Technical Memorandum

TO:	Ron Westmoreland, Cedar Grove Composting
FROM:	Chloe Gore and Robert Koster, PE
DATE:	October 19, 2022
RE:	**Reducing Third-Party Monitoring Frequency at Cedar Grove Composting Facility Maple Valley, Washington Landau Project No. 1224005.080**

Introduction

Cedar Grove Composting (Cedar Grove) operates a composting facility located at 17825 Cedar Grove Road SE in Maple Valley, Washington. The Maple Valley facility is subject to conditions set forth in the Order of Approval, Notice of Construction No. 10645 (permit) issued by the Puget Sound Clean Air Agency (PSCAA). Condition 9 of the permit requires an independent, third-party review and evaluation (monitoring) of Cedar Grove's operation of biofilters and ventilation on a quarterly basis. Landau Associates, Inc. (Landau) has conducted the required third-party monitoring on behalf of Cedar Grove since 2018.

The purpose of the monitoring is to review the performance of emission capture systems for facility buildings and the operating conditions of their respective biofilters. Criteria for monitoring include, but are not limited to:

- Operational condition and integrity of the exhaust/capture (ventilation) system
- Operational condition and integrity of the biofiltration system
- Adequacy and effectiveness of the system maintenance program and practices
- Repair history and troubleshooting errors
- Recommendations for continuous improvement of the integrated system operation.

Cedar Grove requested that Landau review the data collected during monitoring of the building ventilation systems and biofilters to evaluate the efficacy of the quarterly monitoring at the Maple Valley facility. This technical memorandum presents Landau's conclusions after review of historical data since the last filter rebuild or media replenishment for each biofilter. The data (provided in Attachment 1) were reviewed to consider whether 1) the monitoring parameter provides actionable information critical to operational maintenance of the ventilation and/or biofilter systems, 2) the monitoring parameter has a correlative relationship with the degradation of biofilter media, allowing for predictive anticipation of the need to replace media, and 3) whether third-party collection of the data is critical to achieving the operational maintenance needs of the facility. Landau's review supports the conclusion that the operational performance of the ventilation and biofiltration systems at the Maple Valley facility could be adequately maintained under a reduced frequency of third-party monitoring.

Overview of Third-Party Monitoring

The purpose of the third-party evaluations is to review the operational condition and integrity of emission control systems, including ventilation systems and biofilter media.

The ventilation system of each building is evaluated to assess achievement of the design air exchange rate. Air flow from the building to the biofilter is measured at a minimum of three points across the ventilation ducts using a hot wire anemometer, Type S Pitot tube, and digital manometer. Ventilation systems are visually inspected for deterioration to the ducting or fan that could affect system performance and ventilation efficacy. A smoke test is attempted to verify that the building's ventilation system is capturing indoor air to pass it through the biofilter rather than allowing it to escape from the building's enclosure.

Biofilters are visually inspected for the presence of any hotspots, fissures, plant growth, and rodent infestations. These inspections are completed and problems corrected on a schedule in accordance with the facility's Operation and Maintenance (O&M) Plan. Biofilter media samples are collected at least once every 6 months and analyzed for bed temperature, moisture content, bulk density, pH, and void space. Desirable properties include warm temperature, moderate moisture content, low bulk density, low pH, a high void space, and larger particle size distribution. These properties contribute to an optimal microbial environment.[1]

Landau has reviewed the monitoring data for the period since the most recent replacement or replenishment of media in each biofilter to determine if any of the monitored parameters could predict the decay of performance over time. Each parameter is discussed below.

