ARSENIC REMOVAL USING A PARTIALLY RECIRCULATING COAGULATION LOOP COMBINED WITH DIRECT MULTI-MEDIA FILTRATION

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The new EPA Arsenic guideline has created a substantial need for both an economical and an efficient technique for removing arsenic from well water for small utilities. Currently the utilities may have:

- **Little or no infrastructure**
- **Little or no experience in water "treatment"**
- **Lack of funds**
- **Multi-contaminants creating difficult to treat water**

Considerations

- Contaminants besides Arsenic
- Efficiency (water waste)
- Residuals and Disposal of Residuals
- Ease of Operation
- Footprint of System
- Cost

"Contaminants"

Other contaminants that may or may not be over the MCl can interfere with Arsenic removal in some systems.

- Iron
- Silica
- Nitrates
- Fluoride
- Others

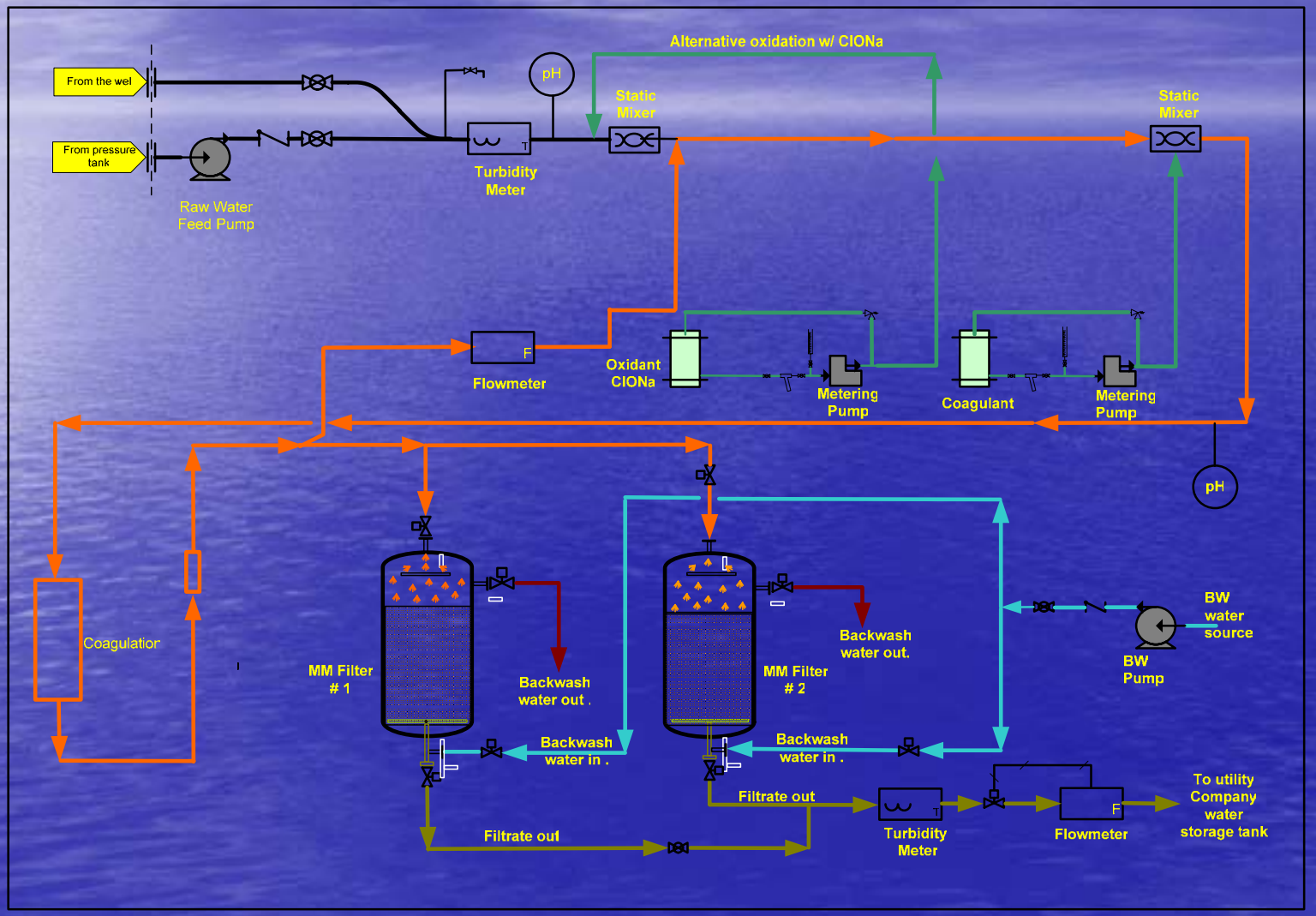
Designing Systems To Meet Economic Needs For Small Systems

- Utilizing low cost automation, data collection, and cost-efficient water treatment technology
- Low cost operation and maintenance for remote sites and small systems utilizing advanced communication technology
- Meeting stringent regulations for finished water quality, such as Arsenic

KemLoop's Three Steps to Arsenic Removal Process:

- Oxidation of arsenic with liquid sodium hypochlorite "bleach" or solid calcium hypochlorite tablets
- Coagulation of arsenic with iron coagulant selected for raw water characteristics
- Filtration, using a standard mix of sand, gravel, and garnet in a media filter or micro-filter

Flow Diagram



Operating Cost is Minimal

- The cost of Chemicals will be dependent on the flow GPM
- The cost of iron coagulant (1mg/l Iron)
- The cost of chlorine "bleach" (1mg/l Cl_2)
- Backwash pump operates for 4 minutes and possible disposal of solids

Operating the System

- Monitor and replace inventory of iron coagulant and oxidant (hypochlorite)
- Calibrate chemical feed pumps to check ml/min of chemical added
- Depending on level of instrumentation maintain instruments

The Filter Performance Verifies Arsenic Removal

- Monitoring turbidity, pH, and chlorine residual in the filtrate can help verify the system is removing arsenic.
- If turbidity is removed to below the incoming raw water turbidity you have removed all the iron coagulant added to the water.
- A decrease in pH below the raw water pH verifies chemical addition.
- Residual chlorine data shows that you converting arsenic +3 to arsenic +5 to insure removal.

