Appendix C

Model Assumptions

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C.1 Introduction

An important part of the City's update to the sewer master plan was to update the City's sewer model. It is important to understand that there are many acceptable ways to develop a sewer model. A hydraulic model of a sewer system is based on assumptions that characterize the area and system under study. The assumptions used in a model are typically based on flow monitoring, learned characteristics of the system, and a general knowledge of sewer flow characteristics gained through past experience with monitoring flows and modeling other sewer systems. Our review and updates to the existing model assumptions were based on discussions with City staff as well as our modeling philosophy, and past experience.

C.2 Model Assumptions and Changes

This section summarizes the assumptions and changes made to the original model.

C.2.1 System Layer

Parameter: Manning's "n"

Discussion: The roughness factor used in the Manning's formula $Q = (1.49/n)AR^{2/3}S_o^{1/2}$. The Manning's formula relates flow in a pipe with the depth of flow, diameter of the pipe and the slope of the pipe. Typical "n" values range from 0.009 for very smooth glass or new plastic to greater than 0.016 for unfinished concrete. For sewer pipes, however, a slime layer develops on any sewer material in contact with sewage and provides relatively consistent roughness regardless of material.

ASCE Manual No. 60 "Gravity Sanitary Sewer: Design and Construction" provides a table of recommended Manning's "n" values based on size and condition. For pipes installed and maintained with 'extra care' they suggest a Manning's "n" range from 0.0092 to 0.0107 for sizes 6" to 60" respectively. For 'typical' installations Manning's "n" range from 0.0106 to 0.0123 for sizes 6" to 60" respectively. For 'substandard' installations Manning's "n" range from 0.0120 to 0.0139 for sizes 6" to 60" respectively.

The WDOE Criteria for Sewage Works Design (C1-4.3) suggests using a Manning's "n" value of 0.013 for the design of all sewer facilities regardless of pipe material.

Model Assumption: Use a Manning's "n" of 0.012 regardless of material, size and age.

Parameter: Design Pipe Sizing Methodology (for future pipes)

Discussion: This parameter is used to size future pipes. The maximum depth of flow/diameter of pipe (d/D) is an indicator of how much of the pipe capacity is being used. When the flow in a pipe reaches the point where the d/D ratio is greater than the maximum d/D ratio, the pipe diameter will increase to the next size. Flows from the Master Plan will be used to size future sewer lines. These flows will also include a rainfall event.

We have used a graduated scale for maximum d/D dependent on the size of the pipe. The scale originated with the ASCE Manual "Design and Construction of Sanitary Sewers," which recommended master planning sewer systems at a d/D of less than 0.5 for sewers less than 18 inches in diameter and 0.75 for larger sewers. This allows for a larger safety factor for smaller sewers where variations in land use and extensions of the service area can have large impacts on the available capacity of the sewer. The larger sewer lines have a smaller safety factor because variations in land use tend to balance out over the larger area served by the large sewer.

Model Assumption: Use a graduated scale for the maximum d/D as listed in **Table C-1** below:

Table C-1 - Depth Over Diameter Ratios for Design Pipes

Size	d/D	Resultant Safety Factor
8"	0.50	2.00
10"	0.55	1.71
12"	0.60	1.49
15"	0.65	1.32
18" to 30"	0.75	1.10
≥36"	0.85	1.09

Parameter: Design Pipe Slope Determination

Discussion: The Ten State Standards list the minimum pipe slope for sizes 8-inches to 21-inches. For pipes larger than 21-inches, a slope of 0.10% was maintained because slopes smaller than 0.10%, constructability becomes difficult.

Model Assumption: Use Ten State Standards minimum slopes as modified and shown below in **Table C-2**.

