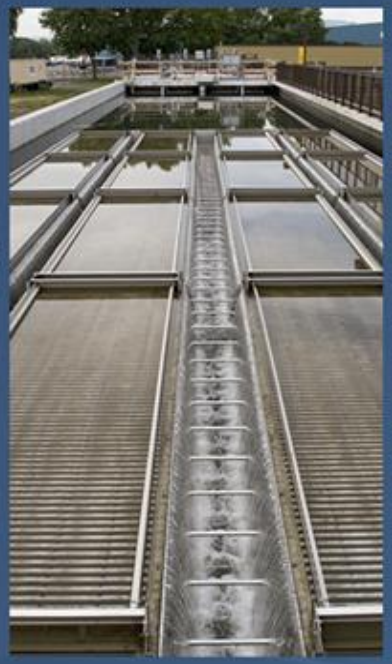
Piloting for Color Removal in a Remote Location

PNWS AWWA Conference 2011
Boise, Idaho



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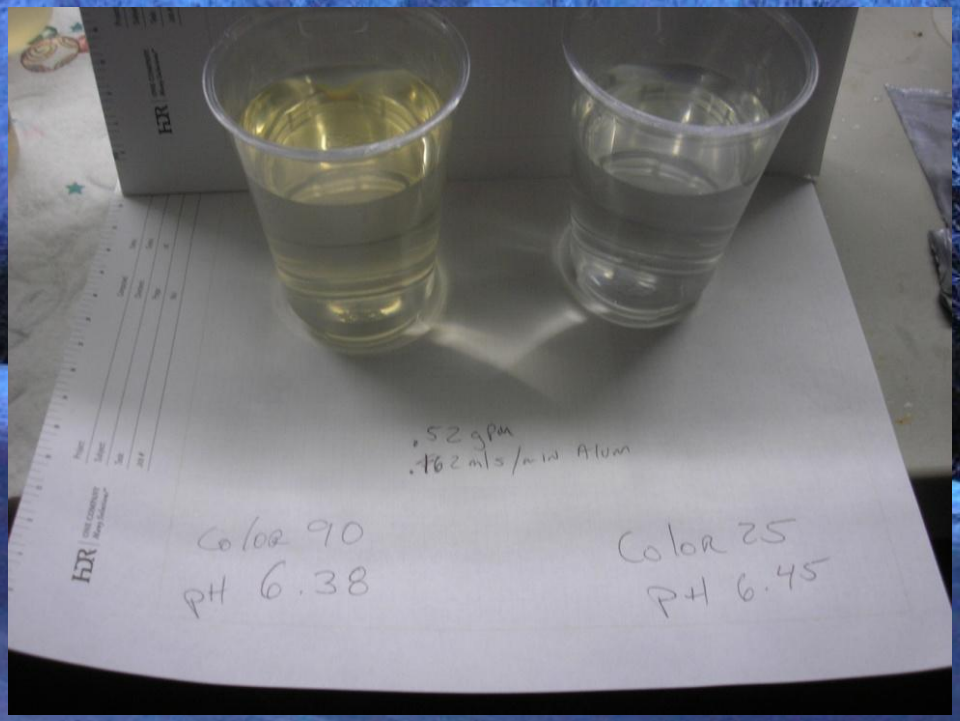
City of Kenai, AK: Color Removal at Well 2 and North & Spruce Well

2 Wells associated with the Beaver Creek Aquifer with taste and odor due to organic tannins:

- 99 PCU at North & Spruce
- 65 PCU at Well 2
- SMCL 15 PCU

Background

City of Kenai was considering chemical addition and filtration to remove color at Well 2 and the North & Spruce Well.



Preliminary Jar Tests at HDR ARTC in Redmond, WA found:

- Alum + Bleach removed color effectively (or Ferric + Bleach)

