

EUA Submission - FloodLAMP QuickFluor™ COVID-19 Test

A. PURPOSE FOR SUBMISSION

Emergency Use Authorization (EUA) request for distribution and/or use of the **FloodLAMP QuickFluor™ COVID-19 Test** for the *in vitro* qualitative detection of RNA from the SARS-CoV-2 in upper respiratory specimens including oropharyngeal and nasopharyngeal swabs, anterior nasal and mid-turbinate nasal swabs **from individuals suspected of COVID-19 by their healthcare provider and from individuals without symptoms or other epidemiological reasons to suspect COVID-19 infection, when tested at a weekly interval with no more than 9 days between tests**. Additional testing and confirmation procedures should be performed in consultation with public health and/or other authorities to whom reporting is required. Test results should be reported in accordance with local, state, and federal regulations.

B. MEASURAND

Specific nucleic acid sequences from the genome of the SARS-CoV-2, targeted by **primers from the ORF1ab, N & E regions** of the virus. Primer names and sequences are listed in Table 1.

Table 1: Primer names and sequences

Primer Name	Sequence (5'-3')
ORF1ab gene (AS1e)	
Orf1ab_FIP	TCAGCACACAAAGCCAAAAATTTATTTTCTGTGCAAAGGAAATTAAGGAG
Orf1ab_BIP	TATTGGTGGAGCTAAACTTAAAGCCTTTTCTGTACAATCCCTTTGAGTG
Orf1ab_F3	CGGTGGACAAATTGTCAC
Orf1ab_B3	CTTCTCTGGATTTAACACACTT
Orf1ab_LF	TTACAAGCTTAAAGAATGTCTGAACACT
Orf1ab_LB	TTGAATTTAGGTGAAACATTTGTCACG
N Gene (N2)	
N2_FIP	TTCCGAAGAACGCTGAAGCGGAAGTATTACAAACATTGGCC
N2_BIP	CGCATTGGCATGGAAGTCACAATTGATGGCACCTGTGTA
N2_F3	ACCAGGAACTAATCAGACAAG
N2_B3	GACTTGATCTTTGAAATTGATCT
N2_LF	GGGGGCAAATTGTGCAATTTG
N2_LB	CTTCGGGAACGTGGTTGACC
E Gene (E1)	
E1_FIP	ACCACGAAAGCAAGAAAAAGAAGTTCGTTTCGGAAGAGACAG
E1_BIP	TTGCTAGTTACACTAGCCATCCTTAGGTTTTACAAGACTCACGT
E1_F3	TGAGTACGAAGTATGTACTCAT
E1_B3	TTCAGATTTTAAACACGAGAGT
E1_LF	CGCTATTAACATTAACG
E1_LB	GCGCTTCGATTGTGTGCGT

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C. APPLICANT

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D. PROPRIETARY AND ESTABLISHED NAMES

Proprietary Name - **FloodLAMP QuickFluor™ COVID-19 Test**

Established Name - **FloodLAMP QuickFluor™ COVID-19 Test**

E. REGULATORY INFORMATION

Approval/Clearance Status:

The **FloodLAMP QuickFluor™ COVID-19 Test** is not cleared, CLIA waived, approved, or subject to an approved investigational device exemption.

Product Code:

QJR

F. PROPOSED INTENDED USE

1) Intended Use:

FloodLAMP QuickFluor™ COVID-19 Test is a reverse transcriptase loop-mediated isothermal amplification (RT-LAMP) assay intended for the qualitative detection of RNA from SARS-CoV-2 in upper respiratory specimens including nasopharyngeal swabs, anterior nasal and mid-turbinate nasal swabs **from individuals suspected of COVID-19 by their healthcare provider and from individuals without symptoms or other epidemiological reasons to suspect COVID-19 infection, when tested at a weekly interval with no more than 9 days between tests.** Testing is limited to **laboratories certified under the Clinical Laboratory**

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Improvement Amendments of 1988 (CLIA), 42 U.S.C. §263a, to perform high complexity tests, or by similarly qualified non-U.S. laboratories.

Results are for the identification of SARS-CoV-2 RNA. The SARS-CoV-2 RNA is generally detectable in upper respiratory specimens including nasopharyngeal swabs, anterior nasal and mid-turbinate nasal swabs during the acute phase of infection. Positive results are indicative of the presence of SARS-CoV-2 RNA; clinical correlation with patient history and other diagnostic information is necessary to determine patient infection status. Positive results do not rule out bacterial infection or co-infection with other viruses. The agent detected may not be the definite cause of disease. Laboratories within the United States and its territories are required to report all test results to the appropriate public health authorities.

Negative results do not preclude SARS-CoV-2 infection and should not be used as the sole basis for patient management decisions. Negative results must be combined with clinical observations, patient history, and epidemiological information.

The **FloodLAMP QuickFluor™ COVID-19 Test** is intended for use by **qualified and trained clinical laboratory personnel specifically instructed and trained in the techniques of *in vitro* diagnostic procedures**. The **FloodLAMP QuickFluor™ COVID-19 Test** is only for use under the Food and Drug Administration's Emergency Use Authorization.

2) Special Conditions for Use Statements:

For Emergency Use Authorization (EUA) only

For prescription use only

For *in vitro* diagnostic use only

3) Special Instrument Requirements:

The **FloodLAMP QuickFluor™ PCR COVID-19 Test** test is to be used with the **RT-PCR instruments listed in Table 2**.

Table 2. RT-PCR Instruments validated for test

Manufacturer	Instrument
ThermoFisher Scientific	Applied Biosystems QuantStudio 7 Pro
Bio-Rad	CFX96 Touch Real-Time PCR Detection System

Designated laboratories will receive an FDA accepted instrument qualification protocol included as part of the **FloodLAMP QuickFluor™ Covid-19 Test** IFU and will be directed to execute the protocol prior to testing clinical samples. Designated laboratories must follow the authorized IFU, which includes the instrument qualification protocol, as per the letter of authorization.

