Metals Removal in Conventional Wastewater Treatment Process and Membrane Bioreactor Process

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Presentation Objectives

- Present metal removal efficiency data from MBR pilot plants.
- Compare metal removal efficiency between MBR pilots and conventional treatment.
- Discuss the effect of process configuration and operating conditions on the metal removal efficiency.

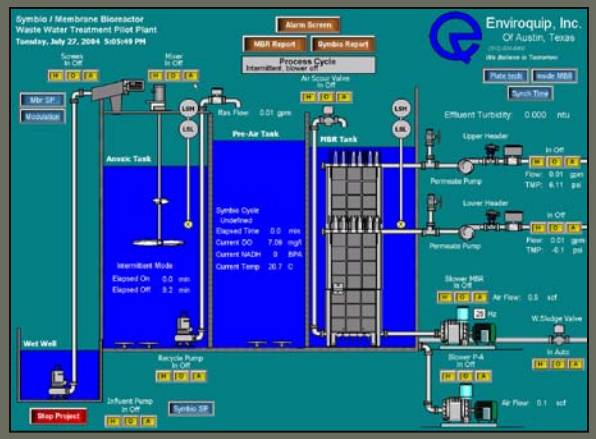
Pilot Plants Operated

- Enviroquip/Kubota
  - Plate membranes
  - West Point Treatment Plant
- Zenon
  - Hollow fiber membranes
  - South Treatment Plant

Pilot Plants Information

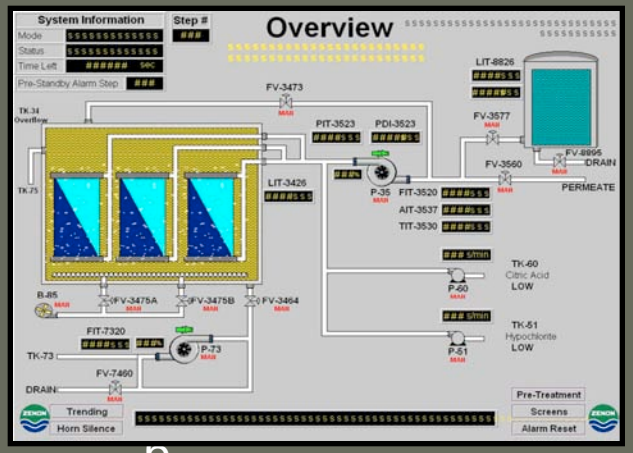
	Enviroquip	Zenon
Feed Source	Raw Sewage	Raw Sewage
Process Volume (gal)	9,000	3,240
Flow (gpm)	36,700	8,000
Flux (gfd)	14-32	8-18
MLSS (mg/L)	2,900-12,300	6,000-11,000
SRT (days)	13-53	10-12
Pore size (micron)	0.40/0.10	0.10/0.04

Enviroquip/MBR pilot



Zenon Pilot


Protecting Our
Environment


System Information
Step #
Overview
Mode
Status
Time Left
Pre-Standby Alarm Step
LIT-8826
FV-3473
FV-3577
PIT-3523
PDI-3523
FV-3560
FV-8895
DRAIN
PERMEATE
LIT-3426
P-35
FIT-3520
AIT-3537
TIT-3530
TK-60
Citric Acid
LOW
P-60
FV-3475A
FV-3475B
FV-3464
TK-51
Hypochlorite
LOW
P-51
FIT-7320
P-73
TK-73
FV-7460
DRAIN
Trending
Horn Silence
Pre-Treatment
Screens
Alarm Reset

Conventional Treatment Plants

	WTP	STP
Process	Pri. Clarifiers HPO Secondary Sec. Clarifiers	Pri. Clarifiers CAS Secondary Sec. Clarifiers
Flow (MGD)	70-110	65 - 95
MLSS (mg/L)	1,800-2,500	2,000-2,500
SRT (days)	2-4	3-5

Conventional Treatment Plants

West Point Treatment Plant (WPTP)
Seattle, WA

South Treatment Plant (STP)
Renton, WA

Operational Comparison (MBR vs. CAS)

- Clarification Method
  - ✓Physical barrier versus gravity settling
- Biological Process
  - ✓Importance of good biological process control
- Adverse Impacts
  - ✓Loss of treatment capacity versus solid carryover
- Process Monitoring
  - ✓MBR parameters (flux, TMP, and permeability)

Metal Sampling During MBR Operation

- 24-hr composite
  - Pilot influent
  - Pilot effluent
  - Treatment plant effluent
- Grab (WTP Study only)
  - Mixed liquor
- Frequency - Bi-weekly
- Analytical Methods - ICP, ICP-MS, CVAA

List of Metals Analyzed

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium *
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Lead
- Magnesium
- Mercury
- Molybdenum
- Nickel
- Selenium *
- Silver
- Thallium *
- Vanadium
- Zinc

*concentrations below MDL (0.2-2 μg/L) in the influent

Influent Metal Concentrations

Metal (µg/L)	WTP	STP	239-plant survey *
Chromium	13	6	145
Copper	124	81	151
Lead	60	6	103
Nickel	17	5	140
Zinc	390	142	354

* Petrasek et al, 1983

WTP and Enviroquip MBR

	MBR			WTP	
	Inf (µg/L)	Eff (µg/L)	%	Eff (µg/L)	%
Aluminum, Total, ICP	< 3847.0	< 100.0	> 92.0	120.0	89.6
Antimony, Total *	1.32	0.67	35.41	0.82	33.37
Arsenic, Total *	3.29	1.36	40.27	1.69	29.76
Barium, Total *	80.51	4.78	85.31	6.20	80.92
Chromium, Total *	13.29	0.61	87.07	0.88	80.48
Cobalt, Total, ICP-MS	2.28	0.36	69.97	0.40	53.04
Copper, Total *	124.06	3.54	93.91	9.74	84.25
Lead, Total *	60.22	0.30	96.67	0.78	92.22
Molybdenum, Total *	10.84	8.33	20.36	8.45	18.24
Nickel, Total *	16.66	2.89	53.01	3.53	46.47
Silver, Total *	< 4.10	0.21	93.66	0.58	84.24
Vanadium, Total *	9.97	1.46	57.44	1.37	62.50
Zinc, Total *	390.39	89.84	28.75	34.83	73.37

