HUMAN-ASSOCIATED *Bacteroidales* HF183 MARKER IN WATER BY QUANTITATIVE POLYMERASE CHAIN REACTION (qPCR) ASSAY

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1. SCOPE AND APPLICATION

1.1. This method describes a quantitative polymerase chain reaction (qPCR) procedure that targets a sequence in the 16S rRNA gene found in multiple *Bacteroides* species which are associated with human feces.

1.2. Tests covered by this SOP are PCR-HF183 and PUR-HF183.

2. SUMMARY OF THE METHOD

2.1. Bacteria present in a water sample are collected by filtration. The filtered sample is processed by a bead beater in the presence of zirconium silica beads to extract the DNA from the bacterial cells into a buffer solution. The clarified extract may also be purified using a purification kit. The extract is analyzed with qPCR amplification and detection in a thermocycler system using a primer/probe assay specific to human associated *Bacteroidales*. Solid samples are weighed and purified prior to PCR amplification and detection.

2.2. Interferences: Colloidal or suspended particulate materials in water can clog the filter and prevent filtration of enough sample needed to detect the target sequence. Some substances, including humic and tannic acids, can act as inhibitors and reduce efficiency by either binding to the DNA polymerase or interfering with the annealing and extension cycles. Sample purification or dilution can help alleviate the effects of inhibitors.

2.3. Definitions:

2.3.1. qPCR: Quantitative Polymerase Chain Reaction is a procedure in which the amount of DNA amplified in each PCR cycle is measured using fluorescent dyes to determine the original amount of DNA in the sample.

2.3.2. Target sequence: The DNA sequence in the Gene of Interest (GOI) that is amplified by the primers/probe in each PCR cycle. The primers/probe set is designed to attach specifically to this sequence.

2.3.3. *Bacteroides*: A genus of anaerobic, Gram-negative rod bacteria that are typically found in the gastrointestinal tract of humans and animals.

2.3.4. Standard Curve: A dilution series of standards with known DNA concentrations is analyzed and plotted on a graph with the log of the known concentrations on the x-axis and the quantification cycle (C_q) value of each dilution on the y-axis to create a standard curve. The standard curve is used to determine the concentrations of unknown samples and the performance of the reaction using several parameters including the slope and correlation of the graph.

3. EQUIPMENT AND SUPPLIES

3.1. Instrumentation –

Instrument Name	Serial Number	Manufacturer
QuantStudio3 Thermocycler	272311740	Applied Biosystems

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PCR3 – Step One Plus Thermocycler	2720010389	Applied Biosystems

3.2. Equipment –

Equipment	Notes
Autoclave	S/N 031761851
Mettler Precision Balance Model XA105DU	S/N B314195659
CBS Optimizer PCR Workstation #1	S/N 007631
CBS Optimizer PCR Workstation #2	S/N 007632
Micropipettes	N/A
Fisher Mini Vortex	N/A
Fisher Microcentrifuges	N/A
Megafuge ST4F Plus Centrifuge	S/N 43085295
PCR#2, Thermo Freezer	S/N 0121174101121218; Maintained at -20 ± 10°C, Room B246A
PCR#4, Thermo Freezer	S/N 0121174201121218; Maintained at -20 ± 10°C, Room B246B
PCR#5, Thermo Fridge/Freezer	S/N 0121174701121218; Maintained at 4 ± 2°C and -20 ± 10°C, Room B246
PCR#7, Thermo ULT Freezer	S/N 0128473401090813; Maintained at -80 ± 10°C, Room B246
PCR#9, Thermo Fridge	S/N 7R1562211012; Maintained at 4 ± 2°C, Room B246A
PCR#10, Thermo TDE Freezer	S/N 1127920701221013; Maintained at -80 ± 10°C, Room B246
Or Equivalent	

