TETRA TECH

Technical Memorandum

Date:	January 4, 2017		
To:	Eric Hansen, City of Stevenson		
Cc:	File		
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Project:	General Sewer Plan Update	***Project Number:***	135-48600-16001
Subject:	Flow and Load Projections - DRAFT		

The purpose of this technical memorandum (TM) is to address Task 5 – Flow and Load Projections (from our contract scope of work), which states:

> "This task involves estimating historical and future flows and loads on the wastewater system, including annual average, maximum month, peak day and peak hour flows and loads and per capita rates. Tetra Tech will summarize historical flows and loads for last 10 years, and estimate future flows and loads for 6- and 20-year conditions."

This TM provides a summary of the process used to develop the projected flows and loads at the Stevenson Wastewater Treatment Plant (WWTP). These flows and loads will be compared to the capacity of the WWTP to determine when facility upgrades will be required to accommodate expected growth.

BACKGROUND

The flow and load projections described in this TM incorporate work documented in three prior TMs:

- Residential and Non-Residential Growth Projections, dated October 24, 2016 (the Growth Projection memo) describes the development of estimates for growth in the City, using the concept of the equivalent residential unit (ERU), which represents the amount of wastewater contributed by an average residential household. Growth was projected through 2040 and broken into the categories of residential and non-residential, with non-residential further broken into beverage and non-beverage subcategories.
- Pretreatment and Source Control Alternatives, dated December 1, 2016 (the Pretreatment memo) describes the findings of a high strength wastewater sampling program conducted by the City between August 30th and September 30th 2016. The sampling results were used to develop estimates of flow and load from high strength dischargers in the City, including Skamania Lodge and three beverage producers.

DESIGN CONDITIONS

To evaluate the capacity of existing WWTP facilities and size future facilities, the following design load conditions were considered for flow, biochemical oxygen demand (BOD), and total suspended solids (TSS):

- Dry weather average: represents typical influent wastewater flow or load, expressed as a daily average

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- Maximum month: represents largest 30-day flow or load anticipated to occur during a continuous 30-day period, expressed as a daily average
- Peak day: represents largest flow or load anticipated to occur during a 24-hour period
- Peak hour: represents largest flow anticipated to occur during a 1-hour period; typically used only for flow as BOD and TSS loads are less likely to exhibit sudden peaks

For future projections, 2025 and 2040 were selected as design years. These were based on the 6- and 20-year conditions described in the scope, rounded up to the nearest half decade.

CURRENT DESIGN CONDITIONS

Base Flows and Loads

Base design conditions were estimated using the number of ERUs. See the Growth Projection memo for a description of how the estimate of ERUs was developed.

Flow

As described in the Growth Projection memo, the average wastewater generation in the City was assumed to be 55 gallons per capita per day (based on City winter water use records) and average household size was assumed to be 2.21 persons per household, meaning that one ERU was equivalent to about 122 gallons per day of wastewater. The starting point for both flow and load projections was the start of calendar year 2016, at which time it was estimated that the City had 489 residential sewer ERUs and 506 non-residential sewer ERUs, resulting in an estimated total base flow of 0.121 million gallons per day (MGD).

Average BOD Load

Residential BOD load was assumed to be 0.2 pounds per day per capita, as recommended in Table G2-2 of the Department of Ecology's *Criteria for Sewage Works Design* (the Orange Book). Using the average household size of 2.21, this results in a base load of 0.44 pounds per day per ERU.

Non-residential beverage BOD load was estimated based on the sampling program results documented in the Pretreatment memo. Samples were collected from three beverage producers, which had average BOD loads of 2.45, 2.82, and 3.05 pounds per day per ERU during the sampling period. The average of these readings is 2.77 pounds per day per ERU, which was used as the base load for beverage ERUs.

The majority of non-residential, non-beverage wastewater in the City is received from Skamania Lodge. During the sampling program, the BOD load for Skamania Lodge was comparable to the assumed residential BOD load of 0.44 pounds per day per ERU, and this was used as the base load for non-residential, non-beverage ERUs.

