Watersprint Core 20 and Core 40

UV-LED Water Disinfection Systems — Performance White Paper

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1. Executive Summary

The Core platform comprises compact, inline UV-LED reactors that share a common form factor while offering performance variants optimized for different service flows. Core 20 is rated for 20 L/min and Core 40 for 40 L/min under NSF/ANSI 55 Class B operation. This report provides a consistent basis for assessing the Core family against Class B criteria and against the UV dose thresholds associated with inactivation of organisms such as Escherichia coli, Legionella pneumophila, Pseudomonas aeruginosa, Giardia, and Cryptosporidium. The key takeaway for customers is that both Core 20 and Core 40 models not only meet a nominal dose target at start-of-life, but retain meaningful dose margin above the 16 mJ/cm^2 Class B reference throughout the tested operating interval.

The performance interpretation in this report is based on four complementary data sources. First, third-party NSF/ANSI 55 Class B Q-beta bacteriophage testing provides direct microbiological evidence under standardized laboratory conditions. Second, a Watersprint internal Q-beta microbioassay provides supporting log-reduction data for Core 20 and Core 40 against Q-beta ATCC 23631-B1; all tests were conducted in accordance with NSF/ANSI 55-2024 Class B protocols at 95%/cm UVT, and the collected samples were independently analyzed and reported by GAP EnviroMicrobial Services (Ontario, Canada) using the single agar layer (SAL) method per EPA 1602. Third, Watersprint internal testing provides delivered UV dose measurements at 96% UVT at beginning-of-life and after extended operating time. Fourth, peer-reviewed fluence-response data compiled by Malayeri et al. provide organism-specific UV dose requirements for incremental log inactivation of bacteria, protozoa, viruses, algae, and other microorganisms.

The delivered UV dose in each test, derived from the inactivation of a standard organism strain with known inactivation kinetics, is compared against published dose requirements for selected organisms. Where a delivered dose exceeds the published 4-log or 5-log fluence requirement for a microorganism, the system can reasonably be described as

having sufficient delivered dose for that level of inactivation under comparable UV wavelength, UVT, water quality, and exposure assumptions.

Third-party NSF testing confirms microbiological reduction performance using Q-beta bacteriophage under the NSF/ANSI 55-2024 Class B protocol at high UV transmittance. For Core 40, NSF testing at 99% UVT and 40 L/min reported a PASS result, with a required reduction of 2.00 log and measured effluent log reductions of 2.443 log and 2.226 log. For Core 20, NSF testing at 99% UVT generated Q-beta reductions across the evaluated flow conditions, including 4.500 log and 3.149 log reduction at the 20 L/min test point in the R&D data set. These results confirm that the Core platform has demonstrated Q-beta reduction performance above the Class B criterion under the tested NSF conditions.

A Watersprint internal Q-beta microbioassay provides further corroboration of Class B–level performance. In this test, all samples were independently analyzed and reported by GAP EnviroMicrobial Services using the single agar layer (SAL) method per EPA 1602 against Q-beta bacteriophage (ATCC 23631-B1). The Core 20 module achieved a mean 2.5 ± 0.1 log reduction at 20 L/min and the Core 40 module achieved a mean 2.5 ± 0.2 log reduction at 40 L/min, at UVT of 95%, each reported as the average of three as-manufactured units with 95% confidence intervals at beginning-of-life. Both results exceed the 2.0-log Class B criterion and are consistent with the third-party NSF Q-beta reductions, providing mutually corroborating microbiological evidence for the Core platform.

2. Scope and Intended Use

This report addresses the microbial disinfection performance of the Watersprint Core 20 and Core 40 UV-LED systems in potable-water and selected process-water applications where water quality, UV transmittance, flow rate, installation configuration, and maintenance are controlled within the validated operating envelope. Core 20 is rated for 20 L/min and Core 40 for 40 L/min under NSF/ANSI 55 Class B operation. The performance claims apply to the specific devices, flow rates, UV transmittance values, and test

protocols described in the supporting evidence and should not be generalized to all water matrices.

Applications involving wastewater, highly turbid water, or strongly UV-absorbing process streams require separate validation under representative conditions. For food, beverage, or HACCP-aligned applications, the Core systems should be considered as candidate microbial risk-control measures only when the delivered UV dose, target organisms, process-water quality, installation design, monitoring strategy, and maintenance plan are validated within the specific process context.

