

A New Method for Control of Nitrification

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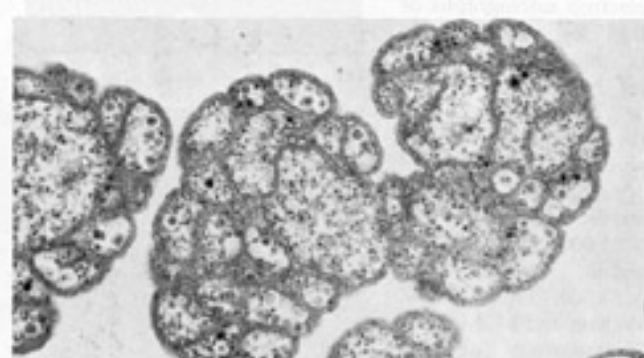
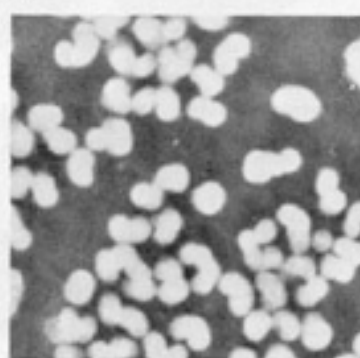
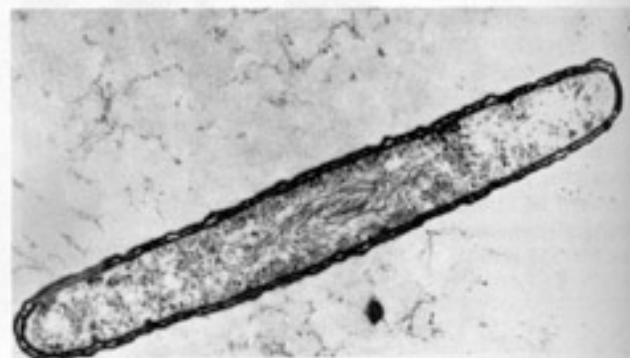
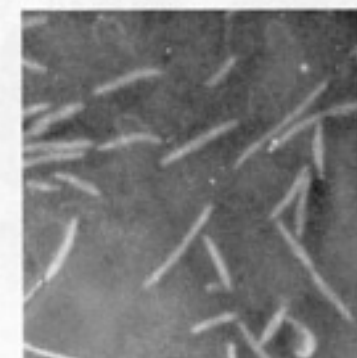
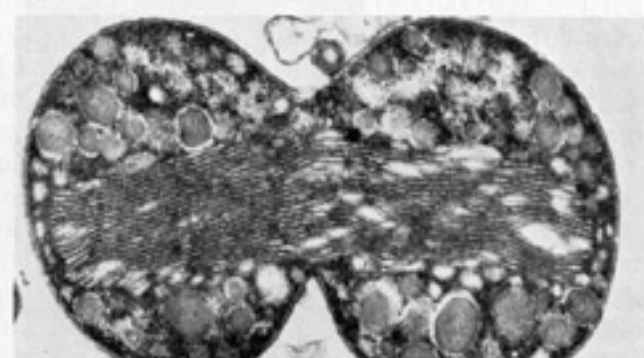
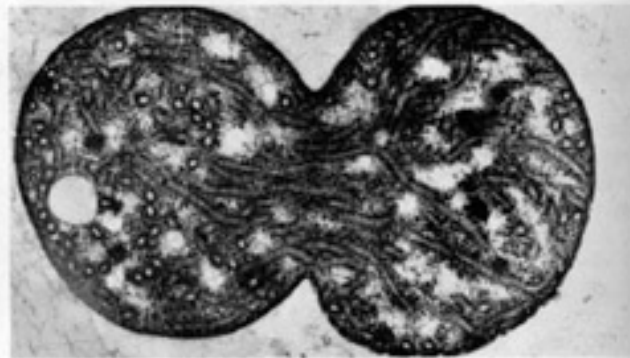
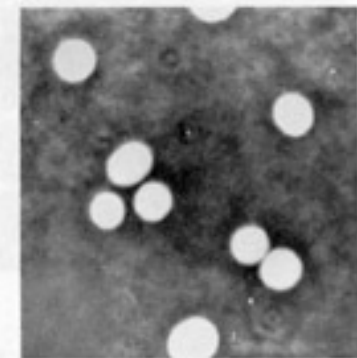
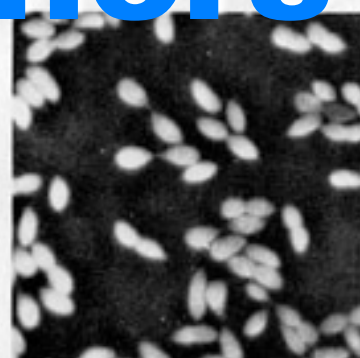
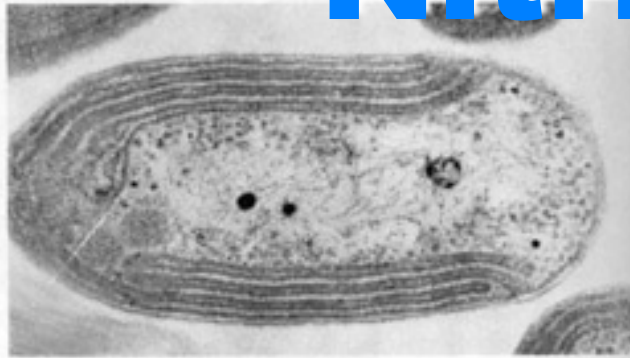
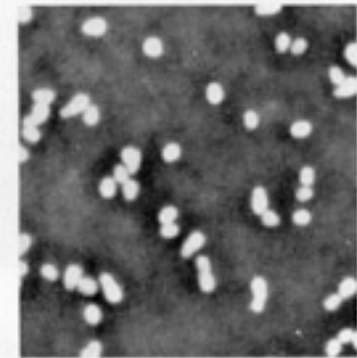
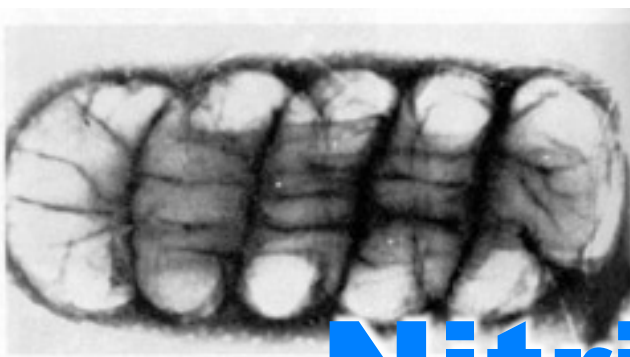
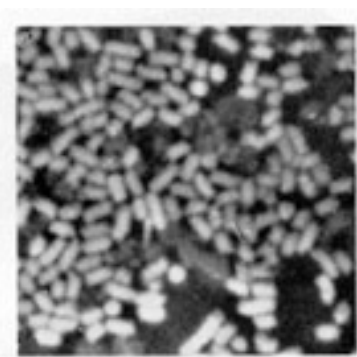
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Nitrification

