TECHNICAL MEMORANDUM No. 1

J·U·B ENGINEERS, INC.

City of Sandpoint
I/I Identification and Reduction

WWTP Influent Flow, Precipitation, and Temperature Comparison

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1.1 Purpose

J-U-B ENGINEERS, Inc. (J-U-B) was tasked by the City of Sandpoint (the City) with performing a review of the hourly flow at the City's Wastewater Treatment Plant (WWTP) versus precipitation and temperature to identify potential patterns related to inflow and infiltration (I/I). This effort is part of the City's overall approach to I/I reduction, which is outlined in the *Inflow and Infiltration Identification Data Collection Plan* (J-U-B, 2019). Key areas of interest for this review include:

- WWTP influent flow versus rainfall.
- Minimum flow (summer/night) vs. wet weather base infiltration (non-precipitation events).
- Peak inflow (the difference between dry weather and peak flow).

This memorandum summarizes potential relationships between WWTP influent flow, temperature, and precipitation to quantify potential base infiltration and peak inflow into the City's collection system.

1.2 Background

The City would like to identify and eliminate sources of I/I in its sanitary sewer collection system and attempt to quantify the efficacy of prior I/I reduction efforts. Reducing extraneous flows will allow the City to reduce the scope of planned future WWTP upgrades, which results in a significant reduction in project capital cost. The recently completed *City of Sandpoint Wastewater Treatment Plant Facility Plan* (J-U-B, 2019) shows that the WWTP experiences peak hour flows of 12.8 million gallons per day (mgd), up from an average dry-weather flow of 1.14 mgd (a peaking factor of 11), despite the City's aggressive efforts to reduce I/I since 2008. Therefore, the City would like to reevaluate its approach to I/I identification and elimination.