3.3. Supplies/Consumables –

Supply/Consumable	Notes
Gloves, Latex or Nitrile	N/A
Tube Racks	N/A
Dispersion Beads, 0.1 mm, Zirconium Silica	Weigh out 0.3 ± 0.01 g of dispersion beads into each extraction tube. Seal tube tightly, making sure the O-ring is seated properly. Autoclave at 121°C for 15 min (15 psi). Record in LIMS Autoclave Log.
Extraction Tubes, Conical, 2 mL Screw Cap with O-Ring Seal	
Centrifuge Tubes, 0.5, 1.5, and 2.0 mL	N/A
Filter Tips, Sterile PCR Grade	N/A
96-Well Reaction Plate, Clear	N/A
96-Well Plate Holders	N/A
96-Well Plate Stands	N/A
Optical Adhesive Seal for Reaction Plates	N/A
Or Equivalent	

4. REAGENTS AND STANDARDS

4.1. Reagents and Standards –

Reagent/Standard	Notes
Deionized Water	N/A
Molecular Biology Grade Water	Corning Molecular Biology Grade Water tested to USP Sterile Water (Catalog Number: MT46000CV)
Bleach Solution, 10% (v/v)	Prepare per SOP BG-05
Bovine Serum Albumin (BSA), 2 mg/mL	Prepare per SOP PCR-3.0
PerfeCta® qPCR ToughMix™, ROX™	Use with Step One Plus Thermocycler
TaqMan™ Environmental Master Mix 2.0	Use with QuantStudio3 Thermocycler
Salmon DNA Standards (10^3, 10^2, 10^1)	Prepare per SOP PCR-3.1
Salmon DNA Extraction Buffer	
Salmon DNA Forward and Reverse Primers, 500 µM Stock	

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Salmon DNA Probe, 100 µM Stock	
HFG2GD gBlock Standards (10^6, 10^5, 10^4, 10^3, 10^2)	Prepare per SOP PCR-3.2
HFG2GD gBlock DNA Spikes (10^6, 10^4)	
HF183 Forward and Reverse Primers, 500 µM Stock	These are purchased from Eurofins (SOP PCR-5.3). **Forward Primer HF183F:** 5'- ATCATGAGTTCACATGTCCG- 3' **Reverse Primer BacR287:** 5'-CTTCCTCTCAGAACCCCTATCC-3' Prepare per SOP PCR-3.2
TaqMan Probe, 100 µM Stock	**Probe BacP234MGB:** [6-FAM]-5'-CTAATGGAACGCATCCC-[MGBEQ] 3' Prepare per SOP PCR-3.2

5. CALIBRATION AND STANDARDIZATION

5.1. See DEP Laboratory Quality Manual, Section 5.5.

5.2. Check the calibration of thermometers annually. See SOP LB-035.

5.3. Check the calibration of micropipettes quarterly for accuracy and precision. See SOP PCR-2.4.

5.4. Refer to SOP PCR-2.3 for use and maintenance of the thermocyclers.

5.5. Refer to SOP BB-036 for calibration and use of the balance.

5.6. Sterilization of the workstation:

5.6.1. UV workstation: After each use, wipe down all surfaces with 10% bleach, then with PCR grade water. Turn on UV lamps for at least 3 minutes. Wipe metallic surfaces with 80% ethanol weekly to prevent corrosion. Never mix bleach and ethanol.

5.6.2. Counters: Clean work area counters after use. Spray surface of work area with 10% bleach solution and wipe down after 15 minutes. Spray and wipe down with sterile DI water.

6. SAMPLE COLLECTION, PRESERVATION, AND HANDLING

6.1. See DEP Field SOP FS 2000 for sample collection and preservation.

6.2. See SOP PCR-5.0 for details on sample custody and printing sample labels.

7. SAMPLE PREPARATION

7.1. Prior to analysis, samples are filtered, per SOP PCR-4.0, and extracted, per SOP PCR-4.1. Inhibited or solid samples are purified according to SOP PCR-4.2.

8. ASSAY PREPARATION

NOTE: Primer/Probe Mix, Master Mix, and Standard preparation for each plate is documented in the PCR-PLATEPREP form. These are saved at \\FLDEP1\DEAR\Labs\Lab3\Biology\qPCR\RxnPlatePrepWS. The Primer/Probe Mix and Master Mix are prepared in PCR Workstation #1.