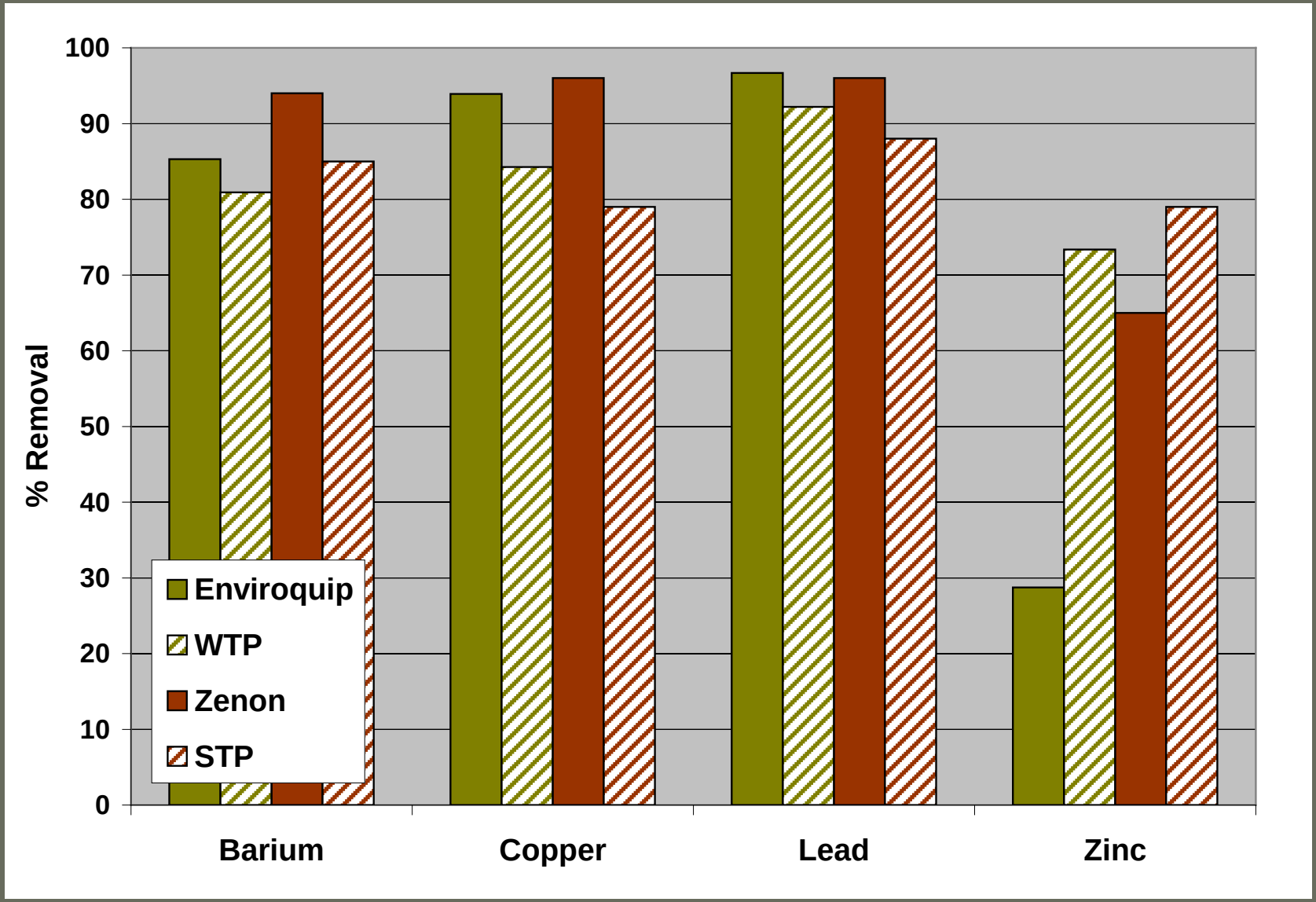
Note: 13 samples collected

STP and Zenon MBR

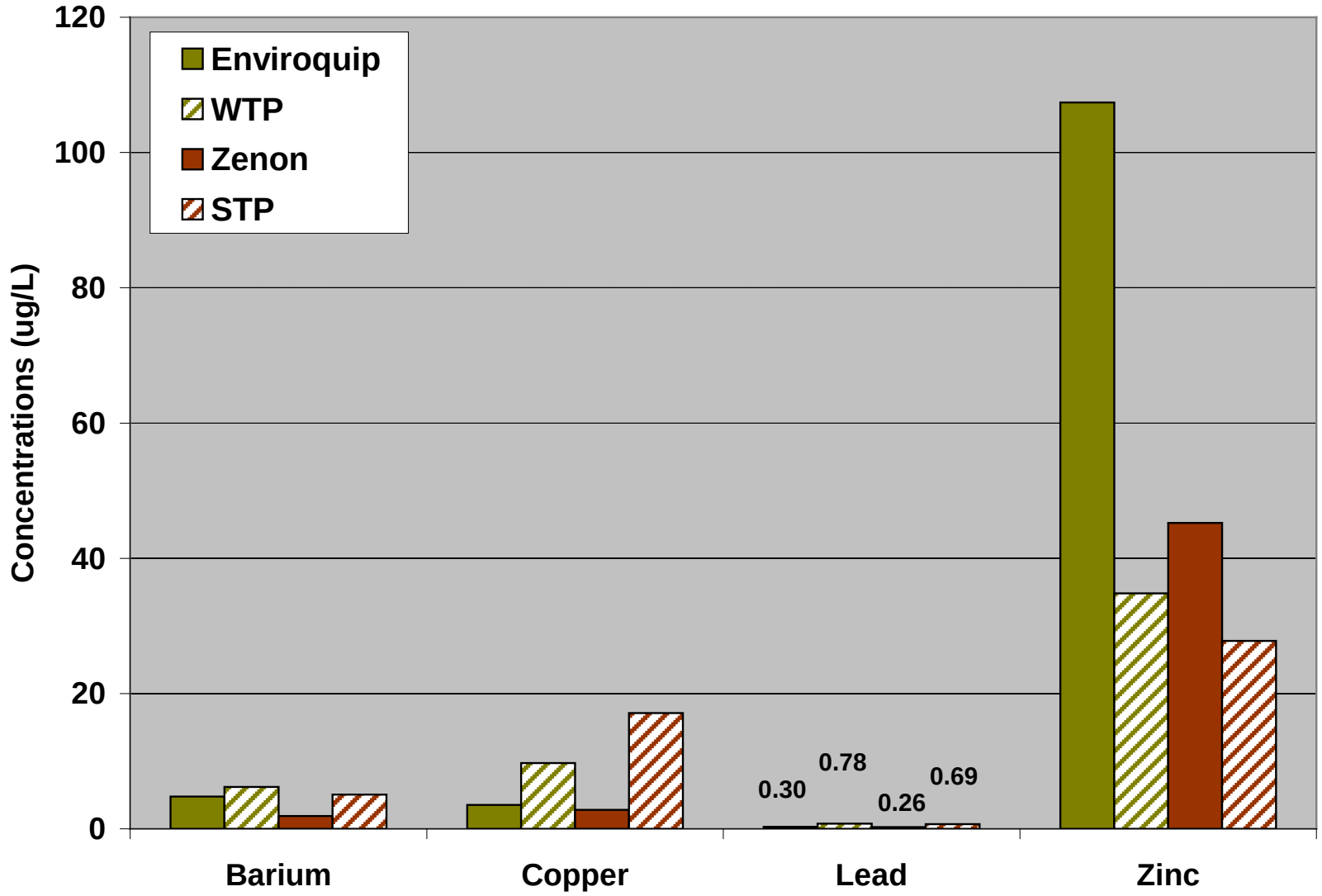
	MBR			STP		
	Inf (µg/L)	Eff (µg/L)	%	Inf (µg/L)	Eff (µg/L)	%
Aluminum, Total, ICP	1309	< 100	> 92	1310	148	> 89
Antimony, Total *	0.63	< 0.42	> 32	1	0.4	41
Arsenic, Total *	2.06	1.04	44	2.06	142	34
Barium, Total *	30.29	1.88	94	31.19	5.07	85
Chromium, Total *	5.77	0.46	90	6.24	1.08	85
Cobalt, Total, ICP-MS	0.81	0.34	57	0.85	0.42	51
Copper, Total *	74.4	2.8	96	81.1	17.11	79
Lead, Total *	5.96	0.26	96	5.84	0.69	88
Mercury, Total, CVAA	0.197	< 0.005	> 96	0.162	0.012	90
Molybdenum, Total *	9.26	7.5	19	10.19	7.87	19
Nickel, Total *	5.3	2.21	60	5.61	2.67	53
Silver, Total *	1.59	< 0.05	> 97	1.76	0.41	76
Vanadium, Total *	2.78	1.24	55	2.86	0.97	66
Zinc, Total *	132.24	45.23	65	141.7	27.8	79