1.3 Comparisons from Historical Data

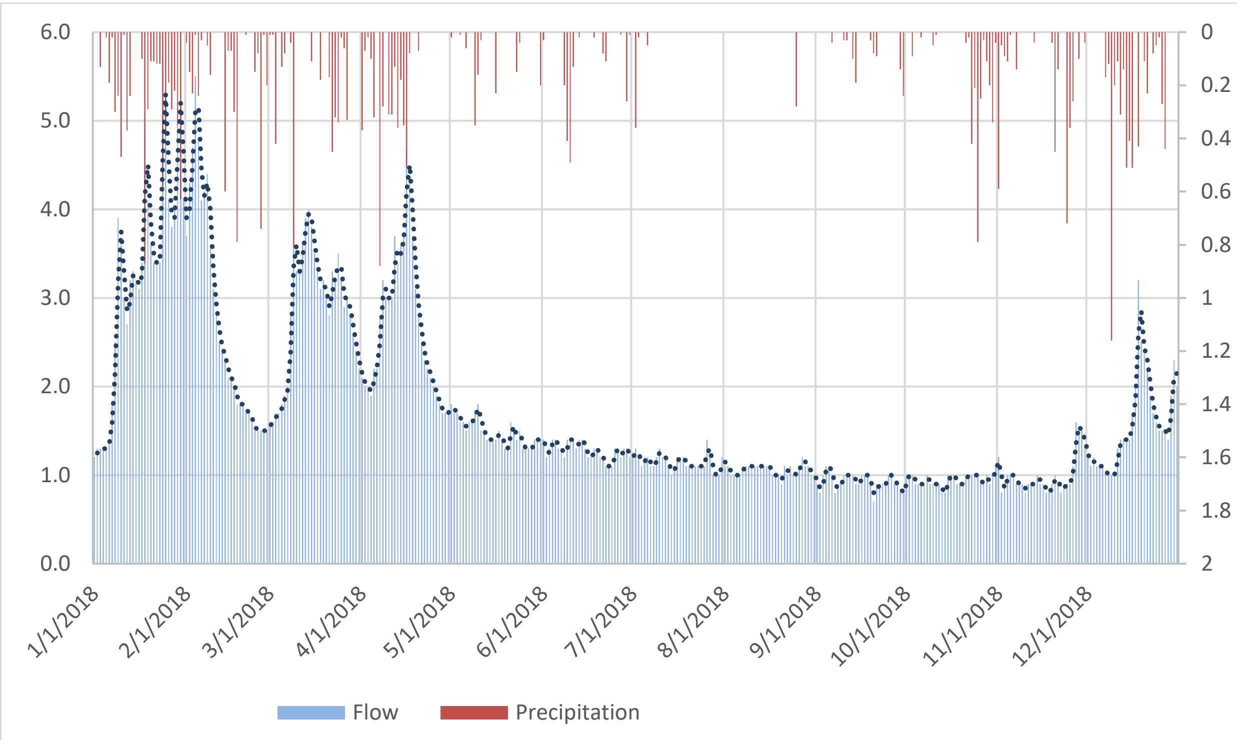
1.3.1. Data Sources

J-U-B obtained daily and hourly WWTP influent flow data from the City. Daily temperature, and snow depth data were obtained from the U.S. Climate Data website (https://usclimatedata.com/). Daily precipitation data was obtained for station US1IDBR0027 northeast of Sandpoint from the National Oceanic and Atmospheric Administration (NOAA) National Climatic Data Center (https://www.ncdc.noaa.gov/cdo-web/).

1.3.2. Influent Flow vs. Rainfall

Influent flow was compared to precipitation to identify the relationship between flow and precipitation. **Figure 1-1** shows a graph of WWTP influent flow versus precipitation for 2018.

Figure 1-1 – WWTP Influent Flow vs. Precipitation (2018)



Influent flows increase considerably after a significant rainfall event or a long period of rain, especially during winter and spring, indicating that a portion of extraneous flows at the WWTP is comprised of rainfall-derived I/I. Comparisons of monthly flow and monthly precipitation show flow increasing with a short lag as precipitation increases, and flows decreasing with a short lag as precipitation decreases.

The highest daily flows in 2018 were recorded in January, following heavy precipitation. In April, groundwater levels are also likely higher, contributing to higher rates of infiltration. Influent flows are lowest in late summer and fall, likely because of low groundwater levels and smaller magnitude precipitation events. One period with no apparent correlation between influent flow and precipitation is from September to November, where precipitation events occur with no apparent corresponding significant increase in flow. Since groundwater levels are likely lower during these months, this may indicate that higher flows at the WWTP are more directly related to groundwater levels than to precipitation events. However, no groundwater level data exist for this time period.

1.3.3. Influent Flow vs. Temperature, Snow Depth, and Precipitation

WWTP influent flow was compared to the ambient air temperature for the winter and spring of 2018 to determine whether a potential correlation exists between periods of increased temperature and influent flow. **Figure 1-2** shows a graph of influent flow and temperature for January through April 2018. **Figure 1-3** shows WWTP influent flow vs. snow depth.

Figure 1-2 suggests higher influent flows have a direct relationship with higher temperatures in winter months when snow is present. This trend is observed in January and early March. Conversely, flows dropped with temperature in mid-February through early March. Contrary to this trend, flows decreased in mid-March through early April despite a rise in temperature as most of the snow had previously melted.

Figure 1-2 – WWTP Influent Flow vs. Temperature (January – April 2018)