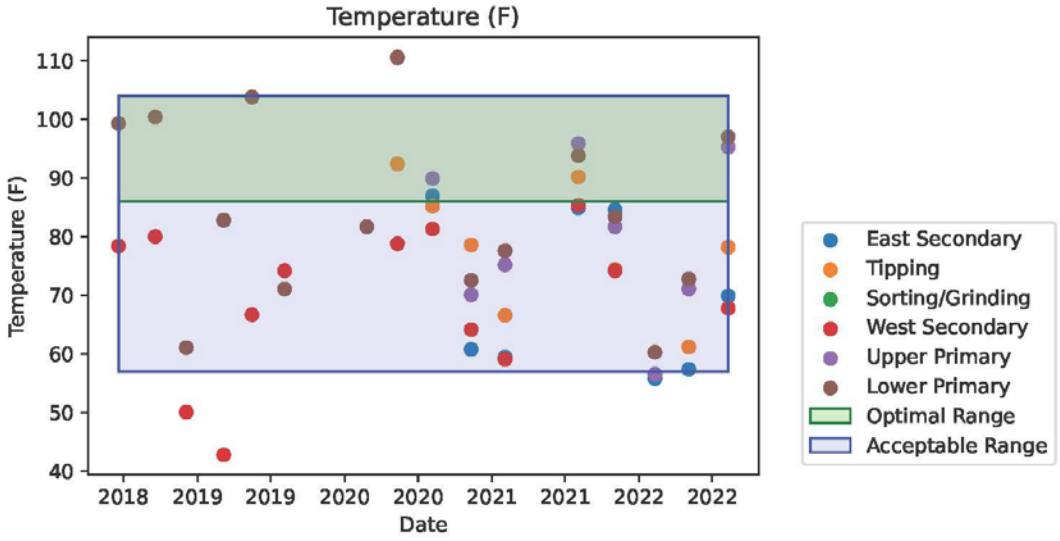
Bed Temperature

Bed temperature refers to the average temperature of the biofilter media. Bed temperature is affected by the temperature of the ambient air and inlet process air. Biofilters contain multiple microbial species, each with its own optimum temperature. Thus, optimal bed temperature is a compromise between different microbial populations and has been identified to be between 86° and 104°F (30° and 40°C). Acceptable temperatures are between 57° and 104°F (14° and 40°C).

The following bullets summarize Landau's review of bed temperature data related to the third-party monitoring considerations identified in the introduction of this technical memorandum:

[1] Notice of Violation (NOV No. 3-009155) stated that PSCAA had determined "the acceptable ranges of a few parameters." The acceptable ranges for biofilter performance identified in NOV No. 3-009155 do not have a regulatory basis and have not been established as facility-applicable criteria in any of Cedar Grove's permit documents. Furthermore, NOV No. 3-009155 is subject to further discussion and resolution following two meetings between Cedar Grove and PSCAA in 2019 and subsequent replacement of NOV No. 3-009155 by NOV No. 3-010458. With that context, the optimal and acceptable ranges presented in this technical memorandum have not been modified to reflect the ranges in NOV No. 3-009155—the ranges presented herein are consistent with past reports for Cedar Grove's Everett facility.

