030 Planning Horizon

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

### Build-out Condition

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

### Population Growth in Study Areas

One critical element in this planning effort that will be required to determine the timing of projects is to have an understanding of when and where development and population growth will occur. The City of Bend is in the process of evaluating future areas for expansion of the UGB. Decisions on where those expansions will take place are unlikely before the end of 2006. The TAZ planning assumptions that have previously been used may not be consistent with the ability of the City to provide water and wastewater service to the planned growth areas.

Due to the uncertainty at this time of where growth will occur, the population growth for the City of Bend will be distributed equally throughout each of the study areas. The population projection model that will be used will have the capability to alter this growth distribution to provide an opportunity to perform a sensitivity analysis.

# POPULATION PROJECTION DEVELOPMENT

The populations will be developed at the parcel-level based on parcel-level information. This will provide the most accurate representation of flows entering the collection system and allows greater flexibility during modeling of the system. Population projections will be developed as follows.

### _____Population Projections for Residential Parcels

The process for determining population from currently sewered parcels will be as follows. The number of dwelling units on each residential parcel will be developed based on its zoning type. The average residential density (***Table 3***) will be multiplied by the number of net acres available on the parcel. The result will be the number of dwelling units on each parcel. The number of dwelling units will then be multiplied by the dwelling unit population of 2.5 to get the build-out population for the parcel.

# FLOW FACTORS

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

### _____Residential Flow Factors

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

### _____Non-residential Flow Factors

For non-residential parcels, the database of winter-quarter average water consumption for Sewer Service codes SO and SM was evaluated to determine initial gpd/acre flow factors. The database was sorted using the LANDUSE field and then a flow factor calculated for each LANDUSE category by dividing the total average consumption by the total acreage. The results of these initial calculations are shown in ***Table 6***.

Table 6
City of Bend
Initial Non-Residential Flow Factors

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

## Seasonal Occupancy Calibration Factors

The occupancy calibration factor was developed to provide a reduced flow for areas that have seasonal homes. These areas were identified by City staff when the calibration of the model was performed. The occupancy calibration factors were developed to obtain model calibration with the flow monitors that were placed in the system in early February 2005. Twenty-two flow monitors were placed in the system. Monitor No. 1 was in the main line to the treatment plant and was not specific to an area of the City. The other monitors and the corresponding occupancy calibration factors are shown in ***Table 7***.

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

Table 7
Residential Unit Flow Factors for Seasonal Occupancy Levels

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

### Seasonal Peaking

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

To determine a peaking factor for the summertime peak weekend, plant influent data for the years 1993 through 2004 were evaluated. This analysis is summarized on ***Table 8***. The maximum peaking factor occurred in 1996. This was due to a 2.6-inch rainfall when inflow was at a maximum. The peaking factor typically ranges from 1.10 to 1.23 depending on the year. As a conservative measure, it is recommended that a summertime peak day peaking factor of 1.25 be applied to the wintertime weekday base flow to obtain the peak day flow.

### Infiltration/Inflow Allowance

It has become apparent in the past year that there are periods when wet weather rainfall events will have a significant affect on the flows in the system. Because of this, some type of Infiltration/Inflow (I/I) allowance needs to be evaluated. The Oregon Administrative Rules specify design conditions in the bacteria standard as the 10-year, 24-hour summer storm and the 5-year, 24-hour winter storm. This criterion works well on the western slopes of the Cascades, but is not applicable to the high desert. This issue was discussed with Dick Nichols of the Oregon Department of Environmental Quality (DEQ). The opinion of DEQ is that there needs to be protection of property and no overflows to the Deschutes River unless there is an unusual event, such as the December 30, 2005 storm event.

An analysis for I/I will take a considerable effort and time to measure and identify flows due to I/I in the system. The time to perform a study such as this is not available within the schedule of this planning effort. Therefore, a simplified rational will be applied for I/I.

It has been shown during multiple rain events that the plant will currently see a peak flow of approximately 4-mgd following a significant storm event. The peak will last about as long as the storm event signifying that the problem is inflow. A hydrograph will be developed for all pump station basins that showed a significant increase in run-times during the December 30, 2005 rain event and the downtown area. The hydrograph will be calibrated to provide a system flow of 4-mgd at the treatment plant.

The collection system will be evaluated using the summer season peak flow at the diurnal peak to meet the 0.8 d/D factor. The system capacity will then be checked using the wet weather event to determine if there are any problems in the modeled pump stations or if there are any overflows in the system. The collection system capacity will then be modified to meet the flows created by this wet weather event.

