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Optimizing Distribution Storage O&M at Seattle Public Utilities

AWWA-PNWS Conference

Tacoma, WA

May 12-14, 2010

Alex Chen, Cheryl Capron,
Jeff Simmons, Darrin Brown and Matt Vining

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Agenda

- Background
- Asset management for storage facilities
- Storage maintenance activities
  - Sanitary inspection
  - Washing
  - Structural & coating inspection
  - Other inspections

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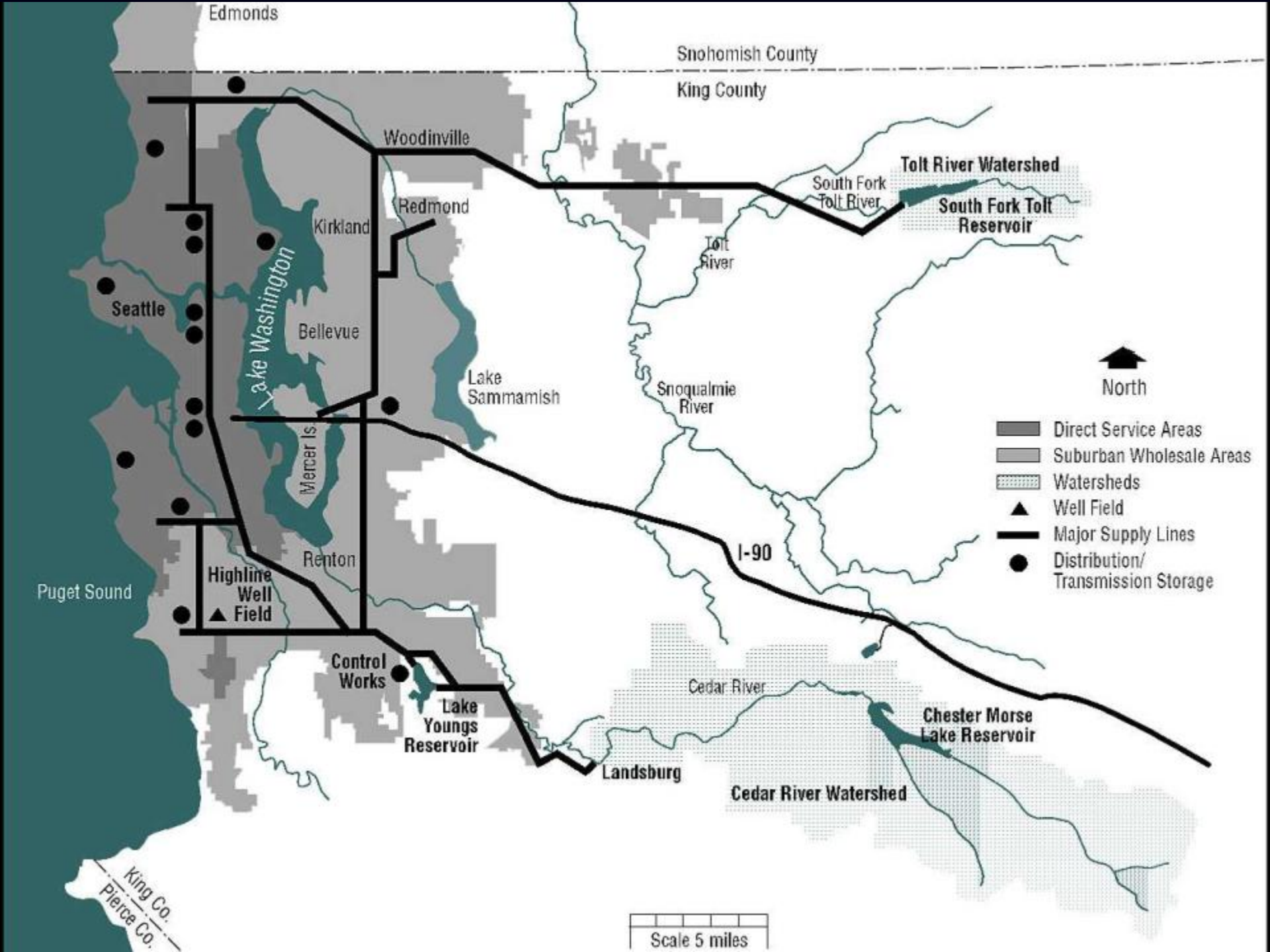
Agenda

- Water quality & mixing
  - Rechlorination
  - In-storage mixing
  - Sampling


Edmonds
Snohomish County
King County
Woodinville
Redmond
Kirkland
Lake Washington
Seattle
Bellevue
Mercer Is.
Lake Sammamish
Tolt River Watershed
South Fork Tolt River
South Fork Tolt Reservoir
Tolt River
Snoqualmie River
North
Direct Service Areas
Suburban Wholesale Areas
Watersheds
Well Field
Major Supply Lines
Distribution/ Transmission Storage
I-90
Renton
Highline Well Field
Puget Sound
Control Works
Lake Youngs Reservoir
Cedar River
Chester Morse Lake Reservoir
Landsburg
Cedar River Watershed
King Co.
Pierce Co.
Scale 5 miles