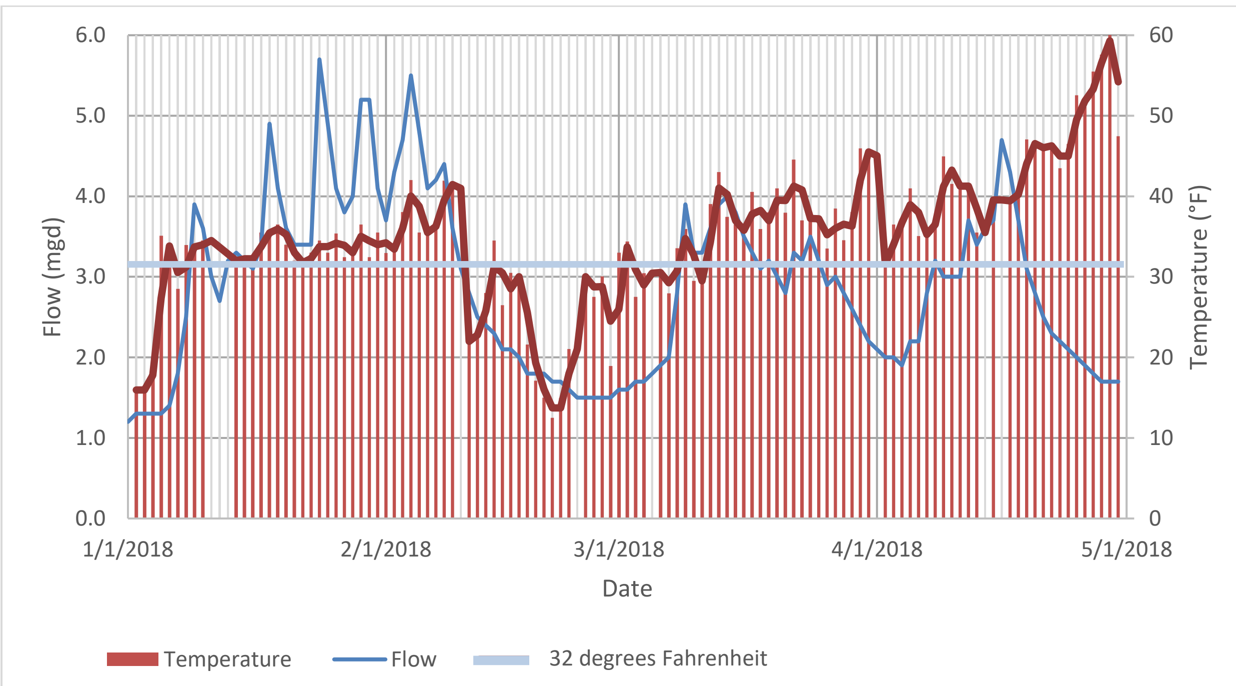


Figure 1-3 shows an inverse relationship between snow depth and influent flow, with flow decreasing as snow accumulates, as seen in mid-February through early March. The end of February exhibits a decrease in snow depth with no significant increase in flow. This may be because melting snow at that time increases the density and water content of the remaining snow rather than flowing to the WWTP. Flows typically increase as snow melts and precipitation occurs in the form of rain rather than snow in mid-March. The lack of snow in mid-March through early April helps explain why flows decreased during this time.

Figure 1-3 – WWTP Influent Flow vs. Snow Depth (January – April 2018)