Filter Backwash and Waste

- The filter backwashes automatically on time, unless conditions such as turbidity, or pressure differential exceed desired limits in program. Usually a 24 hour cycle.
- Backwashing produces approximately 260 gallons of water per day for a 25 gpm system containing the solids of iron and arsenic removed during the process.

Backwash Solids

- The arsenic in backwash is the insoluble ferric arsenate and passes the TCLP test for arsenic, making it a non-hazardous disposal.
- The solid can be settled and disposed, while the clean water is recycled into the KemLoop prior to coagulation.
- This allows the system to waste almost no water.

Operation of Kemloop verified

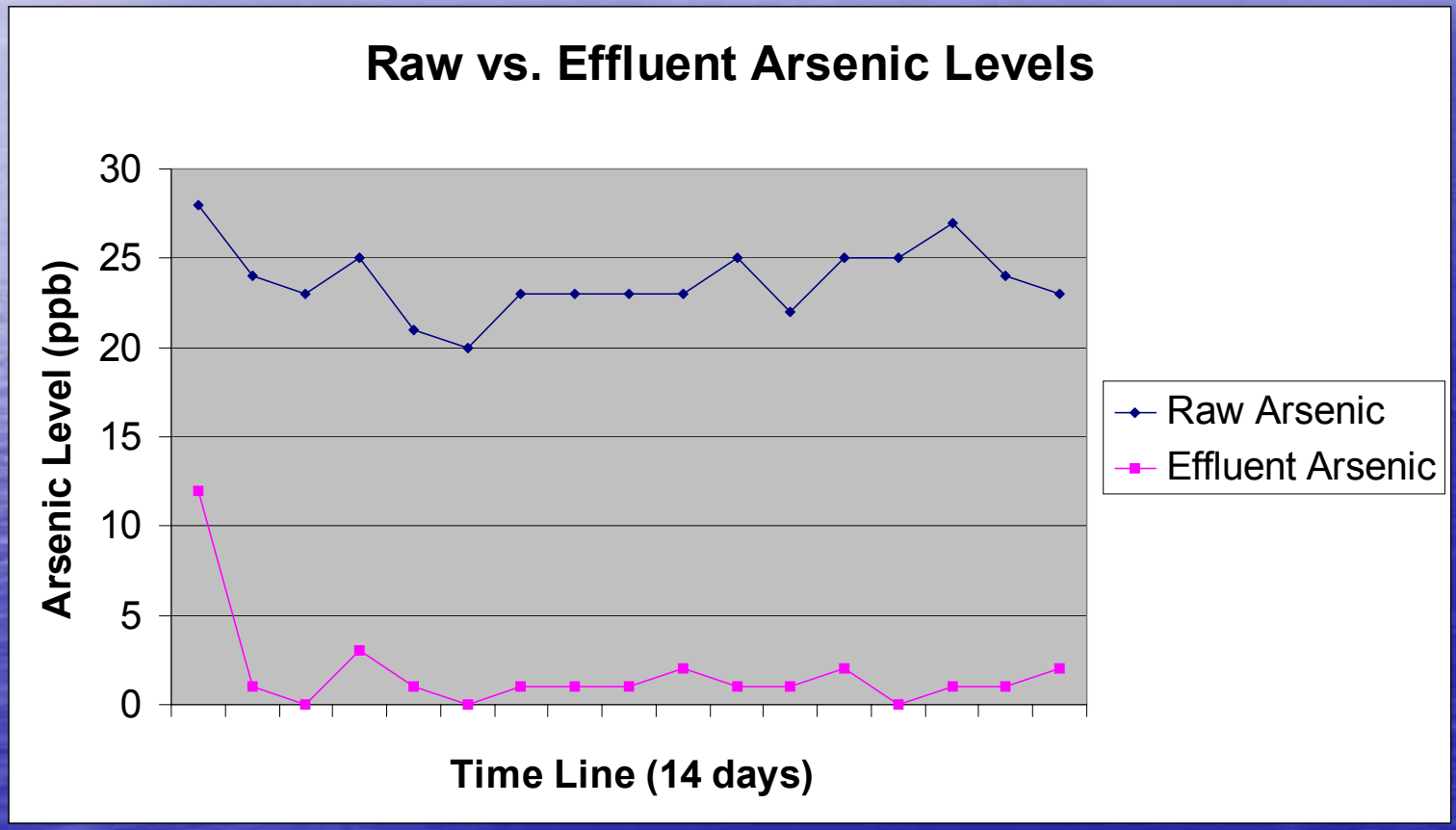
- ETV Study – Midwest U.S.
  Silica and Iron Contaminates
- Plant Trial – Southwest AZ
  High ph water
  Silica and Sulfate contaminates

