



# AGRICULTURAL APPLICATIONS & EVIDENCE BOOK

Water • Growing • Sanitation • Processing • Storage • Reuse

APPLICATIONS | EVIDENCE | VERIFICATION





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O3 AG Science • a division of O3 Science Inc. • ADVANCED OZONE TECHNOLOGY

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Page numbers refer to this complete 109-page master.

Results remain case-specific and tied to documented conditions, methods and evidence class.

# How to read the evidence

The evidence is organized as one connected agricultural story: source-water treatment, crop delivery, facility sanitation, processing, storage and responsible reuse. Each claim is presented with the operating conditions and records needed to understand what the result means.



- The blue water route follows treated water from the well and O3 equipment through irrigation, controlled growing, sanitation and reuse.
- Each application is sized for its own flow, pressure, chemistry, organic demand, contact requirement and treatment objective.
- Laboratory and field findings remain connected to the dose, contact time, medium and endpoint actually reported.
- Regulatory provisions and facility approvals are stated for the exact use and conditions they cover.
- Operational value is demonstrated with water, chemical, labor, quality, loss and production records.



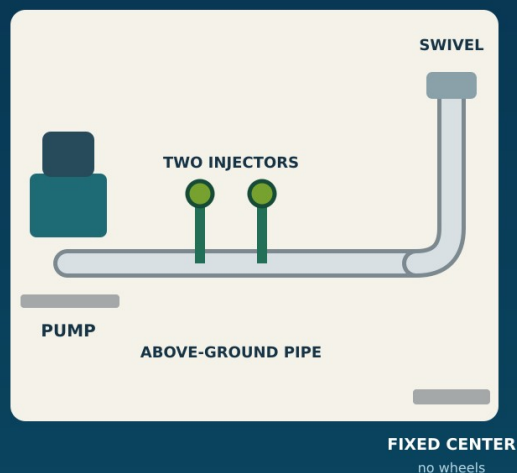
# Field irrigation and root-zone delivery

## PRESSURIZED AGRICULTURE



### TYPICAL PIVOT FEED

Above ground at the pivot installation



### IF A DISTANT RUN MUST BE BURIED:

It resurfaces before the pivot, then continues above ground into the center.

**WHAT IT IS DOING** — O3 treatment is engineered into the pressurized water stream before the fixed pivot point, then delivered through the lateral and sprinkler package to the crop root zone.

- Fixed center pivot and standpipe; mobile drive towers begin under the spans.
- Two injection points are located in the lower half of the supply line before the standpipe.
- System sizing follows flow, pressure, water chemistry, ozone demand, transfer and the treatment objective.

**WHY / PROOF POINT** — Visual is conceptual. Final installation details follow site engineering and approved equipment drawings.

# Drip irrigation, orchards and specialty crops

## TARGETED WATER DELIVERY



**WHAT IT IS DOING** — Controlled treatment can serve pressurized drip, micro-sprinkler and orchard systems when dose, contact and material compatibility are engineered for the site. Drip tape, laterals and emitters remain on the soil surface beside the crop rows.

- A remote supply main may be buried, but it rises before the above-ground field manifold and drip system.
- Monitoring focuses on flow, pressure, treatment residual or ORP where appropriate, and emitter performance.
- Agronomic benefits are evaluated from verified field records together with crop stage, soil condition and water chemistry.

**WHY / PROOF POINT** — Crop response depends on the documented field design and operating conditions; results are not presented as a universal response for every crop or site.



# Greenhouse, hydroponic and aquaponic systems

## RECIRCULATING GROWING WATER



**WHAT IT IS DOING** — The treatment loop is separated from occupied air and direct animal exposure, with contact, filtration and monitoring before water returns to the growing system.

- Applications include soil-grown greenhouse crops, hydroponic channels and properly engineered recirculating aquaculture loops.
- Dose must account for organics, nutrients, temperature, pH, biology and recirculation rate.
- Verification may include water chemistry, dissolved oxygen, ORP where suitable, microbiology and crop or animal performance.

**WHY / PROOF POINT** — Aquaponic and aquaculture systems require careful residual control and validation before treated water returns to animals.

# Dairy and animal facilities

## WATER, EQUIPMENT AND FACILITY SANITATION



**WHAT IT IS DOING** — O3 systems have been applied across agricultural facilities through engineered water treatment, equipment sanitation support, wastewater handling and controlled unoccupied-space treatment.

- Map the exact sanitation plan: water source, contact point, cleaning step, monitoring, corrective action and recordkeeping.
- Keep occupied animal and worker areas protected from unintended ozone exposure.
- Document water, chemical, labor, quality and maintenance changes against a verified baseline.

**WHY / PROOF POINT** — Facility records, sanitation plans, laboratory evidence and the applicable authority define the scope of each documented result and approved use.



# Produce washing, sorting and packaging

## FOOD-HANDLING APPLICATIONS



**WHAT IT IS DOING** — Treatment can be integrated across wash water, contact systems, equipment sanitation, packaging, cold storage and wastewater management under the facility sanitation plan.

- 21 CFR 173.368 permits ozone as an antimicrobial agent in gaseous or aqueous treatment, storage and processing of foods under prescribed conditions and good manufacturing practice.
- Operational proof includes water quality, dose/residual, contact, microbiology, product quality and sanitation records.
- Cost analysis can address water turnover, chemical purchases, labor, downtime, rework, spoilage and wastewater handling.

**WHY / PROOF POINT** — Regulatory foundation: 21 CFR 173.368. Facility-specific requirements and records must also be documented.

# Meat and dairy-food processing

## PROCESS SANITATION AND COLD STORAGE



**WHAT IT IS DOING** — O3 treatment is presented within the established facility process: wash water, equipment and environmental sanitation, packaging, cold storage and wastewater.

- Preserve the actual approved sanitation-plan language and inspection history for each O3 installation.
- Separate aqueous food-contact use, equipment sanitation, controlled air treatment and wastewater into their correct operating procedures.
- Match USDA/FSIS, FDA, health-department and facility records to the exact application and establishment.

**WHY / PROOF POINT** — Each approval entry identifies the issuing authority, facility or application, effective conditions and supporting record so the reader can see precisely what was accepted.



# Fish production and processing

## AQUACULTURE TO PACKAGED PRODUCT



**WHAT IT IS DOING** — The chapter follows water through fish production, recirculation treatment, hygienic processing, cold storage and wastewater management.

- Solids removal and biofiltration remain distinct from the controlled ozone contact loop.
- Residual, off-gas and water-quality controls protect aquatic animals and workers.
- Processing claims connect to the documented sanitation plan and food-handling requirements.

**WHY / PROOF POINT** — Project history, laboratory findings and outside aquaculture science will be presented as separate, traceable evidence layers.

# Silos and root-crop storage

## AERATION-STREAM TREATMENT



**WHAT IT IS DOING** — Ozone is introduced into the existing aeration airflow and distributed through stored grain, potatoes, sugar beets or other commodities under a controlled treatment plan.

- System design follows airflow, storage volume, commodity depth, humidity, leakage and ozone demand.
- Evidence addresses mold and microbial control, insect pressure, quality preservation and chemical-use reduction only where the operating records document those outcomes.
- Access control, concentration monitoring, shutdown, ventilation and verified re-entry protect workers.

**WHY / PROOF POINT** — Treatment outcomes and allowable uses remain tied to the commodity, facility, exposure conditions and supporting records.



# Warehouse and cold-room air sanitation

## CONTROLLED UNOCCUPIED-SPACE PROCESS



**WHAT IT IS DOING** — The treatment cycle isolates the room, distributes a controlled concentration, holds the validated exposure, then destructs or ventilates ozone before verified re-entry.

- Occupied warehouse operations remain physically separated from the active treatment space.
- Distribution, humidity, leakage, reactive surfaces and room contents affect delivered exposure.
- Ambient monitoring and written clearance procedures are required before personnel return.

**WHY / PROOF POINT** — Water-treatment results are never used as air-treatment settings; each air application requires its own validation and safety plan.

# Agricultural well-water treatment

## TWO WATER PATHS: IRRIGATION DELIVERY OR FINISHED-WATER PURIFICATION



**WHAT IT IS DOING** — Ozone can oxidize reduced contaminants, disrupt biological loading and change mineral availability. From that common oxidation step, the system follows the path required by the intended water use.

- **IRRIGATION PATH** — Treated water is normally delivered without routine post-ozone filtration so released, oxidized or chelated nutrient fractions can remain in the irrigation stream and move to the soil and root zone. Filtration is used only when a defined plugging, solids, equipment-protection or contaminant-removal objective requires it.
- **CULINARY / STORAGE / PURIFICATION PATH** — Where finished-water removal is the objective, oxidized iron and solids are separated, and arsenic(III) may be oxidized to arsenic(V) before a properly selected removal barrier. Arsenic is not destroyed by oxidation alone.
- Standard carbon is not presented as a dependable arsenic barrier unless the exact product is certified and rated for that use.

**WHY / PROOF POINT** — Irrigation projects verify delivery, water condition, soil response, plant tissue or sap, BRIX and crop performance. Culinary, storage and purification projects verify finished-water quality, filter loading, backwash and media breakthrough as applicable.



# Ponds, reservoirs and irrigation storage

## SIDE-STREAM TREATMENT AND CIRCULATION



**WHAT IT IS DOING** — A controlled side stream is withdrawn, injected, contacted, filtered and returned to create circulation while limiting disturbance of accumulated sediment.

- Design follows pond volume, turnover, organic load, stratification, intake conditions and irrigation demand.
- Return distribution and monitoring are engineered for the specific reservoir and downstream use.
- Performance proof can include water chemistry, microbiology, turbidity, odor, algae indicators and irrigation-system condition.

**WHY / PROOF POINT** — Open-water applications require site-specific engineering and verification; visual flow is conceptual.

# Wastewater treatment and reuse

## MULTI-BARRIER TREATMENT



**WHAT IT IS DOING** — Ozone is positioned as one controlled stage after appropriate solids and biological treatment, followed by filtration, monitoring and the permitted reuse or discharge pathway.

- Wastewater demand can be far higher than clean-water demand and cannot be compared on time alone.
- Targets may include oxidation, odor control, color reduction, microbial reduction or polishing, depending on the process.
- Final reuse or discharge claims require site testing and applicable permits or authority.

**WHY / PROOF POINT** — Recovered long-contact findings involving wastewater remain labeled by their original medium and are not presented as universal O3 equipment speed.



# Evidence appendix — interpretation and controls

The evidence tables preserve the reported organism, dose, medium, contact time and endpoint. This structure allows readers to distinguish rapid clean-water findings from tests involving fungi, distilled water, sludge effluent or high-demand wastewater.

## Readable recovered timing audit

Every entry remains tied to its reported dose, medium, contact time and endpoint. The three timing groups below replace the small-print raster boxes in the previous proof.

| RAPID — SECONDS        |                                                         |
|------------------------|---------------------------------------------------------|
| Hepatitis A            | 2 sec   0.25 mg/L   phosphate buffer   99.5% reduction  |
| Bacteriophage f2       | 10 sec   0.41 mg/L   water   99.99%                     |
| Coxsackie A9           | 10 sec   0.035 mg/L   water   95%                       |
| E. coli                | approximately 30 sec   0.25 mg/L   clean water   99.99% |
| Several listed viruses | less than 30 sec   0.1–0.8 mg/L   medium not stated     |

| SHORT — 1 TO 5 MINUTES   |                                               |
|--------------------------|-----------------------------------------------|
| B. cereus                | 1 min   0.12 mg/L   water   99%               |
| Echo virus 29            | 1 min   1 mg/L   medium not stated   99.999%  |
| C. difficile             | 2 min   0.6 mg/L   water   99.999%            |
| Coxsackie B5             | 2.5 min   0.4 mg/L   sludge effluent   99.99% |
| Clavibacter michiganense | 5 min   1.1 mg/L   medium not stated   99.99% |

| EXTENDED — 10 TO 29 MINUTES |                                               |
|-----------------------------|-----------------------------------------------|
| Fusarium oxysporum          | 10 or 20 min   1.1 mg/L   medium not stated   |
| Cladosporium                | 12.1 min   0.10 ppm   medium not stated   90% |
| E. coli                     | 19 min   2.2 mg/L   wastewater   99.9%        |
| Legionella                  | 20 min   0.32 mg/L   distilled water   99.99% |
| Enteric virus               | 29 min   4.1 mg/L   raw wastewater   95%      |

**READING RULE** — These recovered entries are not one universal dose-response curve. Compare results only when organism, medium, dose, endpoint and measurement method are equivalent.

# How to read and verify the recovered findings

## CONDITIONS CONTROL THE RESULT

| RECORD ELEMENT            | WHY THE READER NEEDS IT                                                                                     |
|---------------------------|-------------------------------------------------------------------------------------------------------------|
| Organism or target        | Susceptibility varies; results for one target cannot automatically be assigned to another.                  |
| Dose and residual         | Generator output is not the same as the ozone concentration maintained at the point of contact.             |
| Water or process medium   | Clean water, wastewater, sludge effluent and high-organic-load systems impose different ozone demand.       |
| Contact time and endpoint | Seconds or minutes must remain attached to the measured percentage or log reduction.                        |
| Test and sampling method  | A result is reviewable only when the laboratory method, sampling location and detection limit are retained. |

**VERIFICATION STANDARD** — O3 Science project results are presented with their matching controlled test records. A facility claim should point to the applicable laboratory report, operating condition, sanitation record or inspection document.

- The recovered Ozone Effects reference contains results stated in seconds and minutes; it does not list milliseconds.
- Longer entries remain in their reported units and commonly involve fungi, wastewater, raw wastewater, distilled water or an unstated medium.
- Results for different organisms and media are not combined into a universal dose-response curve.
- Faster O3 Science project results are presented with their corresponding controlled test records.

Federal food-use provision: 21 CFR 173.368 states that ozone may be safely used as an antimicrobial agent in gaseous or aqueous treatment, storage and processing of foods under the prescribed conditions and current good manufacturing practice.



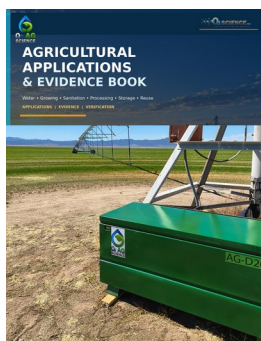


# Contents and proof architecture

## HOW THE EVIDENCE IS ORGANIZED

The book begins with a visual map of agricultural applications, then explains the engineering logic, application-specific proof chain, recovered findings, supporting science, regulatory records and measurable operational value. The same sequence supports both a bound presentation and a clear narrated program.

| SECTION                    | PURPOSE                                               | READER QUESTION                                          |
|----------------------------|-------------------------------------------------------|----------------------------------------------------------|
| Treatment fundamentals     | Explain dose, demand, contact and verification        | How is the system sized and controlled?                  |
| Agricultural growing       | Connect source water to root-zone performance         | What changes in the field and how is it measured?        |
| Food and animal facilities | Map sanitation into established plans                 | Where is O3 used and what records prove control?         |
| Storage and air            | Separate commodity treatment from worker exposure     | How are distribution, treatment and re-entry controlled? |
| Water and wastewater       | Show oxidation plus downstream separation             | What is transformed, removed and verified?               |
| Evidence and approvals     | Keep each claim attached to its source and conditions | What exactly supports the statement?                     |





# Not all ozone systems are created equal

## PRODUCTION METHOD, DELIVERED OUTPUT AND APPLICATION CONTROL

Ozone is the same molecule, O<sub>3</sub>, but ozone systems are not equal in how much ozone they produce, the concentration and gas quality they deliver, how efficiently they transfer it into water or distribute it through air, and how precisely they control exposure. The useful comparison is therefore not the word “ozone” on the machine; it is verified performance at the treatment point.

| SYSTEM FAMILY                               | PRACTICAL CHARACTERISTICS                                                                                                                                                            | DESIGN CONSEQUENCE                                                                                                                          |
|---------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Ultraviolet ozone generation                | Commonly produces comparatively low ozone concentration and output; performance depends strongly on lamp condition, gas path and application demand.                                 | Useful only where verified output and delivered exposure match the limited treatment requirement.                                           |
| Conventional corona discharge               | Electrical discharge can produce substantially higher ozone concentrations, but generator cell design, dielectric, power density, feed-gas purity, cooling and controls vary widely. | Two corona-discharge machines with similar labels can deliver very different gas concentration, stability and usable transfer.              |
| O3 Science higher-strength corona discharge | Company-developed configurations are described as producing stronger, controlled ozone for application-specific systems.                                                             | Claims are verified through machine-output, transfer, process and endpoint records for the installed system.                                |
| O3 Science “chain ozone” platform           | O3 Science describes this as its proprietary, more-reactive technology developed and tested within its platform.                                                                     | Present as proprietary company technology and support external claims with the applicable patent, engineering and comparative test records. |

**CENTRAL POINT** — System effectiveness depends on production, concentration, transfer, demand, contact, distribution, control and verification—not the presence of an ozone generator alone.





# Twenty-plus years of performance-based development

## DESIGN THE PROCESS AROUND THE REAL OPERATING NEED

O3 Science, Inc. describes more than 20 years of development, field application and laboratory testing across water, agriculture, sanitation, processing, storage and controlled air treatment. That experience led to a performance-based approach: begin with the customer's actual process, reduce uncontrolled variables, and design the equipment and operating plan around the endpoint that must be achieved.

| 1. CHARACTERIZE                                                                                                  | 2. DESIGN                                                                                                                | 3. CONTROL                                                                                              | 4. VERIFY                                                                                                                        |
|------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Water or air flow;<br>chemistry; humidity;<br>temperature; organics;<br>solids; microbial or<br>oxidation target | Generator capacity;<br>feed gas; injection or<br>distribution; mixing;<br>contact; filtration;<br>destruction and safety | Output; pressure; flow;<br>residual or<br>concentration; alarms;<br>maintenance; access<br>and re-entry | Laboratory endpoint;<br>water/air result; crop or<br>product response;<br>sanitation record;<br>operating and financial<br>trend |

## Why reducing variables matters

Every uncontrolled variable can consume ozone, shorten its useful life, prevent even distribution or make two tests incomparable. Pretreatment, stable feed gas, known flow, good mixing, defined contact, controlled humidity, solids management and repeatable sampling allow the treatment result to be designed and verified with less uncertainty.

**PERFORMANCE-BASED PROMISE** — O3 Science evaluates the situation first. The system is configured for the customer's need, flow, process, treatment objective and verification plan rather than treating one machine rating as a universal solution.



# The treatment equation

## DOSE IS ONLY ONE PART OF PERFORMANCE

The system must deliver enough oxidant to satisfy immediate water or air demand and still provide the controlled exposure needed for the stated objective. Generator output alone does not establish the delivered treatment.

O<sub>3</sub> SCIENCE, INC.

### Engineering ozone dose to meet the treatment objective

The system is sized around dissolved ozone residual, contact time, water demand and flow—not generator output alone.

#### THE CONTROLLABLE EXPOSURE RELATIONSHIP

$$C \times T = \text{dissolved ozone residual (mg/L remaining after ozone demand)} \times \text{contact time (minutes or seconds at that residual)}$$

For the same illustrative exposure target:

LOWER RESIDUAL / LONGER TIME

$$0.25 \text{ mg/L} \times 2.0 \text{ min} = 0.50 \text{ mg-min/L}$$

MODERATE RESIDUAL / MODERATE TIME

$$0.50 \text{ mg/L} \times 1.0 \text{ min} = 0.50 \text{ mg-min/L}$$

HIGHER RESIDUAL / SHORTER TIME

$$1.00 \text{ mg/L} \times 0.5 \text{ min} = 0.50 \text{ mg-min/L}$$

#### WHAT HAPPENS WHEN WE INCREASE THE USABLE DOSE



#### HOW O<sub>3</sub> SCIENCE BUILDS THE SYSTEM AROUND THE JOB

##### INPUTS WE MEASURE

- Flow rate and pressure
- Water/air quality and ozone demand
- Target organism or treatment objective

##### SYSTEM LEVERS

- Ozone production and concentration
- Injection / mass-transfer efficiency
- Contact volume, time and recirculation

##### CONTROL & PROOF

- Dissolved ozone / ORP as appropriate
- Flow-paced output and alarms
- Validated sampling and documented results

##### SAFE FINISH

- Off-gas management / destruct
- Material compatibility
- Ventilation and verified re-entry for air

ENGINEERING EXPLANATION • The numeric CxT examples are illustrative, not organism claims. Actual targets must be validated for the specific organism, medium, temperature, pH, ozone demand, equipment and operating conditions. Higher dose does not guarantee a linear response.

**ENGINEERING RULE** — Higher applied dose can shorten the time required to reach a defined endpoint only when transfer, mixing, demand, temperature, humidity, pH, medium and organism remain controlled. Unlike tests cannot be combined into a universal curve.



# Treatment equation

O<sub>3</sub> SCIENCE, INC.

## Engineering ozone dose to meet the treatment objective

The system is sized around dissolved ozone residual, contact time, water demand and flow—not generator output alone.

THE CONTROLLABLE EXPOSURE RELATIONSHIP

C × T =

dissolved ozone residual  
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×

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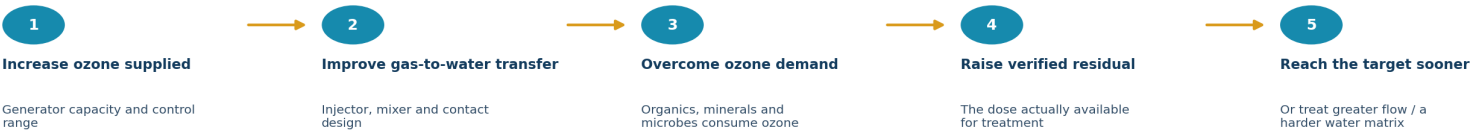
MODERATE RESIDUAL / MODERATE TIME

0.50 mg/L × 1.0 min = 0.50 mg-min/L

HIGHER RESIDUAL / SHORTER TIME

1.00 mg/L × 0.5 min = 0.50 mg-min/L

WHAT HAPPENS WHEN WE INCREASE THE USABLE DOSE



HOW O<sub>3</sub> SCIENCE BUILDS THE SYSTEM AROUND THE JOB

INPUTS WE MEASURE

- Flow rate and pressure
- Water/air quality and ozone demand
- Target organism or treatment objective

SYSTEM LEVERS

- Ozone production and concentration
- Injection / mass-transfer efficiency
- Contact volume, time and recirculation

CONTROL & PROOF

- Dissolved ozone / ORP as appropriate
- Flow-paced output and alarms
- Validated sampling and documented results

SAFE FINISH

- Off-gas management / destruct
- Material compatibility
- Ventilation and verified re-entry for air

ENGINEERING EXPLANATION • The numeric CxT examples are illustrative, not organism claims. Actual targets must be validated for the specific organism, medium, temperature, pH, ozone demand, equipment and operating conditions. Higher dose does not guarantee a linear response.

Large-print chart: supplied ozone, transfer, demand, verified residual and contact time.



# Water treatment: from generation to verification

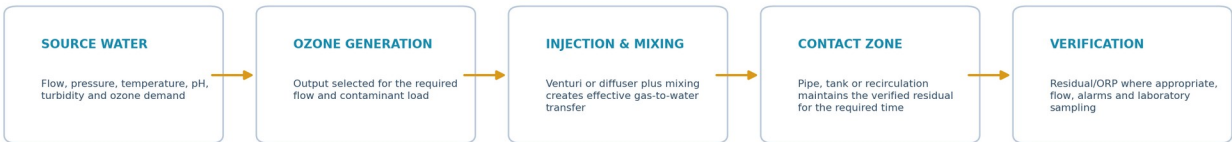
## A CONTROLLED TREATMENT TRAIN

O<sub>3</sub> SCIENCE, INC.

### Water treatment: dose, transfer, contact and proof

The treatment dose is the ozone that is successfully dissolved and maintained in the water—not simply the generator rating.

#### WATER PROCESS



#### HOW INCREASING THE USABLE WATER DOSE CHANGES THE JOB

##### More ozone supplied

Adds treatment capacity when the generator is the limiting factor.

##### More ozone transferred

Improved injection and mixing raise the dissolved fraction.

##### Demand is satisfied

Organics, minerals and microorganisms consume the initial dose.

##### Residual rises

More ozone remains available during the contact period.

##### Treatment capacity increases

Can support shorter time, higher flow or a more difficult water matrix—after validation.

#### SYSTEM-SIZING INPUTS

• gallons per minute / pressure • ozone demand and water chemistry • target endpoint • required contact time • transfer efficiency • operating duty cycle

**$C \times T = \text{dissolved ozone residual} \times \text{contact time}$**

ENGINEERING NOTE • Actual dose and contact time must be validated for the specific organism, water matrix, temperature, pH and operating conditions. Increased applied dose does not guarantee a proportional increase in residual or performance.

| STAGE                       | FUNCTION                                                               | PRIMARY RECORD                                                |
|-----------------------------|------------------------------------------------------------------------|---------------------------------------------------------------|
| Source characterization     | Establish pH, temperature, organics, metals, solids and microbial load | Baseline laboratory and field data                            |
| Generation and injection    | Produce and transfer O <sub>3</sub> into the moving water              | Output, gas flow, water flow and pressure                     |
| Mixing and contact          | Distribute treatment and provide reaction time                         | Contact volume, residence time, residual/ORP when appropriate |
| Separation / polishing      | Capture oxidized solids or use application-specific media              | Pressure loss, backwash and media condition                   |
| Finished-water verification | Confirm that the treatment objective was achieved                      | Laboratory result and release record                          |



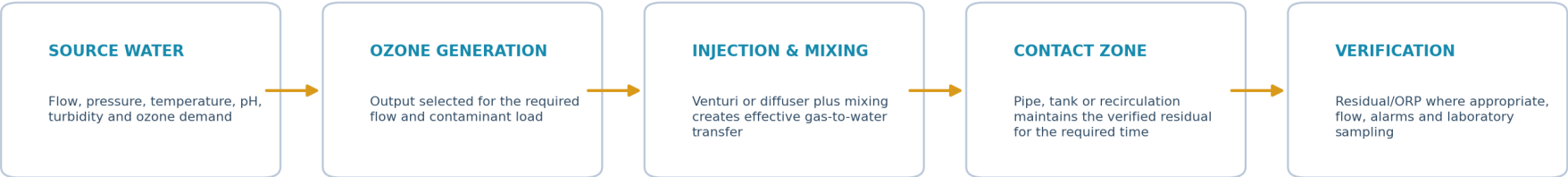
# Water-treatment generation and verification

O<sub>3</sub> SCIENCE, INC.

## Water treatment: dose, transfer, contact and proof

The treatment dose is the ozone that is successfully dissolved and maintained in the water—not simply the generator rating.

### WATER PROCESS



### HOW INCREASING THE USABLE WATER DOSE CHANGES THE JOB

#### More ozone supplied

Adds treatment capacity when the generator is the limiting factor.

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Improved injection and mixing raise the dissolved fraction.

