Performance of GAC Filter-Adsorbers for Herbicide and DBP Control at Higginsville, MO

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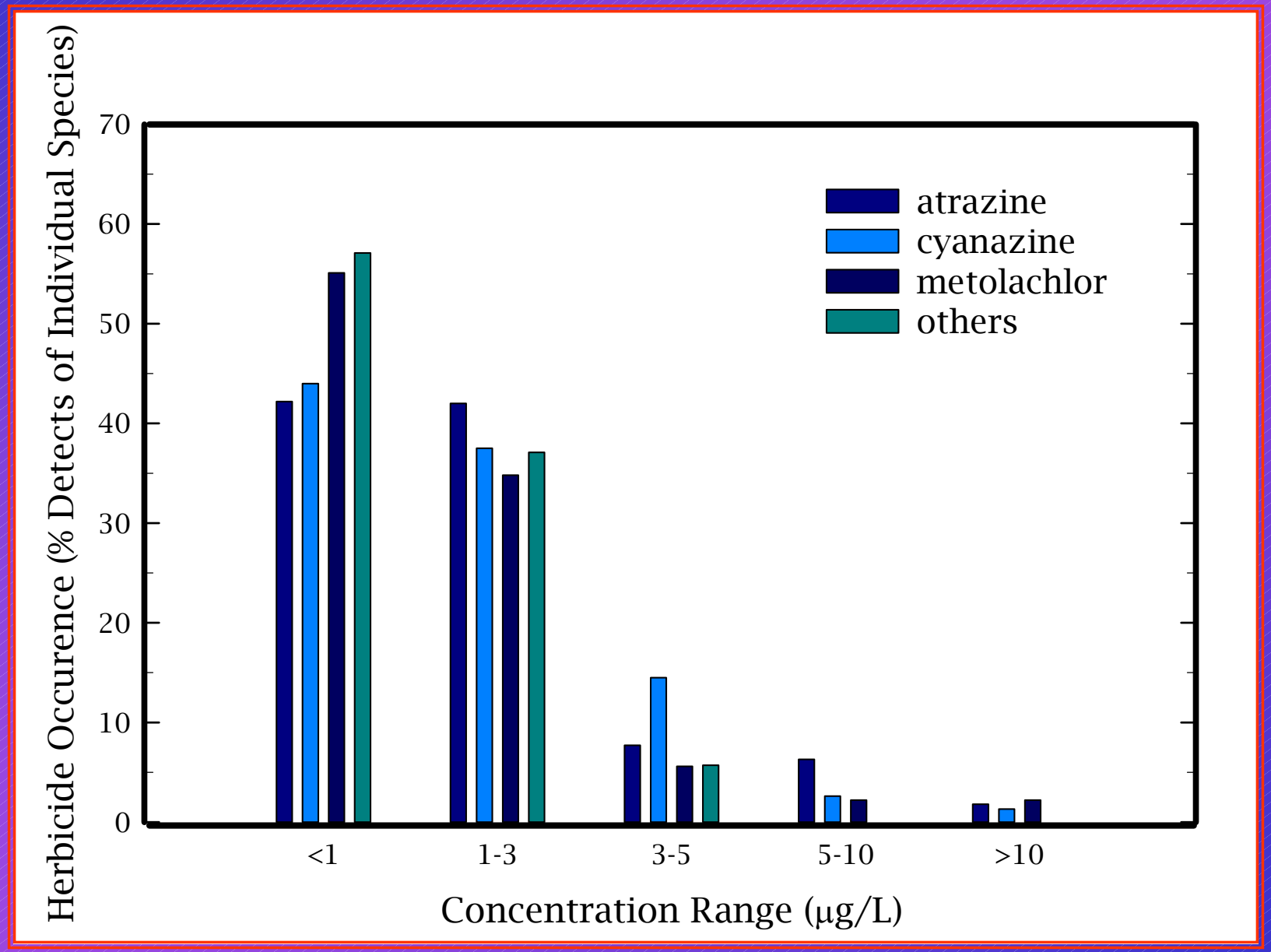
Background

- Atrazine can be detected in most drinking water supplies throughout the northern agricultural region of Missouri and the Midwest.
- Drinking water MCL = 3 µg/L.
- Since 1994, herbicide-impacted water plants have controlled atrazine levels by treatment with powdered activated carbon (PAC) or sought alternative water sources.
- Some plants in Illinois and Iowa have used granular activated carbon (GAC) for atrazine control. No plants in Missouri were using GAC prior to August, 1996, when Higginsville installed GAC into two of its four filters.

Atrazine

- Atrazine enters the water supply via agricultural runoff. Excessive runoff levels (10 to 500 µg/L) occur when atrazine is over-applied, used on highly erodible land, or when an untimely, intense rain follows application.
- Additionally, the runoff may carry other herbicides (cyanazine, metolachlor) and atrazine breakdown products.
- In lakes, the degradation of atrazine is slow. Thus, high levels may persist over time unless the lake is "flushed" with inflow not containing atrazine.

Herbicide Levels in Missouri Surface Water Systems



Overview

Higginsville Water Treatment Plant

* Surface water system, agricultural drainage
* 50-year old lake, 12-year old treatment facility
* ~ 1 MGD production, 10 to 12 hr/d production

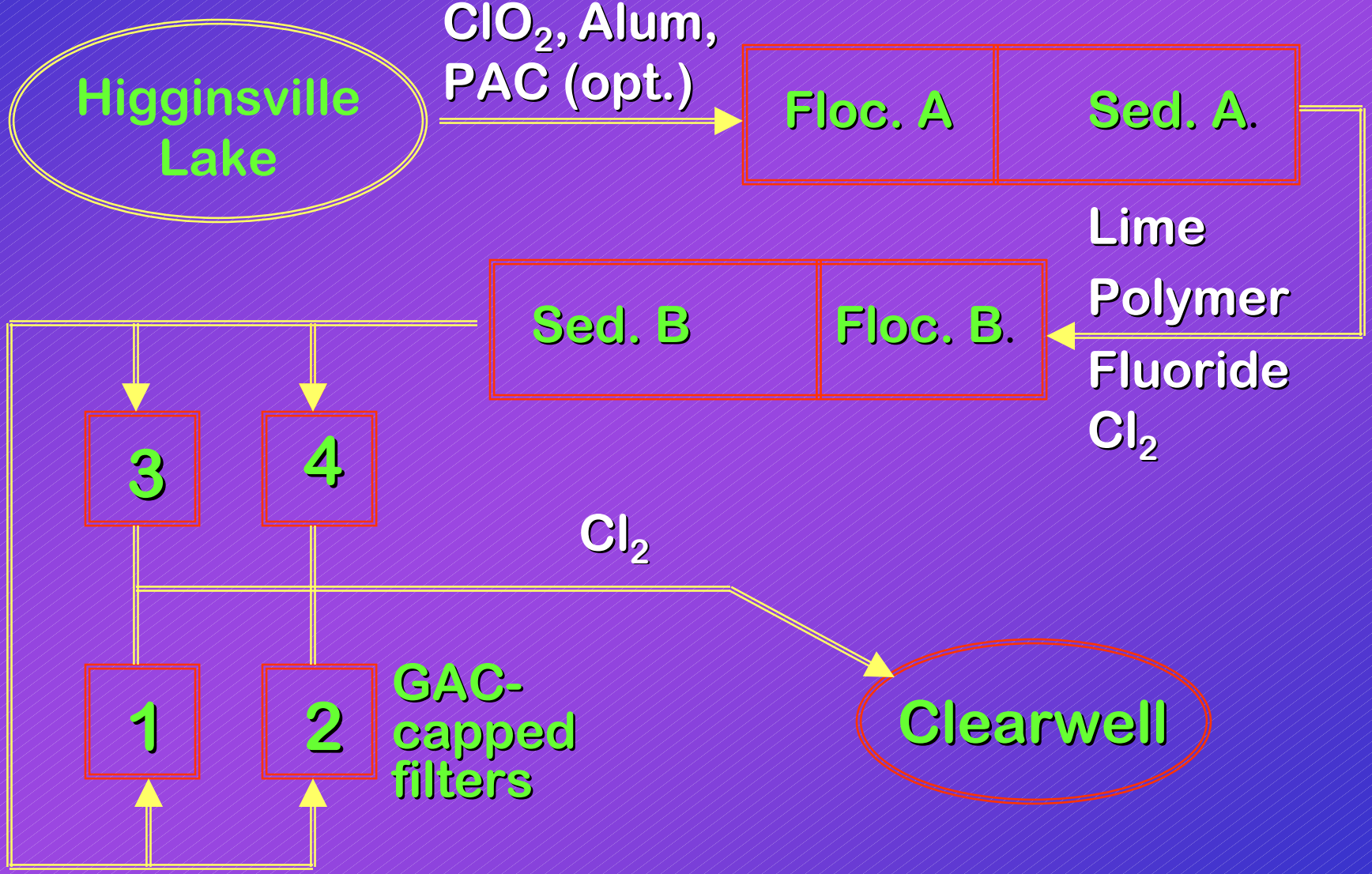
Historical Atrazine and T&O Problems

* Notice of violation for atrazine MCL, 1994
* Feed PAC from 1995 to 1996, 10 to 30 mg/L
* Convert Filters 3&4 to GAC caps (24") in Aug, 96
* Convert Filters 1&2 to GAC caps in March, 99