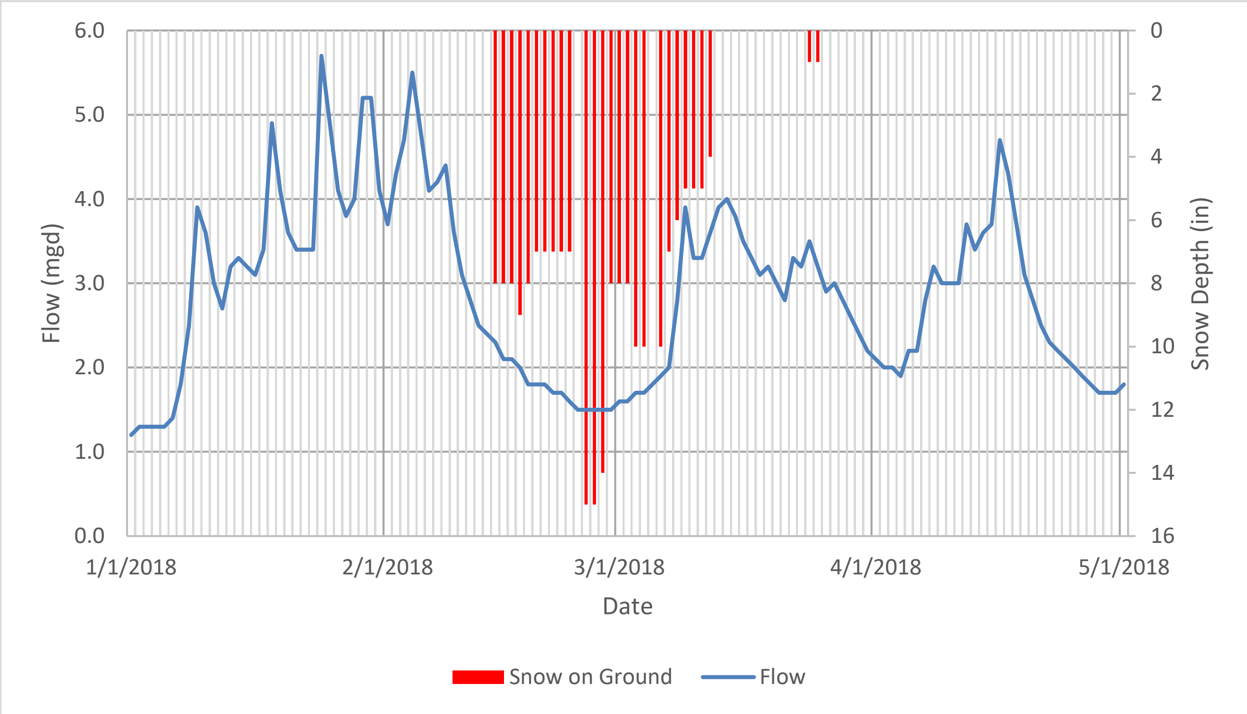
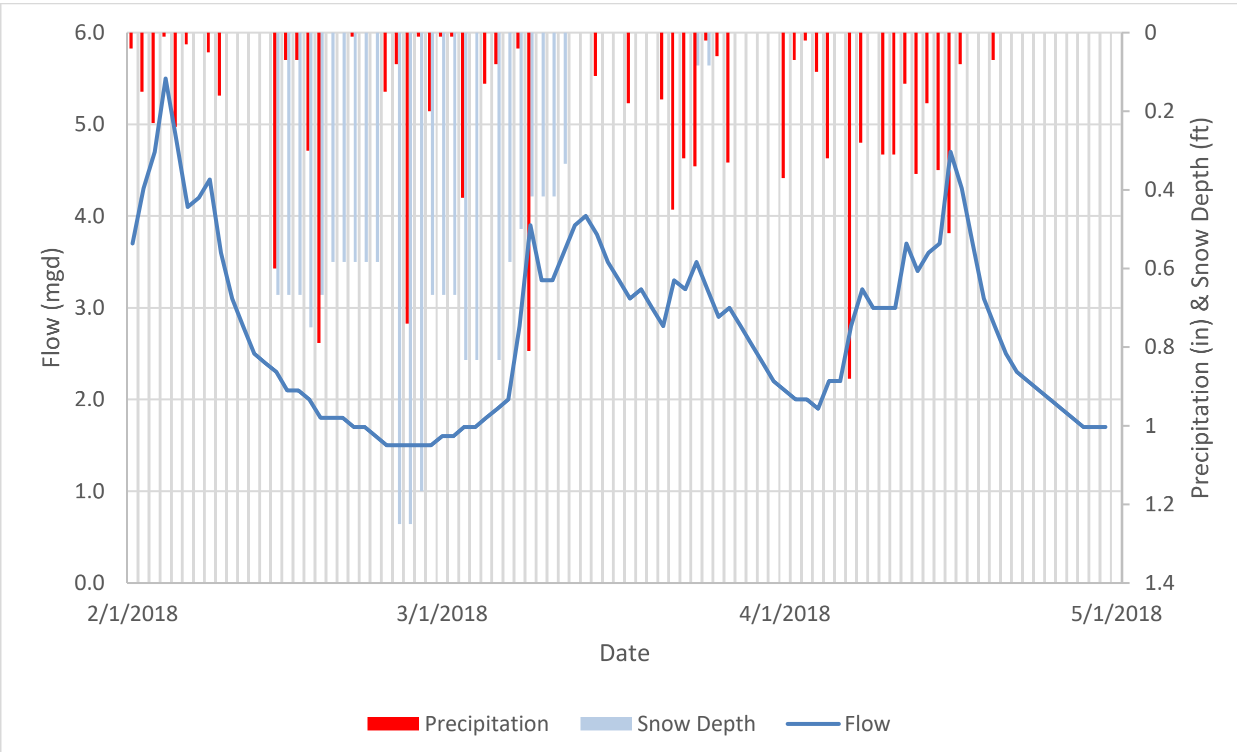


Figure 1-4 shows the relationship between precipitation and influent flow. High precipitation in the form of snow does not affect the flow, but high liquid precipitation events appear to. In mid-April when 1.29 inches of rain fell over a six-day period from April 10th, 2018 to April 15th, 2018 there appears to be a corresponding peak of 4.7 mgd in the WWTP influent flow on April 16, 2018. This suggests peak flows are related to rain and potentially rising groundwater. The lack of groundwater level data makes it difficult to draw a direct correlation between WWTP flows and groundwater levels.