Note: 9 samples collected

Comparing Removal Efficiencies

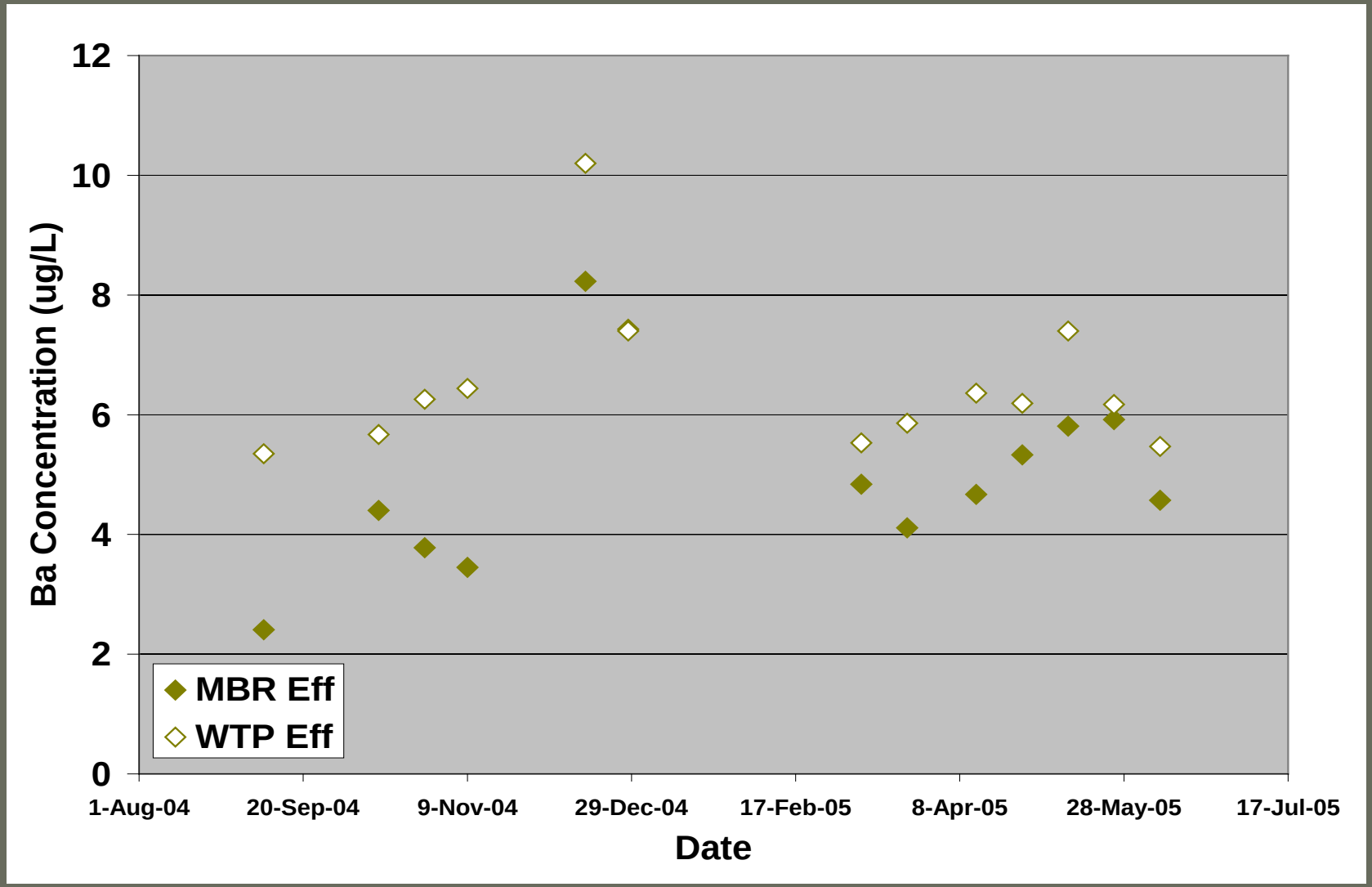


Comparing Effluent Concentrations



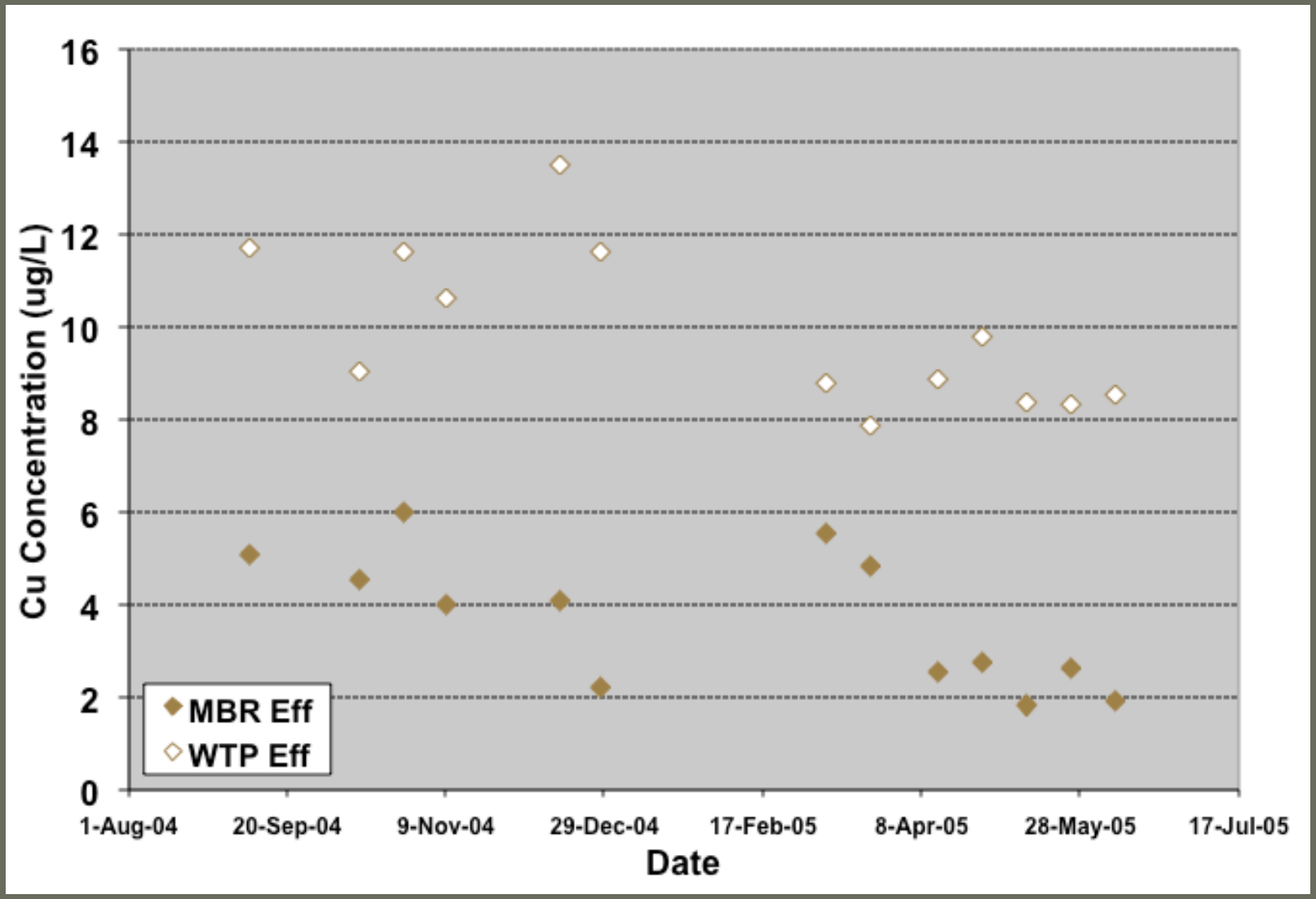