KEMLOOP UNITS:

ETV Study: Raw Water Quality Data

Parameter	Units	Value
Total As	ug / l	24
As III	ug / l	21
pH	S.U.	7.64
Turbidity	NTU	<1
Sulfate	mg / l	21
Iron	mg / l	0.5
Silica	mg / l	17
Alkalinity	mg / l as CaO_3	260

ETV Study: Effluent Arsenic Values



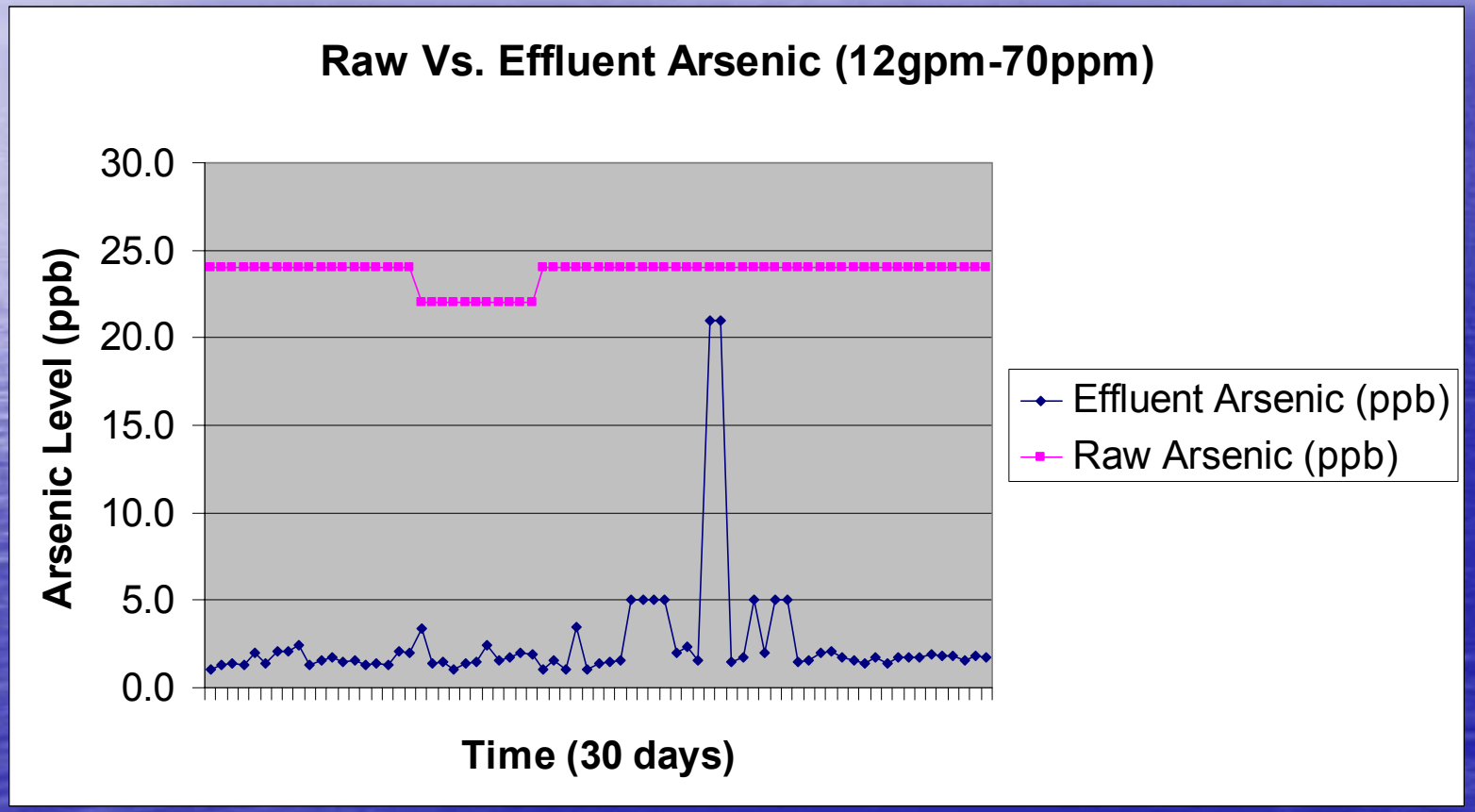
Summary of Results – Verified by the ETV study

- All operations performed by NSF
- All samples analyzed by NSF laboratory
- Filtrate water averaged 3 ppb
- Kemloop system found easy to operate and required little maintenance
- Estimated time to check system is minimal
- PLC set up so main parameters can be monitored without a site visit