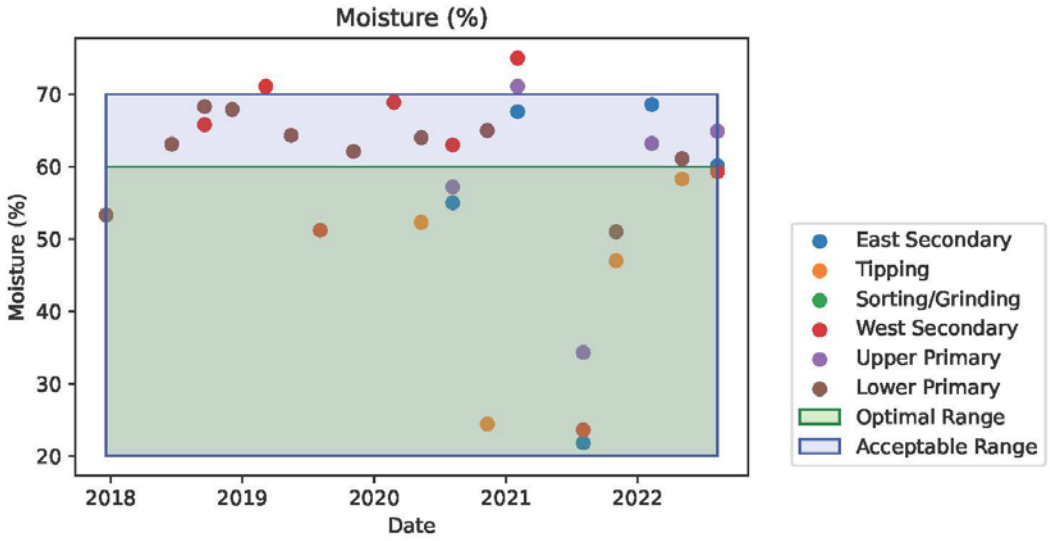
1. *Actionable Information for Maintenance:* As shown in the figure below (bed temperature data summaries for each biofilter operated at Maple Valley), bed temperatures do decline in colder weather, occasionally reaching temperatures that are lower than what has been identified as the acceptable range. The lower temperatures are directly tied to ambient air temperatures in the winter and are not representative of an operational failure of the biofilters as the media age. Temperature monitoring for hot spots, which may occur when biofilter media consolidate with age, is the more important consideration for regular operation and maintenance of the biofilters. Bed temperature monitoring is a helpful means of identifying whether localized maintenance is warranted in biofilters.
2. *Correlation of Monitoring Data for Media Replacement Need:* Bed temperature is unreliable as an indicator for the need to replace biofilter media. Bed temperature fluctuates seasonally and very rarely reaches a temperature that indicates the need for bed replacement before other parameters do so more reliably.
3. *Independent Monitoring Value:* As long as Cedar Grove monitors and records the bed temperature of biofilter media on at least a quarterly basis, addressing hot spots if they develop, semiannual monitoring by an independent third party should be sufficient to verify whether more rigorous biofilter maintenance (including media replacement) is warranted.



Moisture Content

Moisture content refers to the water content of the biofilter media. A sufficient moisture content is required to provide micro-organisms with enough water and facilitate the degradation of odorous compounds. Sufficiently moist media are also important to maintain the structural integrity of the biofilter. When too dry, biofilters are more susceptible to cracks and fissures and, therefore, the ineffective distribution of inlet gases. When too wet, a biofilter may be susceptible to the creation of anaerobic zones, gas channeling, and increased back-pressure. The optimal range for moisture content is between 20 and 60 percent and the acceptable range is between 20 and 70 percent.

1. *Actionable Information for Maintenance:* As shown in the figure below (bed moisture data summaries for each biofilter operated at Maple Valley), bed moisture appears to stay relatively constant over a multi-year period of time. This is likely due to the immediate availability of a fix for visually observed dry spots (increased sprinkling). Visual moisture monitoring is a helpful means of identifying whether localized maintenance is warranted in biofilters.
2. *Correlation of Monitoring Data for Media Replacement Need:* Bed moisture is unreliable as an indicator for the need to replace biofilter media. Bed moisture fluctuates seasonally and very rarely indicates the need for bed replacement before other parameters do so more reliably.
3. *Independent Monitoring Value:* As long as Cedar Grove monitors and records the apparent moisture content of biofilter media on a frequent basis, addressing dry spots if they develop, semiannual monitoring by an independent third party should be sufficient to verify whether more rigorous biofilter maintenance (including media replacement) is warranted.