Barium Effluent Concentration

Enviroquip vs WTP



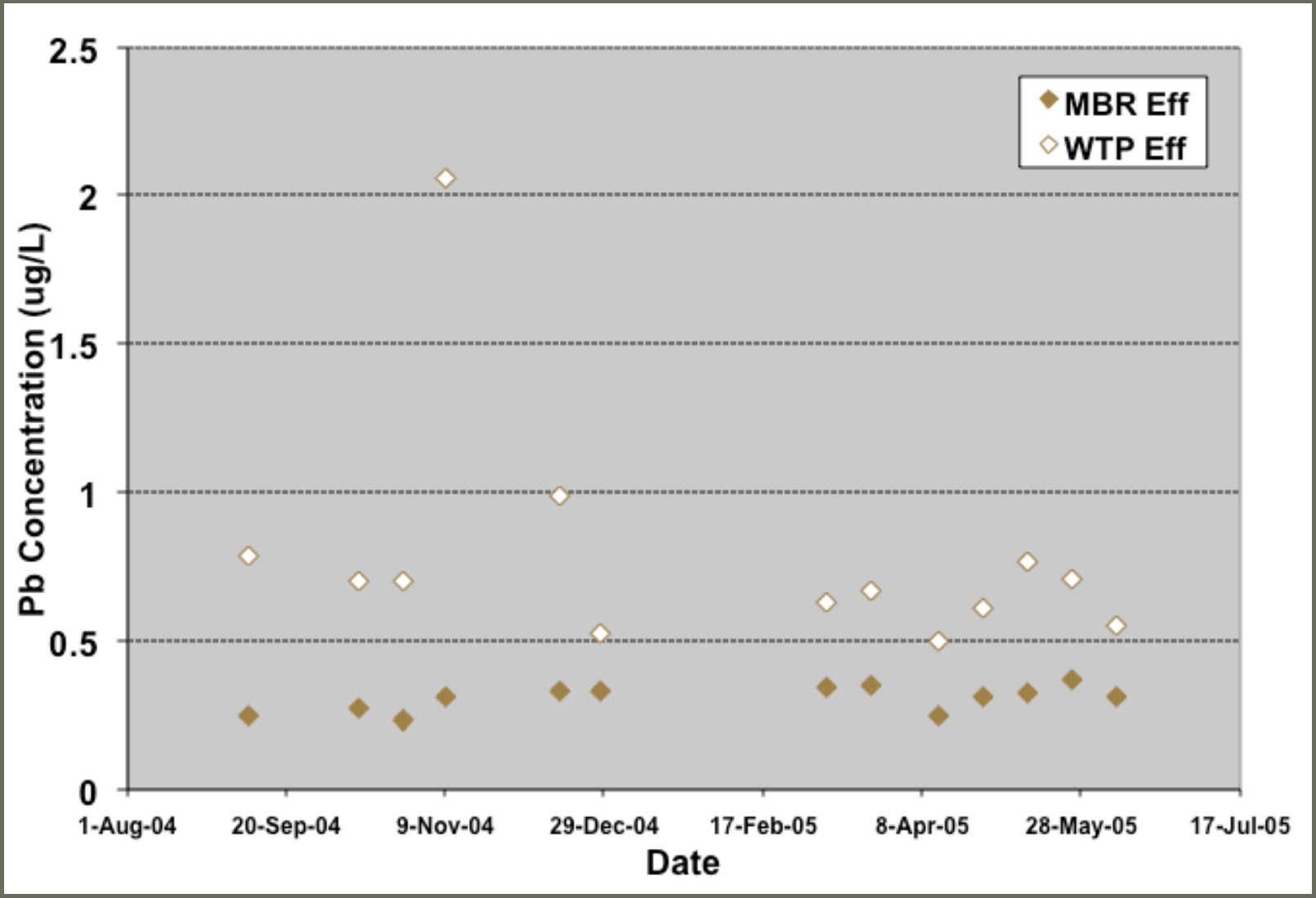
Copper Effluent Concentration

Enviroquip vs WTP