In-plant Operational Studies

* Particle counting study (1997)
* Monitoring of UV_{254} absorbance
* Monitoring of total triazines
* Investigations of ammonia and T&O episodes

Higginsville Treatment Process



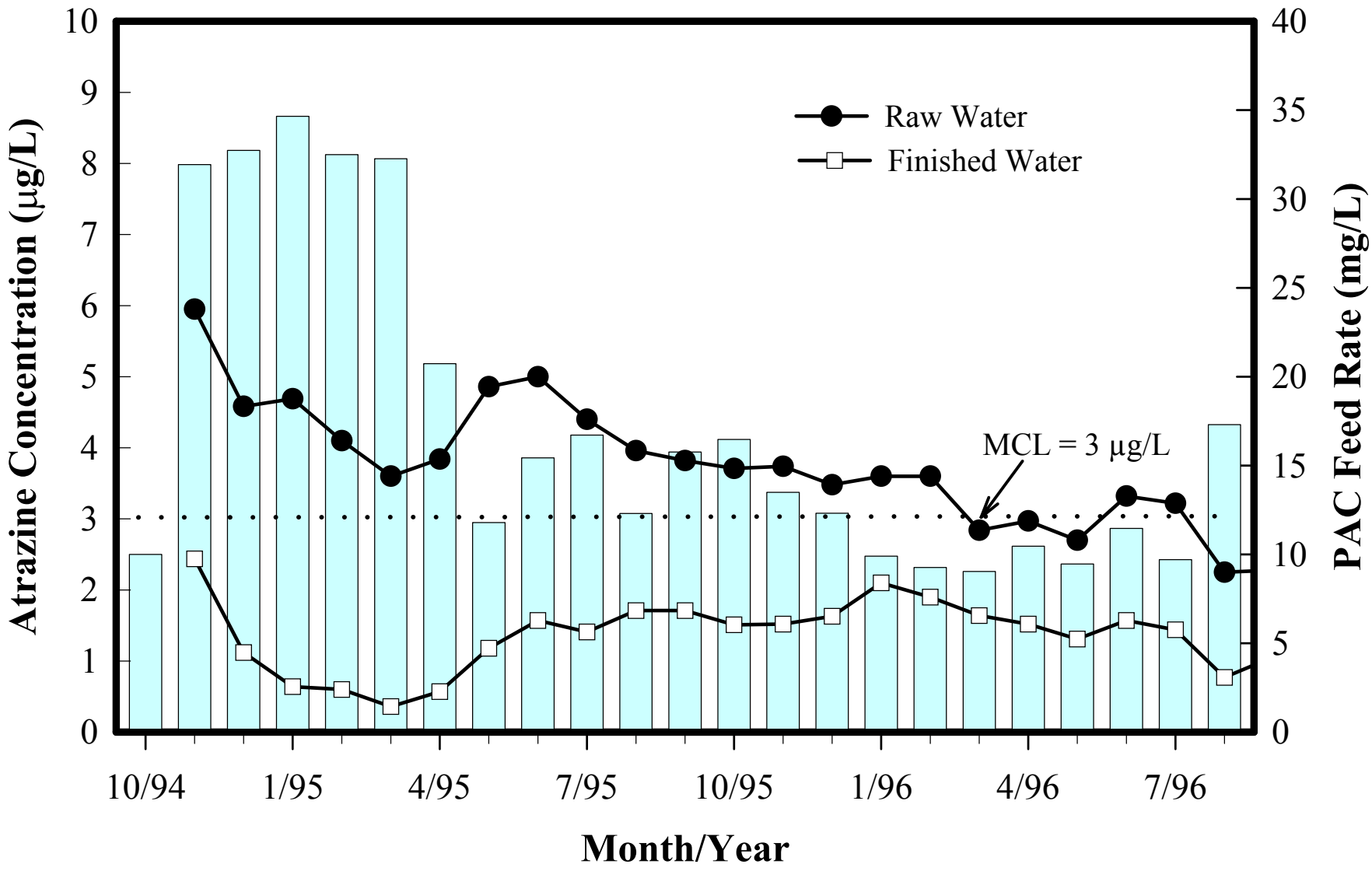
Higginsville Lake Water Quality

Parameter	Units	Range	Mean
Production	Mgd	0.72 – 1.07	0.85
Temperature	°F	45 - 79	63
pH	pH units	7.19 – 9.27	8.14
Total Alkalinity	mg-$CaCO_3$/L	56 - 116	89
Hardness	mg-$CaCO_3$/L	84 - 189	129
Fluoride	mg/L	0.17 - 0.54	0.32
Turbidity	NTU	2.4 - 96	18
Ammonia	mg/L	0.01-0.79	0.13
TOC	mg/L	4 - 17	6
UV_{254}	cm^{-1}	0.08 - 0.3	0.11

PAC Application Considerations

- PAC feeding is a messy operation and requires operator labor. Potentially hazardous (respiratory, explosive).
- Storage and feeding equipment is required.
- Slurry introduction, contacting, and suspension time affect the performance (relatively inefficient). Complete removal of herbicides will not be attained.
- The PAC feed rate may be adjusted according to water quality; thus, PAC usage and costs can be minimized.
- A large amount of black sludge must be disposed of.

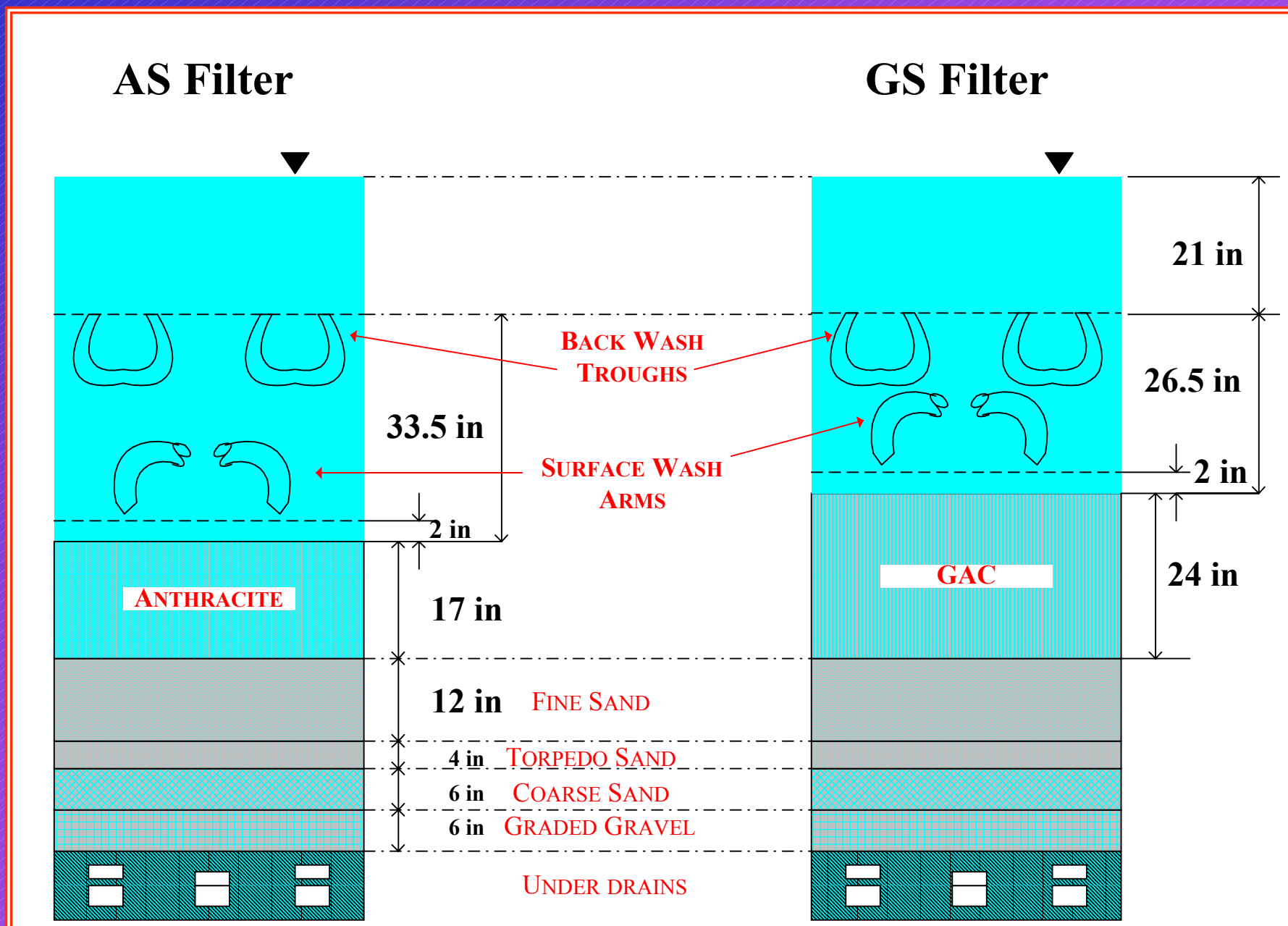
PAC Usage for Atrazine Removal at Higginsville