3. Validation Framework

The performance argument in this white paper is organized according to four complementary evidence classes: third-party NSF/ANSI 55 Class B Q-beta certification testing, an internal Q-beta microbioassay with independent laboratory analysis, internal delivered-dose and lifetime testing, and literature-based UV dose-response interpretation. Directly measured results are treated separately from dose-based or inferred microbial reduction estimates. Table 1 summarizes the evidence sources supporting this assessment, while the measured performance and its interpretation against organism-specific dose requirements are presented in Table 2 and Table 3 (Section 6).

Table 1. Evidence Sources Supporting Core 20 and Core 40 Performance

Evidence source	Evidence type	Microorganism or indicator	Key result	Role in report
Third-party NSF/ANSI 55 Class B test	Certification-aligned third-party test	Q-beta bacteriophage	Core 40 PASS at 40 L/min, 99% UVT; Core 20 reductions above criterion	Core regulatory performance evidence
Internal Q-beta microbioassay (analysis by GAP, SAL EPA 1602)	Internal challenge, independent laboratory analysis	Q-beta bacteriophage (ATCC 23631-B1)	2.5-log mean reduction at rated flow (both models, BOL)	Corroborating microbiological evidence
Internal delivered-dose and lifetime testing	Internal lifecycle measurement	Delivered UV dose (dose indicator)	Dose retained above 16 mJ/cm^2 through 3,200 h	Durability and design-margin evidence
Literature-based dose-response (Malayeri et al.)	Peer-reviewed fluence-response interpretation	Multiple bacteria, protozoa, and viruses	Published organism-specific UV dose requirements	Interpretation of delivered dose, not direct testing for every organism

4. Delivered UV Dose and Lifetime Performance

The Core 20 and Core 40 units were evaluated on an internal test bench under controlled laboratory conditions (Figure 1). Internal testing at 95% UVT shows that both Core devices retain delivered UV dose above the NSF/ANSI 55 Class B reference dose of 16 mJ/cm^2 throughout the tested operating interval (Figure 2). Core 20 at 20 L/min delivered

approximately 29.5 mJ/cm^2 at beginning-of-life and approximately 24 mJ/cm^2 after 3,200 hours, corresponding to roughly 81% dose retention. Core 40 at 40 L/min delivered approximately 28.5 mJ/cm^2 at beginning-of-life and approximately 19.8 mJ/cm^2 after 3,200 hours, corresponding to approximately 70% retention. This trend is technically important: even after substantial operating time, both devices remain above the 16 mJ/cm^2 Class B reference at their rated flows — and do so under a tested 95% UVT condition that is more demanding than the 98% UVT specified in the NSF/ANSI 55 Class B protocol.

For Core 40, additional NSF-derived Q-beta reduction equivalent dose estimates provide evidence of significant beginning-of-life performance headroom (Figure 3). At 99% UVT, one Core 40 unit showed estimated reduction equivalent UV doses of approximately 52.25 mJ/cm^2 at 20 L/min, 52.03 mJ/cm^2 at 30 L/min, and 49.5 mJ/cm^2 at 40 L/min, while a second unit showed approximately 52.25 mJ/cm^2 at 20 L/min, 40.37 mJ/cm^2 at 30 L/min, and 34.65 mJ/cm^2 at 40 L/min. Even the lower data set remains well above the 2.00-log Q-beta reduction requirement at 40 L/min at beginning-of-life.



Figure 1. Core 20 and Core 40 devices on test.