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SPU's Storage – A Diverse Mix

- Age
  - Oldest 1901, newest 2010
  - Average age >50 years
- Size - < 0.05 MG to 60 MG
- Concrete
  - Mix of roof types (including open & float covers)
  - Cast in place & pre-stressed
  - Above & below grade
- Steel standpipes & elevated tanks
  - Mix of coatings & linings
  - Riveted & welded

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Storage Inventory
(Includes Plant Clearwells)

TYPE	NUMBER	TOTAL MG
Open (uncovered) reservoirs	2	71
Concrete reservoirs, floating cover	2	81
Concrete reservoir & cover	13	258
Steel standpipes	10	10.6
Steel elevated tanks	7	8.5
TOTAL	**34**	**429**

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Uncovered (Open) Reservoirs

- Regulatory schedule for covering or decommissioning

- 1901 – Volunteer
- 1911 – Roosevelt

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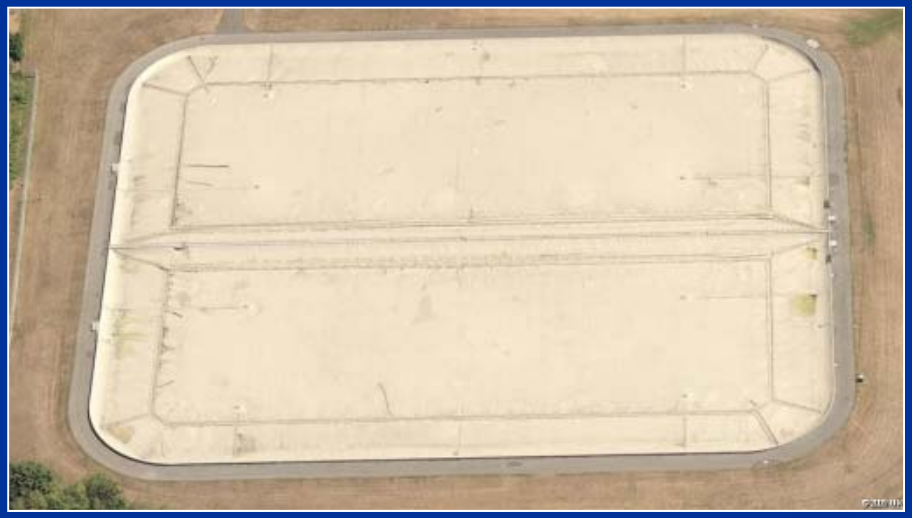
Reservoirs – Floating Covers

- 60 MG
- Center wall
- Sand tube tensioning



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Reservoirs – Floating Covers

- 21 MG
- Cable & counterweight tensioning

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Reservoirs – Buried

- 2.5 MG to 50 MG
- Some sites closed to public
- Some sites open, park use

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Reservoirs – Above Ground

- 6.5 MG to 20 MG
- Some sites closed
- Some sites open

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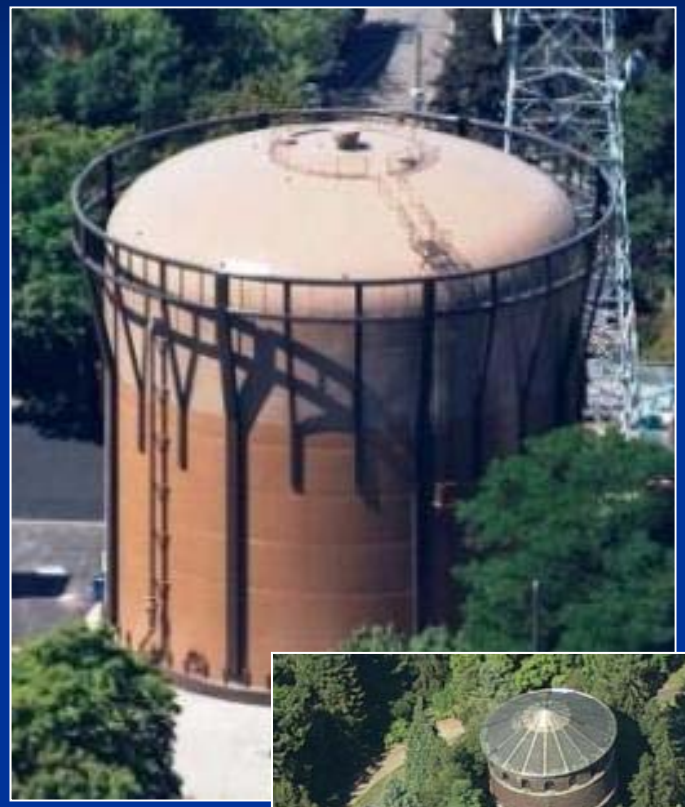
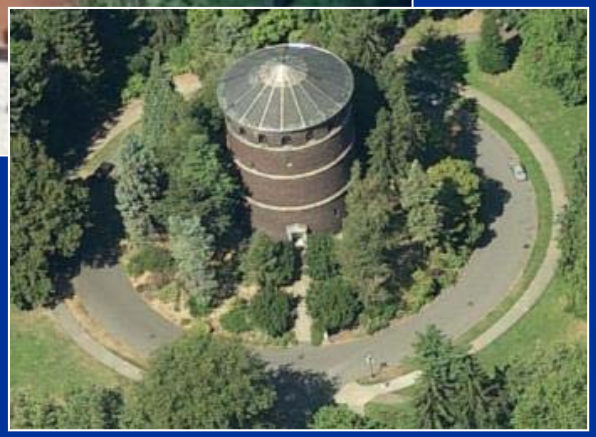
Steel Standpipes