microbially-mediated oxidation of ammonium ion to nitrite, and eventually, nitrate



Nitrifiers



Effects of Nitrification on Water Quality

- Ammonium Ion consumed = Nitrite + Nitrate produced
- Dissolved Oxygen consumed (4.6 O: 1 N)
- Acid produced = Alkalinity consumed; pH lowered in system
- Disinfectant residuals (chlorine, chloramine) consumed by nitrite ion (NO_2^-), a reducing agent formed as an intermediate
- Breakdown of chloramine frees up more ammonium ion, thus enabling further nitrification



The 'New' Thing

sodium chlorite

NaClO_2

H₂O'C

History

1983: Hynes, R. K., and R. Knowles

**Inhibition of Chemoautotrophic Nitrification by Sodium Chlorate and Sodium Chlorite: A Reexamination.
Appl. Environ. Microbiol. 45: 1178-1182**

1999: McGuire, M. J., N. Lieu and M. Pearthree (1999)

Using Chlorite Ion to Control Nitrification. J. AWWA 91:10:52-61

2000: H₂O'C's Willmar, MN distribution study

2001: H₂O'C's Morton, IL filter study



How Does it Work?

Chlorite enters cell, is converted to chlorine dioxide due to acid conditions, resulting in

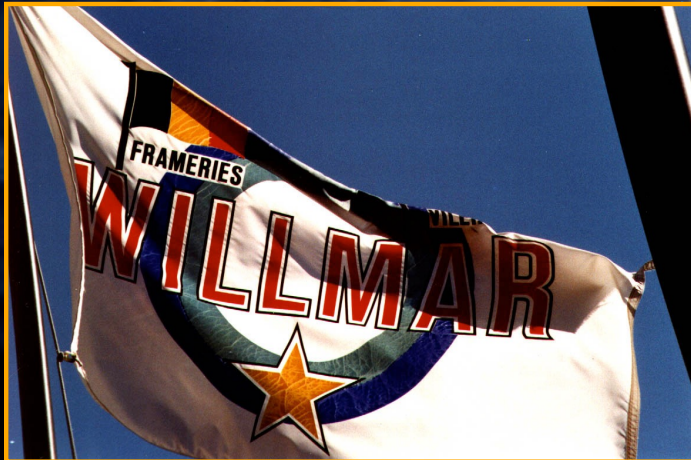
- Alteration of the cell membrane permeability
- Impairment of the cell's enzyme and protein functions
- Nucleic acid damage

0.1 μm

Similar concentrations of chlorite were not found to be toxic to *E. coli* or HPC bacteria