Sludge Dewatering Basin with PAC

GAC Application Considerations

- Useful for T&O control, SOC (herbicides) removal, and partial removal of natural organic matter (THM precursors).
- GAC will scavenge free and combined chlorine. Thus, minimal chlorine should be applied ahead of the GAC.
- Backwash rates may need to be adjusted.
- Biological growth in bed will occur:
  - Beneficial contribution to removal of N & C.
  - May shed bacteria, but not known to grow pathogens.
- Exhausted GAC must be removed for regeneration and replaced. Off-site regeneration is the norm for all but the largest systems.

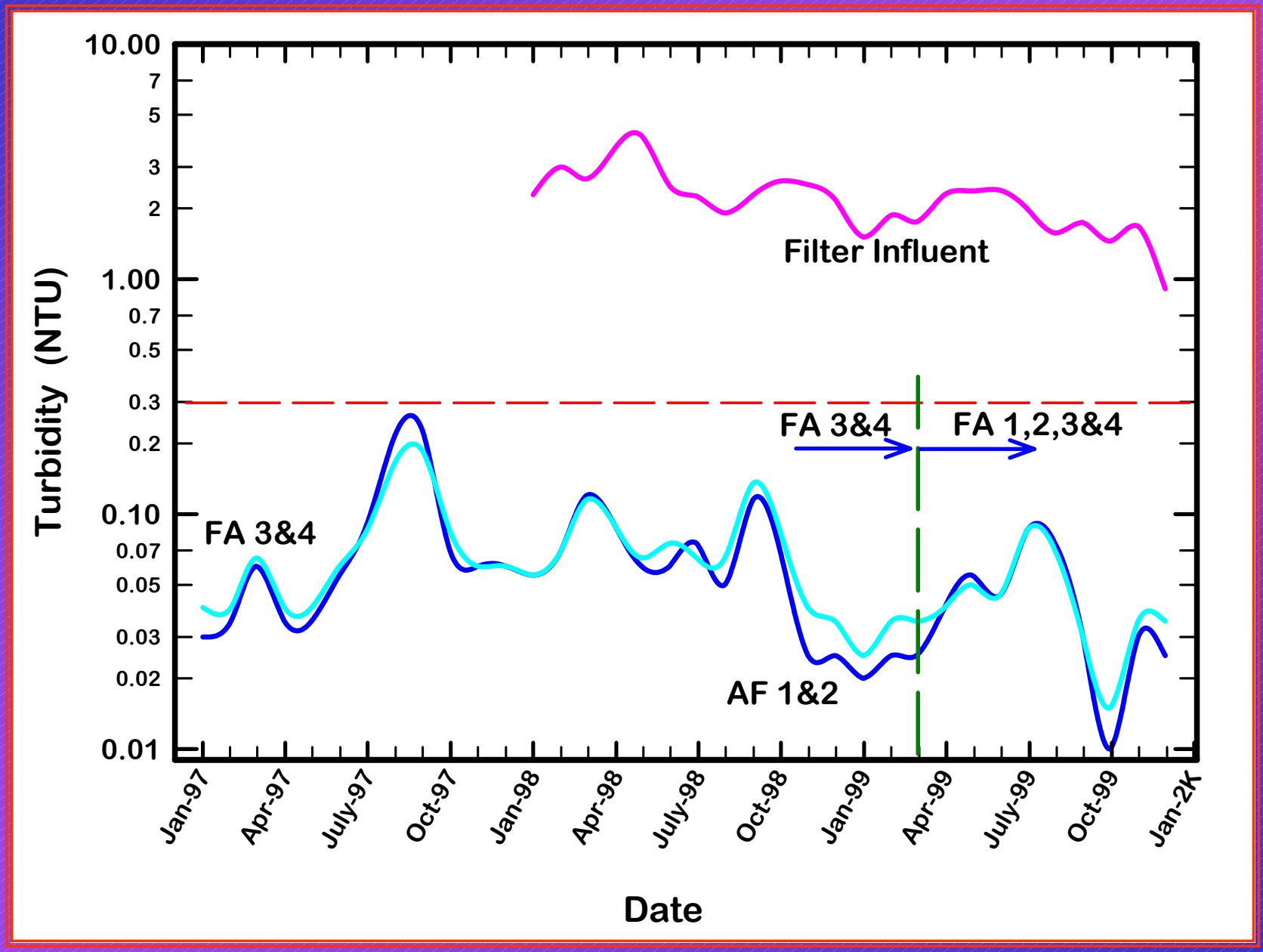

AS Filter
GS Filter
BACK WASH TROUGHS
SURFACE WASH ARMS
33.5 in
2 in
ANTHRACITE
17 in
12 in
FINE SAND
4 in
TORPEDO SAND
6 in
COARSE SAND
6 in
GRADED GRAVEL
UNDER DRAINS
21 in
26.5 in
2 in
GAC
24 in

GAC Bulk Packs Awaiting Installation

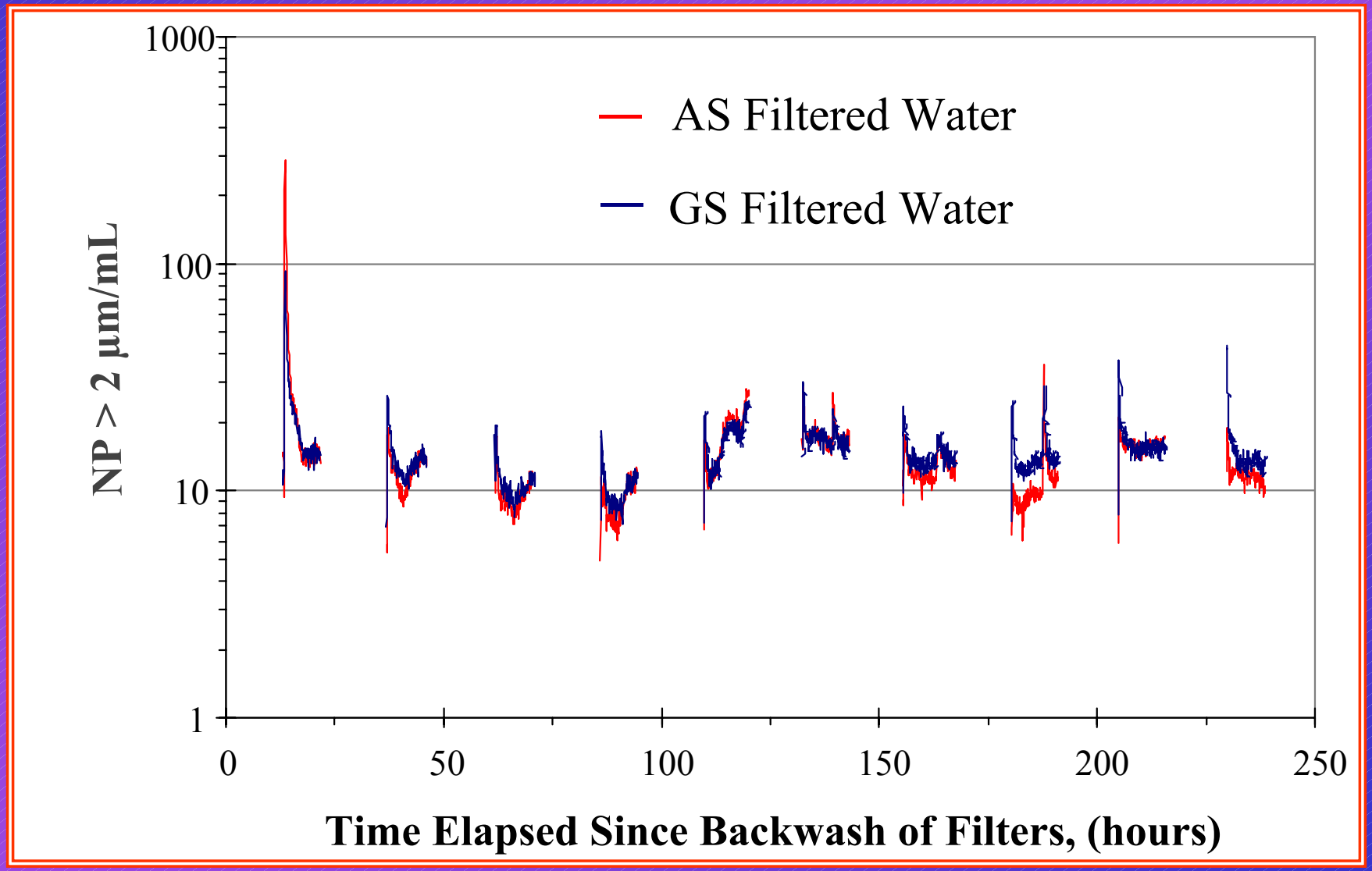
One-step Anthracite Transfer and Dewatering Equipment