Bulk Density

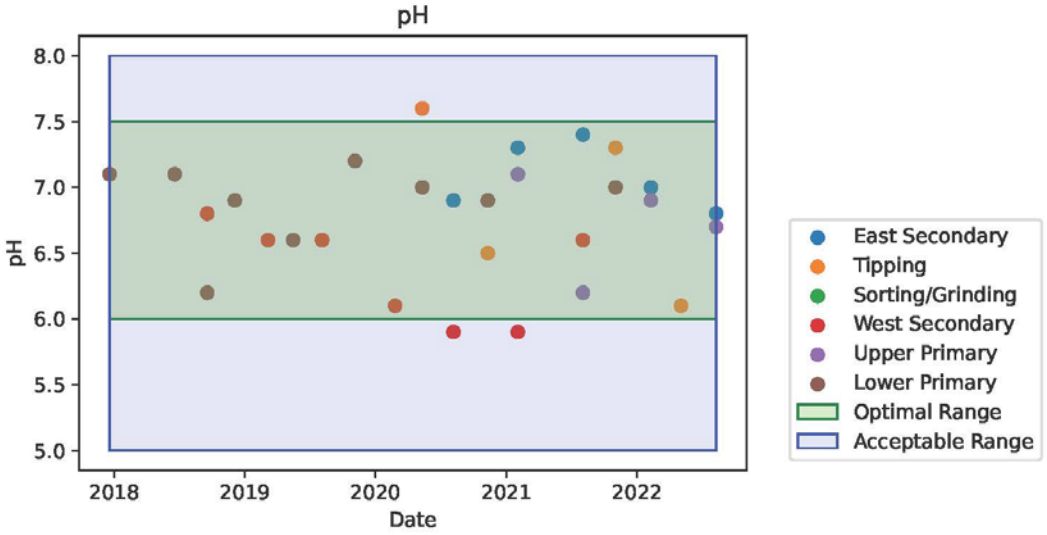
Bulk density refers to the mass per unit volume of biofilter media. A lower bulk density is desirable because it indicates a higher void space and greater surface area for contact between air and micro-organisms. Bulk density is reported in grams per cubic centimeter or pounds per yard. Bulk density increases as free air space decreases, so this measure is captured by the monitoring of free air space described below.

pH

The acidity and alkalinity of the media are indicated by pH value. The acceptable pH range for normal operation is between 5 and 8; optimal operation occurs at a pH between 6 and 7.5. Organic acids that may cause the acidification of media are by-products of microbial degradation; therefore, lower pH values indicate an aged microbial environment and may indicate the need for biofilter media

replacement. A pH value lower than 8 is desirable because ammonia is converted into nitrate in these conditions, avoiding the alkalization of the media.

1. *Actionable Information for Maintenance:* As shown in the figure below (pH data summaries for each biofilter operated at Maple Valley), pH appears to stay relatively constant over a multi-year period of time. The pH monitoring does not appear useful for identifying localized maintenance needs in biofilters.
2. *Correlation of Monitoring Data for Media Replacement Need:* Bed pH is unreliable as an indicator for the need to replace biofilter media. Bed pH stays fairly constant between bed replacements and is almost always in the optimum range and therefore is not a reliable indicator of the need for bed replacement before other parameters.
3. *Independent Monitoring Value:* Semiannual (or even annual) monitoring of pH by an independent third party should be sufficient to verify whether more rigorous biofilter maintenance (including media replacement) is warranted.