G. DEVICE DESCRIPTION AND TEST PRINCIPLE

1) Product Overview/Test Principle:

The **FloodLAMP QuickFluor™ COVID-19 Test** is an RNA-extraction free isothermal RT-LAMP assay which indicates that SARS-CoV-2 RNA is present. FloodLAMP's test uses a set of specific primers that target ORF1ab, N and E genes for the detection of SARS-CoV-2 RNA. Loop Mediated Isothermal Amplification (LAMP) is a nucleic acid amplification technique wherein DNA amplification is carried out at a constant temperature of approximately 65°C. The amplification reaction mix includes a reverse transcriptase (RT) polymerase to create complementary cDNA from RNA. The cDNA is subsequently amplified by a high strand displacement DNA polymerase. An intercalating fluorescent dye is also included in the reaction mix, enabling the real time fluorescence detection of amplicons. A RT-PCR Instrument is utilized for the isothermal amplification incubation and real time fluorescence readout.

2) Description of Test Steps:

Specimens including **nasopharyngeal swabs, anterior nasal and mid-turbinate nasal swabs** are collected in **sterile collection tubes**. Swabs are transported and stored dry prior to processing. At the laboratory, an inactivation solution at 1X containing TCEP (2.5 mM), EDTA (1 mM), and NaOH (11 mM) in 0.9% saline (154 mM) is added to the container with the swab, at the volume of 1ml. Alternatively, for swabs that are collected or eluted in a saline solution or equivalent, the inactivation solution at 100X concentration should be added at 1/100th the sample solution volume.

The container with the specimen and inactivation solution is mixed by vortexing for 30 seconds. Subsequently, the container is heated in a 95°C water bath or dry heat block for 8 minutes. The now inactivated specimen container is allowed to cool at room temperature for 10 minutes and then stored on ice or at 4°C until amplification.

An amplification reaction mix (23 µL) is prepared per manufacturer's specifications, containing the Fluorimetric LAMP master mix (New EB E1700, 12.5 µL), Fluorescent Dye (NEB E1700, .5 µL) a 10X LAMP Primer Mix (2.5 µL of 10X w FIP/BIP at 16 µM, F3/B3 at 2 µM, and LF/BF at 4 µM), and nuclease-free water (7.5 µL).

2µL of the inactivated sample is added to 23µL of the amplification reaction mix. The reaction is then run with the following thermocycler conditions in Table 3:

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Table 3: Thermal cycling conditions and plate read steps

Stage	Temperature	Time	Reps
1	65 C	10 sec	1
2	65 C	10 sec	1
3	65 C	30 sec	25
	65* C	30 sec	

** This step should be the optical read step*

3) Control Materials to be Used with FloodLAMP QuickFluor™ COVID-19 Test:

One Positive Template Control and one Negative (No Template) Control will be included on every 96-well plate with up to 94 samples, or with every batch of strip tubes.

- a) A **“No Template” (Negative) Control (NTC)** is needed to assure the absence of cross-contamination from positive samples, positive controls, or amplicons and is used to determine if sample results are valid. It consists of nuclease-free water.
- b) A **Positive Template Control** is needed to assure proper functioning of reagents and the absence of significant RNase contamination. It consists of synthetic viral RNA at a concentration of approximately 100,000 cp/mL diluted in total human RNA and nuclease-free water. Stock and working aliquots of the positive control are produced from the sources listed in Table 4 or equivalents. Working aliquots should be diluted prior to use to 100,000 cp/mL. Positive control aliquots should be stored for at most 3 months at -80°C, or at most 1 month at -20°C.

Table 4. Components for Positive Template Control

Material	Supplier	Catalog #	Volume
SARS-CoV2 Positive Control RNA	Twist	102019	5 µL
Total Human RNA	Thermo	4307281	100 µL
Nuclease-free Water	Thermo	10977015	4,895 µL

H. INTERPRETATION OF RESULTS

1) **FloodLAMP QuickFluor™ COVID-19 Test Controls**

All test controls should be examined prior to interpretation of patient specimen results. If the controls are not valid and the expected result, the specimen results cannot be interpreted. Target results for the controls will be interpreted according to Table 5 below.

- a) The “No Template” (Negative) Control (NTC) should yield a negative “not detected” result for the Sars target.
- b) The Positive Template Control should yield a positive “detected” result for the Sars target.

If the negative and positive controls do not appear as expected, the specimen results of the corresponding plate or batch should be considered invalid. In the event of a failure of either the positive or negative control, the lab should discard some or all of the consumables utilized for associated run, including the filter tips, tubes, plates, seals, and aliquots of reagents. Additionally, all pipettes, BSC, and appropriate lab surfaces should be thoroughly cleaned with freshly made 10% bleach solution, 70% ethanol, and (optionally) RNaseZAP™ product. In the event of the failure of the positive control, the working aliquot of positive control material should be discarded. Additionally, the lab should review the expiration of the batch of positive control aliquots and verify their integrity by performing qualification reactions of one or more positive control aliquots. If controls continue to fail, labs should not perform additional tests on clinical specimens or report results. Invalid test results should be repeated by performing another amplification reaction.

2) **Examination and Interpretation of Patient Specimen Results:**

Assessment of clinical specimen test results should be performed after the positive and negative controls have been examined and determined to be valid and acceptable. If the controls are not valid, the patient results cannot be interpreted. Patient specimen results will be interpreted according to Table 5 below.