Slurrying the GAC into the Filter Well

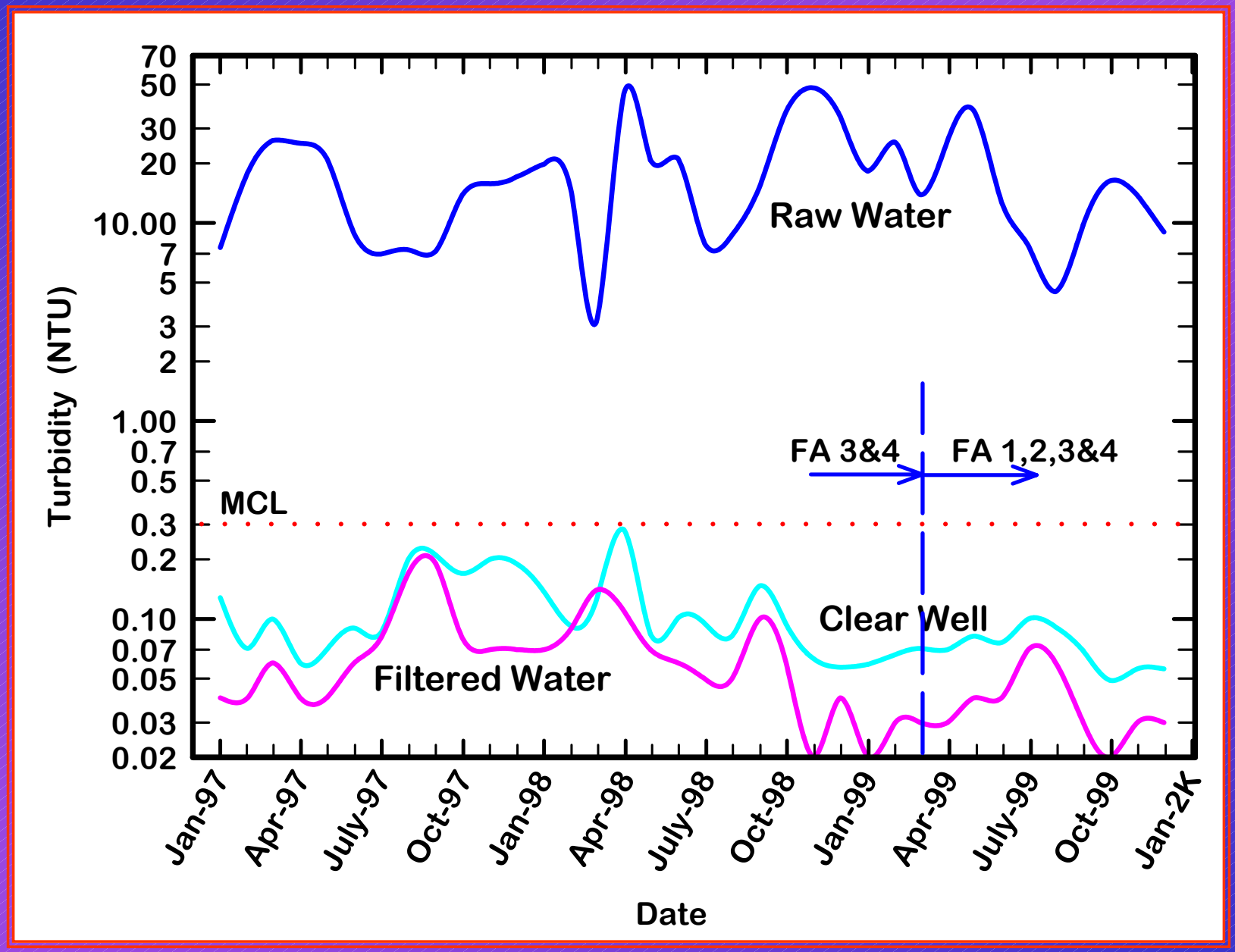
Comparison of Anthracite and GAC Cap



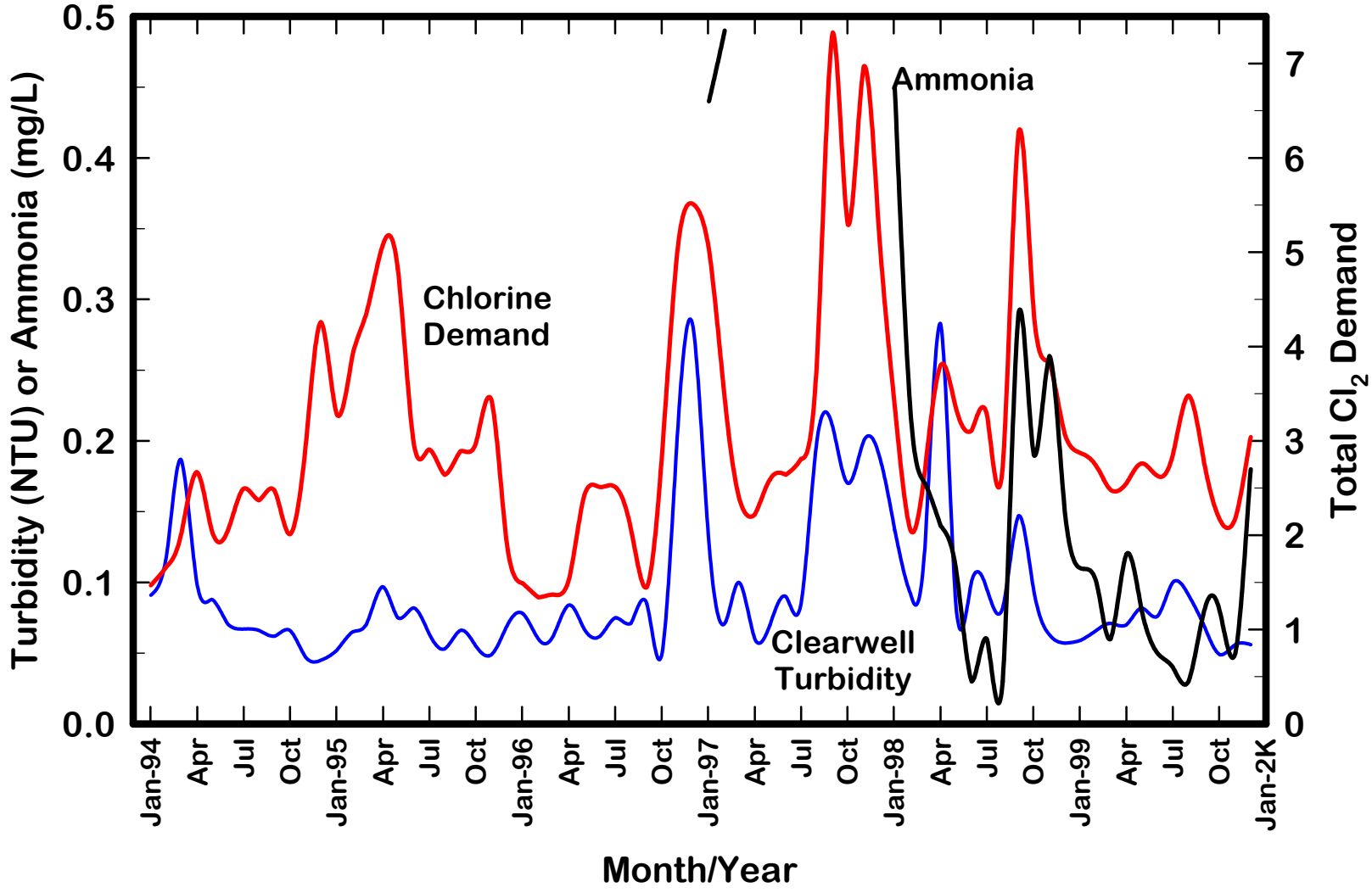
Comparison of Particle Counts

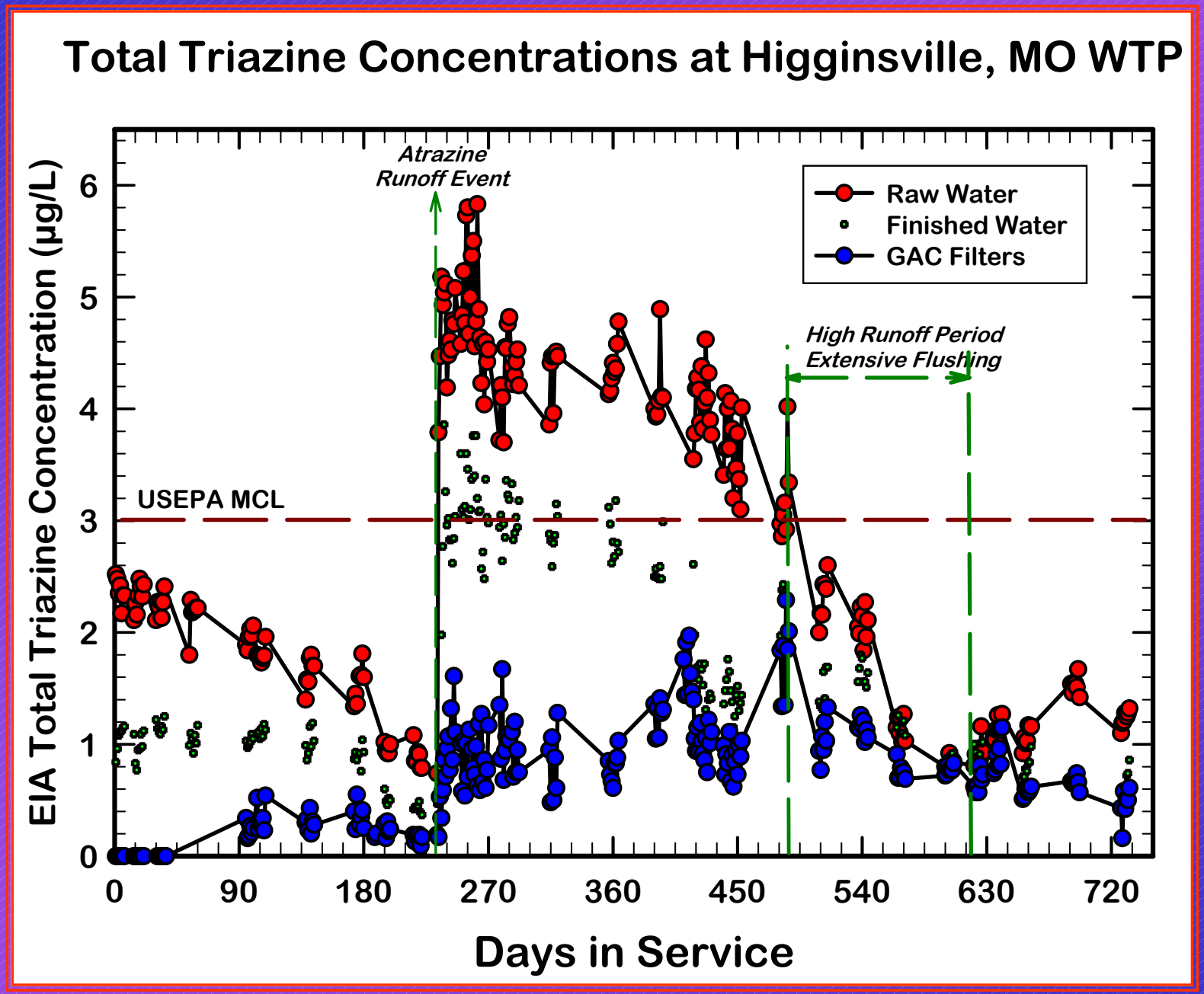


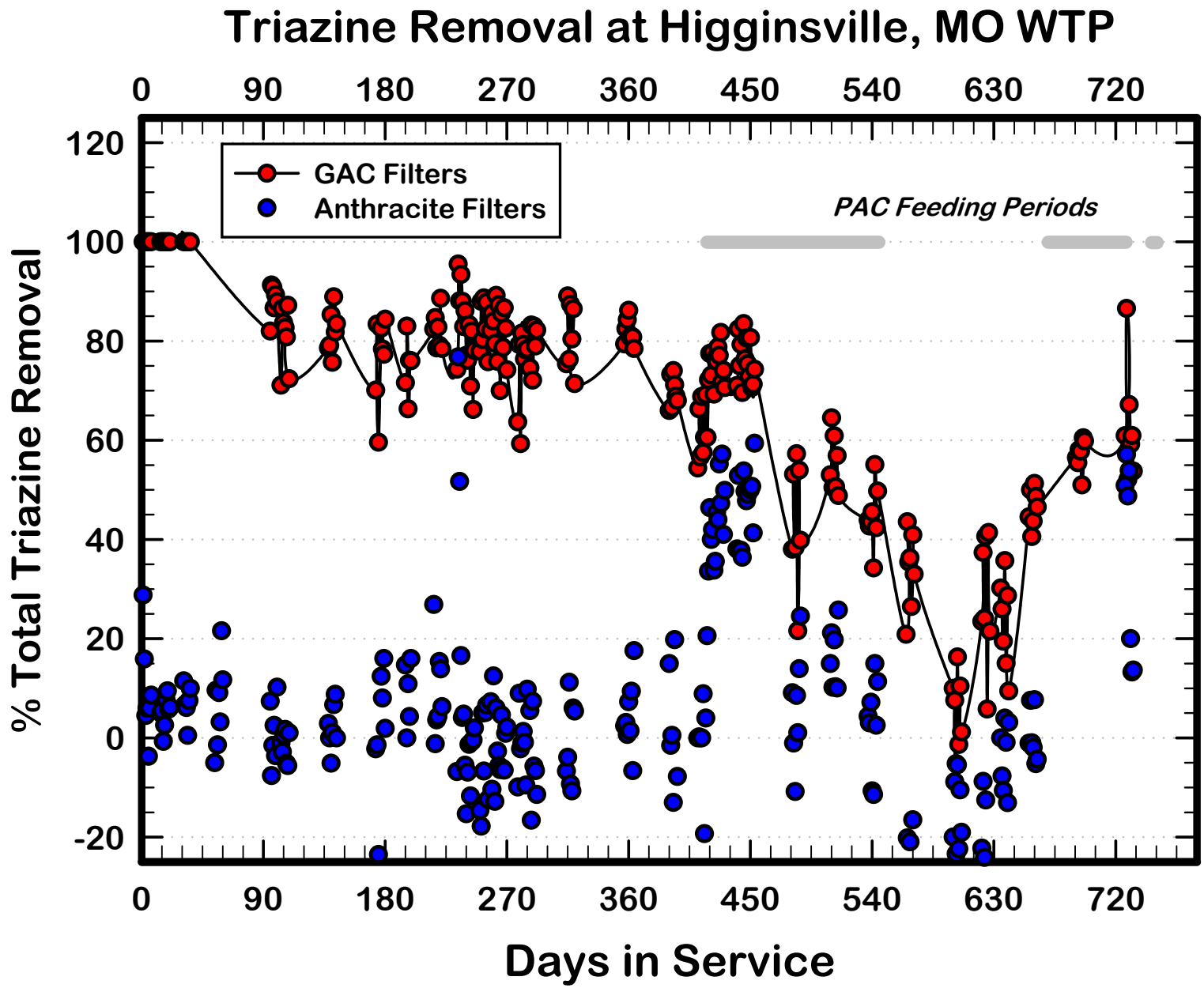
Turbidity Reduction and Return

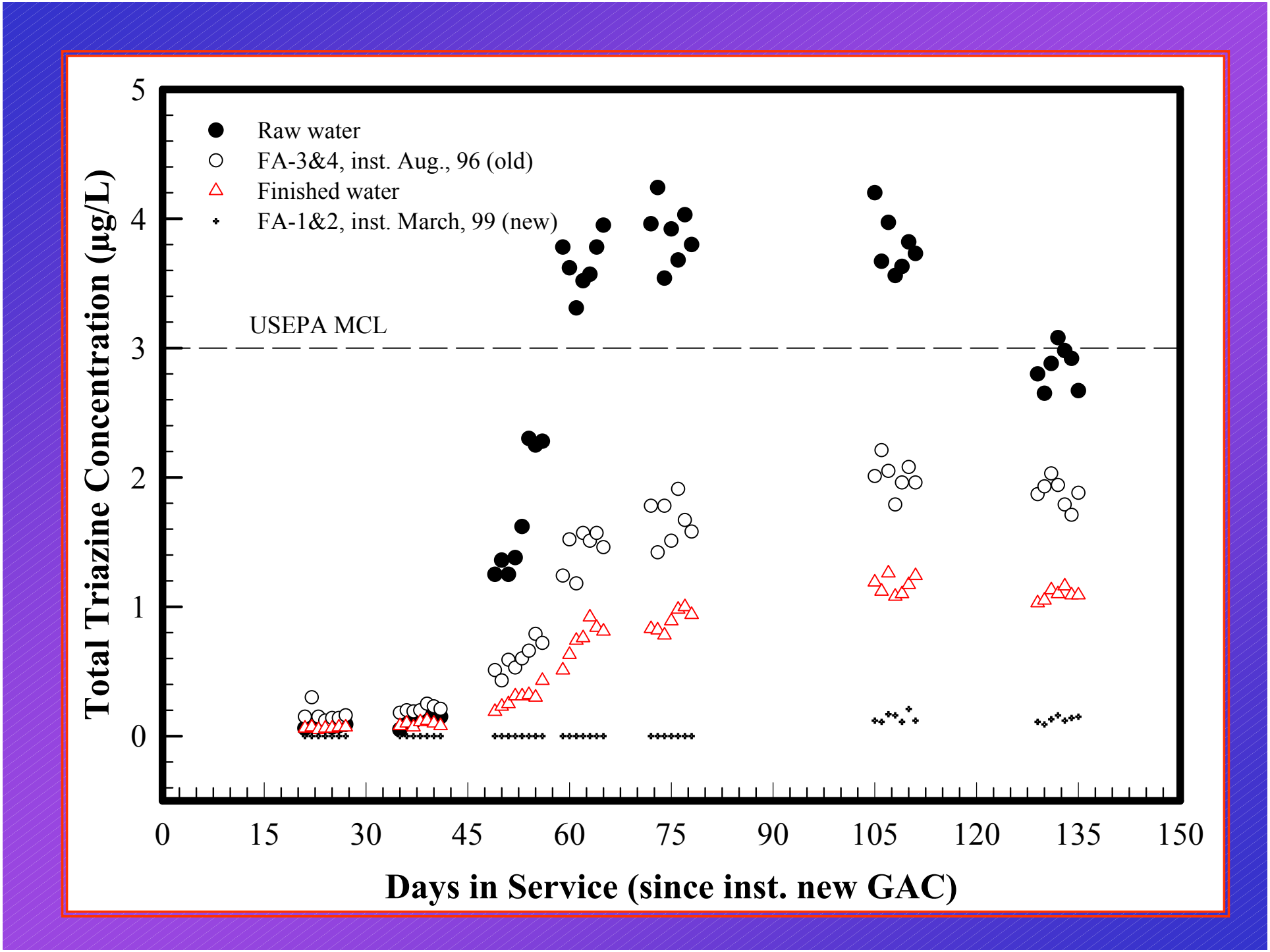


Correlation of Clearwell Turbidity, Raw Water Ammonia, and Overall Chlorine Demand




Total Triazine Concentrations at Higginsville, MO WTP
EIA Total Triazine Concentration (µg/L)