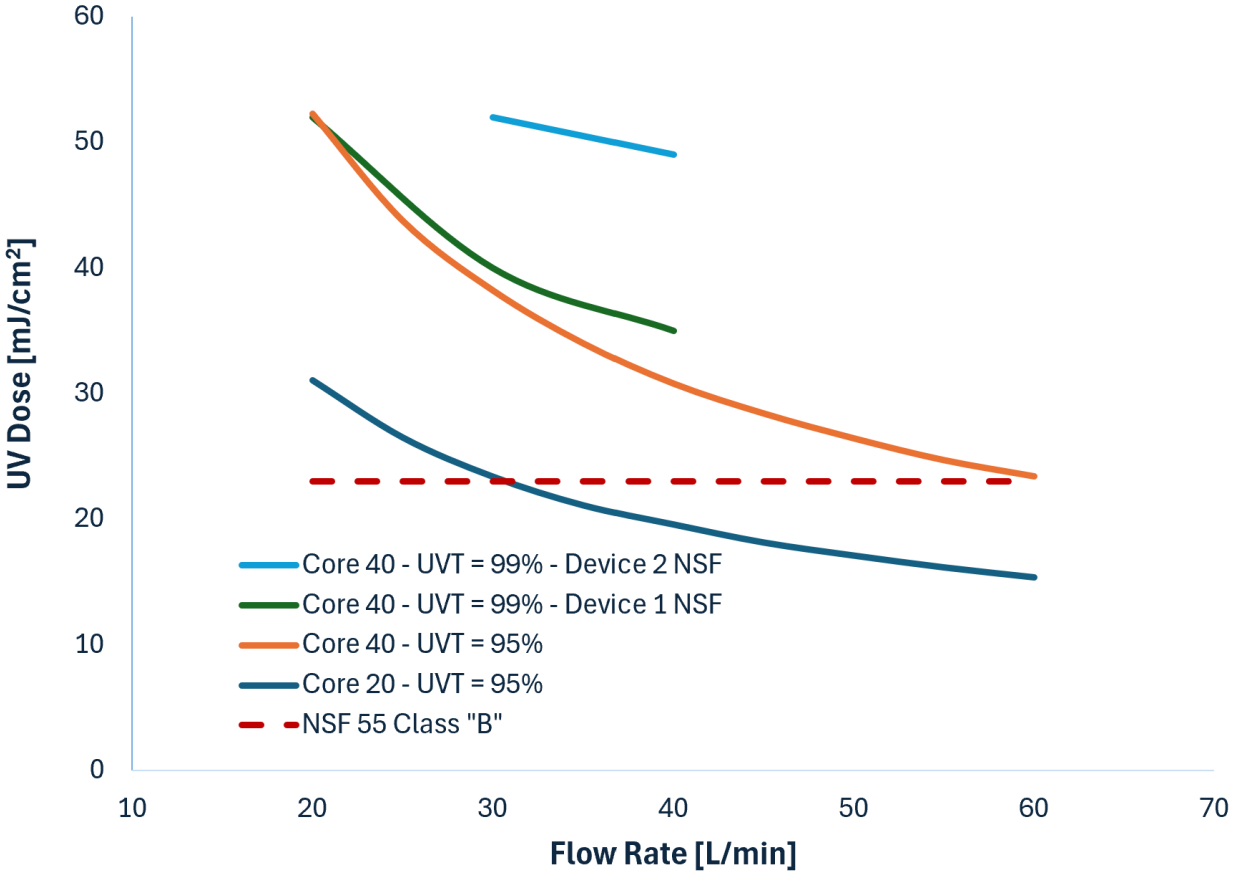


Figure 2. Core 20 and Core 40 delivered UV dose versus flow rate at 95% UVT (throughout the operating lifetime). Each model retains a delivered dose above the 16 mJ/cm² NSF/ANSI 55 Class B end-of-life reference, whereas a representative commercial UV device fell below this reference after approximately 350 hours of operation.

For these beginning-of-life data at 95% UVT, the applicable NSF/ANSI 55 Class B target is the 23 mJ/cm^2 beginning-of-life reference dose (the 16 mJ/cm^2 reference applies at end-of-life). Read from the beginning-of-life curves in Figure 3, each model meets or exceeds the 23 mJ/cm^2 reference at its rated flow.