Table 8
Bend WWTP
Influent Data Analysis--flow, mgd
1993 - 2004

| Statistic | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual Total | 1181.3 | 1164.5 | 1222.1 | 1278.4 | 1322.8 | 1391.2 | 1453.6 | 1571.0 | 1553.9 | 1604.1 | 1699.20 | 1839.03 |
| Max | 4.05 | 4.31 | 3.98 | 5.78 | 4.31 | 4.85 | 4.74 | 4.98 | 5.05 | 5.08 | 5.09 | 6.16 |
| Min | 2.51 | 2.55 | 2.60 | 2.39 | 2.69 | 3.15 | 3.26 | 3.59 | 3.70 | 3.50 | 3.82 | 4.09 |
| Mean | 3.24 | 3.19 | 3.35 | 3.49 | 3.62 | 3.82 | 3.98 | 4.29 | 4.26 | 4.41 | 4.66 | 5.02 |
| Median | 3.23 | 3.15 | 3.34 | 3.49 | 3.60 | 3.78 | 3.95 | 4.31 | 4.27 | 4.41 | 4.66 | 5.00 |
| 90 Percentile | 3.45 | 3.53 | 3.61 | 3.71 | 3.92 | 4.16 | 4.35 | 4.53 | 4.51 | 4.77 | 4.92 | 5.36 |
| 92 Percentile | 3.49 | 3.57 | 3.65 | 3.75 | 3.94 | 4.20 | 4.37 | 4.56 | 4.56 | 4.80 | 4.96 | 5.39 |
| 98 Percentile | 3.68 | 3.76 | 3.76 | 4.10 | 4.05 | 4.37 | 4.49 | 4.67 | 4.68 | 4.96 | 5.03 | 5.58 |
| Std. Dev. | 0.19 | 0.27 | 0.20 | 0.27 | 0.22 | 0.25 | 0.25 | 0.21 | 0.21 | 0.28 | 0.22 | 0.26 |
| Count | 365 | 365 | 365 | 366 | 365 | 364 | 365 | 366 | 365 | 364 | 365 | 366 |
| Peaking factor | 1.25 | 1.35 | 1.19 | 1.65 | 1.19 | 1.27 | 1.19 | 1.16 | 1.19 | 1.15 | 1.09 | 1.23 |

**Notes:**

1. Peaking factor is maximum daily flow / average daily flow.
2. 1996 was a unique year due to the high one-time flow due to storm drainage on Nov. 18 with a 2.6-in rainfall.
3. The most recent daily peaking for 2004 was 1.23.
4. Conservative daily peaking factor would be 1.25.

# FLOW CALCULATIONS

Calculating wastewater flows based on parcel-level information provides the most accurate representation of flows entering a collection system, and allows greater flexibility when modeling the system. All flows used in the analysis will be parcel-level based on the zoning information outlined in the City's General Plan (inside the UGB) and the type of structures on each tax lot based on the City's Residential Land Survey.

Flow analysis for parcels within the UAR will be based on a conservative assumption that all of the development will be residential and development will occur at the average density of 5.3 DU/acre.

The following sections describe the methodology for developing flows for parcels both inside and outside of the UGB.

## Flow Development for Parcels Inside the UGB

Flow development for parcels inside the UGB includes three categories:

- Flow Development for Sewered Parcels
- Flow Development for Vacant Parcels
- Flow Development for Developed Uunsewered Parcels

The flow development for each of the categories is described below.

### Flow Development for Sewered Parcels

Sewered parcels can be either residential or commercial. The flow development for each type of parcel is described below.

#### _____Sewered Residential Parcels

For Residential (Single-family) and Multi-family Residential parcels, the number of dwelling units on each residential parcel, as identified in the Residential Land Survey, will be used unless it is determined that the parcel can be subdivided based on the criteria specified in ***Table 3***.

In the first case for a Residential (Single-family) parcel, the actual number of dwelling units (DU) on each parcel will be multiplied by the flow factor (gallons per day/dwelling unit (gpd/DU)). An example of the equation used to determine residential flows in each parcel is as follows:

$$Flow_{Parcel} = DU * Flow\ Factor\ (gpd/DU)$$

So, assuming there are 4 DU's on a parcel and a flow factor of 200-gpd/DU, the average residential flow from that particular parcel would be 800-gpd.