- 0.88 MG to 2 MG
- Oldest 1909
- Newest 2008

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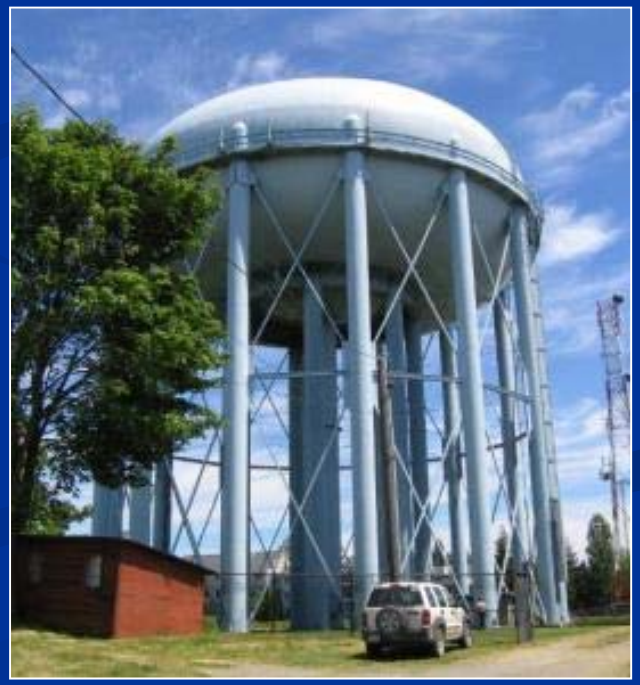
Steel Elevated Tanks

- 0.5 MG to 2 MG
- Oldest 1919
- Newest 1959



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Asset Management of Storage

- Identify necessary volumes
  - Calculate / verify normal operational & emergency storage needs
  - Account for risk of system outages if storage runs dry / system depressurizes
  - Attempt to price out cost of additional risks from less storage

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Asset Management of Storage

- Assess cost-efficient approach for maximizing facility life
  - Frequency of coating reapplication
  - Cathodic protection strategy
- Decisions based on data
  - If it's available

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Asset Management of Storage

- Generally, process results in less volume
  - Rebuilt storage smaller
  - Some existing storage decommissioned
    - But not demolished, just in case
- Controversy over critical assumptions
  - “Typical” response time for emergencies?
  - “Risk cost” of outages?
  - Earthquake and fire preparedness

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Asset Management of Storage

- While all the analysis is taking place
  - Still need to inspect & maintain storage
  - Still need to perform spot & major repairs / recoating
- Decommissioned (but not demolished) storage still needs maintenance

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Maintenance & CIP Activities

Sanitary inspection	Performed regularly, 2-3x / year (ground-level and entire exterior)
Cleaning	Performed every 3-5 years or as needed
Structural / coating inspection	Performed after cleaning
Re-coating (steel)	Last done in early 1980s; tank coatings generally in poor condition
Seismic upgrades	As needed; subject to Asset Management analysis

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Sanitary Inspections

- Document physical integrity of structures
  - Ground level quarterly
  - Roof level & detailed exterior annually
  - Interior when drained for cleaning
- Prevent WQ issues
  - Birds, bats, insects entering at loose screens
  - Rainwater entry through holes or bad gaskets
- Identify potential security issues

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Sanitary Inspections

- Schedule coordinated with O&M staff
  - Storage may have to be taken off-line depending on the particular concern
- Use standard checklists
  - Tailored to site
  - Photo documentation

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Sanitary Inspection Checklists

Overflow Pipe and Chamber

1. Is there standing water in the chamber?	Yes ☒	No ☐
2. Is there any debris on the chamber grating?	Yes ☐	No ☒
3. Is the grating bent, rusted or otherwise damaged?	Yes ☐	No ☒
4. Are there any items in the chamber?	Yes ☐	No ☒
5. Are there holes in the screen at the bottom of the pipe?	Yes ☐	No ☒
6. Is the screen loose on any edge?	Yes ☐	No ☒
7. Are there insects or nests on or inside the screen?	Yes ☐	No ☒

Ground Level Hatches

1. Are the hatches unlocked?	Yes ☐	No ☒
2. Are the hatch seals leaking?	Yes ☐	No ☒
3. Is there evidence of vandalism?	Yes ☐	No ☒

Roof Level Hatch

1. Is the tank ladder easily accessible or unlocked?	Yes ☐	No ☒
2. Is the hatch unlocked?	Yes ☐	No ☒
3. Is there evidence of vandalism?	Yes ☐	No ☒
4. Is rainwater leaking through the hatch into the tank?	Yes ☐	No ☒
5. Is rainwater leaking into the tank around the edges of the hatch?	Yes ☐	No ☒