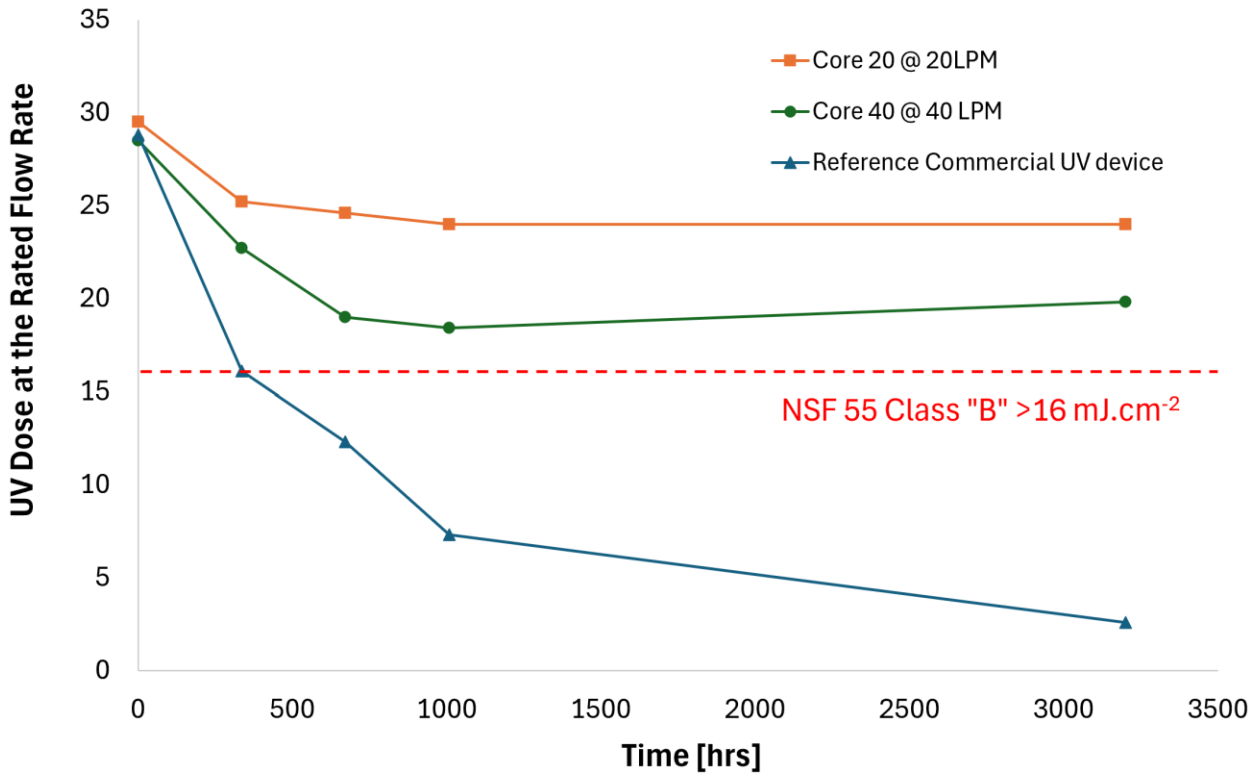


Figure 3. Core 20 and Core 40 delivered UV dose versus flow rate at 95% UVT (beginning-of-life). Each model retains a delivered dose above the UV dose required to achieve >2.0-log reduction of Q-beta for the NSF/ANSI 55 Class B beginning-of-life reference at and below its rated flow, with the dose declining non-linearly as flow increases.

Averaging across the available Core 40 beginning-of-life data points gives an estimated reduction equivalent dose of approximately 43–45 mJ/cm^2 at 99% UVT, consistent with the NSF/ANSI 55 Class B protocol. Applying internal degradation factors at 95% UVT yields estimated remaining doses of approximately 35–42 mJ/cm^2 after 336 hours and approximately 29–35 mJ/cm^2 after 672 hours — still well above the 16 mJ/cm^2 Class B threshold.

The available internal data at 95% UVT also show a useful distinction between the two models. Core 20 provides a comparatively stable delivered dose at its rated 20 L/min

condition, with only modest reduction over the tested interval. Core 40, operating at twice the rated flow, shows greater dose reduction over time but remains well above the NSF/ANSI 55 Class B dose reference under the tested 95% UVT condition.

Because the available Core 40 data include a UV dose versus flow relationship at beginning-of-life, the same dose-based framework can be used to present performance beyond the certified flow condition. For example, if a Core 40 beginning-of-life curve at approximately 95% UVT indicates a delivered dose near or above 20 mJ/cm^2 at a higher flow such as 60 L/min, that value can be compared directly against the organism dose table in this report. A delivered dose of 20 mJ/cm^2 would exceed the 4-log requirements for the listed bacteria and protozoa and would also be sufficient for approximately 5-log reduction for many bacterial organisms whose 5-log dose requirements are below 20 mJ/cm^2. This interpretation should be clearly labelled as dose-based and based on the specific curve condition, not as an NSF-certified flow rating.