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**$C \times T = \text{dissolved ozone residual} \times \text{contact time}$**

ENGINEERING NOTE • Actual dose and contact time must be validated for the specific organism, water matrix, temperature, pH and operating conditions. Increased applied dose does not guarantee a proportional increase in residual or performance.

Large-print process chart. System inputs remain connected to point-of-use verification.



# SP Water Treatment System

## STANDARD WATER TREATMENT AND PURIFICATION PLATFORM

The regular O3 Science SP Water Treatment System is the base water-treatment and purification platform used where the project requires a controlled treatment train rather than irrigation injection alone. The SP is configured from the actual source-water analysis, design flow, pressure, contaminant load, treatment objective and finished-water requirement.

| TREATMENT STAGE                            | WHAT THE SP PLATFORM DOES                                                                                                                                                  | VERIFICATION RECORD                                                                      |
|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| Source and pretreatment                    | Characterize the water and protect downstream equipment from solids or demand that should be handled first.                                                                | Source laboratory report; flow; pressure; turbidity; pH; temperature; demand indicators. |
| O3 generation and transfer                 | Generate controlled ozone and transfer it into the process stream at the engineered injection and mixing point.                                                            | Machine output; feed gas; water flow; pressure; injector or transfer performance.        |
| Contact and reaction                       | Provide the controlled exposure needed for oxidation or microbial-reduction objectives under the actual water conditions.                                                  | Contact volume/time; residual or ORP where applicable; operating alarms and limits.      |
| Separation / polishing (purification path) | For culinary, storage or finished-water objectives, capture oxidized solids and apply the required filtration or certified media. This is not the routine irrigation path. | Filter pressure; backwash; media identification; breakthrough monitoring.                |
| Finished-water release                     | Confirm that the complete SP treatment train—not the generator alone—meets the defined finished-water objective.                                                           | Accredited laboratory result; sanitation or release record; corrective-action history.   |

**WHY IT BELONGS IN THIS BOOK** — The SP platform serves culinary, stored, facility-process and sanitation-water applications that require a complete purification train. Exact components and settings remain project-specific.

**IMPORTANT DISTINCTION** — Irrigation water normally bypasses routine post-ozone filtration so released, oxidized or chelated nutrient fractions remain available to the crop and root zone. Add filtration only for a defined contaminant, plugging, equipment-protection or regulatory need.





# Ozonated water for sanitation delivery

## WASHDOWN, PROCESS AND FOOD-CONTACT APPLICATIONS

Water carries dissolved ozone to the point of use, where it can be sprayed or circulated through an approved sanitation procedure for equipment, work areas, produce-contact systems and carcass-contact operations. Design is based on the dissolved concentration, demand, flow, coverage and contact time at the application point—not generator output alone.

| APPLICATION                     | HOW THE WATER PATH IS USED                                                                               | PROOF / CONTROL RECORD                                                   |
|---------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|
| Equipment and facility washdown | Apply to cleaned surfaces, conveyors, drains and process areas under the facility sanitation plan.       | Point-of-use dissolved ozone; coverage; contact time; inspection.        |
| Produce washing and handling    | Use a controlled loop or spray where permitted by the validated process and food-safety plan.            | Water quality; concentration/contact window; microbial verification.     |
| Carcass and food processing     | Deliver through the establishment-approved intervention or sanitation step and required regulatory plan. | Operating limits; monitoring; validation; sanitation record.             |
| Recirculated process water      | Control accumulated demand so return water stays within the validated sanitation condition.              | Make-up flow; organic load; residual trend; purge and microbial records. |

**WHY FACILITIES USE IT** — Dissolved ozone is generated on site and decomposes without a persistent sanitizer residue. It can reduce chemical storage, handling and discharge burden while providing rapid oxidation at the point of use. Material compatibility is confirmed for ozone-sensitive components.

**PUBLISHED CHLORINE COMPARISONS** — Published evidence supports the exceptional speed and capability of aqueous ozone. U.S. EPA material reports bacterial destruction approximately 600–3,000 times more rapid than chlorine. Peer-reviewed food-safety literature reports reaction with organic material up to 3,000 times faster. Other aqueous-ozone sanitation literature reports that 1 ppm dissolved ozone can provide disinfecting capability equivalent to roughly 10–4,000 times the free-chlorine concentration, depending on pH, temperature and organism. Each project still verifies its required dose and contact time.

**SAFER DELIVERY, VERIFIED CONTROL** — Dissolved delivery carries the active oxidant to the surface, reduces reliance on stored chlorine chemistry and avoids a persistent sanitizer residue. Engineered transfer, ventilation and off-gas control minimize breathing-zone release. Verification records point-of-use dose, exposure, coverage and microbiological outcome.

*Evidence basis: U.S. EPA, Contaminants Associated With Direct and Indirect Reuse of Wastewater; Korany et al., Frontiers in Microbiology 9:2296 (2018), citing EPRI; Hamil, Ozone Sanitation—A Sustainable and Efficacious Approach to Food Safety, citing Morris (1975).*



# The O3 Science performance layer

## THE PUBLISHED OZONE BASELINE IS NOT THE CEILING OF THIS TECHNOLOGY

Most published ozone comparisons describe conventional UV or commodity corona-discharge equipment. O3 Science systems are presented separately because their higher-output corona-discharge and proprietary chain-ozone platform, transfer method and operating controls were developed and refined through more than 20 years of laboratory and field work. The design objective is dependable performance at the point of treatment—not a catalog generator rating.

| PERFORMANCE ELEMENT      | WHAT MAKES THE O3 SCIENCE APPROACH DIFFERENT                                                                                     | WHAT PROVES IT                                                                                            |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|
| Ozone generation         | Higher-output corona-discharge and proprietary chain-ozone technology are configured for the required treatment demand.          | Machine configuration, feed gas, measured output and operating record.                                    |
| Transfer and delivery    | Injection, mixing, dissolved-ozone retention, flow and coverage are engineered so useful ozone reaches the actual target.        | Point-of-use dissolved ozone, pressure, flow, contact time and distribution checks.                       |
| Performance-based design | Each water, air and sanitation project is sized from its real variables rather than treated as a one-size-fits-all installation. | Source load, process demand, temperature, humidity, materials, treatment objective and verification plan. |
| Verified outcome         | The operating condition is adjusted until the required reduction and facility result are repeatedly demonstrated.                | Laboratory results, environmental samples, sanitation records, inspections and corrective-action history. |

**DOCUMENTED O3 SCIENCE FINDINGS** — Company laboratory and facility records report reductions up to 99.999% (5-log) under the documented test conditions, including bacterial targets and tested viral, mold and mildew targets. Meat-processing, produce-processing and fish-processing installations are included in the operating history; fish-processing environments provided an especially demanding sanitation test because of their high organic and microbial load.

**FACILITY AND INSPECTION EXPERIENCE** — The company reports that annual Health Department, FDA and USDA reviews of the operating facilities found no detectable target organisms in the referenced sanitation checks. The evidence package ties each statement to the available inspection report, sampling record, sanitation plan and facility operating condition so the result can be independently reviewed.

**UNDER-PROMISE. OVER-DELIVER.** — O3 Science establishes a conservative operating promise, then designs sufficient generation, transfer, contact and monitoring capacity to meet or exceed the validated requirement. Published literature supports ozone as a category; O3 Science laboratory and field records establish what this technology has accomplished.



# Air treatment: controlled cycle and verified re-entry

## UNOCCUPIED-SPACE APPLICATION

O<sub>3</sub> SCIENCE, INC.

### Air sanitation: controlled concentration, exposure and re-entry

Air treatment is a separate engineering application. Concentration, distribution, humidity, exposure time and safe re-entry must all be controlled.

#### CONTROLLED AIR-TREATMENT SEQUENCE



#### WHAT A HIGHER AIR CONCENTRATION CAN CHANGE

##### Potential benefit

A properly distributed higher concentration may reach a validated exposure target sooner or address a more demanding space.

##### What can interfere

Leaks, poor circulation, reactive surfaces, humidity and room contents can reduce the concentration reaching the target.

##### What must be monitored

Ambient ozone concentration, treatment time, distribution, shutdown and clearance before people return.

##### Non-negotiable safety

High-concentration shock treatment is for controlled, unoccupied areas with ventilation/destruct and verified re-entry procedures.

#### AIR EXPOSURE CONCEPT

**concentration × exposure time — validated for the room, target, humidity, distribution and materials**

#### OCCUPIED-SPACE PROTECTION

Controls must prevent unintended exposure and comply with applicable occupational limits, labeling, codes and operating procedures. Never infer an air-treatment setting from a water-treatment result.

- Isolate and post the treatment zone; remove people, animals and plants as required by the approved procedure.
- Distribute O<sub>3</sub> through the defined air path and validate the treatment concentration and exposure period.
- Shut down generation, use destruction or ventilation, and measure ambient concentration before re-entry.
- Maintain treatment, alarm, shutdown, clearance and corrective-action records.

**CRITICAL DISTINCTION** — Water findings do not establish an air-treatment setting. Air applications require their own concentration, humidity, distribution, material-compatibility, occupational-safety and clearance validation.



# Controlled-air treatment sequence

O<sub>3</sub> SCIENCE, INC.

## Air sanitation: controlled concentration, exposure and re-entry

Air treatment is a separate engineering application. Concentration, distribution, humidity, exposure time and safe re-entry must all be controlled.

### CONTROLLED AIR-TREATMENT SEQUENCE



### WHAT A HIGHER AIR CONCENTRATION CAN CHANGE

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### OCCUPIED-SPACE PROTECTION

Controls must prevent unintended exposure and comply with applicable occupational limits, labeling, codes and operating procedures. Never infer an air-treatment setting from a water-treatment result.

Large-print process chart for isolated, unoccupied treatment and verified clearance.



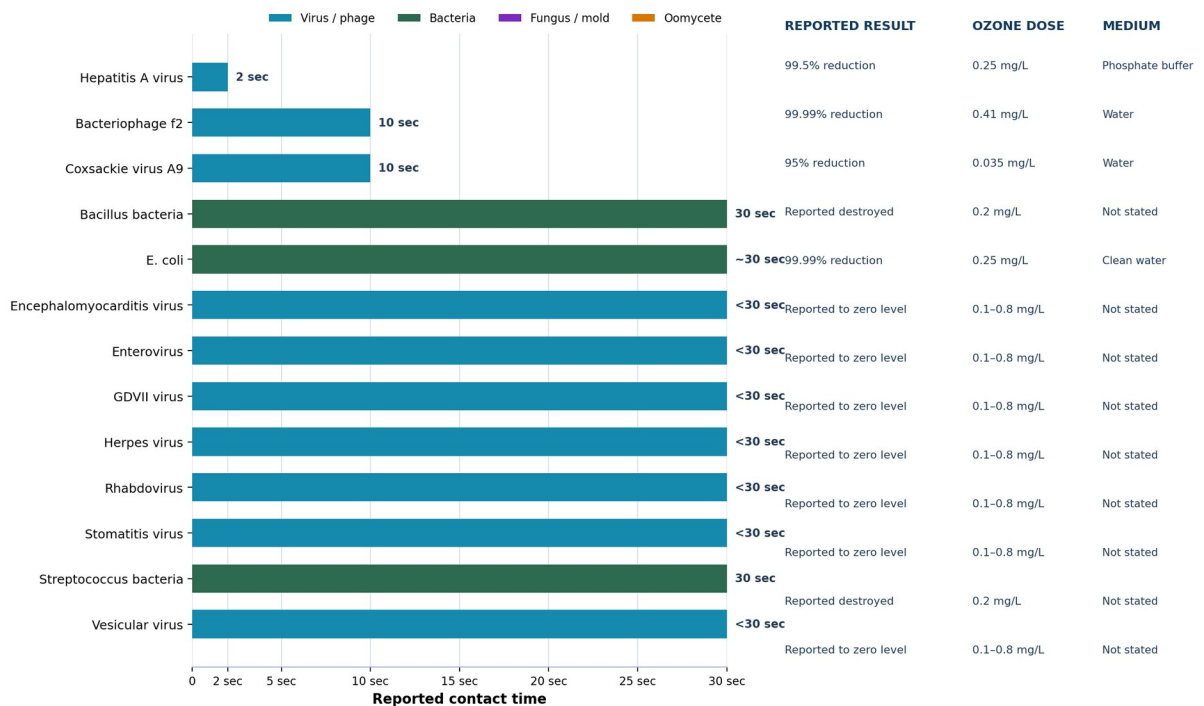
# How dose and contact work together

## CONCEPTUAL RESPONSE - NOT A UNIVERSAL KILL CURVE

O<sub>3</sub> SCIENCE, INC.

### Rapid-contact findings

Reported outcomes at 30 seconds or less



DRAFT FOR APPROVAL • Transcribed from Ozone Effects.odt (Ozone Clean Pro). Source matching and independent verification are in progress. Do not treat these rows as universal machine-performance claims.

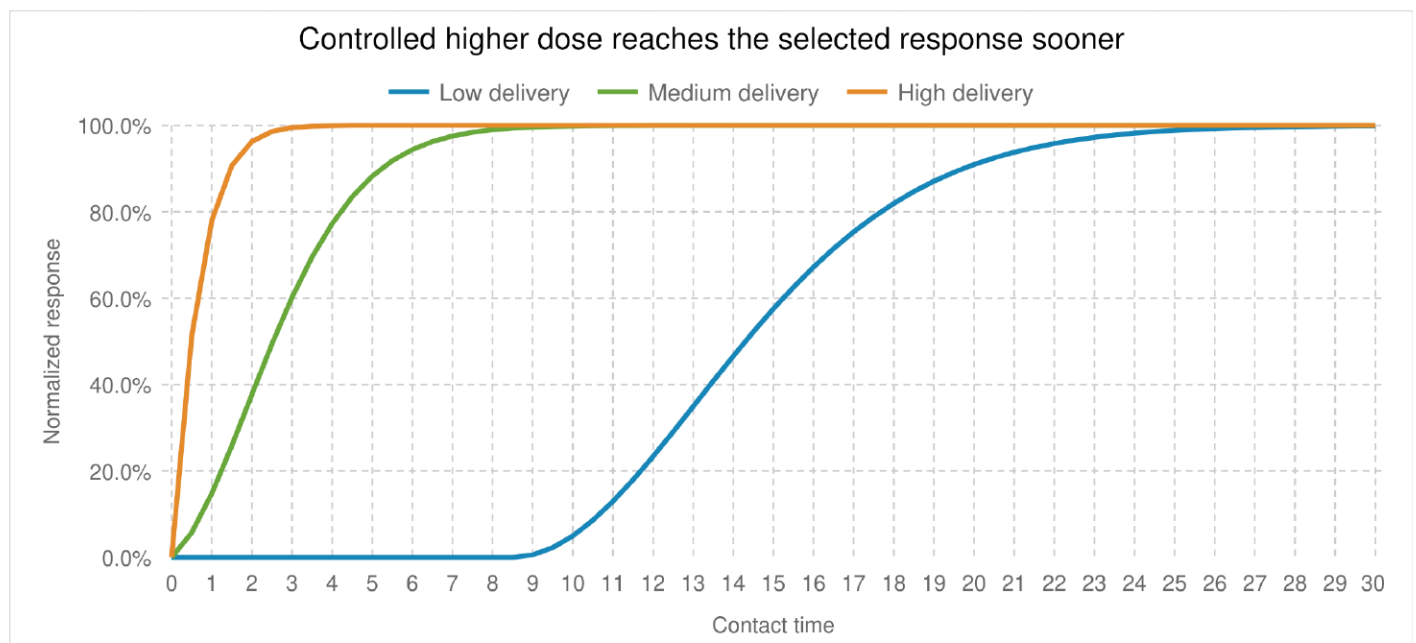
For a defined organism and medium, increasing delivered exposure may accelerate oxidation and reduction. The applicable value is the dose actually transferred into the process, not only generator nameplate output. Demand can consume treatment before a measurable residual is established.

| CHANGE                    | EXPECTED EFFECT                                 | WHAT CAN PREVENT IT                                |
|---------------------------|-------------------------------------------------|----------------------------------------------------|
| Higher transferred dose   | May reach the same endpoint sooner              | Higher competing demand or poor mixing             |
| Longer validated contact  | May increase exposure at a stable dose          | Decay, short-circuiting or incomplete distribution |
| Improved transfer         | More of the generated O3 reaches the medium     | Fouling, pressure or injector mismatch             |
| Lower organic/solids load | More treatment remains available for the target | Rapidly changing source conditions                 |

# Laboratory Evidence and Engineered Results

## REPORTED REDUCTION RATES ACTUAL ENDPOINTS ENGINEERING INTERPRETATION

Reported findings remain attached to the target, medium, concentration, contact time and endpoint. They are evidence points for engineering and verification, not universal operating settings.



## How to interpret the pages that follow

With a controlled O3 Science strong-molecule ozone system, increasing delivered dose can overcome oxidizable demand sooner, establish usable residual faster and reach a selected reduction endpoint in less time. The reaction is engineered through generation, transfer, mixing, concentration, contact time and verification - not concentration alone. Every project must still be designed for the actual water or air quality, temperature, chemistry, organic and microbial load, flow or room volume, distribution pattern, safety controls and required endpoint.

**O3 Science evidence remains O3 Science evidence. Results cannot be transferred to another machine by claim alone.**



## How to read this booklet

The recovered source sheet mixes quantified reduction percentages, legacy words such as destroyed or killed, threshold values, qualitative susceptibility statements, seconds, minutes and CT values. This booklet preserves that wording in the result tables and in the exact-order appendix.

Every result stays attached to its stated target, dose, contact time and medium. A result is placed in the Water and aqueous section only when the recovered wording expressly identifies water, clean water, wastewater, sludge effluent, raw wastewater, distilled water or phosphate buffer. All other rows remain under Medium not stated.

The source states: 1-mg/l = 1-PPM. Unit spelling and obvious source typographical forms are retained in the exact-order appendix. The organized tables retain the complete result wording.

### Important evidence distinction

The actual-results charts plot only rows with reported numerical endpoints. The controlled-dose charts are engineering illustrations. They explain how dose, ozone demand, contact time and usable residual can interact; they are not a universal organism-specific laboratory curve.

### Reported laboratory evidence and actual engineered systems

This booklet contains two evidence streams: reported laboratory results for specific targets under stated conditions, and results from actual O3 Science systems engineered, applied and tested in agricultural, food-processing, storage and facility environments.

O3 Science reports facility sanitation testing up to 99.9999% reduction in produce, meat and fish packing, milk-storage tanks, storage facilities and processing facilities. O3 Science also reports that applicable FDA, USDA and health-department personnel were present during relevant facility testing. These company-reported project results are presented separately from the recovered Ozone Effects source sheet.

### Every system is engineered for its conditions

A dose shown in a laboratory result or past project is an evidence point, not a universal recipe. The engineered dose, transfer, distribution, contact time, monitoring and operating controls can change with water quality, air quality, flow rate, pipe size, room volume, humidity, temperature, organic and microbial load, facility type, process conditions, surface materials and the required endpoint. When those variables change, the dosing recommendation and system engineering may also change.

# Agricultural water and air are different treatment routes



*Left: engineered ozonated irrigation water is treated before crop delivery and followed through the root zone. Right: controlled gaseous treatment occurs in a separate empty, isolated and monitored space. The airflow and root cutaway are educational overlays.*

## Ozonated water before crop delivery

O<sub>3</sub> Science reports that its agricultural laboratory and field testing has repeatedly achieved rapid pathogen reduction in treated water, including complete removal at the measured endpoint under applicable test conditions, using low engineered dissolved-ozone settings. The treatment is engineered into the water before crop delivery and verified through water, root-zone, plant and harvest measurements.

## Controlled air treatment remains separate

Controlled gaseous ozone can also reduce microbial load rapidly, but direct ozone-gas exposure is a plant-safety boundary. Agricultural air treatment is isolated from exposed crops and uses its own concentration, distribution, monitoring, clearance and re-entry controls. Water-treatment settings are never transferred directly to air treatment.

## Why the medium changes the reaction

In water, the useful reaction depends on transfer into solution, water chemistry, temperature, flow, mixing, oxidizable demand and the residual that remains after that demand is satisfied. In air, distribution, humidity, surface access, leakage, room geometry and verified clearance become separate design controls. A concentration reported in one medium cannot be copied into the other.

## What these results apply to

The practical objective is not merely to generate ozone. It is to deliver a measured amount to the target, maintain useful contact under the actual load and verify that the selected biological or process endpoint was achieved.

### O3 Science evidence remains O3 Science evidence

The laboratory data, field testing and engineered-system results identified as O3 Science evidence belong to the O3 Science technology and the conditions under which those results were produced. Recovered reference entries remain separately identified where their original record requires that distinction.

### Results cannot be transferred to another machine by claim alone

O3 Science reports that ozone machines evaluated in its comparative testing did not reproduce the same reaction or verified performance under the tested comparison conditions. Another manufacturer or equipment supplier therefore cannot properly apply O3 Science percentages, reaction rates or project outcomes to its own machine without matched, documented testing. Doing so would misrepresent the origin and meaning of the evidence.

### Why machine and test conditions matter

Performance depends on how ozone is generated, measured, transferred and controlled; the stability and quantity of delivered output; the water or air matrix; temperature and chemistry; organic and microbial load; mixing or distribution; contact time; monitoring; and the required endpoint. A fair comparison must hold those variables in view.

### Independent studies support the science - not an equipment claim

University and peer-reviewed studies support ozone susceptibility, oxidation mechanisms and dose-contact relationships. Their results belong to their own generators and test conditions. They help explain why O3 Science results are scientifically consistent, but they do not authorize another ozone machine to claim O3 Science performance.

### Copyright and evidence use

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## Part 1 - Organized reported lab results

The original source rows are reorganized first by reported medium and then by target class. Wording is preserved; classification labels are editorial navigation only.



*Actual engineered applications do not share one fixed setting. Irrigation, produce washing, dairy tanks, meat and fish processing, and cold storage each create different water, air, load, distribution and contact-time conditions.*

### Engineering follows the conditions

Laboratory results help establish the relationship among target, dose, medium, contact time and endpoint. The installed O3 Science system is then engineered around the conditions it must overcome and the result it must produce. Generation capacity, transfer, mixing or air distribution, contact, residual, monitoring and controls are sized and adjusted together.

### Independent research supports the reaction pattern

University and peer-reviewed studies independently confirm rapid ozone effects on viruses, bacteria, biofilms and fungal spores. They also confirm the same engineering lesson seen in O3 Science work: the response changes with organism, matrix, temperature, pH, surface, organic load, ozone residual and contact time.

Those outside studies use their own generators and their own reported figures. They support the oxidation mechanism and susceptibility pattern, but they are not direct dose settings, performance limits or substitutes for O3 Science laboratory and engineered-system results.

### O3 Science generation distinction

O3 Science uses the term strong-molecule ozone for the higher-output, controllable behavior of its proprietary generation method and distinguishes it from weaker UV-generated ozone. The meaningful comparison is the measured delivered dose, transfer, demand reduction, usable residual, reaction time and verified endpoint under matched conditions - not the generator label by itself.

## Water and aqueous media

This section includes water, clean water, wastewater, sludge effluent, raw wastewater, distilled water and phosphate buffer exactly where the source states those media.

### O3 Science agricultural water result

In O3 Science agricultural practice, the rapid reduction occurs within the engineered water-treatment chain. Correctly controlled ozonated water can reduce pathogen and biofilm pressure before irrigation or recirculating water reaches the crop, while downstream measurements verify the root-zone and plant response.

### Bacteria and bacterial spores

| Target                         | Reported result / dosage - source wording                                 | Reported medium |
|--------------------------------|---------------------------------------------------------------------------|-----------------|
| <b>Bacillus cereus</b>         | 99% destruction after 1-min at 0.12 mg/l in water                         | Water           |
| <b>B. cereus (spores)</b>      | 99% destruction after 1-min at 2.3 mg/l in water                          | Water           |
| <b>c. difficile</b>            | 99.999% destruction at 0.6 mg/l for 2 minutes (in water)                  | Water           |
| <b>E-coli (in clean water)</b> | 99.99% destruction at 0.25 mg/l for +/- 30 seconds                        | Clean water     |
| <b>E-coli (in wastewater)</b>  | 99.9% destruction at 2.2 mg/l for 19 minutes                              | Wastewater      |
| <b>Legionella pneumophila</b>  | 99.99% destruction at 0.32 mg/l for 20 minutes in distilled water         | Distilled water |
| <b>Mycobacterium avium</b>     | 99.9% with a CT value of 0.17 in water (scientifically reviewed document) | Water           |
| <b>Mycobacterium fortuitum</b> | 90% destruction at 0.25 mg/l for 1.6 minutes in water                     | Water           |
| <b>Salmonella typhimurium</b>  | 99.99% destruction at 0.25 mg/l for 1.67 minutes in water                 | Water           |

## Viruses and bacteriophages

| Target                    | Reported result / dosage - source wording                         | Reported medium  |
|---------------------------|-------------------------------------------------------------------|------------------|
| <b>Bacteriophage f2</b>   | 99.99% destruction at 0.41 mg/l for 10-seconds in water           | Water            |
| <b>Coxsackie Virus A9</b> | 95% destruction at 0.035 mg/l for 10-seconds in water             | Water            |
| <b>Coxsackie Virus B5</b> | 99.99% destruction at 0.4 mg/l for 2.5-minutes in sludge effluent | Sludge effluent  |
| <b>Enteric virus</b>      | 95% destruction at 4.1 mg/l for 29 minutes in raw wastewater      | Raw wastewater   |
| <b>Hepatitis A virus</b>  | 99.5% reduction at 0.25 mg/l for 2-seconds in a phosphate buffer  | Phosphate buffer |
| <b>Poliovirus type 1</b>  | 99.5% destruction at 0.25 mg/l for 1.6 minutes in water           | Water            |

## Where the remaining target evidence appears

The recovered record also contains results for molds and fungi, yeast, an oomycete plant pathogen, protozoan cysts and a parasite. Because those entries do not state water or air, they are presented next under Medium not stated instead of being incorrectly shown as unsupported or reassigned to water.



## Additional supported biological targets

These recovered results support the additional target classes. Their original wording does not identify the treated medium, so the booklet preserves that limitation rather than guessing. Several entries describe a target as ozone susceptible or very susceptible; those qualitative susceptibility statements are evidence, but they are not converted into invented percentages.



*Educational microscopy-scale reference showing representative bacteria, virus-like particles, mold structures and yeast cells. The organisms are magnified for teaching and are not shown at literal visible scale.*

### Different structures create different reaction paths

Ozone can attack cell walls and membranes, proteins, enzymes, capsids, nucleic acids and the extracellular material that helps hold a biofilm together. The dominant pathway and the time needed to reach the endpoint differ by organism and by the material surrounding it.

That is why a susceptibility label is useful evidence but not a complete design. A free organism in low-demand water may react quickly, while the same target protected by organic material, an established biofilm or a difficult surface may require more delivered ozone, better contact or a longer controlled treatment.

