Water Reuse Pilot: Influence of Operations on Membrane Performance

Spokane, Washington

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SPOKANE
Water Quality Improvement Program

CITY OF SPOKANE

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Topics of Discussion

- Background / Need
  - » Local resources
  - » Protecting the Spokane River
- Pilot Testing Program
  - » Objectives
  - » Process descriptions
- Results and Next Steps
  - » Brief summary of test results
  - » Full-scale implementation

Top view of Spokane pilot UF membrane fibers

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Background: City of Spokane

- Formed in 1881
  - » 0.2 M (city limits)
  - » 0.5 M (county)
  - » 160 mi^2 service
- Well Water Supply
  - » 50 Wells within service area
  - » ~275 MGD
  - » 22 Billion Gallons Per Year (1998)

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Background: City of Spokane

- Riverside Park Wastewater Reclamation Facility (RPWRF)
  - » 44 MGD Design Average
  - » 100 MGD Wet weather flow full treatment for limited duration

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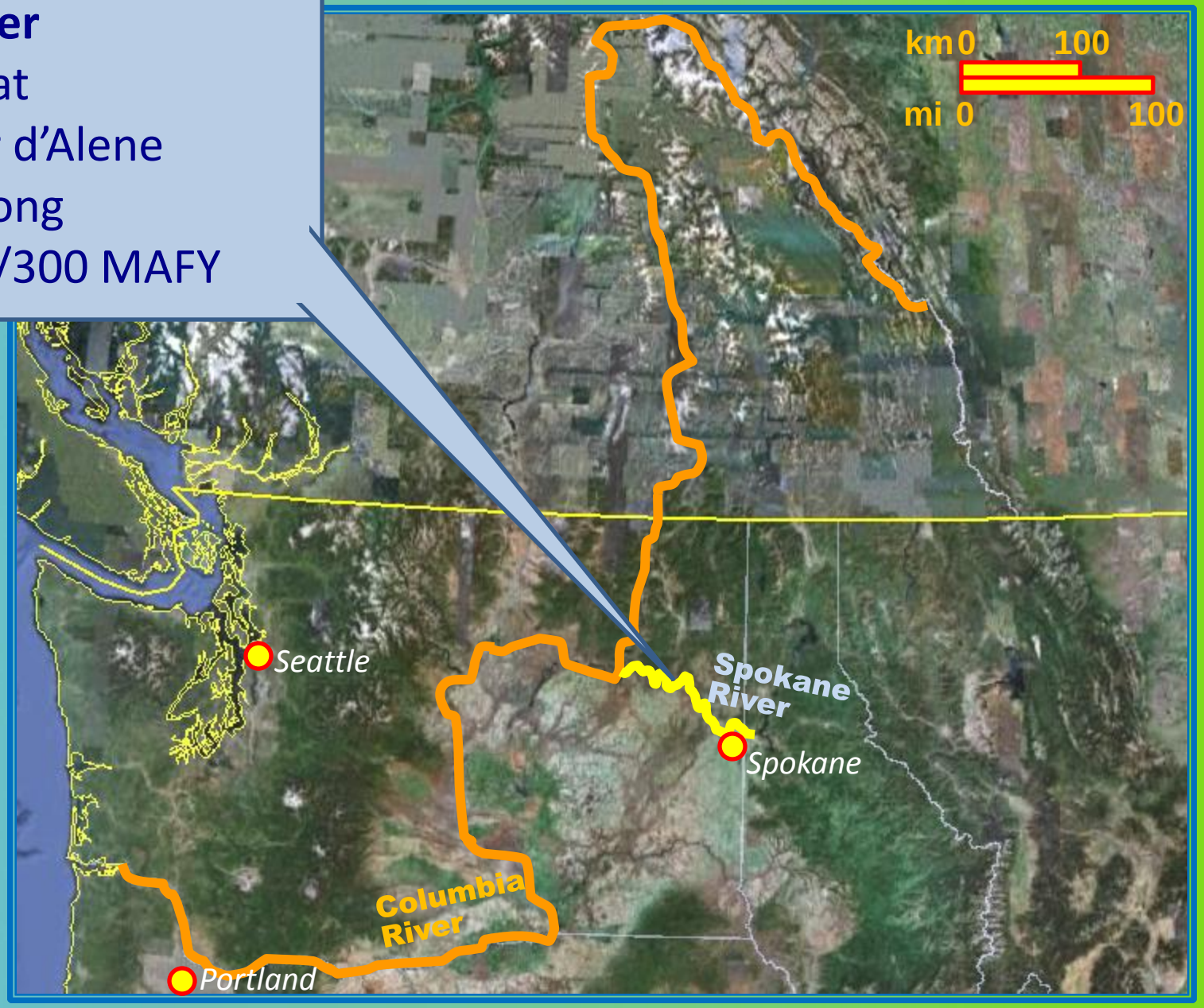
Spokane River