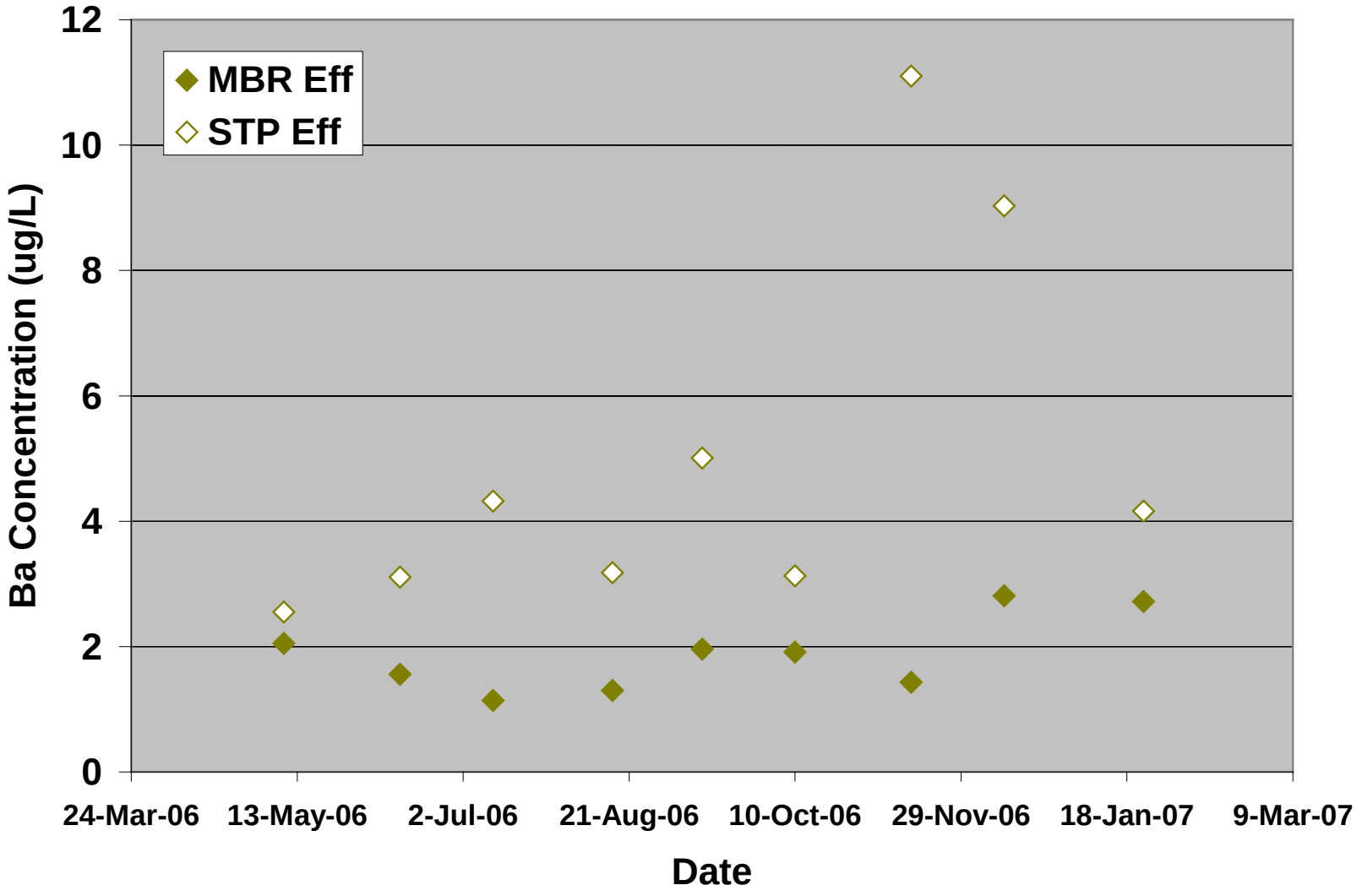
Lead Effluent Concentration

Enviroquip vs WTP



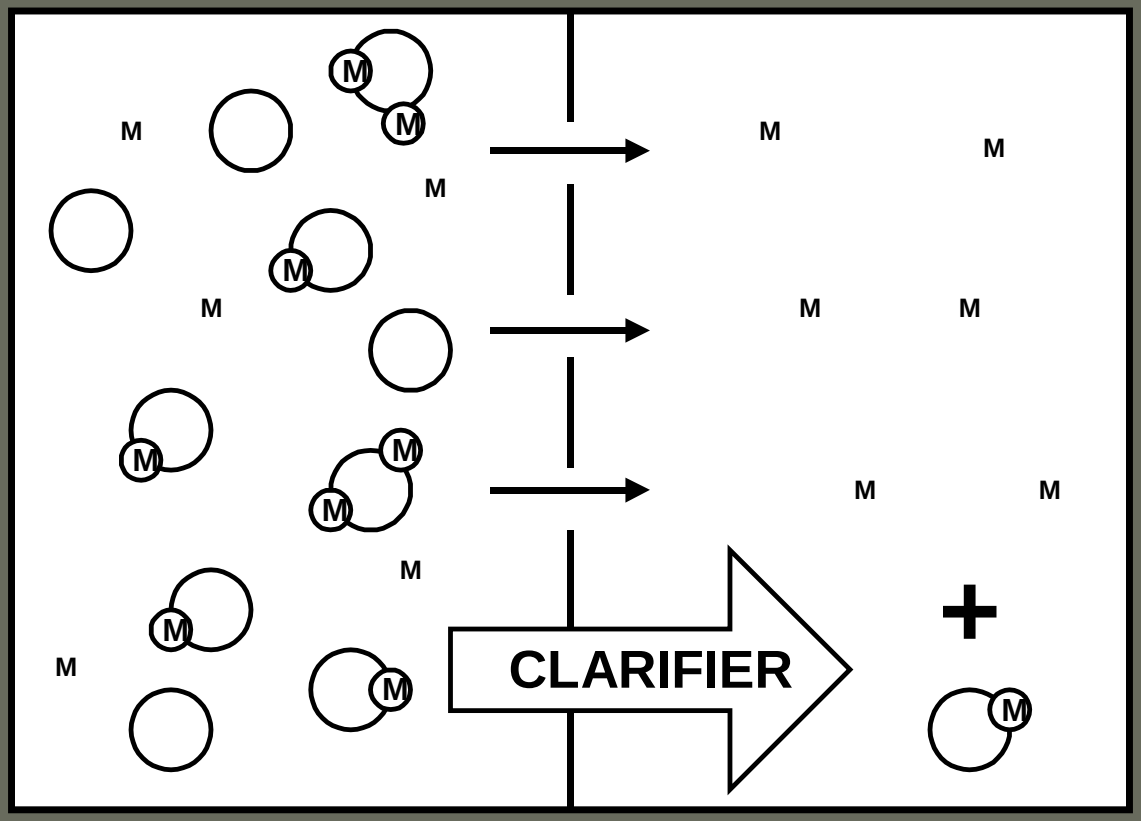
Barium Effluent Concentrations