Days in Service
Atrazine
Runoff Event
High Runoff Period
Extensive Flushing
USEPA MCL
Raw Water
Finished Water
GAC Filters
0
1
2
3
4
5
6
0
90
180
270
360
450
540
630
720


Triazine Removal at Higginsville, MO WTP
0
90
180
270
360
450
540
630
720
120
100
80
60
40
20
0
-20
% Total Triazine Removal
GAC Filters
Anthracite Filters
PAC Feeding Periods
Days in Service


Raw water
FA-3&4, inst. Aug., 96 (old)
Finished water
FA-1&2, inst. March, 99 (new)
USEPA MCL
Total Triazine Concentration (µg/L)
Days in Service (since inst. new GAC)
0
1
2
3
4
5
0
15
30
45
60
75
90
105
120
135
150

Natural Organic Matter (NOM)

NOM is produced from decaying vegetation and leaching of soil humins, and is typically composed of humic substances, fulvic acids, and humic acids.

NOM is often measured as TOC or DOC and UV_{254} is also a useful measure.

TOC concentrations in Midwest surface waters typically range from 3 to 10 mg/L.

Formation of DBP's During Chlorination

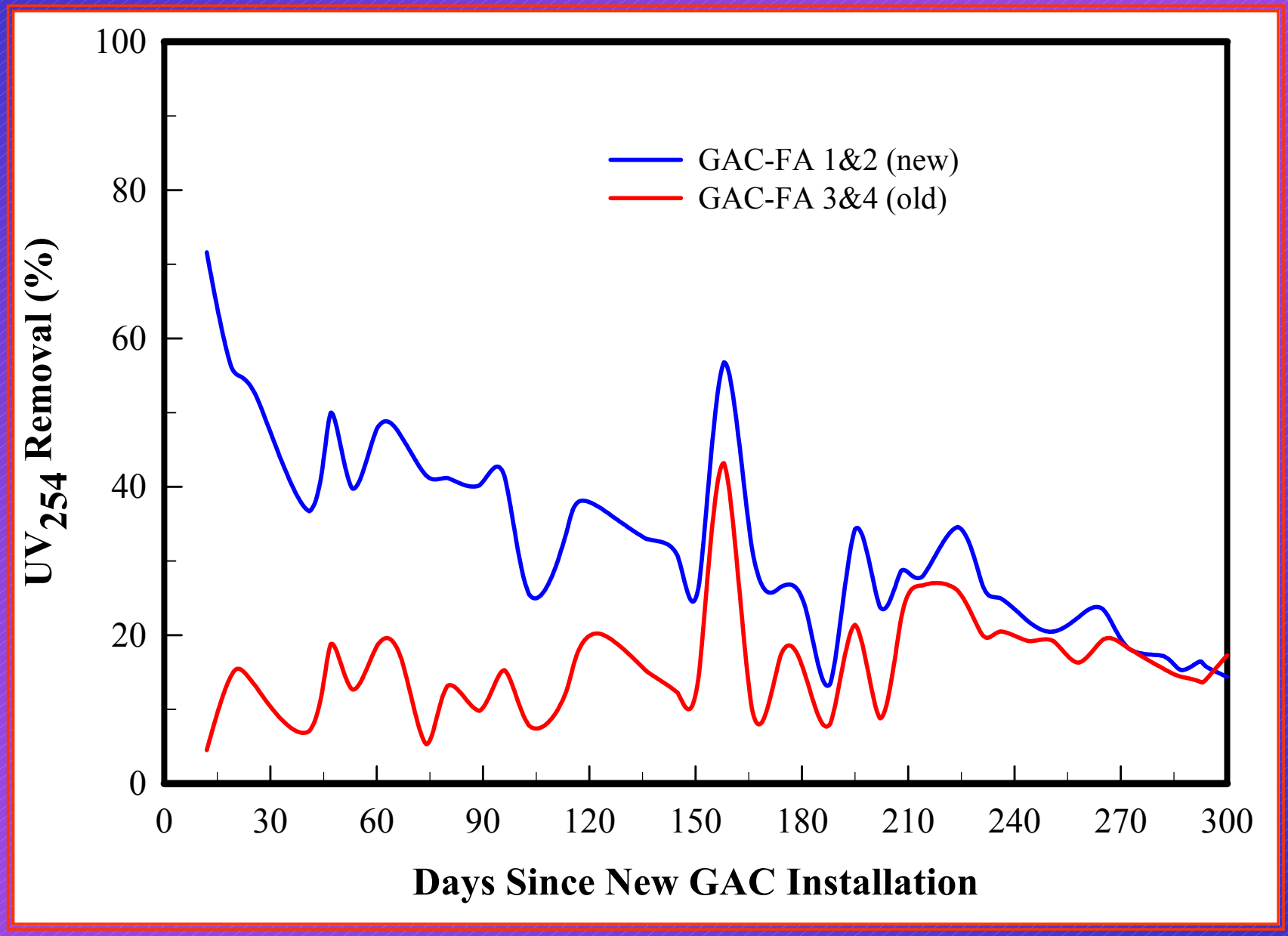
$$Cl_2 + H_2O \Leftrightarrow HOCl + HCl$$