- Originates at Lake Coeur d'Alene
- 111 miles long
- 10,000 CFS/300 MAFY



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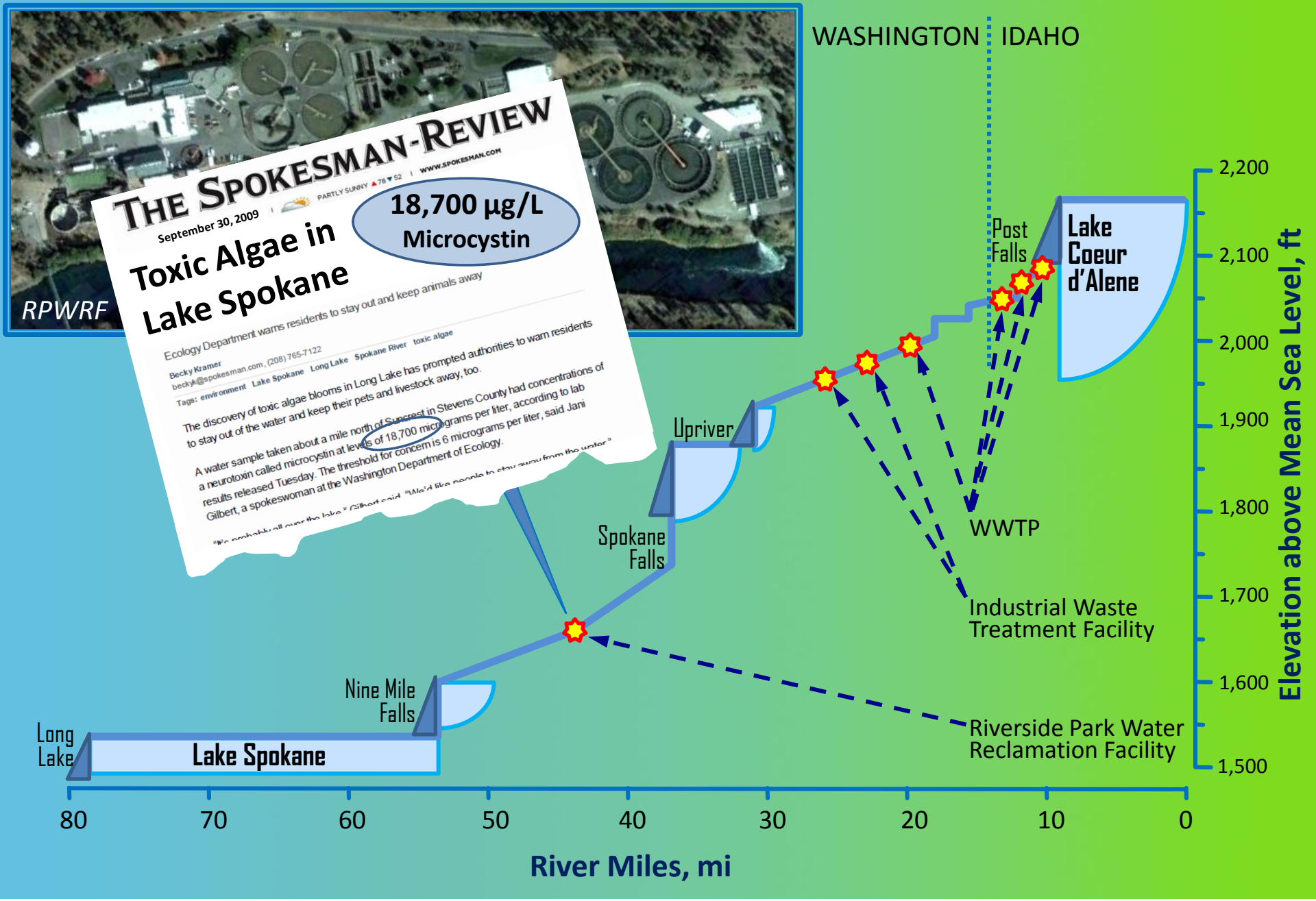
RPWRF
THE SPOKESMAN-REVIEW
September 30, 2009
WWW.SPOKESMAN.COM
Toxic Algae in Lake Spokane
18,700 µg/L Microcystin
Ecology Department warns residents to stay out and keep animals away
Becky Kramer
becky@spokesman.com, (208) 765-7122
Tags: environment Lake Spokane Long Lake Spokane River toxic algae
The discovery of toxic algae blooms in Long Lake has prompted authorities to warn residents to stay out of the water and keep their pets and livestock away, too.
A water sample taken about a mile north of Suncrest in Stevens County had concentrations of a neurotoxin called microcystin at levels of 18,700 micrograms per liter, according to lab results released Tuesday. The threshold for concern is 6 micrograms per liter, said Jani Gilbert, a spokeswoman at the Washington Department of Ecology.
WASHINGTON
IDAHO
Post Falls
Lake Coeur d'Alene
Upriver
Spokane Falls
Nine Mile Falls
Long Lake
Lake Spokane
WWTP
Industrial Waste Treatment Facility
Riverside Park Water Reclamation Facility
2,200
2,100
2,000
1,900
1,800
1,700
1,600
1,500
Elevation above Mean Sea Level, ft
80
70
60
50
40
30
20
10
0
River Miles, mi

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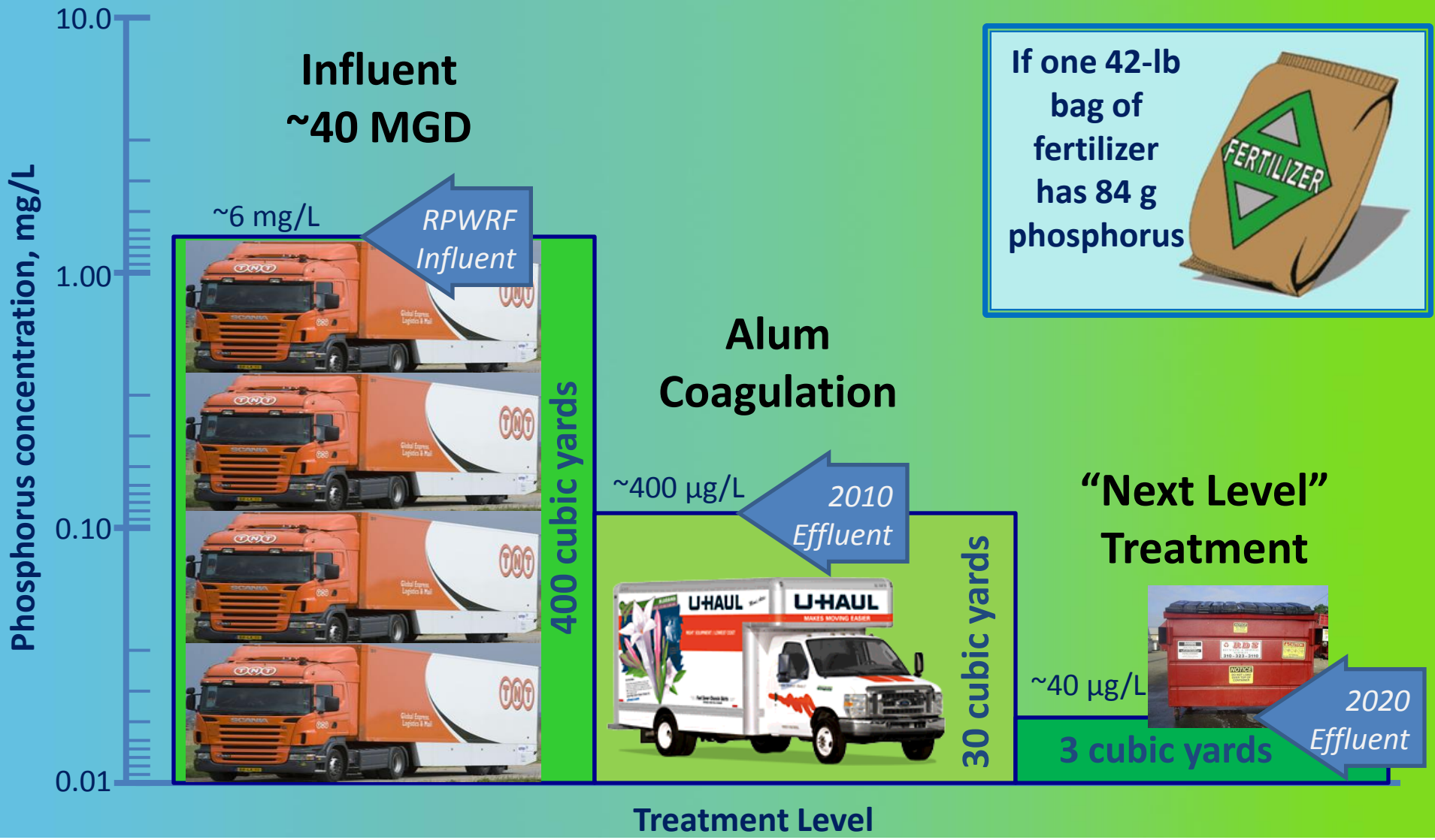
RPWRF Phosphorus Treatment Requirements



If one 42-lb bag of fertilizer has 84 g phosphorus

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Why a RPWRF Reuse Pilot Program?