Using these assumed loads and the estimated number of ERUs of each usage type at the start of 2016, the average BOD load was calculated to be 644 pounds per day (ppd). Currently available influent data (October 2015 through September 2016) show that the recorded average BOD load was 653 pounds per day, which is within 2% of the calculated average BOD load, indicating that the selected assumptions are reasonable.

Average TSS Load

The Orange Book recommends designing for a residential TSS load of 0.2 pounds per day per capita. TSS load data collected during the sampling program showed unexpectedly low TSS loads in proportion to BOD load at the same sampling points, despite TSS loads at the WWTP being comparable to BOD loads during the sampling period. As a result, TSS load results from the sampling period were not used to estimate future TSS load. Instead, projections of TSS load were based on the ratio of total TSS load to total BOD load.

The ratio of BOD to TSS was calculated for daily influent data recorded at the WWTP. The average ratio for the last 10 years was 1.323, and the average ratio for the last two years was 1.291. A BOD to TSS ratio of 1.30 was selected for use in projecting future TSS load.

Using this ratio and the estimated BOD load at the start of 2016, the average TSS load was calculated to be 495 pounds per day (ppd). Currently available influent data (October 2015 through September 2016) show that the recorded average TSS load was 537 pounds per day, which is within 9% of the calculated average TSS load, indicating that the selected assumptions are reasonable.

Maximum Month Flows and Loads

Maximum month design conditions represent seasonal increases in flow or load, and incorporated both the steady growth over time of the base design conditions as well as variations due to weather and other factors.

Flow

Maximum month flows occur in the winter months, indicating that precipitation-driven infiltration and inflow (I/I) in the sewer system is a factor. Due to the importance of weather events, the current maximum month flow was selected based on the highest observed maximum month flow: 0.460 million gallons per day, in January 2006.

BOD Load

Maximum month BOD loading exhibits less variability than maximum month flows, so current maximum month BOD load was estimated using a peaking factor. The peaking factor was calculated by comparing maximum month influent BOD loading for each year to the average day BOD load for that year. The average peaking factor for the last 10 years was 1.57, and the average peaking factor for the last two years was 1.78. In general, data from the last two years were given more weight than earlier data due to the growth of beverage industry sewer users in Stevenson during that period, so a maximum month peaking factor of 1.80 was selected for design purposes.

Using the calculated annual average BOD load of 644 pounds per day and the peaking factor of 1.80, the calculated maximum month BOD load is 1,159 pounds per day. Currently available influent data (October 2015 through September 2016) show that the recorded maximum month BOD load was 1,221 pounds per day, which is within 6% of the calculated max month BOD load, indicating that the selected peaking factor is reasonable.

TSS Load

Current maximum month TSS load was estimated using the same peaking factor approach used for BOD load. The average peaking factor for the last 10 years was 1.53, and the average peaking factor for the last two years was 1.70. A maximum month peaking factor of 1.70 was selected for design purposes.

Using the calculated annual average TSS load of 537 pounds per day and the peaking factor of 1.70, the calculated maximum month TSS load is 842 pounds per day. Currently available influent data (October 2015 through September 2016) show that the recorded maximum month TSS load was 866 pounds per day, which is within 3% of the calculated max month TSS load, indicating that the selected peaking factor is reasonable.

Peak Day Flows and Loads

Peak day flows were selected by reviewing peak day events in past data.

Flow

Like maximum month flows, peak day flows occur in the winter months and are associated with precipitation events. The current peak day flow was selected based on the highest observed peak day flow: 1.290 million gallons per day, on January 21, 2012.

BOD Load

Current peak day BOD load was estimated using a peaking factor approach that compared highest observed peak load to current average load. The highest observed BOD load was 3,071 pounds per day, on January 24, 2012, resulting in a peak day peaking factor of 4.8.