On-site pilot scale testing scheduled for January 2010

Groundwater Quality

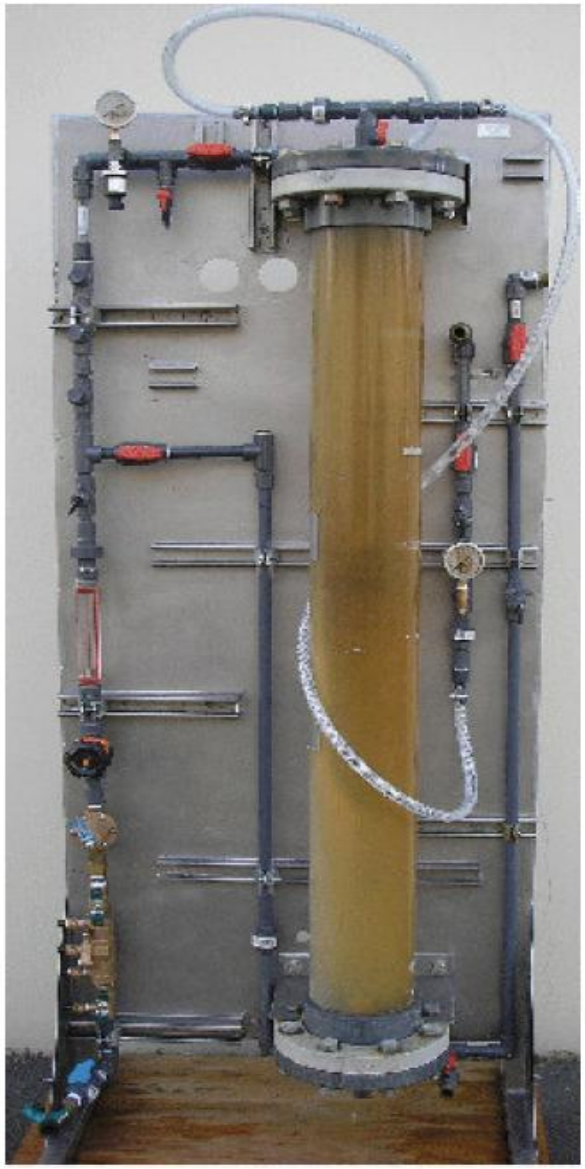
Parameter	Units	Well 2	North & Spruce Well
Alkalinity	mg/L	100	175
Ammonia-N (total)[1]	mg/L	0.207	0.174
Ammonia-N (filtered)[1]	mg/L	0.213	0.182
Arsenic	mg/L	0.005	0.003
Chloride	mg/L	3.06	31.1
Color (apparent)	PCU	64	99
Color (true filtered)	PCU	65	98
Conductivity	mS/cm	0.24	0.534
Hardness	mg/L	2	4
Iron (total)	mg/L	0.063	0.072
Manganese (total)	mg/L	0.030	0.016
pH	s.u.	8.61	8.7
Sulfate	mg/L	0.6	0.2
Temperature	deg. C	4.7	4.7
Total dissolved solids	mg/L	122	268
Turbidity	NTU	0.88	1.32

Pilot Testing Objectives

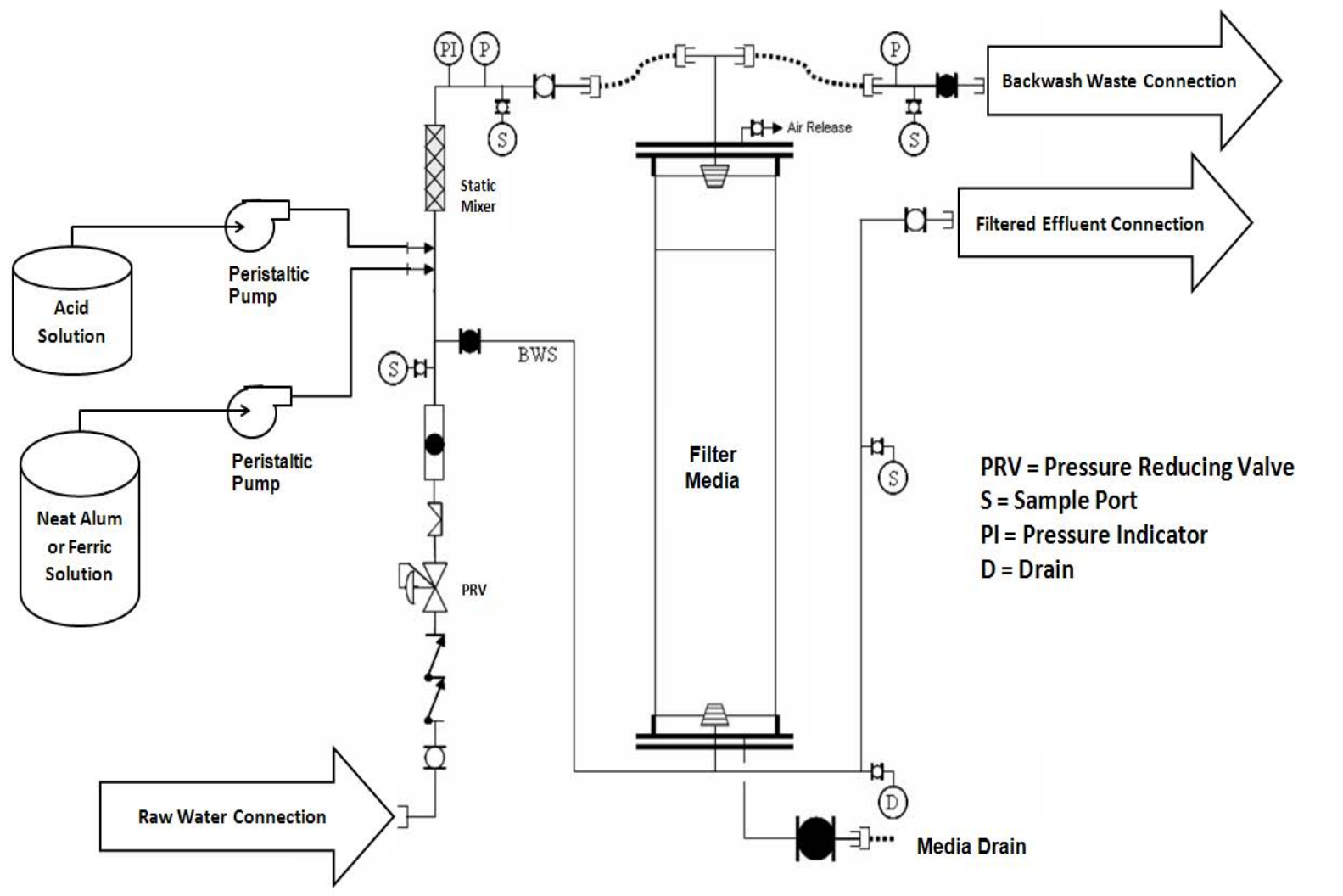
- Identify optimum coagulant and dose:
  - Aluminum Sulfate (alum)
  - Ferric Chloride (ferric)
  - Poly-Aluminum Chloride (SumaClear 700)
  - Polymer addition
- Identify optimal filter media configuration
- Determine impact of chlorine contact time on residual color, and DBP formation
- Identify loading rates, run times, backwash parameters, and waste solids volumes
- Characterize waste solids