Tank Roof

1. Is there evidence of vandalism?	Yes ☐	No ☒
2. Is the roof in poor condition?	Yes ☐	No ☒
3. Are there holes rusted in the roof? Can water leak in?	Yes ☐	No ☒
4. Can anything else get in or be thrown in?	Yes ☐	No ☒
5. Are there bird or bat nests?	Yes ☒	No ☐
6. Is the mesh screening missing from any vent?	Yes ☐	No ☒
7. Are there holes in the vent screens?	Yes ☐	No ☒
8. Is the screening loose on any edge?	Yes ☐	No ☒

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Sanitary Inspections

- SPU has increased frequency of inspections, particularly for steel structures
  - Advanced age of most protective coating systems
  - Known trouble areas
    - air space above water lines
    - vents
    - plate edges for riveted structures
    - thin spots in metal structures
    - certain hatches

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Sanitary Inspections – Roof Corrosion

4” hole in roof

(repair project underway)

Significant corrosion

(tank has been replaced)

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Sanitary Inspections – Roof Edge Corrosion

Roof plate edge

Roof-to-wall

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Sanitary Inspections – Potential Bird & Bat Entry

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Sanitary Inspections – Potential Bird & Bat Entry

Vent screen

Bird nests beneath walkway

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Storage Washing

- Every year for uncovered storage
  - Required by WDOH
- Every 3-5 years for unfiltered, covered storage
- Every 5-10 years for filtered, covered storage
  - Assuming 5-year dive or visual inspection indicates little sediment accumulation

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Storage Washing

- Schedule coordinated months to years in advance
  - 1 week to drain
  - 2-3 weeks to scrub
  - 3-5 days joint seal or liner repair
  - 1 week to refill
  - 3 days for leakage test & WQ sample
- System reliability reduced
  - Reservoir replacement projects
  - Major transit projects impact transmission lines

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Storage Washing

- Water quality
  - Bacteriological
  - Aesthetic
  - Corrosion products from pipes & storage
- Frequency
  - Determined by historical practice, inspection, & WQ monitoring
  - More often for open reservoirs

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Washing Uncovered Reservoirs

In the old days, on concrete liners, you stood on the bottom and sides, with fire hoses.

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Washing Uncovered Reservoirs

Nowadays, with wet plastic slopes, you slip.

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Washing Uncovered Reservoirs

High pressure parking lot cleaners were adapted in-house to clean the liners.

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Washing Covered Reservoirs

- Access
- Confined space
- Safety
- Lighting
- Washdown system
- Sediment disposal
- Waste discharge

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Washing Covered Reservoirs

Heavy sediment load (unfiltered supply) is pumped up to roof, then spread over the grounds.

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Washing Elevated Tanks & Standpipes

- Heights
- Confined space
- Communications
- Other entry considerations

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Floating Cover Inspection & Cleaning

- Potential WQ issues
- Physical integrity
- Drain pump status
- Safety considerations
- Standard checklist

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Floating Cover Inspection & Cleaning

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Structural & Coating Inspections

- Observe & document structural condition
  - In-house coatings / structural inspector
  - Standard checklists for consistency
- Maintain coating & lining integrity
  - Prevent long-term loss of facility life
  - Ensure personnel safety
- May affect WQ / sanitary conditions in storage facilities

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Structural & Coating Exterior Inspections

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Structural & Coating Interior Inspections

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Cathodic Protection Inspection

- Long-term protection of coating system & structure
- Use standard checklist to monitor & trend corrosion potential

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Float Inspections

- Infrequent, special purpose
- Disinfection requirements
- Access
- Safety

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Dive Inspections

- Infrequent, usually for a specific need
- Limits on how much can be inspected
- Disinfection, access, safety considerations

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Storage – Water Quality

In-Storage Mixing	Improve turnover and water quality
Booster chlorination	Maintain adequate chlorine residual throughout system
Water quality monitoring	Grab sample & on-line monitoring of system performance

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In-Storage Mixing

- Reservoirs
  - Pumped mixing systems (together with booster chlorination)
- Standpipes and elevated tanks
  - Momentum mixing systems

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Booster Chlorination

- Free Cl2 residual
- Boost Cl2 at storage
  - Continuous systems for larger storage
  - Intermittent boost for smaller storage
- Contributes to good TCR performance

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Booster Chlorination

Bulk hypochlorite

On-site hypochlorite generation

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Water Quality Monitoring

- On-line instruments (chlorine primarily)
- Multi-parameter contamination event monitors
- Grab samples

Hach Guardian Blue event monitor

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Security Issues

- Security upgrades ongoing
  - Capital improvements
  - Operational policies & emergency response

- Chessboards require a crane to lift outer cover for inspection

- Truck-mounted hydrolift can lift outer cover

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Questions?