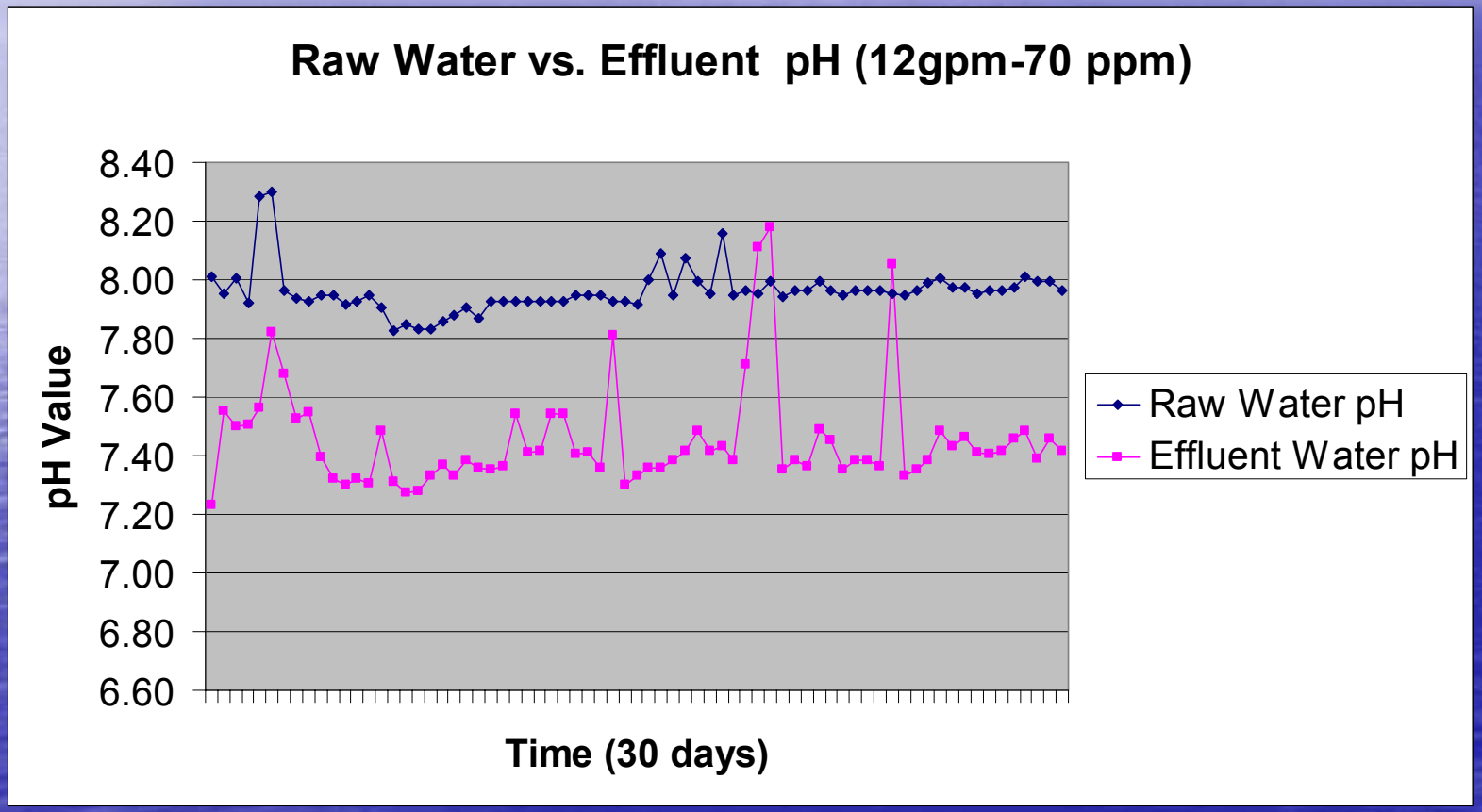
Arizona Study: Raw Water Quality Data

Parameter	Units	Value
Total As	ug / l	26
As III	ug / l	0
pH	S.U.	8.10
Turbidity	NTU	<1
Sulfate	mg / l	130
Iron	mg / l	0
Silica	mg / l	16
Alkalinity	mg / l as CaO_3	74