Filter Column Pilot Skid

- Physical dimensions: 78"x32"x24"
- Shipping crate dimensions: 79"x36"x25"
- Shipping weight (without media): 400 lbs.
- Flowmeter Range: 0-5 gpm
- Pressure gauge limits: 0-100 psi
- Column Inside Diameter: 6.03 in.
- Column pressure limit: 90 psi
- Column Height: 5 ft (Column extensions can be fabricated and installed upon request.)
- Equipped with:
  - Flow control diaphragm valve.
  - PRV and double check backflow control.
  - 3 chemical feed ports with static mixer down stream
  - Multiple sample ports
  - Garden hose style connections.
  - ½" schedule 80 PVC supply

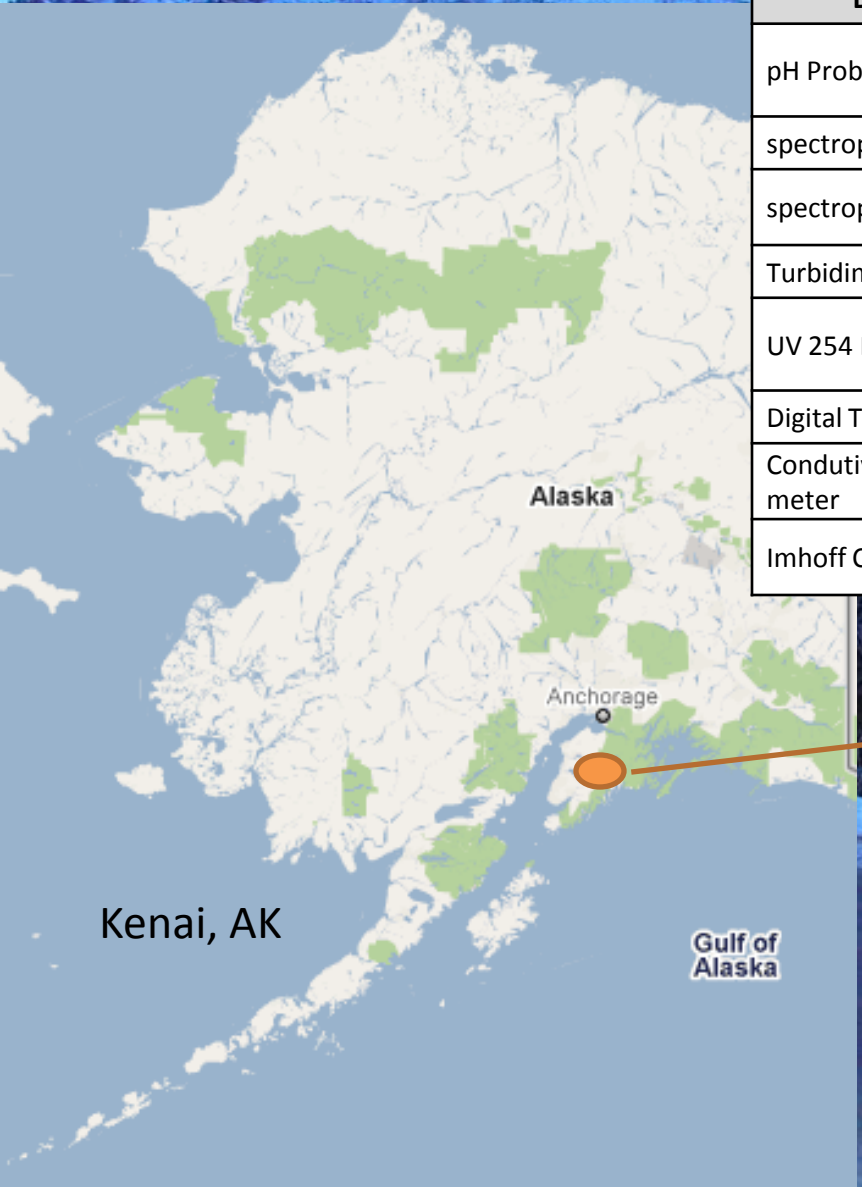


Pilot Unit Process Diagram



Shipping

Device	Manufacturer	Model No.	Analytes Tested
pH Probe	IQ Scientific Instruments	IQ 150 Meter with GP-30probe	pH, Temperature
spectrophotometer	Hach	DR 890	Chlorine, Iron
spectrophotometer	Hach	DR 2800	Color, Aluminum, Iron,
Turbidimeter	Hach	2100P	Tubidity
UV 254 Field Meter	Real Tech	Real Tech UVT Field Meter	UV-A, UV-T
Digital Titrator	Hach	Hach	Alkalinity
Condutivity /TDS meter	Hach	Hach 44600	Conductivity, TDS
Imhoff Cones	Wheaton	1.0 Liter Polycarbonate	Backwash settling rate