- Can Reuse Reduce P-Removal Cost?
- What Are Appropriate Technologies?
- Water Quality and Treatment Design Criteria
  - Process (engineering)
  - Application (agronomics)

Topics of Discussion

- Background / Need
  - » Local resources
  - » Protecting the Spokane River
- Pilot Testing Program
  - » Objectives and goals
  - » Process descriptions
- Results
  - » Brief summary of test results

River Front Park at the Spokane Falls

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RPWRF Reuse Testing Objectives

- Water Quality and Treatment Assessments
  - » Meet State Class A Quality Requirements
  - » Identify design operating criteria / flux rates
    - **Peak**
    - **Average**
  - » Ensure capability to treat RPWRF 2° clarified effluent
- Public Acceptance
  - » Demonstrate water conservation potential
  - » Identify agronomic effects for City Golf Dept.
  - » Identify benefits to RPWRF and Spokane River
- Other? (Integrate System Design w/ P-Removal?)

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RPWRF Reuse Operating Goals

- Regulatory (Class A Reuse Requirements)
  - Fully oxidized (significant dissolved oxygen)
  - 6.5 < pH < 8.5
  - TSS < 30 mg/L
  - BOD_5 < 30 mg/L
  - 7-day median Total Coliform ≤ 2.2/100 mL; always ≤ 23/100 mL
  - Daily average turbidity ≤2 NTU and always <5 NTU
- Operations
  - Balance flux rates and need for chemical cleaning
  - Determine impacts to the pilot UF system from upsets to the current RPWRF treatment process

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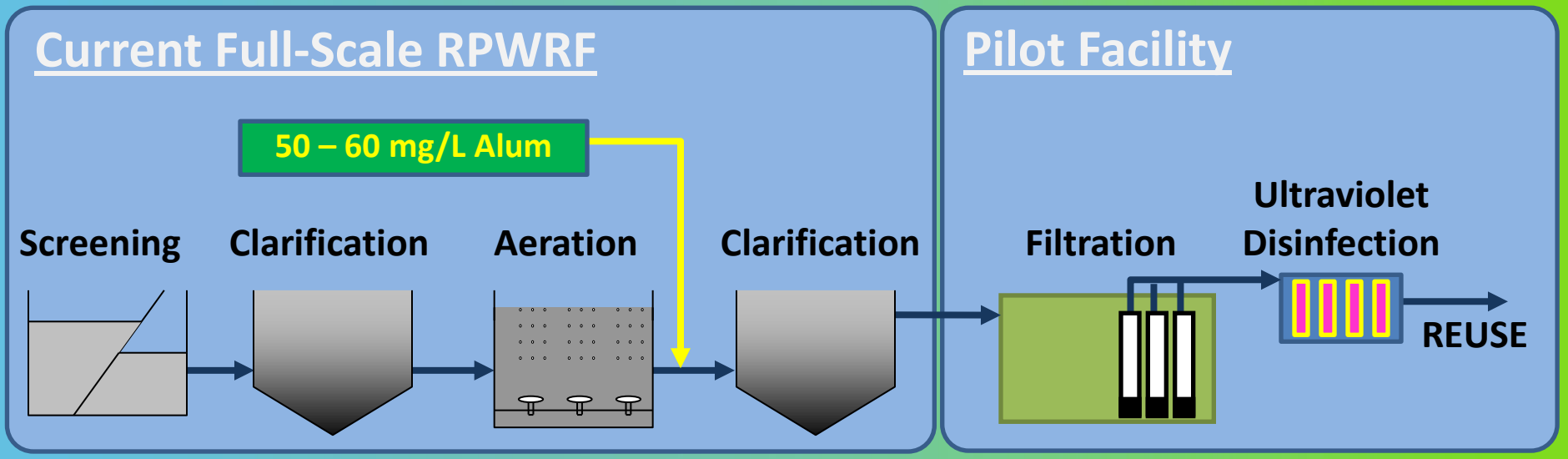
RPWRF Reuse Pilot Program: How?



- Ultrafiltration & Ultraviolet Disinfection Technologies Chosen
- Phased Testing
  - » 2007: Startup / debugging
  - » 2008-2011: Optimize operations and design criteria

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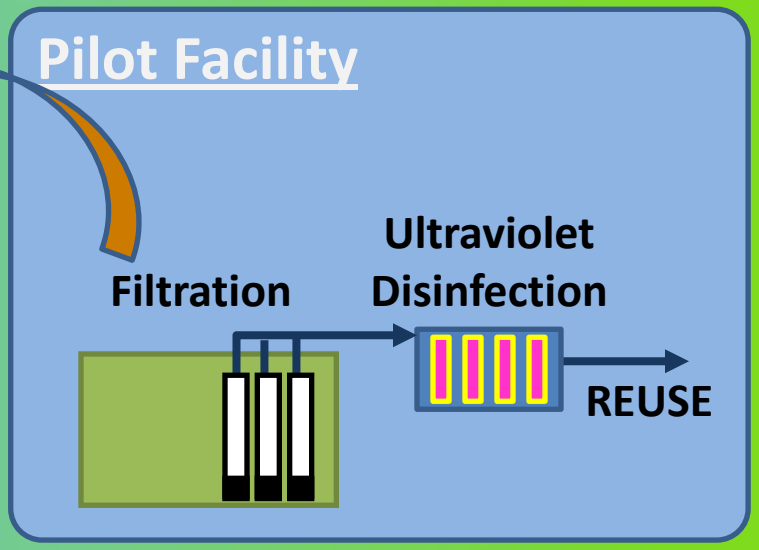
RPWRF Reuse Pilot Program: Filtration



- Vacuum Hollow Fiber
  - » Submerged, Outside in flow path
  - » 0.05 µm pore size
  - » 2 module x 323 ft^2 each