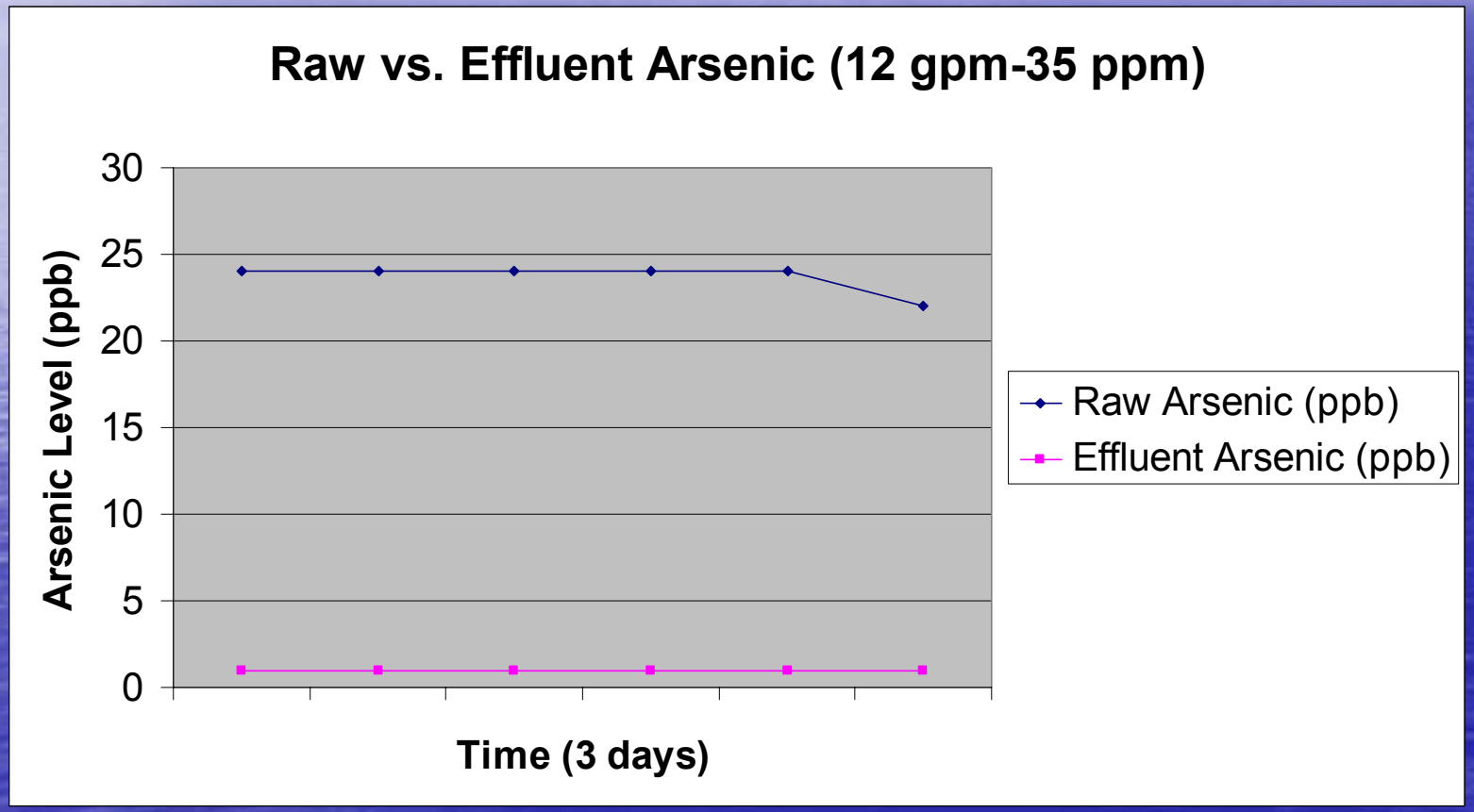
Arizona Study: Effluent Arsenic Values



Arizona Study: Raw vs. Effluent pH



Arizona Study: Effluent Arsenic Values



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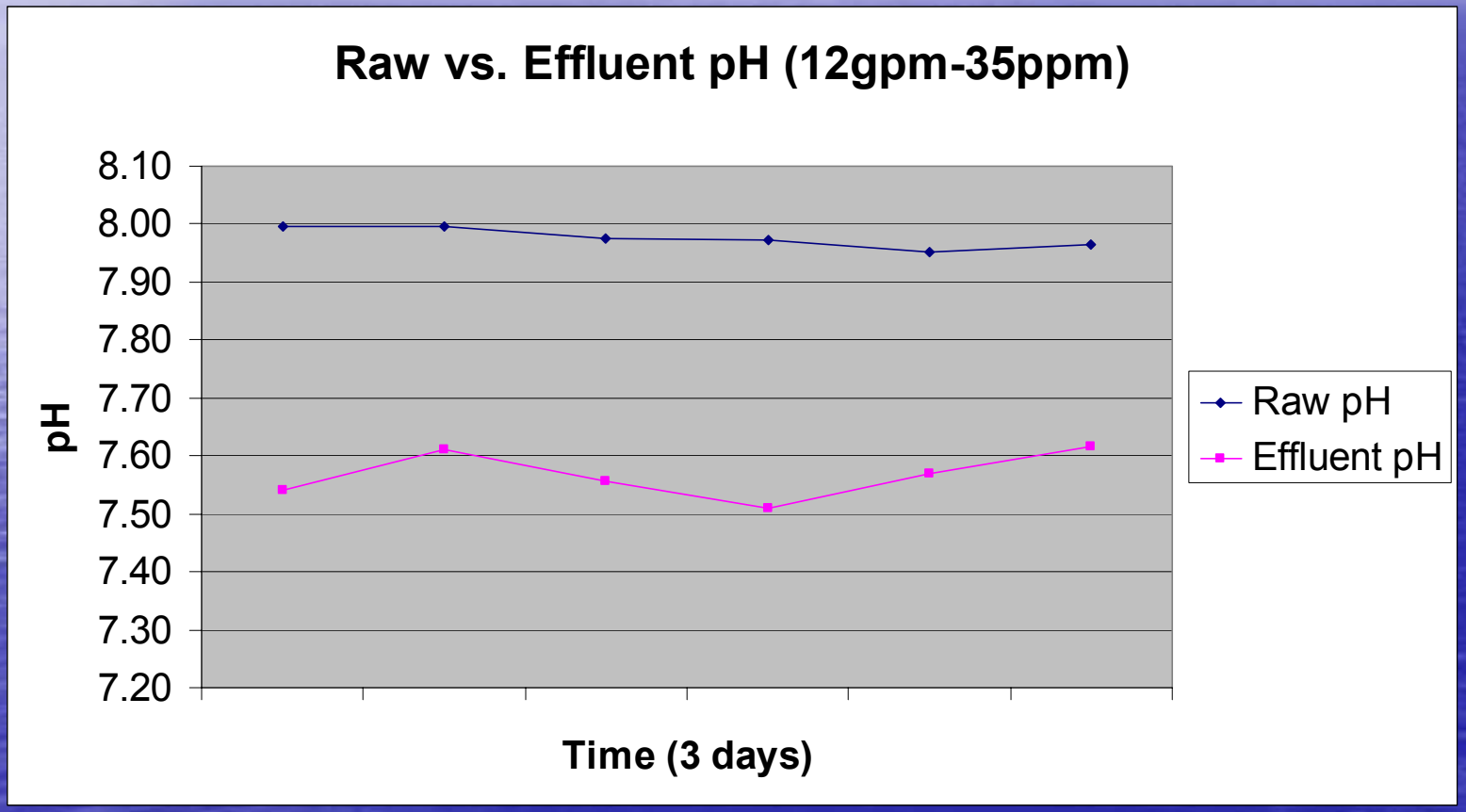