Table 5: Test Results and Interpretation

ABI QuantStudio™ 7 Pro Bio-Rad CFX96 Touch™	
Result	Ct Value: ORF1ab, N2 & E1
Positive	≤25.0
Negative	Undetermined

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I. PRODUCT MANUFACTURING

1) Overview of Manufacturing and Distribution:

The **FloodLAMP QuickFluor™ COVID-19 Test** utilizes standard chemicals available in very large quantities from multiple vendors, with the exception of the LAMP Primers and New England Biolabs Fluorimetric LAMP Master Mix.

FloodLAMP has partnered with LGC Biosearch for the LAMP Primers. LGC Biosearch has very large scale oligo production capacity and mature distribution capabilities. The first production scale lot of the LAMP Primers has been completed, with 1.2 million reactions ready for immediate distribution. FloodLAMP has purchased 600K reactions of the LAMP Primers. LGC Biosearch is supplying FloodLAMP for the **FloodLAMP QuickFluor™ COVID-19 Test** and is also offering the LAMP Primers as a catalog product.

New England Biolabs has expressed strong support for the **FloodLAMP QuickFluor™ COVID-19 Test** and FloodLAMP's other open source protocol EUA submissions that incorporate their products. New England Biolabs has very large quantities of the Fluorimetric LAMP Master Mix product prepared and ready for immediate distribution, typically with 24 hour shipping within the U.S. Their manufacturing capacity is among the largest in the United States and can surge to meet increased demand.

***Under the Emergency Use Authorization (EUA) any of the 21 CFR Part 820 Quality System Regulation (QSR) requirements can be waived for the duration of the EUA but FDA recommends that developers follow comparable practices as much as possible if such requirements are waived. Among other things, FDA may consider previous compliance history when determining whether or not to waive certain QSR requirements for a specific product. Please note adverse events, as per 21 CFR Part 803, have to be reported for authorized devices (see Section P).**

2) Components Included with the Test:

None. Designated CLIA labs may order components directly from vendors.

3) Components Required But Not Included with Test:

The **FloodLAMP QuickFluor™ COVID-19 Test** is to be used with the reagents or equivalents listed in Table 6.

Table 6: Validated reagents used with Test

Item	Concentration	Chemical Composition	Vendor	Catalog No.
TCEP	.5 M	tris(2-carboxyethyl)phosphine hydrochloride	Sigma-Aldrich Millipore Sigma	646547-10X 1ML

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EDTA	.5 M	Ethylenediaminetetraacetic acid	Thermo	15575020
NaOH	10 N	Sodium Hydroxide	Sigma-Aldrich	SX0607N-6
Nuclease-free Water		Ultrapure Water, nuclease free	Thermo	10977015
NaCl	5M	Sodium Chloride	Thermo	24740011
Fluorimetric LAMP Kit*		Fluorimetric LAMP Kit	New England Biolabs	E1700

* Item may not be substituted for equivalents. Only the specified vendor and catalog number may be utilized.

Stocks of TCEP, EDTA, NaOH, and NaCl may be prepared from powder form at the specified concentration using nuclease-free, MilliQ or equivalent molecular biology grade water.

0.9% Saline (154 mM) may be prepared by diluting 15.4 mL of 5 M NaCl in MilliQ or equivalent molecular biology grade water to a final volume of 500 mL. Equivalent preparations or commercial saline products may be utilized, with appropriate validation.

A 100X Inactivation Solution is prepared by mixing the components in Table 7. Equivalent preparations utilizing components with different source concentrations may be used such that the final 100X Concentration is achieved. Aliquots of 100X Inactivation Solution should be stored in the dark at -20°C for up to 3 months. Upon thaw, working aliquots of 100X Inactivation Solution should be stored in the dark at room temperature for up to 1 month.

Table 7: 100X Inactivation Solution

Component	Source Concentration	Volume for 100X	100X Concentration
TCEP	0.5 M	10 mL	250 mM
EDTA	0.5 M	4 mL	100 mM
NaOH	10 N	2.3 mL	1.15 N
Nuclease-free Water		3.7 mL	
TOTAL VOLUME		20 mL	

For swabs that are collected or eluted in 0.9% saline solution or equivalent, the 100X Inactivation Solution should be added at 1/100th the sample solution volume.

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For dry swabs, a preparation of 1X Inactivation Saline Solution should be prepared per Table 5. 1X Inactivation Saline Solution should be kept at room temperature and used within 24 hours of preparation from components or 100X Inactivation Solution.

Table 8: 1X Inactivation Saline Solution

Component	Volume
0.9% Saline (154 mM NaCl) in MilliQ Water	1000 mL
100X Inactivation Solution	10 mL
TOTAL VOLUME	1010 mL

The **FloodLAMP QuickFluor™ COVID-19 Test** uses 18 LAMP primers targeted for 3 different SARS-CoV-2 genes, with 6 primers for each target. Primer names and sequences are shown above in Table 1. All 18 primers are mixed together and input into a single amplification reaction.

Primers may be purchased from the vendor LGC Biosearch Technologies as 3 pre-blended sets, or the primers may be purchased as 18 individual custom oligos. Table 6 below lists the primer products to be ordered.

The LGC Biosearch primer products are provided already blended for each target (6 primers per tube) and dried such that upon resuspension with 1 mL of nuclease-free water, the primers for each target are at 30X concentration. One resuspended tube for each of the 3 targets (i.e. primer blends) are mixed together to yield a 3 mL total volume that contains all individual primers at 10X concentration. This 3 mL of 10X LAMP Primer Mix provides for 1,200 reactions at 2.5 µL per reaction.

Alternatively to the pre-blended LGC Biosearch products, primers may be purchased as individual custom oligos. Custom oligos may be blended to form 30X Primer Set Mixes as intermediates or all mixed together for the 10X LAMP Primer Mix. The FIP and BIP primers for each target require purification by HPLC or an equivalent process. Appropriate validation of primer mixes from custom oligos is required. Primers may be stored at 4°C for up to one month, or at -20°C for up to 1 year.