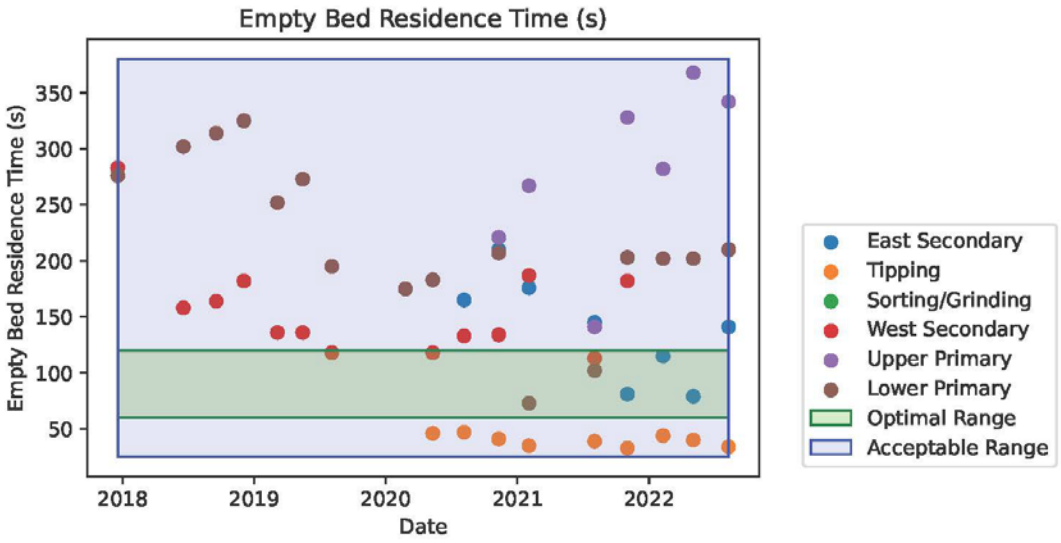


Empty Bed Residence Time

Empty bed residence time (EBRT) is the amount of time microbes are in contact with the contaminated air stream. Residence time is calculated by dividing the empty bed volume by volumetric flow rate. Longer residence times produce higher efficiencies; however, a design air flow rate must minimize residence time to accommodate larger flow rates. An acceptable EBRT is any amount of time greater than 25 seconds and an optimal EBRT is between 60 and 120 seconds.

1. *Actionable Information for Maintenance:* As shown in the figure below (empty bed residence time data summaries for each biofilter operated at Maple Valley), EBRT appears to stay relatively constant over a multi-year period of time. Because a high EBRT is desirable (more time for microbes to act) and because it does not decrease with bed age, EBRT does not appear useful in determining when maintenance is warranted in biofilters.

2. *Correlation of Monitoring Data for Media Replacement Need:* EBRT is unreliable as an indicator for the need to replace biofilter media. Historical data show that EBRT stays fairly constant and very rarely indicates the need for bed replacement before other parameters do so more reliably.
3. *Independent Monitoring Value:* So long as Cedar Grove maintains the air handling equipment (blowers, ductwork, etc.) as designed, semiannual monitoring by an independent third party should be sufficient to verify whether more rigorous biofilter maintenance (including media replacement) is warranted.



Void Space

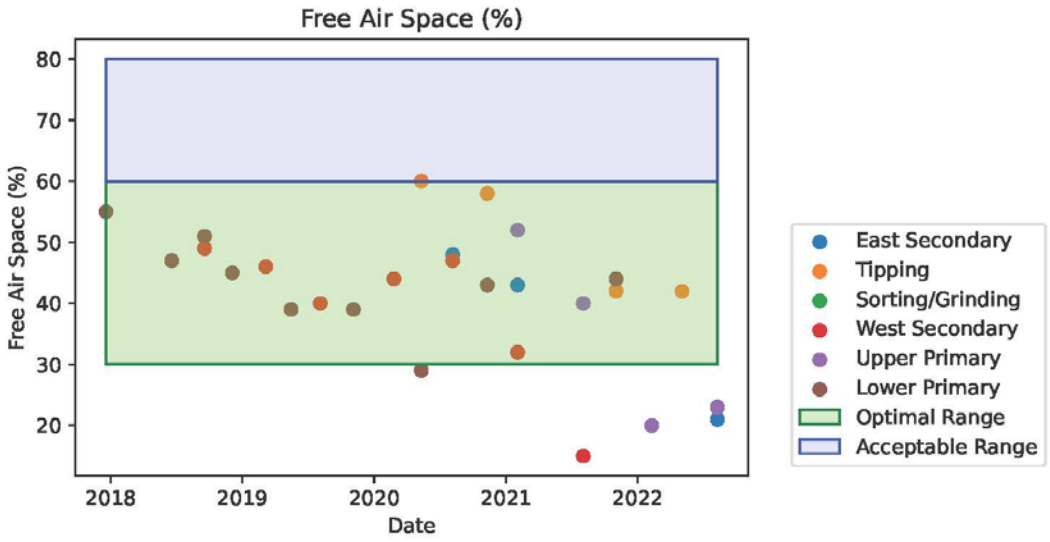
Biofilter samples are measured for total void space. Total void space consists of both the void space that is unoccupied by water, called free air space, and the void space that is occupied by water. Void space is an indicator of available media surface area. Adequate void space is needed for minimal air flow resistance, pressure drop, and blower power requirements. Greater void space is desirable for both contaminant absorption and microbial growth. The desired optimum porosity or void space for the media is in the 30 to 60 percent range. A void space less than 30 percent is undesirable because it increases the pressure drop across the biofilter. It also indicates that the media are breaking down and need to be replaced. There is no upper limit of acceptable void space. It should be noted that the act of collecting a sample to analyze void space actually alters the void space of the media. Therefore, bulk density and particle size distribution are also monitored as an indicator of media porosity and useful life. Void space is reported as a percentage. Free air space, the total void space less the water-occupied void space, does appear to decline over time after the biofilter is refurbished or replaced. It appears to drop to levels suggesting a need for refurbishment or replacement of media approximately every 2 years.