## Bacteria and bacterial spores

| Target                                                                                                                           | Reported result / dosage - source wording    |
|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| <b>Bacillus Bacteria</b>                                                                                                         | Destroyed by 0.2 m/l within 30 seconds       |
| <b>Bacillus Anthracis (causes anthrax in sheep, cattle and pigs. Also a human pathogen)</b>                                      | Ozone susceptible                            |
| <b>Bacillus subtilis</b>                                                                                                         | 90% reduction at 0.10-PPM                    |
| <b>Clavibacter michiganense</b>                                                                                                  | 99.99% destruction at 1.1 mg/l for 5 minutes |
| <b>Clostridium Bacteria</b>                                                                                                      | Ozone susceptible                            |
| <b>Clostridium Botulinum Spores. Its toxin paralyses the central nerve system, being a poison multiplying in food and meals.</b> | 0.4 to 0.5 mg/l threshold value              |
| <b>Diphtheria Pathogen</b>                                                                                                       | Destroyed by 1.5 to 2 mg/l                   |
| <b>Eberth Bacillus (Typhus abdominalis). Spreads typically by aqueous infection and causes typhoid.</b>                          | Destroyed by 1.5 to 2 mg/l                   |
| <b>Escherichia Coli Bacteria (from feces)</b>                                                                                    | Destroyed by 0.2 mg/l                        |
| <b>Klebs-Loffler Bacillus</b>                                                                                                    | Destroyed by 1.5 to 2 mg/l                   |
| <b>Proteus Bacteria</b>                                                                                                          | Very susceptible                             |
| <b>Pseudomonas Bacteria</b>                                                                                                      | Very susceptible                             |
| <b>Salmonella Bacteria</b>                                                                                                       | Very susceptible                             |
| <b>Staph epidermidis</b>                                                                                                         | 90% reduction at 0.1-ppm for 1.7 min         |
| <b>Staphylococci</b>                                                                                                             | Destroyed by 1.5 to 2.0 mg/l                 |
| <b>Streptococcus Bacteria</b>                                                                                                    | Destroyed by 0.2 mg/l within 30 seconds      |
| <b>Virbrio Cholera Bacteria</b>                                                                                                  | Very susceptible                             |

## Viruses and bacteriophages

| Target                                                   | Reported result / dosage - source wording                             |
|----------------------------------------------------------|-----------------------------------------------------------------------|
| <b>Echo Virus 29: The virus most sensitive to ozone.</b> | After a contact time of 1 minute at 1 mg/l of ozone, 99.999% killed.  |
| <b>Encephalomyocarditis Virus</b>                        | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>Enterovirus Virus</b>                                 | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>GDVII Virus</b>                                       | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>Herpes Virus</b>                                      | Destroyed to zero level in less than 30 seconds wit 0.1 to 0.8 mg/l.  |
| <b>Influenza Virus</b>                                   | 0.4 to 0.5 mg/l threshold value                                       |
| <b>Poliomyelitis Virus</b>                               | 99.99% kill with 0.3 to 0.4 mg/l in 3-4 minutes                       |
| <b>Rhabdovirus virus</b>                                 | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l  |
| <b>Stomatitis Virus</b>                                  | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l  |
| <b>Vesicular Virus</b>                                   | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l  |



## Molds and fungi

| Target                                                                 | Reported result / dosage - source wording      |
|------------------------------------------------------------------------|------------------------------------------------|
| <b>Aspergillus Niger (Black Mount)</b>                                 | Destroyed by 1.5 to 2 mg/l                     |
| <b>Botrytis cinerea</b>                                                | 3.8 mg/l for 2 minutes                         |
| <b>Cladosporium</b>                                                    | 90% reduction at 0.10-PPM for 12.1 minutes     |
| <b>Fusarium oxysporum f.sp. lycopersici</b>                            | 1.1 mg/l for 10 minutes                        |
| <b>Fusarium oxysporum f.sp. melonogea</b>                              | 99.99 % destruction at 1.1 mg/l for 20 minutes |
| <b>Luminescent Basidiomycetes (species having no melanin pigment).</b> | Destroyed in 10 minutes at 100-PPM             |
| <b>Mucor piriformis</b>                                                | 3.8 mg/l for 2 minutes                         |
| <b>Penicillium Bacteria</b>                                            | Ozone susceptible                              |
| <b>Verticillium dahliae</b>                                            | 99.99 % destruction at 1.1 mg/l for 20 minutes |

## Yeasts

| Target                  | Reported result / dosage - source wording |
|-------------------------|-------------------------------------------|
| <b>Candida Bacteria</b> | Ozone susceptible                         |

## Oomycetes and plant pathogens

| Target                         | Reported result / dosage - source wording |
|--------------------------------|-------------------------------------------|
| <b>Phytophthora parasitica</b> | 3.8 mg/l for 2 minutes                    |

## Protozoan cysts

| Target                           | Reported result / dosage - source wording |
|----------------------------------|-------------------------------------------|
| <b>Endamoebic Cysts Bacteria</b> | Ozone susceptible                         |

## Parasites

| Target               | Reported result / dosage - source wording |
|----------------------|-------------------------------------------|
| Schistosoma Bacteria | Very susceptible                          |

## Mildews - supplemental application evidence

| Target                  | Reported result / dosage - source wording                                                                                                                                                                                                                                  |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mold and mildew removal | Ozone Shock Systems 091021.odt identifies mold and mildew removal as an ozone shock-treatment application. This is presented as documented application evidence; the source keeps that statement separate from organism-specific laboratory dose and contact-time entries. |

## How to read the susceptibility pattern

The recovered evidence includes fast responses at low reported concentrations for several organisms and qualitative labels such as ozone susceptible and very susceptible for others. That pattern supports ozone sensitivity, but the engineered setting still depends on the target, medium, demand, transfer, distribution and required endpoint.

## What changes between target classes

Viruses do not respond exactly like vegetative bacteria, bacterial spores do not respond exactly like active cells, and fungal spores can show a rapid first-stage reduction followed by a slower surviving fraction. Mildew, yeast, protozoan cyst and parasite results must likewise remain attached to their stated test conditions.

For O3 Science design work, the target class helps define the initial treatment window. Baseline testing, measured delivered ozone and follow-up sampling then determine whether the setting is adequate for the actual water, surface, air volume or process.

## Ozone water at the surface



*Educational microscope-scale demonstration: the visible biological load is enlarged so the reaction can be seen. As ozonated water moves across a food-contact surface, it reacts with organic demand, bacteria, virus particles, mold spores and early biofilm. The measured reduction belongs to the applicable lab or facility result, not to the artwork itself.*



*A trained sanitation worker applies ozonated water to stainless food-processing surfaces. The engineered setting depends on incoming water quality, surface load, spray coverage, flow, pressure, contact time, drainage and the required sanitation endpoint.*



## Ozone water inside the treatment system



*A realistic pump, injection and contact arrangement demonstrates controlled ozone transfer into process water. Pipe size, flow rate, water chemistry, temperature, dissolved and organic load, transfer efficiency, residual and available contact time all affect the engineered dose.*



*Educational cutaway: ozone first satisfies oxidizable demand and attacks organisms and attached biofilm. As the load falls, more usable residual can remain available. The organisms are magnified for teaching and are not shown at literal scale.*

# Air-treatment demonstration and design variables



*Educational microscope-scale demonstration: ozone moving through an unoccupied room reacts with airborne and surface bacteria, virus particles, mold spores and organic residue. The biological structures are magnified to demonstrate reduction and are not literal objects floating at visible scale.*

## Air-treatment variables change the engineered setting

Room volume, air quality, humidity, temperature, ventilation, leakage, equipment geometry, surface load, distribution pattern, ozone demand, contact time, monitoring and the required endpoint determine the engineered air-treatment setting and re-entry control.

## Target-class separation

The current company-reported facility statement is an overall microbial reduction result. The supplied record set does not provide an organism-by-organism air breakdown for bacteria, viruses, molds, mildews, yeasts or other targets, so this booklet does not invent one.



## Part 2 - Actual reported endpoint charts

These visuals use selected numerical endpoints from the recovered source sheet. Each point remains labeled by target and contact time; the underlying rows remain in Part 1 and the exact-order appendix.



*Laboratory evidence connects the treated medium and exposure conditions to measured before-and-after results. The image represents sampling, controlled contact and culture comparison; the tables and charts preserve the reported dose, medium, time and endpoint.*

### How outside studies back the interpretation

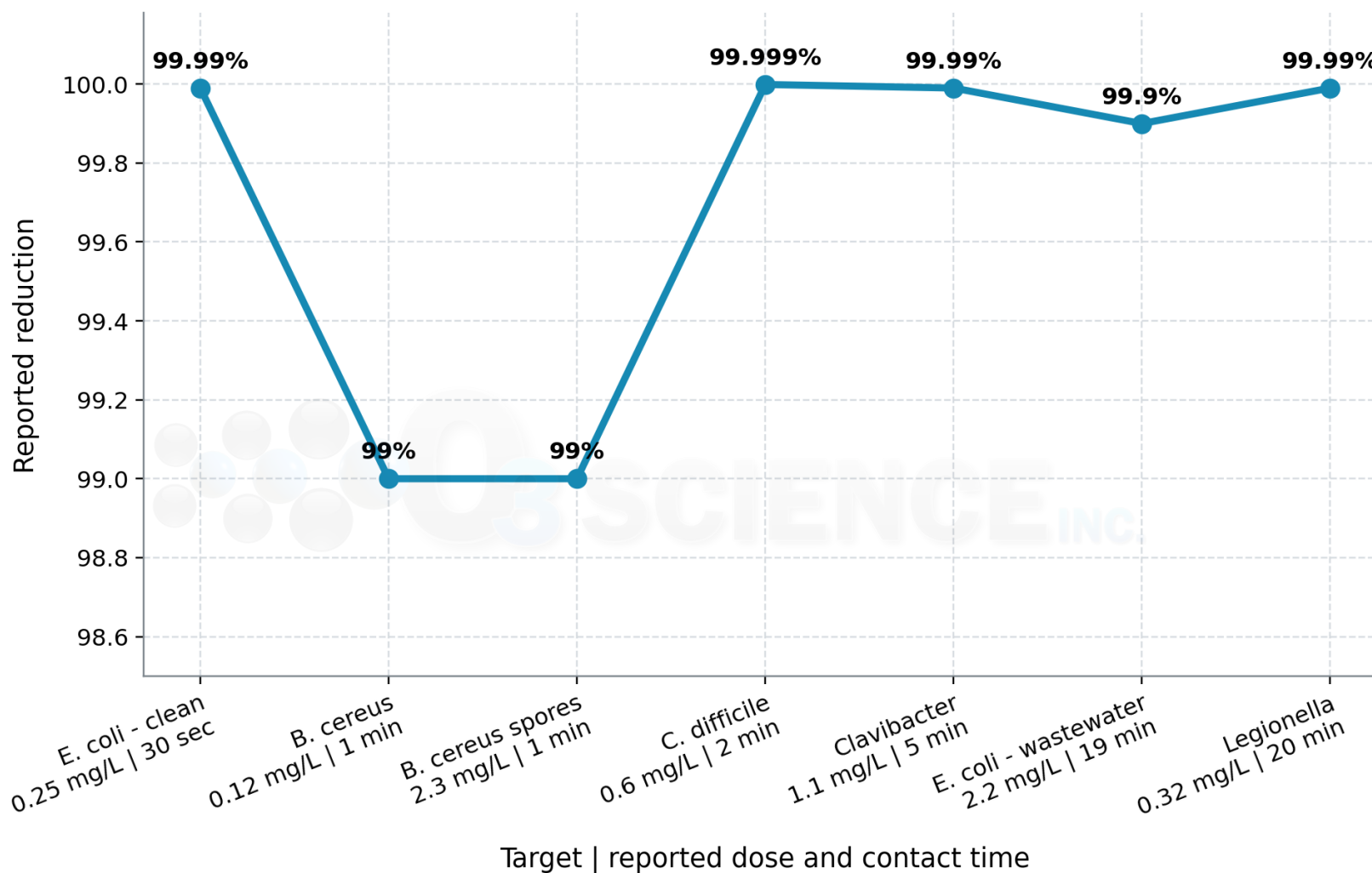
At the University of North Carolina, a bench-scale water study reported more than a 3-log reduction of Norwalk virus within 10 seconds at 0.37 mg/L ozone, pH 7 and 5 C, and more than 4-log reduction by 5 minutes. The same study observed residual ozone falling as sample demand was introduced and rising again after that demand was satisfied.

A Medical University of Warsaw study reported that ozonated water at 1.2-3.6 micrograms/mL reduced viable *Staphylococcus aureus* biofilm cells to background levels after 30 seconds, while *Pseudomonas aeruginosa* was more tolerant. A separate fungal-spore study reported a rapid first stage followed by a slower stage, with pH, temperature and real-water matrix changing the rate.

These are independent examples using different equipment and conditions. They support the response pattern; they do not replace O3 Science figures or set the operating range of an O3 Science system.

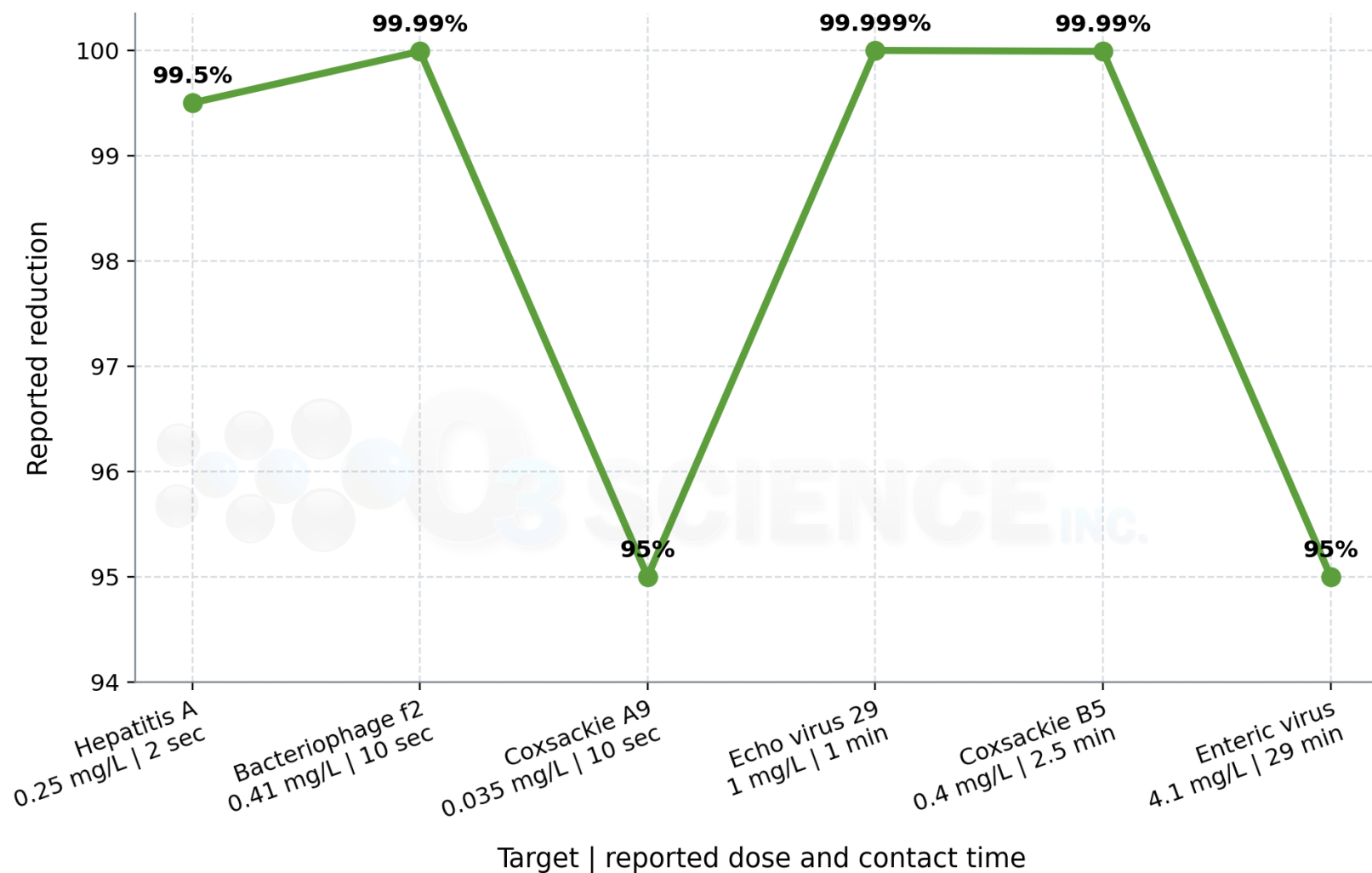


## Bacteria - actual reported endpoints



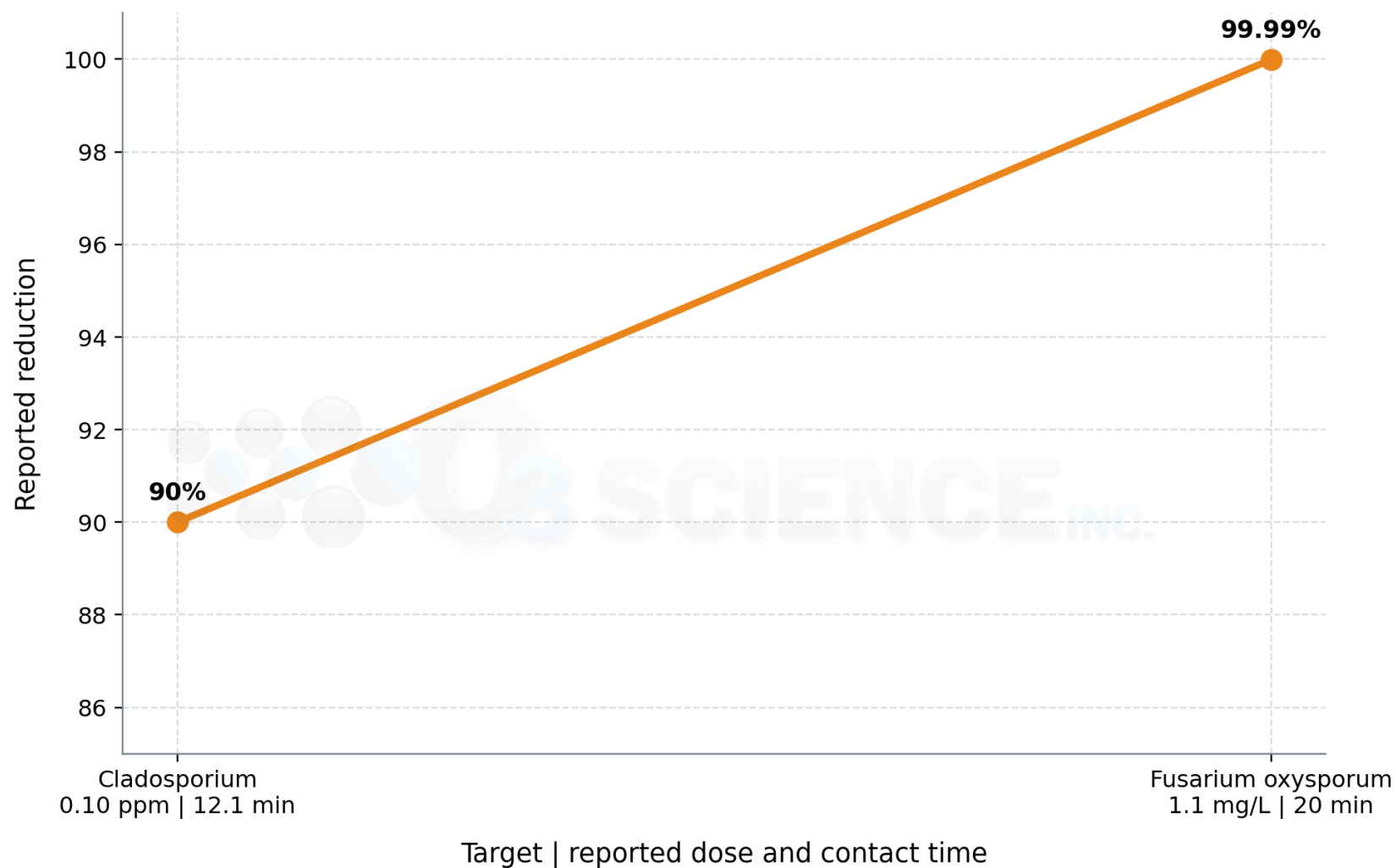
The vertical scale is intentionally narrow so the differences among high reported reductions remain visible. Consult the tables for the target-specific dose, medium and contact time.

## Viruses - actual reported endpoints



This comparison shows reported endpoints, not a single universal response curve. Media and doses differ by target and remain stated in the tables.

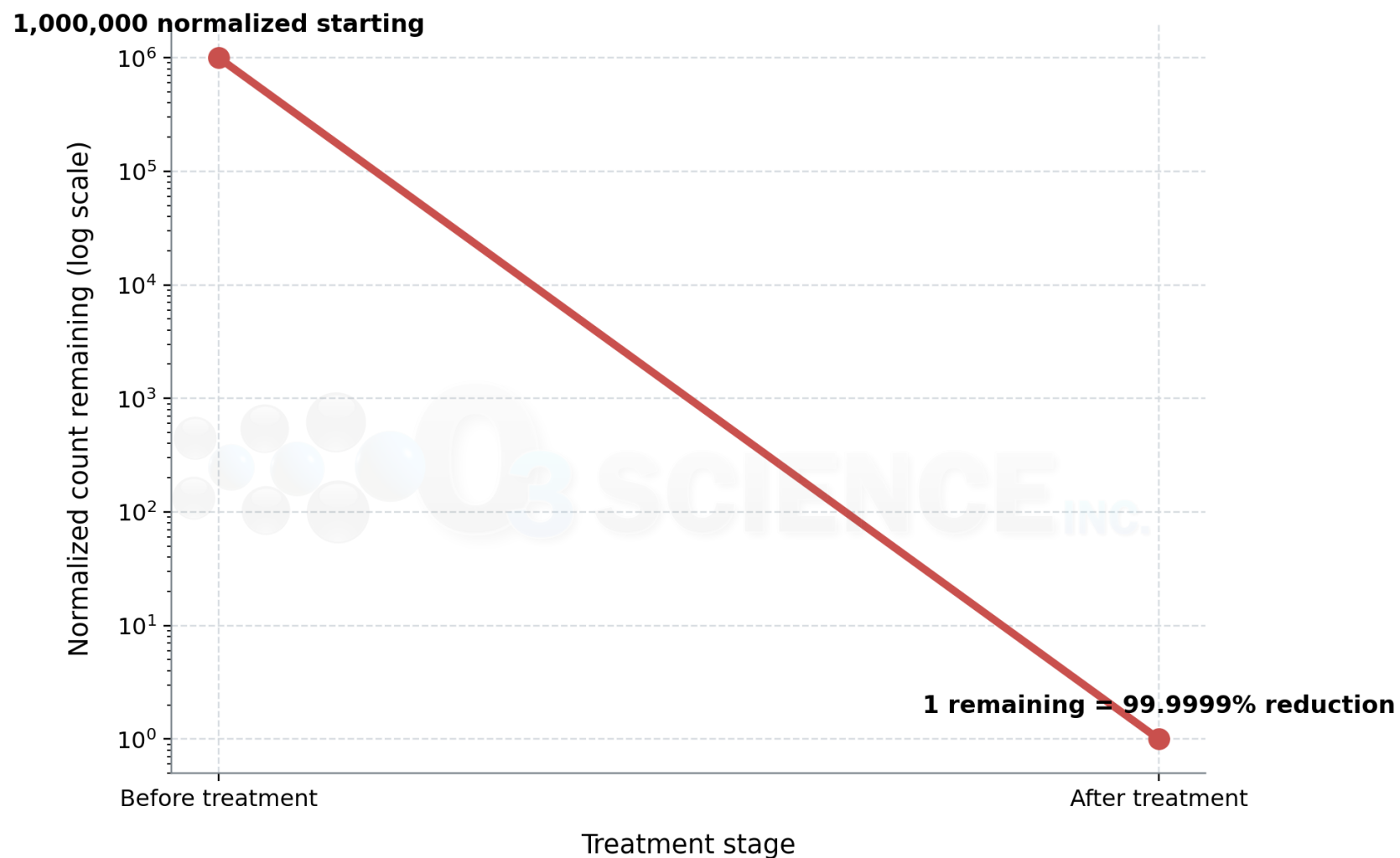
## Molds and fungi - actual reported endpoints



The recovered numerical examples include different targets and contact times. They are shown as separate reported points and are not combined into a universal fungal treatment setting.



## Facility sanitation - company-reported result



O3 Science reports up to 99.9999% reduction in relevant facility sanitation testing. The normalized before/after count is a visual expression of that percentage, not a replacement for the applicable test record.

## Part 3 - Controlled-dose engineering visuals

With a controlled O3 Science strong-molecule ozone system, the delivered dose can be adjusted to pursue the selected result. Increasing the controlled dose can accelerate the reaction because the oxidizable load falls, ozone demand declines and more usable residual becomes available.

The correct setting still depends on the application: flow rate, pipe size, water chemistry, organic and microbial load, distribution, contact time, intended endpoint and monitoring. These visuals are adjustable engineering examples and do not replace site-specific testing.

### O3 Science terminology

O3 Science uses strong-molecule ozone to describe its higher-output controlled system and distinguishes it from weaker UV ozone. In company application experience, the controlled system can produce a faster and more dramatic dose-response, while weak-molecule UV ozone is less adjustable for the same type of result.