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Table 9: 10X LAMP Primer Mix Components

Vendor	Item	Catalog number	Quantity	# Reactions
Order one of the following primer sets				
LGC Biosearch Technologies	SARS-CoV-2 LAMP AS1e 6 primer set at 30X (ORF1ab gene)	LAMP_S2-AS1e-48	6-48 nmol	1,200
		LAMP_S2-AS1e-480	60-480 nmol	12,000
	SARS-CoV-2 LAMP N2 6 primer set at 30X (N gene)	LAMP_S2-N2-48	6-48 nmol	1,200
		LAMP_S2-N2-480	60-480 nmol	12,000
	SARS-CoV-2 LAMP E1 6 primer set at 30X (E gene)	LAMP_S2-E1-48	6-48 nmol	1,200
		LAMP_S2-E1-480	60-480 nmol	12,000
LGC Biosearch Technologies, Eurofins Genomics, Integrated DNA Technologies, Sigma	Orflab_FIP	Custom Order	1,000 nmol	25,000
	Orflab_BIP	Custom Order	1,000 nmol	25,000
	Orflab_F3	Custom Order	125 nmol	25,000
	Orflab_B3	Custom Order	125 nmol	25,000
	Orflab_LF	Custom Order	250 nmol	25,000
	Orflab_LB	Custom Order	250 nmol	25,000
	N2_FIP	Custom Order	1,000 nmol	25,000
	N2_BIP	Custom Order	1,000 nmol	25,000
	N2_F3	Custom Order	125 nmol	25,000
	N2_B3	Custom Order	125 nmol	25,000
	N2_LF	Custom Order	250 nmol	25,000
	N2_LB	Custom Order	250 nmol	25,000
	E1_FIP	Custom Order	1,000 nmol	25,000
	E1_BIP	Custom Order	1,000 nmol	25,000
	E1_F3	Custom Order	125 nmol	25,000
	E1_B3	Custom Order	125 nmol	25,000
	E1_LF	Custom Order	250 nmol	25,000
	E1_LB	Custom Order	250 nmol	25,000

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The final Fluorimetric LAMP Amplification Reaction components are listed in Table 9. PCR plates or strip tubes used for the amplification reactions should be maintained on ice or a cold block until less than 5 minutes before incubation on the heater. Reaction plates/strip tubes comprising the Fluorimetric LAMP Amplification Reaction Solution may be prepared in advance, capped/sealed, and stored at -20°C for up to 1 day prior to addition of the sample. A heated plate sealer is recommended. Alternatively, a manually applied foil or optical seal may be used.

Table 10: Fluorimetric LAMP Amplification Reaction

Component	Volume (1 reaction)	Volume (100 reactions)
10X LAMP Primer Mix	2.5 µL	250 µL
Nuclease Free Water	7.5 µL	750 µL
Fluorimetric LAMP MM	12.5 µL	1250 µL
Fluorescent Dye	.5 µL	50 µL
SUBTOTAL VOLUME	23 µL	2300 µL
Sample	2 µL	
REACTION VOLUME	25 µL	

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4) Software Validation:

The **FloodLAMP QuickFluor™ COVID-19 Test** has been validated on the RT-PCR instruments listed in Table 2 using the baseline threshold settings unless otherwise noted in the Instructions for Use. The test does not require any additional software.

5) Testing Capabilities:

The **FloodLAMP QuickFluor™ COVID-19 Test** has been optimized for a streamlined workflow and rapid turnaround time on results. The total time to perform the test is dependent upon the following factors: number of lab technicians, batch size of samples, and in advance preparation of reaction mixes as well as availability of RT-qPCR instruments. The minimum turnaround time is approximately 1 hour, of which approximately 30 minutes is the RT-PCR instrument run time. Automation can greatly increase overall throughput.

6) Reagent Stability:

A stability test plan for the components of the **FloodLAMP QuickFluor™ COVID-19 Test** will be developed during an interactive review. Briefly, the proposed study includes assessing all prepared solutions including: 100X Inactivation Solution, 1X Inactivation Saline Solution, 30X Primer Stock, 10X Primer Mix, and the full Fluorimetric LAMP Amplification Reaction Mix. Prepared solutions will be assessed both for long term storage stability (typically 1-3 months at -20°C) and short term storage stability prior to usage (typically hours to several days at room temperature, 4°C or -20°C).

The proposed study uses a contrived positive sample consisting of inactivated SARS-CoV-2 virus cell lysate (BEI NR-52287) spiked into negative specimens at approximately 50,000 copies/mL (4X LoD). The contrived positive stability study samples will be prepared, aliquoted and stored at -80°C to permit repeated testing of the various solutions at the appropriate step of the test protocol.

For test components supplied by vendors, such as the Fluorimetric LAMP Kit, the manufacturer's recommended storage conditions and duration will be followed.

7) Sample Stability:

Upper respiratory specimens including nasopharyngeal swabs, anterior nasal and mid-turbinate nasal swabs should be collected using standard procedures and recommendations. Swab specimens should be collected in 0.9% saline, PBS, or dry tubes. Specimens should not be collected in UTM, VTM, or Liquid Amies.

Please refer to Interim Guidelines for Collecting, Handling, and Testing Clinical Specimens for COVID-19: www.cdc.gov/coronavirus/2019-ncov/lab/guidelines-clinical-specimens.html

The stability study of the nasal swab sample transported in saline has been conducted by Quantigen Biosciences, with support from The Gates Foundation and UnitedHealth Group. Quantigen Biosciences has granted a right of reference to any sponsor wishing to pursue an EUA to leverage their COVID-19 swab stability data as part of that sponsor's EUA request.

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Samples can be stored at room temperature for 56 hours after collection prior to inactivation. For longer term storage, samples can be stored at $\leq -70^{\circ}\text{C}$.