1) *Actionable Information for Maintenance:* As shown in the figure below (free air space data summaries for each biofilter operated at Maple Valley), free air space appears to correlate

with time since the most recent replacement or replenishment (bed age). Free air space, then, might be the most reliable parameter to monitor to trigger biofilter replenishment or replacement.

2) *Correlation of Monitoring Data for Media Replacement Need:* Free air space appears to correlate to bed age, staying in the acceptable range for a period of a couple years and then dropping below that. This parameter could be used to determine the frequency of bed replenishment or replacement.

3) *Independent Monitoring Value:* Free air space does not change quickly; therefore, semiannual monitoring by an independent third party should be sufficient to verify whether more rigorous biofilter maintenance (including media replacement) is warranted.



Smoke Tests

Cedar Grove is required to perform a smoke test on each of the enclosure buildings at the two facilities during the third-party monitoring events. The smoke tests, which involve a candle releasing a known volume of smoke over a known period of time, are designed to evaluate the flow of air into the building. The flow direction (into or out of the building) should be constant if the fan and ductwork are intact and operating properly. No evidence was identified that correlates the results of the smoke tests with biofilter age or maintenance, but it is an easily interpreted measure of the direction of air flow in the building(s). This suggests that annual or semiannual smoke tests conducted by a third party would provide helpful additional information to the other measures of air handling performance.

Conclusions and Recommendations

Third-party monitoring and reporting are currently completed on a quarterly basis at Cedar Grove's Maple Valley facility, including visual inspections of biofilters and ventilation systems, and

measurement of temperature and air flow. Twice per year (alternating quarters), samples are collected and analyzed for bed temperature, moisture content, bulk density, pH, and void space.

The analysis presented above indicates that third-party monitoring data correlate poorly with biofilter performance. Landau's review of the data collected since the last refurbishment of each biofilter shows very little to no correlation of the data elements to biofilter age except for the free air space. Free air space appears to decrease after about 2 years of operation, suggesting that a replacement or refurbishing frequency of 2 years would allow the third-party monitoring frequency to be reduced to once or twice per year without compromising biofilter performance. Consolidation of sampling and reporting requirements would also reduce the time required for PSCAA to review quarterly reports.

The third-party monitoring provides benefit in evaluating the external characteristics (appearance) of the filters periodically. The moisture content can be projected from a dry appearance, and general maintenance by the presence or absence of rodent holes and or vegetation. The periodic evaluations of these parameters and maintenance would be best incorporated into the facility O&M Plan. With a suitable frequency of inspection and correction specified in the O&M Plan, optimizing these parameters could be accomplished without third-party attention and with no loss of biofilter performance.

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Attachment

Attachment 1: Biofilter Historical Data

ATTACHMENT 1

Biofilter Historical Data

Attachment 1
Biofilter Historical Data
Cedar Grove Composting Facility
Maple Valley, Washington

	Residence Time (s)	Free Air Space (%)	pH	Temp-erature (°F)	Moisture (%)
Acceptable range	> 25	> 60	5-8	57-104	20-70
Optimal range	60-120	30-60	6-7.5	86-104	20-60

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Media Replaced May 2020			
East Secondary	8/6/2020	165	48	6.9	87.0	55
	11/10/2020	210	--	--	60.8	--
	2/2/2021	176	43	7.3	59.5	67.6
	8/3/2021	145	40	7.4	84.9	21.8
	11/2/2021	81	--	--	84.6	--
	2/9/2022	115	20	7	55.8	68.6
	5/4/2022	79	--	--	57.4	--
	8/10/2022	141	21	6.8	69.9	60.1