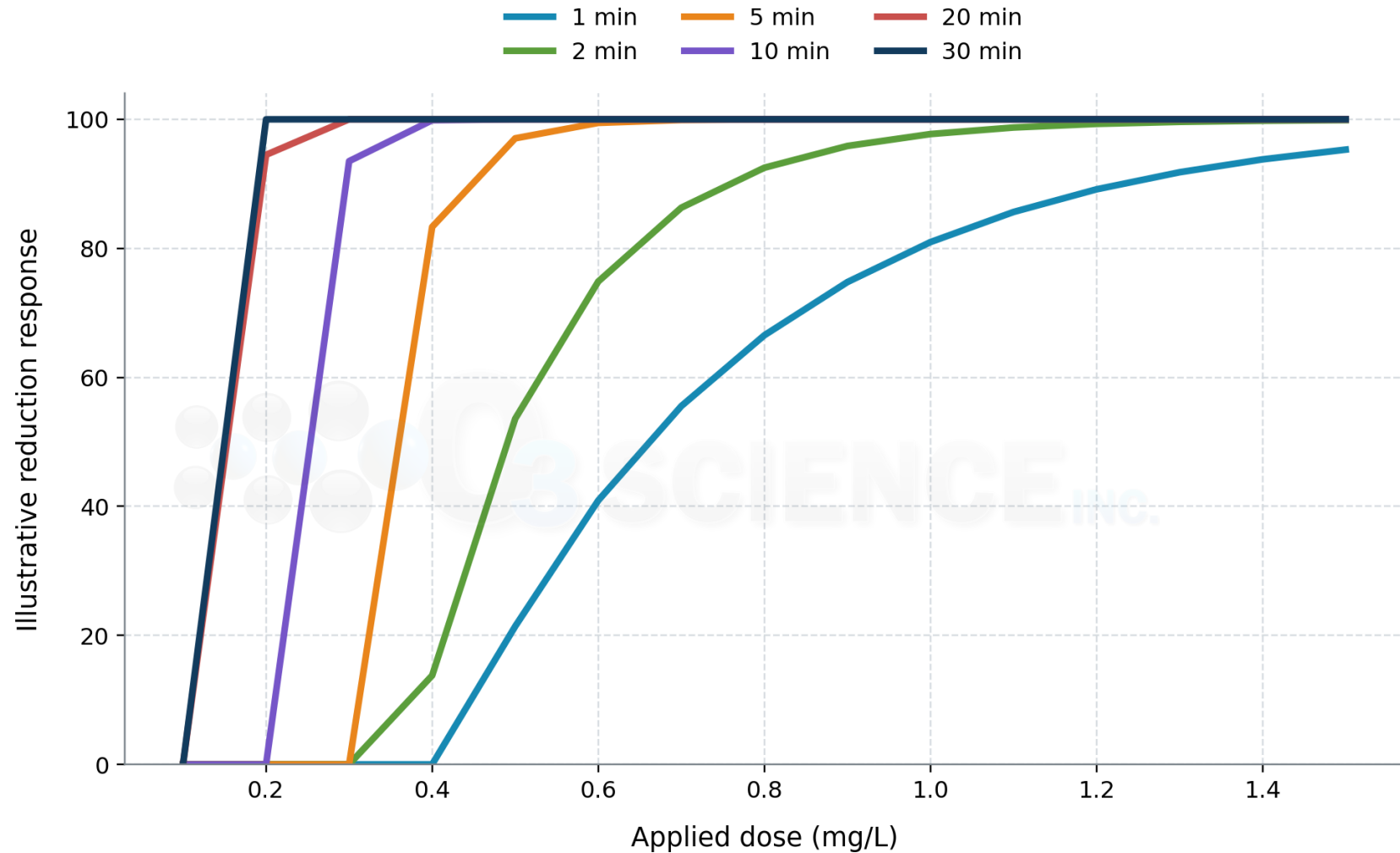
### Why the curve can accelerate

At the beginning of treatment, part of the delivered ozone is consumed by the existing oxidizable load. As that load is reduced, ozone demand falls. A larger share of the next delivered dose can then remain available as usable residual and reach the remaining target.

With a controllable high-output O3 Science system, increasing the delivered dose can therefore change more than the starting concentration. It can shorten the time required to overcome demand, increase the residual available for the next reaction and move the process toward the selected endpoint more quickly.

The effect is still measured, not assumed. Flow, transfer efficiency, temperature, chemistry, load, contact pattern and monitoring determine how the curve behaves in the actual installation.

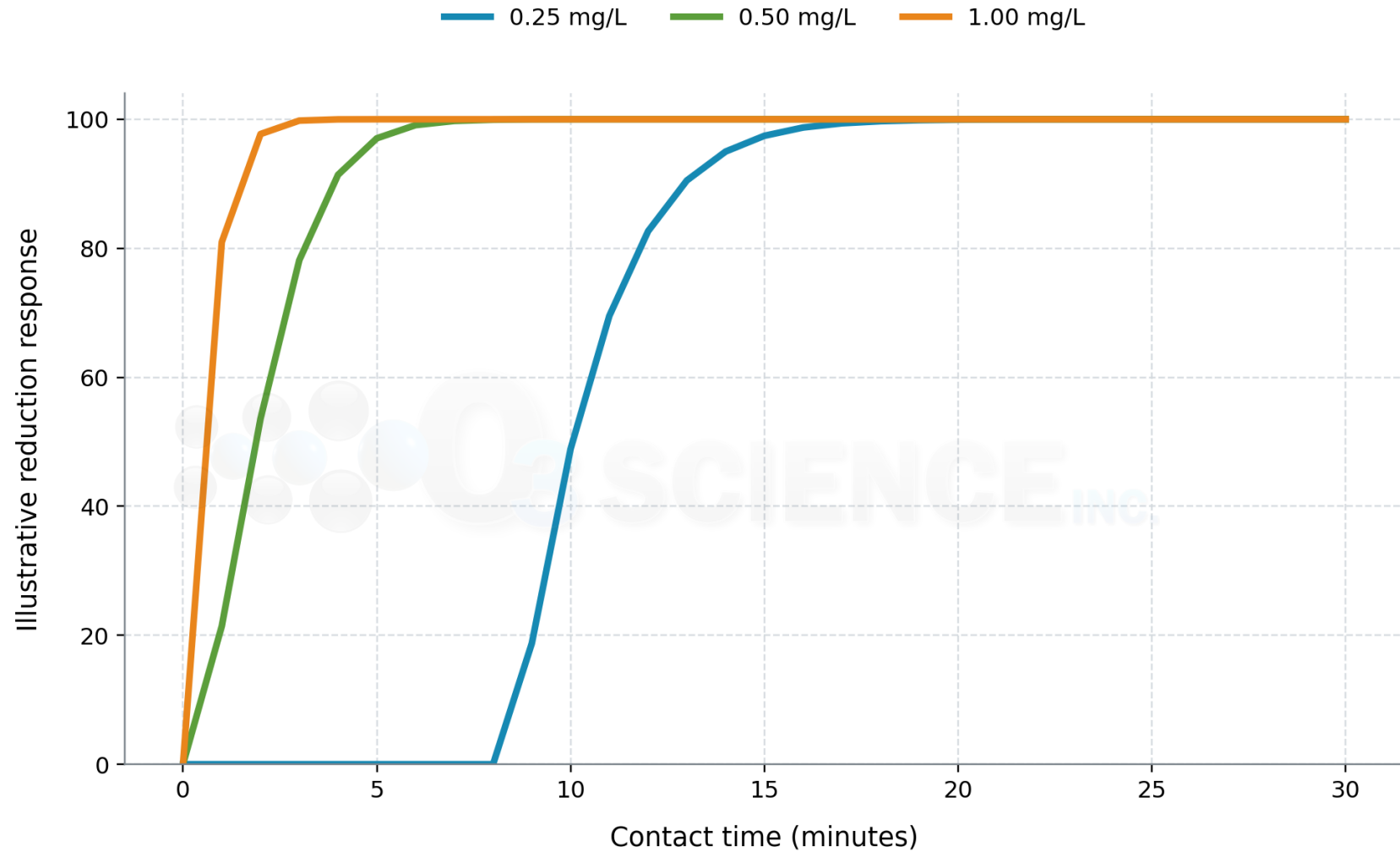
## More controlled dose increases the reduction response



Illustrative response across 1, 2, 5, 10, 20 and 30 minutes. The curves teach the interaction; they are not assigned to a particular organism.

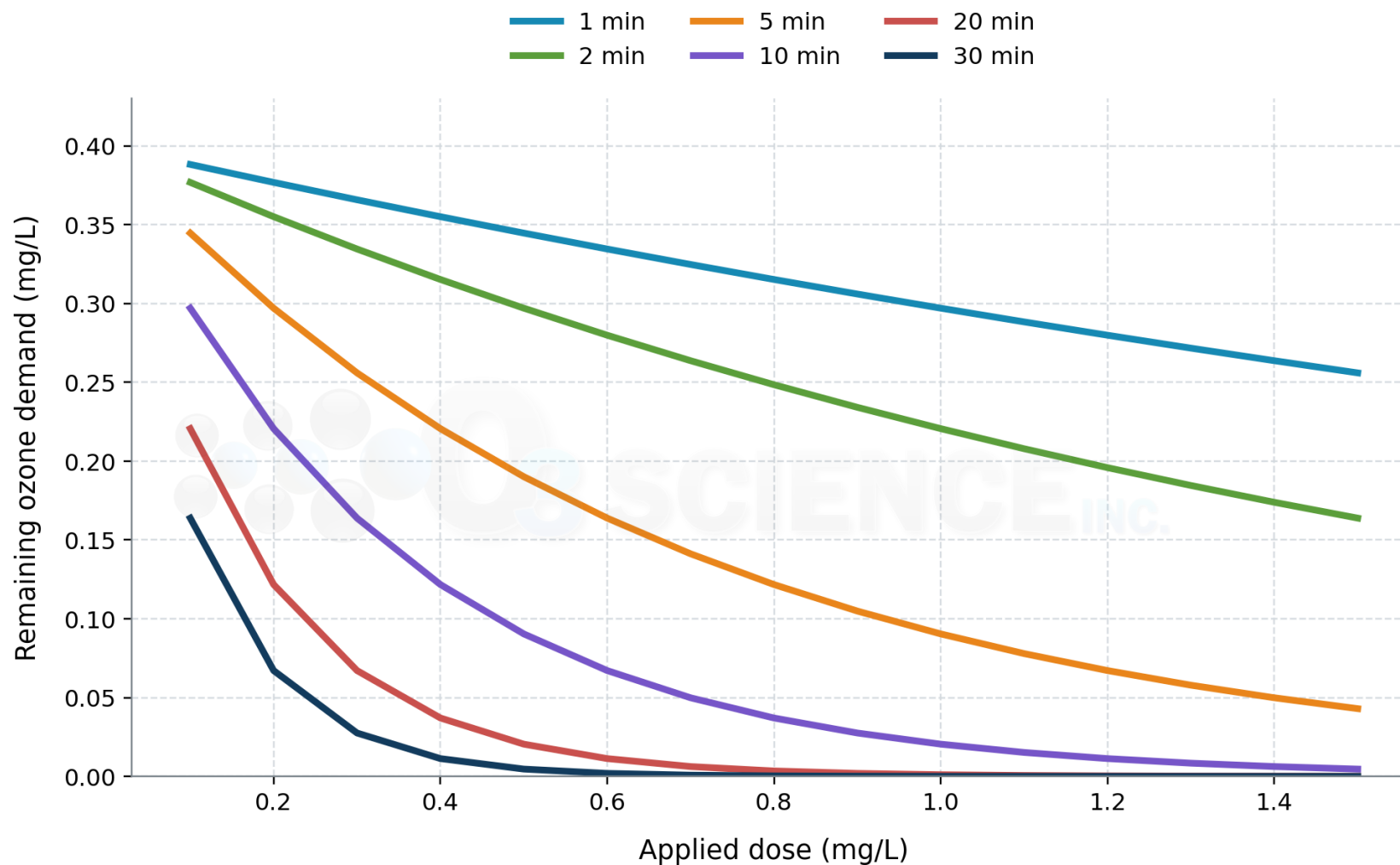


## Higher dose reaches the selected response sooner



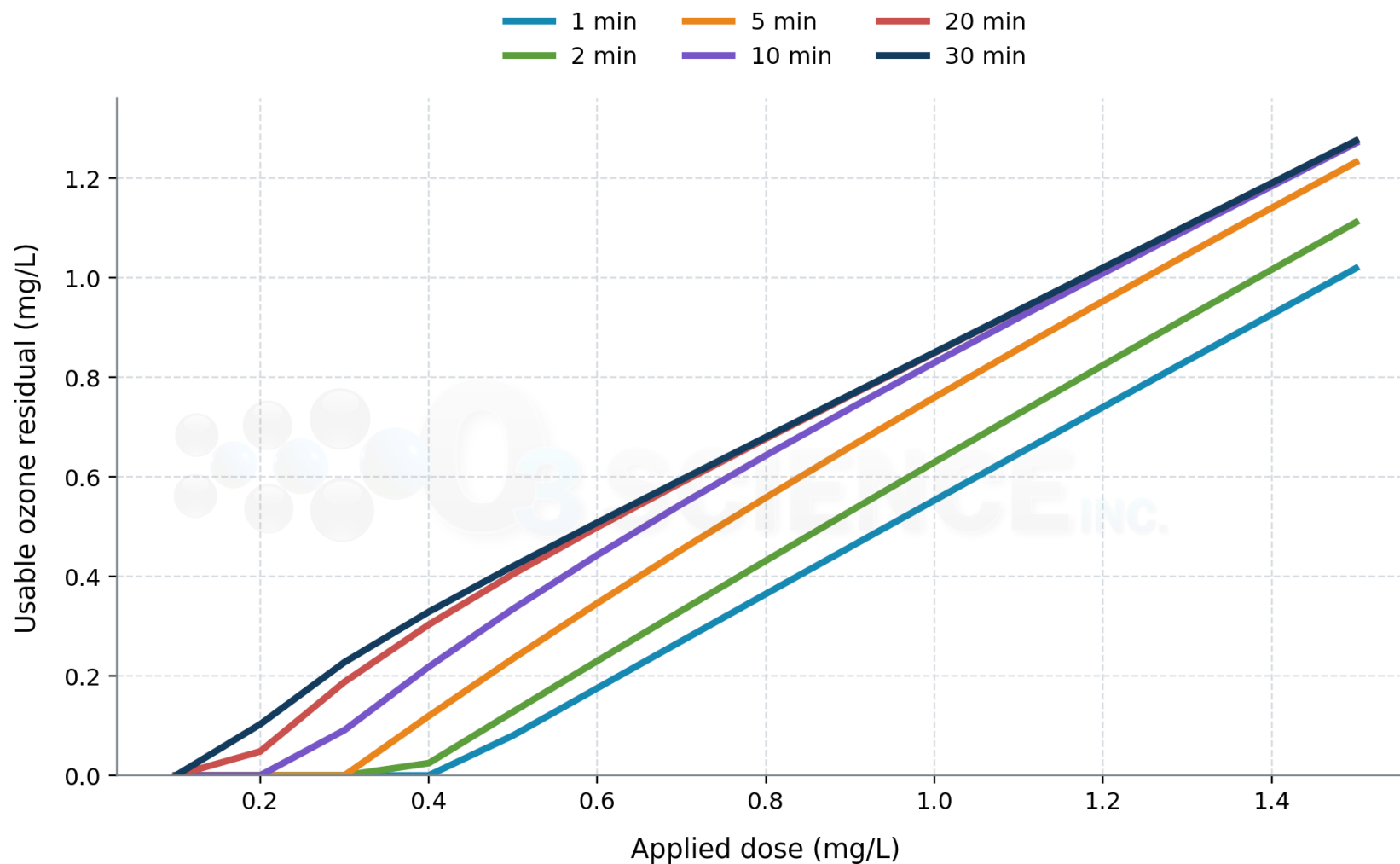
Illustrative comparison at 0.25, 0.50 and 1.00 mg/L. The chart shows why contact time and delivered dose must be considered together.

## Ozone demand falls faster as controlled dose increases



As oxidizable load is consumed, remaining ozone demand can decline more quickly at higher controlled dose. Actual behavior is site- and load-specific.

## Usable ozone residual rises as demand is overcome



Once demand is overcome, more of the delivered ozone can remain available to support the intended reaction. Measurement and control are essential.



## Part 4 - Exact-order recovered source sheet

The following appendix reproduces the recovered Ozone Effects entries in their original order. It retains source terminology, spelling, capitalization and result wording so the reorganized presentation can always be checked against the recovered sheet.

### OZONE EFFECTS ON SPECIFIC BACTERIA, VIRUSES AND MOLDS

Bacteria are microscopically small, single-cell creatures having a primitive structure. The bacteria body is sealed by a relatively solid-cell membrane. Ozone interferes with the metabolism of bacterium-cells, most likely through inhibiting and blocking the operation of the enzymatic control system. A sufficient amount of ozone breaks through the cell membrane, and this leads to the destruction of the bacteria.

Viruses are small, independent particles, built of crystals and macromolecules, Unlike bacteria, they multiply only within the host cell. They transform protein of the host cell into proteins of their own. Ozone destroys viruses by diffusing through the protein coat into the nucleic acid core, resulting in damage of the viral RNA. At higher concentrations, ozone destroys the capsid, or exterior protein shell by oxidation so DNA (deoxyribonucleic acid), or RNA (ribonucleic acid) structures of the microorganism are affected.

1-mg/l = 1-PPM

| Target                                                                                      | Reported result / dosage - source wording                |
|---------------------------------------------------------------------------------------------|----------------------------------------------------------|
| <b>Aspergillus Niger (Black Mount)</b>                                                      | Destroyed by 1.5 to 2 mg/l                               |
| <b>Bacillus Bacteria</b>                                                                    | Destroyed by 0.2 m/l within 30 seconds                   |
| <b>Bacillus Anthracis (causes anthrax in sheep, cattle and pigs. Also a human pathogen)</b> | Ozone susceptible                                        |
| <b>Bacillus cereus</b>                                                                      | 99% destruction after 1-min at 0.12 mg/l in water        |
| <b>B. cereus (spores)</b>                                                                   | 99% destruction after 1-min at 2.3 mg/l in water         |
| <b>Bacillus subtilis</b>                                                                    | 90% reduction at 0.10-PPM                                |
| <b>Bacteriophage f2</b>                                                                     | 99.99% destruction at 0.41 mg/l for 10-seconds in water  |
| <b>Botrytis cinerea</b>                                                                     | 3.8 mg/l for 2 minutes                                   |
| <b>c. difficile</b>                                                                         | 99.999% destruction at 0.6 mg/l for 2 minutes (in water) |
| <b>Candida Bacteria</b>                                                                     | Ozone susceptible                                        |
| <b>Clavibacter michiganense</b>                                                             | 99.99% destruction at 1.1 mg/l for 5 minutes             |
| <b>Cladosporium</b>                                                                         | 90% reduction at 0.10-PPM for 12.1 minutes               |

| Target                                                                                                                           | Reported result / dosage - source wording                             |
|----------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------|
| <b>Clostridium Bacteria</b>                                                                                                      | Ozone susceptible                                                     |
| <b>Clostridium Botulinum Spores.</b> Its toxin paralyses the central nerve system, being a poison multiplying in food and meals. | 0.4 to 0.5 mg/l threshold value                                       |
| <b>Coxsackie Virus A9</b>                                                                                                        | 95% destruction at 0.035 mg/l for 10-seconds in water                 |
| <b>Coxsackie Virus B5</b>                                                                                                        | 99.99% destruction at 0.4 mg/l for 2.5-minutes in sludge effluent     |
| <b>Diphtheria Pathogen</b>                                                                                                       | Destroyed by 1.5 to 2 mg/l                                            |
| <b>Eberth Bacillus (Typhus abdomanalis).</b> Spreads typically by aqueous infection and causes typhoid.                          | Destroyed by 1.5 to 2 mg/l                                            |
| <b>Echo Virus 29: The virus most sensitive to ozone.</b>                                                                         | After a contact time of 1 minute at 1 mg/l of ozone, 99.999% killed.  |
| <b>Enteric virus</b>                                                                                                             | 95% destruction at 4.1 mg/l for 29 minutes in raw wastewater          |
| <b>Escherichia Coli Bacteria (from feces)</b>                                                                                    | Destroyed by 0.2 mg/l                                                 |
| <b>E-coli (in clean water)</b>                                                                                                   | 99.99% destruction at 0.25 mg/l for +/- 30 seconds                    |
| <b>E-coli (in wastewater)</b>                                                                                                    | 99.9% destruction at 2.2 mg/l for 19 minutes                          |
| <b>Encephalomyocarditis Virus</b>                                                                                                | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>Endamoebic Cysts Bacteria</b>                                                                                                 | Ozone susceptible                                                     |
| <b>Enterovirus Virus</b>                                                                                                         | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>Fusarium oxysporum f.sp. lycopersici</b>                                                                                      | 1.1 mg/l for 10 minutes                                               |
| <b>Fusarium oxysporum f.sp. melonogea</b>                                                                                        | 99.99 % destruction at 1.1 mg/l for 20 minutes                        |
| <b>GDVII Virus</b>                                                                                                               | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l. |
| <b>Hepatitis A virus</b>                                                                                                         | 99.5% reduction at 0.25 mg/l for 2-seconds in a phosphate buffer      |

| Target                                                                 | Reported result / dosage - source wording                                 |
|------------------------------------------------------------------------|---------------------------------------------------------------------------|
| <b>Herpes Virus</b>                                                    | Destroyed to zero level in less than 30 seconds wit 0.1 to 0.8 mg/l.      |
| <b>Influenza Virus</b>                                                 | 0.4 to 0.5 mg/l threshold value                                           |
| <b>Klebs-Loffler Bacillus</b>                                          | Destroyed by 1.5 to 2 mg/l                                                |
| <b>Legionella pneumophila</b>                                          | 99.99% destruction at 0.32 mg/l for 20 minutes in distilled water         |
| <b>Luminescent Basidiomycetes (species having no melanin pigment).</b> | Destroyed in 10 minutes at 100-PPM                                        |
| <b>Mucor piriformis</b>                                                | 3.8 mg/l for 2 minutes                                                    |
| <b>Mycobacterium avium</b>                                             | 99.9% with a CT value of 0.17 in water (scientifically reviewed document) |
| <b>Mycobacterium foruitum</b>                                          | 90% destruction at 0.25 mg/l for 1.6 minutes in water                     |
| <b>Penicillium Bacteria</b>                                            | Ozone susceptible                                                         |
| <b>Phytophthora parasitica</b>                                         | 3.8 mg/l for 2 minutes                                                    |
| <b>Poliomyelitis Virus</b>                                             | 99.99% kill with 0.3 to 0.4 mg/l in 3-4 minutes                           |
| <b>Poliovirus type 1</b>                                               | 99.5% destruction at 0.25 mg/l for 1.6 minutes in water                   |
| <b>Proteus Bacteria</b>                                                | Very susceptible                                                          |
| <b>Pseudomonas Bacteria</b>                                            | Very susceptible                                                          |
| <b>Rhabdovirus virus</b>                                               | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l      |
| <b>Salmonella Bacteria</b>                                             | Very susceptible                                                          |
| <b>Salmonella typhimurium</b>                                          | 99.99% destruction at 0.25 mg/l for 1.67 minutes in water                 |
| <b>Schistosoma Bacteria</b>                                            | Very susceptible                                                          |
| <b>Staph epidermidis</b>                                               | 90% reduction at 0.1-ppm for 1.7 min                                      |
| <b>Staphylococci</b>                                                   | Destroyed by 1.5 to 2.0 mg/l                                              |
| <b>Stomatitis Virus</b>                                                | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l      |
| <b>Streptococcus Bacteria</b>                                          | Destroyed by 0.2 mg/l within 30 seconds                                   |



| Target                          | Reported result / dosage - source wording                                                        |
|---------------------------------|--------------------------------------------------------------------------------------------------|
| <b>Verticillium dahliae</b>     | 99.99 % destruction at 1.1 mg/l for 20 minutes                                                   |
| <b>Vesicular Virus</b>          | Destroyed to zero level in less than 30 seconds with 0.1 to 0.8 mg/l                             |
| <b>Virbrio Cholera Bacteria</b> | Very susceptible                                                                                 |
| <b>Vicia Faba progeny</b>       | Ozone causes chromosome aberration and its effect is twice that observed by the action of X-rays |

## Recovered threshold statement

The effect of ozone below a certain critical concentration value is small or zero. Above this level all pathogens are eventually destroyed. This effect is called all-or-none response and the critical level the "threshold value".



## Source and use notes

Recovered source: Ozone Effects.odt. Supplemental application source: Ozone Shock Systems 091021.odt. Legacy reference findings, supplemental application evidence and O3 Science engineered-system results remain clearly separated so each statement can be read with its supplied conditions and evidence class.

Use each result only with its stated organism, dose, contact time, medium and endpoint. Entries such as ozone susceptible, very susceptible, threshold value or a dose/time without a numerical endpoint are qualitative or incomplete and should not be converted into a percentage claim.

For an O3 Science sanitation plan, the operating dose is engineered to the application and verified against the intended result. Water designs account for flow rate, pipe size, water quality, chemistry, temperature, transfer, contact and load. Facility air designs account for air quality, room volume, humidity, temperature, ventilation, distribution, occupancy controls, monitoring and re-entry. Dosing recommendations and system engineering can change when those conditions change.

## What this booklet intentionally excludes

Private manufacturing operations and private service-program details are not included.

## Independent supporting studies

Shin and Sobsey, University of North Carolina at Chapel Hill, Reduction of Norwalk Virus, Poliovirus 1, and Bacteriophage MS2 by Ozone Disinfection of Water, Applied and Environmental Microbiology 69(7), 2003. DOI: 10.1128/AEM.69.7.3975-3978.2003

Bialoszewski et al., Medical University of Warsaw, Activity of ozonated water and ozone against Staphylococcus aureus and Pseudomonas aeruginosa biofilms, Medical Science Monitor 17(11), 2011. DOI: 10.12659/MSM.882044

Wen et al., Xi'an University of Architecture and Technology and Suzhou University of Science and Technology, Inactivation of fungal spores in water using ozone: Kinetics, influencing factors and mechanisms, Water Research 185, 2020. DOI: 10.1016/j.watres.2020.116218

EPA, Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources. Ozone guidance addresses CT, residual measurement, mass transfer and contactor configuration.

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# Center-pivot irrigation

## FIELD GROWING

**THE OPERATING PROBLEM** — Untreated source water may carry biological loading, reduced metals, sediment or other demand into the irrigation system and crop root zone.

### What the O3 system does

O3 is injected into the pressurized supply line before the fixed pivot standpipe, mixed in the flowing water and delivered through the span and sprinkler package.

### Why it is arranged this way

The fixed point provides a consistent engineered treatment location while the drive towers remain mobile. Injection position, flow, pressure and contact are matched to the field system.

| CONTROL POINT        | WHAT MUST BE RECORDED                             |
|----------------------|---------------------------------------------------|
| Treatment target     | Water chemistry and microbial baseline            |
| Delivered treatment  | Flow, pressure, output and injection status       |
| Process response     | Emitter pattern, root-zone and crop observations  |
| Release / acceptance | Scheduled water, tissue, soil and harvest records |

**MEASURABLE VALUE** — Potential value includes cleaner delivery infrastructure, documented water-quality improvement, fewer corrective cleanouts and improved agronomic consistency when confirmed by field records.

### Soil, roots and crop response

Treated irrigation water first interacts with the soil surface and root zone. The field program therefore tracks infiltration, wetting depth, compaction, aeration, root density and crop recovery—not merely generator output. Better water delivery is valuable only when the soil profile and crop measurements confirm it.

**MEASURE FROM START TO FINISH** — Record volumetric water content by depth, irrigation runtime, rainfall credit, root photographs, soil chemistry, tissue results, BRIX by a consistent method, crop stage, tons per acre and harvest quality.



# Drip, orchard and specialty crops

## TARGETED IRRIGATION

**THE OPERATING PROBLEM** — Small emitters are sensitive to solids, biofilm and water-quality changes, while concentrated root-zone delivery makes overdosing or poor control consequential.

### What the O3 system does

A controlled side stream or in-line contact system treats the irrigation water before distribution to drip lines or micro-sprinklers.