TSS Load

Current peak day TSS load was estimated using a peaking factor approach that compared highest observed peak load to current average load. The highest observed TSS load was 2,580 pounds per day, on February 11, 2014, resulting in a peak day peaking factor of 5.0.

Peak Hour Flows

Hourly flow data are not collected at the WWTP, so current peak hour flows were estimated based on the peak day flow. Peaking factors for peak day to peak hour flow were reviewed for nine WWTPs throughout western Oregon and Washington and were found to have an average of 1.50. Using this 1.50 peaking factor and the peak day flow of 1.290 million gallons per day, the peak hour flow was calculated to be 1.935 million gallons per day.

Peak hour loads are not used for design and were not calculated.

PROJECTIONS

Projected flows and loads will be used to determine the required size of modifications to the WWTP and the approximate date when these modifications will be necessary. Projected flows and loads were calculated for each year starting in 2017 and ending in 2040; however, growth and changes in the City cannot be expected to follow the linear assumptions used for these projections. Instead, projection results for the design years of 2025 and 2040 are intended to show the general trend indicated by the projections.

Flow

Flow projections include two components. First, the base flows increase as a result of new residential users and new or expanded non-residential sewer users. Second, I/I contributions increase as the sewer system both grows and ages. Table 1 summarizes flow, BOD loads, and TSS loads in the design years 2025 and 2040. Figure 1 shows historic flow information (annual dry weather average, maximum month, and peak day) and projected flows (base, maximum month, and peak day).

Table 1. Current and Projected Design Conditions

	Base (Dry Weather Average)			Maximum Month			Peak Day			Peak Hour		
Parameter	2016	2025	2040	2016	2025	2040	2016	2025	2040	2016	2025	2040
Flow (MGD)	0.121	0.183	0.212	0.460	0.695	0.804	1.29	1.47	1.72	1.94	2.21	2.62
BOD (ppd)	644	1,567	1,780	1,159	2,821	3,205	3,090	7,523	8,456	n/a	n/a	n/a
TSS (ppd)	495	1,206	1,370	842	2,049	2,328	2,476	6,028	6,848	n/a	n/a	n/a