8.1. Primer/Probe Mix Preparation –

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8.1.1. HF183 Assay –

Forward Primer, 500 µM	8 µL
Reverse Primer, 500 µM	8 µL
Probe, 100 µM	3.2 µL
PCR Grade Water	580.8 µL

In a blue 1.5 µL centrifuge tube, add 8 µL of each primer stock and 3.2 µL of probe to 580.8 µL of PCR grade water to make the primer/probe mix. Mix by tapping then centrifuge briefly.

Label with the date, assay name, and "PP" and store at 4°C. Use within one week.

8.1.2. SKETA Assay –

Forward Primer, 500 µM	10 µL
Reverse Primer, 500 µM	10 µL
Prober, 100 µM	9 µL
PCR Grade Water	571 µL

In a pink 1.5 µL centrifuge tube, add 10 µL of each primer stock and 9 µL of probe to 571 µL of PCR grade water to make primer/probe mix. Mix by tapping then centrifuge briefly.

Label with the date, assay name, and "PP" and store at 4°C. Use within one week.

8.1.3. Primer/Probe Mix Summary –

	HF183 Assay	SKETA Assay
Forward Primer (500µM Stock)	8 µL	10 µL
Reverse Primer (500µM Stock)	8 µL	10 µL
Probe (100µM Stock)	3.2 µL	9 µL
Sterile H_2O	580.8 µL	571 µL

8.2. qPCR Master Mix Preparation –

8.2.1. Count the number of wells needed for each assay to determine the total volume of reagents needed for the assay. Add an additional 3-4 wells to this total to ensure enough Master Mix is available, as some can be lost in mixing and pipetting. Enter the number of wells in the '#Rxns,' column in the Master Mix Preparation section of the reaction plate worksheet.

8.2.2. For each assay add 2 µL X total wells of BSA, 10 µL X total wells of PerfeCta® qPCR ToughMix™ Rox™ for the StepOne Plus or TaqMan™ Environmental Master Mix 2.0 for the QuantStudio3, and 3 µL X total wells of primer/probe mix (PP). Use a pink 1.5 µL centrifuge tube for the SKETA Master Mix and a blue 1.5 µL centrifuge tube for the HF183 Master Mix. Label the tubes "MM".

8.2.3. Master Mix Summary –

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Reagent	HF183 Assay		SKETA Assay	
	Volume per reaction (µL)	Volume (µL) per full plate (68 + 4 extra wells)	Volume per reaction (µL)	Volume (µL) per full plate (28 + 3 extra wells)
BSA 2 mg/mL	2	144	2	62
ToughMix MM	10	720	10	310
Primer/Probe Mix	3	216	3	93
Total of 15 µL of Master Master Mix + 5 µL of DNA template = total volume of 20 µL per reaction				

9. REACTION PLATE PREPARATION

9.1. Plate Layout Map –

	1	2	3	4	5	6	7	8	9	10	11	12	
A	STD Curve E6	STD Curve E6	STD Curve E6	MBLK_	EXBLK_	LFB_BDSPK	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	A
B	STD Curve E5	STD Curve E5	STD Curve E5	MBLK_	EXBLK_	LFB_BDSPK	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	B
C	STD Curve E4	STD Curve E4	STD Curve E4	NTC_1	NTC_2	NTC_3	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	C
D	STD Curve E3	STD Curve E3	STD Curve E3	SURNTC_1	SURNTC_2	SURNTC_3	Sample1_ SUR_	Sample2_ SUR_	Sample3_ SUR_	Sample4_ SUR_	Sample5_ SUR_	Sample6_ SUR_	D
E	STD Curve E2	STD Curve E2	STD Curve E2	LFB_BDLFB	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	E
F	STD Curve E3	STD Curve E3	STD Curve E3	LFB_BDLFB	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	Rep 2	F
G	STD Curve 100	STD Curve 100	STD Curve 100	SUR_BDLFB	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	_SPK_BDSPK	G
H	STD Curve 10	STD Curve 10	STD Curve 10	SUR_BDLFB	Sample7_ SUR_	Sample8_ SUR_	Sample9_ SUR_	Sample10_ SUR_	Sample11_ SUR_	Sample12_ SUR_	Sample13_ SUR_	Sample14_ SUR_	H
	1	2	3	4	5	6	7	8	9	10	11	12	