This parcel flow will then be multiplied by the occupancy calibration factor (from ***Table 7***) developed for each specific flow monitoring area. The result will be the average flow from the specific parcel. Therefore, in the example above, using an occupancy calibration factor of 0.8, the parcel flow of 800-gpd would be multiplied by an occupancy factor resulting in an average flow for the parcel of 640-gpd.

In the second case for a Multi-family Residential parcel, the actual number of multi-family dwelling units (DU) on each parcel will be multiplied by the flow factor (gallons per day/dwelling unit (gpd/DU)). An example of the equation used to determine residential flows in each parcel is as follows:

$$Flow_{Parcel} = DU * Flow\ Factor\ (gpd/DU)$$

So, assuming there are 12 multi-family DU's on a parcel and a multi-family flow factor of 180-gpd/DU, the average residential flow from that particular parcel would be 2160-gpd.

This parcel flow will then be multiplied by the occupancy calibration factor (from ***Table 7***) developed for each specific flow monitoring area. The result will be the average flow from the specific parcel. Therefore, in the example above, using an occupancy calibration factor of 0.9, the parcel flow of 2160-gpd would be multiplied by an occupancy factor resulting in an average flow for the parcel of 1944-gpd.

**_____Sewered Commercial, Industrial, Public Parcels**

For Commercial, Industrial, Public, and Other Improved classifications shown in ***Table 6***, the parcel size (total acres) is multiplied by the appropriate flow factor (gpd/acre) to determine the wastewater flow from each parcel. It has been assumed that all commercial, industrial and public facilities will not be rezoned in the future. An example of the equation used to determine flows from these parcels is as follows:

$$Flow_{Parcel} = Total\ Acreage_{Parcel} * Flow\ Factor\ (gpd/acre)$$

As shown in ***Table 6***, a commercial parcel flow factor of 1300-gpd/acre would be used. Then for a parcel of 15 acres and using the commercial flow factor, the flow for the parcel would be 19,500-gpd. No seasonal occupancy factor or gross to net acreage factors will be used on commercial, industrial or public acreage.

**Flow Development for Unsewered Parcels**

Unsewered parcels can be either residential, commercial, industrial or a public facility. The flow development for each type of vacant parcel is described below.

**_____Vacant Residential Parcels**

It is necessary to develop flows for vacant parcels to perform projections of growth impacts in the future. The wastewater flow for vacant parcels will use the zoning classification for the parcel specified in the approved General Plan. The density as shown in ***Table 3*** will be applied

to residential parcels to determine the number of dwelling units for flow generation. The area used will be the "net acreage" as defined in ***Table 4***. An example of the equation used to determine residential flows in each parcel is as follows:

$$Flow_{Parcel} = Net\ Acreage_{Parcel} * DU/acre * Flow\ Factor\ (gpd/acre)$$

Assuming there is a 20 acre parcel and it is zoned for Residential Standard Density (RS), then the density of 5.3 DU/acre will be used to determine the number of parcels. Net acres of 14 acres (0.7 x 20 acres) will be used. Using the residential flow factor of 200-gpd/DU, the average residential flow from that particular parcel would be 14,840-gpd.

This parcel flow will then be multiplied by the occupancy calibration factor developed for each specific flow monitoring area. The result will be the average flow from the specific parcel. Therefore, in the example above, using an occupancy calibration factor of 1.0, the parcel flow of 14,840-gpd would be multiplied by an occupancy factor resulting in an average flow for the parcel of 14,840-gpd.

**_____Vacant Commercial, Industrial, Public Parcels**

For Vacant Commercial, Industrial, Public, and Other Improved classifications shown in ***Table 6***, the parcel size (actual total acres) is multiplied by the appropriate flow factor (gpd/acre) to determine the wastewater flow from each parcel. An example of the equation used to determine flows from these parcels is as follows:

$$Flow_{Parcel} = Total\ Acreage_{Parcel} * Flow\ Factor\ (gpd/acre)$$

As shown in ***Table 6***, an industrial parcel flow factor of 700 gpd/acre will be used. Then for a parcel of 25 acres and using the average industrial flow, the flow for the parcel would be 17,500-gpd.

**_____Flow Development for Developed Unsewered Parcels**

The wastewater flows for parcels that are currently developed, but unsewered, will be developed using the following approach. For Residential (Single-family) and Multi-family Residential parcels, the number of dwelling units on each residential parcel, as identified in the Residential Land Survey, will be used if the parcel is less than 1 acre in size.