J. PERFORMANCE EVALUATION

1) Limit of Detection (LoD) - Analytical Sensitivity:

The Limit of Detection (LoD) for the **FloodLAMP QuickFluor™ COVID-19 Test** was established using gamma irradiated SARS-CoV-2 virus cell lysate (BEI NR-52287) spiked into negative real specimens. The negative specimens were confirmed by PCR using the CDC primers. The gamma irradiated virus was spiked into the specimen prior to the heat inactivation step, and carried through the entire assay. The concentration of spike was such that the contrived positive sample was at 100,000 copies/mL after the inactivation step. The stock contrived positive was diluted into inactivated negative sample matrix to produce the concentrations for the LOD study. A preliminary LOD run was performed using the concentrations ranging from 100,000 copies/mL to 3,100 copies/mL. Concentrations of 50,000, 25,000 and 12,500 copies/mL were selected for confirmatory LOD runs. LOD run details are provided in Supporting Data, with the results summarized below in Table 10. The LOD, defined as the concentration at which at least 95% of the samples are positive, was determined at 50,000 copies/mL.

Table 11: Confirmatory LOD Data Results

Instrument	LOD	Positive Replicates	Mean Ct Value (SD)
ABI QuantStudio 7 Pro	50,000 copies/mL	95% (20/21)	11.9 (1.5)
Bio-Rad CFX96			

2) Inclusivity (analytical sensitivity):

An inclusivity study was conducted for the ORF1ab, N2, and E1 primer sets against all complete, high coverage SARS-CoV-2 sequences deposited at GISAID as of February 27, 2021. Table 11 summarizes the results of this *in silico* inclusivity analysis. A total of 498,224 sequences were considered. There are 10 sequence isolates that have 1mm to both AS1e and E1 and had N2 excluded due to greater than 15 N's, with the other 498,214 sequence isolates all have at least 1 target region that is a complete match.

Each primer set matched at 100% similarity against the SARS-CoV-2 RefSeq reference genome (Wuhan-Hu-1; NC_045512.1). All three primer sets differed by one or fewer mutations for 99.7% of GISAID sequences, indicating nominal primer hybridization for all SARS-CoV-2 variants under consideration.

Table 12: *In Silico* Inclusivity Analysis for LAMP Primers

Primer	AS1e (ORF1ab gene)	N2 (N gene)	E1 (E gene)
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Total Primer Length	195		169		168	
Total Number of Strains Evaluated	498,224		498,224		498,224	
100% Match	474,717	95.3%	479,548	96.3%	462,538	92.8%
1 Mismatch	19,301	3.9%	15,698	3.2%	30,626	6.1%
2 Mismatches	338	0.1%	161	0.0%	1,455	0.3%
3 Mismatches	9	0.0%	5	0.0%	103	0.0%
> 3 Mismatches	0	0.0%	0	0.0%	1	0.0%
Total Strains Removed	3,859	0.8%	2,812	0.6%	3,501	0.7%

Evaluation of Impact of Viral Mutations

The As1e, E1 and N2 primer regions of all SARS-CoV-2 genomes present in GISAID as of 2/26/2021 were evaluated to assess the potential impact of genomic variants on LAMP primer binding. This analysis was performed with the Primer Monitoring Tool from New England Biolabs (primer-monitor.neb.com), which continually monitors registered primer sets for overlapping variants in sequences from GISAID. Results are summarized by region and locus below in Table 12, including the 30 countries with most sequences in GISAID. Sequences were aligned to the SARS-CoV-2 reference sequence (NC_045512.2) using minimap2 (minimap2 -t 16 -x asm5 -a). Variant sites (excluding Ns) were identified using samtools mpileup and summarized by region and genome position. Genomic positions having ≥ 40 global variant observations are shown (column labels). When present, box labels indicate the fraction of variants observed at a given locus.

The aggregate of current published mutations are not expected to reduce performance of the **FloodLAMP QuickFluor™ COVID-19 Test** by more than 5% from that established by the performance evaluation in this EUA submission. Further, the use of 3 primer sets targeting different regions in the SARS-CoV-2 genome should make the test robust to new genetic variants.

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Table 13: Variant Analysis of LAMP Primers



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3) Cross-reactivity (Analytical Specificity):

In silico cross-reactivity analysis was performed by aligning the primer sequences of the **FloodLAMP QuickFluor™ COVID-19 Test** against sequences of other coronaviruses and common respiratory flora using the BLASTn alignment tool from NCBI. Results of this analysis are presented in Tables 14A, 14B, and 14C.

The % identity range (# identical bases/ # primer bases) is shown for each primer and organism. Darker font indicates % identity greater than 80%. Organisms with $\geq 50\%$ identity primer hits are shown. This analysis is not intended to predict amplification. Near perfect homology across B3, F3, FIP and BIP is necessary to support successful amplification. With the exception of SARS-CoV, simultaneous homologies do not occur between any of the primers and microorganisms screened. With respect to clinical relevance of the *in silico* cross-reactivity analysis, there are no known circulating strains of SARS-CoV circulating in humans, thus the overall probability for the test to produce a cross-reactive signal is negligible.