* HF183 Assay (blue background); SKETA Assay (pink background)

9.2. Collect a 96 well plate and holder. In PCR workstation #1, add 15 µL of appropriate qPCR Master Mix assay to each well of the reaction plate using the electronic Xplorer pipette with a 100 µL tip. Use the figure in Section 9.1. as a guide. Add the HF183 Master Mix to the blue wells and the SKETA Master Mix to all the pink wells. Place the Master Mix, BSA, and any extra PP mix back in PCR#9 refrigerator. Carefully move the plate to PCR workstation #2.

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9.2.1. Occasionally re-mix the Master Mix by tapping the tube, followed by a pulse spin in the minicentrifuge. This ensures that the Master Mix is evenly distributed into all the wells.

9.2.2. Master Mix is more viscous than water and should be pipetted slowly to ensure accuracy. Bubbles can easily form in the pipette tip if pipetted too quickly.

9.3. In PCR workstation #2, add 5 µL of DNA sample extract or control to each well using a 10 µL pipette. Use the figure in Section 9.1. as a guide. To ensure proper mixing, tap mix then centrifuge briefly. Switch tips for each sample or control. If any liquid falls outside of the well or sprays, the plate should be discarded and hood thoroughly cleaned. Use the following order for addition of the template to wells:

9.3.1. Add the HF183 Standard Curve controls (12.1.) to wells A1-E3.

9.3.2. Add the SKETA Standard Curve controls (12.2.) to wells F1-H3

9.3.3. Add the method blank (MBLK; 12.3.2.) control to wells A4-B4.

9.3.4. Add the extraction blank (EXBLK; 12.3.3.) control to wells A5-B5.

9.3.5. Add PCR grade water for the No Template Controls (NTC, SURNTC; 12.3.1.).

9.3.6. Add 1 µL of the HF183 spike standard (LFB_BDSPK, and _SPK_BDSPK; 12.4.3.) to the spike control and 3rd well samples in wells A6-B6, C7-C12, and G5-G12. Then, add 5 µL of PCR Grade water to the 3rd well spike control wells, A6 and B6.

9.3.7. Add the extraction control (LFB_BDLFB, SUR_BDLFB; 12.4.1.) to wells E4-H4.

9.3.8. Add the sample extracts to appropriate wells (4 wells per sample). Add the sample to the three HF183 wells first, change tip, and then add the sample to the final SKETA well.

9.4. Seal plate with optical adhesive. Vortex slowly, on Speed 1, for 30 seconds to mix.

9.5. Centrifuge plate at 1300 gfor 2 minutes (Program 1 the MegafugeST4F Plus Centrifuge). Check to make sure the reaction mix is at the bottom of each well. If not, centrifuge for another minute.

10. SAMPLE ANALYSIS

10.1. Place plate in thermocycler and analyze. Refer to SOP PCR-2.3 for setup and use of the thermal cycler. Use the default thermal cycler cycling conditions for a standard ramp speed (See Table Below).

		PCR	
Step	Enzyme Activation	Cycle (40 cycles)	
	Hold	Denature	Anneal/Extend

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Temperature (°C)	95	95	60
Time	10 min.	15 sec.	1 min

11. DATA ARCHIVAL

11.1. Refer to SOP PCR-2.3 for instrument file setup.

11.2. Refer to SOP PCR-5.0 for worksheet instructions.

11.3. Refer to SOP PCR-5.1 for data upload instructions.

12. QUALITY CONTROL

12.1. HF183 Assay Standard Curves

12.1.1. Analyze an HF183 Assay standard curve per plate. Run five serially diluted standards in triplicate at the following concentrations:10^6, 10^5, 10^4, 10^3, and 10^2.

12.1.2. Standard curve efficiency should be between 90–115% and R^2 should be ≥ 0.99. Reanalyze samples and notify a supervisor if efficiency is < 70% or R^2 is < 0.97.