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Storage Maintenance, Repairs and Replacement: Using In-House Staff vs. Contractors

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Agenda

- Follow Up on Inspection Results
- In-House vs. Contracted Work
  - Spot repairs
  - Minor coating touch-ups
  - Coating prep & re-application
  - Small & medium CIP work
  - Large CIP work

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From Inspection to Follow Up

- Results of sanitary / structural / other inspections feed into spot repairs & major CIP work
  - Discuss with O&M, WQ, & engineering staff
  - Balance between in-house & contracted work
- Managers committed to addressing deficiencies
- Try to stagger work to spread out financial impact
  - Don’t let deferred maintenance get out of hand

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Who Does the Work?

- In-house staff
  - Limited equipment on hand
  - Fixed number of staff – core activities limit availability (inspection, cleaning, minor repairs)
  - Typically more cost-effective than contracting
- Contractor
  - Performing more complex tasks (large-scale repair, environmental control, environmental containment, sandblasting)
  - More flexibility in staffing resources

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SPU Storage Crew

- 6 FTEs

- Responsible for
  - Storage cleaning
  - Sanitary inspections
  - Spot repairs
  - Special projects
  - Assistance with structural & coating inspections
  - Coating repair and/or application

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Storage Crew Workload Shift

- On average, 10 less cleanings per year than in 1998.
- Inspections increased from 100 to 500 per year by 2007.

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SPU In-House Staff

- Changing storage needs
  - Advanced coating age = more frequent sanitary & structural inspections
  - Older facilities need more frequent spot repairs, special projects
  - Additional focus on coatings repair & replacement
- Use SPU staff on smaller projects instead of contracting out

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SPU In-House Staff Also

- Install bird deterrent wires
- Replace floating cover tension cables
- Conduct dam safety inspections
- Design & repair fences
- Upgrade underground chamber hatches
- Build retaining walls
- Perform small concrete & pipe work
- Replace valves
- Install backflow preventers

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Spot Repairs

- Small projects
  - One day
  - < $5000
- Much cheaper & faster to do in-house

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Spot Repairs

- Fence repairs
  - Security issues
  - Timeliness

Open reservoirs must have staff on site when a fence is breached

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Spot Repairs

- Concrete patchwork – old formwork wood (!) found in reservoir roof
  - Wood swelled over time & cracked the concrete covering it

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Spot Repairs

- Tightening tension rods on an elevated tank
  - Improves seismic performance
  - Required rental of hi-lift

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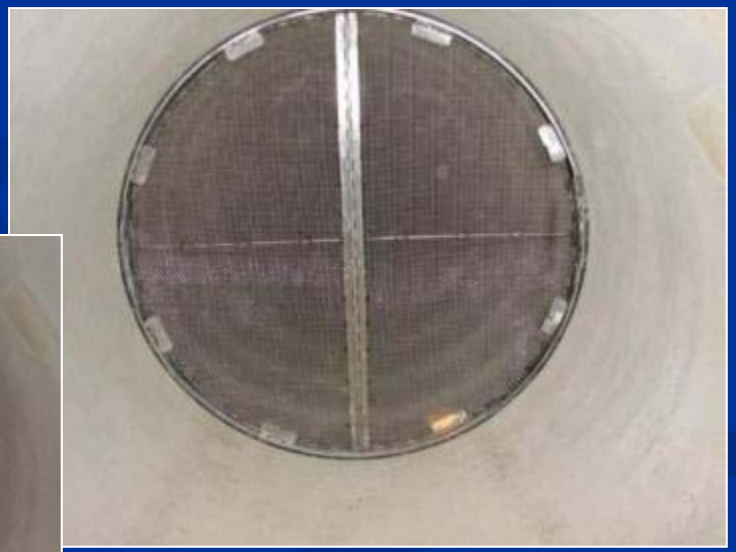
Spot Repairs

- Installing a screen on an existing reservoir overflow line (per DOH requirement)
  - Confined space
  - Rented installation equipment from manufacturer



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Spot Repairs

- Jetting out underdrains under a reservoir
  - Recycled concrete mistakenly allowed in backfill
  - Cementitious material leached into underdrain pipes

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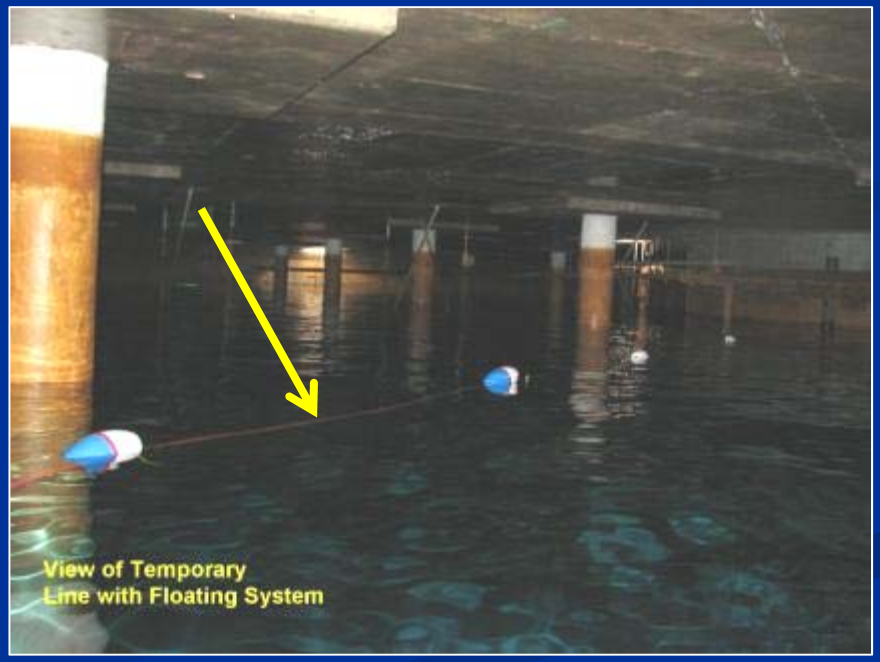
Spot Repairs