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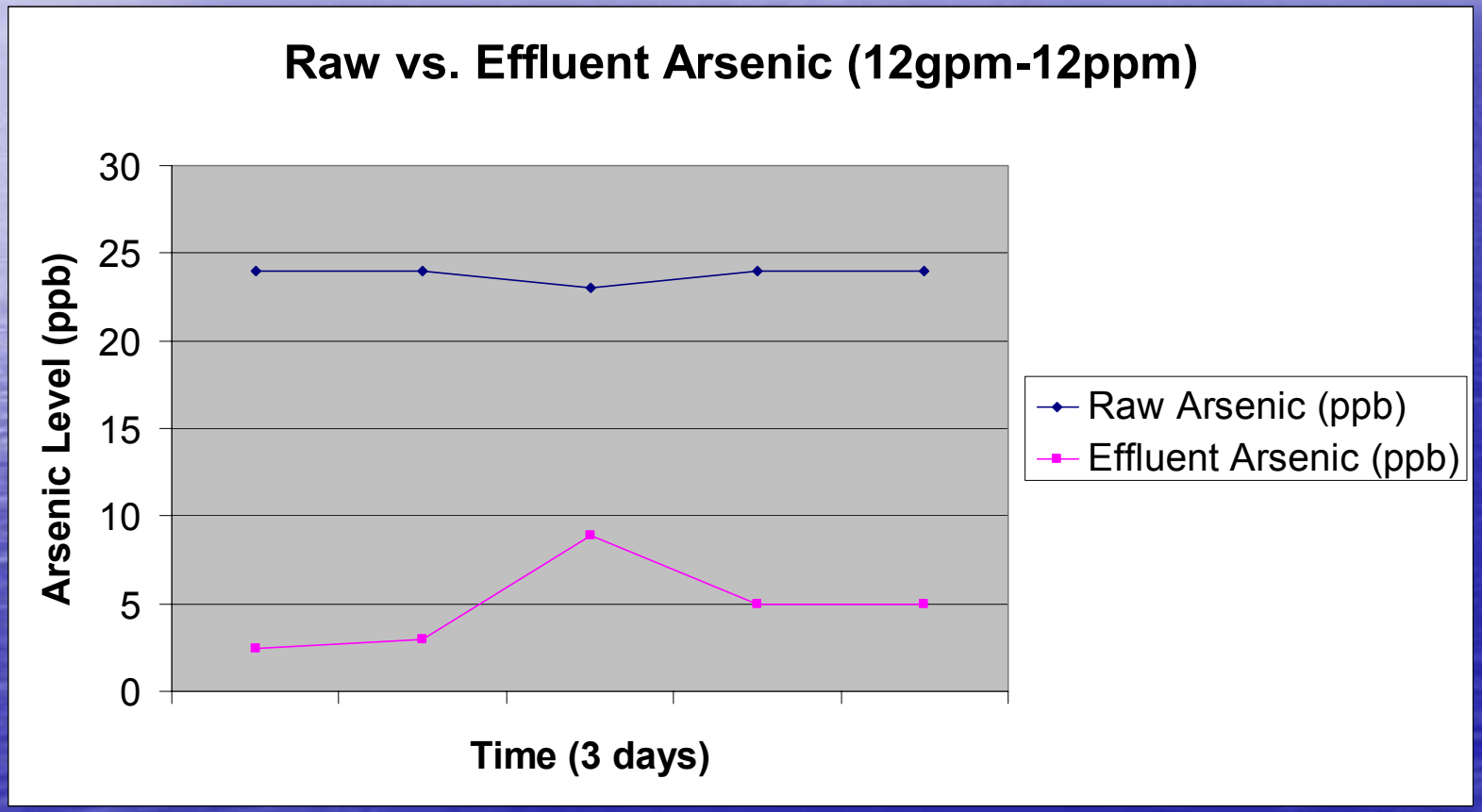