Part One:

Distribution System



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Willmar, MN



- pop. 18,000
- two treatment plants
- breakpoint chlorination to remove ammonium ion and thus inhibit nitrification

Bart Murphy, Water Superintendent

What We Did

1. Fed sodium chlorite directly into finished water

Initial dosage: 0.60 mg ClO_2^- / l

10 gpd added to 3.64 MGD, SW Plant

Dist. Sys. avg. residual: 0.44 mg ClO_2^- / l

2. Monitored distribution system

Dosage was subsequently reduced

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Analyses

Plant:

chlorine, chloramine, chlorite
by DPD method and amperometric titration

Distribution System:

ammonium, nitrite, nitrate ions
temperature, oxygen and pH

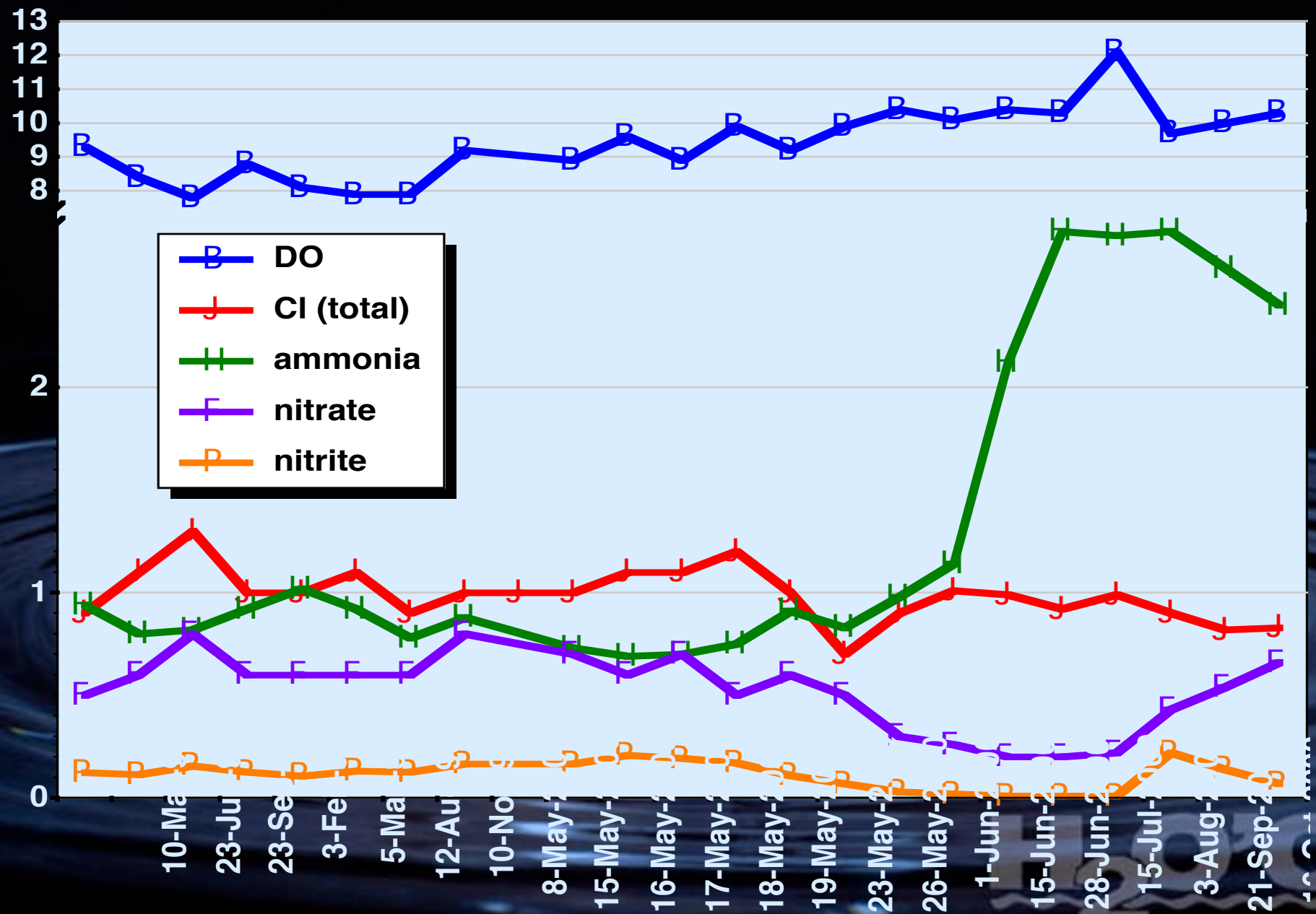
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Chlorite Analysis

- DPD method, amperometric titration were undependable
- samples sent to contract lab



Distribution System Trends



Sodium Chlorite, NaClO_2

- Traditionally used for generation of chlorine dioxide
- 31.25% solution
- \$8 / gallon (\$66/day for both of Willmar's plants)