$$HOCl + Br^- \Leftrightarrow HOBr + Cl^-$$

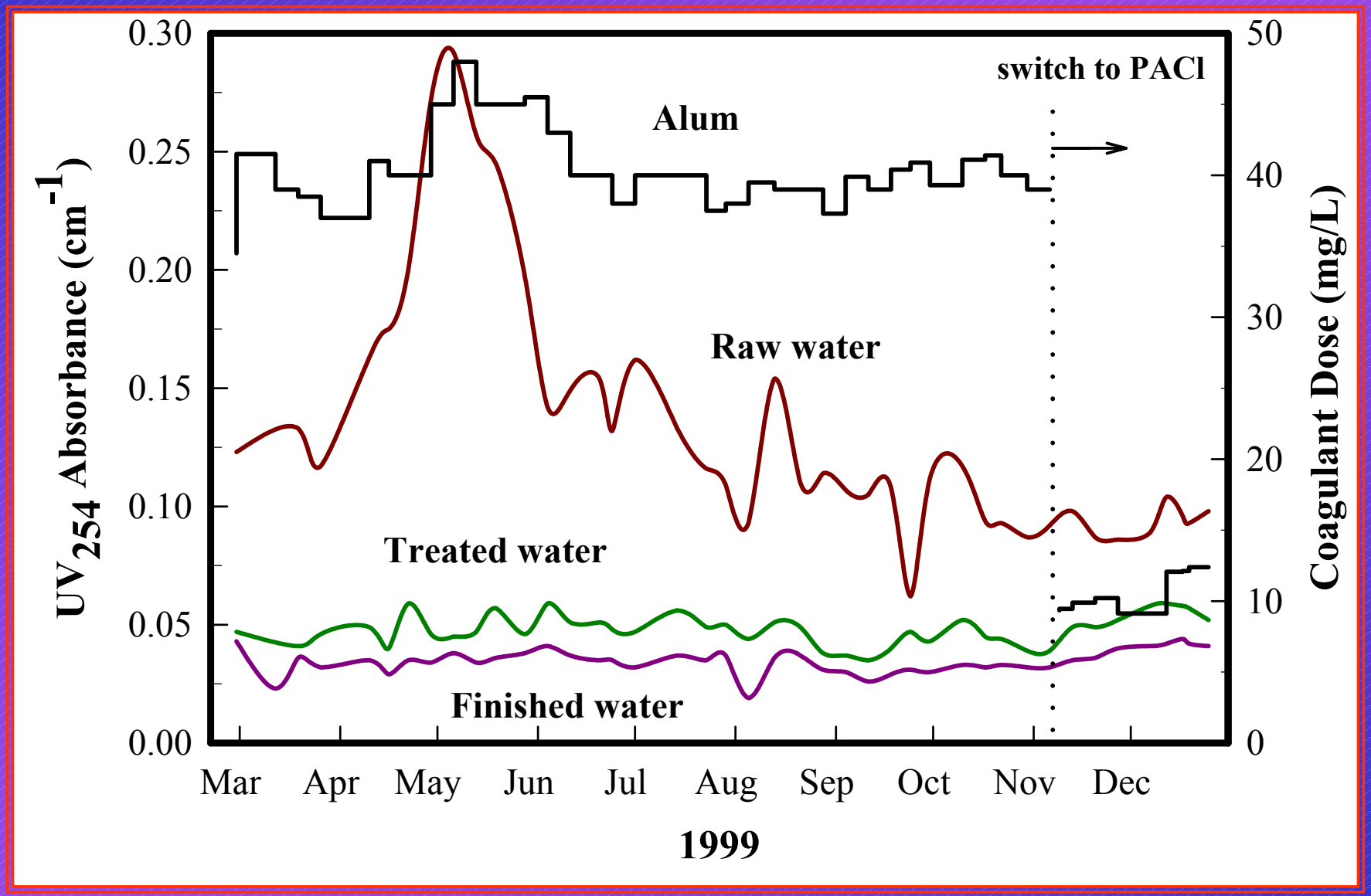
$$HOCl + HOBr + NOM \Rightarrow THM + HHA + RX???$$

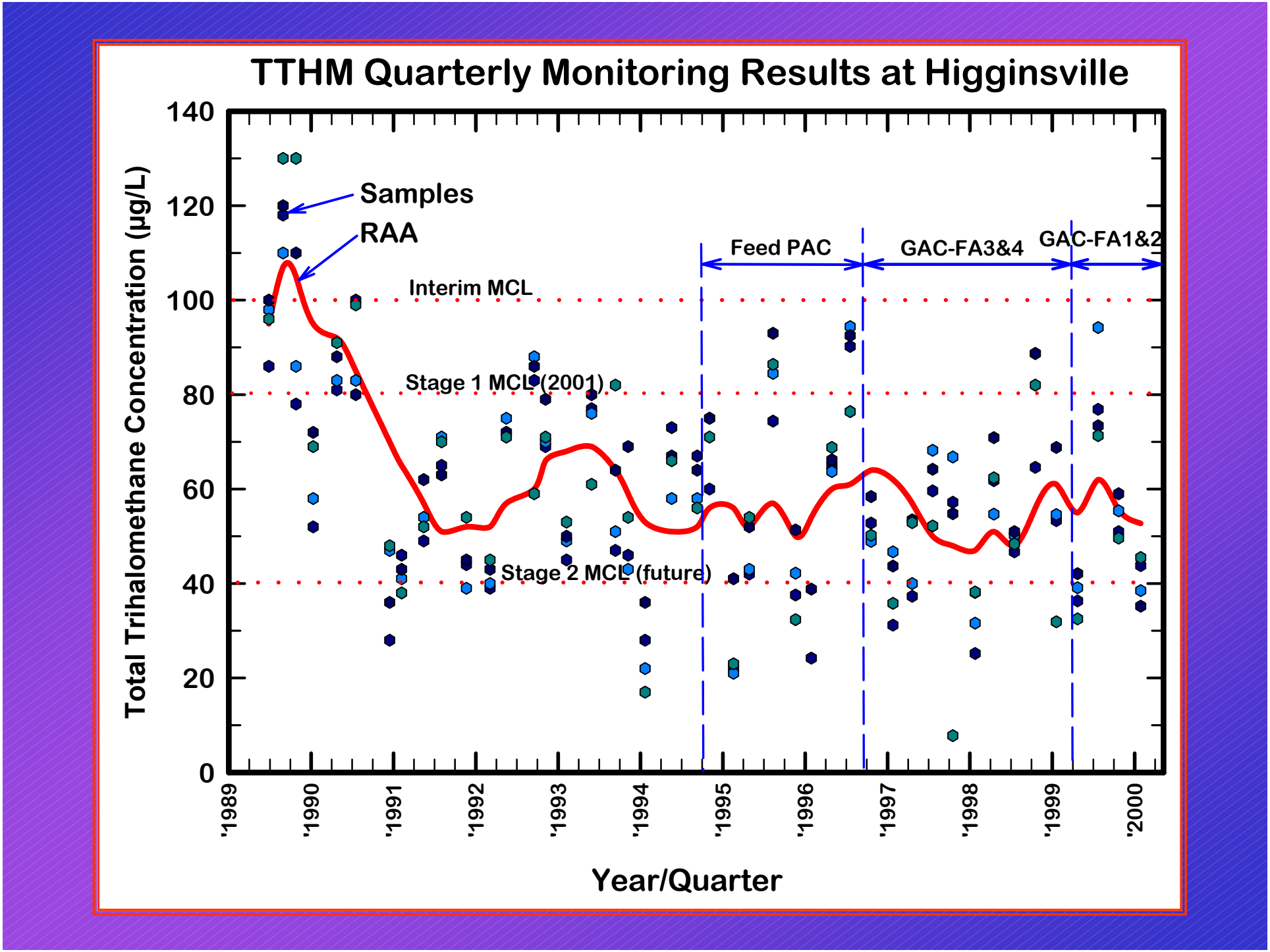
(toxins and carcinogens)