Pilot Unit Housing

Testing Schedule

Phase	Objective(s)	Operating Parameters	Testing Configuration	Estimated Duration
Start-up	Set up and connect piloting equipment at North & Spruce Well.	NA	NA	1-2 days
Coagulant Optimization	Determine optimum coagulant dose for Alum and Ferric at maximum filtration rate. PAC jar tests.	20–100 mg/L alum or ferric	36" sand only, 6 gpm/ft^2.	2 days
Configuration Optimization	Determine optimum media configuration and loading rate for maximum run time	2-6 gpm/ft^2, 36" sand, 24" sand w/ 12" anthracite	Optimized coagulant and coagulant dose from Phase 2	3-4 days
Disinfectant and Backwash Waste Studies	Evaluate chlorine effects, characterize BW Waste, DBP tests	1-6 mg/L-Cl_2	Optimized per Phases 2 and 3	1 day
Re-mobilization	Move and reconnect equipment at Well 2	NA	NA	1 day
Coagulant Optimization	Determine optimum coagulant dose chemical selected at North & Spruce	20–100 mg/L alum or ferric	Optimized set-up from North & Spruce	1 days
Configuration Optimization	Determine optimum media configuration and loading rate for maximum run time	2-6 gpm/ft^2, 36" sand, 24" sand w/ 12" anthracite	Optimized coagulant dose from Phase 6	2 days
Disinfectant and Backwash Waste Studies	Evaluate chlorine effects, characterize BW Waste, DBP tests	1-6 mg/L-Cl_2	Optimized per Phases 6 and 7	1 day
Demobilize	Un-hook and pack equipment for shipping. Deliver to shipping port.	NA	NA	1 day

14 Days of Testing

Coagulant Tests:

- Alum + pH Adjustment
- Alum + pH Adjustment + cationic polymer
- Ferric + pH Adjustment
- Ferric + pH Adjustment + cationic polymer
- PACl + pH Adjustment

Media Configurations:

- Filter Sand Only – 36-inches of AWWA B-100-89
- Filter Sand and Anthracite – 24-inches of AWWA B-100-89 filter sand with 12-inches of anthracite

Bench-Scale Testing

Other Tests:

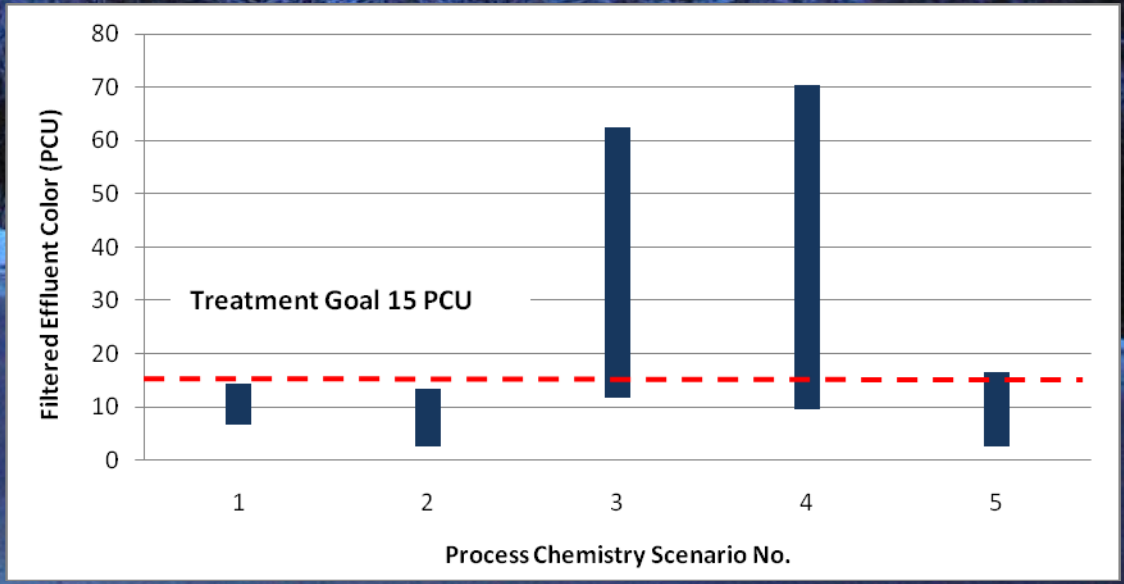
- BWW Turbidity Profiles
- BWW Characterization
- Cl_2 Demand
- DBP Formation

Freezing Conditions

Other Challenges

Piloting Results (North & Spruce)