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Table 14A: *In Silico* Cross-Reactivity Analysis for AS1e Primers

Organism Group	Organism Name	Organism ID	Primer / Primer Length						% Identity Color
			As1_B3 22 bp	As1e_BIP 49 bp	As1_F3 18 bp	As1e_FIP 51 bp	As1_LB 27 bp	As1_LF 28 bp	
Same genetic family	SARS coronavirus 2	NC_045512.2	100%	47%-55%	100%	43%-53%	100%	100%	
	Human coronavirus HKU1	NC_006577.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus NL63	NC_005831.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus OC43 strain ATCC VR-759	NC_006213.1	0%	0%	0%	0%	0%	0%	
	SARS coronavirus	NC_004718	0%	0%	0%	0%	0%	0%	
Other high priority organisms	Candida albicans SC5314 chromosome 6 sequence	NC_032094.1			72%-89%	29%	52%-67%		
	Candida albicans SC5314 chromosome R sequence	NC_032096.1	77%		89%	37%-51%	52%-59%		
	Haemophilus influenzae NCTC8143, chromosome : 1	NZ_LN831035.1	59%-73%	33%-35%	89%	33%-45%	52%		
	Candida albicans SC5314 chromosome 2 sequence	NC_032090.1	59%-73%	31%	72%-83%	29%-59%	52%		
	Mycobacterium tuberculosis H37Rv	NC_000962.3			83%				
	Candida albicans SC5314 chromosome 4 sequence	NC_032092.1	59%-82%	39%		29%-41%	67%	61%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.3	NW_017264777.1	59%-82%		72%	39%-57%	59%		
	Streptococcus pyogenes NCTC8198, chromosome : 1	NZ_LN831034.1	59%-82%	31%	72%	31%	52%-67%		
	Candida albicans SC5314 chromosome 7 sequence	NC_032095.1			72%-78%		70%		
	Mycoplasma pneumoniae FH chromosome	NZ_CP010546.1			72%	29%-35%	78%		
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.15	NW_017264789.1	59%		78%				
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.11	NW_017264785.1	77%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.7	NW_017264781.1	77%			35%	63%		
	Candida albicans SC5314 chromosome 1 sequence	NC_032089.1	59%	43%-49%	72%	29%-57%	63%-74%	68%	
	Legionella pneumophila subsp. pascalii strain NCTC12273, chromosome: 1	NZ_LR134380.1	59%-73%	49%	72%	31%-41%	56%-74%		
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.12	NW_017264786.1				31%-43%	74%		
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.8	NW_017264782.1	73%		72%	29%-39%	52%		
	Staphylococcus epidermidis ATCC 12228	NC_004461.1	59%-68%	31%-37%	72%	29%-35%	56%-67%	57%-71%	
	Streptococcus pneumoniae NCTC7465, chromosome : 1	NZ_LN831051.1	59%-68%	37%-41%	72%	29%-41%	52%-63%	50%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.14	NW_017264788.1				35%		71%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.6	NW_017264780.1				29%-47%	70%	68%	
	Candida albicans SC5314 chromosome 5 sequence	NC_032093.1	59%-68%	35%		29%-43%		68%	
	Chlamydia pneumoniae TW-183	NC_005043.1	68%	37%					
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.2	NW_017264776.1	68%			33%-49%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.5	NW_017264779.1		43%		35%		68%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.16	NW_017264790.1	64%					57%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.1	NW_017264775.1				33%-35%	59%		
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.13	NW_017264787.1	59%					50%	
	Bordetella pertussis 18323	NC_018518.1						57%	
	Rothia mucilaginosa DY-18 DNA	NC_013715.1					52%		
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.25	NW_017264799.1						50%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.66	NW_017264840.1						50%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.4	NW_017264778.1				39%-47%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.54	NW_017264828.1		47%					
	Candida albicans SC5314 chromosome 3 sequence	NC_032091.1		31%		31%-45%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.10	NW_017264784.1				33%-45%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.19	NW_017264793.1				35%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.9	NW_017264783.1				35%			
	Respiratory syncytial virus	NC_001803.1				33%			

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Table 14B: *In Silico* Cross-Reactivity Analysis for N2 Primers

Organism Group	Organism Name	Organism ID	Primer / Primer Length						% Identity Color
			N2_B3 25 bp	N2_BIP 40 bp	N2_F3 21 bp	N2_FIP 42 bp	N2_LB 20 bp	N2_LF 21 bp	
Same genetic family	SARS coronavirus 2	NC_045512.2	100%	53%	100%	48%-55%	100%	100%	■ >80%
	SARS coronavirus	NC_004718	64%	53%	90%	55%	85%	90%	■ <=80%
	Human coronavirus HKU1	NC_006577.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus NL63	NC_005831.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus OC43 strain ATCC VR-759	NC_006213.1	0%	0%	0%	0%	0%	0%	
Other high priority organisms	Streptococcus pneumoniae NCTC7465, chromosome : 1	NZ_LN831051.1	60%-80%		95%		75%	62%-71%	
	Rothia mucilaginosa DY-18 DNA	NC_013715.1				40%	75%-90%		
	Bordetella pertussis 18323	NC_018518.1		35%			65%-80%	81%	
	Candida albicans SC5314 chromosome 6 sequence	NC_032094.1	56%-72%	43%				62%-81%	
	Candida albicans SC5314 chromosome 7 sequence	NC_032095.1	56%-76%		62%-71%	45%		62%-81%	
	Candida albicans SC5314 chromosome R sequence	NC_032096.1	56%-80%	35%-68%	62%			62%-81%	
	Candida albicans SC5314 chromosome 4 sequence	NC_032092.1	60%-80%	35%-45%	71%			62%-71%	
	Candida albicans SC5314 chromosome 1 sequence	NC_032089.1	60%-72%	35%-45%	71%-76%			62%-76%	
	Chlamydia pneumoniae TW-183	NC_005043.1	56%-76%		76%	36%	65%		
	Legionella pneumophila subsp. pascuelli strain NCTC12273, chromosome: 1	NZ_LR134380.1	60%-76%	43%		36%-55%		62%-76%	
	Mycoplasma pneumoniae FH chromosome	NZ_CP010546.1	60%				65%-75%	76%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.7	NW_017264781.1	60%-64%					76%	
	Pseudomonas aeruginosa PAO1	NC_002516.2		35%			75%		
	Candida albicans SC5314 chromosome 2 sequence	NC_032090.1	56%-72%	48%	62%	40%		67%-71%	
	Candida albicans SC5314 chromosome 3 sequence	NC_032091.1	56%-72%		71%			62%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.17	NW_017264791.1	56%-72%					62%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.4	NW_017264778.1	60%-72%		71%				
	Candida albicans SC5314 chromosome 5 sequence	NC_032093.1	56%-68%	35%				62%-71%	
	Human parainfluenza virus 1	NC_003461.1			71%				
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.16	NW_017264790.1	60%-68%					62%-71%	
	Haemophilus influenzae NCTC8143, chromosome : 1	NZ_LN831035.1	60%-68%	50%		43%		62%-67%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.13	NW_017264787.1	68%						
	Staphylococcus epidermidis ATCC 12228	NC_004461.1	60%-68%		62%			62%	
	Mycobacterium tuberculosis H37Rv	NC_000962.3						67%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.1	NW_017264775.1	56%					67%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.3	NW_017264777.1	56%-60%					67%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.8	NW_017264782.1	64%	35%					
	Streptococcus pyogenes NCTC8198, chromosome : 1	NZ_LN831034.1	60%-64%	43%-50%					
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.6	NW_017264780.1	60%					62%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.25	NW_017264799.1	60%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.5	NW_017264779.1	60%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.51	NW_017264825.1	60%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.66	NW_017264840.1	60%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.67	NW_017264841.1	60%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.2	NW_017264776.1	56%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.21	NW_017264795.1	52%						