- Fixing a pressure sensing line while reservoir is in service (temporary “float fix”)



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Spot Repairs

- Retaining wall to enhance access around standpipe

Before

After

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Spot Repairs

- Sidewalk repairs around a reservoir

Before

After

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Spot Repairs & Minor Coating Touch-ups

- Small patches in coating
- Selection of re-coating materials to minimize future damage from vandalism

Vandalism

Rock chips

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Case Studies

- Where have SPU staff made efficient use of time & resources?
- Where has it made more sense to contract out?
- What lessons have we learned with either approach?

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Case Study #1: Bird Wires for Uncovered Reservoirs

- Need bird control at open reservoirs

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High Level Bird Wires

- Contractor-installed at one reservoir
  - $100k cost
  - Maintenance headaches, freezing weather damage, lightning rod

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Low Level Bird Wires

- Staff developed low-level wires
  - $30k for 4 reservoirs

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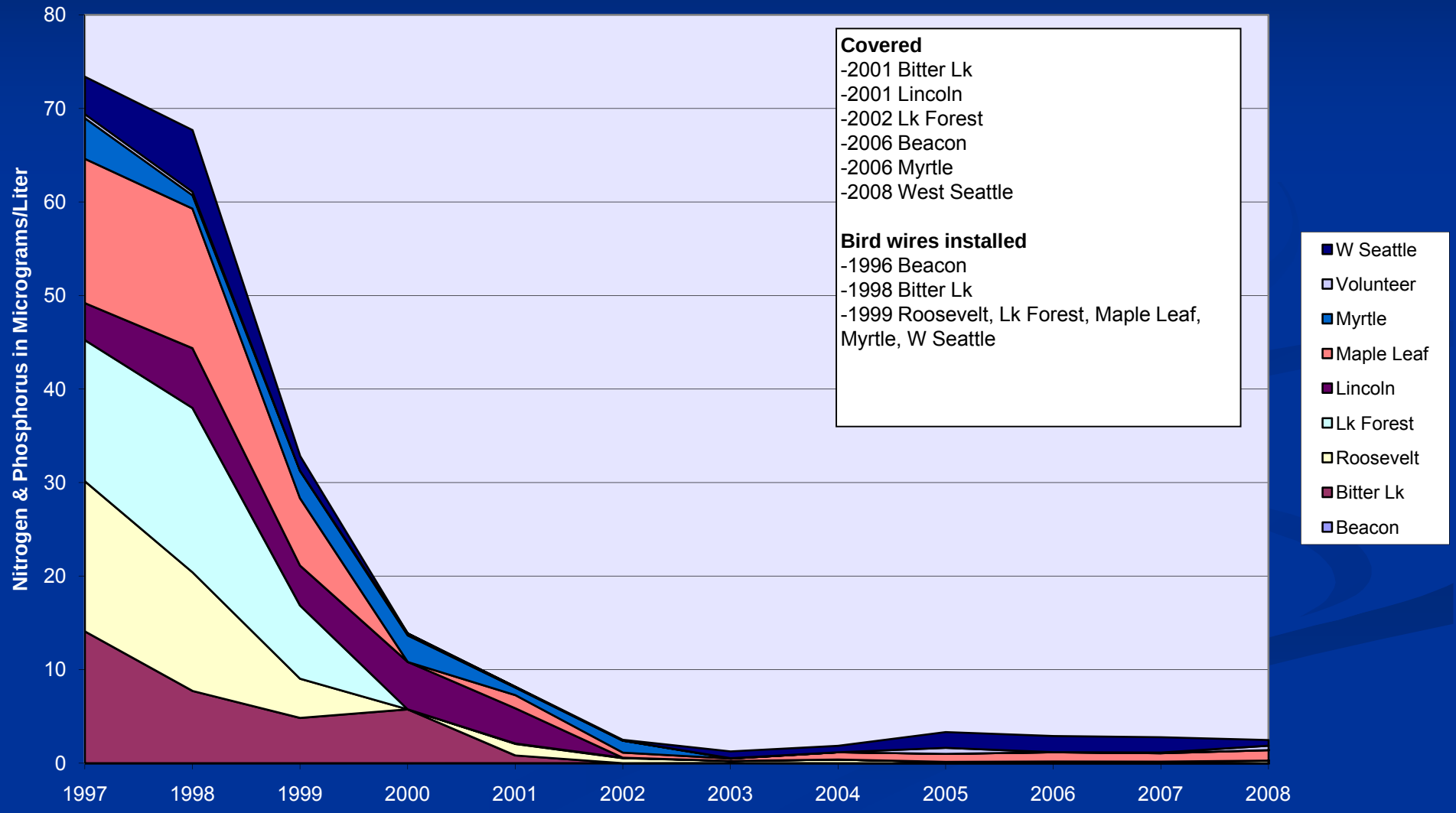
Estimated Total Nutrient Loadings at Open Reservoirs
(Estimates Based Upon Geese, Duck & Seagull Populations)