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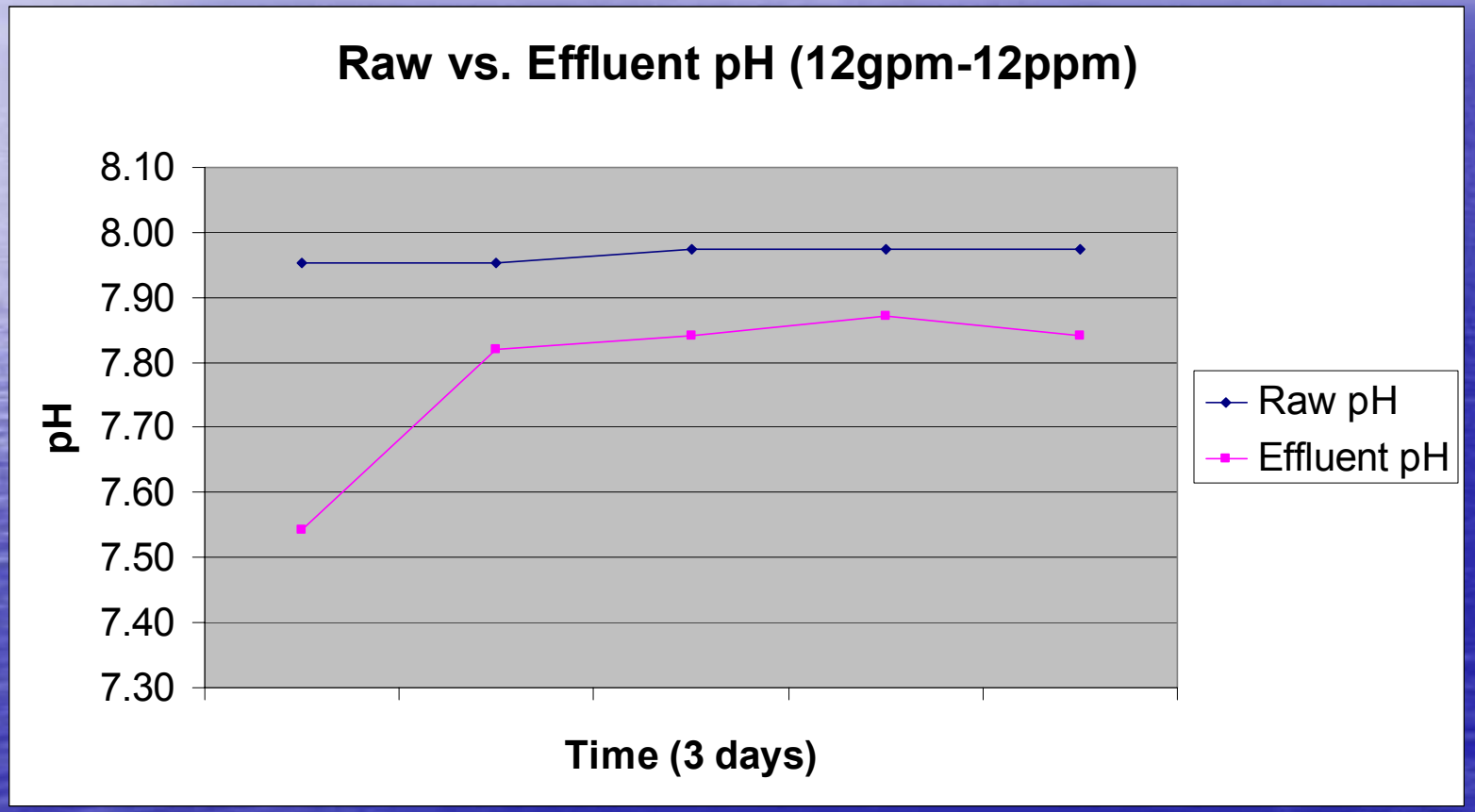

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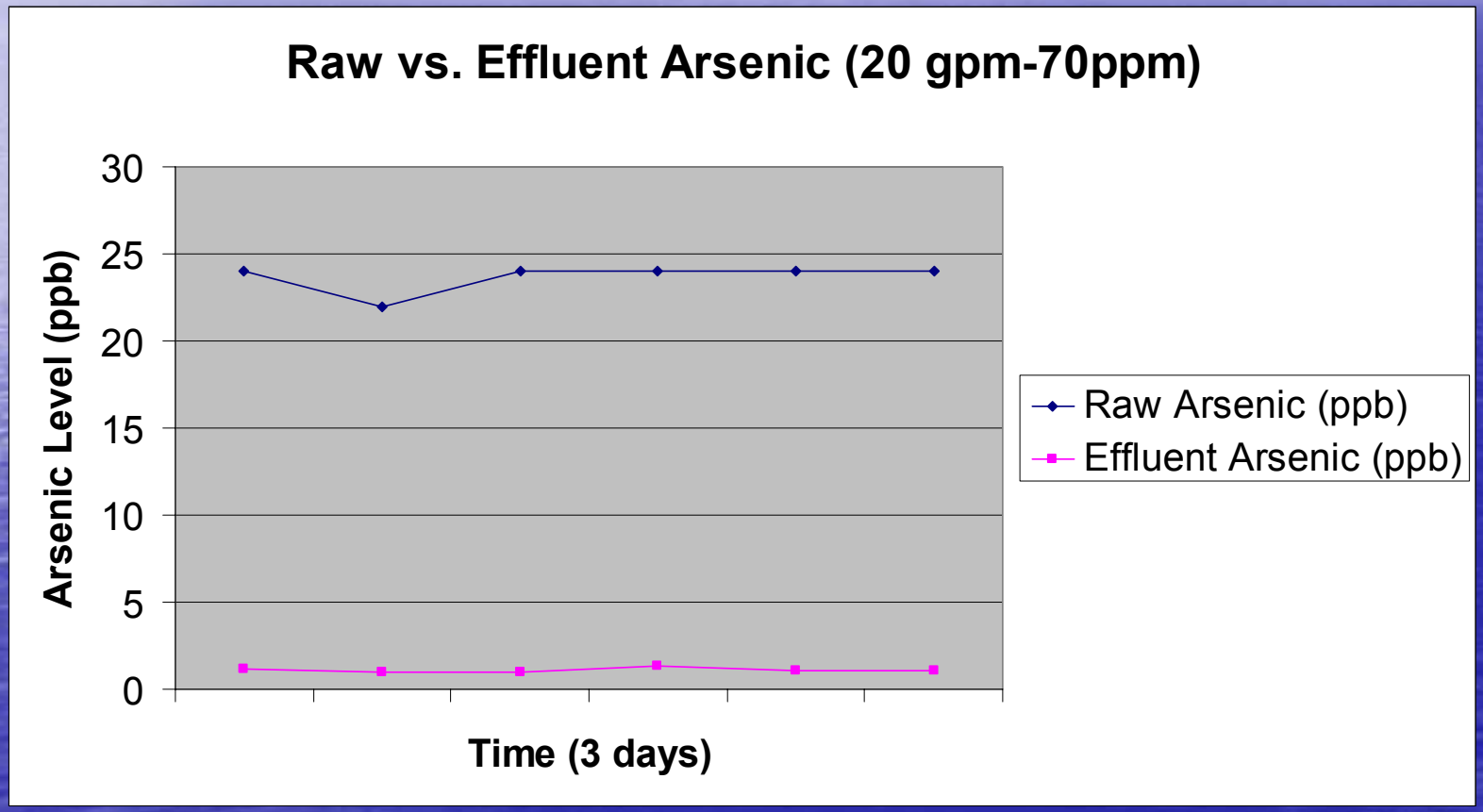