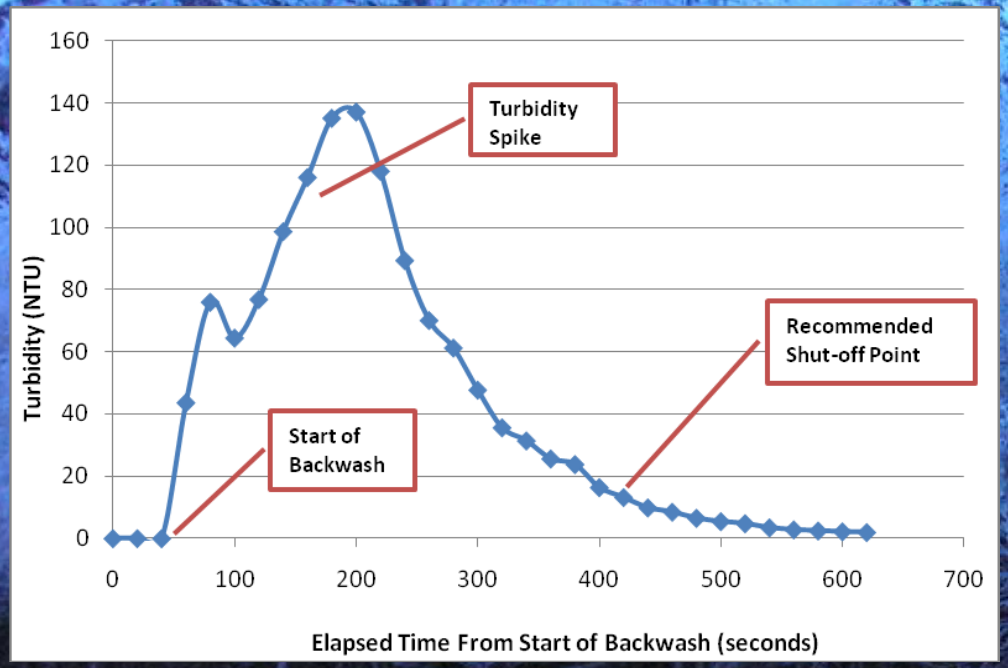
Scenario No.	Scenario Chemicals	Optimized Coagulant Dose Range (mg/L)	Cationic Polymer Dose (mg/L)	Optimized Process pH	Required Acid Dose (mg/L)	Typical Effluent Color Range (PCU)
1	Alum	60-63	0	6.7	20	9-12
2	Alum + Polymer	60-65	0.5	6.7	22	5-11
3	Ferric	64-65	0	6.2	0	14-60
4	Ferric + Polymer	35-40	0.5	6.4	13	12-68
5	PACl	18-22	0	6.5	20	5-14



Piloting Result (North & Spruce)

- Filtration Rates at North and Spruce Well
  - 2 gpm/sft to achieve an 8 hour run
  - 6 gpm/ft resulted in 3 hr run
- No meaningful difference between media configurations.
- Stable Chlorine residuals after breakpoint chlorination.
- Chlorine Contact time had negligible impact on finished water color.

Piloting Results (North & Spruce)

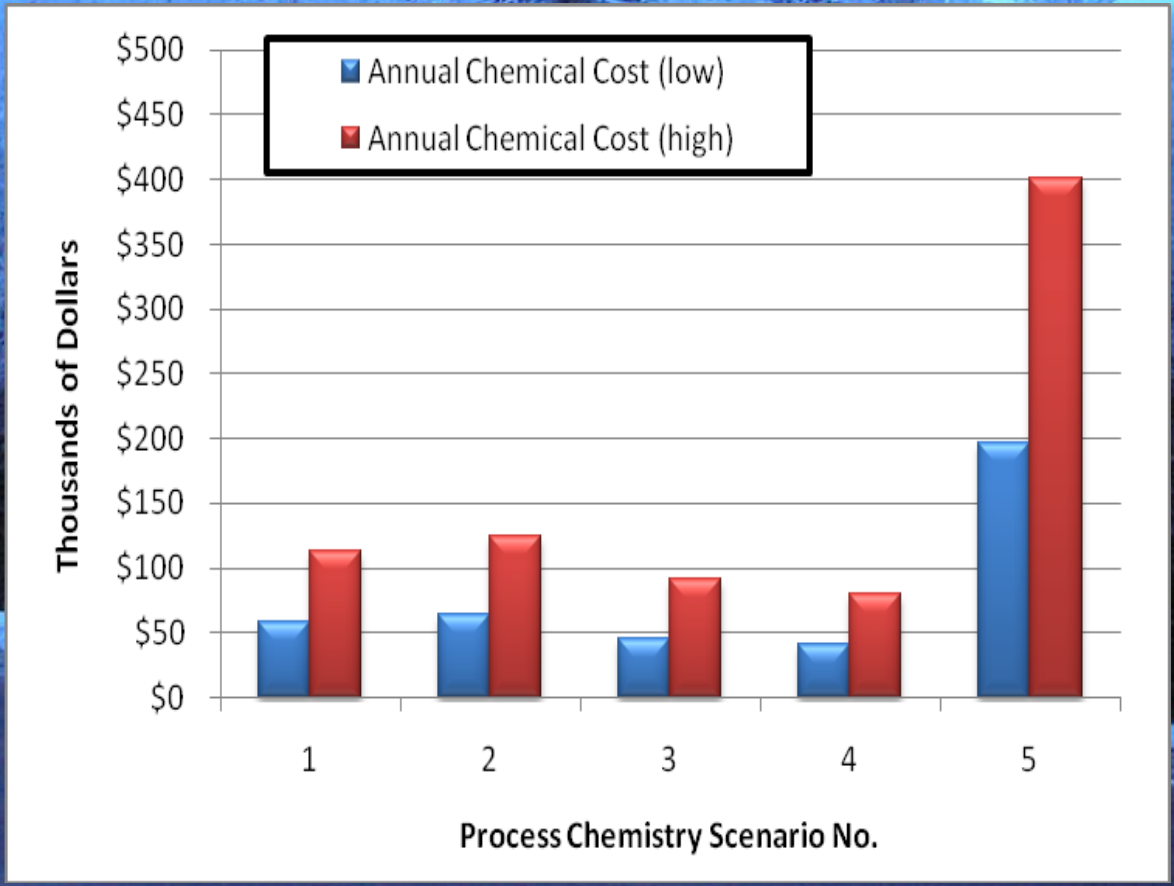


Run #	Backwash Loading Rate (gpm/sft)	Backwash Time (minutes)	Anticipated Water per Backwash at 0.75 MGD (gal)	Anticipated Water per Backwash at 1.5 MGD (gal)
1	14.9	5.6	17,356	34,794
2	14.9	7.0	21,694	43,493
3	13.8	7.0	20,093	40,282
5	16.5	5.3	18,190	36,467
		AVERAGE:	19,333	38,759