Table C-2 – Minimum Slopes for Design Pipes

Size	Slope
8"	0.40%
10"	0.28%
12"	0.22%
15"	0.15%
18"	0.12%
≥21"	0.10%

Parameter: Design Pipe Sewer Match Point

Discussion: When two sewer pipes of different sizes meet at a manhole, the match point can affect pipe hydraulics. Convention and some sewer standards require the design to match the pipe crowns or to match the design depths of the sewers to keep from surcharging the smaller pipe.

Model Assumption: Match pipe crowns for simplicity during design and construction and to reduce the potential of surcharging smaller pipes (when larger pipes are flowing full).

Parameter: Allowable Decreases

Discussion: This allows for smaller diameter pipes to be constructed downstream of larger diameter pipes where additional capacity is gained in the smaller pipe due to an increased pipe slope.

Decreases are not recommended in smaller pipes (< 24 inches) due to the tendency of upstream obstructions to lodge at locations where trunk pipes decrease in size. Decreases may be necessary when connecting a master planned pipe into an existing trunk line, but should be avoided for future pipes.

Model Assumption: Decreases in diameter not allowed.

Parameter: Design Pipe Distance Between Manholes

Discussion: The distances between manholes may vary, but according to the 10 State Standards, should be limited to 400 feet for pipes less than 18 inches in diameter and 500 feet for pipes 18 inches and larger. The average distance between manholes in an existing system is approximately 300 feet.

Model Assumption: Use 400 foot spacing between manholes.

Parameter: Constant Speed Pump Cycle Volume

Discussion: The cycle volume of a pump station is the volume of the wet well between the pump off and pump on settings.

The model performs its calculations in discrete time increments. The results can be provided in time increments down to 1 second or less. A lift station with a cycle time less than the analysis time increment will result in a peak flow that has been reduced.

Model Assumption: Model cycle volume according to the current set points. Set calculation time increment to 1 minute or less.

Parameter: Future Pump Station Capacity

Discussion: The capacity of each lift station in the model is set individually. Lift stations tend to be designed based on assumptions that are more conservative and yield peak flows higher than a system wide model. A safety factor for the lift station is desirable to reduce the chance of overloading the lift station.

Model Assumption: Set the lift station capacity at least 10% higher than the incoming flow.

C.2.2 Flow Generation Layers

Parameter: Existing Flows

Discussion: Water meters are used in the flow generation method for the existing model. Winter water meter data is a good approximation of sanitary sewer flows generated by an individual parcel. Water meter usage is averaged over the winter months to provide an average daily flow for each water meter. This average is then adjusted (using factors refined during model calibration) to represent average weekday or weekend flows.

Model Assumption: Average usage data for the winter months of December 2012 and January and February 2013, will be used to generate existing flows.

Parameter: Residential Infill Flows for Master Plan

Discussion: Committed Model flows assume under- and undeveloped land areas within the 20-year UGA are developed based on their land use code.

Model Assumption: Based on discussions with the City Planning Department, the following assumptions were made for development of residential parcels:

Low Density Residential – assumed level of development based on parcel size

- ≤ 1 acre = leave parcel flow as-is / no further development for Committed Model
- > 1 acre = first reduce (by 23%) parcel size for non-buildable area, then subdivide parcel into 3.5 du/ac and multiply by the Residential Unit Flow (160 gpd) to calculate the Committed Model flows

Medium Density Residential – evaluate the density of each parcel based on the value of the following ratio: (Average Water Meter flow) / (Residential Unit Flow of 160 gpd)

- ≥ 0.75 = leave parcel flow as-is for Committed Model
- < 0.75 = update the parcel's Committed Model flow by the product of (number of du/ac for Medium Density, 5 du/ac)*(Residential Unit Flow)

High Density Residential – same process as for Medium Density Residential, however, use the value of 15 du/ac to update the parcels Committed Model flow

Parameter: Committed Model Flows

Discussion: Committed Model flows represent the maximum flows anticipated in the system when the 20-year UGA area is fully developed.