Figure 1-4 – WWTP Influent Flow vs. Precipitation and Snow Depth (February – April 2018)



1.4 Base Infiltration and Peak I/I Estimates

There are five components to the influent flow values measured at the WWTP:

- Base wastewater generation, which is the amount of flow produced by system users.
- Base infiltration is flow in dry weather in excess of the base wastewater generation, often measured late at night when there is little to no user activity.
- Rapid inflow, which enters the system in large amounts after significant precipitation events.
- Rainfall-derived inflow, which occurs when sump pumps pump higher levels of groundwater influenced by rainfall into the sanitary sewer.
- Additional infiltration, which is infiltration that occurs above the base infiltration level in wet weather.

1.4.1 Base Wastewater Generation and Base Infiltration

To determine the volume of immediate inflow that enters into the collection system, it is necessary to first determine the base infiltration and daily flow produced by the system's users. The recent *WWTP Facility Plan* (J-U-B, 2019), outlines the estimated base wastewater generation, average day dry weather, maximum month, peak day, and peak hour flow values. The flow values from the Facility Plan are shown in **Table 1-1.** Reference the Facility Plan for additional discussion and support for this data.

Table 1-1 – WWTP Probable Existing Flow Conditions

Parameter	Existing Conditions
Flow (mgd)[(a)]	
Base Wastewater Generation	0.67
Average Day Dry Weather	1.14
(I/I Component)	**(0.47)**
Maximum Month	4.90
(I/I Component)	**(4.2)**
Peak Day	10.5
(I/I Component)	**(9.8)**
Peak Hour	12.8
(I/I Component)	**(12.1)**

[(a)] *Based on the period July 1, 2012 through August 31, 2017.*

The average day dry weather flow, estimated as the average monthly flow as measured at the WWTP from June through October (except for 2012), is 1.14 mgd and corresponds to 143 gallons per capita per day (gpcd) based on a service population in 2016 of 7,984 people. This per capita value is relatively high and likely includes a year-round base infiltration component.

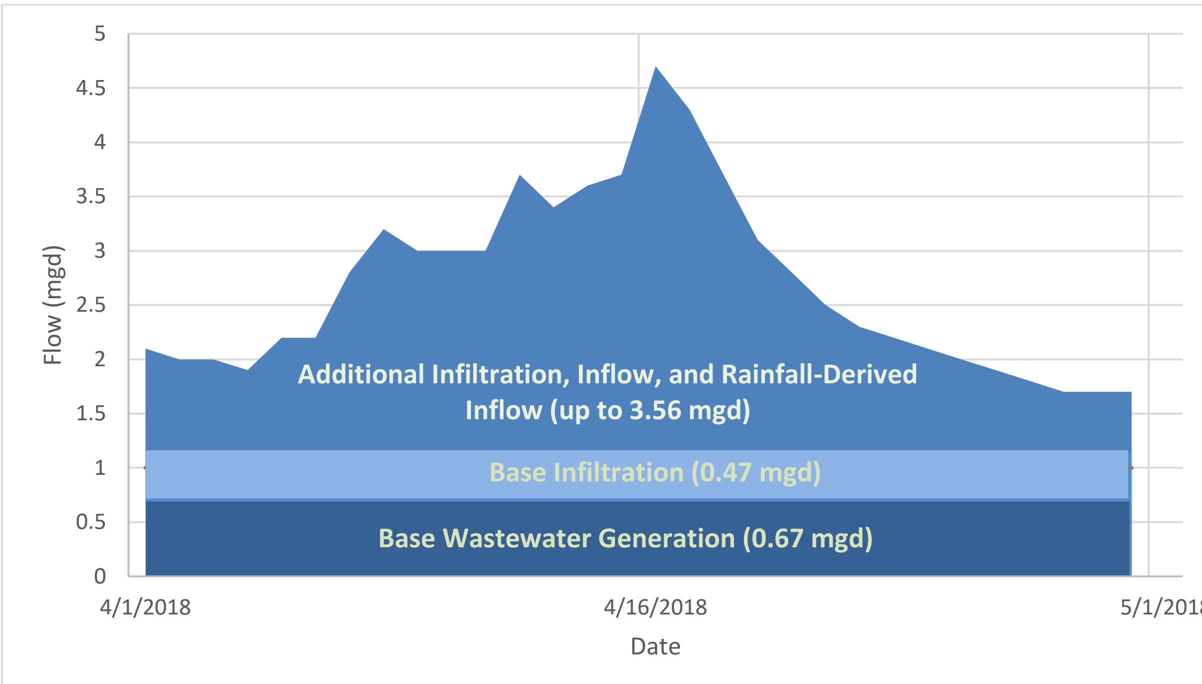
Metered potable water usage during the winter months (mid-November through mid-April) from 2012 through 2017 was provided by the City and used to estimate the base wastewater generation. The metered water usage for that period ranged from 0.65 to 0.70 mgd with an average of 0.67 mgd. Based on the 2016 estimated population noted above, this equates to 81 to 87 gpcd with an average of 84 gpcd which is similar to other communities in northern Idaho. As seen in **Table 1-1,** the difference between the average day dry weather flow and metered water usage is 0.47 mgd, this appears to represent base dry weather infiltration.