- Operational variables
  - » Flux (GFD, lmh)
  - » Trans-mem.-press. (psi, bar)
  - » Cycles / Tank Drain
  - » Backflush settings
  - » Maintenance Clean Settings

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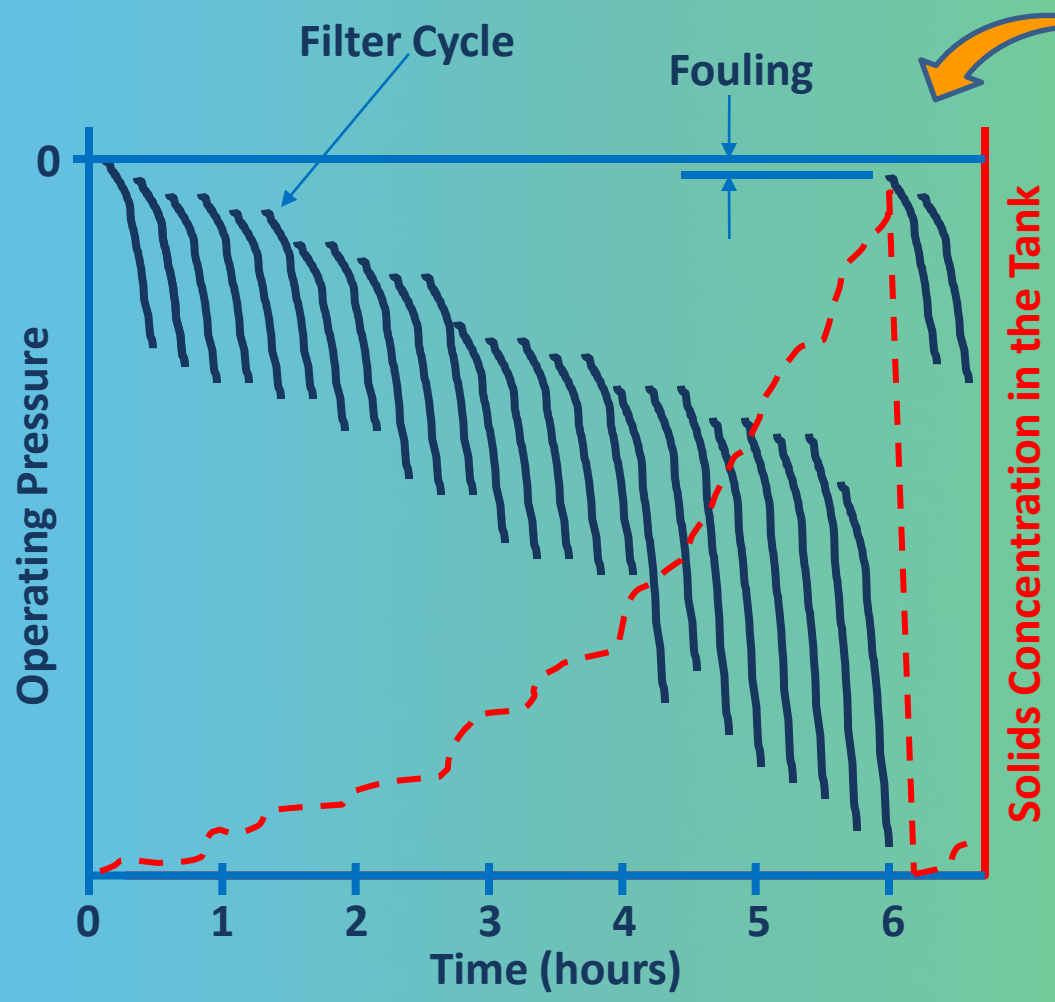
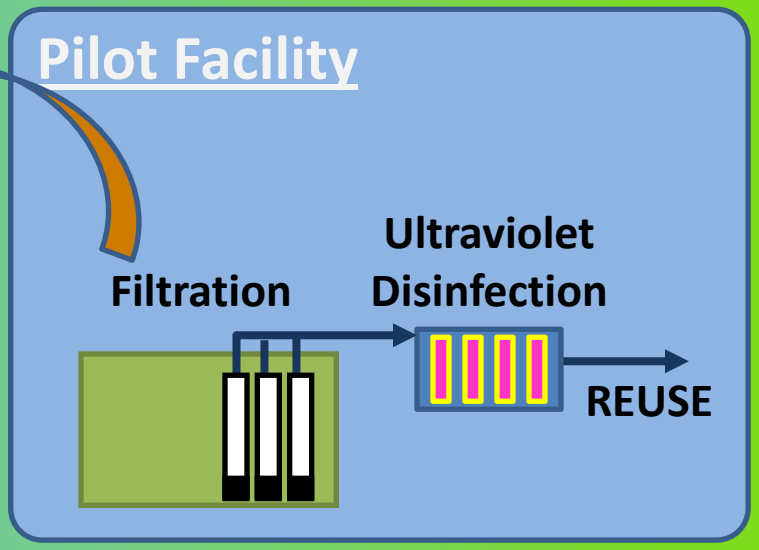
RPWRF Reuse Pilot Program: Filtration



Conceptualization of Filter Run



- Typical Filter Run
  - **Filter cycle (~13 min)**
  - **Backflush after each cycle**
    - Air-scour assisted
    - 30 seconds (<2 GPM)
  - **25 Cycles per run**
  - **Tank drain at end of run**
    - Air-scour assisted
    - Complete drain and re-fill