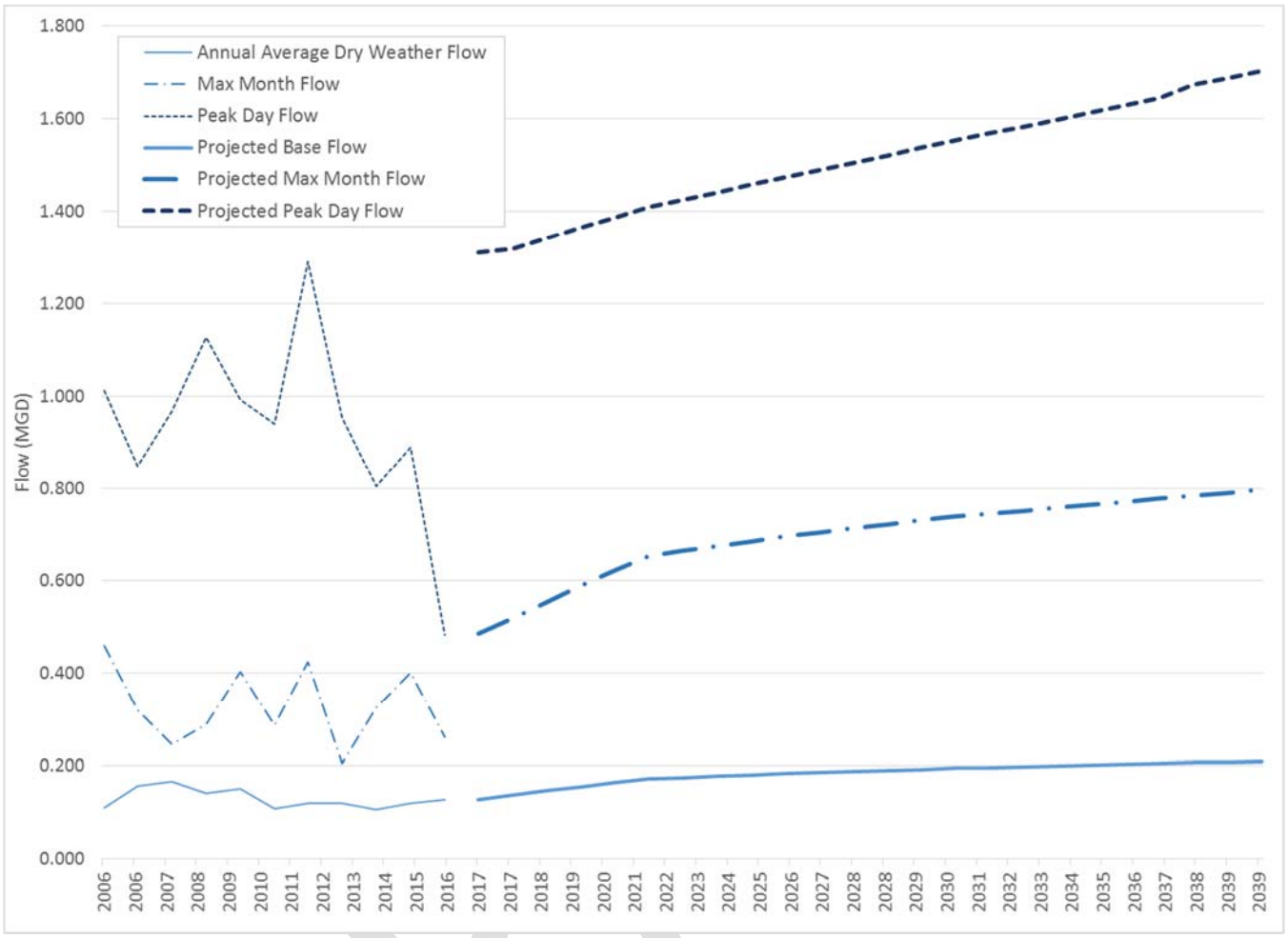

Figure 1. Historic and Projected Base Flows

Projected base flows were calculated using the yearly ERU estimate described in the Growth Projection memo and the assumption that the household size and flow per ERU will remain comparable.

Projected maximum month flows were calculated using a peaking factor based on the selected values for the current base flow and current maximum month flow. 3.80 was selected as the maximum month peaking factor.

Projected peak day flows were calculated by adding the projected base flow to a peak day I/I flow. Peak day I/I flows were obtained from the Stevenson sewer system model developed by Tetra Tech.

Projected peak hour flows were calculated using the projected base flow, projected peak I/I flows obtained from the sewer system model, and a diurnal peaking factor to account for variations in base sewer usage over the course of a typical day. The diurnal peaking factor used for base flows was 2.0, based on flow monitoring results from a similar project.

BOD Load

As described in the base loads section above, BOD loads are calculated based on the number of ERUs in the City. Using the projected number of residential, beverage, and non-residential non-beverage ERUs in the Growth Projection memo, base BOD loads can be calculated for each year. Maximum month and peak day BOD loads are then calculated for each year based on the selected peaking factors. See Table 1 for a summary of BOD load

projections for the design years 2025 and 2040. Figure 2 shows historic monthly BOD loads and projected BOD average, maximum month, and peak day BOD loads through 2040.