### Why it is arranged this way

Pretreatment and monitoring protect emitter performance while placing the treatment where it can be verified before crop delivery.

| CONTROL POINT        | WHAT MUST BE RECORDED                 |
|----------------------|---------------------------------------|
| Treatment target     | Source and filtered-water condition   |
| Delivered treatment  | Flow, pressure, dose and contact      |
| Process response     | Emitter uniformity and line condition |
| Release / acceptance | Crop-stage and harvest comparison     |

**MEASURABLE VALUE** — Value is demonstrated through emitter uniformity, reduced flushing or chemical cleaning, irrigation reliability, water-use records and crop-quality measurements.

### Emitter performance becomes a crop-health issue

A partially restricted emitter changes water and nutrient delivery plant by plant. Line condition, pressure uniformity and root-zone moisture must be evaluated together so improved plant growth is not credited to O3 without confirming that delivery also improved.

**MEASURE FROM START TO FINISH** — Record emitter flow variation, filter pressure, flushing frequency, wetting pattern, root-zone moisture, tissue/sap results, marketable yield, size, grade and rejected product.





# Greenhouse and hydroponics

## RECIRCULATING GROW WATER

**THE OPERATING PROBLEM** — Warm recirculating nutrient water can accumulate organics, root debris and biological pressure while also carrying valuable fertilizer chemistry.

### What the O3 system does

A separated treatment loop removes solids, applies controlled O3 contact, manages off-gas and returns monitored water to the crop system.

### Why it is arranged this way

Separating the contact loop protects workers and crops while allowing dose, residence time and water chemistry to be controlled independently of the grow channels.

| CONTROL POINT        | WHAT MUST BE RECORDED                              |
|----------------------|----------------------------------------------------|
| Treatment target     | Nutrient solution baseline                         |
| Delivered treatment  | Loop flow, O3 transfer and contact                 |
| Process response     | pH, EC, DO, ORP where appropriate and microbiology |
| Release / acceptance | Root, canopy, yield and quality records            |

**MEASURABLE VALUE** — Potential value includes improved recirculation management, cleaner infrastructure, reduced water exchange and more consistent root-zone conditions.

### The nutrient solution is a living production system

O3 does not supply nitrogen, phosphorus, potassium or micronutrients. The agricultural question is whether controlled water treatment changes root-zone conditions in ways associated with nutrient availability, root performance and nutrient-use efficiency while the applied nutrient program is recorded.

**MEASURE FROM START TO FINISH** — Track pH, electrical conductivity, dissolved oxygen, solution temperature, nutrients applied, tissue/sap results, root condition, BRIX, water exchange, marketable yield and quality.



# Aquaponics and aquaculture

## LIVE-ANIMAL WATER

**THE OPERATING PROBLEM** — Fish and beneficial biological processes are sensitive to residual oxidants, rapid water-quality changes and treatment byproducts.

### What the O3 system does

Solids removal and biofiltration remain separate while a controlled O3 side stream is contacted, degassed and verified before return.

### Why it is arranged this way

The arrangement treats a controlled fraction of the flow and prevents uncontrolled residual from reaching animals or the biofilter.

| CONTROL POINT        | WHAT MUST BE RECORDED                             |
|----------------------|---------------------------------------------------|
| Treatment target     | Animal and water baseline                         |
| Delivered treatment  | Side-stream flow and delivered exposure           |
| Process response     | DO, ORP, residual, turbidity and solids           |
| Release / acceptance | Animal behavior, mortality and production records |

**MEASURABLE VALUE** — Value can include improved clarity, solids management, water reuse and system stability when animal-safety limits and performance are documented.

### Balance treatment with biology

Water clarity and oxidation must be balanced with fish health and beneficial biofiltration. A successful system improves the managed water condition without exposing animals or the biological filter to an uncontrolled residual.

**MEASURE FROM START TO FINISH** — Track feed, biomass, mortality, turbidity, solids, ammonia, nitrite, nitrate, dissolved oxygen, temperature, pH, ORP where suitable, water exchange and harvest weight.



# Dairy and animal facilities

## ANIMAL CARE AND SANITATION

**THE OPERATING PROBLEM** — High organic loading, water use, equipment sanitation and occupied-animal areas create multiple treatment needs that cannot be managed as one exposure.

### What the O3 system does

Water treatment, equipment sanitation, wastewater support and unoccupied-space processes are separated into individual operating procedures.

### Why it is arranged this way

Separation keeps each application attached to its own dose, contact, monitoring, worker protection and sanitation-plan requirements.

| CONTROL POINT        | WHAT MUST BE RECORDED                           |
|----------------------|-------------------------------------------------|
| Treatment target     | Application-specific baseline                   |
| Delivered treatment  | Treatment and cleaning records                  |
| Process response     | Microbiology, water and surface verification    |
| Release / acceptance | Chemical, labor, quality and maintenance totals |

**MEASURABLE VALUE** — Value is established from chemical use, wash-water volume, labor, cleaning downtime, equipment condition and verified sanitation performance.

### Connect sanitation to animal and product quality

The evidence chain can extend from drinking and process water through equipment cleaning, animal areas, milk handling and wastewater. Each pathway has a different endpoint and must be measured separately.

**MEASURE FROM START TO FINISH** — Track microbial verification, water use, chemical use, cleaning labor, equipment condition, milk-quality measures where applicable, animal observations, downtime and wastewater load.



# Produce washing and packing

## FOOD PROCESSING

**THE OPERATING PROBLEM** — Incoming soil, organic matter and produce load can rapidly change wash-water demand and sanitation performance.

### What the O3 system does

O3 is integrated into the defined wash-water or equipment-sanitation step with filtration, contact, monitoring and corrective actions.

### Why it is arranged this way

A controlled treatment loop allows the facility to respond to changing product load and maintain records under its sanitation and food-safety plan.

| CONTROL POINT        | WHAT MUST BE RECORDED                       |
|----------------------|---------------------------------------------|
| Treatment target     | Incoming water and product load             |
| Delivered treatment  | Dose/residual, contact and water condition  |
| Process response     | Microbial and product-quality checkpoints   |
| Release / acceptance | Release, corrective action and verification |

**MEASURABLE VALUE** — Value may be measured in water turnover, chemical purchases, labor, shelf-life, spoilage, rework and wastewater handling without making unsupported universal claims.

### Protect both sanitation and product quality

The treatment objective is not simply a high reading in the wash system. The facility must maintain microbial control while protecting color, texture, flavor, pack-out and shelf life as organic loading changes through the production day.

**MEASURE FROM START TO FINISH** — Track product load, turbidity, temperature, pH, dose/residual, contact, microbial results, water replacement, marketable pack-out, shelf life, rejects and rework.





# Meat and dairy-food processing

## FOOD SANITATION

**THE OPERATING PROBLEM** — Food-contact processes require tightly defined sanitation steps, establishment records and separation of product, equipment, environmental and wastewater applications.

### What the O3 system does

O3 is assigned to a specific approved use point: aqueous food treatment, equipment sanitation, controlled air treatment or wastewater polishing.

### Why it is arranged this way

Exact use-point separation lets the facility match 21 CFR provisions and establishment procedures to operating data and inspection history.

| CONTROL POINT        | WHAT MUST BE RECORDED                      |
|----------------------|--------------------------------------------|
| Treatment target     | Approved use and sanitation procedure      |
| Delivered treatment  | Dose, contact and process monitoring       |
| Process response     | Microbial/environmental verification       |
| Release / acceptance | Pre-operational release and records review |

**MEASURABLE VALUE** — Value is documented through chemical reduction, rinse water, labor, downtime, product loss, wastewater cost and sanitation performance.

### Build O3 into the sanitation control plan

Every use point must have a purpose: product treatment, equipment sanitation, environmental control, cold storage or wastewater. Verification demonstrates that the defined step works without confusing one application with another.

**MEASURE FROM START TO FINISH** — Track sanitation-standard-operating-procedure records, pre-operational inspection, environmental monitoring, water and chemical use, labor, downtime, product loss and corrective actions.



# Fish processing

## AQUACULTURE TO PACKAGED PRODUCT

**THE OPERATING PROBLEM** — Production water, processing water, food-contact surfaces, cold storage and wastewater have different loads and regulatory controls.

### What the O3 system does

The system uses separate treatment stages for live-water management, hygienic processing, cold-room treatment and final wastewater handling.

### Why it is arranged this way

Separate stages prevent live-animal operating limits from being confused with food-contact or unoccupied-space sanitation settings.

| CONTROL POINT        | WHAT MUST BE RECORDED                    |
|----------------------|------------------------------------------|
| Treatment target     | Water/product baseline                   |
| Delivered treatment  | Stage-specific dose and contact          |
| Process response     | Product, environmental and water testing |
| Release / acceptance | Release and sanitation-plan verification |

**MEASURABLE VALUE** — Value may include water reuse, odor control, sanitation support, cold-chain quality and reduced process interruptions when documented.

### Follow the product and water as separate evidence chains

Live-production water, food-contact processing water, cold storage and wastewater differ in biological load and allowable operating conditions. Each stage is verified with its own data.

**MEASURE FROM START TO FINISH** — Track water quality, product temperature, microbial results, ice or wash-water use, sanitation records, cold-chain condition, shelf life, rejects, odor and effluent quality.



# Grain silos and root-crop storage

## COMMODITY STORAGE

**THE OPERATING PROBLEM** — Stored grain, potatoes and sugar beets face moisture, mold, odor and insect-pressure risks across a large, nonuniform commodity mass.

### What the O3 system does

O3 is introduced through the existing aeration stream and distributed through the stored commodity under a scheduled, monitored cycle.

### Why it is arranged this way

Using the established airflow path improves distribution; concentration, leakage, humidity, pressure and worker access still require site validation.

| CONTROL POINT        | WHAT MUST BE RECORDED                     |
|----------------------|-------------------------------------------|
| Treatment target     | Commodity and facility baseline           |
| Delivered treatment  | Airflow, concentration and exposure cycle |
| Process response     | Mold, insect, odor and quality indicators |
| Release / acceptance | Shutdown, clearance and worker re-entry   |

**MEASURABLE VALUE** — Potential value includes reduced commodity loss, chemical use, pest pressure and quality deterioration when confirmed against untreated or historical baselines.

### Preserve harvested value after the field

Yield is not fully realized until the commodity survives storage. Air distribution, temperature, moisture, mold indicators, insect pressure and quality must be followed through the storage period.

**MEASURE FROM START TO FINISH** — For grain record bushels, test weight, moisture, dockage, grade and shrink. For potatoes and beets record stored tons, temperature, humidity, rot, sugar/quality measures, shrink and pack-out.



# Warehouse and cold-room air

## UNOCCUPIED-SPACE SANITATION

**THE OPERATING PROBLEM** — Large rooms have leakage, shadowed areas, reactive surfaces and variable humidity that can prevent uniform exposure.

### What the O3 system does

The room is isolated, treated through a controlled distribution cycle, then destructed or ventilated before measured clearance.

### Why it is arranged this way

A defined cycle separates treatment from occupancy and makes distribution and re-entry conditions testable.

| CONTROL POINT        | WHAT MUST BE RECORDED                     |
|----------------------|-------------------------------------------|
| Treatment target     | Room volume and leakage survey            |
| Delivered treatment  | Concentration at representative locations |
| Process response     | Cycle completion and decay/ventilation    |
| Release / acceptance | Ambient clearance and authorized release  |

**MEASURABLE VALUE** — Value is measured through odor events, spoilage, environmental testing, chemical fogging labor, downtime and product-quality records.

### Distribution is part of the treatment

A generator operating in one corner does not prove uniform room treatment. Representative monitoring points, airflow, humidity, leakage and room contents determine whether the intended exposure reaches the facility.

**MEASURE FROM START TO FINISH** — Record room volume, fan configuration, concentration by location, humidity, treatment and decay times, clearance, environmental results, spoilage, odor events and product loss.





# Iron bacteria and arsenic water

## OXIDATION AND REMOVAL

**THE OPERATING PROBLEM** — Iron-related biofilm and reduced dissolved contaminants can foul infrastructure; arsenic speciation affects removal performance.

### What the O3 system does

O3 oxidizes reduced iron and can convert arsenic(III) to arsenic(V); solids separation and arsenic-rated media then provide the removal barrier.

### Why it is arranged this way

Oxidation changes the contaminant form but does not make arsenic disappear. Downstream filtration, backwash and certified media are essential.

| CONTROL POINT        | WHAT MUST BE RECORDED                         |
|----------------------|-----------------------------------------------|
| Treatment target     | Raw-water speciation and loading              |
| Delivered treatment  | Delivered oxidation and contact               |
| Process response     | Filter pressure, backwash and media condition |
| Release / acceptance | Finished-water laboratory confirmation        |

**MEASURABLE VALUE** — Value includes reduced staining, slime and fouling plus a verifiable treatment train; arsenic claims are based only on finished-water testing and media certification.

### Oxidation must be followed by physical removal

O3 can change reduced iron and arsenic speciation, but finished-water performance depends on separation, backwash and the correct removal media. The proof is the water leaving the full treatment train.

**MEASURE FROM START TO FINISH** — Track raw and finished iron, arsenic speciation where available, pH, turbidity, filter pressure, backwash, media age, staining, slime, flow and accredited laboratory results.



# Wastewater and reuse

## MULTI-BARRIER TREATMENT

**THE OPERATING PROBLEM** — Solids, color, odor and high organic demand can consume O3 rapidly and make clean-water contact times irrelevant.

### What the O3 system does

O3 is placed after suitable solids and biological treatment, followed by filtration, monitoring and the permitted reuse or discharge path.

### Why it is arranged this way

Reducing upstream demand allows the oxidation stage to be sized for a defined polishing target instead of attempting to replace every treatment barrier.

| CONTROL POINT        | WHAT MUST BE RECORDED                        |
|----------------------|----------------------------------------------|
| Treatment target     | Influent and upstream-treatment condition    |
| Delivered treatment  | Dose transfer, contact and demand indicators |
| Process response     | Target contaminant or microbial response     |
| Release / acceptance | Permit/reuse verification and trend record   |

**MEASURABLE VALUE** — Value can include odor/color reduction, reuse, lower downstream chemical demand or improved discharge consistency when supported by site testing.

### Measure the entire treatment barrier

High-demand wastewater can consume O3 before the target receives the intended exposure. Upstream solids and biological treatment, O3 contact, filtration and the final permitted pathway must be evaluated as one system.

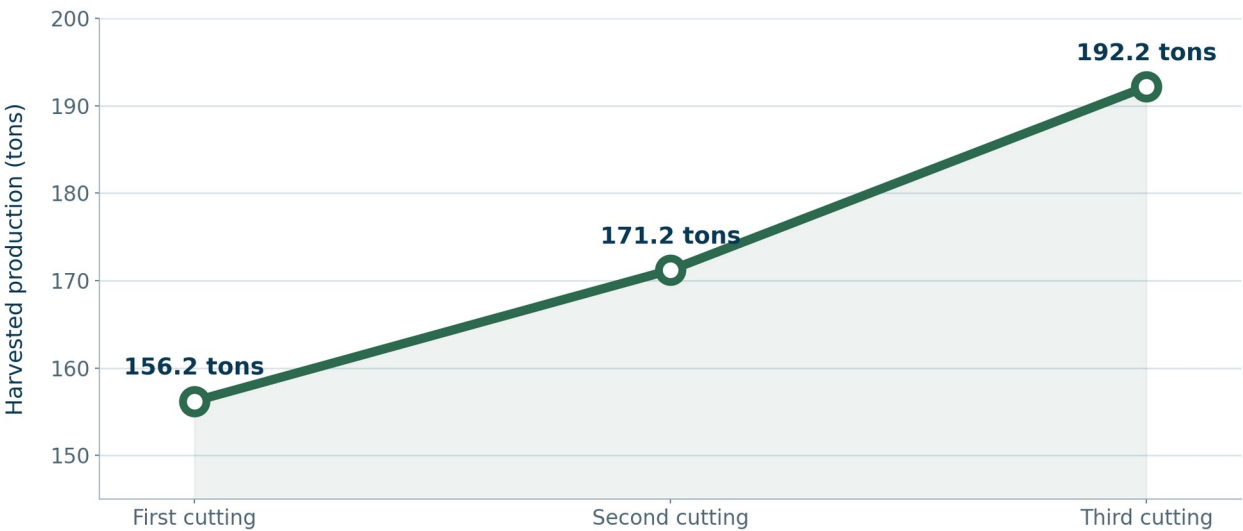
**MEASURE FROM START TO FINISH** — Track flow, solids, chemical oxygen demand or other demand indicators, color, odor, target organisms, O3 transfer, contact, filtration, reuse volume, discharge results and operating cost.



# Verified field case: three-cut alfalfa production

## 2026 DOCUMENTED SEASON

### Verified 2026 three-cut alfalfa production 519.5 tons across the documented season



Source: O3 field-scale records; first, second and third cutting totals.

The documented cutting sequence increased from 156.2 tons in the first cutting to 171.2 tons in the second and 192.2 tons in the third. The three verified cut totals equal 519.5 tons for the season. This progression is presented as a field-specific result with the season and operating context attached, not as a universal production guarantee.

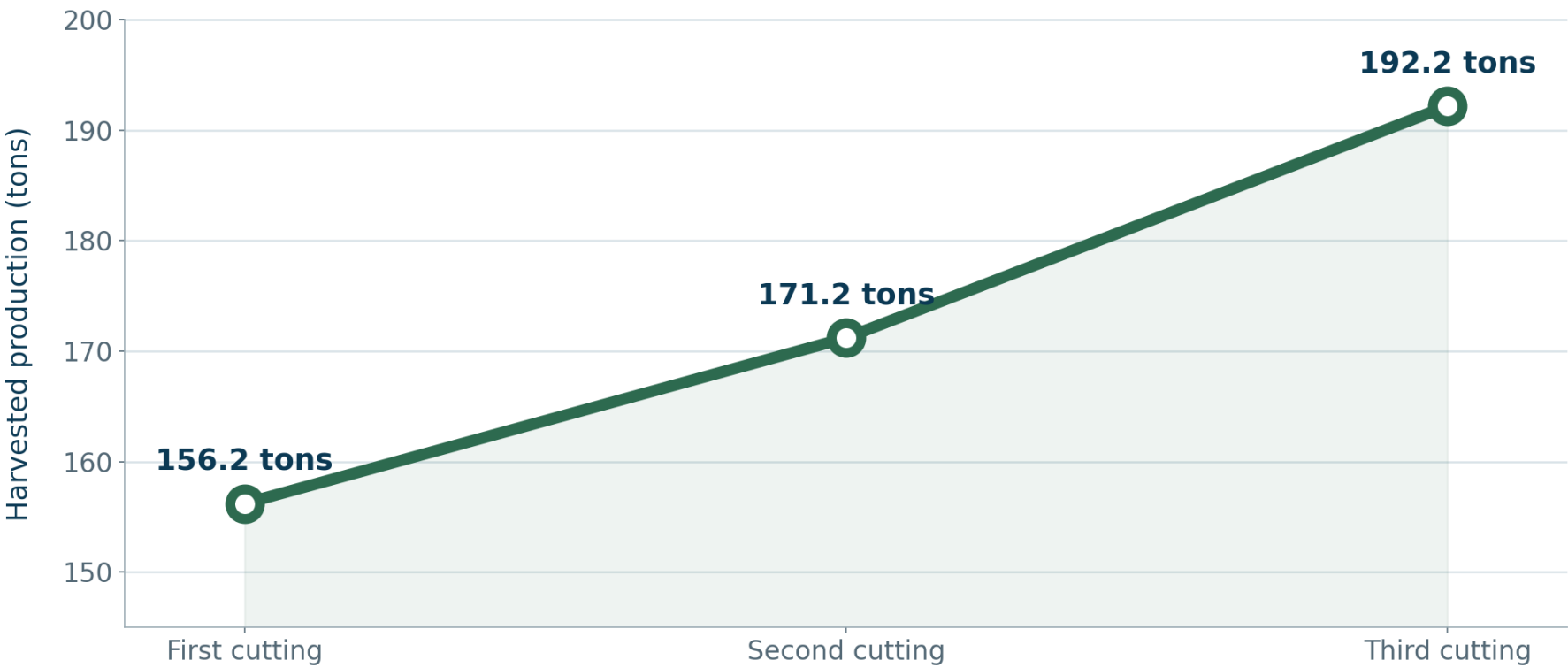
| CUTTING | BALES | AVERAGE BALE | TOTAL WEIGHT | HARVESTED TONS |
|---------|-------|--------------|--------------|----------------|
| First   | 194   | 1,610 lb     | 312,300 lb   | 156.2          |
| Second  | 210   | 1,630 lb     | 342,300 lb   | 171.2          |
| Third   | 252   | 1,525 lb     | 384,300 lb   | 192.2          |
| Season  | 656   | —            | 1,038,900 lb | 519.5          |

**WATER RESULT** — The verified three-cut record documents 20% less water versus its standard comparison for the season. That result remains case-specific and is not presented as a universal water-saving guarantee.

# Three-cut alfalfa: harvested tons

## Verified 2026 three-cut alfalfa production

519.5 tons across the documented season



Source: O3 field-scale records; first, second and third cutting totals.

Large-print field-result chart.

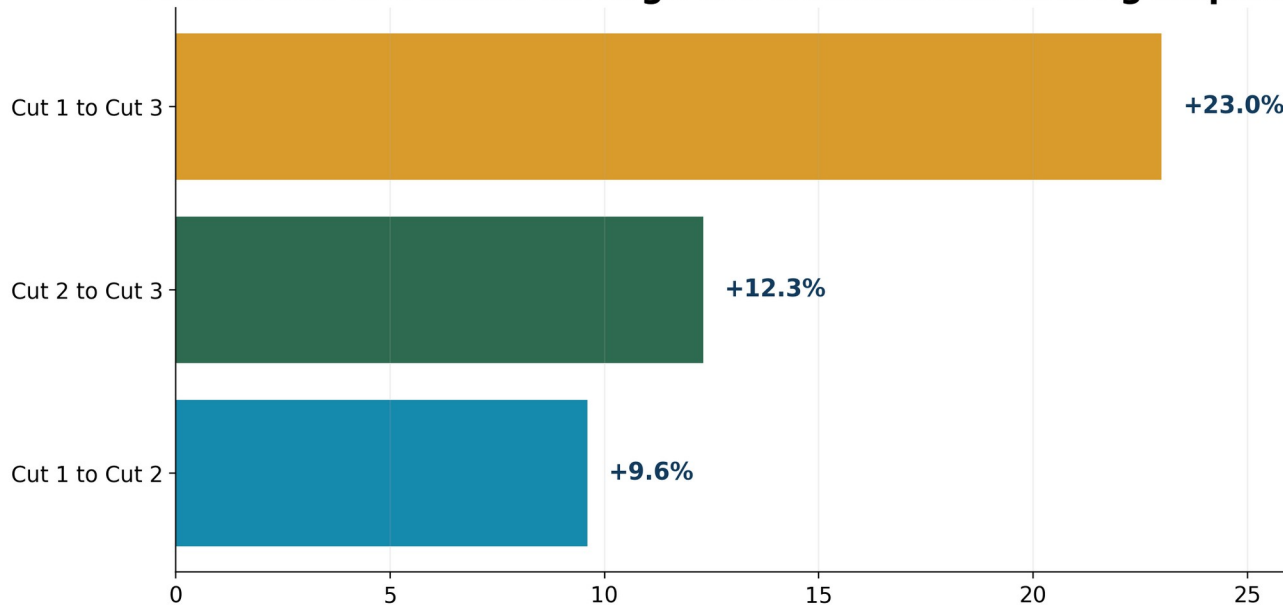




# What changed through the cutting sequence

## MEASURED PRODUCTION, NOT VISUAL IMPRESSION

### Production increased through the documented cutting sequence



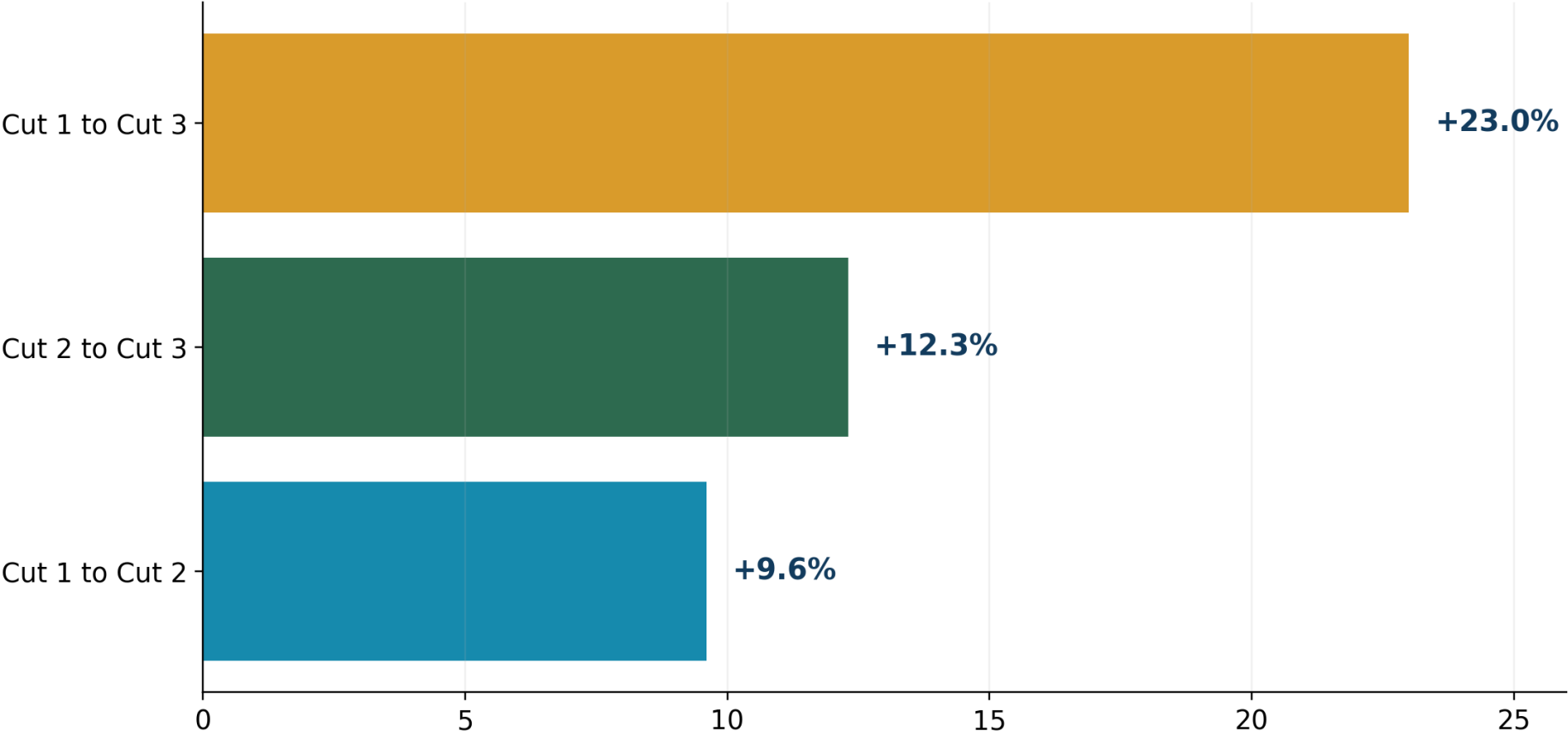
Calculated from verified cut totals: 156.2, 171.2 and 192.2 tons. This does not constitute a universal yield guarantee.