Model Assumption: Committed Model flows are generated by the unit flows for each land use type in the comprehensive plan. The latest comprehensive map will be used to establish master plan flows. Based on discussions with the City Planning Department, the following assumptions will also be made:

- The master plan improvements (Meadow Springs Interceptor and East Badger South Lift Station) identified in the SRSR project were included.
- Development of the Badger Mountain South planned development was based

on specific planning values provided by the developer's consulting engineer.

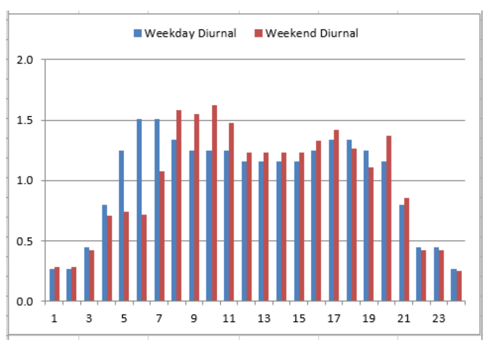
- The area west of the By-Pass Highway (SR 240) and southwest of the Richland Airport, currently zoned Agriculture, was not developed.
- Stevens Drive divides the upper North Richland area into two separate drainage basins with different land uses.
- Undeveloped industrial area in and around the Horn Rapids Industrial Park (HRIP) was developed using a value of 1,500 gpad (as selected by the City) – this includes the Bechtel laydown yards south of Battelle Blvd

Parameter: Diurnal Curves

Discussion: A diurnal curve is the shape of a type of sanitary flow contribution to the collection system over a 24-hour period. Diurnal curves differ for each type of land use. Diurnal curves are modified and refined during the calibration process by comparison to flow monitoring data.

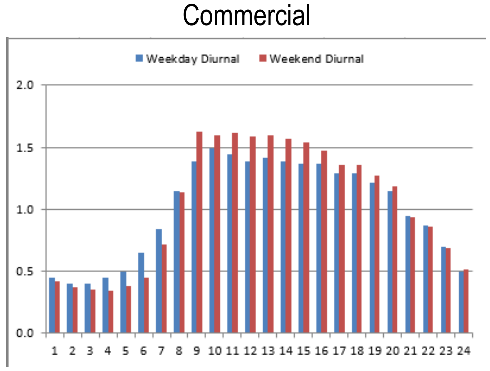
Model Assumption: The following diurnal curves will be used for the land use types listed below:

Residential



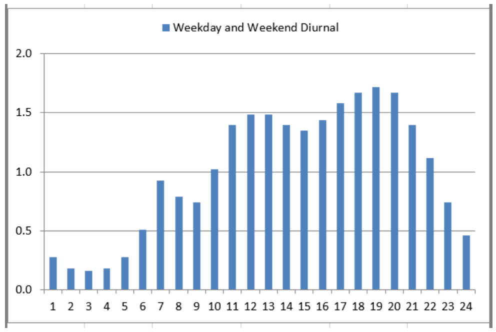
- Low Density Residential
- Medium Density Residential (includes RV & Mobile Home Parks, condo's and townhomes)
- High Density Residential
- Assisted Living