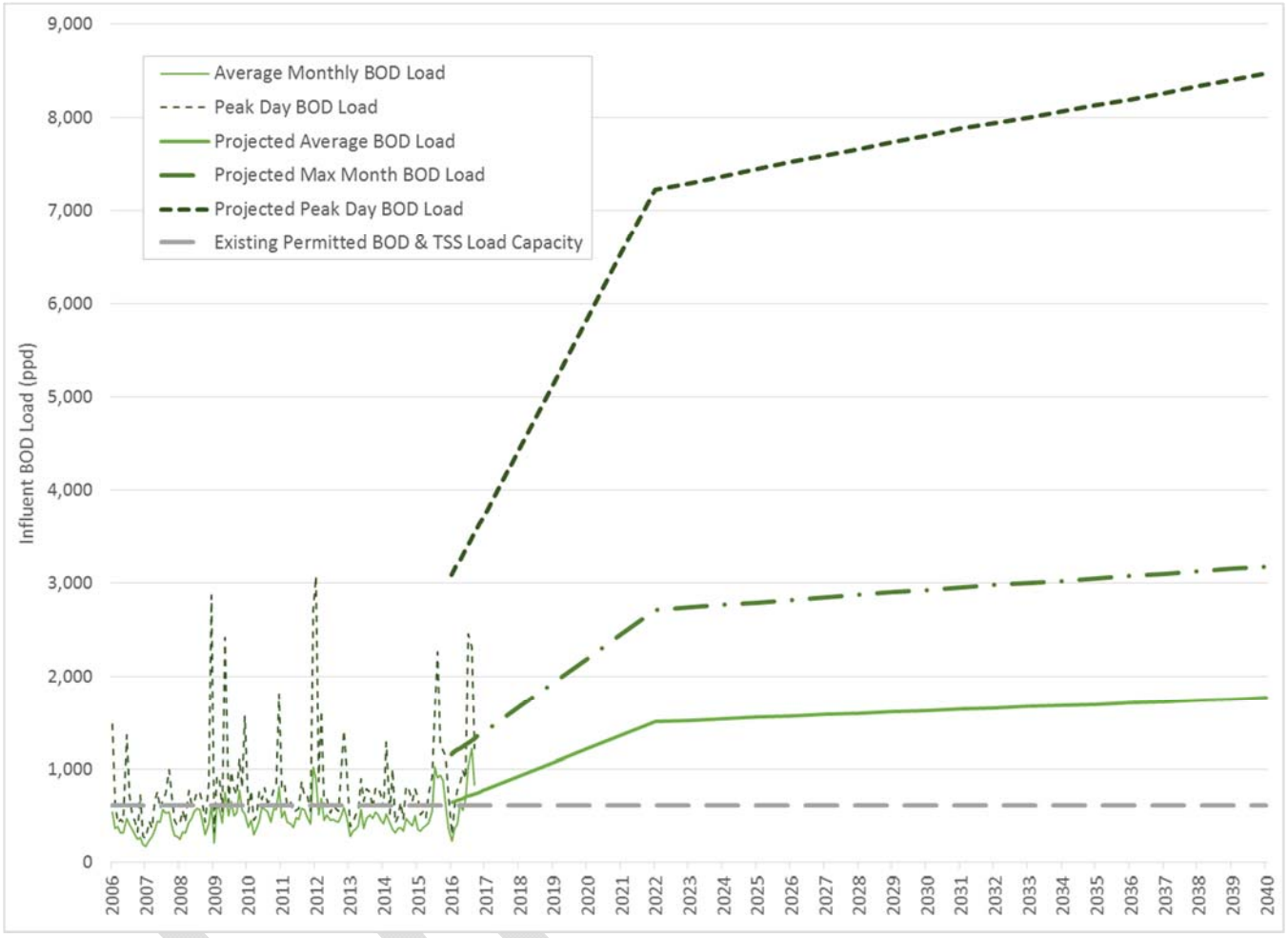

Figure 2. Historic and Project BOD Loads

TSS Load

As described in the base loads section above, TSS loads are calculated based on a ratio between BOD and TSS. Maximum month and peak day TSS loads are then calculated for each year based on the selected peaking factors. See Table 1 for a summary of TSS load projections for the design years 2025 and 2040. Figure 3 shows historic monthly TSS loads and projected TSS average, maximum month, and peak day TSS loads through 2040.