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Table 14C: *In Silico* Cross-Reactivity Analysis for E1 Primers

Organism Group	Organism Name	Organism ID	Primer / Primer Length						% Identity Color
			E1_B3 22 bp	E1_BIP 44 bp	E1_F3 23 bp	E1_FIP 42 bp	E1_LB 19 bp	E1_LF 18 bp	
Same genetic family	SARS coronavirus 2	NC_045512.2	100%	45%-57%	100%	45%-62%	100%	100%	
	SARS coronavirus	NC_004718	95%	55%	100%	43%-62%	100%	100%	
	Human coronavirus HKU1	NC_006577.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus NL63	NC_005831.2	0%	0%	0%	0%	0%	0%	
	Human coronavirus OC43 strain ATCC VR-759	NC_006213.1	0%	0%	0%	0%	0%	0%	
Other high priority organisms	Candida albicans SC5314 chromosome R sequence	NC_032096.1				40%-50%		72%-89%	
	Pseudomonas aeruginosa PAO1	NC_002516.2					84%	72%	
	Legionella pneumophila subsp. pascuelli strain NCTC12273 , chromosome: 1	NZ_LR134380.1	59%-73%			36%-40%		78%-83%	
	Candida albicans SC5314 chromosome 2 sequence	NC_032090.1	59%-82%			43%		72%	
	Candida albicans SC5314 chromosome 4 sequence	NC_032092.1				43%-50%		78%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.12	NW_017264786.1						78%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.7	NW_017264781.1						78%	
	Staphylococcus epidermidis ATCC 12228	NC_004461.1		45%		43%-48%		72%-78%	
	Haemophilus influenzae NCTC8143, chromosome : 1	NZ_LN831035.1	77%			36%-43%			
	Candida albicans SC5314 chromosome 1 sequence	NC_032089.1	59%-73%			38%-48%		72%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.3	NW_017264777.1	59%-73%		65%	43%			
	Streptococcus pyogenes NCTC8198, chromosome : 1	NZ_LN831034.1	73%	41%		48%		72%	
	Candida albicans SC5314 chromosome 3 sequence	NC_032091.1	59%			43%-48%		72%	
	Candida albicans SC5314 chromosome 7 sequence	NC_032095.1				36%-50%		72%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.4	NW_017264778.1						72%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.5	NW_017264779.1			65%			72%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.9	NW_017264783.1	59%-68%					72%	
	Streptococcus pneumoniae NCTC7465, chromosome : 1	NZ_LN831051.1	59%-68%			40%	68%	72%	
	Candida albicans SC5314 chromosome 6 sequence	NC_032094.1			70%	40%-50%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.13	NW_017264787.1			70%				
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.1	NW_017264775.1	68%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.2	NW_017264776.1	68%			45%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.6	NW_017264780.1	68%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.16	NW_017264790.1	59%-64%			40%			
	Candida albicans SC5314 chromosome 5 sequence	NC_032093.1	59%			40%-43%			
	Chlamydia pneumoniae TW-183	NC_005043.1	0%-59%	0%	0%	0%-36%	0%	0%	
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.10	NW_017264784.1	59%						
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.20	NW_017264794.1	59%						
	Mycobacterium tuberculosis H37Rv	NC_000962.3		34%	57%				
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.30	NW_017264804.1				50%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.69	NW_017264843.1				50%			
	Mycoplasma pneumoniae FH chromosome	NZ_CP010546.1				43%			
	Pneumocystis jirovecii RU7 chromosome Unknown supercont1.8	NW_017264782.1				40%			

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Wet testing was performed to demonstrate that the **FloodLAMP QuickFluor™ COVID-19 Test** does not react with related pathogens, high prevalence disease agents and normal or pathogenic flora that are reasonably likely to be encountered in a clinical specimen. SARS-CoV, RSV, Flu, Human Metapneumovirus, and Streptococcus Salivarius were tested for potential cross-reactivity, as shown in Table 15 and Supporting Data. 5 µL of each stock of cross-reactivity organism was spiked on dried AN swab specimens. A contrived positive control was produced by spiking gamma irradiated SARS-CoV-2 virus cell lysate (BEI NR-52287) onto dried AN swab specimens. Control dried swabs obtained simultaneously were confirmed to be SARS-CoV-2 negative by PCR using the CDC primers. The gamma irradiated SARS-CoV-2 virus and cross-reactivity organisms were spiked into the dried swabs prior to the heat inactivation step, and carried through the full test protocol. The contrived positive had 38 µL of 1e6 copies/mL irradiated virus stock spiked in, producing after elution of the swab in 1 mL of Inactivation Saline Solution at most a concentration of 38,000 copies/mL in the sample input into the amplification reaction.