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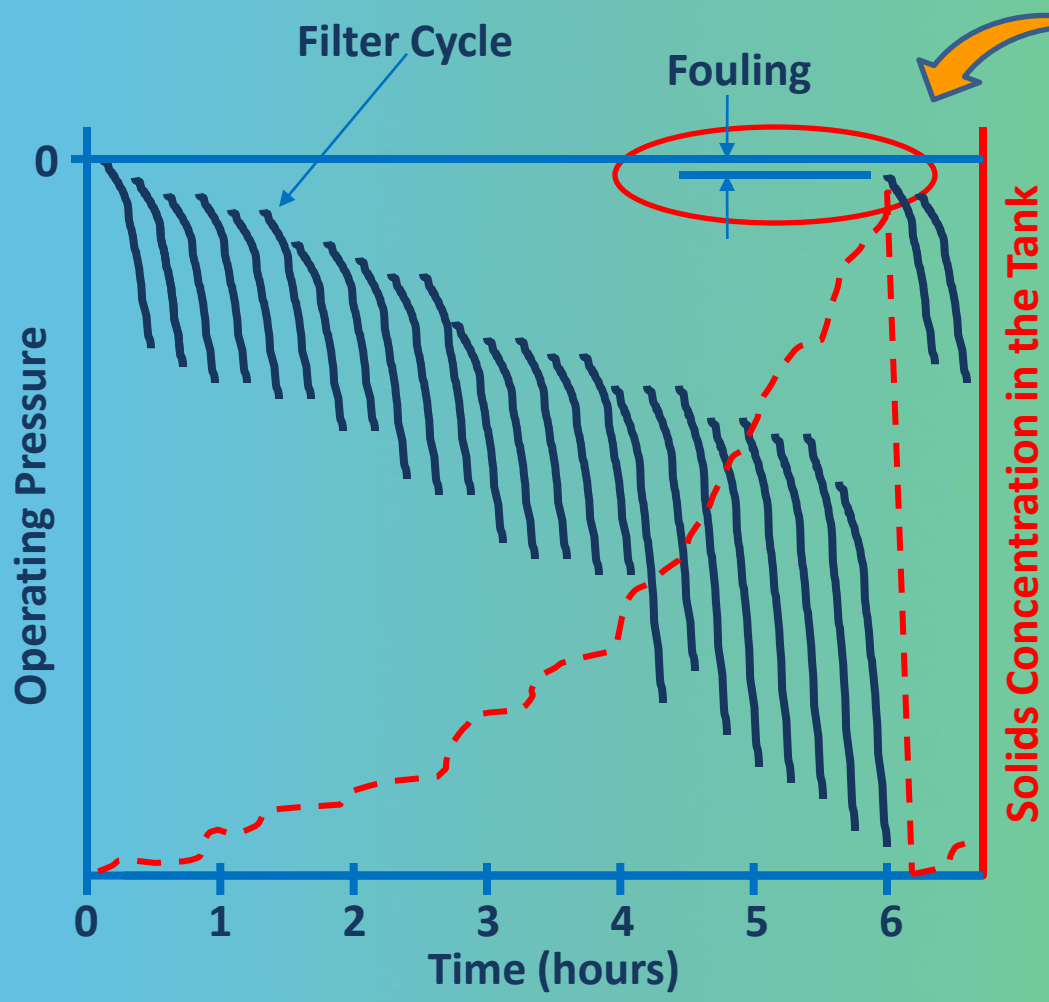
RPWRF Reuse Pilot Program: Filtration



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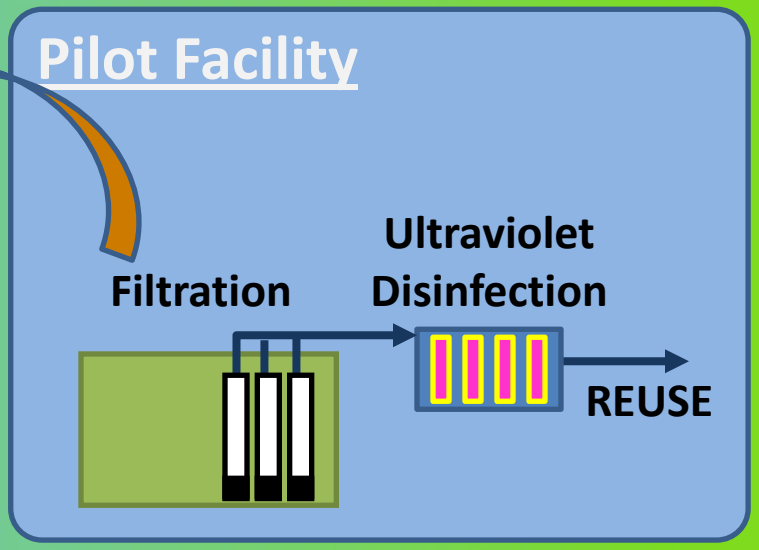

- In situ Maintenance Clean
  - ~ 30 min. Oxidant soak (sodium hypochlorite) removes organic fouling
  - ~ 30 min. Acid soak (citric acid) removes inorganic fouling
  - Typically use both in sequence

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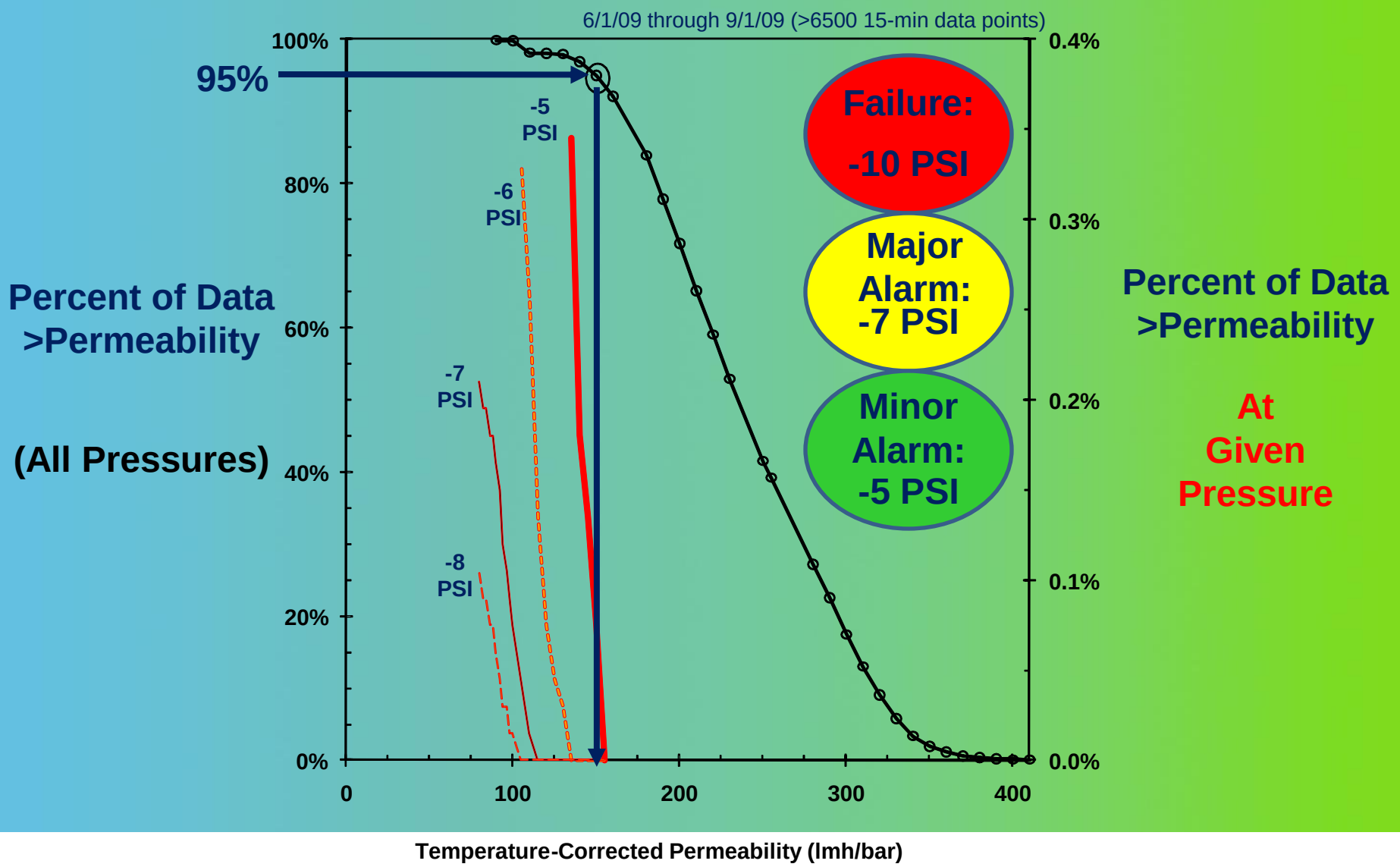
Identification of End-of-Filter-Run