According to the 2019 Facility Plan, extraneous flows to the WWTP increase to an average of 4.2 mgd during the maximum month, 9.8 mgd during peak day, and 12.1 mgd during peak hour.

1.4.2 Rapid Inflow and Additional Infiltration Estimation

April 2018 and August 2019 flows were compared to better understand the response of the system under significant rain events with high and low groundwater levels. Although groundwater data are not available, groundwater levels in April of 2018 are assumed to be high due to precipitation and snowmelt. **Figure 1-5** summarizes WWTP influent flow for April 2018 with estimates of infiltration and inflow.

Figure 1-5 – WWTP Influent Flow vs. Base Wastewater Generation and Base Infiltration (April 2018)

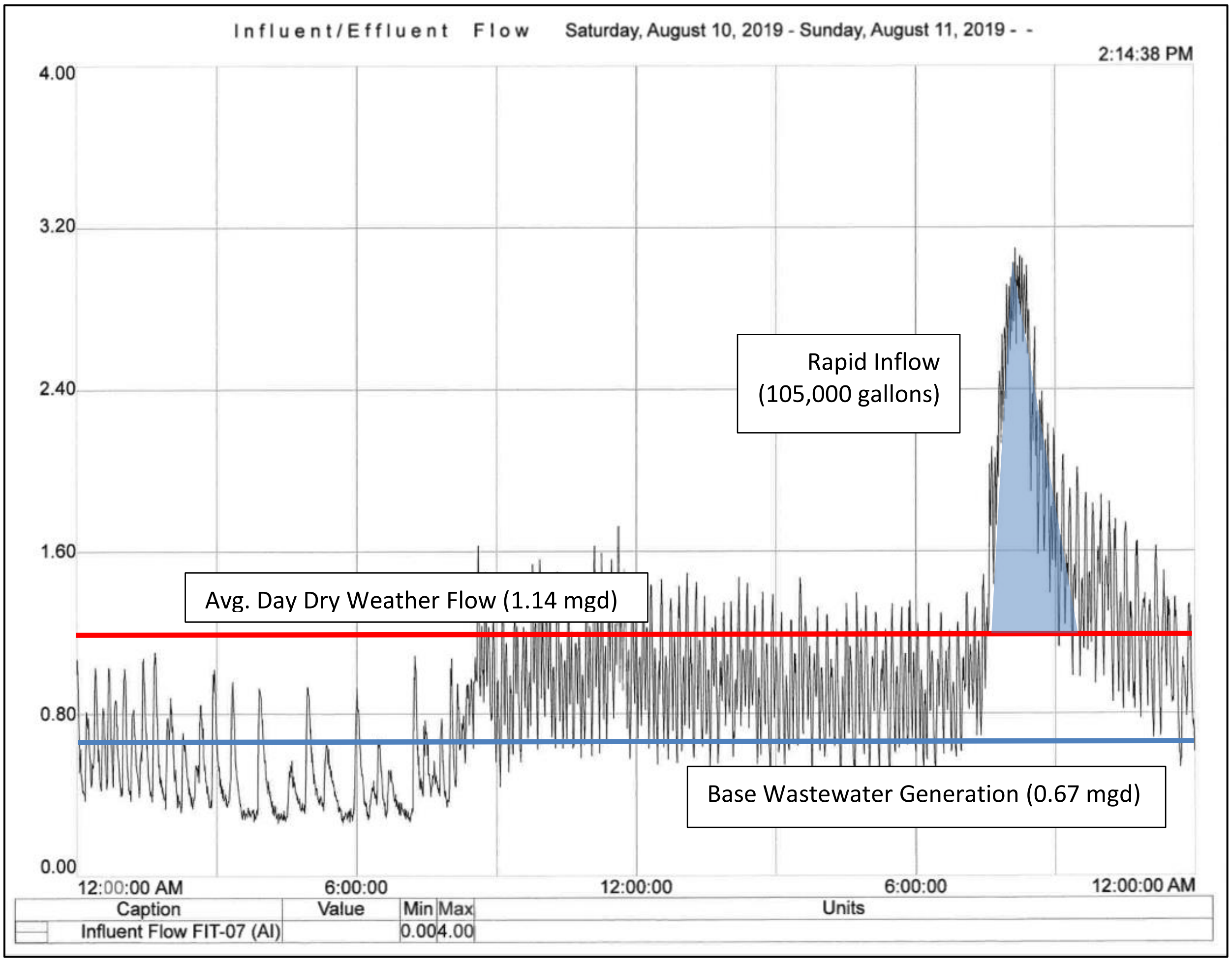


Influent flows in excess of the 1.14 mgd base wastewater generation and infiltration are a combination of rainfall-induced inflow, rapid inflow, and infiltration, with a combined peak of 3.56 mgd.

1.4.3 August 2019 Rainfall Event

The City experienced 1.03 inches of precipitation on August 10, 2019. The WWTP experienced a subsequent increase in influent flow, shown in **Figure 1-6**.

Figure 1-6 – WWTP Influent Flow Increase for August 10, 2019



Source: *City of Sandpoint*

The influent flow at the WWTP spiked to 3.0 mgd, apparently as a result of this storm event. Due to the unavailability of hourly precipitation data, the time of the storm is unknown. The increase in flow after 6:00 am is similar to the typical diurnal patterns, and the flow remains fairly constant until approximately 7:30 pm, when a severe increase in flow rate occurs. The flow rate decreased to pre-spike levels within a matter of hours, so the spike was likely due to the short, high-intensity storm event. The speed at which the flow rate returned to normal may suggest that the extraneous flows were due to rapid inflow. Infiltration was not likely a significant factor because groundwater levels are typically low in August. This conclusion is supported by the speed of the response since flow increases from infiltration typically occur over a longer duration. The rate of rapid inflow exhibited in this storm was approximately 1.86 mgd from the 1.03 inches of precipitation.

1.5 Conclusion

Based on the review of historical data, precipitation, temperature, and snow depth all affect the WWTP influent flow. The highest flows occur in winter and spring during periods of high precipitation and temperatures above freezing while snow is present.