Harvested tonnage increased 9.6% from the first to the second cutting, 12.3% from the second to the third, and 23.0% from the first to the third. The evidence is stronger because the conclusion comes from recorded harvested weight rather than plant appearance or bale count alone.

- Bale count and average bale weight are retained so the reported tonnage can be checked.
- Rain, cutting timing, field area, irrigation and management context remain part of the case record.
- Acreage-normalized tons per acre are stated only when the exact harvested acreage is verified.

# Cutting progression

## Production increased through the documented cutting sequence



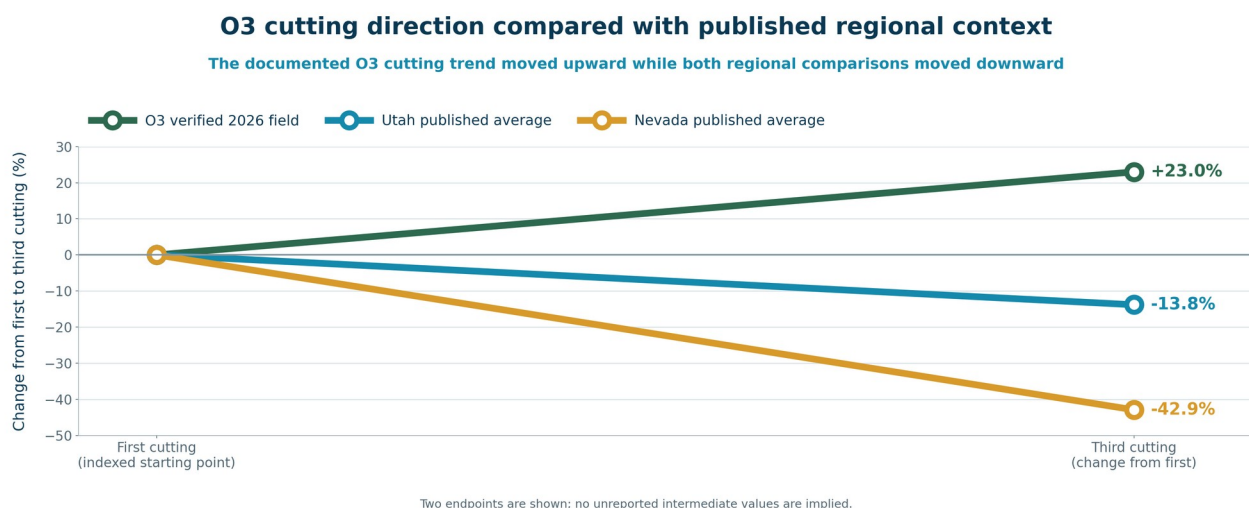
Calculated from verified cut totals: 156.2, 171.2 and 192.2 tons. This describes this documented region, not a universal yield guarantee.

Large-print field-result chart.



# O3 cutting direction compared with published regional context

UTAH AND NEVADA AVERAGES ARE CONTEXT, NOT CONTROL FIELDS



The verified 2026 O3 field increased 23.0% from the first cutting to the third. The approved O3 AG performance brochure reported a Utah published average of approximately 13.8% lower and a Nevada published average of approximately 42.9% lower for the same directional comparison. The contrast shows why the cutting sequence deserves attention: the O3 field moved upward while the reported regional averages moved downward.

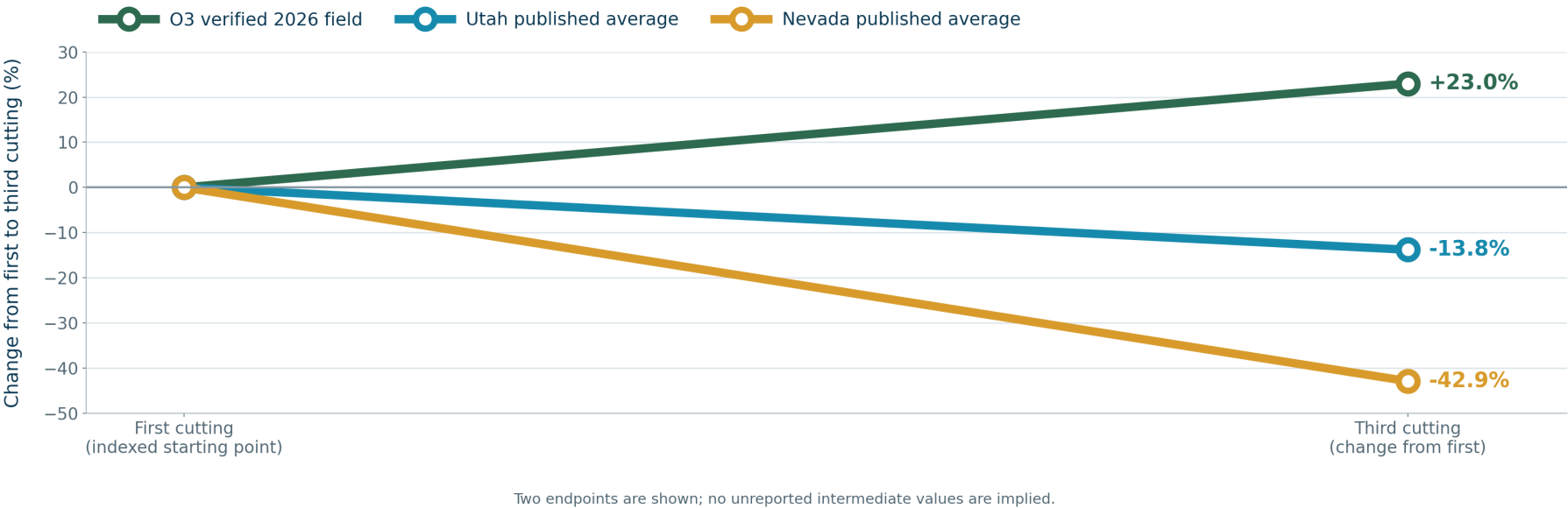
- The regional figures are external published averages and are not untreated strips beside the O3 field.
- Weather, stand age, variety, soil, water, cutting dates, acreage and measurement methods may differ.
- The source appendix must retain the underlying university publication, years, geography, units and calculation method before unrestricted public release.

**HOW TO STATE IT** — “In this documented O3 field, third-cut harvested weight was 23.0% above first-cut weight. Published Utah and Nevada averages reported in the approved comparison moved downward. Those external averages provide context and are not O3 control fields.”

# Regional context comparison

## O3 cutting direction compared with published regional context

The documented O3 cutting trend moved upward while both regional comparisons moved downward



Large-print comparison chart.

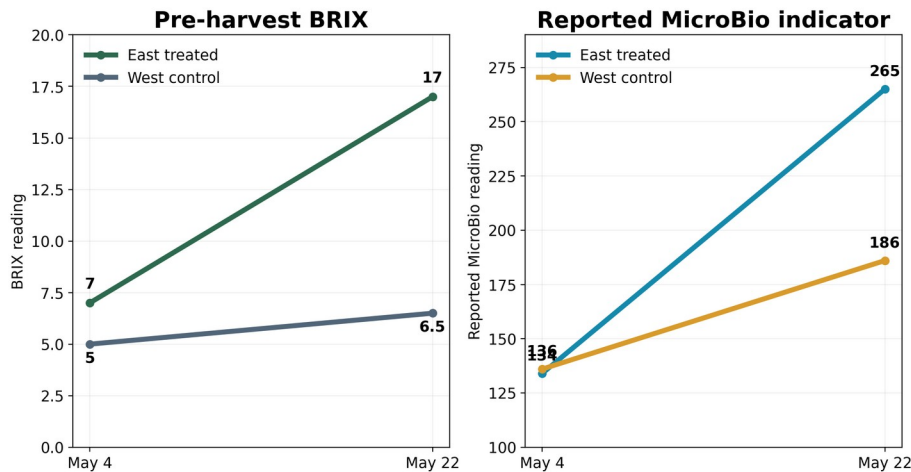




# Actual treated and control fields separated before harvest

## BRIX AND REPORTED MICROBIO READINGS

Actual treated and control field indicators separated through May



Source: O3 Utah Crop Report 0626. East Field treated; West Field control. BRIX: 7 vs 5 on May 4 and 17 vs 6.5 on May 22. Reported MicroBio: 134 vs 136 and 265 vs 186. Preserve sampling method and field identity.

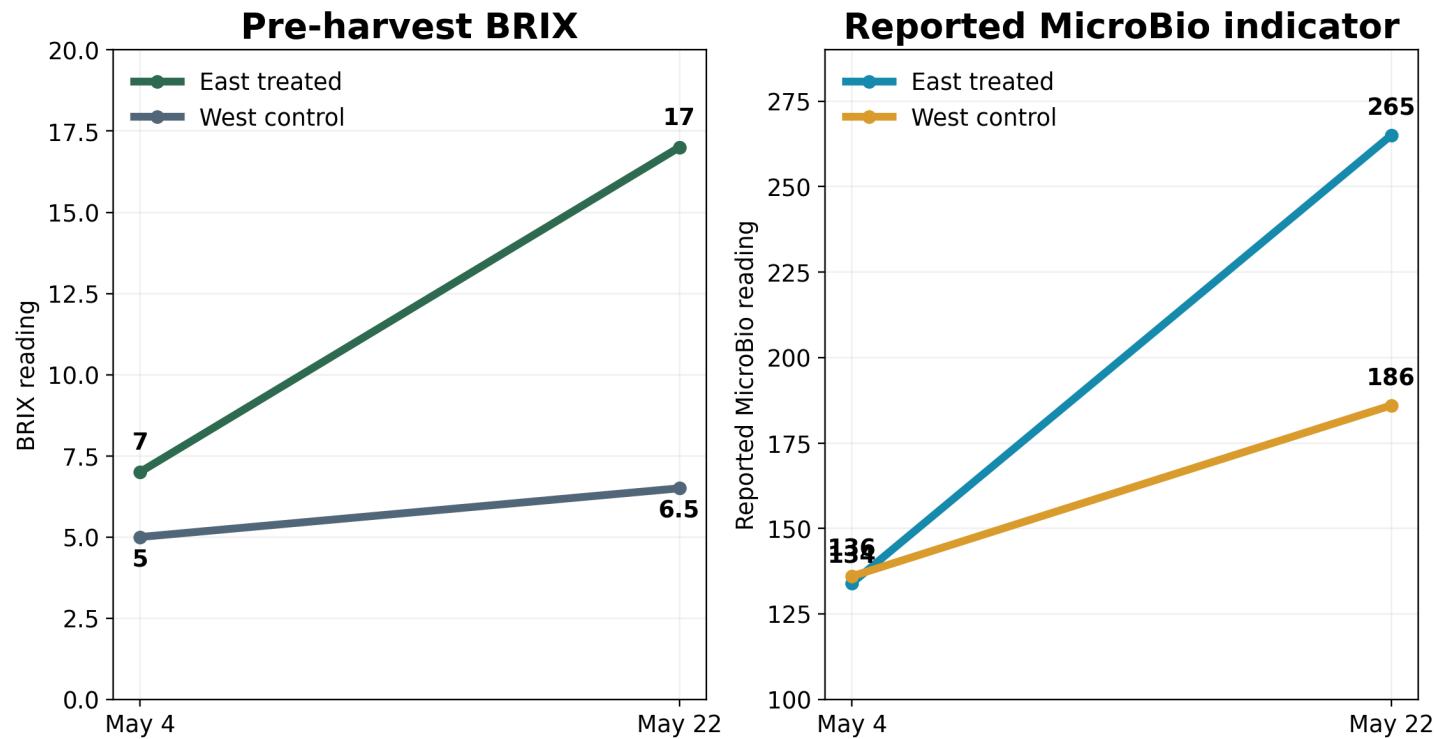
The 2026 field record compares the East Field treated with the O3 AG Pro and AG D20G systems against the West Field control. On May 4, BRIX measured 7 in the treated field and 5 in the control. By May 22, the treated reading had increased to 17 while the control measured 6.5. The reported MicroBio indicator moved from 134 to 265 treated and from 136 to 186 control.

| MEASURE             | EAST FIELD — TREATED    | WEST FIELD — CONTROL    | SEPARATION ON MAY 22       |
|---------------------|-------------------------|-------------------------|----------------------------|
| BRIX                | 7 → 17                  | 5 → 6.5                 | +10.5 treated over control |
| Reported MicroBio   | 134 → 265               | 136 → 186               | +79 treated over control   |
| Harvest production  | 206 bales; 167.993 tons | 152 bales; 123.348 tons | +54 bales; +44.645 tons    |
| Average bale weight | 1,631 lb                | 1,623 lb                | +8 lb                      |

**HOW THE MEASURES CONNECT** — Rising pre-harvest BRIX documents increasing soluble solids in the sampled plant juice. RFV and RFQ are separate laboratory forage indexes based on fiber, digestibility and intake relationships. Present them as complementary evidence; BRIX alone does not calculate or prove RFV or RFQ.

# Treated and control field measurements

## Actual treated and control field indicators separated through May



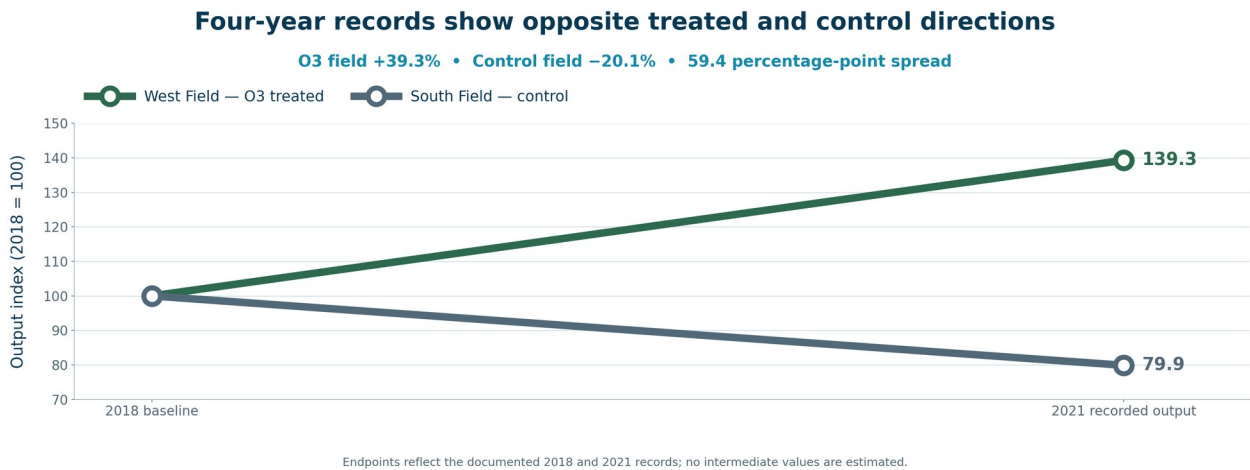
Source: O3 Utah Crop Report 0626. East Field treated; West Field control. BRIX: 7 vs 5 on May 4 and 17 vs 6.5 on May 22. Reported MicroBio: 134 vs 136 and 265 vs 186. Preserve sampling method and field identity.

Large-print BRIX and microbial-count comparison.



# The actual control field moved down while the O3 field moved up

## 2018–2021 HISTORICAL OUTPUT INDEX



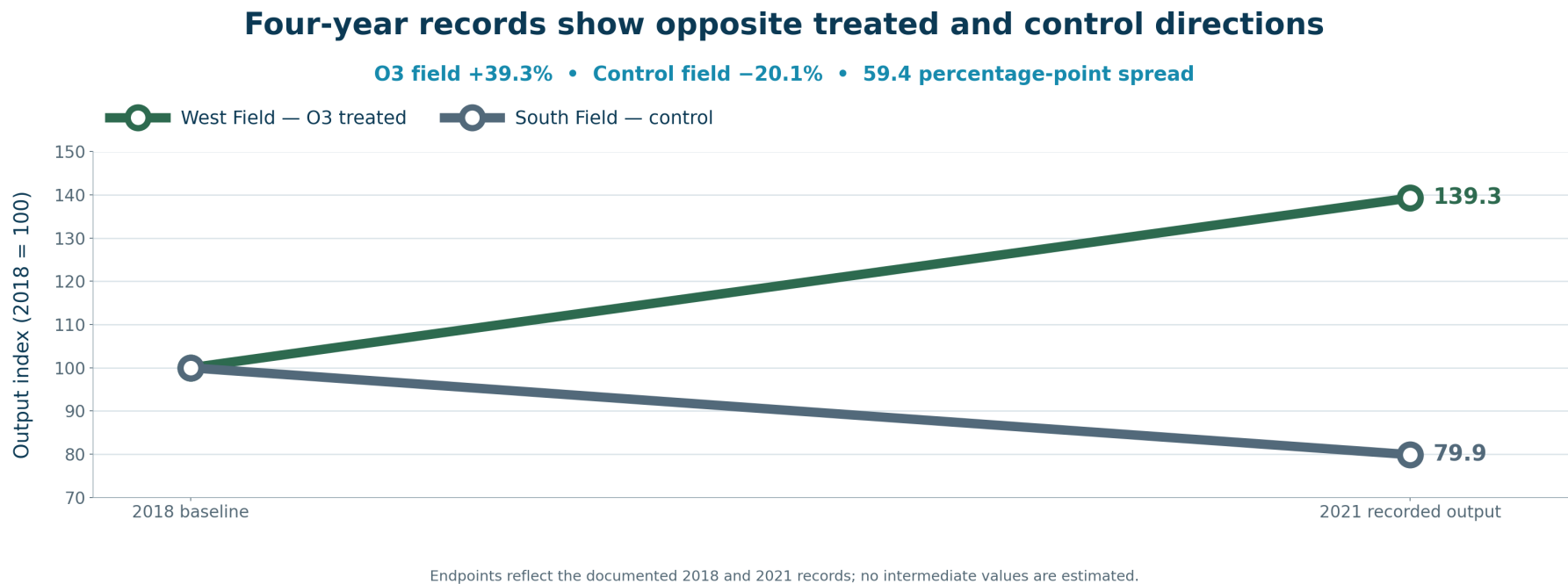
Across the 2018–2021 record, the West Field operated with ozone treatment and a 10% water cut while the South Field remained the standard control. The O3 field moved from a 2018 baseline of 965 bales to 1,344 in 2021: an increase of 379 bales, reported as a 39.3% output-index gain. The control moved from 503 to 402: a decline of 101 bales, reported as a 20.1% decrease. The difference between those directions is 59.4 percentage points.

| FIELD                 | 2018 BASELINE | 2021 OUTPUT | CHANGE        | CUMULATIVE  |
|-----------------------|---------------|-------------|---------------|-------------|
| West Field — O3       | 965 bales     | 1,344 bales | +379 / +39.3% | 4,333 bales |
| South Field — control | 503 bales     | 402 bales   | –101 / –20.1% | 1,808 bales |

The four-year cumulative record totals 4,333 bales for the O3 field and 1,808 for the control, a reported cumulative surplus of 2,525 bales. The source report provides the verified 2018 and 2021 endpoints and the four-year cumulative totals; it does not provide separate annual 2019 and 2020 values, so those intermediate points are not invented or interpolated.

**EVIDENCE BOUNDARY** — These historical values remain labeled as an output index until the complete harvested acreage, event-level weights and comparable moisture basis are matched. They demonstrate opposite recorded field directions; they are not converted into tons per acre in this edition.

# Historical output index



Large-print treated and control output chart.

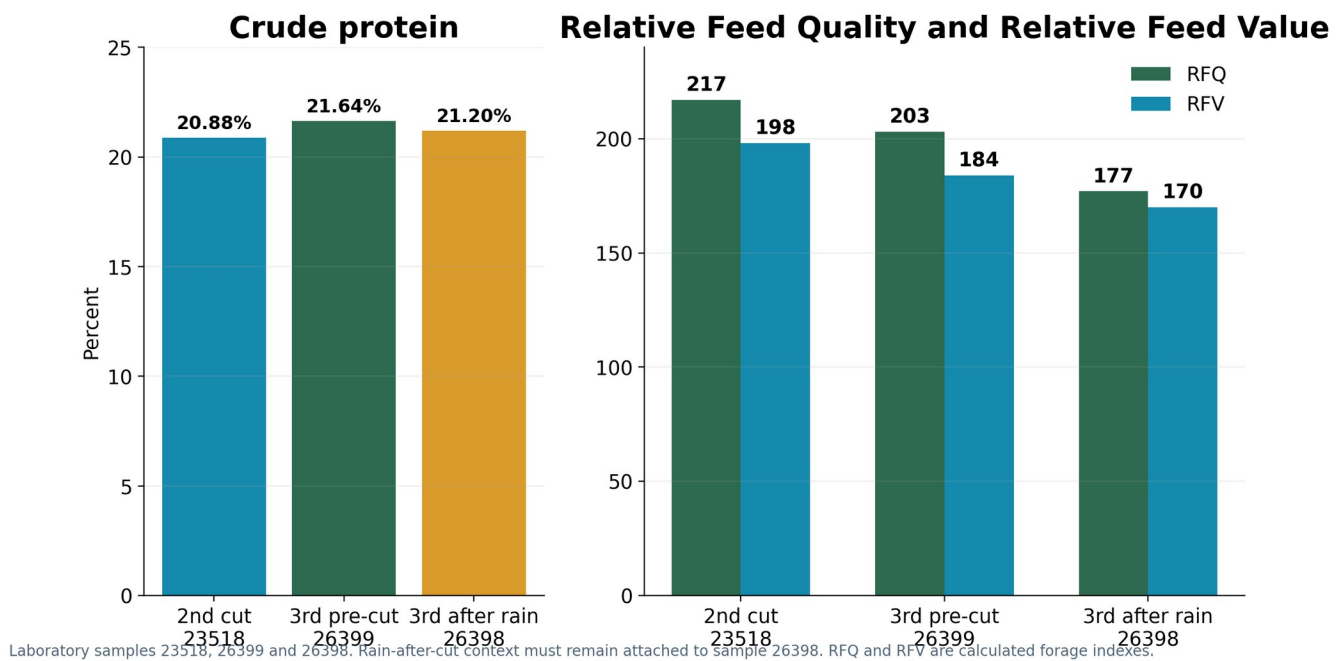




# Verified forage quality beside yield

## PROTEIN, RFQ AND RFV

### Verified forage quality remained strong across documented samples

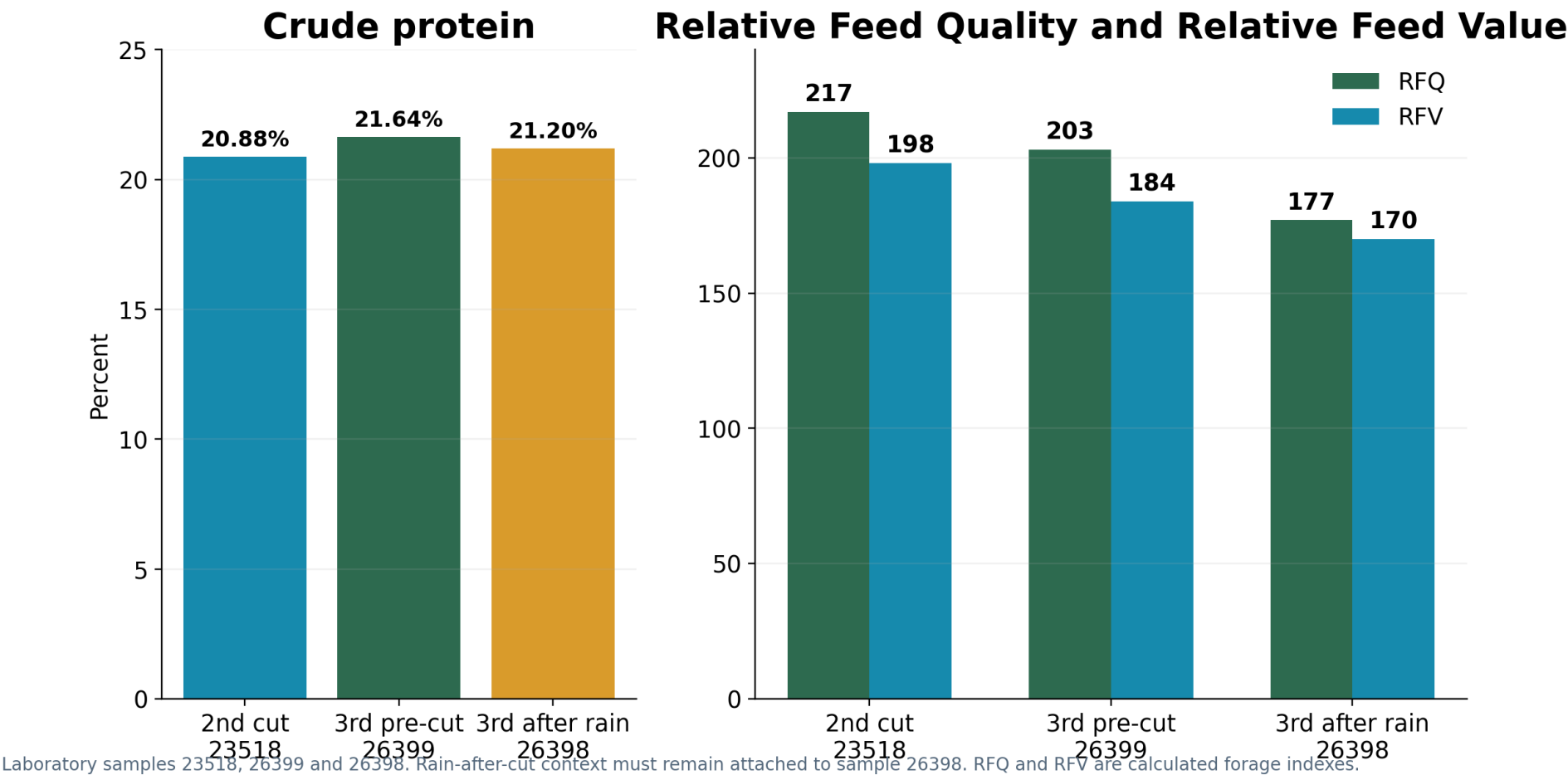


Production quantity must be interpreted with feed quality. Laboratory sample 23518 from the second cutting reported 20.88% protein, RFQ 217 and RFV 198. Third-cut sample 26399 reported 21.64% protein, RFQ 203 and RFV 184. Sample 26398, collected after cutting and rain, still reported 21.20% protein, RFQ 177 and RFV 170. The rain-after-cut condition stays attached because it affects a fair comparison.

**INTERPRETATION** — Relative Feed Quality and Relative Feed Value are calculated forage indexes. They support feed-quality interpretation but do not replace the complete laboratory analysis or the harvested-weight record.