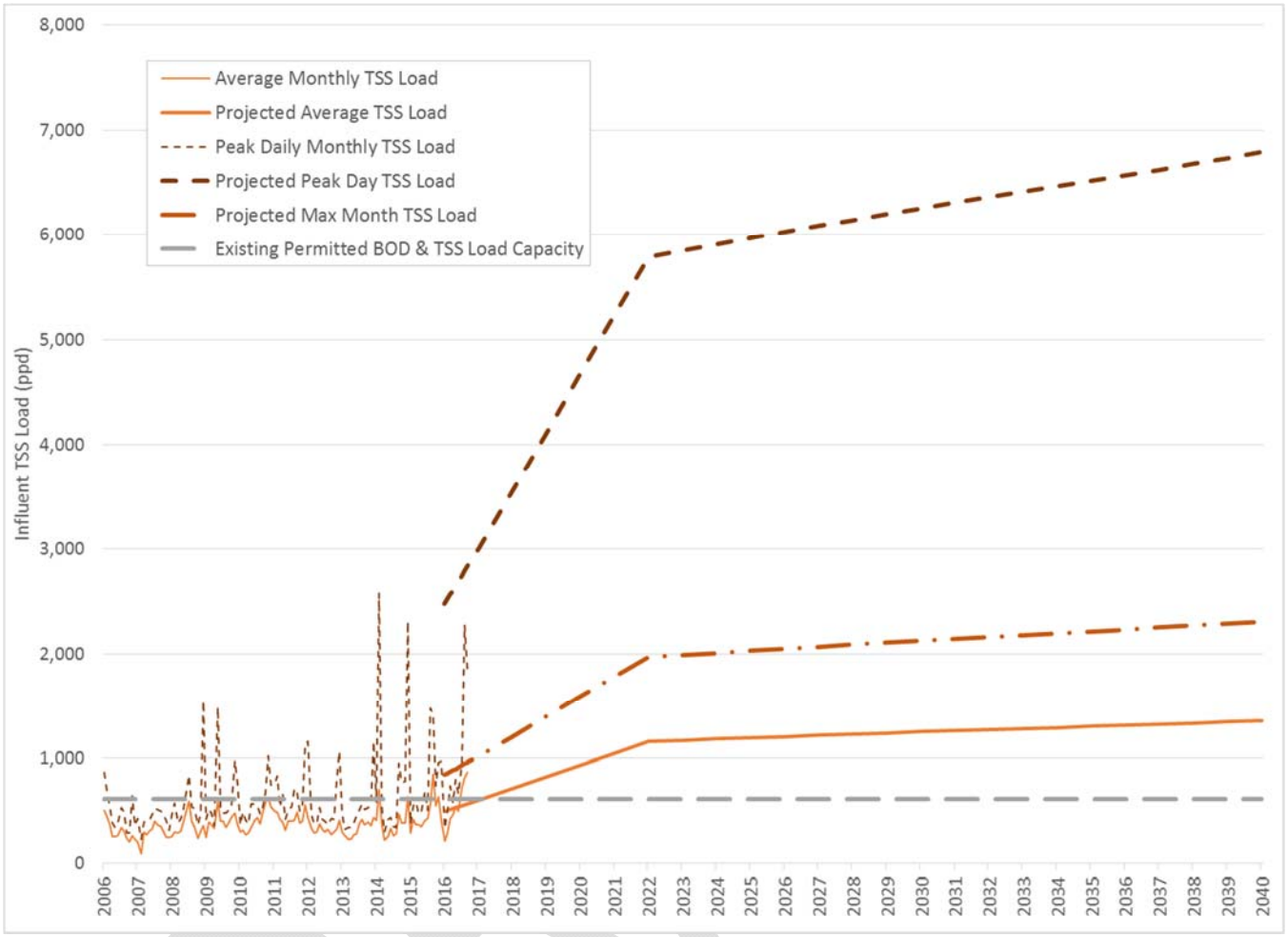

Figure 3. Historic and Projected TSS Loads