Zenon vs STP



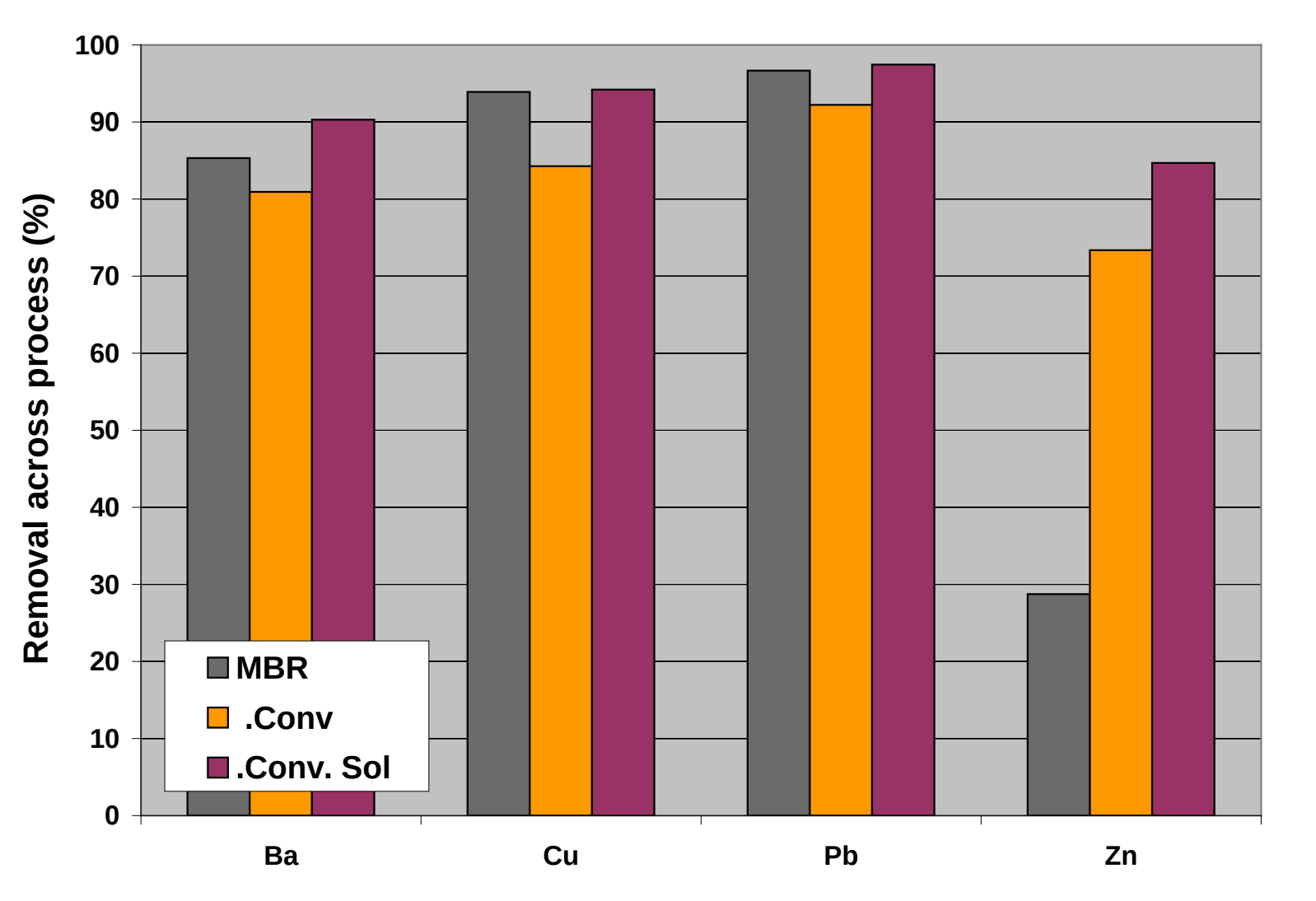
Metals Removal – Solids Separation

HYPOTHESIS: Membrane filtration provides enhanced metals removal.