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Cost Savings

Reduced Chlorine Use: 600 → 80 lbs / day

Cl₂ Cost Savings: \$130 / day

ClO₂⁻ Feed (0.3 mg / l): \$66 / day

(\$12 / million gallons)

On a mass basis, overall chemical usage is significantly reduced



Health & Safety Benefits

Reduced THM formation

Reduced nitrite formation and chlorine and oxygen depletion during distribution

Reduced hazards from the transport, storage and handling of chlorine gas

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Chlorite is a Regulated DBP

USEPA MCL: 1 mg ClO_2^- / l

USEPA MCLG: 0.8 mg ClO_2^- / l

100 mg ClO_2^- / l causes mild anemia and minor suppression of thyroid function in laboratory animals

These effects have been found to be reversible



Part Two:

Filters



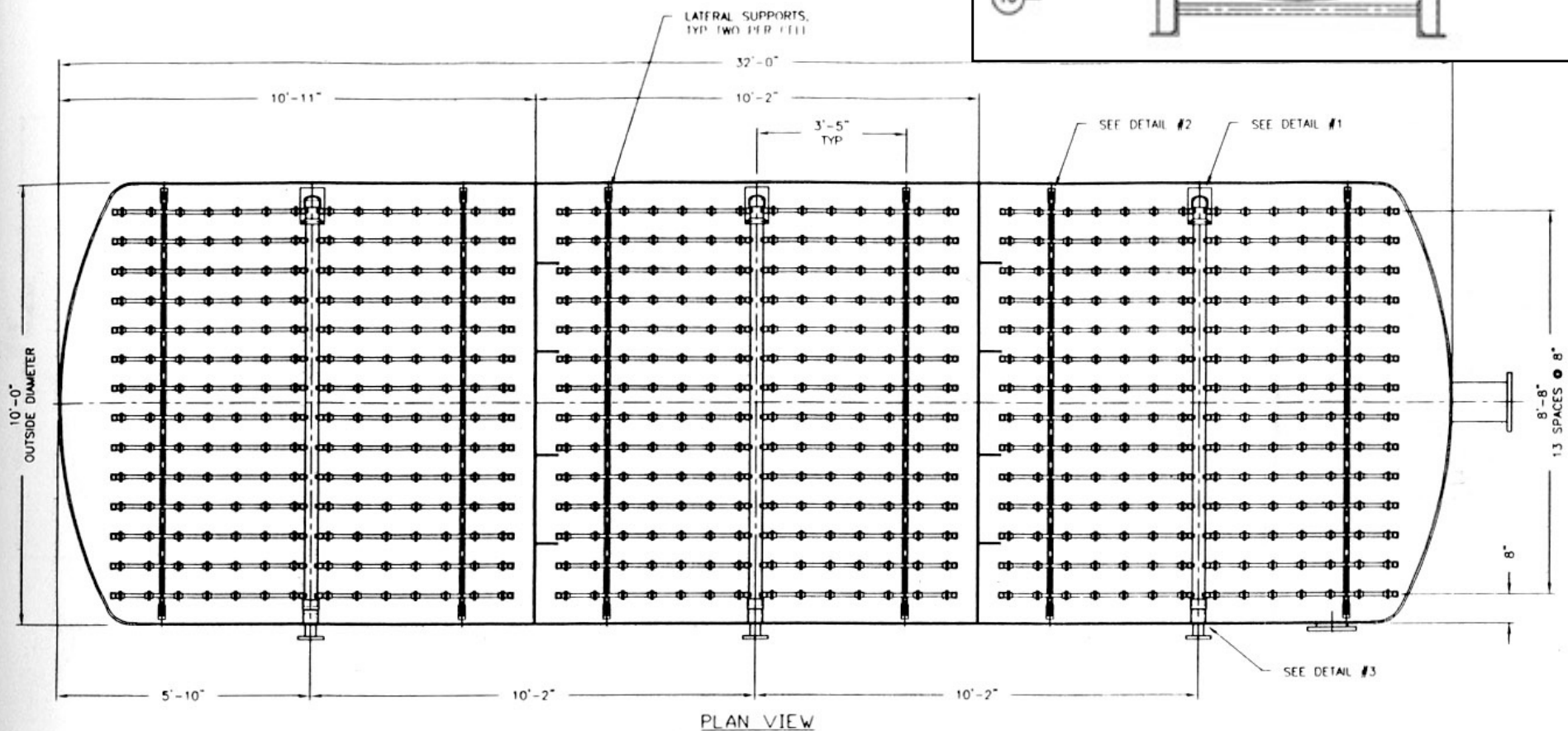
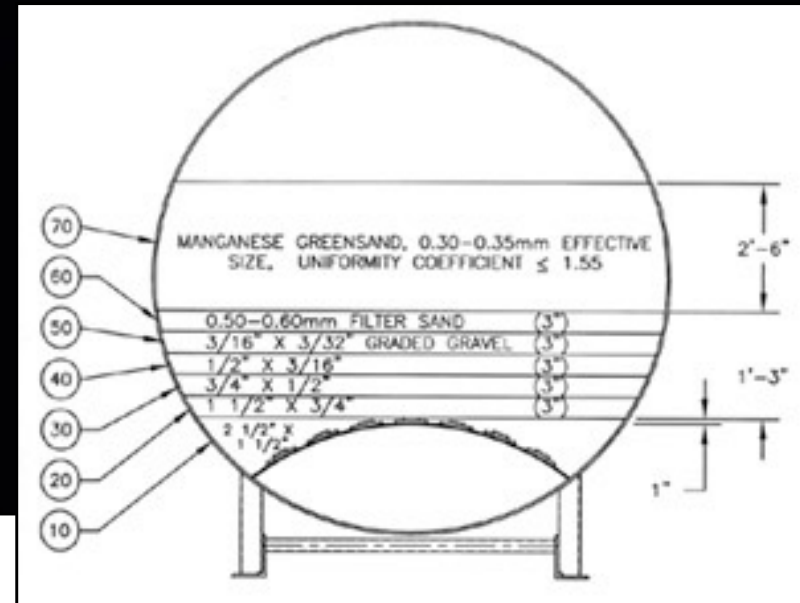
Old Filters and New Filters