# Forage quality by cutting

Verified forage quality remained strong across documented samples



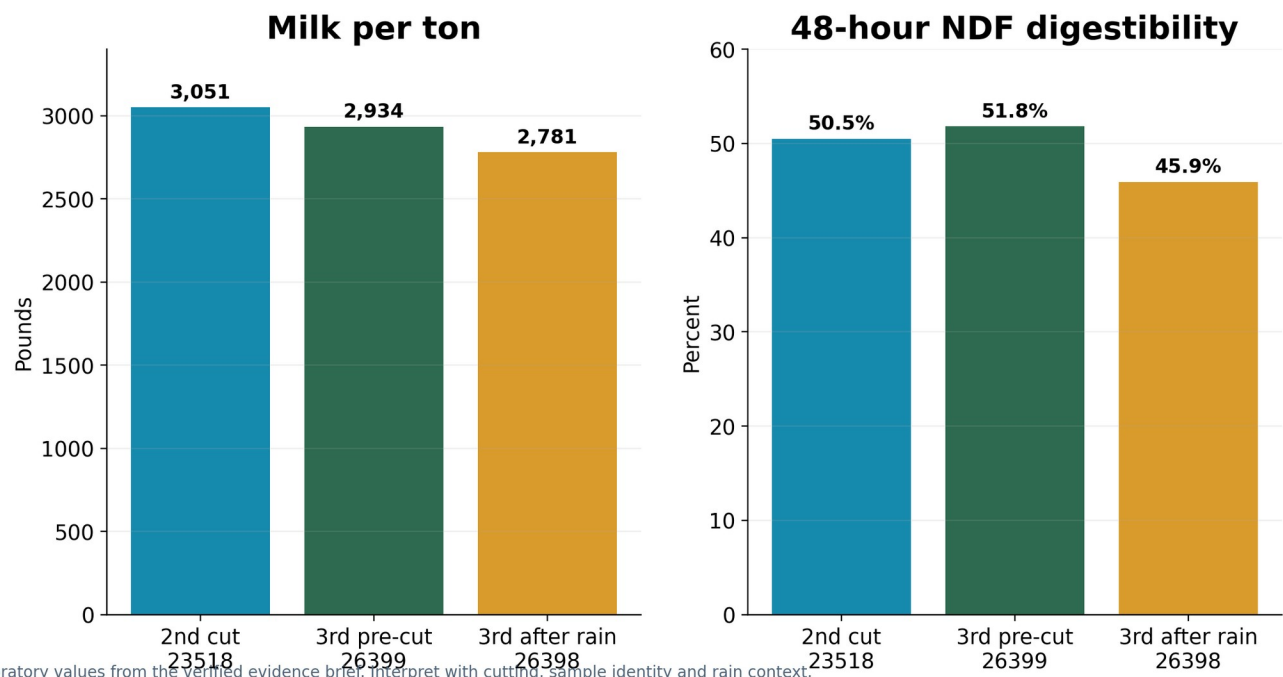
Large-print crude-protein, RFQ and RFV chart.



# Digestibility and production-quality indicators

## LABORATORY MEASURES IN CONTEXT

### Laboratory quality measures beside harvested production



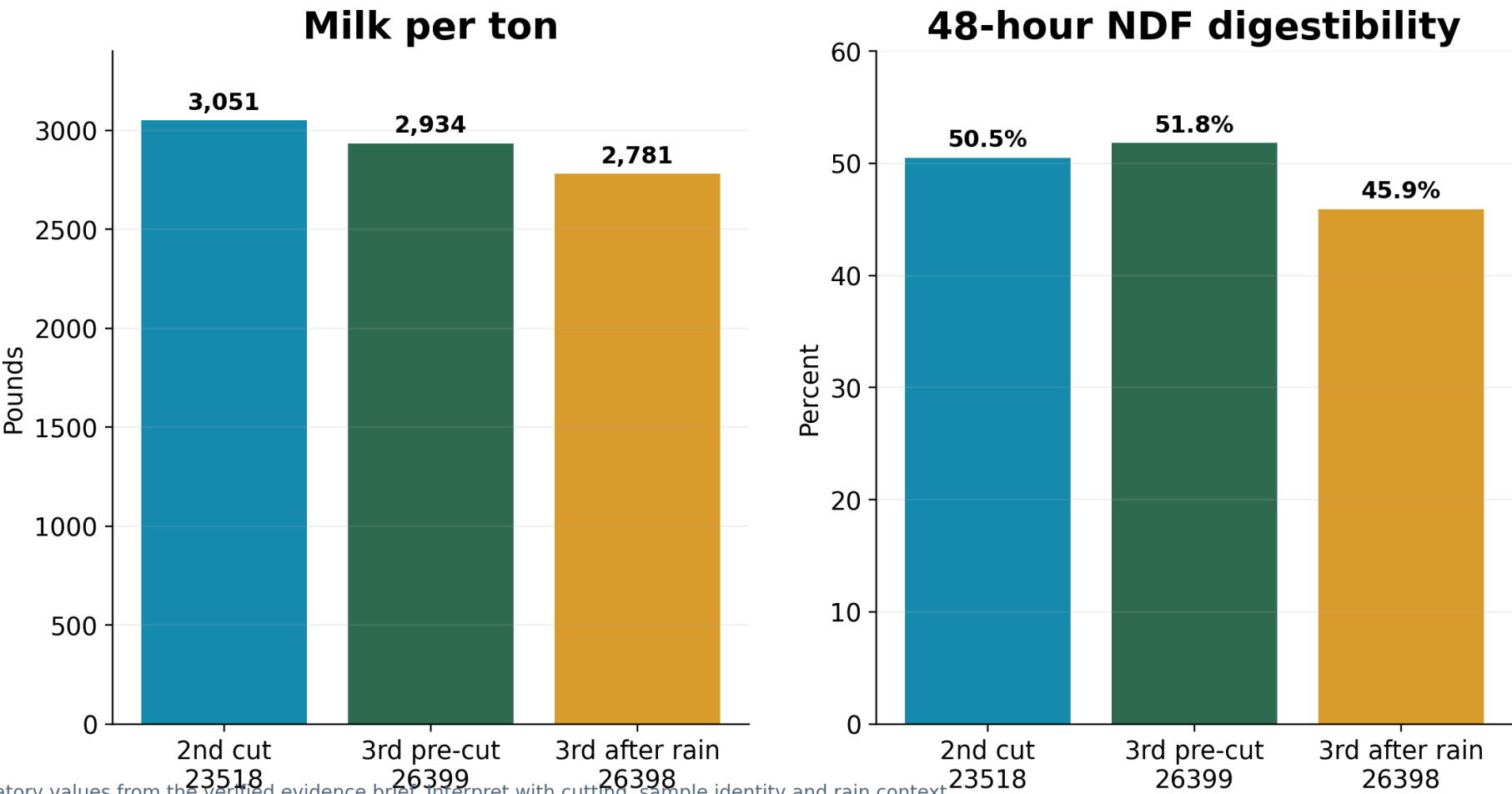
Laboratory values from the verified evidence brief. Interpret with cutting, sample identity and rain context.

The verified laboratory records also include 48-hour neutral detergent fiber digestibility and calculated milk per ton. These measures help explain whether added harvested weight is accompanied by useful forage characteristics. They are read with protein, ADF, aNDF, RFQ, RFV, cutting identity and weather context.

| SAMPLE                   | NDFD48 | MILK / TON | CLASSIFICATION  |
|--------------------------|--------|------------|-----------------|
| 23518 - second cut       | 50.5%  | 3,051 lb   | Supreme         |
| 26399 - third pre-cut    | 51.8%  | 2,934 lb   | Supreme/Premium |
| 26398 - third after rain | 45.9%  | 2,781 lb   | Still Premium   |

# Digestibility and milk-per-ton

## Laboratory quality measures beside harvested production



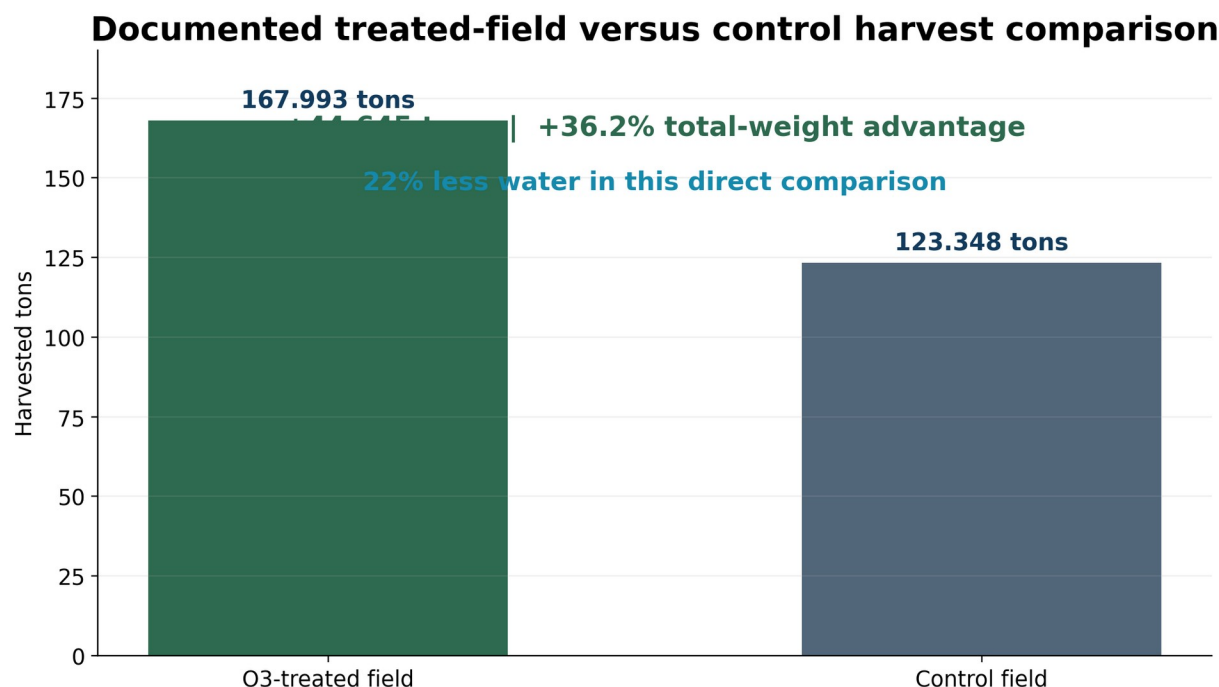
Large-print forage-quality chart.





# Direct treated-field and control comparison

## PRODUCTION AND WATER BELONG ON THE SAME PAGE

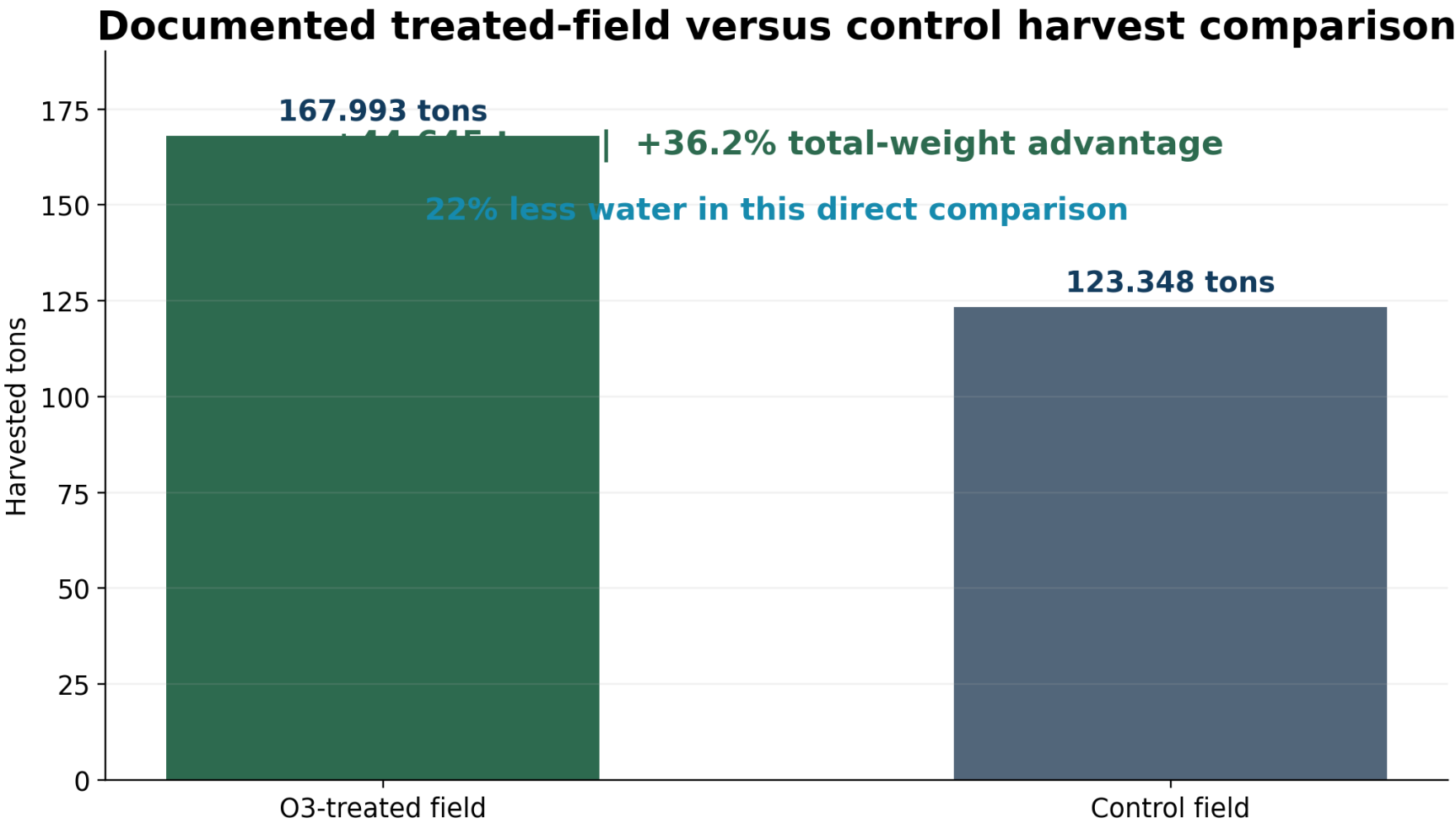


Source: O3 AG Visual Story Booklet field comparison. Tons per acre require verified equal acreage; do not convert total weight to per-acre yield without acreage.

A separate documented comparison reported 167.993 total tons from the O3-treated field and 123.348 total tons from the control: 44.645 additional tons, or a 36.2% total-weight advantage, while using 22% less water in that comparison. This is distinct from the three-cut seasonal record and must not be blended with it.

**ACREAGE CONTROL** — If the harvested acreages are equal, the total-weight percentage also represents the per-acre percentage advantage. Absolute tons per acre are not calculated until the exact acreage for both fields is confirmed.

# Direct treated and control comparison



Source: O3 AG Visual Story Booklet field comparison. Tons per acre require verified equal acreage; do not convert total weight to per-acre yield without acreage.

Large-print harvested-weight and water-use comparison.



# Soil, roots, nutrients and BRIX

## THE AGRICULTURAL VERIFICATION CHAIN

O3 does not become fertilizer. It does not supply nitrogen, phosphorus, potassium, calcium, magnesium or micronutrients. The testable agricultural question is whether treated water changes conditions within the water-soil-root system in ways associated with nutrient availability, nutrient uptake, plant health, water-use efficiency, yield or quality.

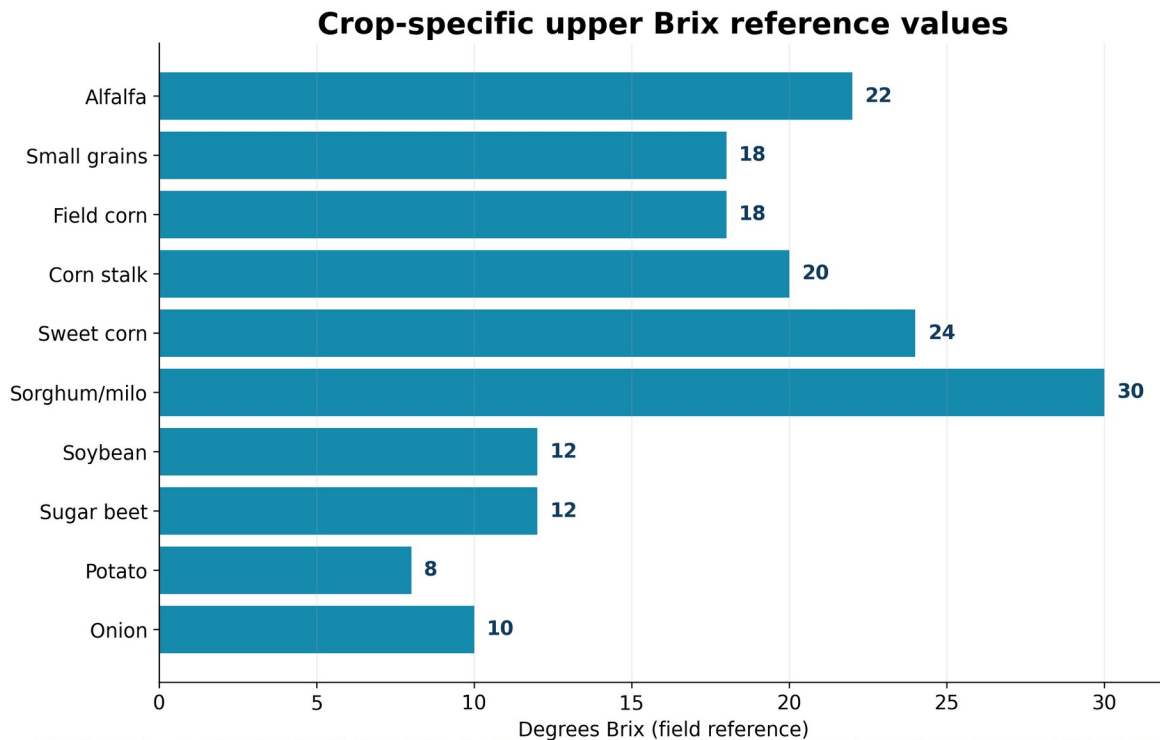
| BEFORE TREATMENT                                                                                                                                                                                                                                                                                                                                                                                                     | DURING THE SEASON                                                                            | AT HARVEST                                                                                |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| Soil nutrients, pH, EC, compaction, infiltration and moisture by depth                                                                                                                                                                                                                                                                                                                                               | Water chemistry, irrigation volume, weather, root condition, crop stage, tissue/sap and BRIX | Tons or bushels per acre, grade, protein/oil, RFV/RFQ, dry matter, pack-out and economics |
| <ul style="list-style-type: none"><li>• Repeat comparable measurements at the same field zone, depth, plant part, growth stage and time-of-day window.</li><li>• Record fertilizer and all other management changes so an observed response is not incorrectly attributed to O3.</li><li>• Use roots, soil, tissue, BRIX, yield and quality together; no single measurement proves the complete mechanism.</li></ul> |                                                                                              |                                                                                           |





# BRIX must be crop-specific

## EDUCATIONAL REFERENCE - NOT AN O3 RESULT

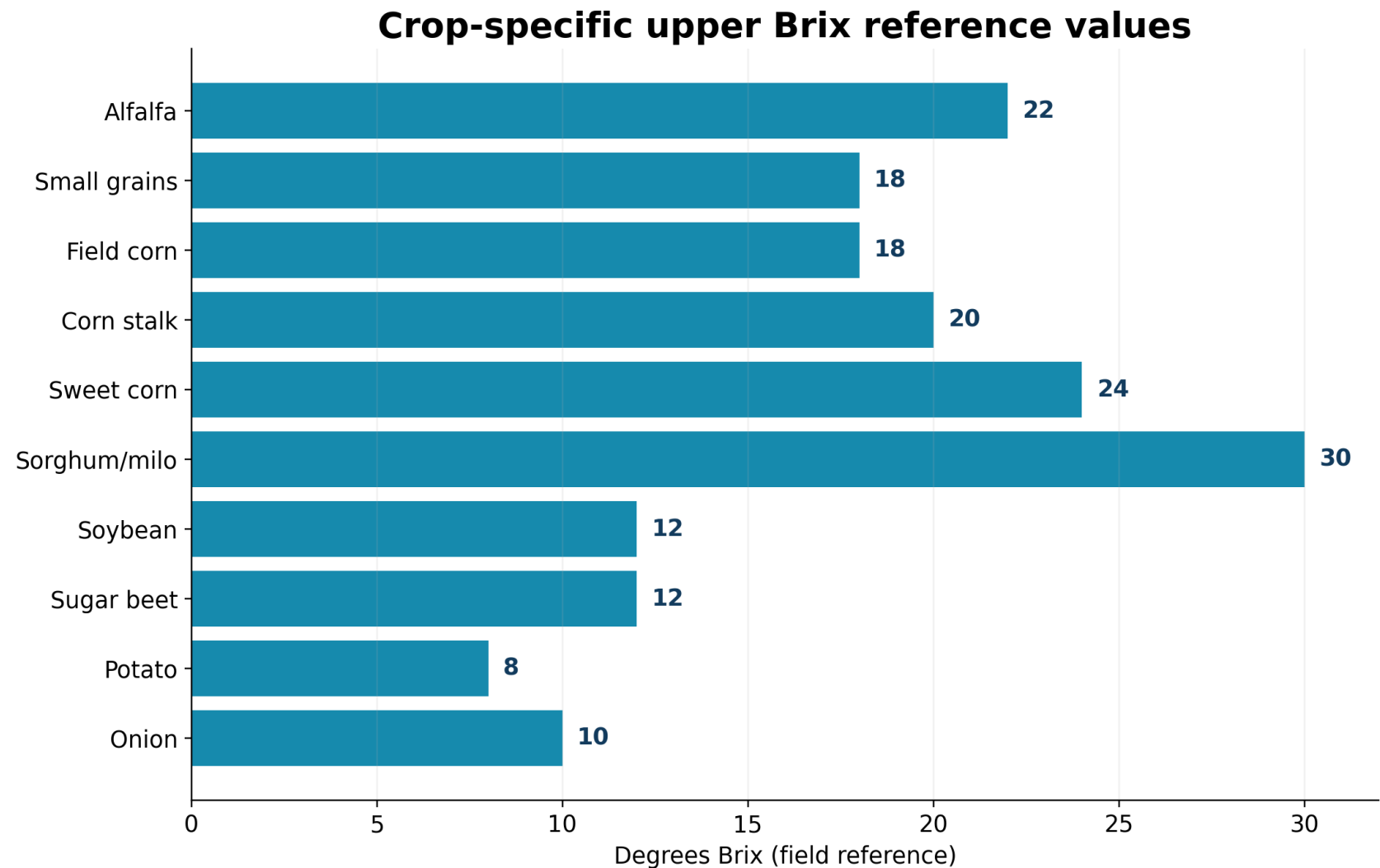


Educational reference values from the O3 AG Agricultural Systems & Field Reference Guide. These are crop reference tiers, not measured O3 treatment results or guarantees.

BRIX is a refractometer reading of soluble solids in expressed plant juice. It can support field scouting, but comparisons require the crop, plant part, growth stage, time of day, irrigation or rainfall, temperature and sampling method. Field corn, corn stalk and sweet corn are not interchangeable samples.

**USE WITH OTHER PROOF** — A BRIX value is not a complete nutrient test and is not a substitute for yield, nutritional analysis, tissue testing or crop health. It becomes useful when it is repeatable and interpreted beside roots, soil moisture, tissue/sap, harvested production and quality.

# Crop BRIX reference values



Educational reference values from the O3 AG Agricultural Systems & Field Reference Guide. These are crop reference tiers, not measured O3 treatment results or guarantees.

Large-print crop reference chart.





# Crop-by-crop harvest proof

USE THE UNIT THE INDUSTRY ACTUALLY BUYS AND SELLS

| CROP / COMMODITY         | PRIMARY PRODUCTION UNIT                        | QUALITY PROOF                                                      |
|--------------------------|------------------------------------------------|--------------------------------------------------------------------|
| Corn                     | Bushels per acre                               | Moisture, test weight, grade and grain quality                     |
| Alfalfa / hay            | Tons per acre                                  | Protein, RFV, RFQ, NDFD, dry matter and class                      |
| Soybean / small grains   | Bushels per acre                               | Protein/oil, test weight and grade                                 |
| Potato / sugar beet      | Tons per acre                                  | Marketable size, sugar/quality, pack-out and storage loss          |
| Produce                  | Marketable pounds or cartons per acre          | Grade, size, BRIX where applicable, shelf life and rejects         |
| Greenhouse / hydroponics | Marketable weight or units per area and time   | Pack-out, consistency, nutrient analysis and water use             |
| Dairy / livestock        | Facility-specific production and quality units | Product quality, animal records, sanitation and water/chemical use |

A defensible comparison records planted and harvested acreage, variety, planting date, population, soil zone, irrigation, fertility, weather, harvest method and actual scale or ticket data. Bushels, bales and total tons are not interchangeable; the book keeps the original production unit and calculates normalized results only when the required area and weight data are verified.



# Recovered findings: how these tables must be read

## OZONE EFFECTS SOURCE AUDIT

The recovered Ozone Effects document contains a mixture of seconds, minutes, threshold values and qualitative susceptibility statements. It does not contain milliseconds. Each entry remains attached to its written dose, medium, contact time and endpoint until the original report is matched.

### Large-print timing-group guide

| REPORTED GROUP              | HOW IT MUST BE INTERPRETED                                                                   |
|-----------------------------|----------------------------------------------------------------------------------------------|
| Rapid — seconds             | Reported clean-water or buffer findings. Read the organism, dose and endpoint with the time. |
| Short — 1 to 5 minutes      | Reported intermediate findings across water, sludge effluent or an unstated medium.          |
| Extended — 10 to 29 minutes | Reported fungi, wastewater, raw-wastewater, distilled-water or unstated-medium findings.     |

**WHERE TO FIND THE FULL VALUES** — The Evidence appendix now presents every recovered timing entry in editable 10.5–11 point type, followed by a separate interpretation-and-verification page.

**LANGUAGE CONTROL** — The review edition uses reduction, inactivation, oxidation or below-detection-limit wording when supported. Legacy words such as destroyed or killed are preserved only inside a clearly labeled source transcription, not promoted as a universal claim.



# Rapid-contact recovered findings

## RECOVERED REFERENCE VALUES - REPORTED CONDITIONS PRESERVED

| TARGET                     | DOSE / MEDIUM                 | CONTACT     | REPORTED ENDPOINT  |
|----------------------------|-------------------------------|-------------|--------------------|
| Hepatitis A virus          | 0.25 mg/L; phosphate buffer   | 2 seconds   | 99.5% reduction    |
| Bacteriophage f2           | 0.41 mg/L; water              | 10 seconds  | 99.99% reduction   |
| Coxsackie virus A9         | 0.035 mg/L; water             | 10 seconds  | 95% reduction      |
| E. coli - clean water      | 0.25 mg/L; clean water        | ~30 seconds | 99.99% reduction   |
| Encephalomyocarditis virus | 0.1-0.8 mg/L; medium unstated | <30 seconds | Legacy: zero level |

These values are transcribed and normalized for readability. They are not O3 Science equipment specifications and cannot be transferred to another medium without validation.