Commercial



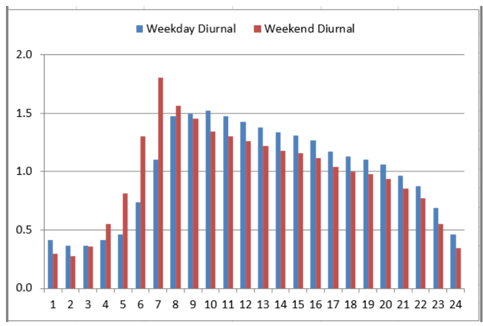
- Commercial
- Mixed Use

Restaurant



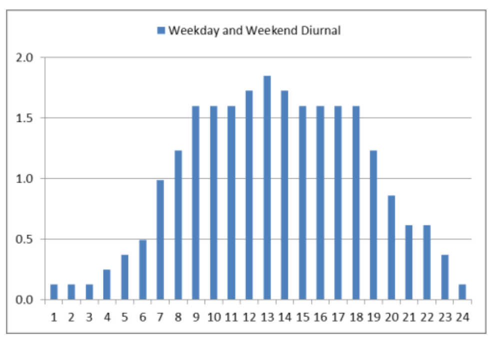
- Restaurant

Hotel



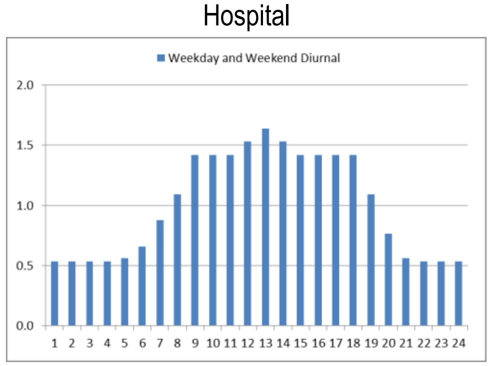
- Hotel

Office



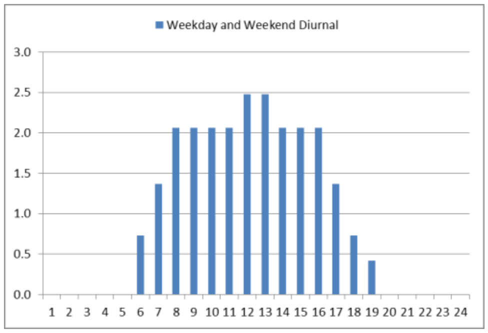
- Office
- Public
- Industrial

Hospital



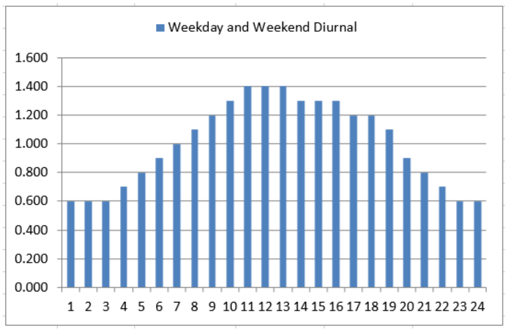
- Hospital

School



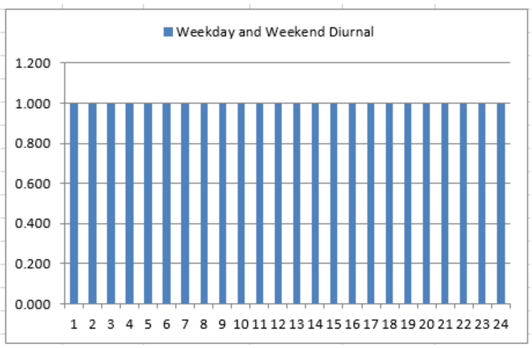
- School
- Church

Industrial (Dry)



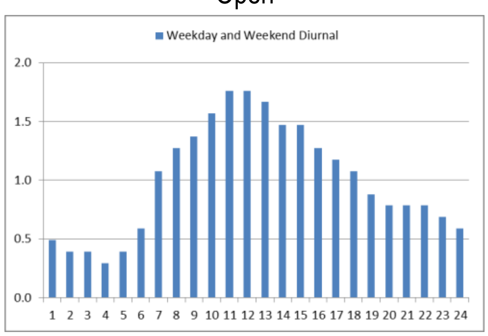
- Industrial (Non-permitted/Non-SIU)

Industrial (Wet)



- Permitted Industrial (SIU)

Open



- Open Space
- Park

Parameter: Residential Unit Flows (GPDU)

Discussion:	Residential unit flows are measured in gallons per dwelling unit (GPDU). The GPDU for each residential density is estimated from the winter water meter data.
Model Assumption:	Low Density Residential 160 GPDU Medium Density Residential 149 GPDU High Density Residential 147 GPDU

Parameter: Non-Residential Unit Flows (GPAD)

Discussion: Non-residential unit flows are measured in gallons per acre per day (GPAD). The GPAD for each non-residential land use type is estimated from the winter water meter data and net parcel area.