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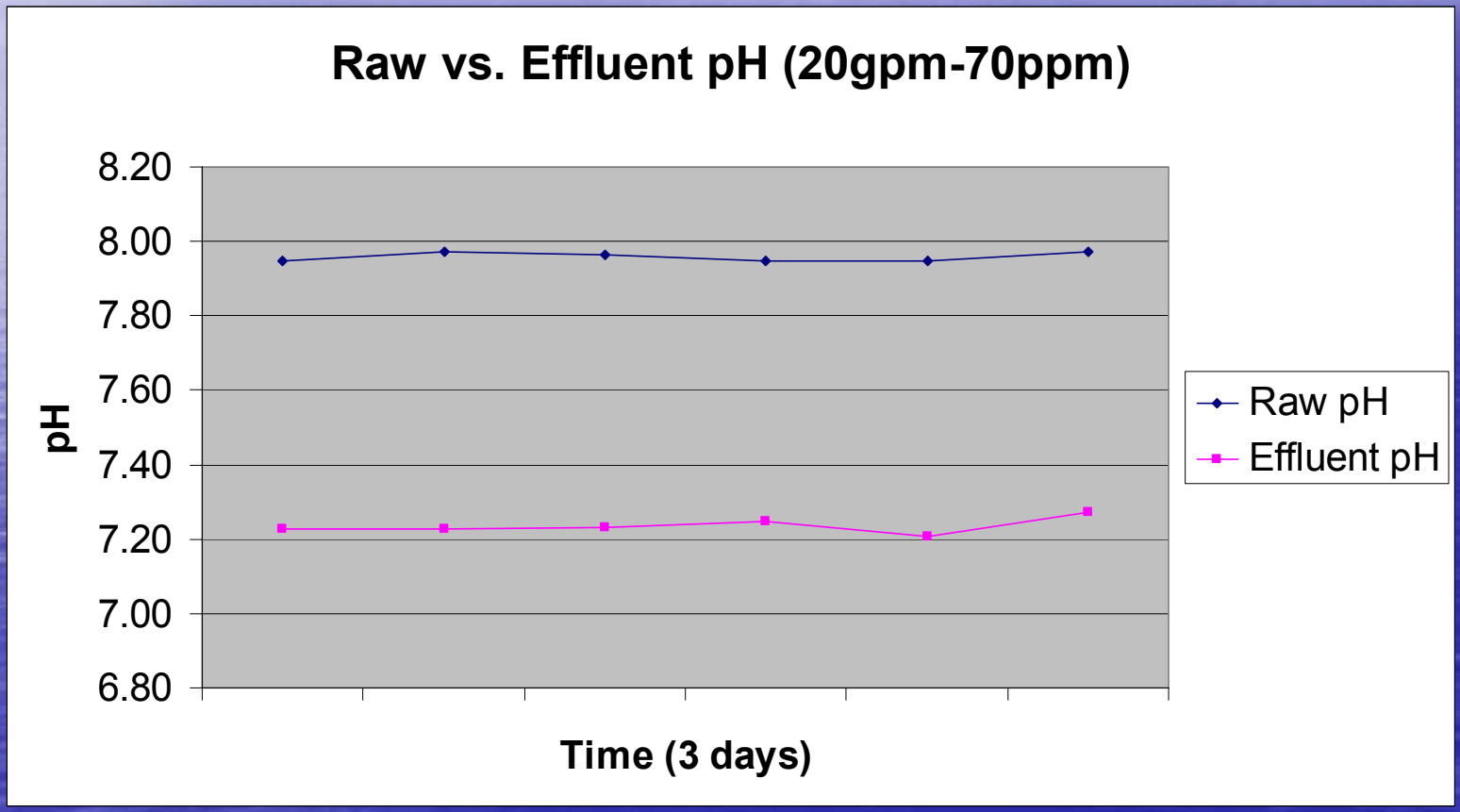

Summary of Results – Arizona Study

- System monitoring equipment works well
- Unit design is conservative and can handle increases in flow
- Unit is more efficient than theoretical and can operate at lower than calculated dose rate
- Higher sulfate in feed water does not effect operation of the system

General Conclusions :

- Coagulation can effectively and economically remove arsenic.
- No pH adjustment is necessary.
- Common contaminants do not interfere with the arsenic removal process.
- The unit is able to run 24/7 un-attended.
- Cost of equipment and O&M costs are very competitive.

The Advantages of the KemLoop

- The process is simple and compact requiring no pH adjustments
- The granular filtration system is a standard filtration technology
- Fully automated control allows only periodic attention by operator
- Use of low cost material of construction
- System is compatible with chlorine and other common treatment chemicals