DO	Cl	NO ₂ ⁻
9.7	8.9	0.004
—	—	—
1.7	0.7	0.460

DO	Cl	NO ₂ ⁻
9.7	8.9	0.004
—	—	—
9.5	7.5	0.012

Filter Cells

- cells on ends were worse than center cells











Column Studies

Got a better offer

What We Did

1. Ran aerated, chlorinated well water through filters at 18 gpm per cell
2. Fed $0.5 \text{ mg ClO}_2^-/\text{l}$ sodium chlorite directly into of one of the three filter cells (Cell C)
3. Monitored individual filter cell effluents

Dilution and Feed

- Target dosage of $0.5 \text{ mg ClO}_2^-/\text{l}$



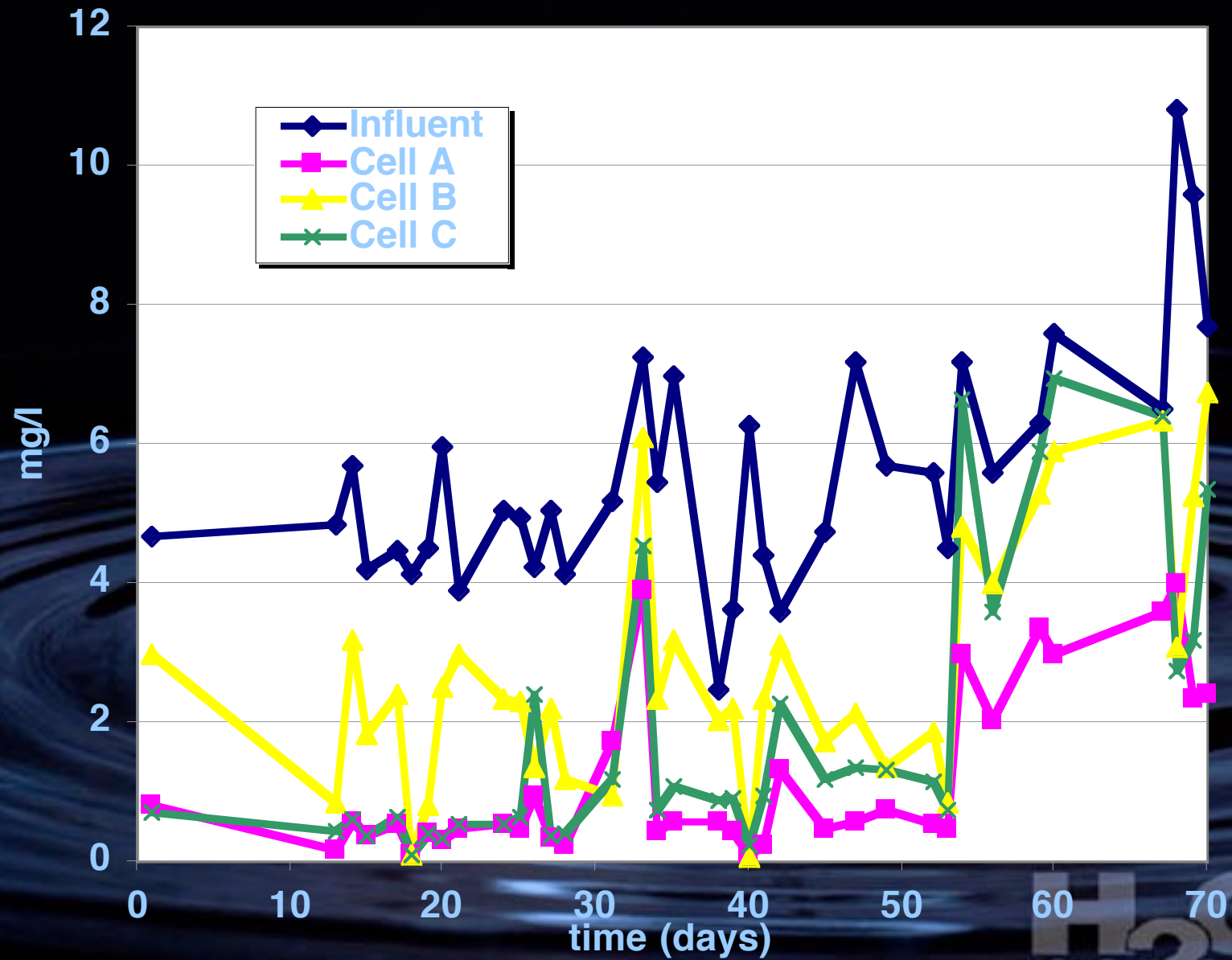


Timeline

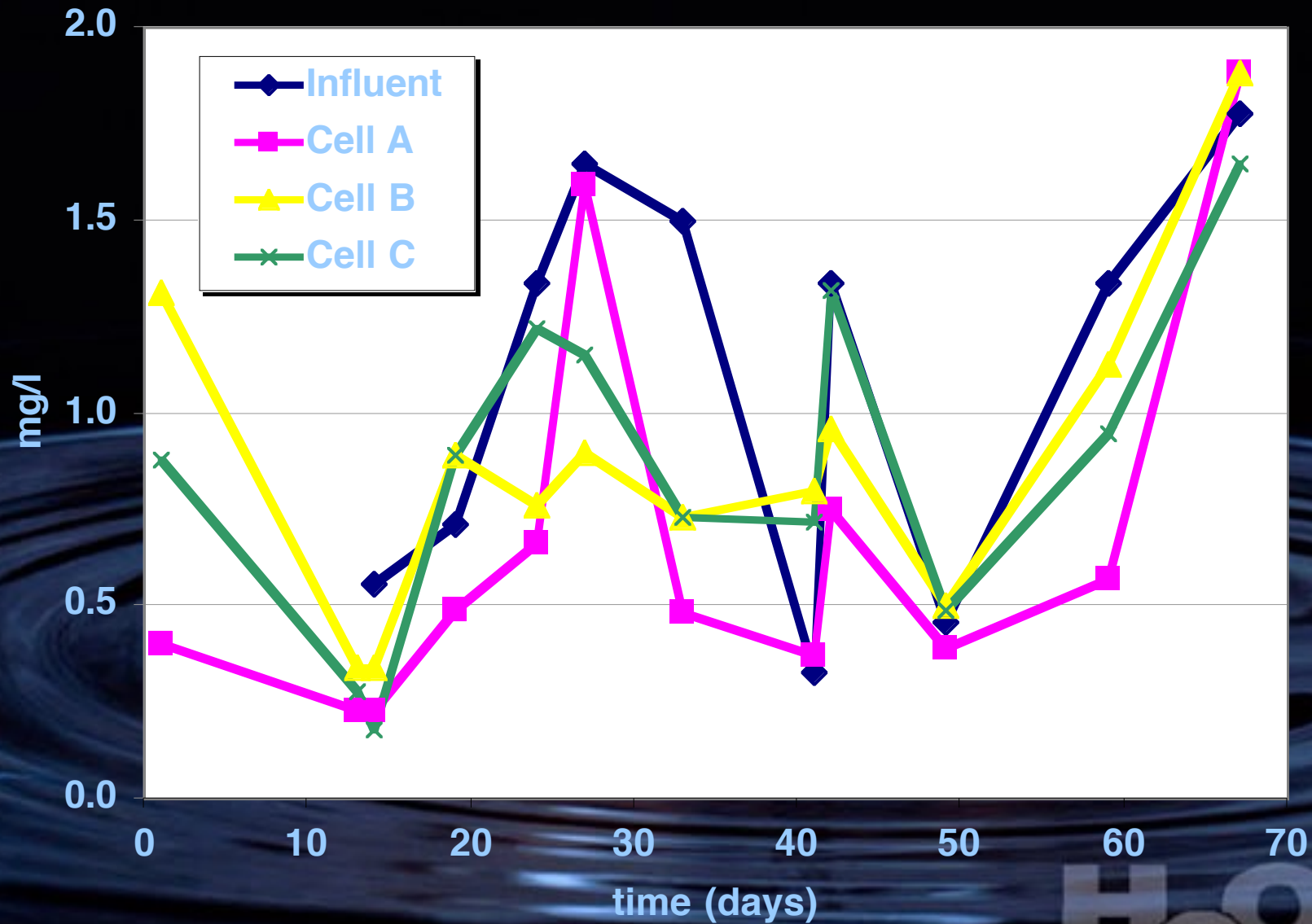
DAY	EVENT
1	beginning of data collection
13	sodium chlorite feed started
19	filter airwashed and backwashed
26	filter airwashed and backwashed
33	filter airwashed and backwashed
39	filter backwashed
40	filter sat idle for several hours
41	36 hours of service on filters
42	filter airwashed and backwashed
50	sodium chlorite feed stopped
53	filter returned to full service
67	started full-strength chlorite feed in Cell A