Model Assumption:

Assisted Living	3,300	GPAD
Church	150	GPAD
Commercial	350	GPAD

Includes a range of commercial businesses, from convenience stores to big box stores, along with laundromat and car wash.

Hospital	5,500	GPAD
Hotel	3,000	GPAD
Industrial	60	GPAD

Based on dry industrial flows only. Wet industrial (heavy) were separated

Industrial Heavy	3,000	GPAD

Based on Richland's 11 permitted industries

Office	350	GPAD
Public	540	GPAD
Restaurant	2,500	GPAD
School	170	GPAD
Composite Comm.	625	GPAD

Includes: commercial, hotel, restaurant, hospital, office, and public/municipal building.

C.2.3 Flow Injection Method

Parameter: Sewer Service Connection Point

Discussion: Flows for each sewer service were assigned to the corresponding parcel. Each parcel was then assigned a point on the system where it connects to the collection system. The connection point can affect the sizing of the trunk pipes. To ensure the pipe is large enough for all the connections between manholes, all flow injections should be added at the upstream manhole.

Model Assumption: Connect each parcel to the nearest collector pipes and inject the flow in the model to the upstream manhole.

C.2.4 Infiltration and Inflow

Parameter: Design Storm

Discussion: A design storm will be used to simulate a rainfall event. As per the Stormwater Management Manual for Eastern Washington (SMMEW), published by the Washington Department of Ecology (WDOE) two design storms exist for Eastern Washington the 24-hour storm and the 3-hour short duration thunderstorm. Of the two storms, the 3-hour storm is used in designing collection systems because of the higher peak flow. The storm peak will be aligned with the sanitary peak to evaluate the worst case scenario. Aligning these peaks significantly increases the return period for the storm.

Model Assumption: Three-hour short duration storm with 2-year return period and a total precipitation equal to 0.424 inches. The peak of the storm hydrograph is timed to occur when the peak sanitary flow occurs.

Parameter: Infiltration

Discussion: Infiltration describes the groundwater or rainfall that enters the sewer system through imperfections in the pipes and manholes. Infiltration values are estimated for large basins from flow monitoring data. It is described in gallons per acre per day (GPAD).

The City currently has several areas of high infiltration, visible in its existing pipes and manholes. New construction will consist of gasketed plastic pipe with gasketed manhole pipe connections.

Model Assumption: Infiltration will be assigned to the existing collection system but not to any new committed or master plan extensions or components.

C.2.5 Elevation and Datum Assumptions

Parameter: Vertical Datum

Discussion: A different vertical datum can cause differences in elevations at the same point by many feet. The majority of the City record drawings and existing model data used the National Geodetic Vertical Datum of 1929 (NGVD 29); however any new projects within the past two years have been on the North American Vertical Datum of 1988 (NAVD 88).

Model Assumption: To limit the amount of model revisions due to datum issues, NGVD 29 was used.

Parameter: Coordinate System

Discussion: The North American Datum of 1983 (NAD 83) is the base for many coordinate systems. The NAD 83 State Plane system consists of several coordinate systems for each state. The City uses the NAD 1983 State Plane Washington South Zone coordinate system.

Model Assumption: NAD 1983 State Plane Washington South Zone

Parameter: Elevation Data for Master Planned Area

Discussion: In the Upper North area of Richland two-foot contours collected from a 1999 city fly-over survey were used; these referenced the NGVD 29 vertical datum. In South Richland, two-foot contours from a 2013 city survey were used; these referenced the NAVD 88 datum. The local conversion between the datum's was provided by the City's survey crew – **+3.34-ft** will convert NGVD 29 values to NAVD 88 values.

Model Assumption: Use the City of Richland contours shifted to the NGVD 29 datum.