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Case Study #2: Riverton Reservoir Cleaning

- 20.5 MG reservoir overdue for cleaning
  - Drain & disposal issues – discharge to waters of the state
  - Cleaning deferred many years due to discharge issues
- Dive inspection to quantify sediment levels
- Considered dive cleaning vs. drain & wash out with SPU staff
  - Divers vacuum sediment off bottom & pump out of reservoir

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Alternatives for Cleaning

- Dive cleaning lump sum bid: $80,000
  - Quote based on 1-in depth of sediment
  - Proposal to filter out & haul sediment off-site
- Staff completed work for $25,000
  - 3 inches actual sediment vs. 1 inch noted in dive inspection
  - Reservoir drained of clear water
  - Sediment-laden water pumped to on-site land application

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Washing Riverton Reservoir

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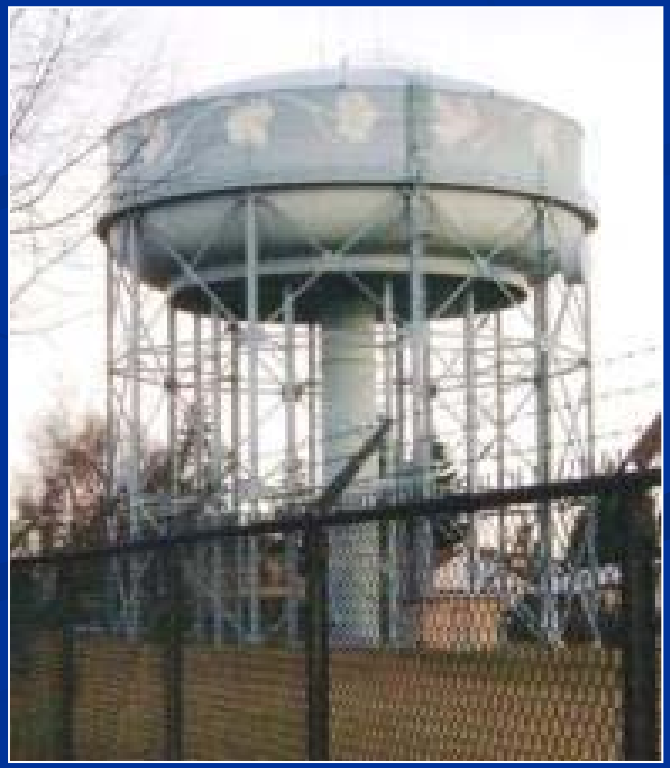
Case Study #3: Recoating Maple Leaf Tank

- Maple Leaf – 1 MG steel elevated tank
  - High visibility neighborhood “icon”
  - Identified for decommissioning by AM analysis
  - Keep generating revenue from antenna leases
  - Keep serviceable for future use
  - Exterior roof coating failed in many spots
  - Existing lead primer



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Used In-House Staff

- Test capability & availability of SPU storage maintenance staff for major coating work
  - Prep requirements
  - Selection & application of 4-part coating system
  - Training & rental of appropriate equipment

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Maple Leaf Tank Recoating

Before

After

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In-House vs. Contractor – Cost Comparison

- In-House cost:
  - Completed project cost of $40,000
- Contractor cost:
  - Engineering estimate of $100,000

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Case Study #4: Recoating Myrtle Tank #1

- Myrtle 1 – 0.5 MG steel elevated tank
  - Identified for decommissioning by AM analysis
  - Keep usable for future
  - Exterior coating loss, failure in many spots
  - Initial loss of metal in limited areas
  - Existing lead primer

- 2nd test of staff for major coating work

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Recoating Myrtle Tank #1

"Before"

Pressure washing. Capture of paint flakes not shown.

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Recoating Myrtle Tank #1

South side of tank prepped for primer.

Zinc primer applied.

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Recoating Myrtle Tank #1

Special attention to rivets.