5. Microorganism Reduction Interpretation

When the Core delivered doses are compared with published UV fluence-response data (Table 3), they support high levels of inactivation for many common bacterial organisms. Literature values summarized by Malayeri et al. indicate that 4-log inactivation of several relevant bacteria typically requires UV fluence values below or near 10 mJ/cm^2, including representative data for Escherichia coli, Legionella pneumophila, Pseudomonas aeruginosa, Salmonella, Shigella, Vibrio, and Yersinia species. The measured Core delivered doses at the rated flows — particularly the approximately 24 mJ/cm^2 retained by Core 20 and approximately 18–20 mJ/cm^2 retained by Core 40 during internal lifetime testing — are therefore expected to provide substantial reduction of many common bacterial organisms under comparable UVT and water-quality conditions.

The same dose comparison suggests strong relevance for protozoan organisms that are known to be highly UV-sensitive, such as Giardia and Cryptosporidium. Published fluence-

response data indicate that Giardia and Cryptosporidium can achieve multiple-log inactivation at relatively low UV fluence values, often below or near the 16 mJ/cm^2 Class B reference dose depending on assay method and organism strain. On this basis, Core 20 and Core 40 delivered doses at the tested rated conditions provide a reasonable basis to expect meaningful protozoan inactivation performance.

For viruses and viral surrogates, interpretation should be more conservative. Q-beta bacteriophage was used directly in the NSF/ANSI 55 testing and therefore provides the most relevant direct viral surrogate evidence for Class B performance. Published data show that UV susceptibility varies significantly across virus types. Some viruses and bacteriophages require UV doses comparable to, or higher than, the NSF Class B reference dose for multi-log inactivation, while adenoviruses and certain resistant viral targets may require substantially higher fluence. Accordingly, the Core data support NSF/ANSI 55 Class B reduction performance using Q-beta under the tested conditions, but the available data should not be generalized to claim broad high-log virus inactivation beyond organisms and conditions supported by dose-response literature.

6. Results Interpretation

The key message is that Core 20 and Core 40 are engineered to do more than meet a nominal UV dose target at beginning-of-life — they retain a meaningful dose margin throughout their service life, as summarized in Table 2. Core 20 retains approximately 24 mJ/cm^2 after 3,200 hours at 20 L/min, and Core 40 retains approximately 18–20 mJ/cm^2 after extended operation at 40 L/min, both at 95% UVT. These retained doses stay above the 16 mJ/cm^2 NSF/ANSI 55 Class B reference and above the 4-log dose requirements for the bacterial and protozoan organisms summarized in Table 3.

Taken together, the evidence indicates that both models meet their intended NSF/ANSI 55 Class B positioning at their rated flows. Core 20 is supported by internal 95% UVT lifetime data and by high Q-beta reductions in NSF testing at 99% UVT; Core 40 is supported by a

formal NSF PASS at 40 L/min and 99% UVT — with measured Q-beta reductions above the 2-log Class B requirement — and by internal 95% UVT lifetime data. When these delivered doses are compared with peer-reviewed fluence-response data, both devices provide dose sufficient for ≥4-log reduction of the listed bacteria and protozoa, and in many cases for ≥5-log bacterial reduction, while retaining appropriate caution for more UV-resistant viral targets.

Table 2. Core 20 and Core 40 Performance Summary

Model & data source	Rated flow	UVT	UV dose — start of life	UV dose — extended operation	NSF/ANSI 55 Class B interpretation
Core 20 — internal lifetime data	20 L/min	96%	≈ 29.5 mJ/cm^2	≈ 24 mJ/cm^2 at 3,200 h (~81% retained)	Retains strong margin above the 16 mJ/cm^2 reference throughout life
Core 40 — internal lifetime data	40 L/min	96%	≈ 28.5 mJ/cm^2	≈ 18.4–19.8 mJ/cm^2 (~65–70% retained)	Remains above the 16 mJ/cm^2 reference at rated flow
Core 40 — NSF certification test	40 L/min	99%	2.443 & 2.226 log Q-beta reduction	—	Formal PASS (≥2.00-log required)
Core 20 — internal microbioassay (analysis by GAP, SAL EPA 1602)	20 L/min	95%+	2.5 ± 0.1 log Q-beta (BOL)	—	Exceeds the ≥2.0-log Class B criterion
Core 40 — internal microbioassay (analysis by GAP, SAL EPA 1602)	40 L/min	95%+	2.5 ± 0.2 log Q-beta (BOL)	—	Exceeds the ≥2.0-log Class B criterion