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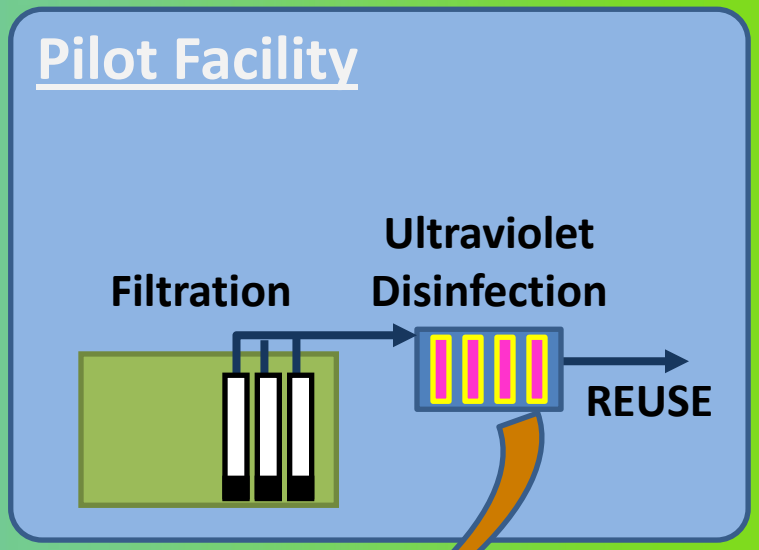
RPWRF Reuse Pilot Program: Disinfection



- 80 mJ/cm^2 design dose
  - » Actually operated at higher dose
  - » One standby reactor

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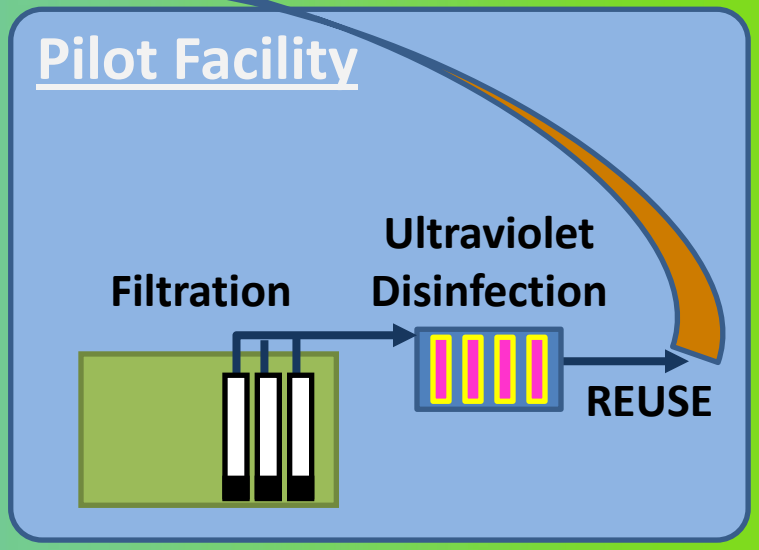
RPWRF Reuse Pilot Program: Distribution



- Two Application Sites
  - » City golf courses
  - » 14,000 Gal (Treatment)
  - » 18,400 Gal (Downriver)
  - » 25,000 Gal (Qualchan)
  - » Turf studies by Washington State Univ.

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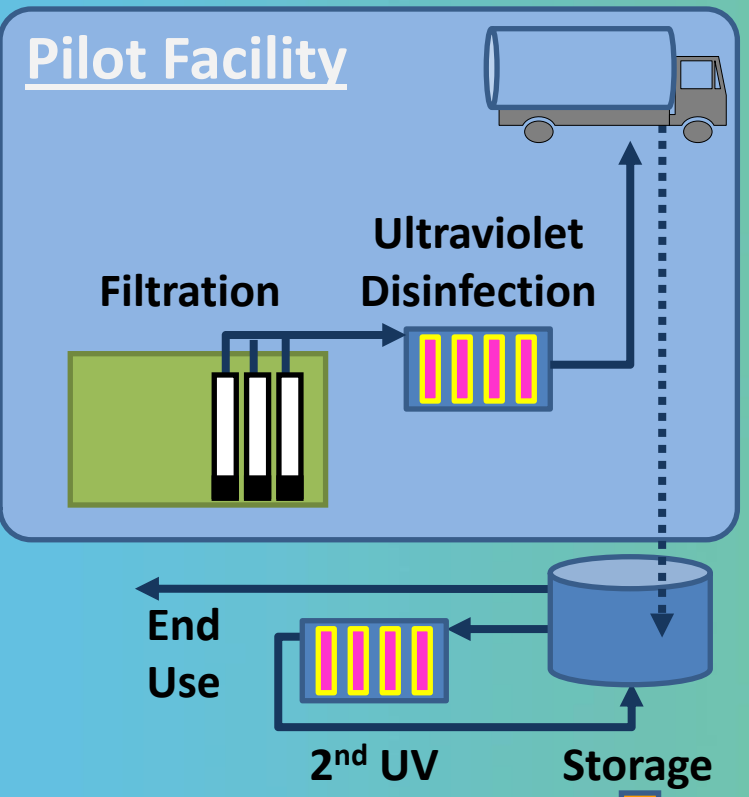
RPWRF Reuse Pilot Program: Use