If the parcel is greater than one acre in size, the number of dwelling units (DU) on each parcel will be calculated based on the net acreage of the parcel (0.7 * Total Acreage) multiplied by the DU density that corresponds to the parcel zoning.

To obtain the flow for the parcel, the number of DU will then be multiplied by the calibrated flow factor (gallons per day/dwelling unit (gpd/DU)) that corresponds to the parcel zoning. An example of the equation used to determine residential flows in each parcel is as follows:

$$Flow_{Parcel} = DU * Flow\ Factor\ (gpd/DU)$$

So, assuming there are 4 DU's on a parcel that is less than 1 acre in size and a flow factor of 200-gpd/DU, the average residential flow from that particular parcel would be 800-gpd. This therefore assumes that there will be no increase in flows from this parcel.

This parcel flow will then be multiplied by the occupancy calibration factor developed for each specific flow monitoring area. The result will be the average flow from the specific parcel. Therefore, in the example above, using an occupancy calibration factor of 0.8, the parcel flow of 800-gpd would be multiplied by an occupancy factor resulting in an average flow for the parcel of 640-gpd.

#### _____ Timing of Connection of Currently Developed Unsewered Parcels

The statistics that have been developed for the City of Bend UGB shows that there are currently 4246 parcels that are developed that are currently not being served by the City's sewer system. This means that these developed parcels are on septic tanks. As septic tanks fail in the area, many of these parcels will need to be connected to the sewer system. There is much uncertainty in knowing exactly when these parcels will be connected, but some assumption needs to be made to ensure that the planning is appropriate to provide capacity for these residents when they want to connect to the system. Therefore, the following assumptions will be made for the connection of currently developed but unsewered parcels within each of the study areas in the existing UGB:

- Assume 35% in each area by 2011
- Assume 70% in each area by 2016
- Assume 100% in each area by 2021

This assumption assumes that all 4246 parcel that are currently unsewered will be connected to the sanitary system by 2021.

### Flow Development for Parcels Outside the UGB

There are 8358 acres in the UAR that is being considered in the Master Plan. All flows that have been developed for the UAR has been assumed to be residential parcels. This is because there is currently no planning information to refine this assumption. The assumption that all of the areas will be developed as residential is conservative, and will ensure that the trunk systems that are being planned are of adequate size. The sizing of the local systems can be developed when each specific parcel is developed. The flow development for each parcel was done using the methodology described below for a vacant residential parcel.

#### _____Vacant Residential Parcels

The wastewater flow for each vacant parcel will be developed by determining the number of DU that can potentially be developed on the parcel and then a flow factor will be applied. The average residential density of 5.3 DU/acre will be applied to each parcel to determine the number of dwelling units for flow generation. The area used will be the "net acreage" based on a factor of 0.7. An example of the equation used to determine residential flows in each parcel is as follows:

$$Flow_{Parcel} = Net\ Acreage_{Parcel} * DU/acre * Flow\ Factor\ (gpd/acre)$$

Assuming there is a 550 acre parcel, then the density of 5.3 DU/net acre will be used to determine the number of dwelling units. 385 net acres (0.7 x 550 acres) will be used. Using the residential flow factor of 200-gpd/DU, the average residential flow from that particular parcel would be 408,100-gpd.

No occupancy factor was applied to parcels in the UAR. This was done to ensure that the flow estimates would be conservative.

### _____Cascade Highlands, Juniper Ridge Development and Section 11

The flow development for Cascade Highlands, Juniper Ridge Development and the proposed development in Section 11 is based on specific estimated zoning and planning information specific to each development. (See sections on each development earlier in TM)

## DIURNAL CURVES

The system capacity is determined by the peak system flow. For the City, the peak flow is the diurnal flow peak on a weekend. The diurnal curves that will be applied are described below.

### _____Diurnal Curves

The specific diurnal curve needs to be applied to develop the peak flow in the system. A typical residential weekday and weekend residential diurnal curve was developed from the flow monitoring data taken in areas of the City that are predominately residential. In addition, a combination residential/commercial diurnal curve was developed to accommodate sub-basins within the City that consisted of a combined land use. These curves have been normalized (i.e., an average flow value of one over 24 hours) so their values can be used as multipliers on the base flow value being loaded into the model. The diurnal curves developed during Task 1 of the planning work will be used during the Master Plan.