Very poor settling of backwash waste sludge without polymer addition

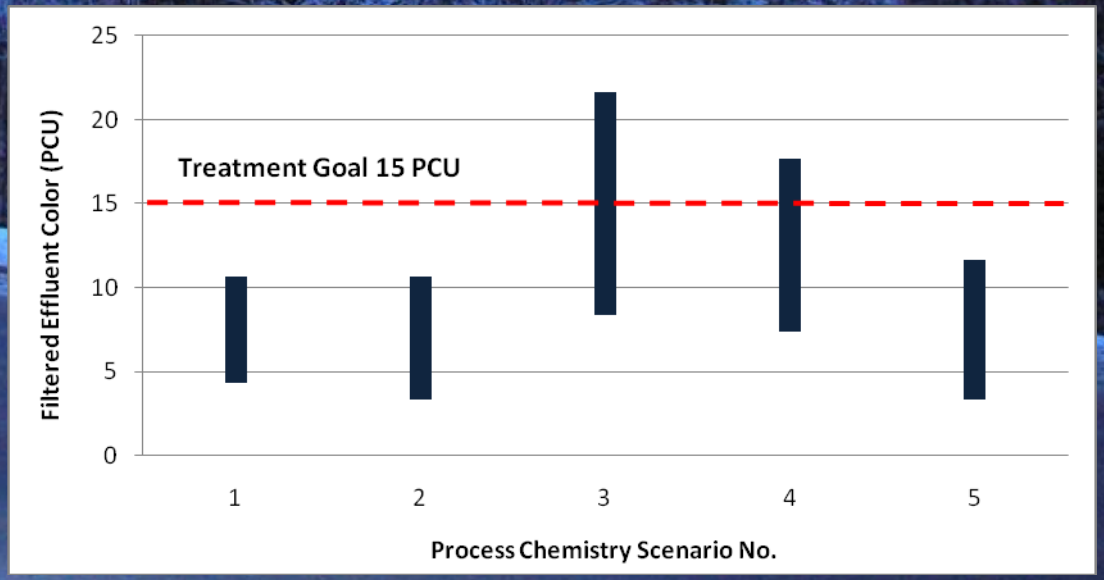
Piloting Results (North & Spruce)

Scenario No.	Scenario Chemicals
1	Alum
2	Alum + Polymer
3	Ferric
4	Ferric + Polymer
5	PACl



Piloting Results (Well 2)

Scenario No.	Process Chemicals	Optimized Coagulant Dose Range (mg/L)	Cationic Polymer Dose (mg/L)	Optimized Process pH	Required Acid Dose (mg/L)	Typical (PCU)
1	Alum	34-37	0	6.7	20	5-10
2	Alum + Polymer	33-37	0.25 - 0.5	6.7	20	4-10
3	Ferric	30	0	6.5	15	9-21
4	Ferric + Polymer	28	0.5	6.5	10	8-17
5	PACl	12	0	6.5	20	4-11



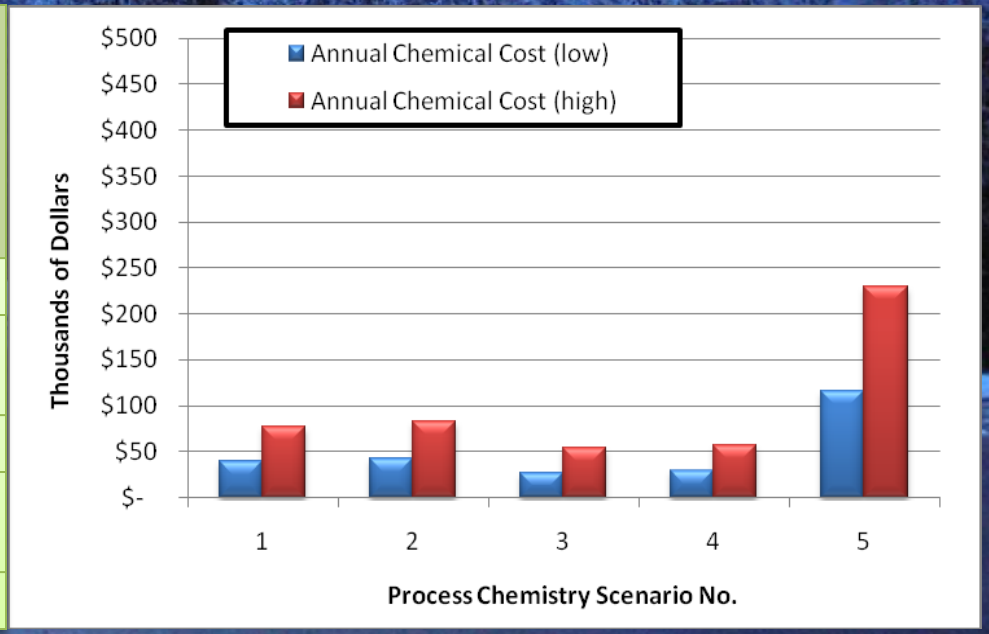
Piloting Result (Well 2)