- Add Residual Cl_2<< 3 ppm
- No Coliforms
- Meet Golf Irrigation Demand

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- Results and Next Steps
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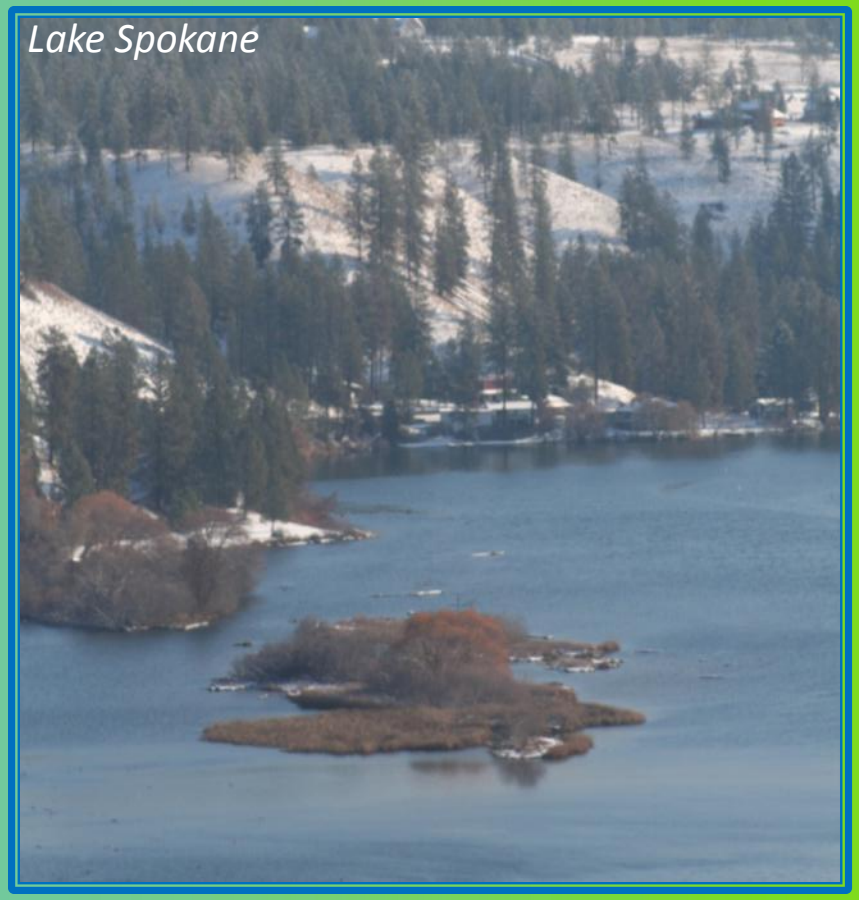
  - » Full-scale implementation



Winter view of the Lake

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Water Quality Summary

	Raw	Regulation	Min	Avg.	Max
Alkalinity	40 - 150	---	87	96	105
BOD_5, mg/L	3 - 20	≤30 mg/L	0.04	1	10
pH, units	5.2 - 8.3	6.5 – 8.5	6.5	7.4	7.8
Tot. Phosphorus, mg/L	0.2 - 3.3	---	0.1	0.1	0.5
Tot. Coliforms, #/100 mL	TNTC	≤2	<1	<1	2
Temperature, ^oC	---	---	15.5	19.6	24.3
TDS, mg/L	245 - 353	---	---	---	---
Transmittance, Percent	69 - 83	---	71	80	87
TSS, mg/L	2 - 24	≤30	<1	<1	1.6
Turbidity, NTU	---	<2	0.03	0.04	0.16

--- = No value recorded

Does not include 2010 data

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Spokane UF Pilot Operational Parameters

- Flux Settings
  - 30 lmh (18 gfd) to 76 lmh (45 gfd)
- Level Control Setting
  - Set point 87%
- Permeate Pressure
  - Ranged from ~0 to failure set point of -10 psi during normal operations
- Maintenance Clean
  - ~30 min. soak in oxidant and/or followed by ~30 min. acid soak
- Cycles / Drain
  - Filter run duration
    - 12 hr filter runs (50 cycles / tank drain)
    - 6 hr runs (25 cycles / tank drain)
  - Cycle Duration: 800 sec. (~13 min.) to 1600 s (~26 min.)
- Seasonal Alum Addition
  - ~May to October Alum is added before Secondary Clarifiers to remove P in the summer
  - ~November to April no alum is added before Secondary Clarifiers

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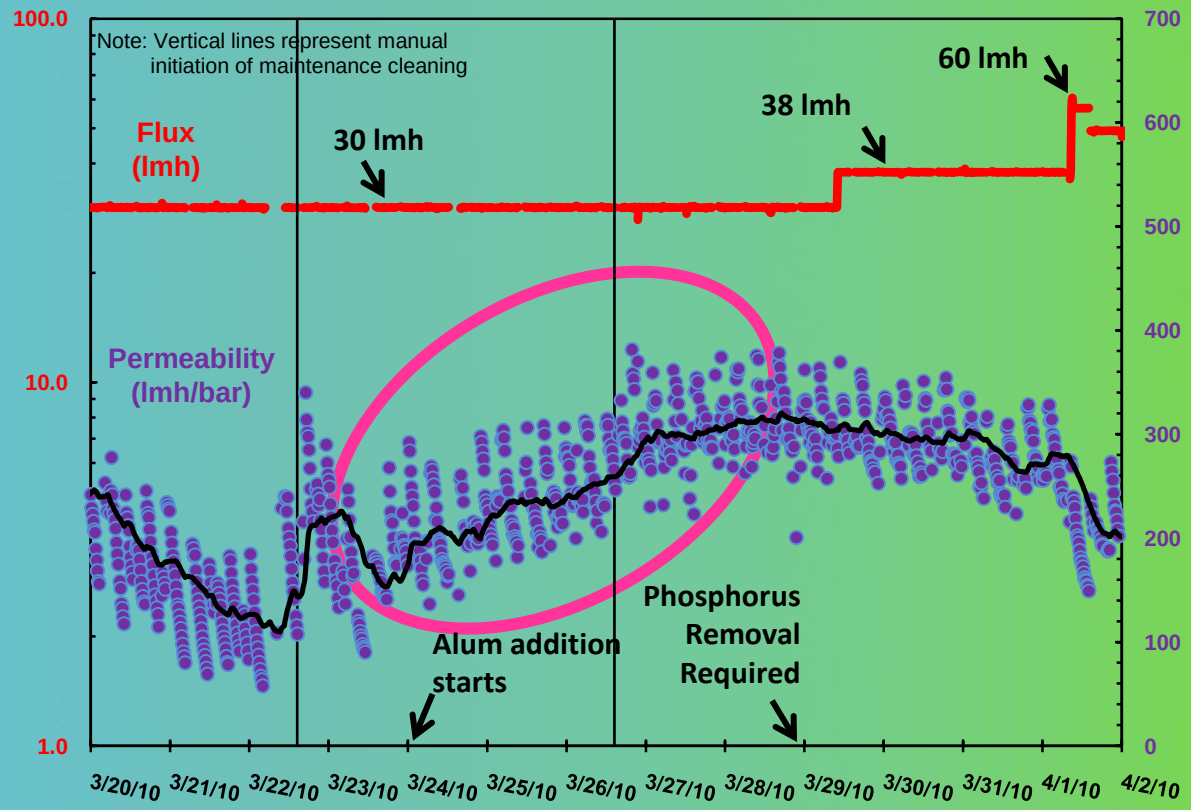
Seasonal Alum Addition Influence