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Media Replaced November 2017			
Lower Primary	12/19/17	276	55	7.1		53.3
	06/19/18	302	47	7.1	99.3	63.1
	09/18/18	314	51	6.2	100.4	68.3
	12/04/18	325	45	6.9	61.1	67.9
	03/07/19	252	--	--	82.8	--
	05/16/19	273	39	6.6	103.8	64.3
	08/05/19	195	--	--	71.1	--
	11/05/19	--	39	7.2		62.1
	02/25/20	175	--	--	81.7	--
	5/11/2020	183	29	7	110.6	64
	11/10/2020	207	43	6.9	72.6	65
	2/2/2021	73	--	--	77.6	--
	8/3/2021	102	--	--	93.8	--
	11/2/2021	203	44	7	83.4	51
	2/9/2022	202	--	--	60.3	--
	5/4/2022	202	27	6	72.8	61.1
	8/10/2022	210	--	--	97	--

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Optimal range	60-120	30-60	6-7.5	86-104	20-60

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Biofilter Rebuilt November 2019			
	02/25/20	62	56	7.4	43.1	58.9
	5/11/2020	83	--	--	70.3	--
	8/6/2020	128	58	7.2	79.4	56.6
	11/10/2020	97	--	--	59.8	--
Sorting/Grinding	2/2/2021	54	40	6.9	56.6	70.9
	8/3/2021	68	31	7	79.1	21.8
	11/2/2021	63	--	--	59.4	--
	2/9/2022	35	31	6.9	50.8	68.5
	5/4/2022	44	--	--	57.4	--
	8/10/2022	49	23	6.5	72.5	48

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Media Added April 2020			
	5/11/2020	46	60	7.6	92.4	52.3
	8/6/2020	47	--	--	85.2	--
	11/10/2020	41	58	6.5	78.6	24.4
Tipping	2/2/2021	35	--	--	66.6	--
	8/3/2021	39	--	--	90.2	--
	11/2/2021	33	42	7.3	74.4	47
	2/9/2022	44	--	--	56.6	--
	5/4/2022	40	42	6.1	61.2	58.3
	8/10/2022	34	--	--	78.2	--

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Biofilter Rebuilt February/March 2020			
	5/11/2020	295	--	--	110.5	--
	8/6/2020	379	44	7.3	89.9	57.2
			Media Added August 2020			
	11/10/2020	221	--	--	70.1	--
Upper Primary	2/2/2021	267	52	7.1	75.2	71.1
	8/3/2021	141	40	6.2	95.9	34.3
	11/2/2021	328	--	--	81.7	--
	2/9/2022	282	20	6.9	56.6	63.2
	5/4/2022	368	--	--	71.1	--
	8/10/2022	342	23	6.7	95.3	64.9

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Maple Valley, Washington

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Optimal range	60-120	30-60	6-7.5	86-104	20-60

Biofilter	Date	ResidenceTime(s)	Free Air Space (%)	pH	Temperature (°F)	Moisture (%)
			Media Replaced September 2017			
	12/19/17	283	--	--		--
	06/19/18	158	--	--	78.4	--
	09/18/18	164	49	6.8	80	65.8
	12/04/18	182	--	--	50.1	--
	03/07/19	136	46	6.6	42.8	71.1
	05/16/19	136	--	--	66.7	--
	08/05/19	118	40	6.6	74.2	51.2
West Secondary	02/25/20	--	44	6.1		68.9
	5/11/2020	118	--	--	78.8	--
	8/6/2020	133	47	5.9	81.3	63
	11/10/2020	134	--	--	64.2	--
	2/2/2021	187	32	5.9	59.1	75
	8/3/2021	113	15	6.6	85.4	23.6
	11/2/2021	182	--	--	74.2	--
			Biofilter Rebuilt February-June 2022			
	8/10/2022	199	43	7.4	67.8	59.3