- Filtration Rates at Well 2
  - 6 gpm/sft to achieve an 8 hour run
- No meaningful difference between media configurations
- DBP formation in filtered water << than Stage 2 MCLs
- Chlorine Demand Minimal
- Finished pH low for LCR compliance (6.5 – 6.7)

Piloting Result (Well 2)

Run #	Backwash Loading Rate (gpm/sft)	Backwash Time (minutes)	Anticipated Water per Backwash at 0.75 MGD (gal)	Anticipated Water per Backwash at 1.5 MGD (gal)
1	16.5	6.6	9,474	18,840
2	14.3	6.6	8,211	16,328
3	12.5	8.0	8,700	17,300
		AVERAGE:	8,795	17,489

Scenario No.	Scenario Chemicals
1	Alum
2	Alum + Polymer
3	Ferric
4	Ferric + Polymer
5	PACl



Recommendations

- Alum with pH adjustment
  - provided most consistent and cost effective results
- pH adjustment of filtered water with NaOH required
- Polymer Required to Settle BWW sludge, but up to 90% recycling of supernatant feasible

City Decision

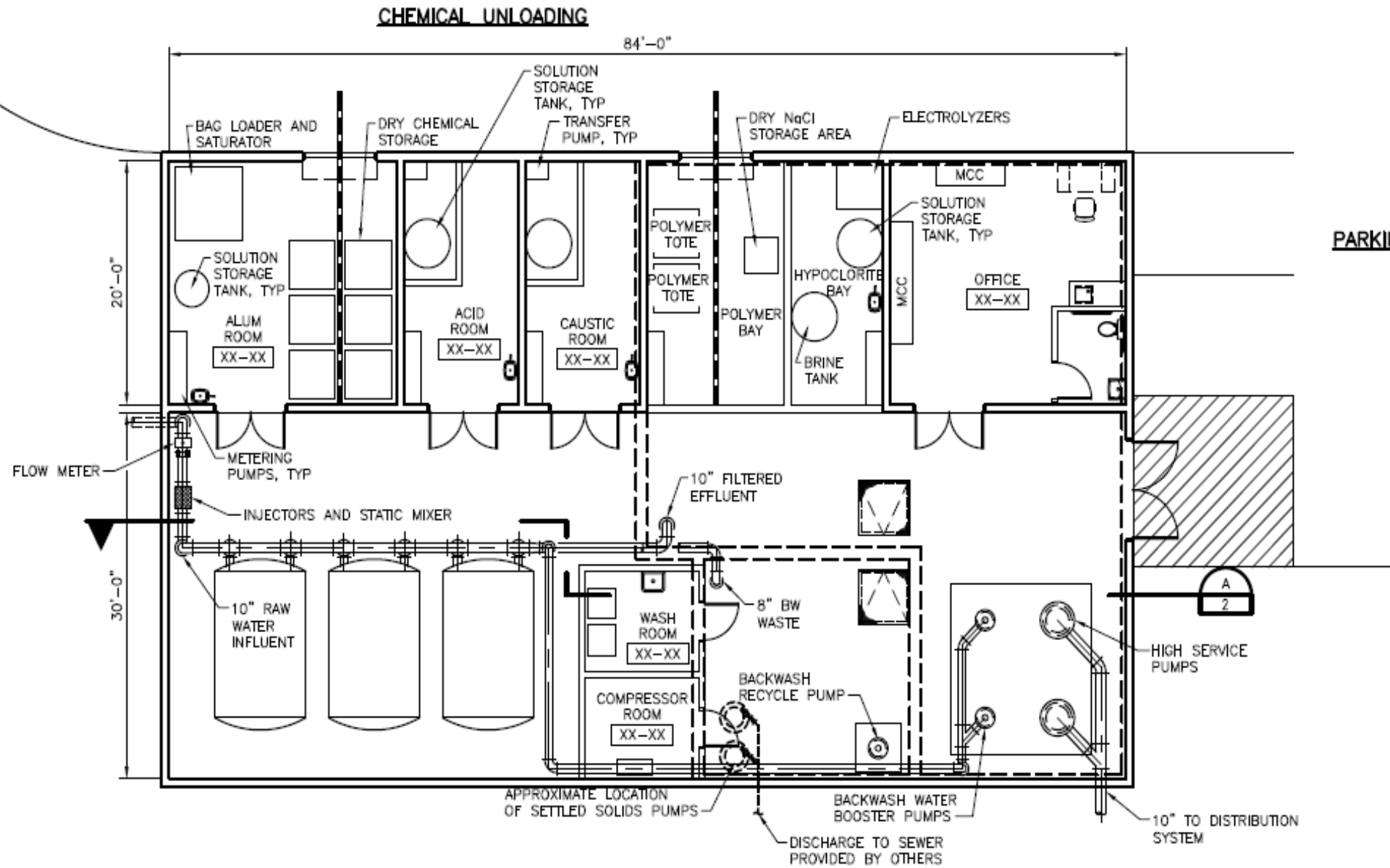
- Chemical Demand at North and Spruce too High
  - Expand Capacity of Well 2 to 2 MGD and Abandon North & Spruce
  - Chemical use and storage based on 1.5 MGD average daily demand
  - Provide Basis of Design for Well 2 facility using dry alum, neat 98% acid, 25% caustic, and on-site hypochlorite generation