All wet testing showed no cross-reactivity with the viral pathogens and common respiratory flora, as shown in Table 15.

Table 15: Wet Testing Cross-Reactivity Results

Organism	Description	BEI Number	Detected Replicates
SARS-CoV	UV-inactivated virus	NR-3882	0/3
Human Metapneumovirus	Genomic RNA	NR-49122	0/3
RSV	Genomic RNA	NR-43976	0/3
Influenza B	Genomic RNA	NR-45848	0/3
Streptococcus salivarius	Bacterial cell culture	HM-121	0/3

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Endogenous Interference Substances Studies:

Exogenous and endogenous substances were tested for potential interference with the **FloodLAMP QuickFluor™ COVID-19 Test**. 10 µL of each stock of interfering substance was spiked on dried AN swab specimens. A contrived positive control was produced by spiking gamma irradiated SARS-CoV-2 virus cell lysate (BEI NR-52287) onto dried AN swab specimens. Control dried swabs obtained simultaneously were confirmed to be SARS-CoV-2 negative by PCR using the CDC primers. The gamma irradiated SARS-CoV-2 virus and interfering substances were spiked into the dried swabs prior to the heat inactivation step, and carried through the full test protocol. The contrived Positive Control Spiked comprised 20 µL of 8e6 copies/mL irradiated virus stock spiked in, producing after elution of the swab in 1 mL of Inactivation Saline Solution at most a concentration of 160,000 copies/mL in the sample input into the amplification reaction.

All interfering substance testing showed no disagreement with expected positive and negative results, as shown in Table 16 and Supporting Data.

Table 16: Interfering Substances Results

Interfering Substance	Active Ingredient	Concentration	% Agreement with Expected Results	
			Positive Control Spiked	Negative Control Unspiked
Blood	N/A	1% v/v	100% (3/3)	100% (3/3)
Nasal Congestion Spray	Acetaminophen, Guaifenesin, Phenylephrine HCl	20% v/v	100% (3/3)	100% (3/3)
Nasal Allergy Spray	Oxymetazoline HCl	15% v/v	100% (3/3)	100% (3/3)
Lozenges	Menthol	10% w/v	100% (3/3)	100% (3/3)
Mucin	N/A	0.5% w/v	100% (3/3)	100% (3/3)

4) Clinical Evaluation:

The clinical evaluation of the **FloodLAMP QuickFluor™ COVID-19 Test** utilized confirmed clinical anterior nares swab specimens. 40 positive and 40 negative clinical specimens were evaluated and compared to a high sensitivity EUA authorized test run on the original fresh samples. The **FloodLAMP QuickFluor™ COVID-19 Test** showed a positive agreement of 80% and a negative agreement of 100%. The 6 false negative results were specimens with high

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Ct values as previously measured by the comparator test, indicating low viral load. A summary of the clinical performance is below in Table 16.

Anterior nares swab specimens were collected from patients in phosphate buffered saline by the Stanford COVID-19 clinical testing program. Specimens were initially tested by the Stanford clinical laboratory using the Hologic Panther Fusion and Aptima SARS-CoV-2 Assays, which serves as the high sensitivity comparator test.

For the **FloodLAMP QuickFluor™ COVID-19 Test**, materials and the Instructions For Use were provided to the Stanford clinical laboratory. The materials provided consisted of the validated reagents listed in Table 3, the LGC primers and probes, and an aliquot of the positive control. After thawing the frozen specimens, 1 mL of each specimen was transferred to 5mL tubes for the inactivation step. The positive and negative clinical specimens were assigned a new ID in a random order, then transferred to new tubes that were barcoded and labeled with the new ID. The Bio-Rad CFX96 instrument was used to perform the isothermal amplification. Line Item data are provided in the Supporting Data.

Table 16: Clinical Evaluation Results

FloodLAMP QuickFluor™ COVID-19 Test Results	Comparator - High Sensitivity EUA Authorized Test		
	Positive	Negative	Total
Positive	34	0	34
Negative	6	40	46
Total	40	40	80
Positive Agreement	80.0% (34/40) 95% CI: 70.2% to 94.3%		
Negative Agreement	100% (40/40) 95% CI: 91.2% to 100%		

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K. UNMET NEED ADDRESSED BY THE PRODUCT

This section will be completed by FDA.

L. APPROVED/CLEARED ALTERNATIVE PRODUCTS

Currently no methods for the detection of the SARS-CoV-2 have been approved/cleared by FDA.

M. BENEFITS AND RISKS:

This section will be completed by FDA.

N. FACT SHEET FOR HEALTHCARE PROVIDERS AND PATIENTS:

Fact Sheets for Patients and Healthcare Providers attached.

O. INSTRUCTIONS FOR USE/ PROPOSED LABELING/PACKAGE INSERT:

Instructions for Use attached.

P. RECORD KEEPING AND REPORTING INFORMATION TO FDA:

Authorized laboratories will collect information on the performance of the test and report to DMD/OHT7-OIR/OPEQ/CDRH (via email: CDRH-EUA-Reporting@fda.hhs.gov) and FloodLAMP Biotechnologies, PBC support center (via email: eua.support@floodlamp.bio) any suspected occurrence of false positive or false negative results and significant deviations from the established performance characteristics of the test of which they become aware.

QuantStudio is a trademark of Thermo Fisher Scientific (NYSE: TMO)

Bio-Rad and Bio-Rad CFX96 Touch is a trademark of Bio-Rad Laboratories, Inc. (NYSE: BIO)