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Recoating Myrtle Tank #1

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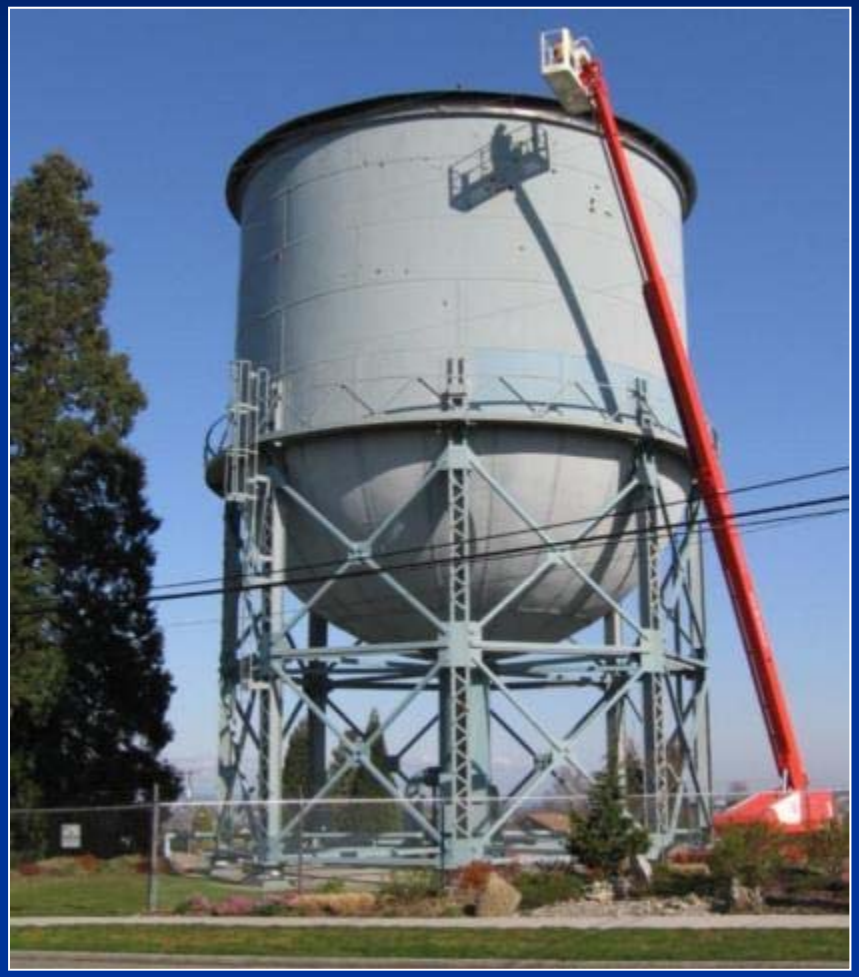
Recoating Myrtle Tank #1



Before

After

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In-House vs. Contractor – Cost Comparison

- In-House cost
  - Completed project cost of $65,000
- Contractor cost
  - Engineering estimate of $125,000

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Case Study #5: Recoating Myrtle Tank #2

- 60 year old riveted elevated tank, 1 MG
- Seismically upgraded recently
- Blast & re-coat interior & exterior
  - 27 years since last re-coating
  - Corrosion of structural members, pitting, metal loss
- No capability in-house, contract out

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Field Conditions
(Some Anticipated, Some Not)

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Recoating Myrtle Tank #2

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Case Study #6: Queen Anne Standpipes

- Two 100+ year old SPs, 1.2 MG total storage
  - Historical & neighborhood issues
- Seismic vulnerability
- Advanced corrosion
- Demolish & replace with a new 2 MG standpipe
- No capability in-house, contract out

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Demolition / Construction

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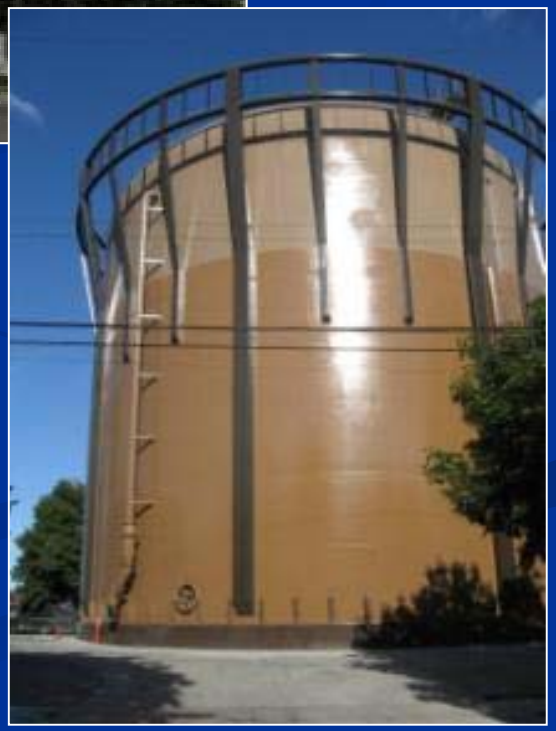
Queen Anne SP Construction



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In-House Storage Maintenance – Lessons Learned

- In-House Staff
  - Sense of ownership in facilities
  - Use experience, creativity to improve maintenance practices
- Management
  - Trust your staff
  - Don’t be afraid to try doing work in-house, instead of hiring contractors by default
  - Willingness to adapt to changing conditions

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Contracted Work – Lessons Learned

- Restricted to low bid lump sum approach
- Limited flexibility & high cost if conditions change
  - Heavy price for deferring re-coating too long

- Keep up with inspections to avoid surprises
  - Regular structural & coatings inspections
  - Pay special attention to metal supports & panels above water line
  - Make contractors aware of everything you know as part of bid process

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Questions?

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