Basis of Design

- Chemical use for 1.5 MGD average daily demand at Well 2:

Alum	463lbs/day
Acid	275lbs/day
Caustic	156lbs/day
Chlorine	20lbs/day - Cl_2

Conceptual Layout (#1)



Basis of Design

- More chemicals than city operators were comfortable with.
- Loading dry chemical to hoppers represented operational burden greater than anticipated.
- Re-evaluate IX; previously removed from consideration due to waste considerations

IX Evaluation (By Others)

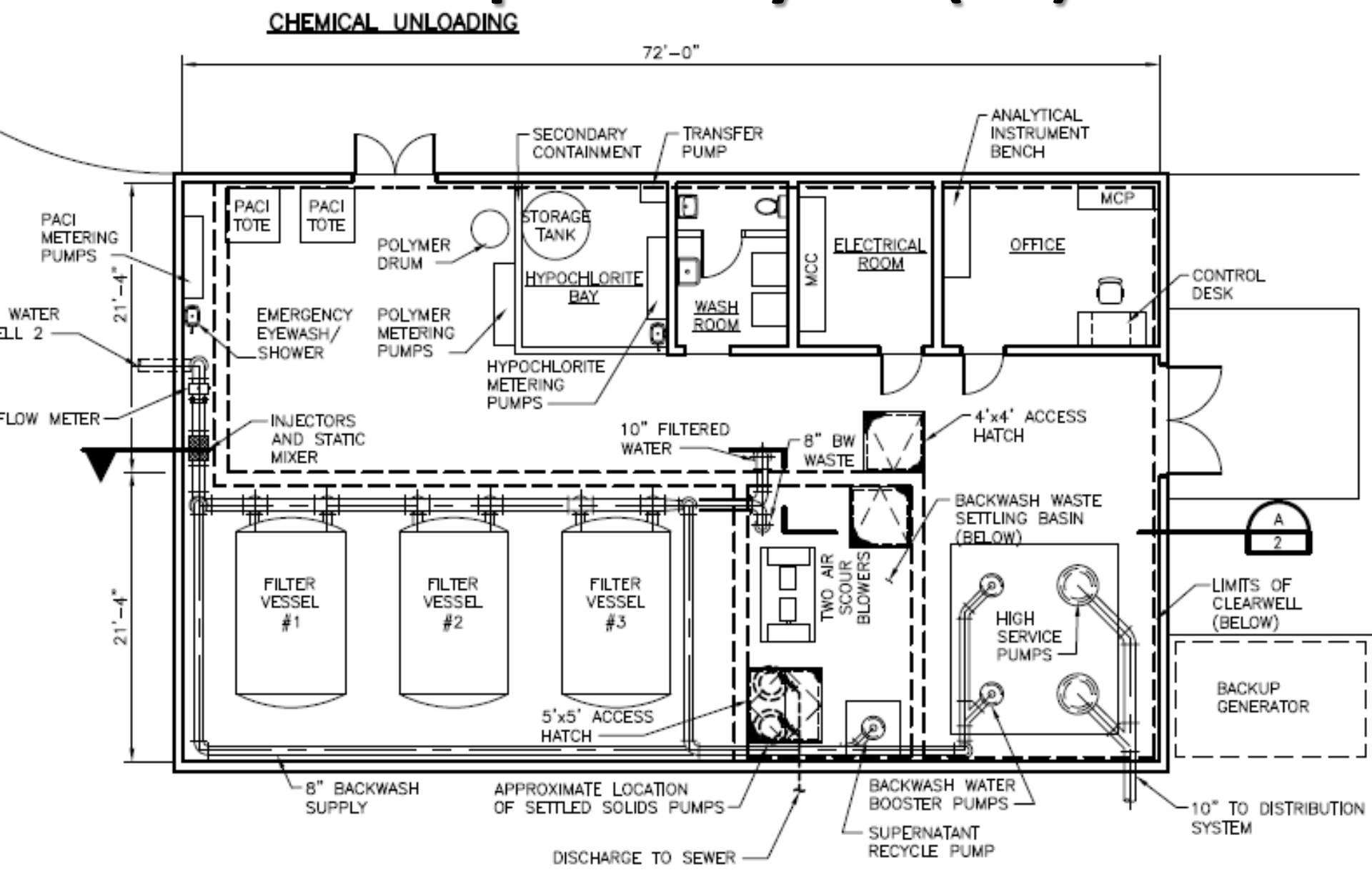
- Also required H_2SO_4 and NaOH.
- Space required for 30 tons/month salt for regeneration.
- No discharge of waste brine to wastewater plant.
- Brine corrosive to pumps.
- 65,000 gallon exterior tank required for waste treatment prior to discharge.

Basis of Design 2

- Coagulation/filtration piloting results indicated color reduction to 20 PCU using PACl without pH adjustment.
- City accepted not quite meeting secondary MCL, while reducing O&M costs and complexity.
- Chemical use for 1.5 MGD average daily demand:

PACl	13-20gal/day

Conceptual Layout (#2)



(Final Design included 36,000 gal Waste Tank Outdoors)

Thank You