Appendix G. Quality Assurance & Quality Control

Researchers followed quality control procedures to ensure the precision and completeness of collected data and minimize bias. The staff lead for quality control performed periodic sampling design evaluations by reviewing the field measurements collected and the number of samples collected.

Transfer of data from field logs and lab reports to an electronic format was performed regularly throughout the study period so that errors in the field logs could be identified and fixed. The lead staff person for quality control analysis reviewed the electronic databases of the field and lab data and all transfer errors were corrected. The quality control analysis lead also reviewed the laboratory data package with special attention to quality control results and verified any improbable data.

1.1. Precision

Duplicate and split samples were used to ensure that inconsistencies in field sampling procedures and laboratory analysis methods were not contributing to imprecision of measurements. Field researchers collected duplicate samples at 4 (18%) of the 22 sites with access to free-fall UVD unit effluent.[1] The duplicates were collected within 5 minutes of each other and were handled identically until field and lab analysis was completed. Additionally, the laboratory staff analyzed split samples from the same sample collection bottle (1 split sample per day).

Researchers analyzed duplicate and split samples by calculating the relative percent difference with the following equation:

$$RPD = \{(S - D) / [(S+D)/2]\} \times 100\% \qquad (1)$$

Where:

RPD = relative percent difference
S = Analytical result of sample of origin
D = Analytical result of the duplicate sample

Fecal coliform values are highly variable, especially when taking samples of flowing wastewater. For fecal coliform values that were less than or equal to 50 CFU/100 mL (5 times the reporting limit), precision was achieved if the duplicate sample values were within 20 CFU/100 mL (2 times the reporting limit) of the sample value. Table G.1 shows a summary of the precision analysis for field and lab parameters.

[1] Because of a misunderstanding of the quality control procedures outlined in the QAPP, daily grab sample duplicates were not routinely collected. Instead, the field researchers collected a duplicate sample at 10% of the site visits.

Table G.1. Precision of wastewater quality measurements in duplicate free-fall samples, expressed as relative percent differences (RPDs)

	Target RPD	Mean RPD	SD RPD	Min RPD	Max RPD	% Passed
Field Analysis						
Ultraviolet Transmittance [%]	≤ 10%	1.77	1.42	0.47	1.42	100
Turbidity [NTU]	≤ 10%	14.0	12.1	0.95	25.0	33
Conductivity [µS/cm]	≤ 10%	1.09	0.61	0.39	1.49	100
Dissolved Oxygen [mg/L]	≤ 10%	1.14	1.67	0.16	3.08	100
pH [s.u.]	≤ 10%	1.05	0.80	0.15	1.69	100
Temperature [℃]	≤ 10%	1.13	0.62	0.49	1.72	100
Laboratory Analysis						
Duplicate Samples FC [CFU/100 mL]	≤ 35%	-	-	-	-	NA*
* All samples < 50 CFU/100 mL						
Split Samples FC [CFU/100 mL]	≤ 35%	9.0**	13.1	0	28.6	100
**4 samples < 50 CFU/100 mL						

The study achieved high precision for ultraviolet transmittance (UVT), conductivity, dissolved oxygen (DO), pH, and temperature. The precision of turbidity measurements did not meet desired RPDs because the turbidity meters used for the study did not stabilize well. Field researchers maximized precision by measuring turbidity multiple times until two consistent measurements were obtained. Field researchers determined that instrument drift did not introduce bias to the results, but that turbidity results should be considered estimates (within 10 NTU) of the true turbidity.

Because fecal coliform measurements are highly variable, it is not informative to estimate RPDs from only 4 field duplicates, so the usability of the data was determined by reviewing the results, as Mathieu has recommended (Mathieu, 2006). The discrepancies between field duplicate fecal coliform concentrations were likely due to the differences in wastewater influent during the time that elapsed between taking the duplicate samples (≥ 5 minutes). Although the inherent variability of the wastewater effluent contributed to limited precision of duplicate samples, the researchers determined that the free-flow grab sampling procedure was followed at each site and that the fecal coliform measurements could still be used as point estimates of wastewater microbial quality.

1.2. Bias

Bias of analytical results was minimized by consistent calibration of field instruments and adherence to SOPs for sample collection, storage, transportation, and analysis. Field instruments, which were used to measure wastewater quality parameters, were checked for instrument drift and calibrated before each day of use. Appendix D includes calibration logs, which include information about calibration checks. All calibration checks were within the acceptable range, and no bias was introduced due to calibration problems.