Rainfall induced infiltration, rainfall induced inflow, and direct inflow are all a concern in the City's sanitary sewer collection system. The duration and timing of sustained peak flows during winter and spring months appears to indicate that rainfall-induced infiltration and inflow due to increased groundwater levels have the most significant impact on WWTP influent flows. Direct inflow also has the potential to cause spikes in flow to the WWTP year-round as observed after the August 10, 2019 rainfall. The peak resulting from that event, however, receded quickly and may indicate that direct inflow is only a small portion of peak flows experienced at the WWTP.

Though rainfall induced infiltration and inflow are likely more significant than direct inflow, it is currently unknown whether peak flows occur as a result of cracks and joints in sewer mainlines and laterals (rainfall induced infiltration) or are caused by increased use of sump pumps and yard drains (rainfall induced inflow). Groundwater levels and localized precipitation data may assist in quantifying rainfall derived infiltration versus inflow. For this purpose, the City has installed five groundwater monitoring wells and are recording groundwater levels on a regular basis. Data collection will be periodic, with frequency increasing during storm events and/or high flow events at the WWTP. Additionally, the City has installed precipitation gauges at the WWTP and the Lake Water Treatment Plant.

Sustained high flows resulting from increased groundwater levels, especially during wet weather months, are a primary issue for the City and create a significant potential for process bypass at the WWTP. The City should consider prioritizing reducing rainfall induced infiltration and inflow which, in turn, may reduce the magnitude and duration of these sustained high flows to help reduce the scope of future WWTP upgrades.

References

Climate Data for Sandpoint, Idaho, https://www.usclimatedata.com/climate/sandpoint/idaho/united-states/usid0230/.

J-U-B ENGINEERS, Inc. *City of Sandpoint Wastewater Treatment Plant Facility Plan*, January 2019.

J-U-B ENGINEERS, Inc. *Inflow and Infiltration Identification Data Collection Plan*, April 2019.

National Oceanic and Atmospheric Administration's National Climatic Data Center, https://www.ncdc.noaa.gov/cdo-web/.