- Alum Addition ~ May to Oct
  - » Change in pilot influent characteristics
    - Decrease in Phosphorus, BOD_5, and TSS
  - » Permeability increases allowing higher operational fluxes (45 – 70 lmh)
- No Alum Addition ~ Nov to Apr
  - » Change in pilot influent characteristics
    - Increase in Phosphorus, BOD_5, and TSS
  - » Permeability decreases lowering operational fluxes (30 – 37.5 lmh)



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Spokane Pilot UF Flux Rate Analysis

Hours of Filter Operation

Flux	Manually Terminated Filter Operation			Failure-Terminated Filter Operation		
	Min	Avg.	Max	Min	Avg.	Max
❑ 53 lmh	22	86	128	6	44	124
❑ 64 lmh	7	59	97	90	93	95
❑ 70 lmh	6	32	84	17	26	38
❑ 76 lmh	2	32	117	---	---	---

Notes:

» 45 lmh has been well established to operate monthly w/o failure

» Does not include 2010 data

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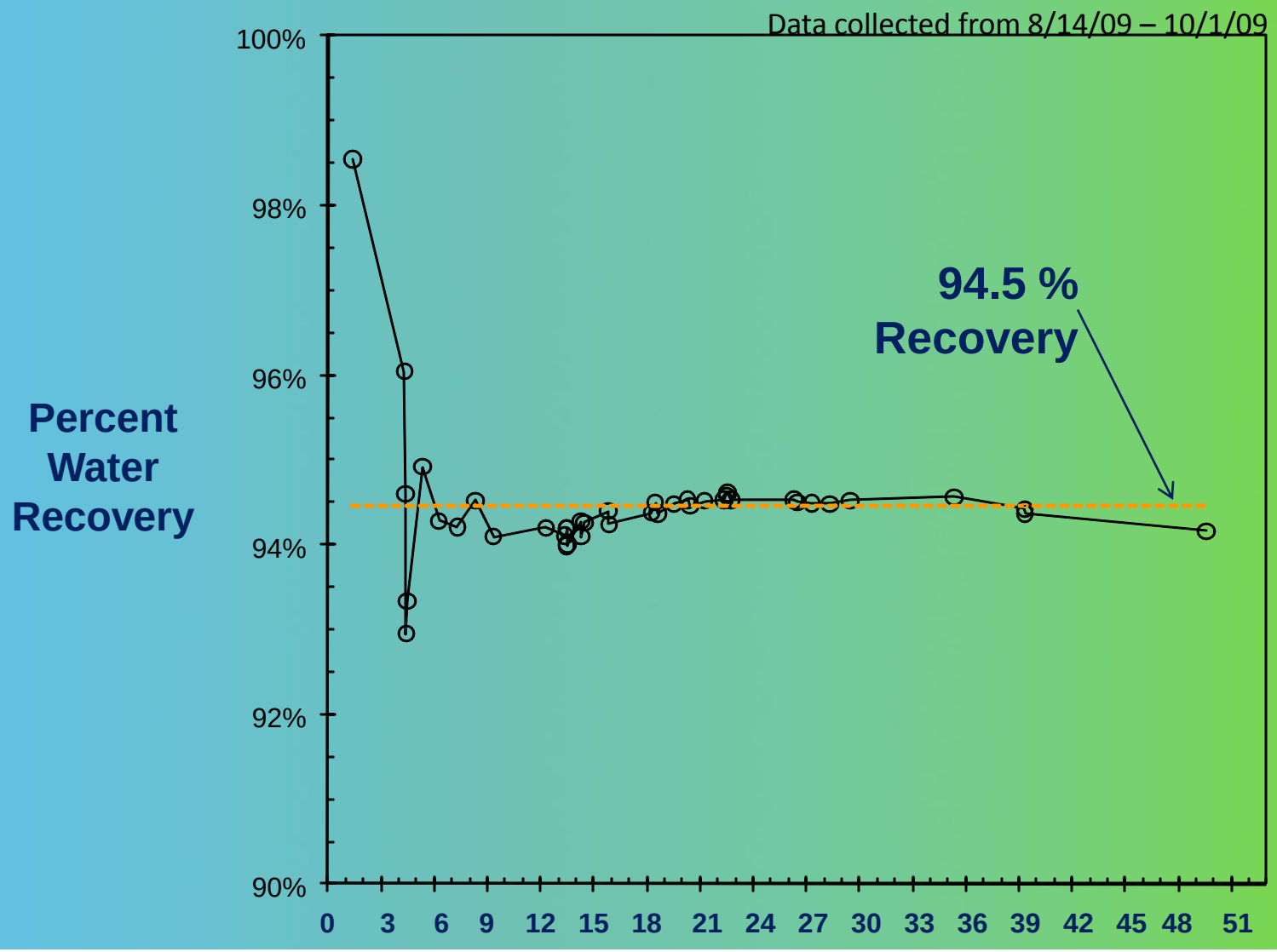
Site Specific Operational Parameters

Flux	Approx. Avg. Maintenance Clean Frequency	Cycle Duration	Cycles / Tank Drain
❑ 45 lmh	1 / 2-3 weeks	800 sec	50
❑ 53 lmh	1 / week	800 sec	25
❑ 64 lmh	2-3 / week	800 sec	25
❑ 70 lmh	Daily	800 sec	25
❑ 76 lmh	Daily	800 sec	25

Spokane Pilot UF Water Recovery



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RPWRF Reuse Testing Results

- Class A Water Requirements Met
  - » Coliforms effectively controlled
- Identified potential design operating criteria/fluxes
  - » Long-term operation at 45 lmh
  - » Peak day operation at 64-76 lmh
- Met Client's Daily Watering Demands
- Agronomic Impacts: Reuse Benefits
- Feasible Reuse Options for City
  - » Potential to reduce cost of P-removal facilities

RPWRF Reuse Next Steps

- Feasibility Study
  - » Identify customers and municipal needs
    - **Golf**
    - **Transportation landscaping / greenbelts**
    - **Local cemeteries**
    - **Industrial**
  - » Cost benefit analysis
- Preliminary Design
  - » Siting and configuration: RPWRF

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