Instrument drift was minimal for all instruments except the Global Water turbidity meter. Two different Global Water turbidity meters were used throughout the course of the study. The first meter experienced significant drift over the 7-hour period of field sampling. Field researchers minimized the drift by comparing turbidity results to visual analysis of the sample and, when needed, recalibrating before measuring sample turbidity. When recalibration was necessary, researchers transported samples to the lab and measured turbidity at the end of the sampling period (always ≤ 6 hours from sampling time). The initial turbidity meter was exchanged for a different meter on July 10th, 2017. Instrument drift was lower with this meter, but researchers still experienced trouble with instrument stabilization.

Inducing flow through some of the observed OSSs to provide adequate flow to collect an effluent sample could have biased the wastewater quality measurements by diluting the wastewater. Researchers induced flow as early in the treatment train as possible (in the household or in the primary tank) in order to minimize its effects on the final effluent.

1.3. Sensitivity

The sensitivity of the field measurements and laboratory analysis were determined by the method detection limits (MDLs). Table G.2 shows MDLs for all measured parameters.

Table G.2. MDLs for Wastewater Quality Parameters

Parameter	MDL
UVT	1%
Turbidity	0.1 NTU
Conductivity	0.1
DO	0.1 mg-DO/L
pH	0.1 s.u.
Temp	0.1
Fecal Coliform	10 CFU/100 mL

1.4. Comparability

All researchers were trained to use appropriate sampling and testing procedures and follow SOPs for study methods. This ensured comparability across sampling days and research. Researchers maximized comparability of field measurements by calibrating field instruments before each sampling day, measuring field parameters immediately, and consistently performing field measurements in the same order. Laboratory staff used standard lab methodology and trained lab personnel. No comparability issues were identified for the study.

1.5. Representativeness

The collected grab samples are representative of the wastewater effluent during a small period of time. Because residential wastewater generation varies significantly depending on residents' behaviors, time of day, and status of wastewater infrastructure, information from grab samples should be interpreted with caution. Because flowrates were slow for most samples, the data collected is representative only of UVD effluent with slow flowrates.

When compared to all OSSs with UVD units in Pierce and Thurston Counties, the study sample represents well the age and models of the total OSSs in both counties. On average, the OSSs included in the sample have been maintained slightly more recently than the average maintenance time for all OSSs with UVD units. Researchers expected that the study sample would exclude some of the units that are not being maintained. Because of this, the results from the study may underestimate the proportion of UVD units that are currently malfunctioning. For a more detailed comparison of the representativeness of the sample, see Tables G.4 and G.5.

1.6. Completeness

Researchers determined whether they completed the planned sampling goals by calculating percent completeness:

Percent completeness = (V/T) x 100%

Where:

V = number of measurements that are valid

T = total number of measurements planned in the study

The number of valid measurements was determined by multiplying the total number of measurements for each wastewater quality parameter by the fraction that passed the precision criteria.

A summary of the completeness achieved for wastewater quality measurements is shown in Table G.3. Several unexpected challenges caused the completeness to be under the desired 95%. Researchers were under the impression that all OSSs with UVD units in Thurston County were designed with access to a free-fall sampling. However, 10 (31%) of the studied OSSs in Thurston County did not have access to a free-fall sampling port. Because the study time schedule was limited, additional OSSs could not be added to the sample. This significantly decreased the percent completeness. Additionally, the imprecision of the turbidity meter decreased the percent completeness for turbidity measurements. Although the study was not able to characterize wastewater quality at the desired number of OSSs, the data that was obtained was sufficient to provide important insight into the field effectiveness of UVD units in onsite wastewater treatment.

Table G.3 Completeness Achieved for Wastewater Quality Measurements

	Valid Measurements	Planned Measurements	Percent Completeness
UV Transmittance	22	27	81.5
Turbidity	7.26	27	26.9
Dissolved Oxygen	22	27	81.5
pH	22	27	81.5
Conductivity	22	27	81.5
Temperature	22	27	81.5
Fecal Coliform	22	27	81.5

Appendix G from https://www.doh.wa.gov/Documents/Pubs/337-155.pdf.