TESTING: Compare filtered (0.45 µm) and unfiltered CAS effluent to identify the effect of filtration.

Comparing MBR and Conventional



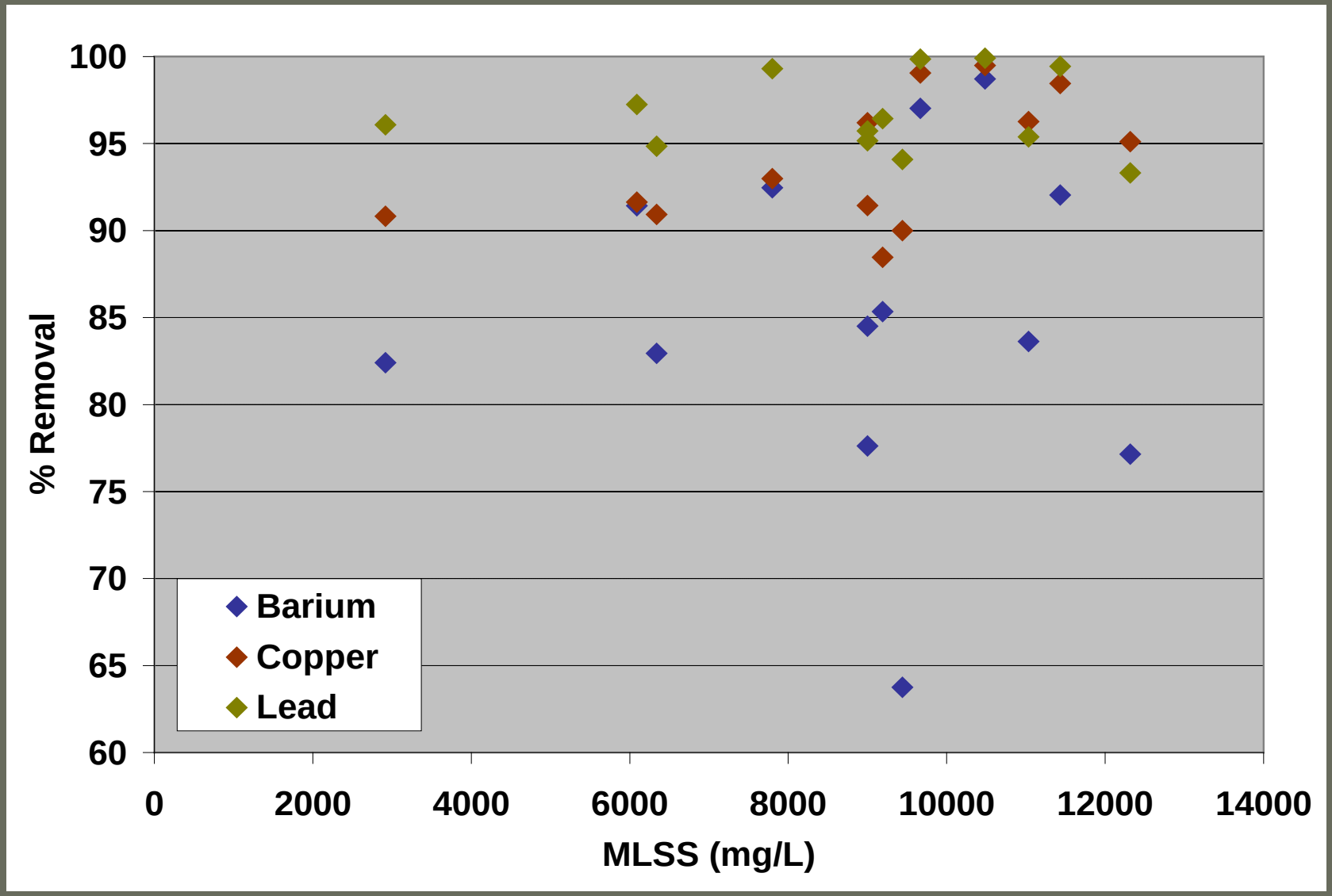
Enviroquip MBR and WTP data from Sep 04- Jun 05

Metals Removal - Effect of Biological Process Operating Conditions

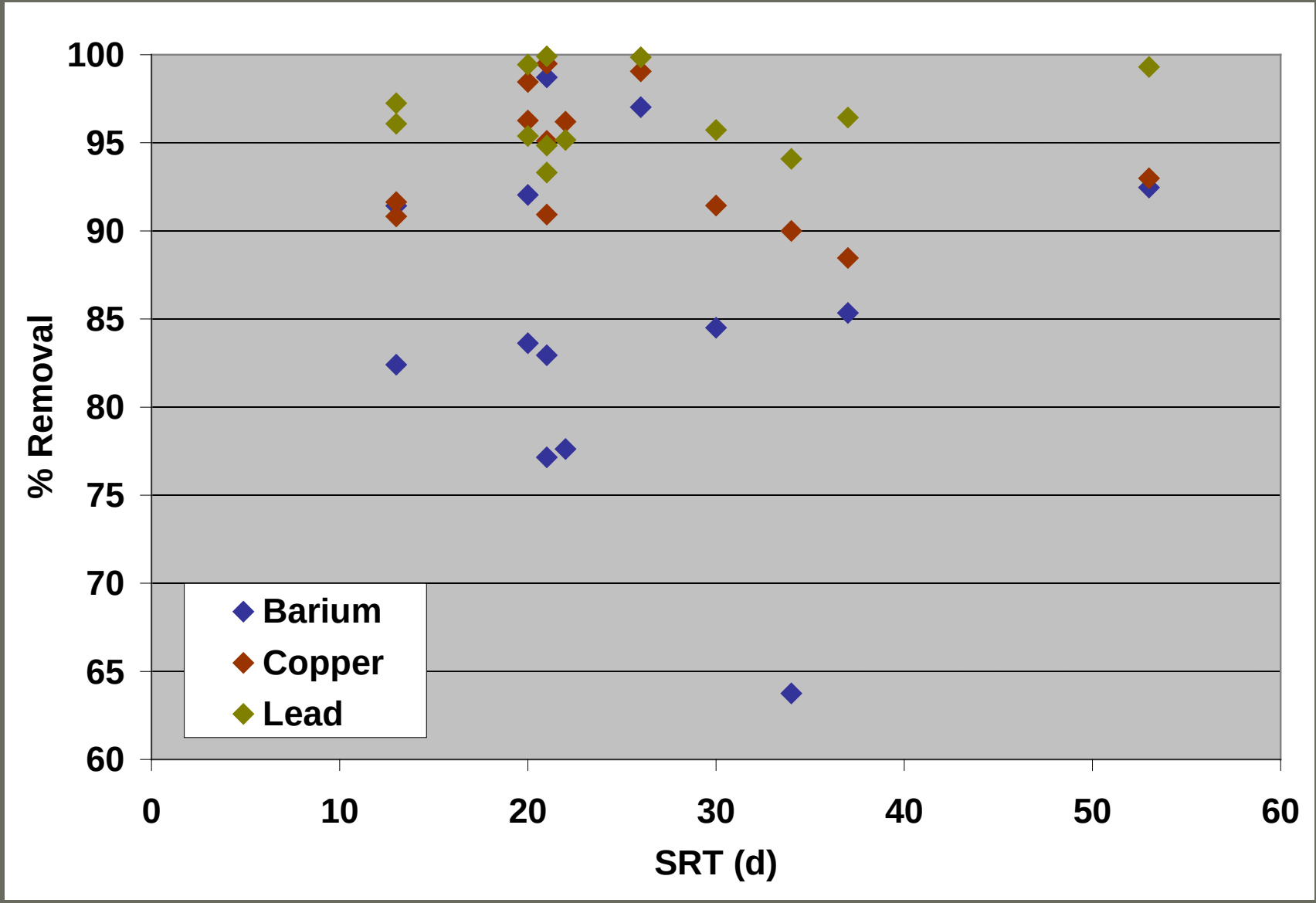
Hypothesis: Higher MLSS concentration and longer SRT will enhance metals removal.