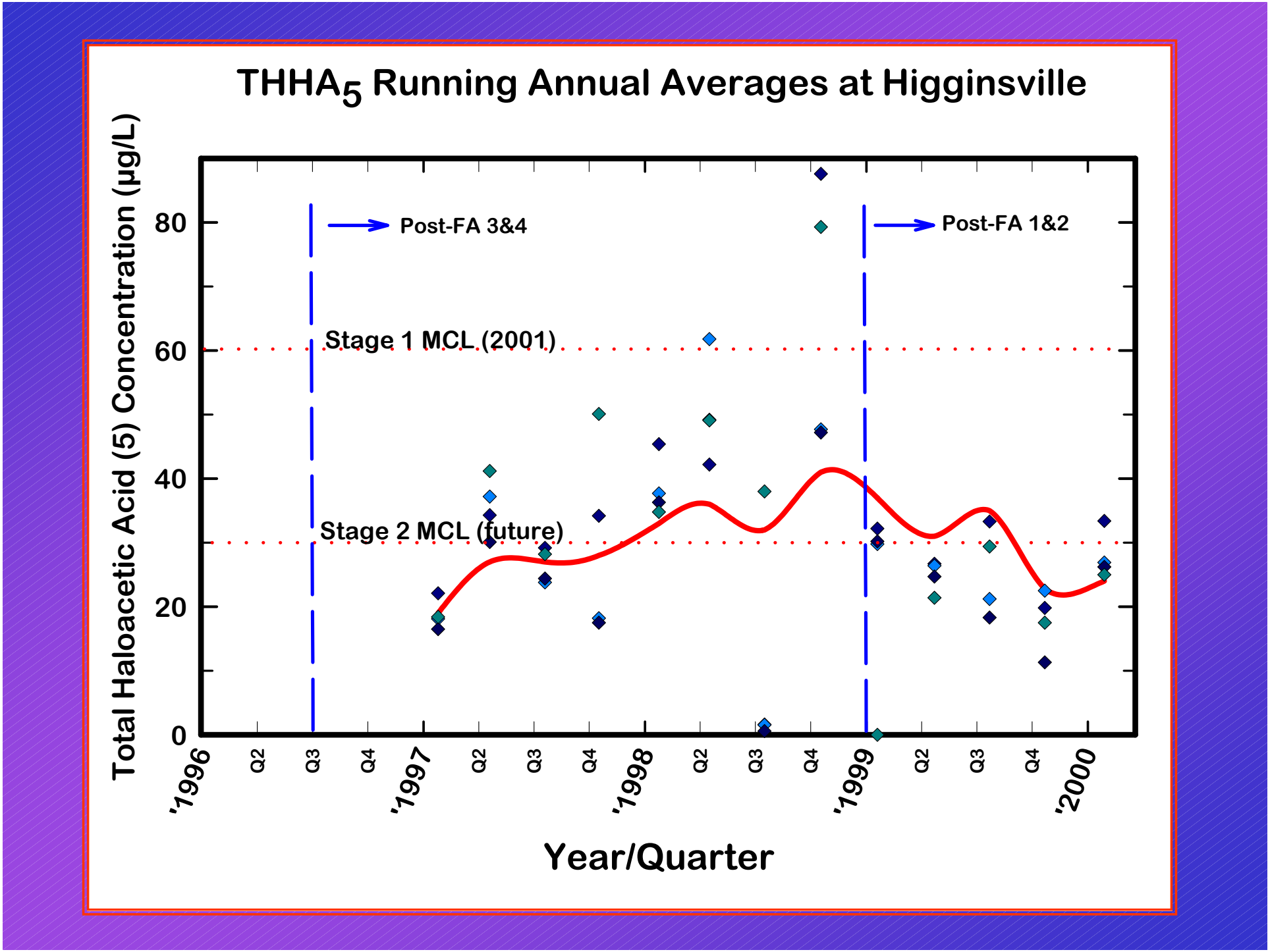
Removal of NOM by GAC Filter-Adsorbers



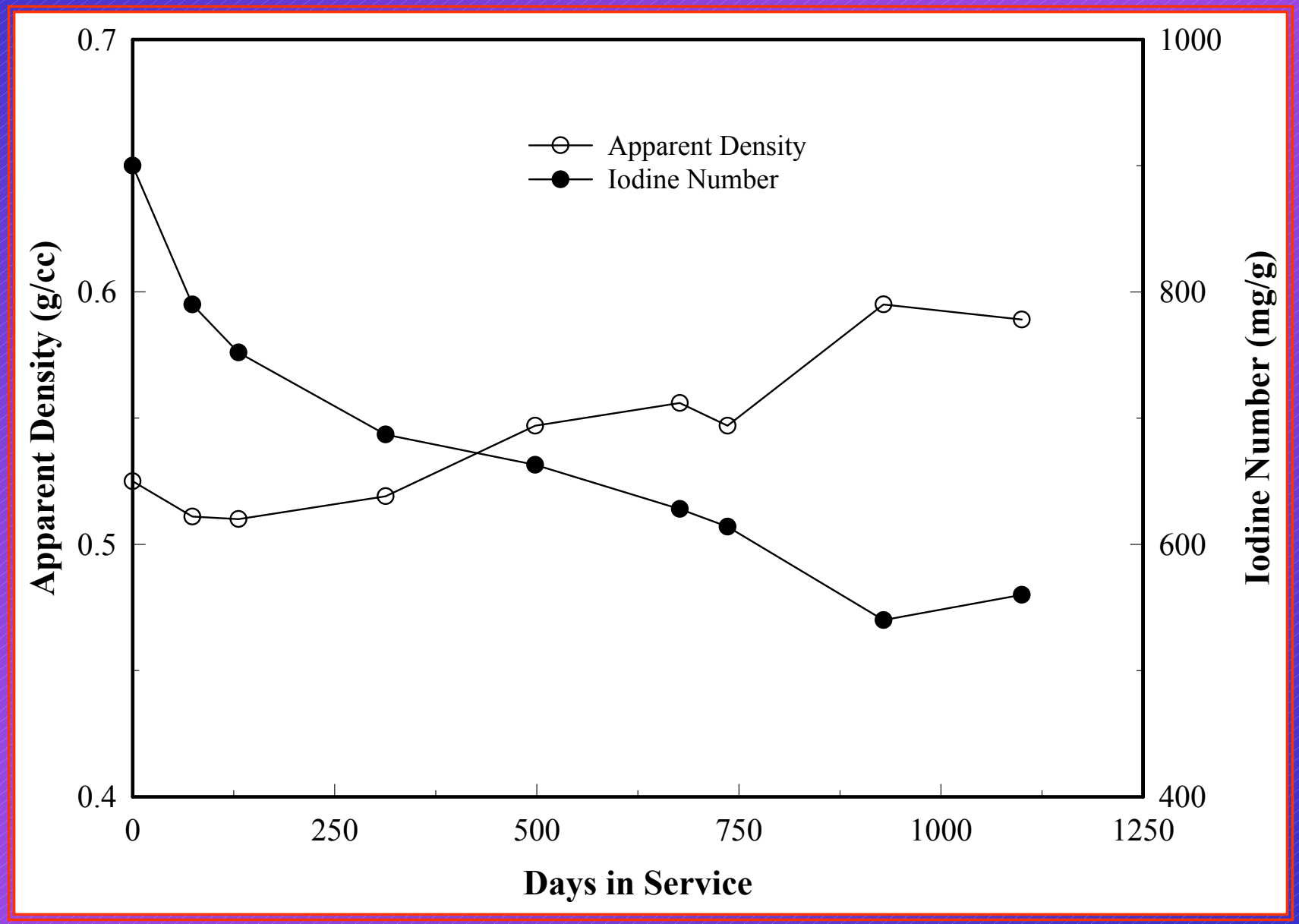
Overall Removal of NOM by Coagulation and GAC




TTHM Quarterly Monitoring Results at Higginsville
Total Trihalomethane Concentration (µg/L)
Year/Quarter
Samples
RAA
Interim MCL
Stage 1 MCL (2001)
Stage 2 MCL (future)
Feed PAC
GAC-FA3&4
GAC-FA1&2
0
20
40
60
80
100
120
140
'1989
'1990
'1991
'1992
'1993
'1994
'1995
'1996
'1997
'1998
'1999
'2000


THHA5 Running Annual Averages at Higginsville
Total Haloacetic Acid (5) Concentration (µg/L)
0
20
40
60
80
Post-FA 3&4
Post-FA 1&2
Stage 1 MCL (2001)
Stage 2 MCL (future)
'1996
Q2
Q3
Q4
'1997
Q2
Q3
Q4
'1998
Q2
Q3
Q4
'1999
Q2
Q3
Q4
'2000
Year/Quarter

Characterization of GAC Physical Deterioration



Conclusions

1. Atrazine removal is acceptable with high removal in the first year of service declining to minimal removal after 4 years of service.
2. GAC buffers against sudden increases in atrazine.
3. Operational adjustments must be made with backwashing and chlorination practice.
4. High, short-term removal of NOM is obtained for three months followed by long-term biological removal of 20 %.
5. Particle removal is comparable to anthracite.
6. Reduction of HAA_5 is apparent with use of ClO_2 as preoxidant and good coagulation (alum).
7. Staggered replacement offers operational flexibility and reduces costs.