12.2. SKETA Assay Standard Curves

12.2.1. Analyze a SKETA Assay standard curve per plate. Run three serially diluted standards in triplicate at the following concentrations: 10^3, 10^2, and 10^1.

12.2.2. Standard curve efficiency should be between 80–120% and R^2 should be ≥ 0.99. Samples are not affected if the efficiency or R^2 are outside limits.

12.3. Negative Controls

12.3.1. No Template Control (NTC)

12.3.1.1. For each Master Mix used on a reaction plate, add 15 µL of Master Mix and 5 µL of sterile water to three wells.

12.3.1.2. Label the HF183 NTCs as NTC_1, NTC_2, and NTC_3. Label the SKETA NTCs as SURNTC_1, SURNTC_2, and SURNTC_3.

12.3.1.3. If any of the NTCs have a result of less than 35 C_q, the reaction plate may have contamination. Re-run if samples are affected and notify a supervisor.

12.3.2. Method Blank (MB) – labeled MBLK_#

1.1.1.1. 12.3.2.1. Analyze a method blank for each batch of samples filtered (maximum of 13 samples per batch). Filter 50 mL of sterile PBS at the beginning of each sample batch. Extract and analyze with the same batch of samples. Add 5 µL of the MB extract to duplicate wells containing 15 µL HF183 Master Mix.

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12.3.2.2. If the MB has a result above the MDL, there may be possible sample contamination. All sample detects in the batch that are less than ten times the amount of contamination should be "V" qualified and the following comment should be added: "Result is V-qualified due to a control blank failure." For samples that are greater than 10X the blank, add the following comment: "Control blank failure. Result is >=10 times blank result." No "V" qualifier is needed.

12.3.3. Extraction Blank (EB) – labeled EXBLK_#

12.3.3.1. Analyze an extraction blank for each batch of samples extracted (maximum of 13 samples per batch). Place a sterile filter in an extraction tube labeled EB, add 600 µL of salmon buffer, and extract along with the samples. Add 5 µL of the EB extract to duplicate wells containing 15 µL HF183 master mix.

12.3.3.2. If the EB has a result less than 35 C_q, there may be possible contamination at the extraction step. Reanalyze samples, as they may be affected and notify a supervisor.

12.4. Positive Controls

12.4.1. Extraction Control (EC)

12.4.1.1. Analyze an extraction control for each batch of samples extracted (max.imum of 13 samples per batch). Place a sterile filter in an extraction tube labeled EC. Pipette 5 µL of 10^6 HF183 standard into the filter and add 595 µL of salmon buffer.

12.4.1.2. On the plate, the HF183 assay EC is labeled LFB_BDLFB# and the SKETA assay EC is labeled SUR_BDLFB#.

12.4.1.3. The extraction control helps determine extraction recovery. Percent recovery of extraction control for both the HF183 and SKETA assay should be 75–150%. If recovery is low, extraction efficiency may be low.

12.4.2. Sample Processing Control (SPC) (SKETA Assay)

12.4.2.1. The SKETA assay serves as a sample processing and inhibition control. Salmon DNA is added to the extraction buffer and each sample is analyzed for both the HF183 and SKETA assays. The SKETA assay measures the amount of recovery of Salmon DNA and therefore the efficiency of the extraction process. Low recovery indicates an inefficient extraction process or the presence of inhibition. This control is reported as a surrogate.

12.4.2.2. Analyze each sample, replicate, and extraction control with the SKETA assay alongside the HF183 Assay.

12.4.2.3. Compare extraction control Salmon DNA recovery to the Salmon DNA recovery in each of the samples. If sample

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recovery is <50% of the extraction control recovery, then the sample may be inhibited.

12.4.3. Inhibition control (3rd well spike)

12.4.3.1. A known amount of HF183 DNA is added to each sample as a matrix spike to check for inhibition. For each sample and replicate, spike the 3rd well of the HF183 assay with 1 µL of E4 HF183 spike standard. Also add 1 µL of the standard to the spike control wells.