Core 20 / 40 — dose vs. flow (attached graphs)	20–40 L/min	95%	≈ 31 mJ/cm^2 (Core 20 @ 20 L/min); ≈ 30.8 mJ/cm^2 (Core 40 @ 40 L/min)	—	Each model above the 23 mJ/cm^2 beginning-of-life reference at its rated flow

Table 3. UV Dose Requirements and Core Delivered-Dose Capability for Selected Microorganisms

Microorganism	Group	Published UV dose for 4-log (mJ/cm^2)	Core delivered-dose capability (end-of-life, 18–24 mJ/cm^2)
Escherichia coli (ATCC 11229)	Bacteria	6.5–8.4	Sufficient for ≥5-log
E. coli O157:H7	Bacteria	5.5–7.0	Sufficient for ≥5-log
Legionella pneumophila	Bacteria	5.4–9.3	Sufficient for ≥5-log (representative strains)
Pseudomonas aeruginosa	Bacteria	3.1–7.5	Sufficient for ≥5-log (representative strains)
Salmonella spp.	Bacteria	7.0–8.3	Sufficient for ≥5-log (representative strains)
Shigella spp.	Bacteria	2.8–8.2	Sufficient for ≥5-log where data available
Vibrio cholerae	Bacteria	2.8–3.9	Sufficient for ≥5-log
Yersinia enterocolitica	Bacteria	5.1–5.8	Sufficient for ≥5-log
Cryptosporidium parvum / spp.	Protozoa	Often < 10 (assay-dependent)	Sufficient for high-log, dose-based reduction
Giardia spp.	Protozoa	1–3.4	Sufficient for ≥5-log, dose-based reduction

Q-beta bacteriophage	Virus (NSF test organism)	Direct NSF challenge organism	Directly certified — Core 40 PASS at 40 L/min, 99% UVT
Adenovirus and UV-resistant viruses	Virus	Substantially higher than bacteria/protozoa	Not claimed without additional validation

Note: Published 4-log fluence values are drawn from the peer-reviewed compilation by Malayeri et al. Delivered-dose capability is a dose-based interpretation under comparable wavelength, UVT, and water-quality assumptions; it is not a substitute for organism-specific challenge testing. 1 LRV = 1-log reduction value (e.g., 4.0 LRV = 99.99% reduction).

7. Assumptions and Limitations

- Performance results apply to the specific Core 20 and Core 40 devices, flow rates, UV transmittance values, water matrices, and test protocols described in the supporting reports.
- UV transmittance, flow rate, hydraulic behavior, fouling, temperature, and maintenance condition materially affect delivered UV dose.
- Delivered-dose comparisons against published fluence values are a dose-based interpretation and are not a substitute for organism-specific device validation.
- Claims for flow rates beyond the certified condition are presented as dose-based estimates tied to a specific curve condition, not as NSF-certified flow ratings.
- Virus inactivation beyond the Q-beta surrogate used in NSF testing should not be generalized without additional validation, as UV susceptibility varies significantly across virus types.
- Applications involving wastewater, high turbidity, high absorbance, or unusual process-water chemistry require separate validation under representative conditions.

8. Conclusions

The compiled evidence supports a technically defensible conclusion that both Core 20 and Core 40 meet their intended NSF/ANSI 55 Class B positioning at their rated flows. The strongest direct evidence consists of third-party NSF/ANSI 55 Class B Q-beta testing — a formal PASS for Core 40 at 40 L/min and 99% UVT, and Q-beta reductions above the Class B criterion for Core 20 — corroborated by an internal Q-beta microbioassay independently analyzed by GAP EnviroMicrobial Services. Internal delivered-dose and lifetime testing further shows that both models retain a meaningful dose margin above the 16 mJ/cm^2 Class B reference throughout the tested operating interval, as summarized in Table 2.

When these delivered doses are compared with peer-reviewed fluence-response data (Table 3), both devices provide dose sufficient for ≥4-log reduction of the listed bacteria and protozoa, and in many cases for ≥5-log bacterial reduction, while retaining appropriate caution for more UV-resistant viral targets. Presented with clear separation between direct validation, corroborating microbioassay data, lifecycle evidence, and dose-based interpretation, this report forms a credible scientific white paper suitable for technical, regulatory, and customer-facing audiences.