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Chloramine

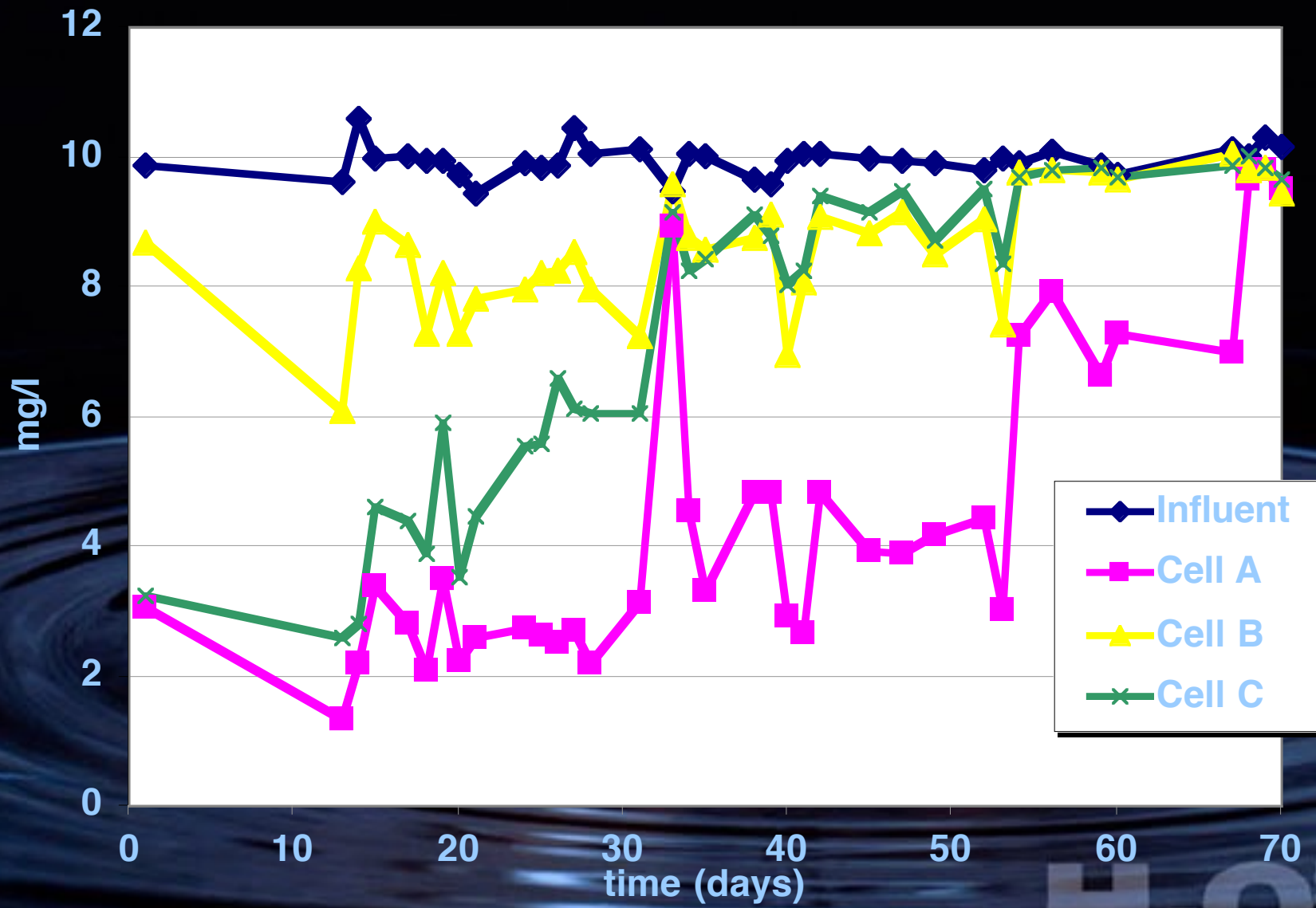


Ammonium Ion



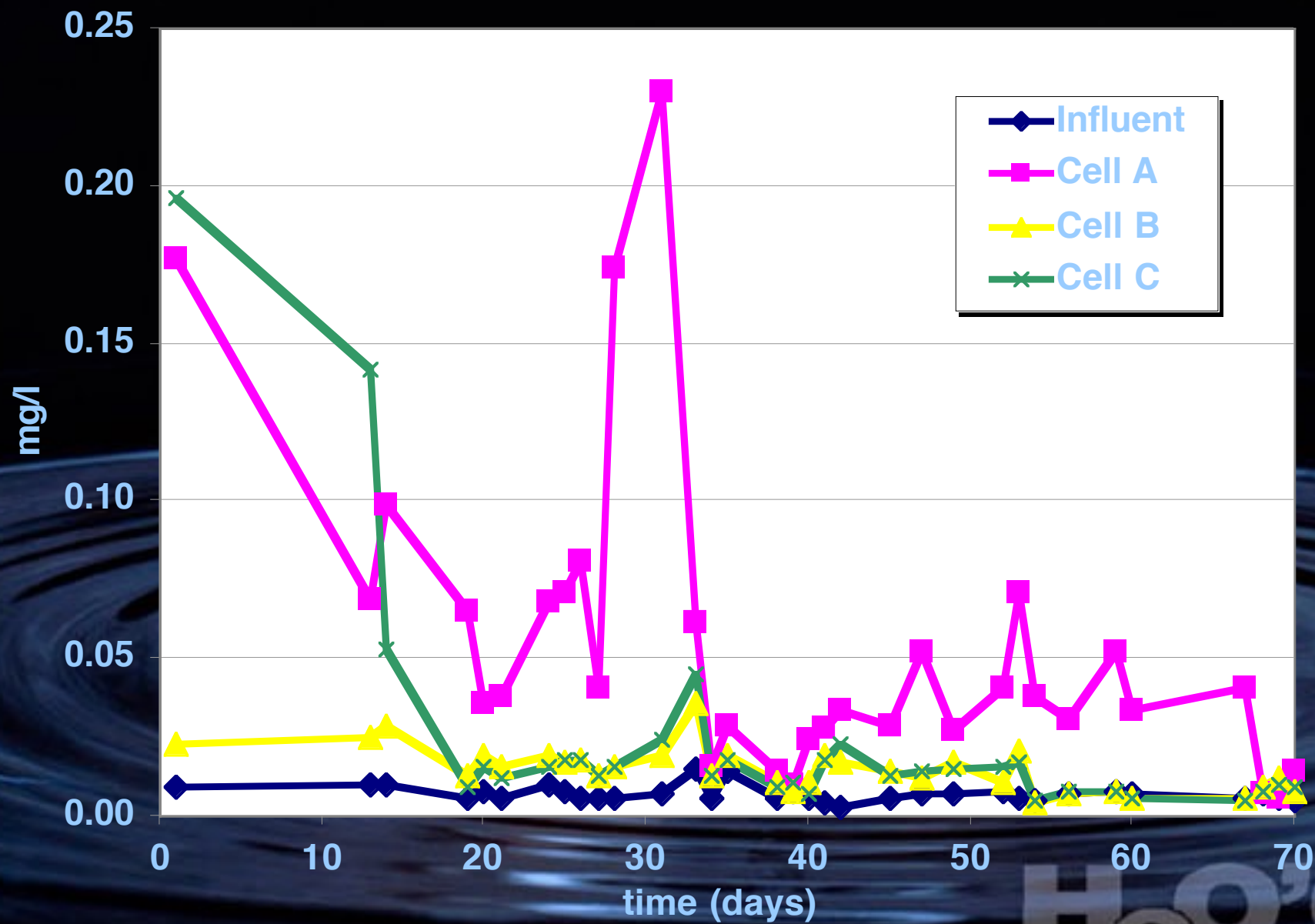
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Dissolved Oxygen



H₂O'C

Nitrite



H₂O'C

Conclusions

- We have demonstrated the effectiveness of sodium chlorite as an inhibitor of nitrification both within the plant and out in the distribution system
- Don't try this at home

Tom O'Connor
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877-22-WATER
www.h2oc.com



Sodium Chlorite, NaClO_2

Technical : 31.25% solution, 25% active

Vulcan Chemicals, Birmingham, AL

55 gal. drums (565 lbs. net) \$450/drum

Water Treatment:

Used for generation of chlorine dioxide

H₂O'C

Materials Safety Data

USEPA MCL: 1 mg ClO_2^- / l

- 100 mg ClO_2^- / l causes mild anemia and minor suppression of thyroid function in laboratory animals

Effects found to be reversible



NaClO₂ Dosage, Cost

Initial target dosage of 0.6 mg ClO₂- / l

10 gpd added to 3.64 MGD (Southwest Plant)

Distribution system residuals 0.44 mg ClO₂- / l (USEPA Method 300.0)

Dosage was cut in half. At a chemical cost of \$8.22 per gallon, the halved dosage would cost approximately \$41 per day at the SW Plant and \$25 per day at the 2 MGD NE Plant.