12.4.3.2. Compare spike control recovery to sample matrix recovery. If sample amplification is <50% of the control recovery, the sample matrix may have inhibitory effects.

12.4.4. If both the SPC and 3rd well spike show inhibition, re-run the sample from a diluted or purified extract. The purification kit may remove inhibitors.

12.4.4.1. If only one of the two controls show possible inhibition, consult a supervisor prior to dilution or reanalysis.

12.5. Replicate Sample

12.5.1. Analyze at least one replicate per filtration batch (maximum of 13 samples per batch). Filter and analyze the replicate in the same manner as original sample and within the same batch. Replicate samples are numbered SAMPLE ID_DUP_A and SAMPLE ID_DUP_B and 100 mL is filtered for each.

12.5.2. The target replicate relative percent different (RPD) ≤25%. If RPD >25%, the duplicate will automatically be "J" qualified at the job authorization step. A comment regarding precision is automatically added to the report.

12.5.3. If a replicate sample is not run, all samples in the batch should have the comment "Precision data unavailable for HF183-qPCR component" or "Precision data unavailable for HF183-purified-qPCR component" added to the results.

12.6. Refer to SOP PCR-5.1 for further details on uploading quality control data into LIMS, including calculations and control limits.

13. SAFETY/HAZARDOUS WASTE MANAGEMENT

13.1. All plates must be autoclaved for 45 minutes before disposal.

13.2. Refer to the Health and Safety Plan. Read MSDS information for reagent handling and disposal.

14. REFERENCES

14.1. EPA 815-B-04-001, Quality Assurance/Quality Control Guidance for Laboratories Performing PCR Analyses on Environmental Samples (October 2004)

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14.2. PerfeCta® qPCR ToughMix™, Rox™ Protocol

14.3. DEP Laboratory Quality Manual DEP Laboratory Quality Assurance Manual

14.4. Health and Safety Plan Health and Safety Plan

14.5. DEP SOP FS 2000, *General Water Sampling*

14.6. DEP SOP LB-035, *Calibration of Lab Thermometers using a Constant Temperature Calibration Bath*

14.7. DEP SOP BB-36, *Calibration, Use and Maintenance of Mettler Toledo XA105DU Balance*

14.8. DEP SOP PCR-2.3, *Use and Calibration of StepOnePlusTMReal-Time PCR System and QuantStudio3 Reat-Time PCR System*

14.9. DEP SOP PCR-2.4, *Calibration and Use of Mechanical Pipettes using PCS® Pipette Calibration System*

14.10. DEP SOP PCR-3.0, *Preparation of Reagents for quantitative Polymerase Chain Reaction (qPCR)*

14.11. DEP SOP PCR-3.1, *Preparation of SKETA assay standards and reagents for qPCR analysis*

14.12. DEP SOP PCR-3.2, *Preparation of HF183 Assay Reagents and Standards for qPCR analysis*

14.13. DEP SOP PCR-4.0, *Preparation of samples for qPCR*

14.14. DEP SOP PCR-4.1, *Crude Lysate Extraction Method for qPCR samples*

14.15. DEP SOP PCR-4.2, *Purification of Filtered Samples using the Qiagen DNeasy PowerLyzer PowerSoil Kit*

14.16. DEP SOP PCR-5.0, *Sample Custody, Preparation Labels, and Worksheet Instructions for Molecular Biology*

14.17. DEP SOP PCR-5.1, *LIMS QC Manager Data upload, Verification, and Sample Authorization for qPCR samples*

Appendix of Significant Changes

09/29/2016	Updated SOP references and master mix reagent.
08/16/2019	Updated new QuantStudio Thermocycler and DEP Laboratory Quality Manual
07/31/2020	Updated Autoclave serial number and DEP Laboratory Quality Manual
07/09/2021	Updated HF183 assay primer, probes and standards to EPA method 1696
07/18/2022	Added new -80 ºC freezer information with serial number. Removed B. Dorei reference. Updated naming convention of primer/probe sequence. Updated link to QA manual. Removed reference of archived SOP PCR-2.5.
07/05/2023	Reformatted SOP and added tables to Sections 3, 4, 8, and 10.

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