Testing: Evaluate metals removal as a function of MLSS and SRT.

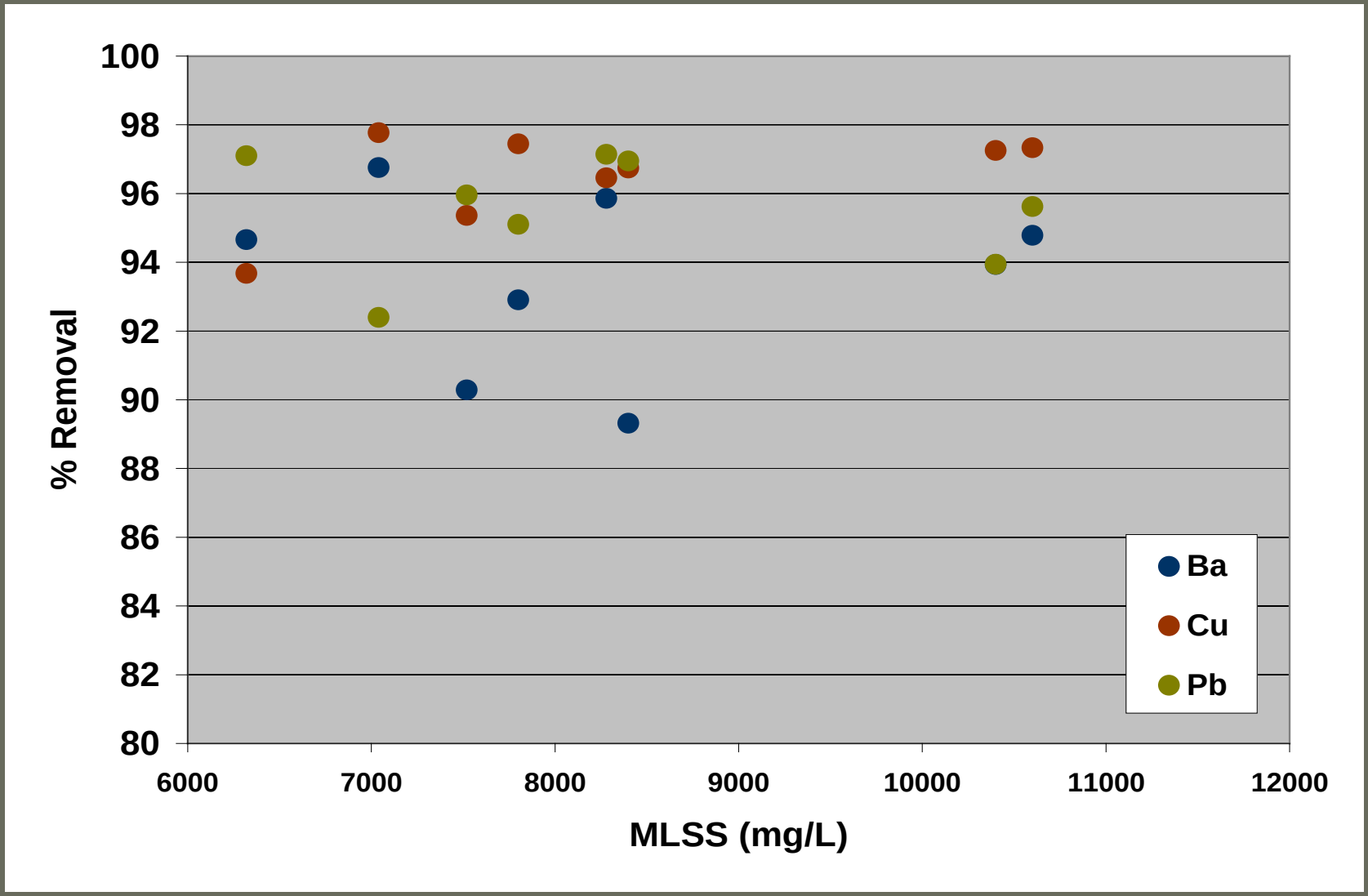
Enviroquip Metal Removal vs. MLSS



Enviroquip Metal Removal vs SRT



Zenon Metal Removal vs. MLSS



Summary

- MBR pilots had better metal removal efficiency compared to conventional activated sludge/clarifier.
- Membrane filtration is a contributing factor in the increased metal removal efficiency.
- No clear correlation existed between biological operating conditions (SRT or MLSS) and metals removal.

Acknowledgements

- Enviroquip/Kubota and GE-Zenon for providing pilot equipment.

- King County treatment plant staff for maintenance and operations support.

- King County treatment plants process laboratory and Environmental Laboratory for analytical support.

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QUESTIONS

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