**WHAT THIS GROUP SHOWS** — Under the reported clean-water or buffer conditions, susceptible targets reached the stated endpoint within seconds. The entries demonstrate why contact units must be preserved and why a seconds result must not be redrawn as minutes.

- Use the stated concentration, medium and endpoint together; time alone is not the treatment specification.
- Confirm generator output, gas concentration, transfer efficiency, water demand and actual contact before applying the finding to equipment design.
- A field or facility claim requires the matching laboratory report, method, detection limit and operating record.



# One- to five-minute recovered findings

## RECOVERED REFERENCE VALUES - REPORTED CONDITIONS PRESERVED

| TARGET                      | DOSE / MEDIUM                | CONTACT     | REPORTED ENDPOINT |
|-----------------------------|------------------------------|-------------|-------------------|
| Bacillus cereus             | 0.12 mg/L; water             | 1 minute    | 99% reduction     |
| B. cereus spores            | 2.3 mg/L; water              | 1 minute    | 99% reduction     |
| Echo virus 29               | 1 mg/L; medium<br>unstated   | 1 minute    | 99.999% reduction |
| Botrytis cinerea            | 3.8 mg/L; medium<br>unstated | 2 minutes   | Endpoint unstated |
| C. difficile                | 0.6 mg/L; water              | 2 minutes   | 99.999% reduction |
| Coxsackie virus B5          | 0.4 mg/L; sludge<br>effluent | 2.5 minutes | 99.99% reduction  |
| Clavibacter<br>michiganense | 1.1 mg/L; medium<br>unstated | 5 minutes   | 99.99% reduction  |

These values are transcribed and normalized for readability. They are not O3 Science equipment specifications and cannot be transferred to another medium without validation.

**WHAT THIS GROUP SHOWS** — These entries occupy a different exposure range from the seconds findings. Their reported media include water, an unstated medium and sludge effluent, so the table is a comparison of documented conditions—not a ranking of organism resistance.

- Higher demand can consume ozone before the target receives the intended exposure.
- A validated process may change dose, transfer or contact, but a new condition requires its own confirmation.
- System sizing uses the treatment objective and process demand; it does not copy a contact time from a different test.



# Longer-contact and high-demand findings

RECOVERED REFERENCE VALUES - REPORTED CONDITIONS PRESERVED

| TARGET                               | DOSE / MEDIUM              | CONTACT      | REPORTED ENDPOINT |
|--------------------------------------|----------------------------|--------------|-------------------|
| Fusarium oxysporum f.sp. lycopersici | 1.1 mg/L; medium unstated  | 10 minutes   | Endpoint unstated |
| Cladosporium                         | 0.10 ppm; medium unstated  | 12.1 minutes | 90% reduction     |
| E. coli - wastewater                 | 2.2 mg/L; wastewater       | 19 minutes   | 99.9% reduction   |
| Legionella pneumophila               | 0.32 mg/L; distilled water | 20 minutes   | 99.99% reduction  |
| Fusarium oxysporum f.sp. melonogea   | 1.1 mg/L; medium unstated  | 20 minutes   | 99.99% reduction  |
| Enteric virus                        | 4.1 mg/L; raw wastewater   | 29 minutes   | 95% reduction     |

These values are transcribed and normalized for readability. They are not O3 Science equipment specifications and cannot be transferred to another medium without validation.

**WHAT THIS GROUP SHOWS** — The longer entries are retained because they document materially different organisms, matrices and endpoints. Removing them would hide the effect of medium and demand; presenting them as a universal equipment speed would be equally misleading.

- Wastewater, raw wastewater and fungal targets can require a different treatment train from clear source water.
- Pretreatment and solids removal can reduce demand before the ozone contact stage.
- The release decision belongs to the measured endpoint and applicable permit or sanitation plan, not elapsed time alone.





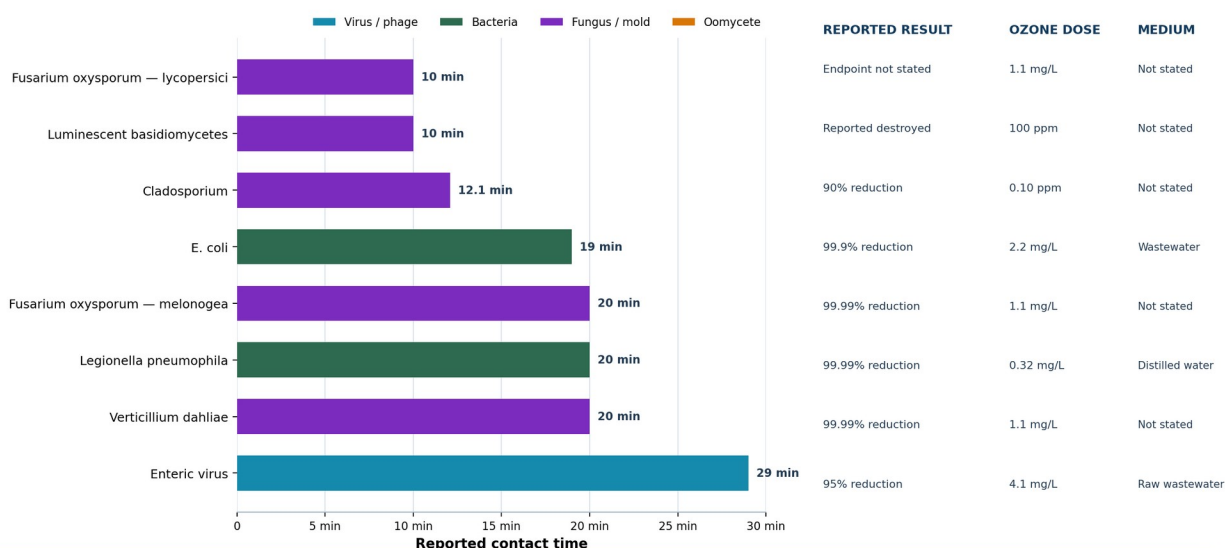
# Why the longer times remain in the record

## MEDIUM AND DEMAND MATTER

O<sub>3</sub> SCIENCE, INC.

### Extended-contact findings

Reported outcomes from 10 through 29 minutes; difficult media remain visible



#### RETAINED FROM ORIGINAL TABLE — NOT CHARTED WITHOUT NUMERIC CONTACT TIME

- Susceptible only: B. anthracis; Candida; Clostridium; Endamoebic cysts; Penicillium; Proteus; Pseudomonas; Salmonella; Schistosoma; Vibrio cholera.
- Dose or threshold only: Aspergillus niger; B. subtilis; C. botulinum spores; Diphtheria; Eberth bacillus; E. coli from feces; Influenza; Klebs-Löffler bacillus; Staphylococci.
- CT only: Mycobacterium avium (99.9% at CT 0.17 in water). Separate source verification required before interpretation.
- Excluded from pathogen chart: Vicia faba progeny chromosome-aberration statement.

DRAFT FOR APPROVAL • Transcribed from Ozone Effects.odt (Ozone Clean Pro). Source matching and independent verification are in progress. Do not treat these rows as universal machine-performance claims.

- Raw wastewater and sludge effluent have substantially different oxidant demand from clean water.
- Fungal structures and spores may require different exposure than vegetative bacteria or susceptible viruses.
- A reported time without medium, temperature, pH and analytical method is incomplete and stays flagged.
- O3 Science faster controlled results belong in a separate project-results table after the matching laboratory report is located.

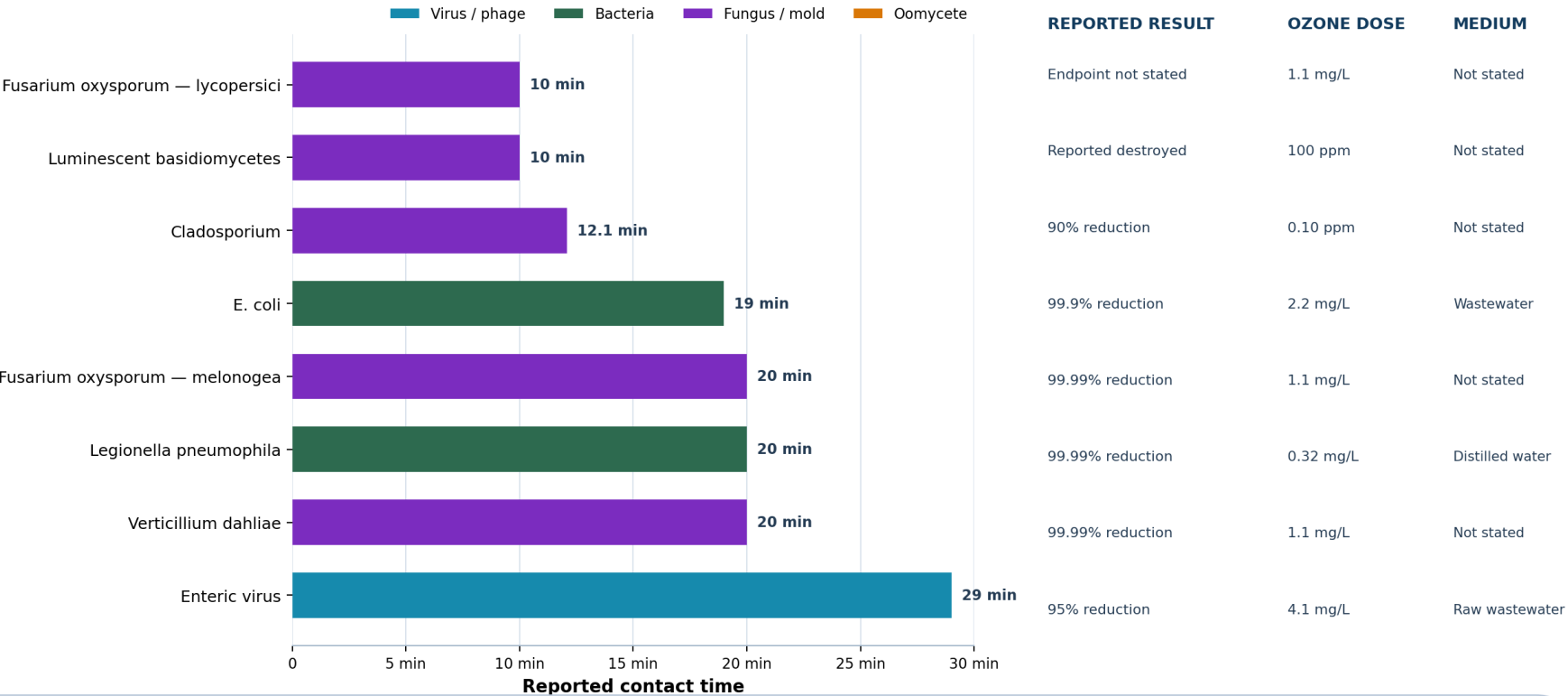
**NO INVENTED CONVERSION** — A minute value will never be relabeled as seconds or milliseconds without the original laboratory record establishing that unit.

# Longer-contact and high-demand findings

O<sub>3</sub> SCIENCE, INC.

## Extended-contact findings

Reported outcomes from 10 through 29 minutes; difficult media remain visible



RETAINED FROM ORIGINAL TABLE — NOT CHARTED WITHOUT NUMERIC CONTACT TIME

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DRAFT FOR APPROVAL • Transcribed from Ozone Effects.odt (Ozone Clean Pro). Source matching and independent verification are in progress. Do not treat these rows as universal machine-performance claims.

Large-print evidence chart. Different organisms, matrices and endpoints remain separate.



# Regulatory and approval evidence matrix

EXACT USE - EXACT AUTHORITY - EXACT RECORD

| EVIDENCE LAYER                 | WHAT IT CAN ESTABLISH                                        | WHAT MUST BE ATTACHED                                                 |
|--------------------------------|--------------------------------------------------------------|-----------------------------------------------------------------------|
| Federal food-use provision     | A defined substance use is permitted under stated conditions | Current provision and conditions of use                               |
| USDA/FSIS establishment record | Use within an inspected meat or poultry process              | Establishment, sanitation plan, correspondence and inspection history |
| FDA-regulated facility record  | Use within the facility food-safety system                   | Hazard analysis, sanitation controls and verification                 |
| State/local health approval    | Acceptance for the named installation or operation           | Issuing authority, facility, date and conditions                      |
| Independent laboratory report  | Measured result for a defined sample and method              | Full report, chain of custody, method, units and detection limit      |
| University study               | Outside scientific support under published conditions        | Full citation and application match                                   |

**PRIMARY FEDERAL ANCHOR** — 21 CFR 173.368 states that ozone may be safely used as an antimicrobial agent in gaseous or aqueous treatment, storage and processing of foods, including meat and poultry, in accordance with prescribed conditions and current good manufacturing practice. This is a use authorization, not blanket approval of every machine or claim.



# Current federal source register

## PRIMARY AUTHORITIES CHECKED FOR THIS REVIEW

| TOPIC                | PRIMARY SOURCE                                                            | WHAT IT SUPPORTS                                                                                                                                                                 |
|----------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Food use             | Electronic Code of Federal Regulations, 21 CFR 173.368, Ozone             | Permitted antimicrobial use in gaseous or aqueous food treatment, storage and processing under the stated conditions and current good manufacturing practice.                    |
| Worker exposure      | CDC/NIOSH Pocket Guide to Chemical Hazards: Ozone                         | Lists a NIOSH ceiling REL of 0.1 ppm, an OSHA PEL TWA of 0.1 ppm, and an IDLH value of 5 ppm; facility rules and applicable law still control.                                   |
| Arsenic regulation   | U.S. EPA Chemical Contaminant Rules / Arsenic Rule                        | Confirms arsenic as a regulated inorganic contaminant and the 10 ppb drinking-water standard for covered public water systems; it does not certify a particular treatment train. |
| O3 project approvals | Facility sanitation plans, correspondence, inspection records and permits | Establish the actual facility, application, authority, conditions and operating history; these records must be attached before a facility-specific approval claim is published.  |

DIRECT LINKS — eCFR: <https://www.ecfr.gov/current/title-21/chapter-I/subchapter-B/part-173/subpart-D/section-173.368> • NIOSH: <https://www.cdc.gov/niosh/npg/npqd0476.html> • EPA: <https://www.epa.gov/dwreginfo/chemical-contaminant-rules>

**REVIEW STATUS** — Federal sources were checked September 8, 2026. University publications, independent laboratory reports and facility approval records remain source-controlled attachments and are not represented by this federal register page.



# Facility approval record page

REPEAT ONCE FOR EVERY DOCUMENTED INSTALLATION

| FIELD                    | REQUIRED ENTRY                                                              |
|--------------------------|-----------------------------------------------------------------------------|
| Facility / establishment | Name, location and establishment number where applicable                    |
| Application              | Exact water, food, equipment, air, storage or wastewater use                |
| Authority                | FDA, USDA/FSIS, health department, permitting body or customer authority    |
| Record                   | Letter, sanitation-plan page, inspection note, permit or written acceptance |
| Effective conditions     | Dose/contact, operating limits, monitoring, corrective action and release   |
| Evidence location        | File name, date, custodian and source-library identifier                    |

This page prevents a valid approval from being stretched beyond the facility, application or conditions it actually covers. Multiple approved installations will be summarized in a separate index and supported by the complete records in the appendix.





# Worker and animal protection

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## DESIGNING TREATMENT AROUND OCCUPANCY

- Define whether the application is occupied, separated-process, or unoccupied-space treatment before selecting equipment and controls.
- Use interlocks, signage, access control, alarms, ventilation or destruct equipment appropriate to the site.
- Measure ambient conditions with maintained instruments and written response thresholds.
- Document shutdown, fault, evacuation, clearance and authorized re-entry procedures.
- Protect animals and biological treatment systems from uncontrolled residual exposure.

**EXTERNAL SAFETY BENCHMARK** — The CDC/NIOSH Pocket Guide lists a NIOSH ceiling REL of 0.1 ppm, an OSHA PEL TWA of 0.1 ppm and an IDLH value of 5 ppm for ozone. Applicable law, facility rules, instrument procedures and the site-specific safety plan must be confirmed for each installation.

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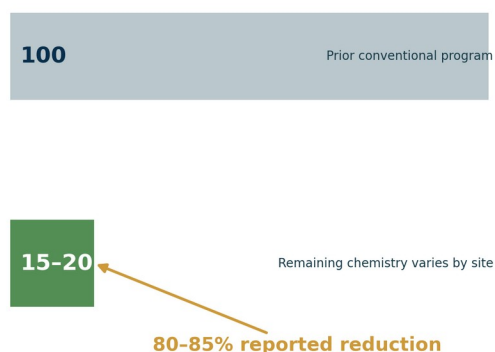
# Chemical-use reduction: show the baseline and the proof

## REPORTED O3 OPERATING RANGE — 80–85% REDUCTION

### WHY CONVENTIONAL CHEMICAL USE CAN FALL

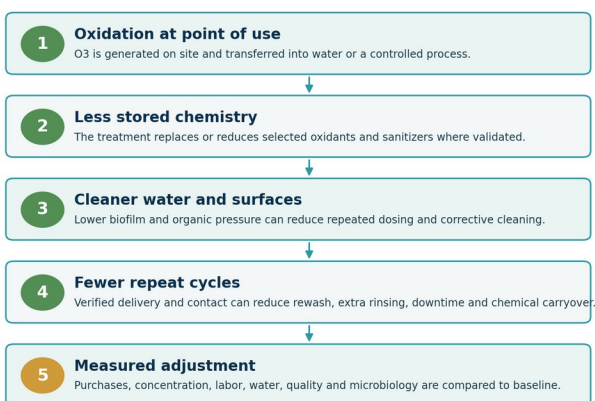
Reported O3 operating results: 80–85% reduction in conventional chemical use where the process is fully integrated and verified.

#### CHEMICAL PURCHASE / USE INDEX



Illustrative index based on the stated operating range—not a universal guarantee.

#### THE REDUCTION COMES FROM THE PROCESS CHAIN



**CONTROL BOUNDARY** | Cleaning, food-safety, animal-health and regulatory requirements remain in force. Keep chemistry where the hazard analysis or validated sanitation plan requires it.

**WHY THE REDUCTION CAN OCCUR** — Ozone is produced at the point of use and can replace or reduce selected conventional oxidants and sanitizers where the process is engineered, integrated and validated. Cleaner water, distribution and surfaces can also reduce repeated dosing, rewash, extra rinsing, corrective cleaning and chemical carryover.

- Start with invoices, inventory withdrawals, concentration, frequency, purpose and production volume from a representative pre-O3 period.
- Separate replaceable chemistry from products still required by the sanitation plan, hazard analysis, animal-health program, permit or authority.
- Normalize the comparison for production, season, water chemistry, organic load, product mix and sanitation frequency.
- Verify the reported 80–85% reduction with chemical, water, labor, microbiology, quality, wastewater and exception records.

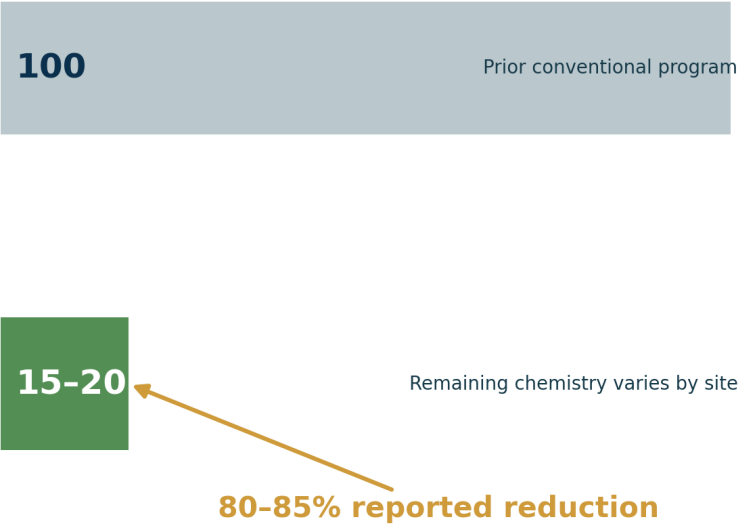
**CLAIM BOUNDARY** — The 80–85% range is a documented O3 operating result for applicable, fully integrated processes. It is not a universal guarantee, and the remaining chemical program is determined by the actual facility and its governing requirements.

# Reported chemical reduction

## WHY CONVENTIONAL CHEMICAL USE CAN FALL

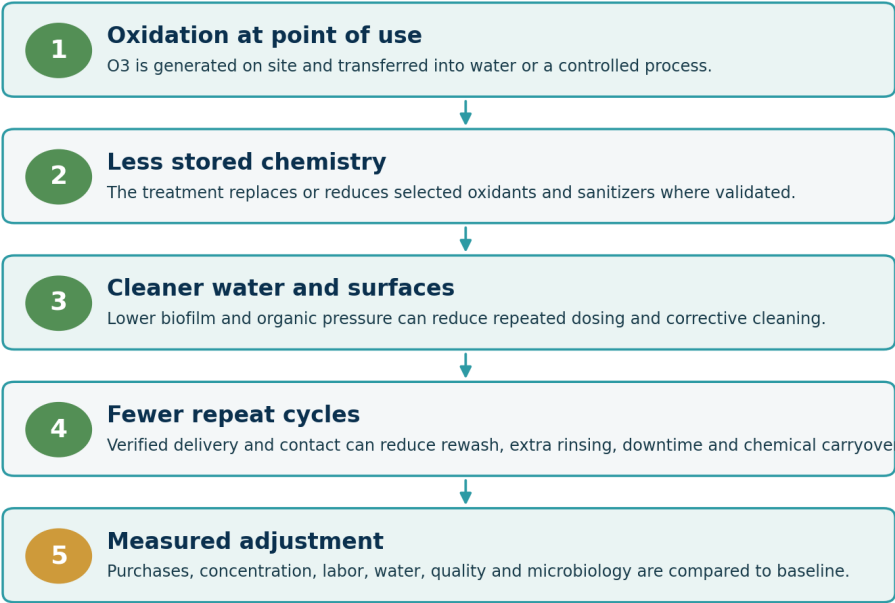
Reported O3 operating results: 80–85% reduction in conventional chemical use where the process is fully integrated and verified.

### CHEMICAL PURCHASE / USE INDEX



Illustrative index based on the stated operating range—not a universal guarantee.

### THE REDUCTION COMES FROM THE PROCESS CHAIN



**CONTROL BOUNDARY** | Cleaning, food-safety, animal-health and regulatory requirements remain in force. Keep chemistry where the hazard analysis or validated sanitation plan requires it.

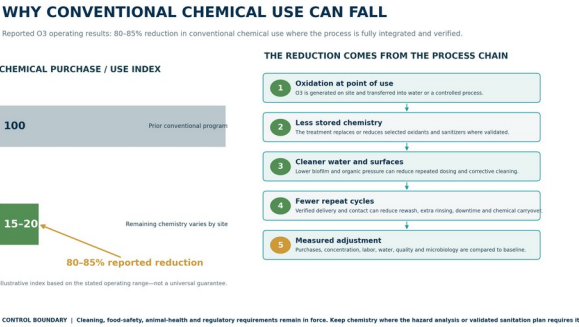
Large-print case-result chart. Case-specific result, not a universal guarantee.

# Operational and financial proof

## SHOW THE BASELINE, NOT A PROMISE

| VALUE CATEGORY     | BASELINE                                  | AFTER O3                                                               | PROOF RECORD                                                   |
|--------------------|-------------------------------------------|------------------------------------------------------------------------|----------------------------------------------------------------|
| Chemical purchases | Product, volume and cost                  | Reported 15–20% remaining use where records verify an 80–85% reduction | Invoices, inventory, dosing, production and sanitation records |
| Water use          | Gallons per batch/day/acre                | Comparable operating interval                                          | Meter and irrigation records                                   |
| Labor              | Cleaning, flushing and corrective hours   | Same tasks after implementation                                        | Work orders and payroll hours                                  |
| Downtime           | Sanitation or process interruption        | Comparable production interval                                         | Production logs                                                |
| Loss / spoilage    | Rejected, downgraded or discarded product | Same commodity and season context                                      | QA and inventory records                                       |
| Yield / quality    | Tons/acre, RFV/RFQ, grade or pack-out     | Comparable field/process result                                        | Harvest and laboratory records                                 |

**COMMERCIAL WORDING** — Use documented ranges and project examples. Return-on-investment may be presented as a target based on site data, never as a guaranteed universal outcome.





# Required records for a verified project

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## BUILDING A DEFENSIBLE EVIDENCE PACKAGE

- Original laboratory reports and the spreadsheet or chart source supporting each reported finding.
- Facility sanitation plans, approval correspondence and inspection records for meat, fish, produce and dairy-food installations.
- Health-department and permitting records tied to the exact facility and authorized use.
- University publications and independent studies matched to the organism, crop, commodity or treatment medium discussed.
- Machine model, output, flow, pressure, contact, monitoring and maintenance records for the installation.
- Before-and-after water, microbial, crop, quality, chemical, labor and financial records.
- Photographs and engineered drawings showing the actual equipment and installation configuration.

**EVIDENCE CLASSIFICATION** — A statement is identified as a verified project result, recovered reference finding, supporting published science or conceptual design. This distinction protects the strength of documented approvals and results while keeping every claim understandable.

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# How the evidence story is presented

## BOOK AND NARRATED PROGRAM

| VIDEO CHAPTER            | VISUAL STORY                                    | NARRATION PURPOSE                          |
|--------------------------|-------------------------------------------------|--------------------------------------------|
| 1. The challenge         | Water, crop, facility and storage problems      | Establish why treatment is needed          |
| 2. How O3 works          | Generation, injection, contact and oxidation    | Explain the technology in plain language   |
| 3. Growing applications  | Pivot, drip, greenhouse and reservoirs          | Follow water from source to root zone      |
| 4. Facility applications | Dairy, produce, meat and fish                   | Show sanitation inside real workflows      |
| 5. Storage and air       | Silos, root crops and cold rooms                | Explain controlled distribution and safety |
| 6. Water chemistry       | Iron bacteria, arsenic and filtration           | Show oxidation plus removal                |
| 7. The proof             | Labs, universities, approvals and field records | Connect every claim to traceable evidence  |
| 8. The value             | Water, chemicals, labor, quality and loss       | Explain measurable customer outcomes       |

Each page begins with a plain-language explanation suitable for narration. Dense evidence tables are summarized visually during the presentation, while the printed edition retains the complete conditions, citations and supporting records for technical review.



## ONE CONNECTED AGRICULTURAL SYSTEM

This evidence book follows water and air treatment from generation and contact through field delivery, root-zone measurement, facility sanitation, processing, storage and responsible reuse.

Every result is presented with its evidence class, operating conditions and verification records so readers can distinguish documented project findings, recovered reference values, supporting science and regulatory provisions.

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